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5. Key Words

Retrieval, Seismic, Tank, 241C106, Analysis

6. Author

Name: D. A. Wallace

DaWallace

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7. Abstract

This report gives the results of a seismic analysis, tank-to-tank interaction, and the seismic and in situ load combination.

8. RELEASE STAMP

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SEISMIC EVALUATION OF TANK 241C106 IN SUPPORT OF RETRIEVAL ACTIVITIES

October 1994

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WESTINGHOUSE HANFORD COMPANY
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for the
U.S. Department of Energy

INDEPENDENT REVIEW

Document Reviewed Seismic Evaluation of Tank 241C106 in Support of Retrieval Activities

Author D. A. Wallace Report No. WHC-SD-W320-ANAL-002 Rev. 0 EDT No. 142757

The subject document has been reviewed by the undersigned. The reviewer reviewed and verified the following items as applicable [EP.4.1].

- Engineering Specification
- Design Input
- Basic Assumption
- Approach/Design Methodology
- Related Information
- Conclusion/Result Interpretation

Reviewer: [signature] Date: 11/1/94

CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed Seismic Evaluation of Tank 241C106 in Support of Retrieval Activities

Author D. A. Wallace

Yes	No	N/A	
[x]	[ ]	[ ]	Problem completely defined.
[x]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[x]	[ ]	[ ]	Computer codes and data files documented.
[x]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[x]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[x]	[ ]	[ ]	Mathematical derivations checked including dimensional consistency of results.
[x]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[ ]	[ ]	[x]	Hand calculations checked for errors.
[x]	[ ]	[ ]	Code run streams correct and consistent with analysis documentation.
[x]	[ ]	[ ]	Code output consistent with input and with results reported in analysis documentation.
[x]	[ ]	[ ]	Acceptability limits on analytical results applicable and supported. Limits checked against sources.
[x]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[x]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[x]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.

MANDATORY Software QA Log Number 94-065 thru -068

R. S. Marlow [signature] 11/1/94
Reviewer Date

DESIGN VERIFICATION METHOD

The need for design verification has been reviewed with the method selected as indicated below:

[signature]	Independent Review
______	Alternative Calculations
______	Qualification Testing
______	Formal Design Review

[signature] 10/31/94
Cognizant Project/Design Manager
J. B. Truitt

SD # WHC-SD-W320-ANAL-002

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DWG(S) # ______

ENGINEERING ANALYSIS SOFTWARE REPORT FORM

ABAQUS Ver. 4.9*, SECC
(ABAQUS is a trademark of Hibbitt, Karlsson and Sorensen, Inc.) 94-065

SOFTWARE APPLICATION KEY NUMBER (IF APPLICABLE)

* with ANACAP-U Ver. 92.2-2, SECC
(ANACAP-U is a trademark of ANATECH Research Corporation.)

Phillip R. Kich WHC-SD-W320-ANAL-002

ANALYST (PRINTED NAME) EDT/DOCUMENT NUMBER

J. B. Truitt

ANALYST'S MANAGER

August 1994

DATE PERFORMED

DESCRIPTION OF ANALYSIS:

Structural static, nonlinear analysis of tank 241C106 for the effects of dead loads, live loads, and soil-surface loads associated with Past-Practice Sluicing operations. The user-defined subroutine, ANACAP-U, was used to define the constitutive behavior of the concrete: Model 2 (elastic, perfectly plastic compressive behavior) was defined. The model is a 3-D model of one-half of the tank.

Elements: Four-node quadrilateral shell elements with *REBAR subelements, and eight-node 3-D solid elements.

Loads: Distributed pressure loads (*DLOAD) including gravity loads, concentrated loads (*CLOAD), and thermal loads (*TEMPERATURE).

Materials: *USER MATERIAL for concrete, *ELASTIC and *PLASTIC for reinforcing steel, *DRUCKER-PRAGER and *YIELD for soil plasticity, *INITIAL CONDITIONS to define the initial state of stress of the soil.

Boundary Conditions: *BOUNDARY conditions to impose roller-type restraints at the soil boundaries and to impose symmetry boundaries at the plane of symmetry.

Solution: *STATIC analysis with the NOSTOP option.

Phillip R. Kich 10/27/94

SIGNATURE OF ANALYST DATE

ENGINEERING ANALYSIS SOFTWARE REPORT FORM

ANSYS Ver. 4.4A, ADVENT
(ANSYS is a registered Trademark of Swanson Analysis System, Inc.)
SOFTWARE APPLICATION

94-066
KEY NUMBER (IF APPLICABLE)

James P. Day
ANALYST (PRINTED NAME)

WHC-SD-W320-ANAL-002
EDT/DOCUMENT NUMBER

J. B. Truitt
ANALYST'S MANAGER

March through August 1994
DATE PERFORMED

DESCRIPTION OF ANALYSIS:

PREP7 preprocessing of converted HOUSE input files (used for visual checking of geometry, materials, and boundary conditions of HOUSE models).

James P. Day
SIGNATURE OF ANALYST

10/27/94
DATE

ENGINEERING ANALYSIS SOFTWARE REPORT FORM

SASSI Ver. P.C.C.-CRAY-1.0, RL Cray*
SASSI Ver. P.C.C.-CRAY-1.0, INEL**
SASSI Ver. P.C.C.-CRAY-1.0, LANL***

SOFTWARE APPLICATION

94-067

KEY NUMBER (IF APPLICABLE)

* Run IDs 9,9a,9b,Q2,Q3,Q4,Q5,Q5.5,Q6,Q7,Q7B,Q8,Q8V,TTT (ref: Appendix O)
** Run ID Q7V,Q9,50H (ref: Appendix O)
*** All remaining Run IDs from Appendix O

James P. Day

ANALYST (PRINTED NAME)

WHC-SD-W320-ANAL-002

EDT/DOCUMENT NUMBER

J. B. Truitt

ANALYST'S MANAGER

November 1993 through August 1994

DATE PERFORMED

DESCRIPTION OF ANALYSIS:

Seismic soil-structure interaction analyses using the direct flexible volume method; postprocessing to obtain transfer functions, response spectra, and structural response of shell elements.

James P. Day

SIGNATURE OF ANALYST

10/27/94

DATE

ENGINEERING ANALYSIS SOFTWARE REPORT FORM

SHAKE for MS-DOS (January 1985)
SOFTWARE APPLICATION

94-068
KEY NUMBER (IF APPLICABLE)

James P. Day
ANALYST (PRINTED NAME)

WHC-SD-W320-ANAL-002
EDT/DOCUMENT NUMBER

J. B. Truitt
ANALYST'S MANAGER

November 1993 through May 1994
DATE PERFORMED

DESCRIPTION OF ANALYSIS:

Site response analyses using grout vault soil data and Rohay-Weiner control motion.

SIGNATURE OF ANALYST

10/27/94
DATE

CONTENT

CONTENT (cont.)

FIGURES

FIGURES (cont)

FIGURES (cont)

FIGURES (cont)

FIGURES (cont)

FIGURES (cont)

FIGURES (cont)

FIGURES (cont)

FIGURES (cont)

TABLES

TABLES (cont)

SEISMIC EVALUATION OF TANK 241C106 IN SUPPORT OF RETRIEVAL ACTIVITIES

1.0 INTRODUCTION

Tank 241C106 (C106) is a domed, single-shell high-level waste storage tank that has been in service in the 200 East Area of the Hanford Site since 1947. Tank C106 is one of twelve tanks in a 4 x 3 array with a 100-ft center-to-center spacing. Each of the tanks is approximately 75 ft in diameter, 24-ft high at the haunch, and 33-ft high at the dome apex. The level of waste in C106 and the associated thermal environment have varied throughout the life of the tank with the peak temperature in the concrete reaching approximately 300 °F at the base of the tank in the mid-1970's (Bander 1992). The calculated peak temperature in the concrete has decreased since that time to approximately 200 °F. The peak temperature occurs at the inside bottom of the tank; concrete temperatures in the wall and dome are less than 130 °F. The waste inside the tank is primarily solid matter approximately 7- to 8-ft deep. The tank is completely buried in dry, sandy soil to a depth of approximately 6 ft at the dome apex. Bedrock at the site lies approximately 300 ft below the base of the tank. Figure 1.0-1 shows a schematic view of the tank; Figure 1.0-2 shows a schematic cross-section of the site.

The in situ evaluation of C106 documented in Julyk 1994 includes only the effects of gravity and thermal loads. A preliminary seismic evaluation of C106 considering only horizontal excitation (Moore 1993) demonstrated the finite-element program SASSI (A System for Analysis of Soil-Structure Interaction) (Lysmer et al. 1991a and 1991b) and provided an estimate of seismic effects including soil-to-structure interaction (SSI). This final seismic evaluation expands on the preliminary seismic evaluation (Moore 1993) to include further verification and refinement of analysis parameters, quantification of tank-to-tank and waste-to-tank interaction, and examination of the effects of vertical seismic excitation. The concrete structure of tank C106 is classified as a Safety Class 1 non-reactor structure (Kidder 1993) in accordance with the definition given in SDC 4.1 (1993).

Figure 1.0-1. Schematic of Tank 241C106.

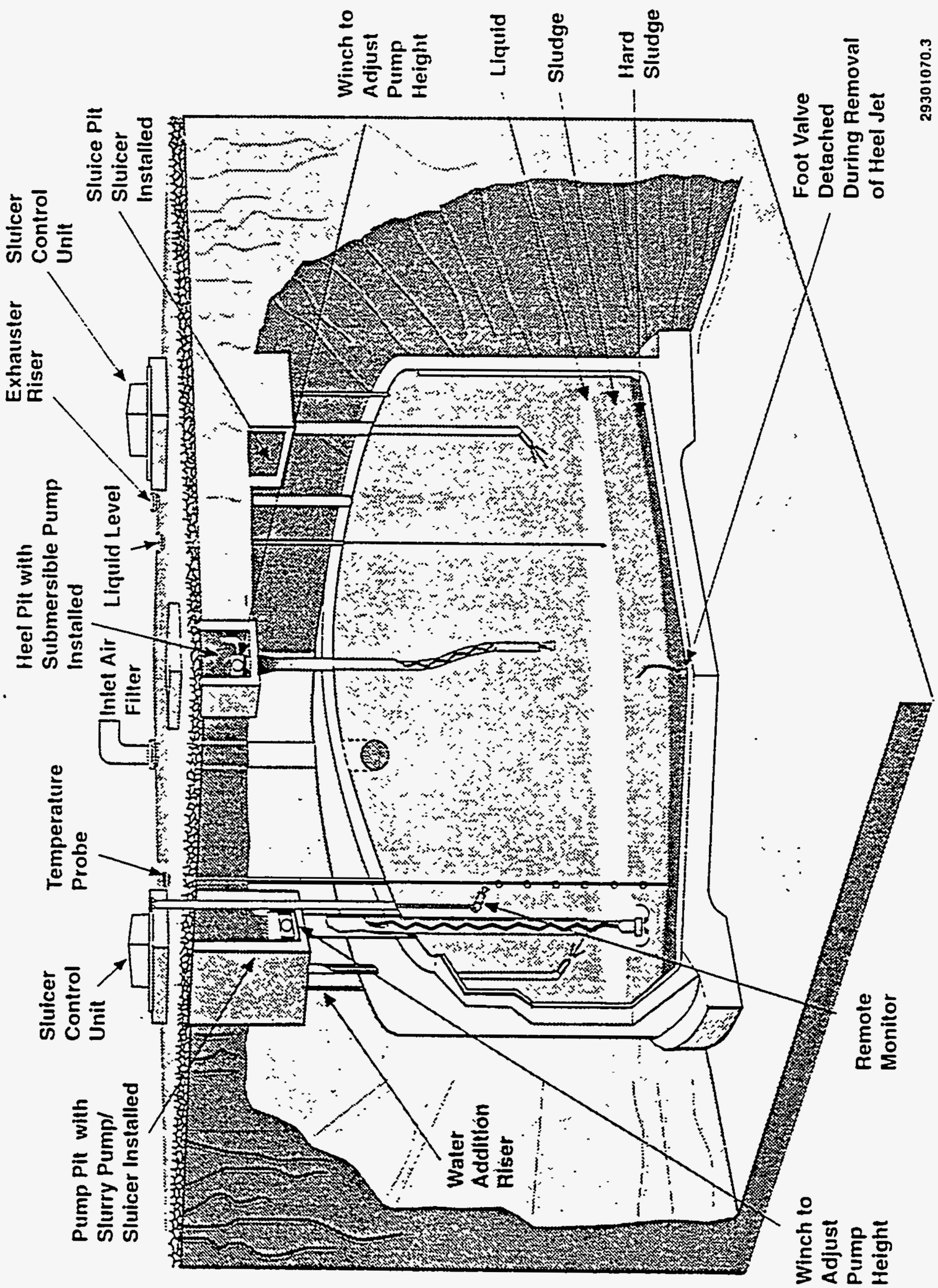
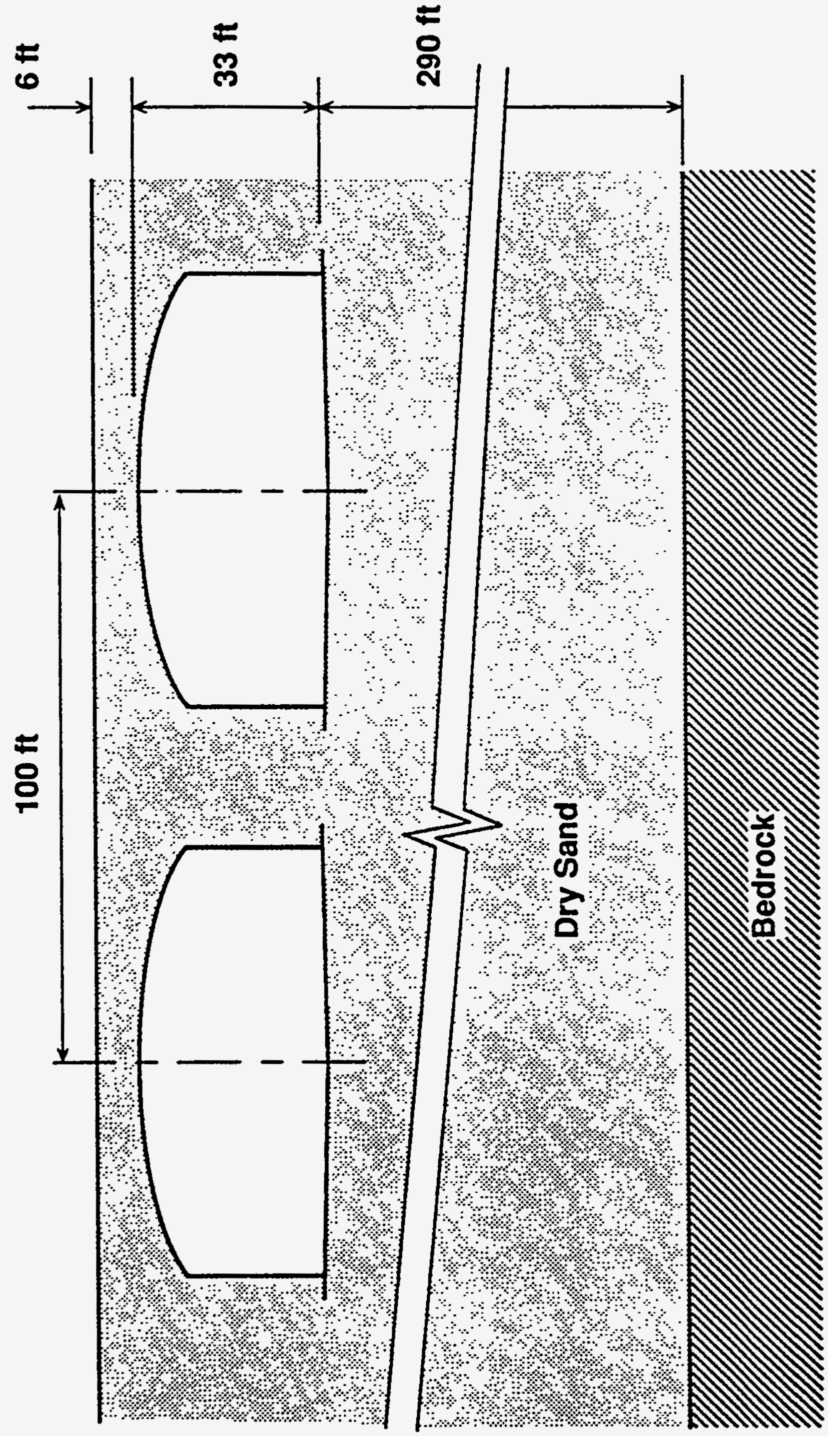


Figure 1.0-2. Site Cross Section.



2.0 SCOPE OF WORK

This work completes the structural evaluation of C106 in support of retrieval activities by performing a refined seismic analysis, combining the results with nonseismic response that includes the effects of retrieval activity loads, and evaluating the combined response against code-based section capacities (ACI 1990). The in situ condition of the tank calculated by Julyk (1994) is the baseline condition for calculating the seismic response. The evaluation considers combined seismic and nonseismic loads in accordance with the provisions of ACI 349-90 (ACI 1990). Sensitivity studies are performed to quantify the effect of analysis uncertainties.

In accordance with the Hanford Plant Standards (SDC-4.1 1993) for non-reactor Safety Class 1 structures, the seismic hazard is based on the Newmark-Hall response spectra anchored to a peak horizontal ground acceleration of 0.2 *g*. The analysis of the tank for vertical seismic excitation includes the effect of a 100-ton live load. The effect of the live load on response from horizontal seismic excitation is neglected.

In any seismic analysis the calculated seismic response is but an approximation of the actual seismic response. To maintain conservatism in the seismic evaluation, uncertainties associated with dynamic soil properties and with the inherent inaccuracies of an approximate analysis approach are considered. In accordance with seismic analysis standards (ASCE 1986, NUREG 1989), these uncertainties are addressed by using best-estimate values of soil shear moduli as well as bounding values of 50% and 200% of best-estimate moduli.

Uncertainties in the in situ state of the reinforced concrete are addressed by calculations of the seismic response using best-estimate and lower-bound values of tank section and material properties. The best-estimate values are congruent with the calculated in situ cracking state of the concrete and with best-estimate concrete moduli. The values defining the lower bound of the tank stiffness are based on assumed widespread cracking of concrete sections and pseudo-lower-bound concrete moduli equal to 87% of the best-estimate moduli.

Response of the tank from nonseismic loads is computed with the nonlinear finite-element program ABAQUS (HKS 1989) using the model discussed in Marlow (1994). Input runstreams for the nonseismic analysis, computed output, and a brief description of the nonseismic finite-element model are provided herein. Details of the ABAQUS model and nonseismic analysis approach appear in Marlow.

The vertical risers extending from the tank dome to the pits above the tank are analyzed for seismic loads and evaluated to AISC acceptance criteria (AISC 1992).

3.0 CONCLUSIONS

Tank C106 was structurally evaluated for combined seismic and nonseismic response. Using the ACI 349 code-based approach as documented in nonseismic tank evaluations (Julyk 1994, Marlow 1994), the evaluation showed that all reinforced concrete section demands from seismic load combinations (which include unfactored nonseismic loads) were less than the section capacities. Section capacities were consistent with the lower-bound (95/95) concrete compressive strength as computed by the ANACAP-U material subroutine for Hanford concrete (James 1993) in the C106 in situ analysis (Julyk 1994). The C106 vertical steel risers were evaluated to AISC acceptance criteria (AISC 1992). Riser demands from seismic loads were found to be within code allowables. Riser demands from nonseismic loads were assumed to be negligible.

Tank axial forces and bending moments from nonseismic loads were found to be significantly larger than the corresponding demands from seismic loads. Nonseismic loads controlled for transverse shear demands in the tank while seismic loads governed for in-plane shear demands. Further, seismic load combinations (seismic loads plus unfactored nonseismic loads) were less severe in terms of tank response than the nonseismic load combinations (nonseismic loads with load factors).

The seismic analysis considered three sets of soil moduli. The lower-bound soil moduli case resulted in the largest values of tank response while the upper-bound soil moduli case resulted in the smallest values of tank response. Tank response was measured primarily in terms of internal bending moments and axial forces. The largest demands (those from the lower-bound soil moduli case) were used in the final structural evaluation of the tank.

Horizontal seismic response in the wall and dome computed with the best-estimate tank stiffness model was three- to four-times larger than response computed with the lower-bound tank stiffness model (both analyses used best-estimate soil properties). Conversely, peak seismic response in the base of the tank was larger for the lower-bound tank stiffness condition. The larger of the horizontal seismic demands from the lower-bound tank stiffness condition and the best-estimate tank stiffness conditions were considered in the structural evaluation of the tank presented in Appendix L. An upper-bound tank stiffness condition based on circumferential rather than meridional reinforcement would not represent a significant deviation from the best-estimate tank stiffness condition; therefore, such an upper-bound tank stiffness condition was not included in the seismic analysis.

Seismic tank-to-tank interaction was small but nonetheless was included in the seismic evaluation. In computing the tank-to-tank interaction, the effect of only one adjacent tank was considered and that tank was assumed to be identical to C106 (no difference in contents, in situ loads, or materials).

The component of seismic response from vertical excitation was significant compared to the component from horizontal excitation. The vertical excitation response, in fact, was shown to be larger than the horizontal excitation response in some cases, e.g., meridional response in the dome and the upper part of the wall. Further, a large vertical amplification of motion, resulting in an acceleration approximately equal to 2.0 *g* at 12 Hz, was predicted at the tank dome. A comparison of results of vertical excitation analyses showed the effect of a 100-ton live load over the dome apex to be negligible except near the dome apex, i.e., the effect was highly localized. The conclusion was that the consideration of live-load mass in the seismic analysis is of minor importance.

Seismic response computed with SASSI with only seven analysis frequencies and a maximum (cutoff) frequency of 13 Hz was judged to be adequate, a judgement based on a comparison with response computed by use of 18 analysis frequencies and a cutoff frequency of 24 Hz. To ensure accuracy of results for evaluation purposes, however, a cutoff frequency of 24 Hz was maintained with no fewer than 11 analysis frequencies.

4.0 SEISMIC ANALYSIS METHODOLOGY

Two approaches are commonly used for the dynamic analysis of SSI problems. The spring-damper or lumped-parameter approach traditionally used in SSI analysis generally is believed to be less rigorous than the more recently developed finite-element impedance approach. It is now practical to solve three-dimensional (3-D) SSI problems with the finite-element method; therefore, the impedance approach is used for the seismic analysis of tank C106.

The SASSI finite-element code is used for the seismic analysis and combines the Site response analysis, the SSI or impedance analysis, and the structural analysis in one software package. The program SHAKE (Schnabel et al. 1973) performs an independent soil-column analysis and is run as a precursor to SASSI to determine iteratively the strain-compatible soil properties used as input to SASSI.

In a finite-element approach to the SSI problem, a linear substructuring methodology is followed whereby the SSI problem is subdivided into a number of simpler sub-problems. The sub-problems are solved separately, and the results are combined by the principle of linear superposition to obtain the complete solution. With SASSI, the SSI problem is solved via the flexible volume method of substructuring with three substructures. The substructures are the free-field soil, the excavated soil, and the C106 tank with its near-field soil. The site soil is represented as a continuum by use of transmitting boundaries. This approach allows proper wave propagation and energy dissipation and avoids unrealistic reflections of waves off boundaries that would be encountered with a finite representation of the soil. The free-field soil is modeled with horizontal, viscoelastic soil layers of varying thickness overlying a "rigid" basalt base. The soil layers become stiffer and denser as depth increases. The stiffness and damping properties of each soil layer are determined via an iterative approach in the SHAKE program to obtain soil properties consistent with the effective strain profile in the free-field associated with the horizontal seismic excitation.

The SASSI code is subdivided into several modules. The functions of the key modules as stated in the SASSI documentation (Lysmer et al. 1991a and 1991b) are summarized below.

SITE: In mode 1, SITE forms and solves the transmitting boundary eigenvalue problem for Rayleigh and Love wave cases. In mode 2, the mode shapes and complex wave numbers defining wave propagation speed and decay in the horizontal x-direction for each wave type are computed. Knowing the wave types of the seismic environment and the nature of the control motion, SITE scales and superimposes the results of the wave types to obtain the free-field displacement amplitudes at the interaction nodes.

POINT: Using the eigensolutions computed by SITE and the soil layer properties, POINT solves for point loads at the surface of each soil layer in the embedment zone. The point loads are computed for each specified frequency and depend on the radius of the central zone specified by the user.

HOUSE: HOUSE computes the frequency-independent global mass and stiffness matrices for the structure and excavated soil.

ANALYS: For each frequency, ANALYS computes the complex dynamic stiffness matrices of the structure, the excavated soil, and the free field. The last matrix is referred to as the impedance matrix. The three matrices are assembled into the stiffness matrix of the total system, which includes the effects of mass and damping. The load vector is computed by multiplying the impedance matrix with the free-field displacement amplitudes. The equations of motion are solved to obtain the uninterpolated acceleration transfer functions relative to the control motion.

MOTION: MOTION uses a fast Fourier transform (FFT) to convert the control motion into the frequency domain. Transfer functions from ANALYS are multiplied by the control motion to compute nodal accelerations in the frequency domain. These accelerations are transformed back to the time domain via an inverse FFT algorithm. At the analyst's request, corresponding response spectra are computed.

STRESS: Using transfer functions from ANALYS and stiffness matrices of the structure from HOUSE, STRESS calculates stresses, forces, or moments for each specified element at each frequency. Through interpolation and convolution with the control motion, and application of the inverse FFT algorithm, time histories of response are obtained.

Appendix B contains independent calculations of the numerical operations performed by MOTION. These independent checks are provided to demonstrate clearly details of the numerical operations and to assist in providing a general illustration of some of the theory incorporated into SASSI.

5.0 SEISMIC FINITE-ELEMENT MODELS

The seismic response of tank C106 was calculated by the SASSI code with 3-D linear finite-element models. The models include a "baseline" quarter-model described in Section 5.1 and derivatives of the baseline model described in Section 5.3. Validation and sensitivity studies supporting the development of the baseline model are described in Appendix A. Baseline model derivatives were developed to quantify tank-to-tank interaction (TTI), to investigate the effects of uncertainties in dynamic soil properties or in tank stiffness, and to evaluate tank risers.

5.1 GENERAL DESCRIPTION OF BASELINE MODEL

The SASSI baseline model for calculating seismic response to a horizontal excitation is a 3-D quarter-model employing a vertical plane of symmetry parallel to the excitation direction and a vertical plane of antisymmetry perpendicular to the excitation direction. Both planes intersect the centroidal axis of the tank in such a way that only one quadrant of the system is modeled explicitly, hence the designation "quarter-model." In the case of a vertical excitation, the antisymmetry plane is replaced with a second symmetry plane. The baseline model does not account for tank-to-tank interaction (TTI); TTI is addressed via a half-model as described in Section 5.3.1.

The baseline finite-element model is shown in Figures 5.1-1 and 5.1-2. Figure 5.1-1(a) and 5.1-1(b) show the near-field soil and the tank, respectively, which together make up the structural model. The reinforced concrete base, wall, and dome of the tank are modeled with thin-shell elements (680 elements). The near-field soil, which is considered part of the structural model, is modeled with solid elements (1,450 elements). The near-field soil mesh extends 50-in. radially outward from the tank wall, 74½-in. above the dome apex, and 28-in. beneath the tank base. Eight-node bricks (third-order integration) as well as degenerate eight-node elements (tetrahedrons, wedges, pyramids) are used in modeling the near-field soil. All degenerate elements use fourth-order integration. Validation of the degenerate elements is provided in Section A.2.1 of Appendix A. The near-field soil is included in the structural model primarily to facilitate the transition from the refined tank geometry to the relatively coarse horizontal soil layering. Nodes are shared by the tank and near-field soil at the tank-soil interface. Shell-element numbers and associated node numbers corresponding to the tank mesh in the baseline quarter-model are provided in Appendix S. Element numbers relevant to the structural evaluation are provided in Table 5.1-1 under the heading of "Quarter-Model."

The role of the steel liner in a single-shell tank is essentially that of an impermeable membrane with no intended role as a structural component. For this reason and because the issue of disparate coefficients of thermal expansion between steel and concrete is irrelevant from a seismic viewpoint, the liner is not included in the seismic model. Waste inside the tank is modeled as described in Section 5.2.3.

Figure 5.1-2 shows the excavated soil, which is modeled with 480 solid elements and occupies the same volume in space as the structural model. Only the nodes on the outer radius and bottom of the excavated soil are coincident with corresponding nodes in the structural model. These 558 nodes of the excavated soil model are the prescribed interaction nodes. Thus, the vertical spacing of the nodes in the excavated soil as shown in Figure 5.1-2 is indicative of soil-layer thicknesses. Additional layers of soil are included in the site response analysis in such a way that soil is defined to bedrock at a depth of 330 ft from the ground surface.

The HOUSE input file for the baseline quarter-model for a horizontal excitation appears in Section I.1 of Appendix I.

5.2 MATERIAL MODELING

Sections 5.2.1, 5.2.2, and 5.2.3 discuss the approaches used in modeling the soil, the reinforced concrete, and the tank waste, respectively.

5.2.1 Soil Modeling

Soil is modeled as a viscoelastic material. As there are no test data available for soil at the C106 site, the Grout Vault soil testing report (Dames & Moore 1988) was used as the primary basis for the C106 seismic soil properties. Of all the sites where soil test data were available, the Grout Vault site best fit the C106 site profile.

The best-estimate soil properties were developed with the following approach. Soil density as a function of depth, shear modulus as a function of depth and effective strain, percentage of critical damping as a function of effective strain, and a horizontal control motion at the ground surface are provided as input to the computer program SHAKE (Schnabel et al. 1972). The variation of density and shear modulus with depth is taken from the Grout Vault soil testing report (Dames and Moore 1988) while the variation of shear modulus and damping with effective strain is taken from an Earthquake Engineering Research Center report (Seed and Idriss 1970). Data used are those corresponding to the upper-bound shear modulus degradation curve and lower-bound damping curve published in the report. An absence of data has led to the assumption that, for a constant value of effective strain, damping does not vary with depth. The horizontal control motion provided as input to SHAKE is described in Section 6.1. SHAKE calculates the motion throughout the depth of the free-field soil, on the assumption that motion arises solely from shear waves propagating vertically from bedrock through a horizontally layered site. The computation of free-field motion by SHAKE is iterative, because soil properties (shear moduli and damping ratios) and effective strains in the free-field soil are mutually dependent. SHAKE input and output files are provided in Appendix H.

The best-estimate soil properties, including shear moduli and damping ratios calculated by SHAKE, are given in Table 5.2.1-1. In this table, damping is given as a ratio and not as a percentage. Through the depth of embedment of the structure (first four SHAKE soil layers), each SHAKE soil layer is split into two or three soil sublayers in the SASSI baseline model; therefore, some duplication of soil properties exist in the SASSI input. The following relationships based on elastic half-space theory are used in calculating the wave propagation speeds for SASSI.

$$V_S = \sqrt{\frac{G}{\rho}} \qquad V_P = V_S \sqrt{\frac{2-2\nu}{1-2\nu}}$$

where

ν = Poisson's ratio
V_S = shear wave speed
G = shear modulus
ρ = mass density
V_P = compression wave speed.

Poisson's ratio of the soil is taken as a constant equal to 0.44 and is based on wave speeds reported in Dames & Moore 1988. Only the data for soil at depths greater than 9 ft from the ground surface are used in determining Poisson's ratio, as data for soil at shallower depths appear suspect. Because Poisson's ratio is assumed to be a constant, compression-wave speed is directly proportional to shear-wave speed.

The damping ratios of the soil calculated by SHAKE and used in SASSI are typically within a range of 0.01 to 0.04 (1% to 4% of critical damping) and thus are well within the maximum damping value of 15% allowed by BNL 52361 (Bandyopadhyay et al. 1993).

Free-field soil and near-field soil are assumed to have the same fundamental material properties. Further, the effective strain profile in the near-field soil used in developing strain-compatible shear moduli and damping ratios is approximated as being equal to the effective strain profile in the free-field soil.

The vertical excitation analysis uses the same set of soil properties as the horizontal excitation analysis. As summarized above, SHAKE provides soil properties consistent with the free-field motion arising from vertically propagating shear waves. The shear waves are such that the horizontal control motion from Weiner and Rohay 1992 is produced at the surface of the first "competent" soil layer. The free-field motion calculated in SHAKE does *not* include contributions from the vertical seismic excitation; thus, the seismic strains are underestimated to some degree in determining strain-compatible soil properties. From the Seed and Idriss data (1970), a 100% increase in effective strain (from 0.015 percent to 0.030 percent) affects soil shear modulus by less than 20%. Because soil strains from vertical excitation generally can be expected to be significantly less than strains from horizontal excitation, inaccuracies in soil properties attributable to neglecting soil strains from vertical excitation are relatively minor.

5.2.2 Reinforced Concrete Modeling

The reinforced concrete tank is modeled with shell elements of elastic, isotropic material. In the baseline model (and all models on which the seismic evaluation is based), the thickness of each shell element and the Young's modulus of the elastic, homogeneous material are prescribed to take approximately into account the effect of steel reinforcement, the state of cracking, and the "true" material stiffness of the concrete and reinforcement including degradation from time and temperature. The material and section properties of the shell elements are tuned to obtain membrane and bending stiffnesses of the corresponding in situ tank sections. The "target" stiffnesses are based on the 2002 (55-year), best-estimate in situ state as determined by the nonseismic analysis (Julyk 1994). The effective weight density of the shell element material is adjusted so that the true mass of the tank is retained though the effective shell thickness may be different from the true thickness. Table 5.2.2-1 summarizes the nominal section and material data for each tank section and the equivalent shell properties for the corresponding ring of shell elements. Details of the procedure are provided in Appendix U. Section A.3.2 of Appendix A compares the responses in two cases: one case in which nominal material and gross section properties were used and another in which the shell properties were "tuned" to those of the in situ state properties.

Quantities and/or placements of steel reinforcement (rebar) in the tank are different in the two orthogonal directions. Table 5.2.2-2 summarizes the major differences in quantity of steel; the differences in bar placement (cover) are relatively minor. The table shows that the overall differences in reinforcement in the two directions are small in the base and the dome, large in the footing and wall (approximately twice as much steel in the hoop direction), and very large in the haunch (approximately ten to fifteen times as much steel in the hoop direction). These differences in circumferential and meridional reinforcement cause the reinforced concrete to behave in an orthotropic manner; however, the analysis software is limited to isotropic representations. Because meridional demands generally control over circumferential demands, the effective shell properties are computed on the basis of meridional reinforcement. In effect, the shell element model is an idealization of the actual tank where the circumferential reinforcement is the same as the meridional reinforcement. The error associated with this modeling approximation is relatively insignificant given that the quantity of reinforcement has only a secondary effect on the stiffness of an uncracked section and that most of the tank is uncracked.

The cracked status of each section is based on the in situ (calculated) crack plot provided in the in situ tank evaluation (Julyk 1994). As shown in plots of the in situ crack pattern (Figures 5.2.2-1 and 5.2.2-2), cracking associated with in situ loading occurs locally only at the top of the wall, at the bottom of the wall, and in the base near the knuckle. Transformed concrete sections (Figure 5.2.2-3) are used as the basis for calculating equivalent section stiffnesses. Where the in situ crack plot indicates any degree of cracking, the cracked, transformed section is considered on the assumption that concrete can take no load in tension. Because axial load is generally small relative to axial capacity, the influence of axial load on the location of the neutral axis of the transformed section is neglected for simplicity.

Damping of the concrete is specified as 7% of critical damping in accordance with BNL 52361 (Bandyopadhyay et al. 1993) seismic analysis guidelines for response level 2 reinforced concrete structures. The response level is defined by the ratio of total demand (seismic demand plus nonseismic demand) to code strength capacity in the majority of the seismic load-resisting components of the structure. For ratios between 0.5 and 1.0, the appropriate response level is response level 2.

5.2.3 Waste Modeling

In the case of a horizontal excitation, the waste is modeled simplistically via lumped masses attached to nodes along the tank wall. Similarly, waste is modeled simplistically as additional mass on the tank base in the case of a vertical excitation.

The hydrodynamic effect of the tank waste from a horizontal seismic excitation is composed of impulsive and convective components. In the general case of an inviscid liquid inside a tank, the convective (sloshing) component is small relative to the impulsive component (Bandyopadhyay et al. 1993, Section 4.3.2.4 and Appendix F, p. F-10). As the tank waste is primarily viscous sludge, the effect of sloshing is reduced (Bandyopadhyay et al. 1993, pp. 2-3, 2-4). The tank is less than half-full of waste, a fact that further reduces the effect of sloshing on the tank wall and eliminates the possibility that the slosh height will reach the dome. In view of the insignificance of the convective mode for tank C106, only the impulsive effect of the waste is considered. As the waste mass associated with convective modes is assumed to be zero, the total mass of the waste is considered for the impulsive mode.

The impulsive effects of the waste associated with a horizontal seismic excitation are approximated by prescribing lumped masses at nodes on the tank wall. Each lumped mass corresponds to a tributary volume of waste with the sum of the lumped masses being equal to 100% of the waste mass. Each mass is active in all directions; hence, a potential rocking motion of the tank arising from a horizontal excitation is considered in an approximate fashion in that vertical acceleration of the lumped masses will impose vertical load on the wall. Details of calculating the tributary masses for each wall node are presented in Appendix N, and effects of waste on horizontal tank response are summarized in Section A.3.3 of Appendix A. This approach to modeling hydrodynamic waste effects is approximate and typically conservative in that waste mass is distributed around the full circumference of the tank. In reality, impulsive waste forces are applied to only one-half the tank wall at any given point in time. Further, the effects of dynamic earth pressures and impulsive waste forces, rather than being additive, are generally counteracting to some degree (if small or zero phasing differences are assumed in the two loads). In the SASSI model, the counteracting effect of impulsive waste forces on dynamic earth pressures tends to be underestimated.

In an approach similar to that described above, the impulsive effects of the waste associated with a vertical seismic excitation are approximated by increasing the density of the tank base material to include the waste mass. In this approach, the hydrodynamic pressure on the tank wall from the vertical seismic acceleration of the waste is not considered. From an structural evaluation perspective, hydrodynamic pressure on the wall from vertical excitation of the waste counteracts response from dynamic earth pressures. For single-shell tanks, BNL 52361 (Bandyopadhyay et al. 1993) states that a phasing difference in the two opposing wall pressures may exist and recommends evaluating the tank by considering each of the two wall loads to act alone, not in combination. Because the tank is less than half full, lateral earth pressure dominates over waste load on the tank wall; therefore, it is within the guidelines to neglect the waste load on the wall that results from vertical excitation. A set of SASSI inputs for a vertical excitation analysis is provided in Section I.3 of Appendix I.

Calculations of lumped masses and of the revised tank-base material densities representing the waste for the horizontal and vertical excitation cases, respectively, are provided in Appendix N.

5.3 DEVIATIONS FROM BASELINE MODEL

The baseline model is used to compute the seismic response of the tank neglecting tank-to-tank interaction and considering only the best-estimate values of soil properties and tank stiffness. Deviations from these assumptions/conditions require the use of models described in Sections 5.3.1 to 5.3.3. Further, Section 5.3.4 describes modifications made to the baseline model to predict the response of the vertical steel risers and concrete pits over the tank.

5.3.1 Tank-to-Tank Interaction

Tank-to-tank interaction (TTI) is a function of a number of variables including soil stiffness, tank stiffness, tank spacing, and seismic environment. Many studies have used plane-strain models of underground waste tanks in an attempt to quantify TTI effects. There remains considerable debate as to the validity and usefulness of these two-dimensional studies. TTI associated with a horizontal excitation was examined by means of 3-D models as described in the remainder of this section. TTI associated with a vertical excitation generally is regarded as being small relative to that associated with horizontal excitation; therefore, TTI for a vertical excitation is not considered in the seismic evaluation.

In lieu of explicitly modeling two adjacent tanks (two half-tanks) to predict horizontal TTI, a single half-tank with a plane of antisymmetry defined at a location in the soil corresponding to the midway point between two adjacent tanks is used (Figure 5.3.1-1). The former approach was impractical from the standpoint of computing resource requirements. Validation of the latter approach is provided in Sections A.1.1 and A.1.2.

As in the baseline quarter-model, the TTI half-model includes a vertical plane of symmetry through the tank centroidal axis and parallel to the excitation direction. The near-field soil and tank in the TTI half-model are shown in Figure 5.3.1-2. As mesh refinement in the TTI half-model is exactly the same as in the baseline quarter-model, the TTI model has exactly twice the number of elements. Shell-element numbers and associated node numbers corresponding to the tank mesh in the TTI half-model are provided in Appendix T. Element numbers relevant to the structural evaluation are provided in Table 5.1-1 under the heading "Half-Model."

The HOUSE input file for the TTI half-model with lower-bound soil properties is found in Section I.2 of Appendix I. This input file was generated with the aid of the computer program *MGEN.for*, a listing of which is provided in Appendix R. Appendix R also contains portions of the baseline model HOUSE input that serve as input files to *MGEN.for*.

5.3.2 Soil Properties Variation

For a number of reasons including shortage of test data for site-specific soil, there is substantial uncertainty in the soil parameters used in the SSI analysis. To help maintain conservatism in computed seismic response, seismic analysis guidelines recommend that bounding values of the soil shear moduli be used. This approach is intended to account for uncertainties not only in the soil properties but in other aspects of the SSI analysis as well (ASCE 1986). The upper-bound shear moduli are equal to the best-estimate moduli times the quantity $1 + C_v$ where C_v is an uncertainty factor. For the lower-bound case, the soil shear moduli are equal to the best-estimate moduli divided by the quantity $1 + C_v$. If C_v cannot be determined in a probabilistic manner, ASCE requires that a value of no less than 0.5 be used for C_v. Other seismic analysis guidelines (Bandyopadhyay et al. 1993 and NUREG 1989) suggest that C_v be set to unity. The bounding seismic analyses of C106 use C_v equal to one; thus, the lower-bound soil shear moduli are set equal to 50% of the best-estimate moduli, and the upper-bound shear moduli are set equal to 200% of the best-estimate moduli. The moduli are adjusted before the SHAKE program is run.

BNL 52361 guidelines (Bandyopadhyay et al. 1993) state that when a soft soil layer (V_s less than 750 ft/s) overlies a stiffer (competent) layer, the control motion should be specified at an outcrop of the stiffer layer. Such is the case for the C106 lower-bound soil condition. In the lower-bound SHAKE analysis (Appendix H), the control motion is specified at an outcrop of the second soil layer because the first layer has a shear wave speed of less than 750 ft/s. The motion is deconvolved to the bedrock and then convolved back to the surface of the soft soil layer (Layer 1). The acceleration time history calculated by SHAKE at the surface of the soft soil layer is used as the new control motion in the SASSI analysis for the lower-bound soil condition. As in all cases, soil properties that are consistent with the free-field strain profile are determined by SHAKE and are used as input in the SSI (SASSI) analysis.

The lower-bound (50%) and upper-bound (200%) soil properties, including strain-compatible shear moduli and damping ratios calculated by SHAKE, are given in Tables 5.3.2-1 and 5.3.2-2, respectively. Given shear modulus, Poisson's ratio, and density of each soil layer, relationships based on elastic half-space theory are used in calculating the wave propagation speeds for SASSI.

The SASSI user's manual (Lysmer et al. 1991b) gives a guideline for establishing appropriate spacing of interaction nodes based on shear wave speed and the highest frequency of the analysis (one-fifth wavelength rule). Using the one-fifth wavelength rule, Tables 5.3.2-3, 5.3.2-4, and 5.3.2-5 list the highest analysis frequency consistent with the thickness and shear wave speed in each soil layer for the best-estimate, lower-bound, and upper-bound soil conditions, respectively. When applied to horizontal spacing of interaction nodes, the one-fifth wavelength rule may be relaxed by approximately a factor of two without a significant sacrifice in solution accuracy for the case of vertically propagating waves (Lysmer in Appendix P). Lysmer also states that the "selection of the correct vertical dimension [layer thickness] is most important within the depth of embedment. At greater depths you can gradually increase the vertical dimension of elements beyond that specified by the wavelength rule." With a cutoff analysis frequency of

24 Hz, violations of the wavelength rule within the depth of embedment of the tank are evident for the lower-bound and upper-bound soil cases as indicated in Tables 5.3.2-4 and 5.3.2-5 by shaded cells. These violations are minor, i.e., the highest analysis frequencies defined by the wavelength rule (20.5 Hz for lower-bound soil properties and 21.6 Hz for upper-bound soil properties) are near the 24-Hz cutoff. Further, it is evident from comparisons of results based on 13- and 24-Hz cutoff frequencies that contributions from higher frequencies are relatively unimportant. This conclusion regarding the insignificance of higher frequency response may not apply alternate control motions having higher frequency content.

For the upper-bound soil properties case in which wave speeds are relatively large, the refinement (558 interaction nodes) offered by the baseline model is not warranted; therefore, a computationally efficient coarse model (95 interaction nodes) is used. There is no difference in the tank mesh densities of the baseline and coarse models; the difference lies primarily in the refinement of the excavated soil mesh (number and spacing of interaction nodes). The HOUSE input file for the upper-bound soil analysis is provided in Section I.4 of Appendix I.

5.3.3 Tank Stiffness Variation

BNL 52361 guidelines (Bandyopadhyay et al. 1993, Section 3.4) recommend that structural frequency variations be considered. As the guidelines state that it is often appropriate to skew the frequency variation to the low side, rerunning the analyses with all sections considered as cracked should meet the intent of the frequency variation recommendation. As the addition of seismic loads to the generally dominant nonseismic loads is not likely to induce widespread cracking, the assumption of widespread cracking represents more of an arbitrary bounding state than an expected state. To soften the tank further, the concrete elastic modulus is reduced to correspond approximately to the 2002 (55-year) nonseismic analysis with lower-bound concrete properties (Julyk 1994). (The lower-bound concrete modulus is taken as 87% of the best-estimate concrete modulus. This reduction is based on the square root of the ratio of lower-bound concrete compressive strength to best-estimate compressive strength.) The combination of lower-bound concrete modulus with the assumption of universal cracking is referred to as the "soft tank" condition.

The development of equivalent shell element properties for the soft tank condition uses the approach documented in Section 5.2.2 and Appendix U. Table 5.3.3-1 summarizes the nominal section and material data for each tank section and the equivalent shell properties for the corresponding ring of shell elements in the soft tank model.

In accordance with BNL 52361 only best-estimate soil properties are used in conjunction with the soft tank model. Further, the computationally efficient coarse model (95 interaction nodes) is used for the soft tank SSI analysis. The HOUSE input file is provided in Section I.5 of Appendix I.

As stated in Appendix U, the derivation of equivalent shell element properties of the best-estimate (stiffness) tank considers meridional reinforcement. Consideration of circumferential rather than meridional reinforcement would constitute a reasonable approximation of an upper-bound tank stiffness condition. Because reinforcement has only a secondary effect on stiffness values of uncracked sections and the (best-estimate) tank is largely uncracked, the proposed upper-bound tank stiffness condition represents much less of a deviation from the best-estimate tank stiffness condition than does the lower-bound tank stiffness condition. Although a nominal increase in tank stiffness may result in increased section demands, demands associated with a upper-bound-tank-stiffness/best-estimate-soil-properties condition are unlikely to exceed the demands associated with the best-estimate-tank-stiffness/lower-bound-soil-properties condition. Because bounding conditions of soil properties and tank stiffness need not be considered in combination (Bandyopadhyay et al. 1993), the upper-bound tank stiffness is not a controlling condition and is not included as a separate analysis case.

5.3.4 Model with Pits and Risers

Tank C106 has three reinforced concrete pits located above the tank dome and embedded in the soil. As shown in Figure 5.3.4-1, each box-shaped pit is separated from the tank dome by a layer of soil. Steel pipes (risers) span vertically between the floor of each pit and the tank dome. The top end of each riser is coupled with the pit floor in the horizontal direction but not in the vertical direction.

Because the pits are small relative to the tank, their presence has little influence on the seismic tank response. Therefore, the pits and risers are not considered in the general tank evaluation. The risers and crude representations of the pits are added to the tank model for two reasons:

- To assess seismically induced riser response for use in an evaluation of the steel risers (Section 9.3)

- To calculate pit-floor response spectra for use in an evaluation of allowable loads in the pit floor.

The baseline SASSI model with the following modifications is used in the riser evaluation.

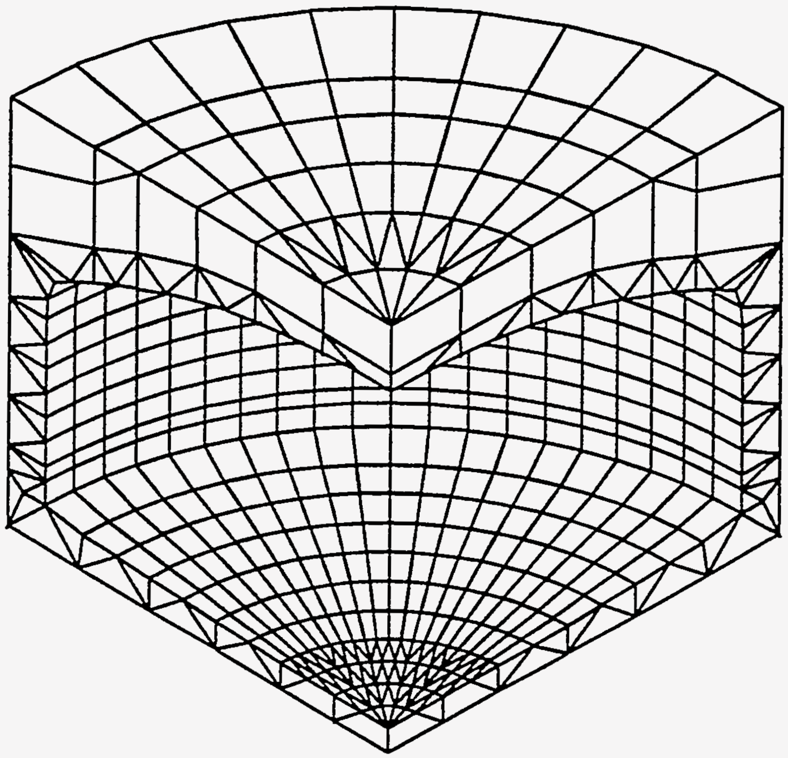
- The arrangement of nodes and solid elements in the region above the tank dome is modified slightly so that volumes occupied by pits are better represented.

- The material properties (density and wave speeds) of near-field soil elements occupying volume actually occupied by the pits are modified to represent a "pseudo-pit." Because the pits are not solid blocks of concrete, Young's modulus of the pseudo-pit material is (arbitrarily) taken to be equal to 50% that of concrete with compressive strength equal to 3,000 lbf/in^2. Poisson's ratio of concrete (0.15) is used. Density is prescribed so that the mass of the pseudo-pit agrees with that of the actual pit. Wave speeds are determined on the basis of elastic half-space theory.

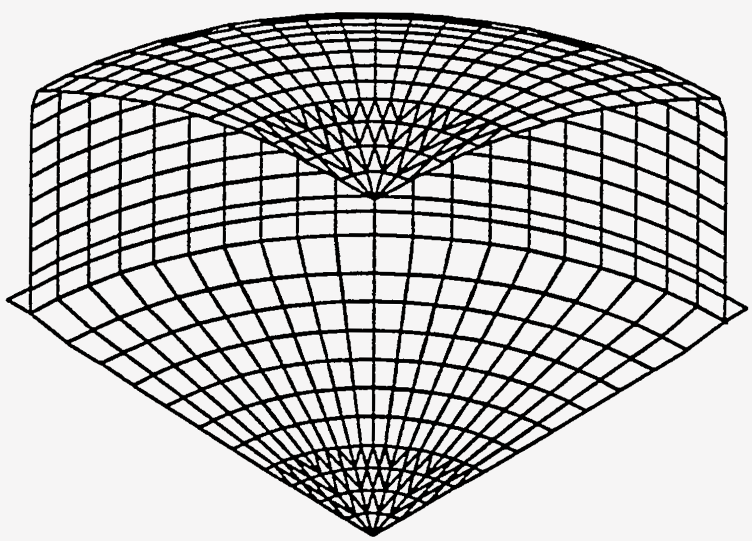
- Vertical beam elements representing the steel risers are added. Each beam spans from a point on the dome to the bottom of a pseudo-pit. The top node of each riser beam is end-released so that only horizontal forces and no moments may be transferred to that node. Beam section properties are set in accordance with the diameter and thickness of the risers. Material properties correspond to those of steel.

Three variations of the quarter-model were generated: one for a vertical excitation, and because the pits/risers introduce nonsymmetry into the problem, two for the two orthogonal horizontal excitations. Additional modeling details are provided in Appendix Q, and SASSI input files for the y-direction excitation analysis are provided in Section I.6 of Appendix I.

Figure 5.1-1. Baseline Quarter-Model.



(a) Near-Field Soil



(b) Tank

Figure 5.1-2. Excavated Soil in Baseline Quarter-Model.

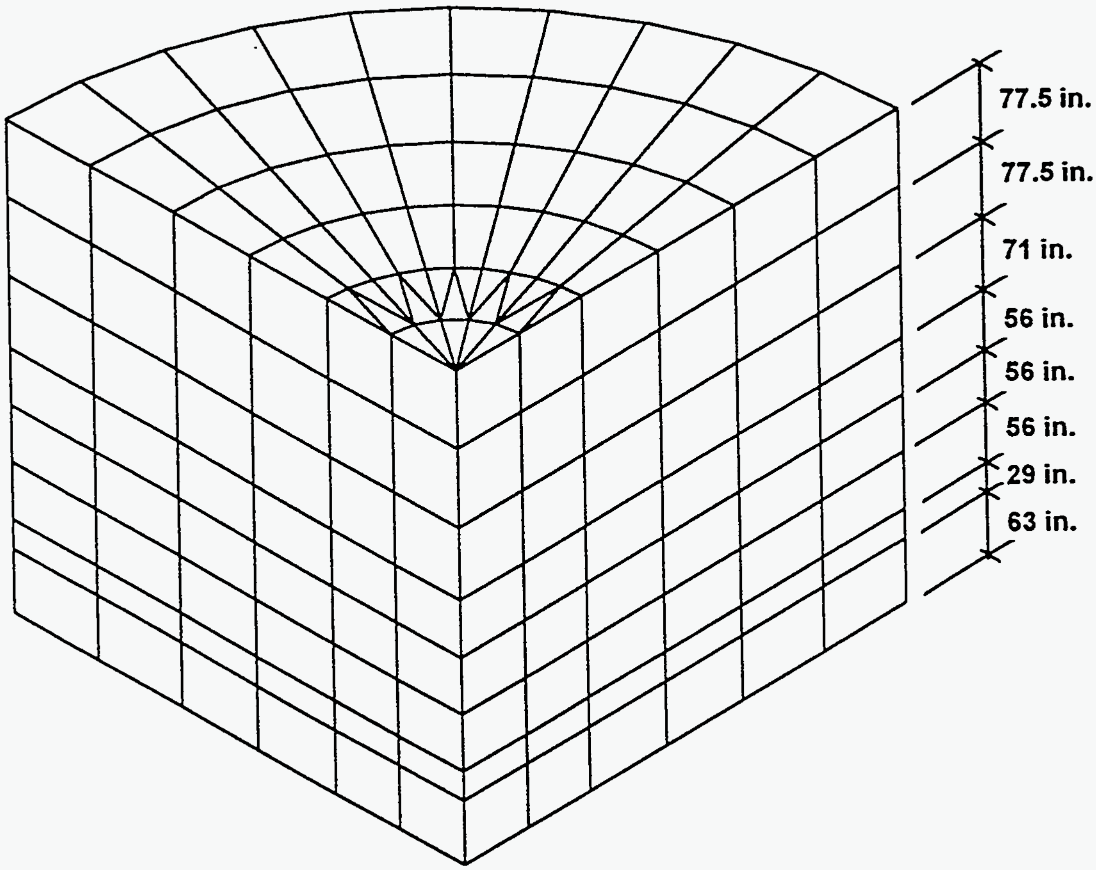


Figure 5.1-3. Elements Along 180° Meridian in Half-Model.

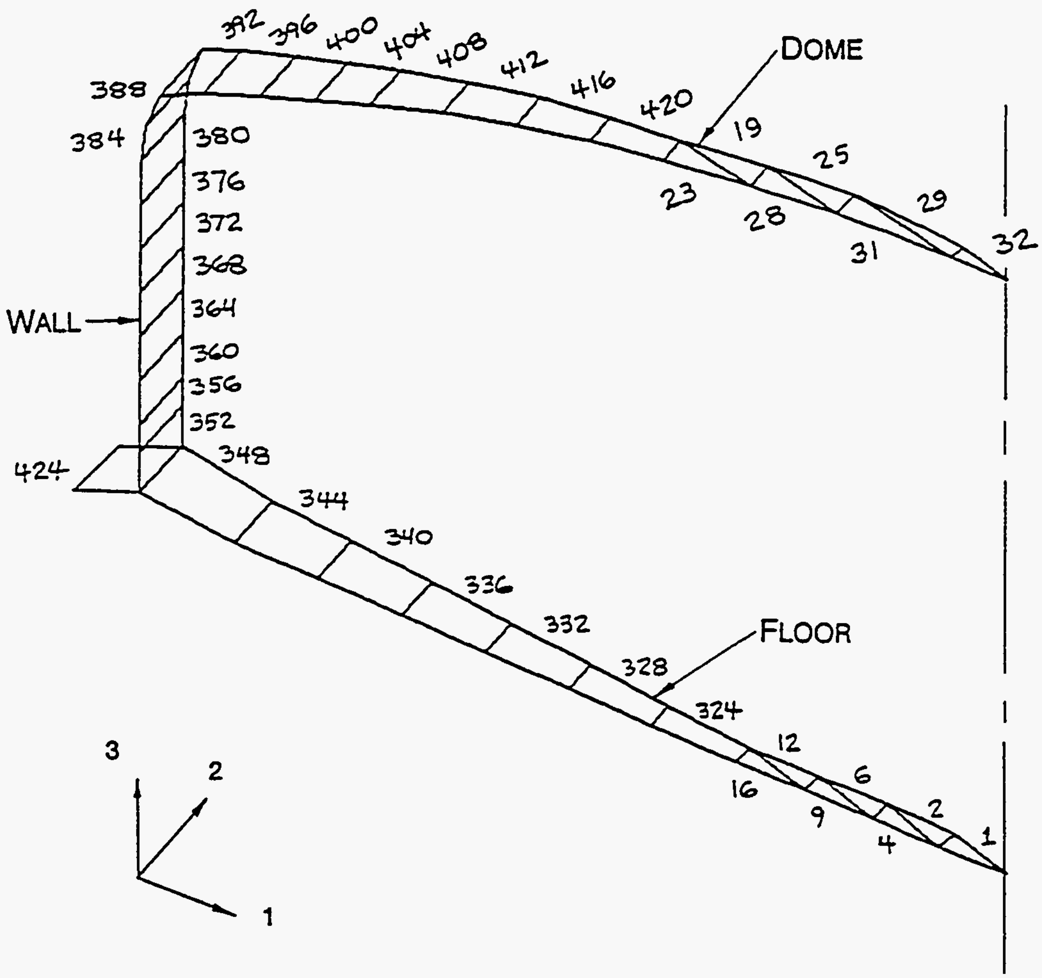


Figure 5.2.2-1. Crack Pattern at Upper Wall of 241C106 (Best-estimate Concrete Strength at 55 Years (Julyk 1994).

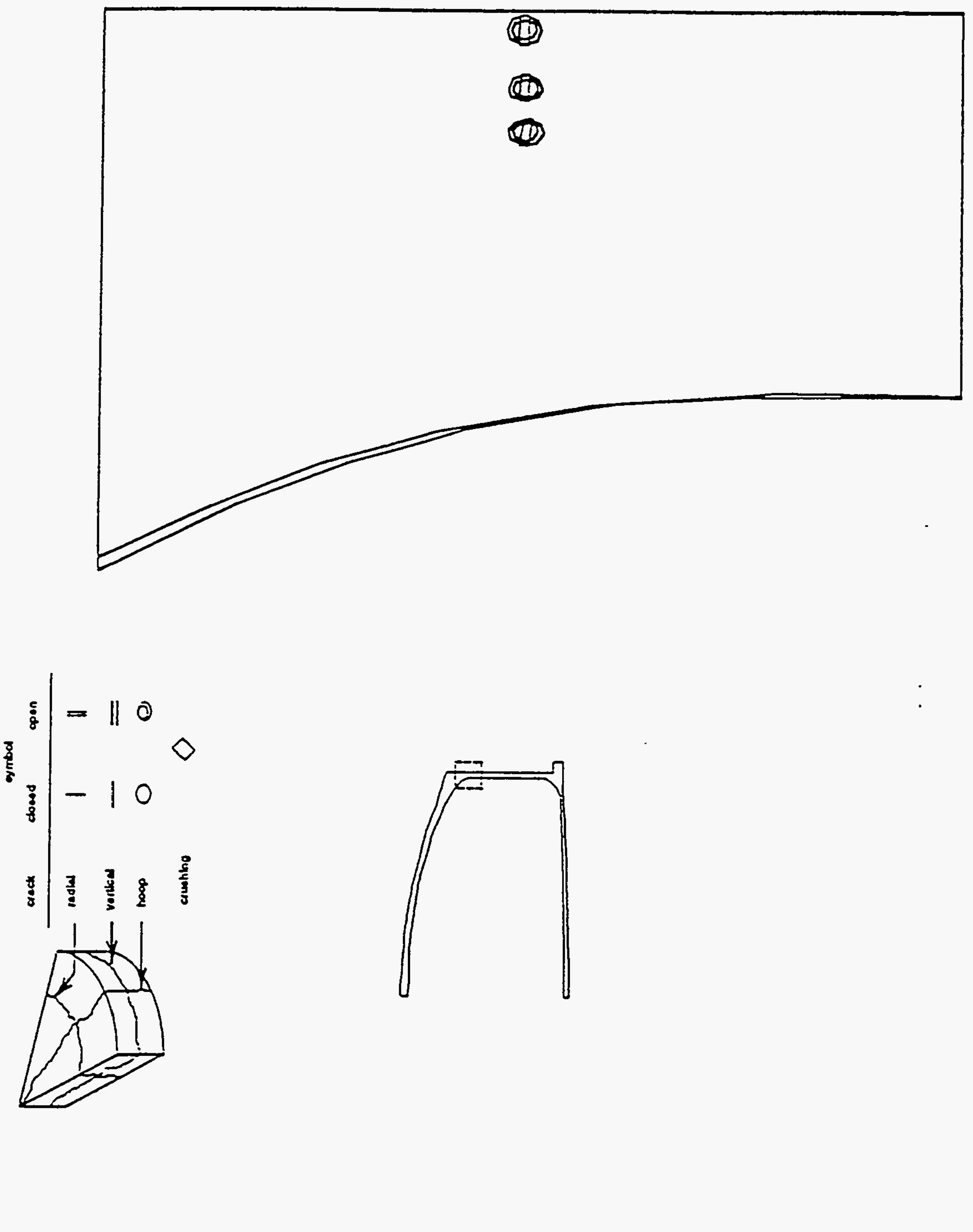


Figure 5.2.2-2. Crack pattern at Knuckle of 241C106 (Best-estimate Concrete Strength at 55 Years (Julyk 1994).

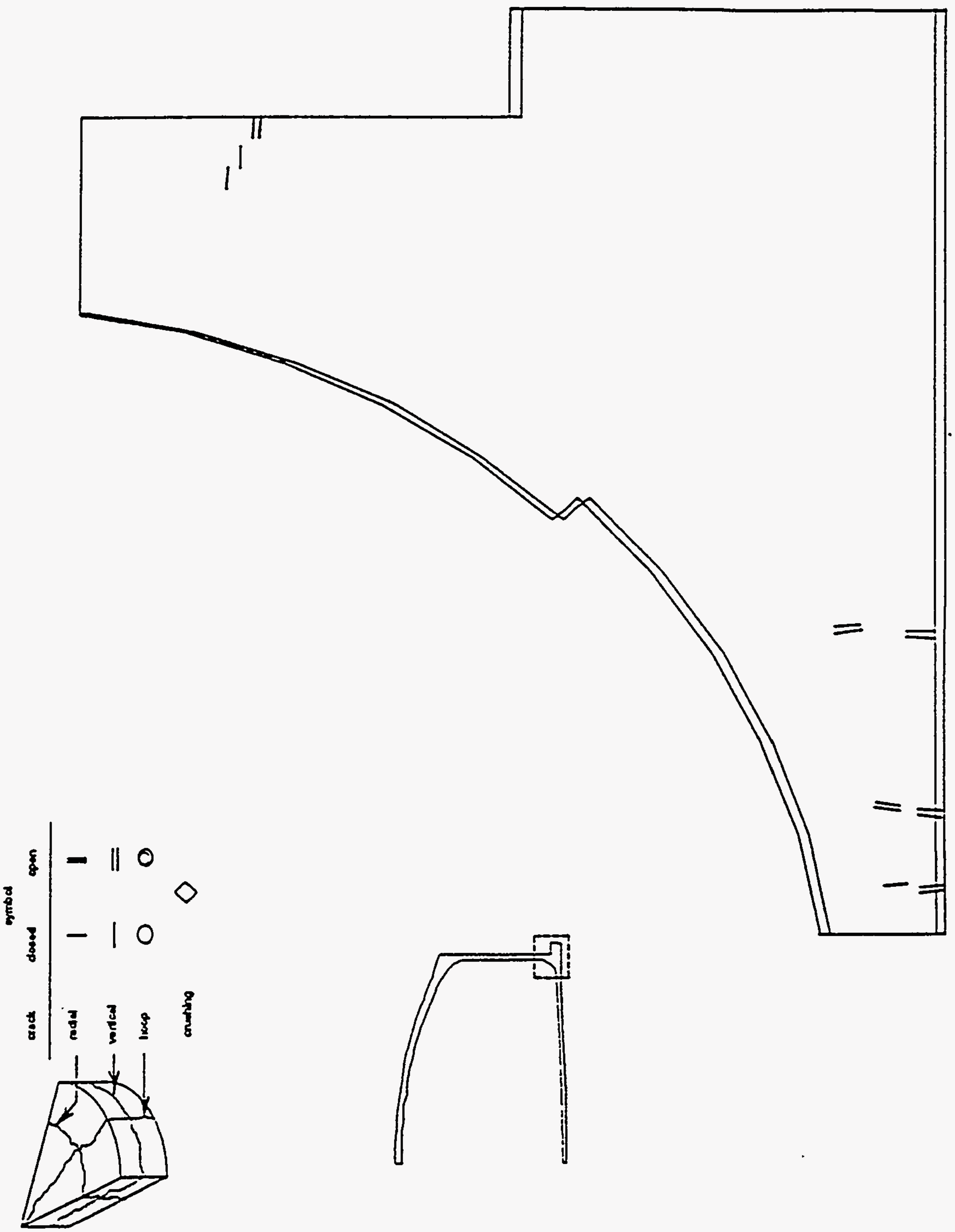


Figure 5.2.2-3. Transformed Reinforced Concrete Sections.

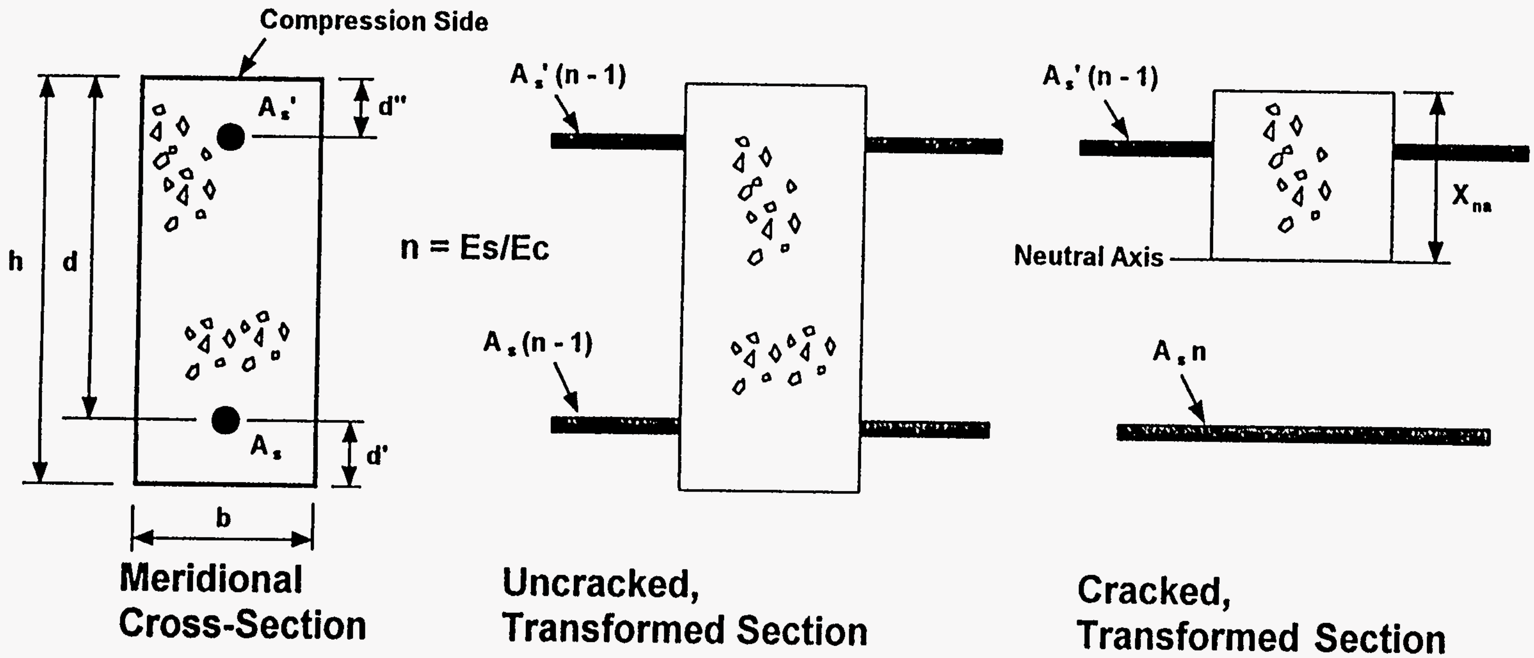


Figure 5.3.1-1. Antisymmetry for Tank-to-Tank Interaction.

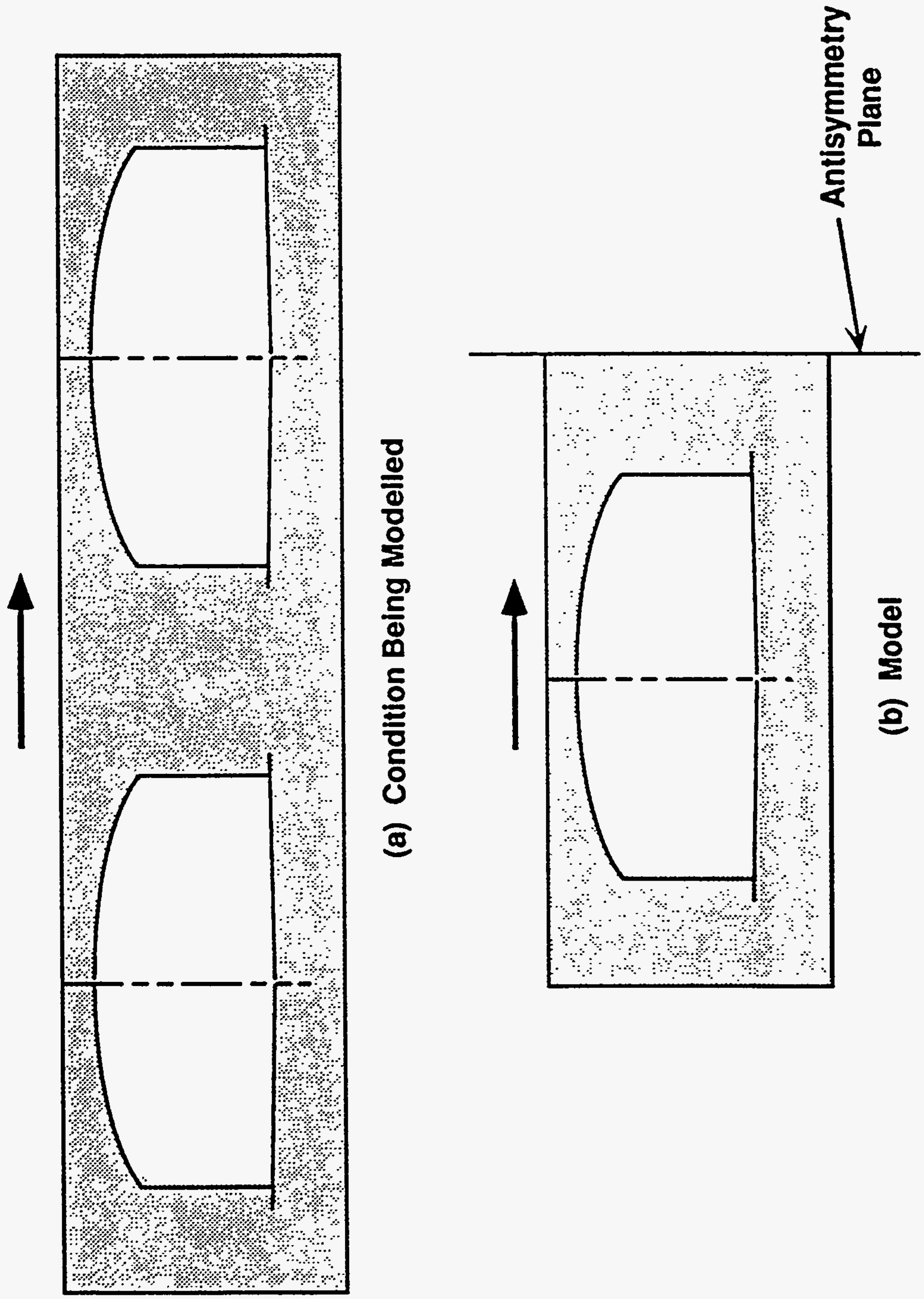
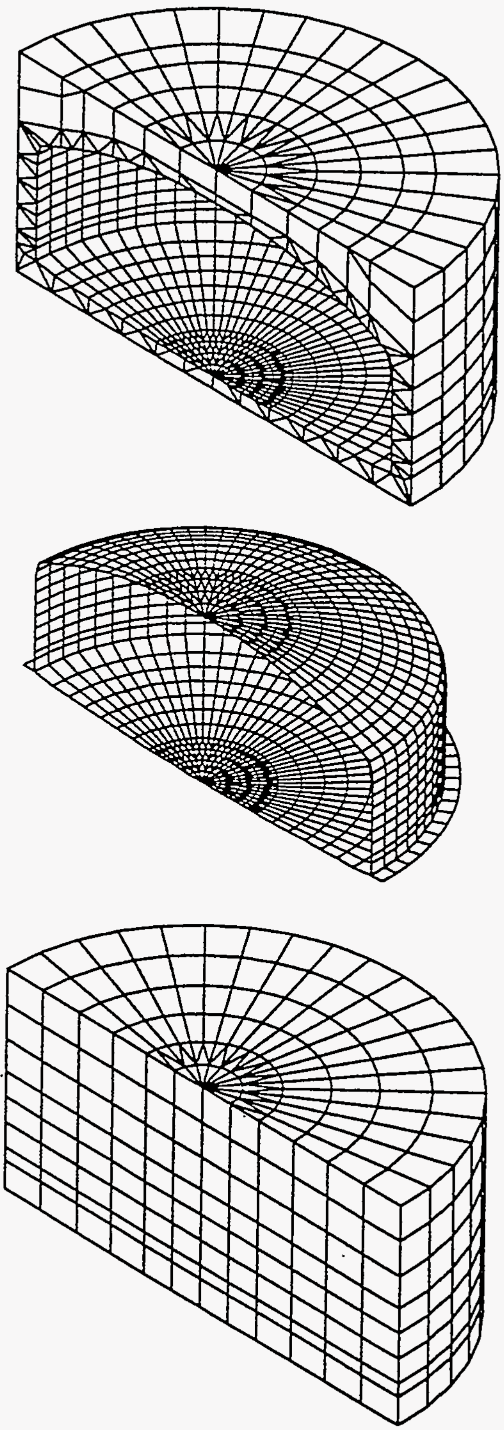


Figure 5.3.1-2. Tank-to-Tank Interaction Half-Model.



(a) Near-Field Soil

(b) Tank

(c) Excavated Soil

Figure 5.3.4-1. Cross Section of Tank 241C106.

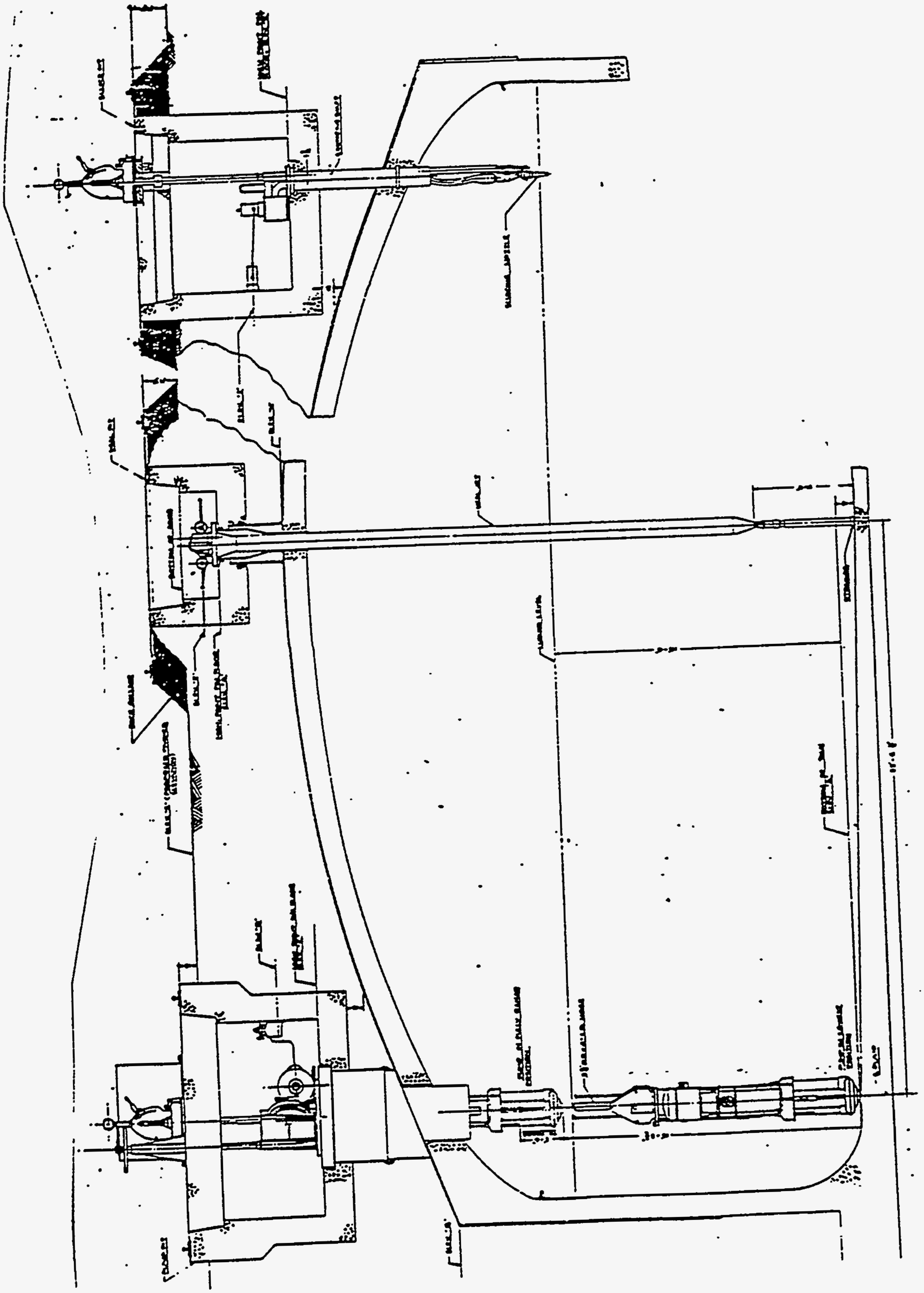


Table 5.1-1. 241C106 Tank Shell Elements.

		SASSI		SASSI and ABAQUS		
Nominal	Element	Quarter Model		Half Model		
Thick. (in)	Location	180 degree meridian	90 degree meridian	0 degree meridian	90 degree meridian	180 degree meridian
6.00	floor	1	129	289	161	1
6.00	floor	4	131	291	164	4
6.00	floor	9	135	295	169	9
6.00	floor	16	141	301	176	16
6.00	floor	164	577	1257	844	324
6.00	floor	168	581	1261	848	328
6.00	floor	172	585	1265	852	332
6.00	floor	176	589	1269	856	336
6.00	floor	180	593	1273	860	340
6.00	floor	184	597	1277	864	344
14.49	floor (stress3)	188	601	1281	868	348
18.30	wall	192	605	1285	872	352
12.30	wall	196	609	1289	876	356
12.00	wall (stress2)	200	613	1293	880	360
12.00	wall	204	617	1297	884	364
12.00	wall	208	621	1301	888	368
12.00	wall	212	625	1305	892	372
12.00	wall	216	629	1309	896	376
12.00	wall	220	633	1313	900	380
12.00	haunch (stress1)	224	637	1317	904	384
27.29	haunch	228	641	1321	908	388
31.62	haunch	232	645	1325	912	392
21.31	dome	236	649	1329	916	396
18.08	dome	240	653	1333	920	400
17.38	dome	244	657	1337	924	404
16.91	dome	248	661	1341	928	408
16.38	dome	252	665	1345	932	412
15.83	dome	256	669	1349	936	416
15.28	dome	260	673	1353	940	420
15.00	dome	23	148	308	183	23
15.00	dome	28	154	314	188	28
15.00	dome	31	158	318	191	31
15.00	dome	32	160	320	192	32
24.00	footing	264	677	1357	944	424

Notes:

1. Node numbers for coarse mesh models are different from node numbers for fine mesh (baseline) models.
2. See Figure 5.1-3 for plot of typical meridian showing element location.

elements.xls

Table 5.2.1-1. Best-Estimate Soil Properties.

Layer No.	Layer Thickness (in)	Depth to Mid-layer (ft)	Depth to Bottom (ft)	Poisson's Ratio	S	[SHAKE] G (kip/ft^2)	G (lbf/in^2)	M (lbf/in^2)	Weight Density (lbf/ft^3)	Weight Density (lbf/in^3)	Mass Density (lbf-s^2/in^4)	Vs (in/s)	Vp (in/s)	[SHAKE] Damping Ratio
1	155	6.5	12.92	0.44	0.3273	3,101	21,535	200,991	105	0.06076	0.00015726	11,702	35,751	0.015
2	127	18.2	23.50	0.44	0.3273	8,079	56,104	523,639	110	0.06366	0.00016474	18,454	56,378	0.015
3	112	28.2	32.83	0.44	0.3273	7,747	53,799	502,120	110	0.06366	0.00016474	18,071	55,207	0.019
4	147	39.0	45.08	0.44	0.3273	7,508	52,139	486,630	110	0.06366	0.00016474	17,790	54,349	0.022
5	83	48.5	52.00	0.44	0.3273	7,359	51,104	476,972	110	0.06366	0.00016474	17,613	53,807	0.024
6	156	58.5	65.00	0.44	0.3273	11,829	82,146	766,694	110	0.06366	0.00016474	22,330	68,219	0.021
7	180	72.5	80.00	0.44	0.3273	11,572	80,361	750,037	110	0.06366	0.00016474	22,086	67,474	0.023
8	240	90.0	100.00	0.44	0.3273	11,296	78,444	732,148	110	0.06366	0.00016474	21,821	66,664	0.025
9	240	110.0	120.00	0.44	0.3273	10,738	74,569	695,981	110	0.06366	0.00016474	21,275	64,997	0.03
10	300	132.5	145.00	0.44	0.3273	21,312	148,000	1,381,333	125	0.07234	0.00018721	28,117	85,898	0.022
11	300	157.5	170.00	0.44	0.3273	21,015	145,938	1,362,083	125	0.07234	0.00018721	27,920	85,298	0.023
12	360	185.0	200.00	0.44	0.3273	20,782	144,319	1,346,981	125	0.07234	0.00018721	27,765	84,824	0.024
13	360	215.0	230.00	0.44	0.3273	20,638	143,319	1,337,648	125	0.07234	0.00018721	27,669	84,529	0.025
14	360	245.0	260.00	0.44	0.3273	20,508	142,417	1,329,222	125	0.07234	0.00018721	27,581	84,262	0.026
15	420	277.5	295.00	0.44	0.3273	20,493	142,313	1,328,250	125	0.07234	0.00018721	27,571	84,232	0.026
16	420	312.5	330.00	0.44	0.3273	20,412	141,750	1,323,000	125	0.07234	0.00018721	27,517	84,065	0.026

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Table 5.2.2-1. Shell Elements Section and Material Properties (Best-estimate Tank Stiffness).

tank region	1/2 model shell el. # (180 deg)	1/4 model shell el. # (180 deg)	nominal thickness, t [in]	Merid. coord. of centroid [in]	ABAQUS solid ele. # (Julyk 1994)	Best-est, 55 yrs: E c [lbf/in^2]	Best-est, 55 yrs: Temp [deg F]	E st [lbf/in^2]	As/inch [in^2]	d' [in]
floor	1	1	6.00	R= 23.8	4	2.144E+06	157.3	2.78E+07	0.0170	1.750
floor	4	4	6.00	53 6	10	2.147E+06	157	2.78E+07	0.0170	1.750
floor	9	9	6.00	89.4	16	2.156E+06	156.4	2.78E+07	0.0170	1.750
floor	16	16	6.00	125	22	2.168E+06	155.6	2.78E+07	0.0170	1.750
floor	324	164	6.00	165	28	2.185E+06	154.3	2.78E+07	0.0170	1.750
floor	328	168	6.00	209	34	2 210E+06	152.5	2.79E+07	0.0170	1.750
floor	332	172	6.00	253	42	2.242E+06	150.2	2.79E+07	0 0170	1.750
floor	336	176	6.00	297	48	2.283E+06	147.2	2.79E+07	0.0170	1.750
floor	340	180	6.00	341	56	2.341E+06	142 9	2.79E+07	0.0170	1.750
floor	344	184	6.00	385	64	2.420E+06	137.6	2.79E+07	0.0170	1.750
knuckle	348	188	14.49	432	108	2.597E+06	129.1	2.80E+07	0.0550	3.130
knuckle	352	192	18.30	Z= 37.4	131	2.624E+06	125.3	2.80E+07	0.0367	2.375
wall	356	196	12.30	59.4	122	2 843E+06	113	2.81E+07	0.0367	2.375
wall	360	200	12.00	82	140	3.155E+06	103.1	2.81E+07	0.0367	2.375
wall	364	204	12.00	110	149	3.632E+06	95.15	2.82E+07	0.0367	2.375
wall	368	208	12.00	138	151	3.739E+06	94.02	2.82E+07	0.0367	2.375
wall	372	212	12.00	166	161	3.771E+06	92.75	2.82E+07	0.0367	2.375
wall	376	216	12.00	194	163	3.825E+06	92.16	2.82E+07	0.0367	2.375
wall	380	220	12.00	222	172	3.835E+06	91.64	2.82E+07	0.0367	2.375
wall	384	224	12.00	247.9	188	3.959E+06	90.77	2.82E+07	0.0367	2.375
haunch	388	228	27.29	271.15	190	4.100E+06	89.57	2.82E+07	0.0367	2.375
haunch	392	232	31.62	R= 436.45	192	4.050E+06	89.52	2.82E+07	0.0960	4.375
haunch	396	236	21.31	410.2	195	3.972E+06	89.86	2.82E+07	0.0780	4.375
dome	400	240	18.08	380.7	232	3.943E+06	89.97	2.82E+07	0.0490	4.375
dome	404	244	17.38	351.95	234	4.036E+06	89.2	2.82E+07	0.0470	4.375
dome	408	248	16.91	318.4	235	3.958E+06	89.74	2.82E+07	0.0530	4.375
dome	412	252	16.38	279.85	237	4.068E+06	88.84	2.82E+07	0.0600	4.375
dome	416	256	15.83	240.65	238	3.983E+06	89.47	2.82E+07	0.0460	1.625
dome	420	260	15.28	200.95	240	4.090E+06	88.59	2.82E+07	0.0430	1.625
dome	23	23	15.00	158.5	241	4.022E+06	89.11	2 82E+07	0.0570	1.625
dome	28	28	15.00	113.4	243	4 025E+06	89 07	2 82E+07	0.0480	1.625
dome	31	31	15.00	68.1	245	4.100E+06	88.46	2.82E+07	0.0480	3.375
dome	32	32	15.00	30.3	246	3 998E+06	89.26	2.82E+07	0.0370	3.375
footing	424	264	24.00	R= 472	111	3 188E+06	121.5	2.80E+07	0.0550	3.130

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Table 5.2.2-1. Shell Elements Section and Material Properties (Best-estimate Tank Stiffness) (cont.).

							Uncracked section		Cracked section			
tank region	1/2 model shell el. # (180 deg)	As'/inch [in^2]	d" [in]	d [in]	n=E st/E c	I gross [in^4]	X na [in]	I eff [in^4]	(X na)tr [in]	X na [in]	I eff [in^4]	Is section cracked?
floor	1	0.0000	0.000	4.250	12.983	18.00	3.04	18.31	1.167	1.167	2.63	N
floor	4	0.0000	0.000	4.250	12.963	18.00	3.04	18.31	1.166	1.166	2.62	N
floor	9	0.0000	0.000	4.250	12.913	18.00	3.04	18.31	1.164	1.164	2.62	N
floor	16	0.0000	0.000	4.250	12.842	18.00	3.04	18.30	1.161	1.161	2.60	N
floor	324	0.0000	0.000	4.250	12.746	18.00	3.04	18.30	1.158	1.158	2.59	N
floor	328	0.0000	0.000	4.250	12.602	18.00	3.04	18.30	1.152	1.152	2.57	N
floor	332	0.0000	0.000	4.250	12.429	18.00	3.04	18.29	1.145	1.145	2.54	N
floor	336	0.0000	0.000	4.250	12.212	18.00	3.04	18.29	1.137	1.137	2.50	N
floor	340	0.0000	0.000	4.250	11.920	18.00	3.04	18.28	1.125	1.125	2.45	N
floor	344	0.0000	0.000	4.250	11.542	18.00	3.04	18.27	1.110	1.110	2.39	N
knuckle	348	0.0000	0.000	11.360	10.777	253.53	7.39	262.31	3.125	3.125	50.37	Y
knuckle	352	0.0367	8.675	15.925	10.673	510.71	9.27	526.80	3.633	3.675	85.06	N
wall	356	0.0367	2.675	9.925	9.875	155.07	6.16	163.64	2.379	2.382	25.14	Y
wall	360	0.0367	2.375	9.625	8.913	144.00	6.00	151.63	2.220	2.222	21.57	N
wall	364	0.0367	2.375	9.625	7.755	144.00	6.00	150.51	2.101	2.105	19.21	N
wall	368	0.0367	2.375	9.625	7.534	144.00	6.00	150.30	2.077	2.081	18.75	N
wall	372	0.0367	2.375	9.625	7.472	144.00	6.00	150.24	2.070	2.074	18.62	N
wall	376	0.0367	2.375	9.625	7.368	144.00	6.00	150.14	2.058	2.063	18.40	N
wall	380	0.0367	2.375	9.625	7.349	144.00	6.00	150.12	2.056	2.061	18.36	N
wall	384	0.0367	2.375	9.625	7.121	144.00	6.00	149.90	2.030	2.035	17.88	Y
haunch	388	0.0367	2.375	24.915	6.876	1693.67	13.65	1748.40	3.248	3.248	129.95	N
haunch	392	0.0370	1.625	27.245	6.961	2634.54	15.92	2753.39	5.269	5.269	374.43	N
haunch	396	0.0400	1.625	16.935	7.097	806.43	10.69	845.05	3.695	3.695	114.91	N
dome	400	0.0430	1.625	13.705	7.150	492.51	9.01	513.59	2.678	2.678	49.29	N
dome	404	0.0470	1.625	13.005	6.986	437.49	8.65	456.74	2.525	2.525	41.65	N
dome	408	0.0530	1.625	12.535	7.123	402.95	8.40	423.44	2.616	2.616	43.43	N
dome	412	0.0600	1.625	12.005	6.932	366.24	8.13	386.70	2.654	2.654	42.98	N
dome	416	0.0460	4.375	14.205	7.079	330.57	7.96	345.10	2.868	2.888	50.45	N
dome	420	0.0430	4.375	13.655	6.895	297.30	7.68	309.14	2.708	2.730	42.97	N
dome	23	0.0570	4.375	13.375	7.010	281.25	7.56	296.36	3.031	3.051	52.76	N
dome	28	0.0480	4.375	13.375	7.006	281.25	7.55	293.98	2.826	2.847	45.75	N
dome	31	0.0480	3.375	11.625	6.879	281.25	7.50	290.85	2.543	2.555	32.95	N
dome	32	0.0370	3.375	11.625	7.052	281.25	7.50	288.87	2.310	2.324	27.04	N
footing	424	0.0000	6.250	20.870	8.791	1152.00	12.16	1185.12	4.035	4.035	158.93	N

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Table 5.2.2-1. Shell Elements Section and Material Properties (Best-estimate Tank Stiffness) (cont.).

(wt density) nom = 0.0870

tank region	1/2 model shell el. # (180 deg)	Axial stiff. (EA) shl [lbf]	Bend. stiff. (12EI) shl [lbf-in^2]	Effective shell properties E shl [lbf/in^2]	t shl [in]	(weight density) shl [lbf/in^3]
floor	1	1.330E+07	4.709E+08	2.235E+06	5.95	0.1170
floor	4	1.332E+07	4.717E+08	2.238E+06	5.95	0.1170
floor	9	1.337E+07	4.735E+08	2.247E+06	5.95	0.1170
floor	16	1.344E+07	4.762E+08	2.259E+06	5.95	0.1169
floor	324	1.354E+07	4.798E+08	2.276E+06	5.95	0.1169
floor	328	1.370E+07	4.854E+08	2.301E+06	5.95	0.1169
floor	332	1.389E+07	4.922E+08	2.333E+06	5.95	0.1169
floor	336	1.414E+07	5.011E+08	2.374E+06	5.95	0.1169
floor	340	1.448E+07	5.136E+08	2.432E+06	5.96	0.1169
floor	344	1.496E+07	5.307E+08	2.511E+06	5.96	0.1168
knuckle	348	9.652E+06	1.569E+09	7.569E+05	12.75	0.1125
knuckle	352	4.987E+07	1.659E+10	2.735E+06	18.24	0.0873
wall	356	8.829E+06	8.574E+08	8.960E+05	9.85	0.1086
wall	360	3.969E+07	5.741E+09	3.301E+06	12.03	0.0868
wall	364	4.538E+07	6.559E+09	3.774E+06	12.02	0.0868
wall	368	4.666E+07	6.744E+09	3.881E+06	12.02	0.0868
wall	372	4.704E+07	6.799E+09	3.913E+06	12.02	0.0868
wall	376	4.768E+07	6.891E+09	3.966E+06	12.02	0.0868
wall	380	4.781E+07	6.909E+09	3.977E+06	12.02	0.0868
wall	384	1.012E+07	8.494E+08	1.105E+06	9.16	0.1140
haunch	388	1.137E+08	8.603E+10	4.132E+06	27.51	0.0863
haunch	392	1.313E+08	1.338E+11	4.112E+06	31.93	0.0862
haunch	396	8.751E+07	4.028E+10	4.079E+06	21.46	0.0864
dome	400	7.352E+07	2.430E+10	4.044E+06	18.18	0.0865
dome	404	7.242E+07	2.212E+10	4.144E+06	17.48	0.0865
dome	408	6.950E+07	2.011E+10	4.086E+06	17.01	0.0865
dome	412	6.953E+07	1.888E+10	4.220E+06	16.48	0.0865
dome	416	6.528E+07	1.649E+10	4.107E+06	15.90	0.0866
dome	420	6.457E+07	1.517E+10	4.212E+06	15.33	0.0867
dome	23	6.309E+07	1.430E+10	4.190E+06	15.06	0.0867
dome	28	6.269E+07	1.420E+10	4.166E+06	15.05	0.0867
dome	31	6.381E+07	1.431E+10	4.261E+06	14.97	0.0871
dome	32	6.177E+07	1.386E+10	4.123E+06	14.98	0.0871
footing	424	7.787E+07	4.534E+10	3.227E+06	24.13	0.0865

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Table 5.2.2-2. Tank 241C106 Reinforcement.

Region	Meridional Reinforcement (bar size, spacing-inches)	Hoop Reinforcement (bar size, spacing-inches)	Reinforcement Area (in^2/in.)	
			Meridional	Hoop
Base	0.5 dia @ 12	0.5 dia @ 12	0.0167	0.0167
Footing (bottom)	0.75 dia @ 8	1 sq @ 8	0.0550	0.125
Wall	0.75 dia @ 12	0.875 dia @ 6 min, 10 max	0.0367	0.0600 to 0.100
Haunch	0.75 dia @ 6	1.25 sq @ 6 w/ 3 to 7 interior layers	0.0733	0.651 to 1.17
Dome	0.75 dia @ 13.2	0.75 dia @ 12	0.0333	0.0366

Table 5.3.2-1. Lower-Bound Soil Properties (Control Motion at Second Soil Layer).

Layer No.	Layer Thickness (in)	Depth to Mid-layer (ft)	Depth to Bottom (ft)	Poisson's Ratio	S	[SHAKE] G (kip/ft^2)	G (lbf/in^2)	M (lbf/in^2)	Weight Density (lbf/ft^3)	Weight Density (lbf/in^3)	Mass Density (lbf-s^2/in^4)	Vs (in/s)	Vp (in/s)	[SHAKE] Damping Ratio
1	155	6.5	12.92	0.44	0.3273	1,426	9,903	92,426	105	0.06076	0.00015726	7,935	24,243	0.023
2	127	18.2	23.50	0.44	0.3273	3,752	26,056	243,185	110	0.06366	0.00016474	12,576	38,420	0.022
3	112	28.2	32.83	0.44	0.3273	3,588	24,917	232,556	110	0.06366	0.00016474	12,298	37,571	0.026
4	147	39.0	45.08	0.44	0.3273	3,295	22,882	213,565	110	0.06366	0.00016474	11,785	36,005	0.035
5	83	48.5	52.00	0.44	0.3273	3,055	21,215	198,009	110	0.06366	0.00016474	11,348	34,669	0.042
6	156	58.5	65.00	0.44	0.3273	5,213	36,201	337,880	110	0.06366	0.00016474	14,824	45,287	0.033
7	180	72.5	80.00	0.44	0.3273	4,865	33,785	315,324	110	0.06366	0.00016474	14,320	43,749	0.04
8	240	90.0	100.00	0.44	0.3273	4,596	31,917	297,889	110	0.06366	0.00016474	13,919	42,523	0.045
9	240	110.0	120.00	0.44	0.3273	4,439	30,826	287,713	110	0.06366	0.00016474	13,679	41,790	0.049
10	300	132.5	145.00	0.44	0.3273	9,942	69,042	644,389	125	0.07234	0.00018721	19,204	58,669	0.029
11	300	157.5	170.00	0.44	0.3273	9,824	68,222	636,741	125	0.07234	0.00018721	19,090	58,320	0.03
12	360	185.0	200.00	0.44	0.3273	9,512	66,056	616,519	125	0.07234	0.00018721	18,784	57,386	0.034
13	360	215.0	230.00	0.44	0.3273	9,216	64,000	597,333	125	0.07234	0.00018721	18,490	56,486	0.037
14	360	245.0	260.00	0.44	0.3273	9,123	63,354	591,306	125	0.07234	0.00018721	18,396	56,201	0.038
15	420	277.5	295.00	0.44	0.3273	8,947	62,132	579,898	125	0.07234	0.00018721	18,218	55,656	0.04
16	420	312.5	330.00	0.44	0.3273	8,619	59,854	558,639	125	0.07234	0.00018721	17,881	54,626	0.043

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Table 5.3.2-2. Upper-Bound Soil Properties.

Layer No.	Layer Thickness (in)	Depth to Mid-layer (ft)	Depth to Bottom (ft)	Poisson's Ratio	S	[SHAKE] G (kip/ft^2)	G (lbf/in^2)	M (lbf/in^2)	Weight Density (lbf/ft^3)	Weight Density (lbf/in^3)	Mass Density (lbf-s^2/in^4)	Vs (in/s)	Vp (in/s)	[SHAKE] Damping Ratio
1	155	6.5	12.92	0.44	0.3273	6,365	44,201	412,546	105	0.06076	0.00015726	16,765	51,219	0.012
2	127	18.2	23.50	0.44	0.3273	16,582	115,153	1,074,759	110	0.06366	0.00016474	26,438	80,770	0.012
3	112	28.2	32.83	0.44	0.3273	16,320	113,333	1,057,778	110	0.06366	0.00016474	26,228	80,129	0.014
4	147	39.0	45.08	0.44	0.3273	16,058	111,514	1,040,796	110	0.06366	0.00016474	26,017	79,483	0.015
5	83	48.5	52.00	0.44	0.3273	15,740	109,306	1,020,185	110	0.06366	0.00016474	25,758	78,693	0.017
6	156	58.5	65.00	0.44	0.3273	25,197	174,979	1,633,139	110	0.06366	0.00016474	32,590	99,565	0.015
7	180	72.5	80.00	0.44	0.3273	24,756	171,917	1,604,556	110	0.06366	0.00016474	32,304	98,690	0.016
8	240	90.0	100.00	0.44	0.3273	24,317	168,868	1,576,102	110	0.06366	0.00016474	32,016	97,811	0.018
9	240	110.0	120.00	0.44	0.3273	23,861	165,701	1,546,546	110	0.06366	0.00016474	31,714	96,889	0.019
10	300	132.5	145.00	0.44	0.3273	45,543	316,271	2,951,861	125	0.07234	0.00018721	41,102	125,569	0.016
11	300	157.5	170.00	0.44	0.3273	44,665	310,174	2,894,954	125	0.07234	0.00018721	40,704	124,353	0.017
12	360	185.0	200.00	0.44	0.3273	43,936	305,111	2,847,704	125	0.07234	0.00018721	40,371	123,334	0.019
13	360	215.0	230.00	0.44	0.3273	43,330	300,903	2,808,426	125	0.07234	0.00018721	40,091	122,480	0.02
14	360	245.0	260.00	0.44	0.3273	42,892	297,861	2,780,037	125	0.07234	0.00018721	39,888	121,860	0.021
15	420	277.5	295.00	0.44	0.3273	42,575	295,660	2,759,491	125	0.07234	0.00018721	39,740	121,409	0.021
16	420	312.5	330.00	0.44	0.3273	42,338	294,014	2,744,130	125	0.07234	0.00018721	39,630	121,070	0.022

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Table 5.3.2-3. Soil Shear Wavelength vs. Analysis Frequency (Best-estimate Soil Properties).

Soil Layer No.	Vs, Shear Wave Speed (in/s)	h, Modeled Layer Thickness (in)	Depth to Top of Layer (ft)	Highest Analysis Frequency (Based on 1/5 W'length Rule Using "h") (hz)	s, Max. Horizon. Interaction Node Spacing (in)	Highest Analysis Frequency (Based on 1/5 W'length Rule Using "s") (hz)
1	11,702	77.5	0.0	30.2	94.0	49.8
2	11,702	77.5	6.5	30.2	94.0	49.8
3	18,454	71.0	12.9	52.0	94.0	78.5
4	18,454	56.0	18.8	65.9	94.0	78.5
5	18,071	56.0	23.5	64.5	94.0	76.9
6	18,071	56.0	28.2	64.5	94.0	76.9
7	17,790	29.0	32.8	122.7	94.0	75.7
8	17,790	63.0	35.3	56.5	94.0	75.7
9	17,790	55.0	40.5	64.7	94.0	75.7
10	17,613	83.0	45.1	42.4	94.0	74.9
11	22,330	156.0	52.0	28.6	94.0	95.0
12	22,086	180.0	65.0	24.5	94.0	94.0
13	21,821	240.0	80.0	18.2	94.0	92.9
14	21,275	240.0	100.0	17.7	94.0	90.5
15	28,117	300.0	120.0	18.7	94.0	119.6
16	27,920	300.0	145.0	18.6	94.0	118.8
17	27,765	360.0	170.0	15.4	94.0	118.1
18	27,669	360.0	200.0	15.4	94.0	117.7
19	27,581	360.0	230.0	15.3	94.0	117.4
20	27,571	420.0	260.0	13.1	94.0	117.3
21	27,517	420.0	295.0	13.1	94.0	117.1

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Table 5.3.2-4. Soil Shear Wavelength vs. Analysis Frequency (Lower-Bound Soil Properties).

Soil Layer No.	Vs, Shear Wave Speed (in/s)	h, Modeled Layer Thickness (in)	Depth to Top of Layer (ft)	Highest Analysis Frequency (Based on 1/5 W'length Rule Using "h") (hz)	s, Max. Horizon. Interaction Node Spacing (in)	Highest Analysis Frequency (Based on 1/5 W'length Rule Using "s") (hz)
1	7,935	77.5	0.0	20.5	94.0	33.8
2	7,935	77.5	6.5	20.5	94.0	33.8
3	12,576	71.0	12.9	35.4	94.0	53.5
4	12,576	56.0	18.8	44.9	94.0	53.5
5	12,298	56.0	23.5	43.9	94.0	52.3
6	12,298	56.0	28.2	43.9	94.0	52.3
7	11,785	29.0	32.8	81.3	94.0	50.2
8	11,785	63.0	35.3	37.4	94.0	50.2
9	11,785	55.0	40.5	42.9	94.0	50.2
10	11,348	83.0	45.1	27.3	94.0	48.3
11	14,824	156.0	52.0	19.0	94.0	63.1
12	14,320	180.0	65.0	15.9	94.0	60.9
13	13,919	240.0	80.0	11.6	94.0	59.2
14	13,679	240.0	100.0	11.4	94.0	58.2
15	19,204	300.0	120.0	12.8	94.0	81.7
16	19,090	300.0	145.0	12.7	94.0	81.2
17	18,784	360.0	170.0	10.4	94.0	79.9
18	18,490	360.0	200.0	10.3	94.0	78.7
19	18,396	360.0	230.0	10.2	94.0	78.3
20	18,218	420.0	260.0	8.7	94.0	77.5
21	17,881	420.0	295.0	8.5	94.0	76.1

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Table 5.3.2-5. Soil Shear Wavelength vs. Analysis Frequency (Upper-Bound Soil Properties).

Soil Layer No.	Vs, Shear Wave Speed (in/s)	h, Modeled Layer Thickness (in)	Depth to Top of Layer (ft)	Highest Analysis Frequency (Based on 1/5 W'length Rule Using "h") (hz)	s, Max. Horizon. Interaction Node Spacing (in)	Highest Analysis Frequency (Based on 1/5 W'length Rule Using "s") (hz)
1	16,765	155.0	0.0	21.6	223.0	30.1
2	26,438	127.0	12.9	41.6	223.0	47.4
3	26,228	112.0	23.5	46.8	223.0	47.0
4	26,017	147.0	32.8	35.4	223.0	46.7
5	25,758	83.0	45.1	62.1	223.0	46.2
6	32,590	156.0	52.0	41.8	223.0	58.5
7	32,304	180.0	65.0	35.9	223.0	57.9
8	32,016	240.0	80.0	26.7	223.0	57.4
9	31,714	240.0	100.0	26.4	223.0	56.9
10	41,102	300.0	120.0	27.4	223.0	73.7
11	40,704	300.0	145.0	27.1	223.0	73.0
12	40,371	360.0	170.0	22.4	223.0	72.4
13	40,091	360.0	200.0	22.3	223.0	71.9
14	39,888	360.0	230.0	22.2	223.0	71.5
15	39,740	420.0	260.0	18.9	223.0	71.3
16	39,630	420.0	295.0	18.9	223.0	71.1

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Table 5.3.3-1. Shell Element Section and Material Properties (Lower-Bound Tank Stiffness).

Table 5.3.3-1
Shell Element Section and Material Properties (Lower-Bound Tank Stiffness)

tank region	1/2 model shell el. # (180 deg)	1/4 model shell el. # (180 deg)	nominal thickness, t [in]	Merid. coord. of centroid [in]	ABAQUS solid ele. # (Julyk 1994)	Best-Est E c [lbf/in^2]	Lower-Bound, 55 yrs E c [lbf/in^2]	Lower-Bound, 55 yrs Temp [deg F]	E st [lbf/in^2]	As/inch [in^2]
floor	1	1	6.00	R= 23.8	4	2.144E+06	1.864E+06	157.3	2.78E+07	0.0170
floor	4	4	6.00	53.6	10	2.147E+06	1.867E+06	157	2.78E+07	0.0170
floor	9	9	6.00	89.4	16	2.156E+06	1.874E+06	156.4	2.78E+07	0.0170
floor	16	16	6.00	125	22	2.168E+06	1.885E+06	155.6	2.78E+07	0.0170
floor	324	164	6.00	165	28	2.185E+06	1.900E+06	154.3	2.78E+07	0.0170
floor	328	168	6.00	209	34	2.210E+06	1.922E+06	152.5	2.79E+07	0.0170
floor	332	172	6.00	253	42	2.242E+06	1.950E+06	150.2	2.79E+07	0.0170
floor	336	176	6.00	297	48	2.283E+06	1.985E+06	147.2	2.79E+07	0.0170
floor	340	180	6.00	341	56	2.341E+06	2.036E+06	142.9	2.79E+07	0.0170
floor	344	184	6.00	385	64	2.420E+06	2.105E+06	137.6	2.79E+07	0.0170
knuckle	348	188	14.49	432	108	2.597E+06	2.258E+06	129.1	2.80E+07	0.0550
knuckle	352	192	18.30	Z= 37.4	131	2.624E+06	2.281E+06	125.3	2.80E+07	0.0367
wall	356	196	12.30	59.4	122	2.843E+06	2.472E+06	113	2.81E+07	0.0367
wall	360	200	12.00	82	140	3.155E+06	2.744E+06	103.1	2.81E+07	0.0367
wall	364	204	12.00	110	149	3.632E+06	3.158E+06	95.15	2.82E+07	0.0367
wall	368	208	12.00	138	151	3.739E+06	3.251E+06	94.02	2.82E+07	0.0367
wall	372	212	12.00	166	161	3.771E+06	3.279E+06	92.75	2.82E+07	0.0367
wall	376	216	12.00	194	163	3.825E+06	3.326E+06	92.16	2.82E+07	0.0367
wall	380	220	12.00	222	172	3.835E+06	3.335E+06	91.64	2.82E+07	0.0367
wall	384	224	12.00	247.9	188	3.959E+06	3.442E+06	90.77	2.82E+07	0.0367
haunch	388	228	27.29	271.15	190	4.100E+06	3.566E+06	89.57	2.82E+07	0.0367
haunch	392	232	31.62	R= 436.45	192	4.050E+06	3.522E+06	89.52	2.82E+07	0.0960
haunch	396	236	21.31	410.2	195	3.972E+06	3.454E+06	89.86	2.82E+07	0.0780
dome	400	240	18.08	380.7	232	3.943E+06	3.429E+06	89.97	2.82E+07	0.0490
dome	404	244	17.38	351.95	234	4.036E+06	3.510E+06	89.2	2.82E+07	0.0470
dome	408	248	16.91	318.4	235	3.958E+06	3.442E+06	89.74	2.82E+07	0.0530
dome	412	252	16.38	279.85	237	4.068E+06	3.537E+06	88.84	2.82E+07	0.0600
dome	416	256	15.83	240.65	238	3.983E+06	3.463E+06	89.47	2.82E+07	0.0460
dome	420	260	15.28	200.95	240	4.090E+06	3.556E+06	88.59	2.82E+07	0.0430
dome	23	23	15.00	158.5	241	4.022E+06	3.498E+06	89.11	2.82E+07	0.0570
dome	28	28	15.00	113.4	243	4.025E+06	3.500E+06	89.07	2.82E+07	0.0480
dome	31	31	15.00	68.1	245	4.100E+06	3.565E+06	88.46	2.82E+07	0.0480
dome	32	32	15.00	30.3	246	3.998E+06	3.477E+06	89.26	2.82E+07	0.0370
footing	424	264	24.00	R= 472	111	3.188E+06	2.772E+06	121.5	2.80E+07	0.0550

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Table 5.3.3-1. Shell Element Section and Material Properties (Lower-Bound Tank Stiffness) (cont.).

tank region	1/2 model shell el. # (180 deg)	d' [in]	As'/inch [in^2]	d" [in]	d [in]	n=E st/E c	I gross [in^4]	Uncracked section X na [in]	Uncracked section I eff [in^4]	Cracked section (X na)tr [in]	Cracked section X na [in]	Cracked section I eff [in^4]	Is section cracked?
floor	1	1.750	0.0000	0.000	4.250	14.931	18.00	3 05	18.36	1.237	1.237	2.94	Y
floor	4	1.750	0.0000	0.000	4.250	14 907	18.00	3.05	18.36	1.236	1.236	2.93	Y
floor	9	1.750	0.0000	0.000	4.250	14.850	18.00	3.05	18.35	1.234	1.234	2.92	Y
floor	16	1.750	0 0000	0.000	4.250	14.768	18.00	3.05	18.35	1.231	1.231	2.91	Y
floor	324	1.750	0.0000	0.000	4.250	14.658	18.00	3.05	18.35	1.227	1.227	2.89	Y
floor	328	1.750	0.0000	0.000	4.250	14.492	18.00	3.05	18.35	1.222	1.222	2.87	Y
floor	332	1.750	0.0000	0.000	4.250	14.294	18.00	3.05	18.34	1.215	1.215	2.84	Y
floor	336	1.750	0.0000	0.000	4.250	14.044	18.00	3.04	18.33	1.206	1.206	2.80	Y
floor	340	1.750	0.0000	0.000	4.250	13.708	18.00	3.04	18.33	1.194	1.194	2.74	Y
floor	344	1.750	0.0000	0.000	4.250	13.273	18 00	3.04	18.32	1.178	1.178	2.67	Y
knuckle	348	3.130	0.0000	0.000	11.360	12.393	253.53	7.42	263.70	3.312	3.312	56.26	Y
knuckle	352	2.375	0.0367	8 675	15 925	12.274	510.71	9.29	529.42	3.854	3.891	95.11	Y
wall	356	2.375	0.0367	2.675	9.925	11.356	155.07	6.16	165.07	2.510	2.512	28.18	Y
wall	360	2.375	0.0367	2.375	9.625	10.250	144 00	6.00	152.91	2.344	2.344	24.22	Y
wall	364	2.375	0.0367	2.375	9.625	8.919	144.00	6.00	151.63	2.221	2.223	21.59	Y
wall	368	2.375	0.0367	2.375	9.625	8.664	144.00	6.00	151.39	2.196	2.198	21.07	Y
wall	372	2.375	0.0367	2.375	9.625	8.593	144.00	6 00	151.32	2.189	2.191	20.93	Y
wall	376	2.375	0.0367	2.375	9.625	8.473	144.00	6.00	151.20	2.176	2.179	20.69	Y
wall	380	2.375	0.0367	2.375	9.625	8.451	144.00	6.00	151.18	2.174	2.177	20.64	Y
wall	384	2.375	0.0367	2.375	9.625	8.189	144.00	6.00	150.93	2.147	2.150	20.11	Y
haunch	388	2.375	0.0367	2.375	24.915	7.907	1693.67	13.65	1758.01	3.450	3 450	147.57	Y
haunch	392	4.375	0.0370	1.625	27.245	8.005	2634 54	15.93	2774.13	5.589	5.589	422.69	Y
haunch	396	4.375	0.0400	1.625	16.935	8.162	806.43	10.70	851.79	3.909	3.909	129.43	Y
dome	400	4.375	0.0430	1.625	13.705	8.222	492 51	9.01	517.26	2.831	2.831	55.65	Y
dome	404	4.375	0.0470	1.625	13.005	8.034	437.49	8.64	460.10	2.668	2.668	47.04	Y
dome	408	4.375	0.0530	1.625	12.535	8.191	402.95	8.40	427.01	2.761	2.761	48.98	Y
dome	412	4.375	0.0600	1.625	12.005	7.972	366.24	8.12	390.28	2.798	2.798	48.42	Y
dome	416	1.625	0.0460	4.375	14.205	8.141	330.57	7.97	347.63	3.040	3.056	56.71	Y
dome	420	1.625	0.0430	4.375	13.655	7.929	297.30	7.69	311.21	2.872	2.890	48.31	Y
dome	23	1.625	0.0570	4.375	13.375	8.062	281.25	7.57	299.00	3.207	3.223	59.13	Y
dome	28	1.625	0.0480	4.375	13.375	8.057	281.25	7.56	296.19	2.994	3.012	51.36	Y
dome	31	3.375	0.0480	3.375	11.625	7.911	281.25	7.50	292.54	2.691	2.700	36.98	Y
dome	32	3.375	0.0370	3.375	11.625	8.110	281.25	7.50	290.20	2.448	2.460	30.42	Y
footing	424	3.130	0.0000	6.250	20.870	10.109	1152.00	12.18	1190.61	4.293	4.293	179.16	Y

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Table 5.3.3-1. Shell Element Section and Material Properties (Lower-Bound Tank Stiffness) (cont.).

(wt density) nom = 0.0870

tank region	1/2 model shell el. # (180 deg)	Axial stiff. (EA) shl [lbf]	Bend. stiff. (12EI) shl [lbf-in^2]	Effective shell properties: E shl [[bf/in^2]	Effective shell properties: t shl [in]	Effective shell properties: (weight density) shl [lbf/in^3]
floor	1	2.778E+06	6.565E+07	5.716E+05	4.86	0.1432
floor	4	2.781E+06	6.568E+07	5.722E+05	4.86	0.1432
floor	9	2.786E+06	6.574E+07	5.736E+05	4.86	0.1433
floor	16	2.794E+06	6.583E+07	5.757E+05	4.85	0.1434
floor	324	2.805E+06	6.595E+07	5.785E+05	4.85	0.1435
floor	328	2.822E+06	6.613E+07	5.828E+05	4.84	0.1438
floor	332	2.842E+06	6.635E+07	5.881E+05	4.83	0.1440
floor	336	2.868E+06	6.664E+07	5.949E+05	4.82	0.1444
floor	340	2.904E+06	6.703E+07	6.045E+05	4.80	0.1449
floor	344	2.953E+06	6.754E+07	6.175E+05	4.78	0.1455
knuckle	348	9.018E+06	1.524E+09	6.936E+05	13.00	0.1103
knuckle	352	1.093E+07	2.604E+09	7.081E+05	15.43	0.1032
wall	356	8.267E+06	8.357E+08	8.222E+05	10.05	0.1064
wall	360	8.494E+06	7.973E+08	8.767E+05	9.69	0.1078
wall	364	9.085E+06	8.180E+08	9.574E+05	9.49	0.1100
wall	368	9.213E+06	8.222E+08	9.752E+05	9.45	0.1105
wall	372	9.251E+06	8.236E+08	9.805E+05	9.44	0.1107
wall	376	9.314E+06	8.256E+08	9.893E+05	9.41	0.1109
wall	380	9.326E+06	8.260E+08	9.910E+05	9.41	0.1109
wall	384	9.469E+06	8.305E+08	1.011E+06	9.37	0.1115
haunch	388	1.424E+07	6.314E+09	6.761E+05	21.06	0.1127
haunch	392	2.330E+07	1.786E+10	8.416E+05	27.69	0.0994
haunch	396	1.669E+07	5.365E+09	9.309E+05	17.93	0.1034
dome	400	1.215E+07	2.290E+09	8.853E+05	13.73	0.1146
dome	404	1.185E+07	1.981E+09	9.164E+05	12.93	0.1169
dome	408	1.231E+07	2.023E+09	9.600E+05	12.82	0.1147
dome	412	1.307E+07	2.055E+09	1.042E+06	12.54	0.1136
dome.	416	1.318E+07	2.357E+09	9.853E+05	13.37	0.1030
dome	420	1.270E+07	2.062E+09	9.972E+05	12.74	0.1044
dome	23	1.449E+07	2.482E+09	1.107E+06	13.09	0.0997
dome	28	1.325E+07	2.157E+09	1.038E+06	12.76	0.1023
dome	31	1.233E+07	1.582E+09	1.089E+06	11.33	0.1152
dome	32	1.064E+07	1.269E+09	9.740E+05	10.92	0.1195
footing	424	1.344E+07	5.960E+09	6.384E+05	21.06	0.0992

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6.0 SEISMIC ANALYSIS

UCRL-15910 (Kennedy et al. 1990) and BNL 52361 (Bandyopadhyay et al. 1993) take probabilistic approaches in defining the appropriate seismic environment. The approaches depend on the structure's performance goal (P_F), a measure of the consequences of a structural failure, and the seismic hazard exceedance probability (P_H), the probability that an earthquake will produce a peak ground acceleration of a given magnitude in a year.

In the UCRL-15910 approach, specific values of P_F and P_H are associated with a "usage category." For example, the values of P_F and P_H for a structure classified as high-hazard usage are 1×10^{-5} and 2×10^{-4}, respectively. The site-specific hazard curve and P_H are used to determine the appropriate peak horizontal ground acceleration. The input spectrum for computing elastic earthquake demand is anchored to this peak ground acceleration. The inelastic seismic demand used in the evaluation is equal to the computed elastic seismic demand divided by the inelastic demand-capacity ratio F_μ where the value of F_μ dependents on the usage category and the type of structural system. When the fundamental frequency of the structure exceeds the frequency range corresponding to the peak spectral acceleration, F_μ must equal unity unless the peak of the input response spectrum is extended out to the fundamental frequency.

The BNL 52361 approach, similar to that of UCRL-15910, introduces the concept of a seismic load factor. The inelastic seismic demand is equal to the elastic seismic demand multiplied by a seismic load factor L_S and then divided by $F_{\mu D}$. The seismic load factor increases with the risk reduction factor R_R where R_R equals P_H divided by P_F. For a high-hazard structure, R_R equals 20 and L_S equals 1.15. The inelastic energy absorption factor $F_{\mu D}$ may be prescribed simply on the basis of the location and type of demand, e.g., $F_{\mu D}$ equals 1.75 for meridional flexure in the tank wall. $F_{\mu D}$ is subject to the same limitations related to fundamental frequency described above.

Inelastic seismic demand used in the C106 evaluation is determined via the UCRL-15910 procedure. Because the range of the peak spectral acceleration in the input response spectrum is not modified, F_μ is taken as unity. Thus, the inelastic seismic demand associated with a single excitation direction is the same as the elastic seismic demand computed via SASSI.

6.1 CONTROL MOTION

In accordance with SDC-4.1 (1993) for non-reactor Safety Class 1 (high-hazard) structures, the C106 seismic environment is based on the Newmark-Hall response spectrum corresponding to 7% damping. The spectrum is anchored to a 0.2 *g* peak horizontal ground acceleration. Stated differently, the zero-period acceleration (ZPA) of the horizontal design spectrum is 0.2 *g*. Synthetic acceleration time histories that correspond to this spectrum have been developed by Weiner and Rohay (1992). The synthetic time histories have an "overall appearance similar to actual earthquakes, although the duration of strong motion is longer because of numerical needs in fitting the Newmark-Hall spectrum at low frequency." The histories are "quantitatively evaluated with respect to the industry guidelines in terms of their acceleration, velocity, and displacement characteristics, energy content, power spectral densities, and response spectra for a range of damping values." The horizontal control motion applied at the surface of the uppermost competent soil layer in the C106 seismic analysis is the first of the Weiner and Rohay acceleration time histories (TH1) with the acceleration amplitudes scaled by a factor of 1.08. The scaling factor is applied so that ASCE (1986) and NRC (NUREG 1989) criteria are met. The SSI analysis assumes that the horizontal ground motion is due entirely to vertically propagating shear waves. The response spectrum corresponding to the horizontal control motion is shown alongside the 7% damped, Newmark-Hall design spectrum in Figure 6.1-1.

Per ASCE 4-86 (1986) and UCRL-15910 (Kennedy et al. 1990), the acceleration amplitudes in the vertical control motion are set equal to two-thirds the horizontal control motion accelerations. Use of statistically independent time histories in each of the three orthogonal directions is not required because the peak responses from the three excitations are combined via square-root-of-the-sum-of-the-squares (SRSS) as opposed to an algebraic summation of response time histories. The SSI analysis assumes that the vertical ground motion is due entirely to vertically propagating compression waves.

6.2 DYNAMIC SEISMIC RESPONSE

Results of the seismic analyses include tank structural response (moments, axial forces, and shears), transfer functions, and response spectra. Tank structural response is used directly in the structural evaluation of the tank. Selected response spectra and transfer functions are reported as an aid to understanding the nature of the overall system response and as a matter of general interest. Plots showing circumferential variations of tank seismic response indicate that the maximum response occurs along the plane-of-symmetry (0° or 180° meridian). Therefore, the seismic analysis results presented in this section focus primarily on those locations.

<u>Soil Properties Variation</u>

Table 6.2-1 and Figures 6.2-1 to 6.2-6 compare horizontal seismic response based on lower-bound (50%) soil properties, upper-bound (200%) soil properties, and best-estimate soil properties. Effects of tank-to-tank interaction are not included. Upper-bound soil is clearly not the governing condition except in the case of meridional response in the outer part of the dome (Figure 6.2-5). At this location, axial load is larger in the upper-bound soil case; however, this increased axial demand has only a small and inconsequential effect on the evaluation of combined moment and axial load (see Section 9.2.1).

The analyses based on lower-bound and best-estimate soil properties are compared further in Figures 6.2-7 to 6.2-12, which present the total seismic demands (SRSS of horizontal and vertical components) at the 180° meridian. In these plots, tank-to-tank interaction is included in the horizontal excitation response. The figures indicate that the lower-bound soil condition is controlling; thus this condition is considered in the tank evaluation.

Circumferential variations of horizontal seismic response at the upper wall, lower wall, and base near the knuckle are shown in Figures 6.2-13 to 6.2-15 for the lower-bound soil condition, Figures 6.2-16 to 6.2-18 for the best-estimate soil condition, and Figures 6.2-19 to 6.2-21 for the upper-bound soil condition. Similarly, circumferential variations of vertical seismic response at the upper wall, lower wall, and base near the knuckle are shown in Figures 6.2-22 to 6.2-24 for the lower-bound soil condition and Figures 6.2-25 to 6.2-27 for the best-estimate soil condition. As expected in the case of axisymmetric loading, the variation of vertical excitation demands with circumferential location is negligible.

Tank-to-Tank Interaction

Table 6.2-2 and Figures 6.2-28 to 6.2-33 compare horizontal seismic demands neglecting tank-to-tank interaction (TTI) to demands including TTI for the case of lower-bound (50%) soil properties. Because response is not the same at the 0° meridian as at the 180° meridian when TTI effects are included, demands at both locations are provided in the figures. For the lower-bound soil property case, Table 6.2-2 indicates that TTI decreases the peak meridional bending moment in the base by 4%. Other peak bending moments increase as a result of TTI, the most significant increase being a 21% growth in peak meridional moment in the dome. Peak bending moments in the wall increase by no more than 6%.

Similarly, for the best-estimate soil properties case, Table 6.2-3 and Figures 6.2-34 to 6.2-39 compare horizontal seismic demands neglecting TTI to demands including TTI. For the best-estimate soil property case, Table 6.2-3 indicates that TTI increases the peak bending moments in the base, the wall, and the dome. The largest percentage of increase in peak bending moment (80%) is in the circumferential direction at the base of the tank; however, this increase does not affect the margin at the base (meridional bending controls). The most significant increases are in meridional bending moment at the base and the dome where increases are 20% and 10%, respectively. Peak bending moments in the wall increase by no more than 5%.

Circumferential variations of horizontal seismic response including tank-to-tank interaction are shown at the upper wall, lower wall, and base near the knuckle in Figures 6.2-40 to 6.2-42 for the lower-bound soil condition and in Figures 6.2-43 to 6.2-45 for the best-estimate soil condition. The nonsymmetry of response about the 90° meridian is indicative of tank-to-tank interaction.

The comparisons suggest that the effects of tank-to-tank interaction are relatively minor; however, these effects are included in the tank evaluation.

Tank Stiffness Variation

Table 6.2-4 and Figures 6.2-46 to 6.2-51 compare seismic demands from the horizontal excitation computed with the lower-bound tank stiffness model to demands computed with the best-estimate tank stiffness model. Both sets of demands were computed with the coarse SASSI model using best-estimate soil properties. In the wall and the dome, peak bending response from the best-estimate tank stiffness model is approximately three- to four-times larger than the response from the lower-bound tank stiffness model. Conversely, peak bending response in the base of the tank is 66% and 49% larger in the meridional and circumferential directions, respectively, for the lower-bound tank stiffness condition.

Single Tank - Horizontal Excitation versus Vertical Excitation

Table 6.2-5 and Figures 6.2-52 to 6.2-57 compare seismic demands from the horizontal excitation to demands from the vertical excitation. Recall that the amplitude of the vertical excitation is equal to two-thirds that of the horizontal excitation. Both analyses use lower-bound soil properties and neither considers tank-to-tank interaction. The vertical excitation analysis includes a live load equal to 100 tons at the ground surface directly over the dome apex. Peak bending demands in the nearly horizontal elements of the tank, i.e., the tank base and dome, are significantly larger from the vertical excitation than from the horizontal excitation. Conversely, peak bending demands in the vertical elements of the tank, i.e., the tank wall, are significantly larger from the horizontal excitation. In similar fashion, peak axial force demands are controlled in some locations by the vertical excitation and in other locations by the horizontal excitation. Clearly, seismic response associated with the vertical excitation is significant and must be considered in the tank evaluation.

Response spectra at the dome apex calculated with best-estimate soil properties and lower-bound soil properties are provided in Figures 6.2-58 and 6.2-59, respectively. For the horizontal excitation, amplification at the dome is negligible for all frequencies and both soil conditions. For the combination of best-estimate soil and vertical excitation, considerable amplification occurs at the dome for frequencies greater than 4 Hz with the peak spectral acceleration of 1.0 *g* occurring at approximately 12 Hz. When lower-bound soil conditions are used, the vertical excitation produces significant amplification at the dome for frequencies greater than 3 Hz with the peak spectral acceleration of 1.8 *g* occurring at approximately 9 Hz.

Effect of Remediation Live Load

Table 6.2-6 and Figures 6.2-60 to 6.2-65 compare vertical seismic demands computed without consideration of remediation live loads to demands computed with a point mass equal to 518 $lbf\text{-}s^2/in.$ (100 tons) at the ground surface directly over the dome apex. Both analyses use lower-bound soil properties. The effect of live load on bending moments is minor except for circumferential moment near the center of the dome where demand increases by a factor of 7.5. Similarly, the effect of live load on axial forces is significant only in the dome.

Circumferential variations of vertical seismic response at the upper wall, lower wall, and base near the knuckle are shown in Figures 6.2-22 to 6.2-24 for the case of no live load and in Figures 6.2-66 to 6.2-68 for the case with the 100-ton live load. As expected with any axisymmetric loading condition, the variation of vertical excitation demands with circumferential location is negligible.

In summary, the effects of a concentrated live-load mass above the dome apex are minor in the tank base and wall while the effects are significant in the dome. Judgement is that the effects of live-load mass placed in locations other than over the dome apex would be less significant. Further, the effects of live-load mass on tank response from a horizontal excitation are assumed to be negligible. Therefore, the effects of remediation live loads on seismic response are addressed in approximate fashion simply by including a concentrated 100-ton live load (mass) directly over the dome apex in the vertical excitation analysis.

Combination of Excitation Directions

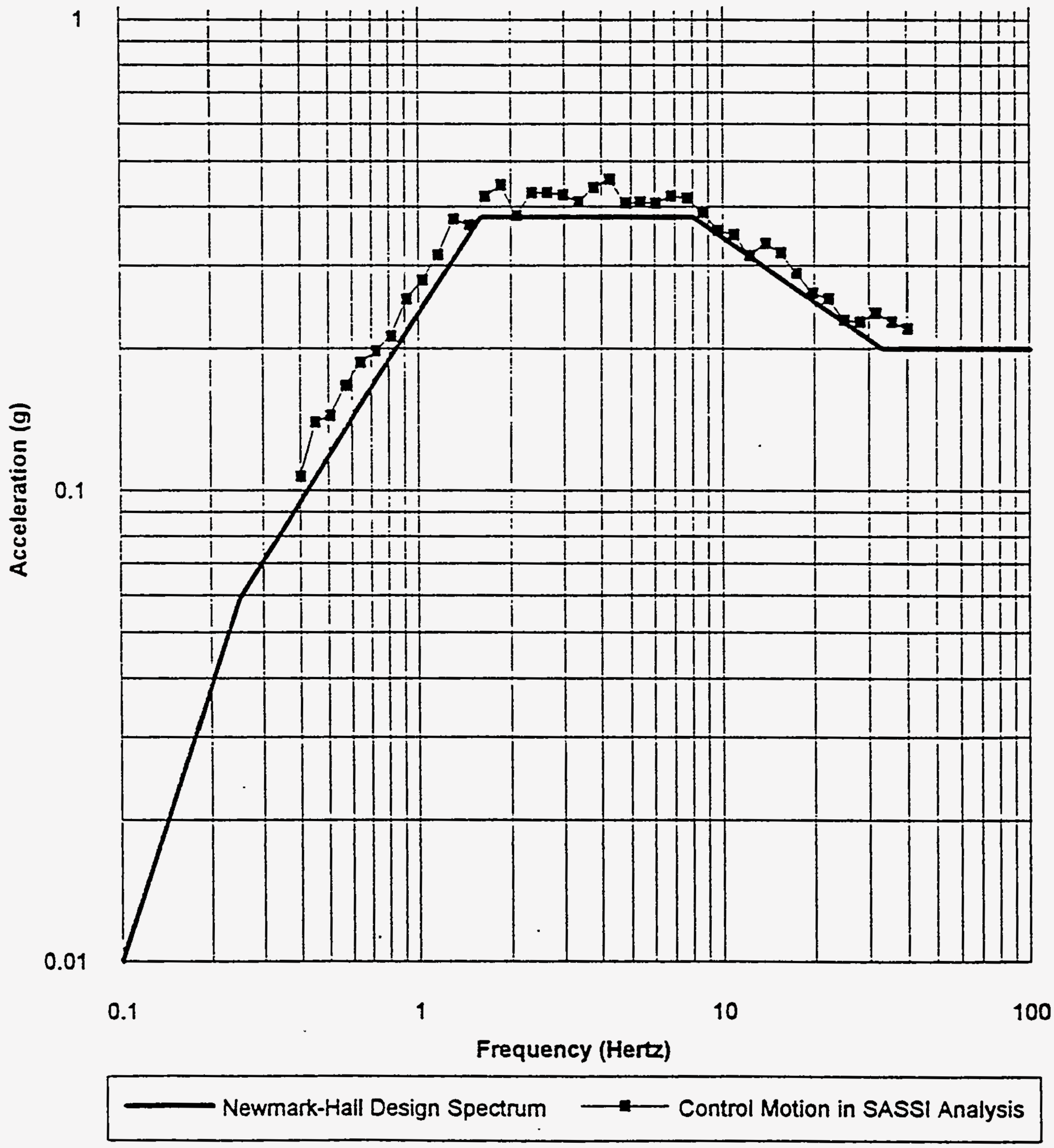
In accordance with ASCE 4-86, total seismic demand is calculated as the SRSS of the peak seismic demands from the vertical seismic excitation and two orthogonal horizontal excitations. Demands from the two horizontal excitations are computed in a single seismic analysis simply by using response at the 0/180° meridian as demand associated with one horizontal excitation and response at the 90° meridian as demand associated with the second (perpendicular) excitation direction. Considering response at the 90° meridian, i.e., response from the second horizontal excitation, includes peak in-plane shears in the evaluation. A spreadsheet given in Appendix D (*combin.xls*) is used to combine the demands from the three seismic excitations and obtain total elastic seismic demand. This spreadsheet is linked to two additional spreadsheets given in Appendix D: *stress-h.xls*, which contains demands from the horizontal seismic excitation, and *stress-v.xls*, which contains demands from the vertical seismic excitation.

Seismic Response versus Nonseismic Response

Figures 6.2-69 through 6.2-77 compare seismic demands to nonseismic demands. The plotted seismic results are the combination of horizontal and vertical excitation analyses using lower-bound soil properties. Recall that the lower-bound soil property condition maximizes seismic response. Tank-to-tank interaction is considered in the horizontal excitation component of the seismic response. Further, a 100-ton concentrated live load over the dome apex is considered in the vertical excitation component. The plotted nonseismic demands are at the 0° meridian and arise from load case 1a described in Section 7.1. Absolute values of response are compared.

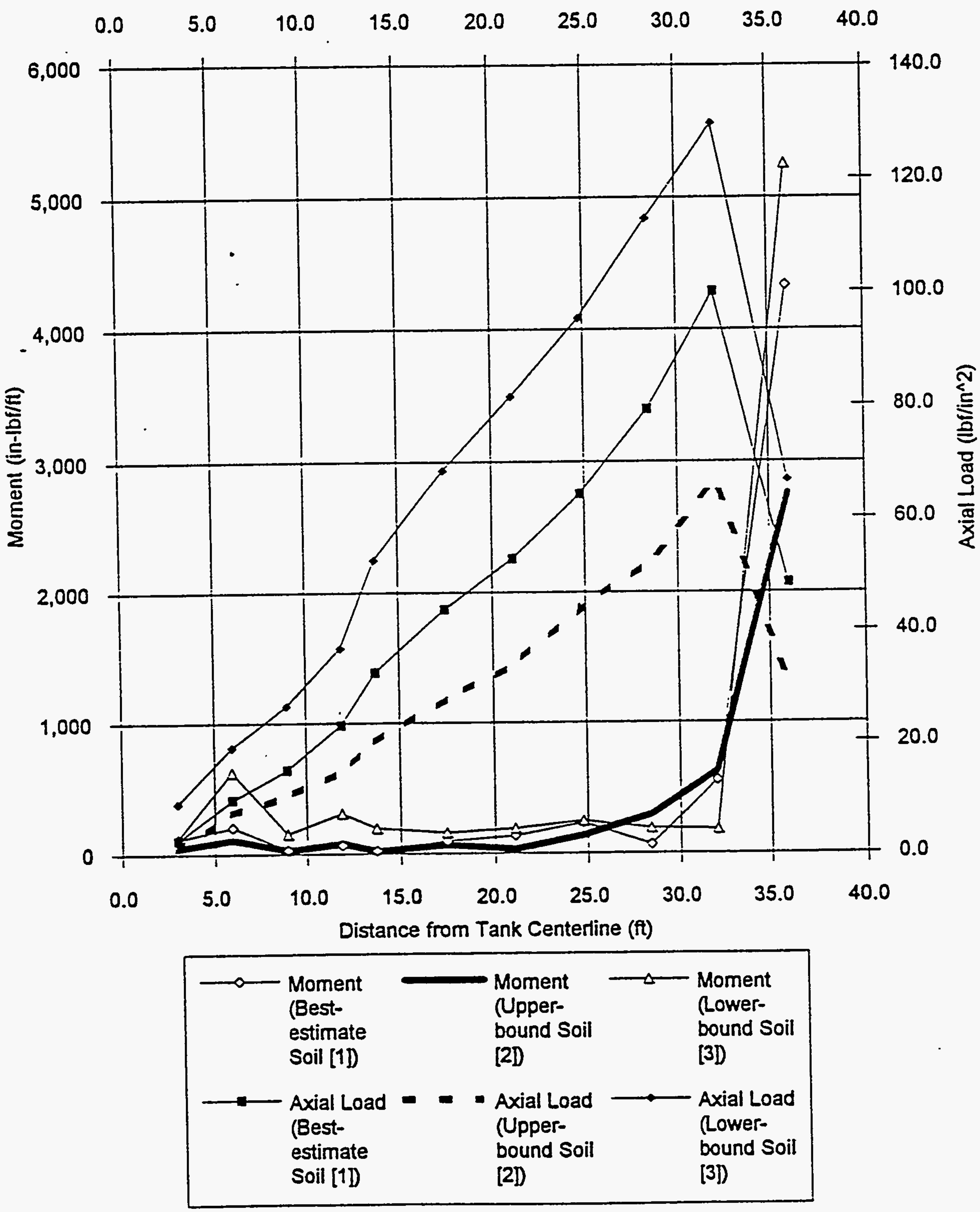
Axial and bending demands from nonseismic loads are significantly larger than the corresponding seismic demands (Figures 6.2-69 through 6.2-74). Shear demands shown in Figures 6.2-75 through 6.2-77 indicate that nonseismic loads control for transverse shear while seismic loads control for in-plane shear.

Figure 6.1-1. Horizontal Response Spectra (0.2 *g* Earthquake/7% Damping).



q7v\anl\RESHORIZ.XLC

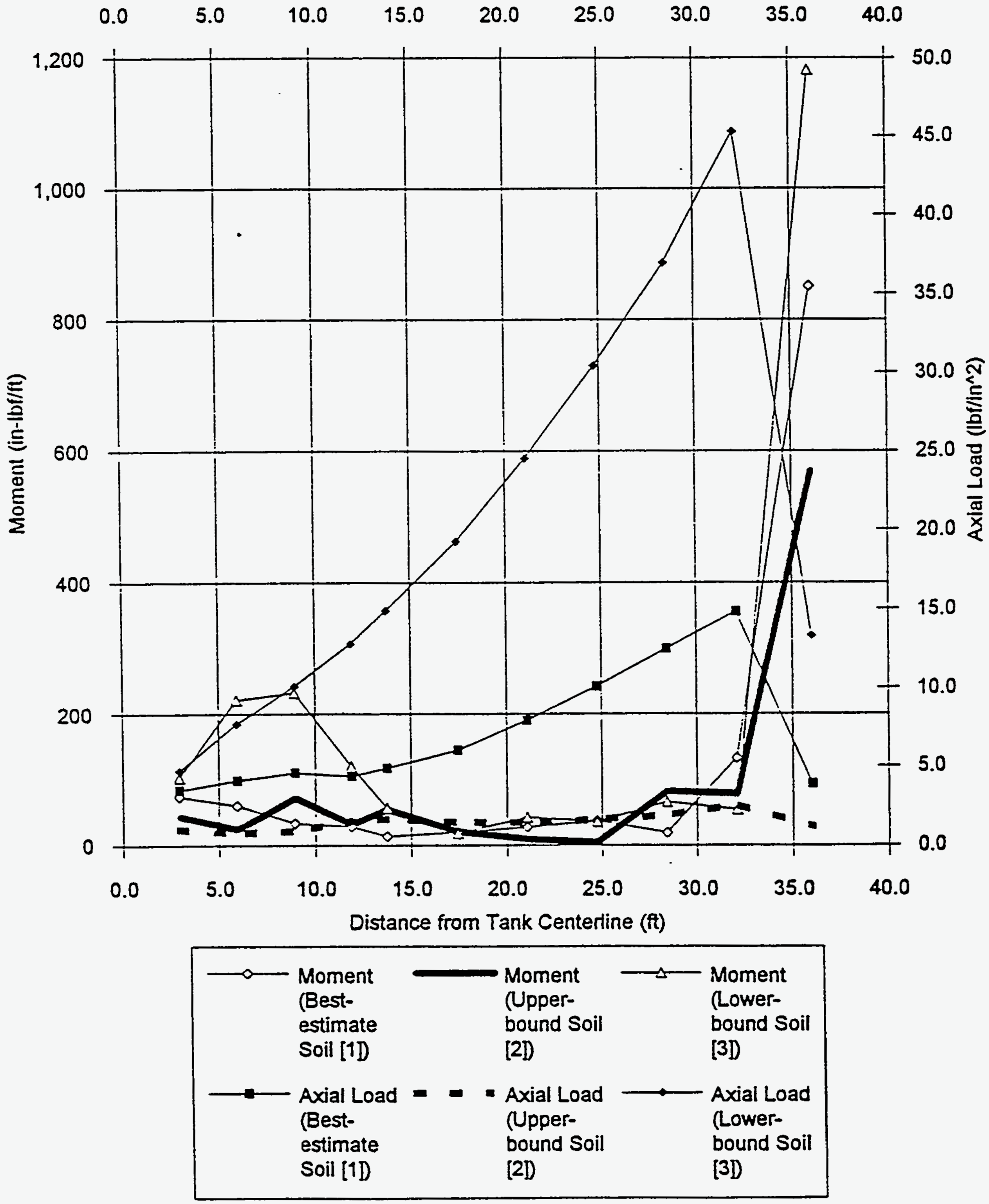
Figure 6.2-1. Meridional Seismic Response of Tank Base at 180° Meridian from Horizontal Excitation: Effects of Soil Properties Variation.



Note: [1] = Run ID "Q7pnt4", [2] = Run ID "QHI", [3] = Run ID "cmot50 QLOWpnt4".

qhi\CBASEI2.XLC

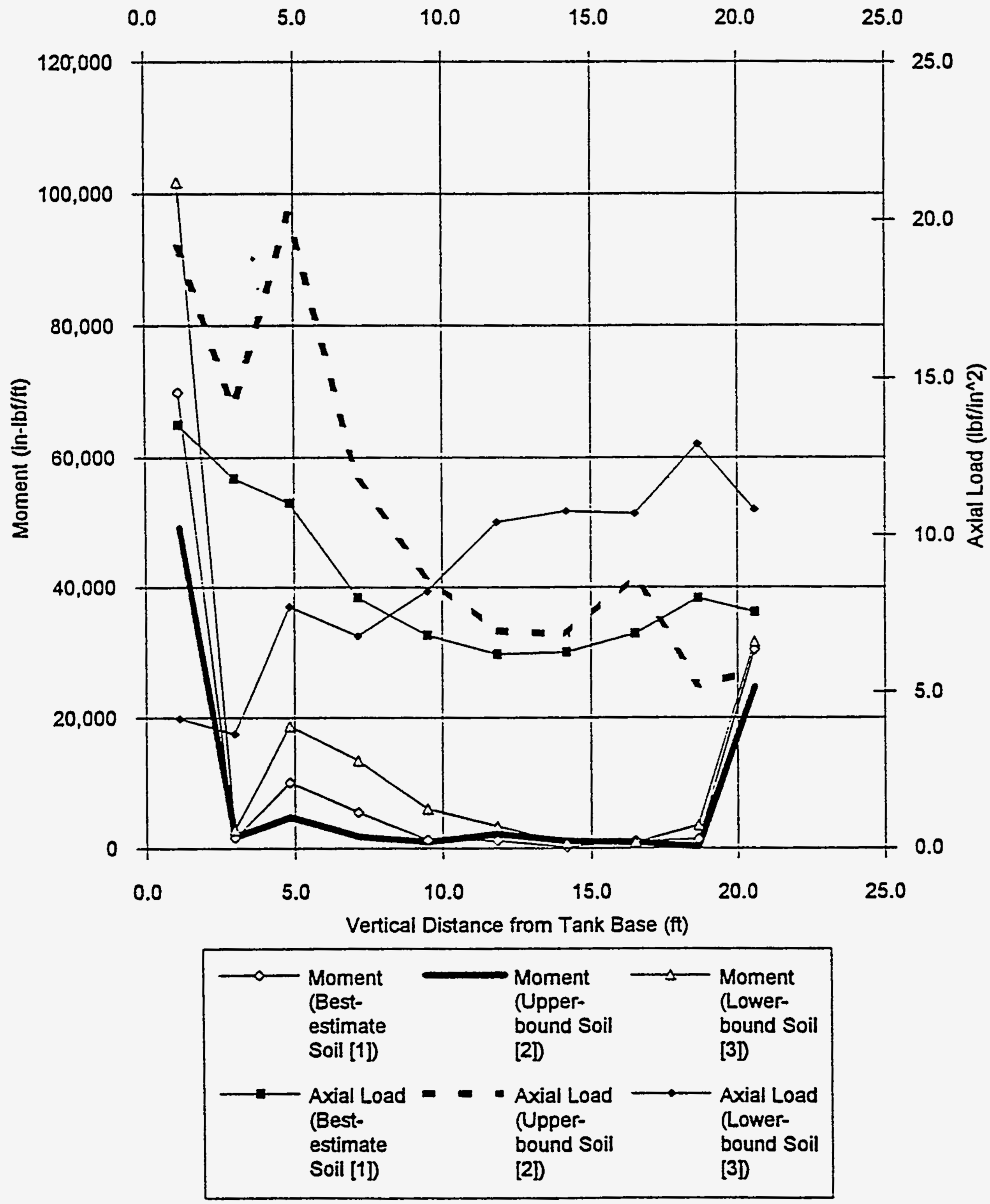
Figure 6.2-2. Circumferential Seismic Response of Tank Base at 180° Meridian from Horizontal Excitation: Effects of Soil Properties Variation.



Note: [1] = Run ID "Q7pnt4", [2] = Run ID "QHI", [3] = Run ID "cmot50 QLOWpnt4".

qhi\CBASEO2.XLC

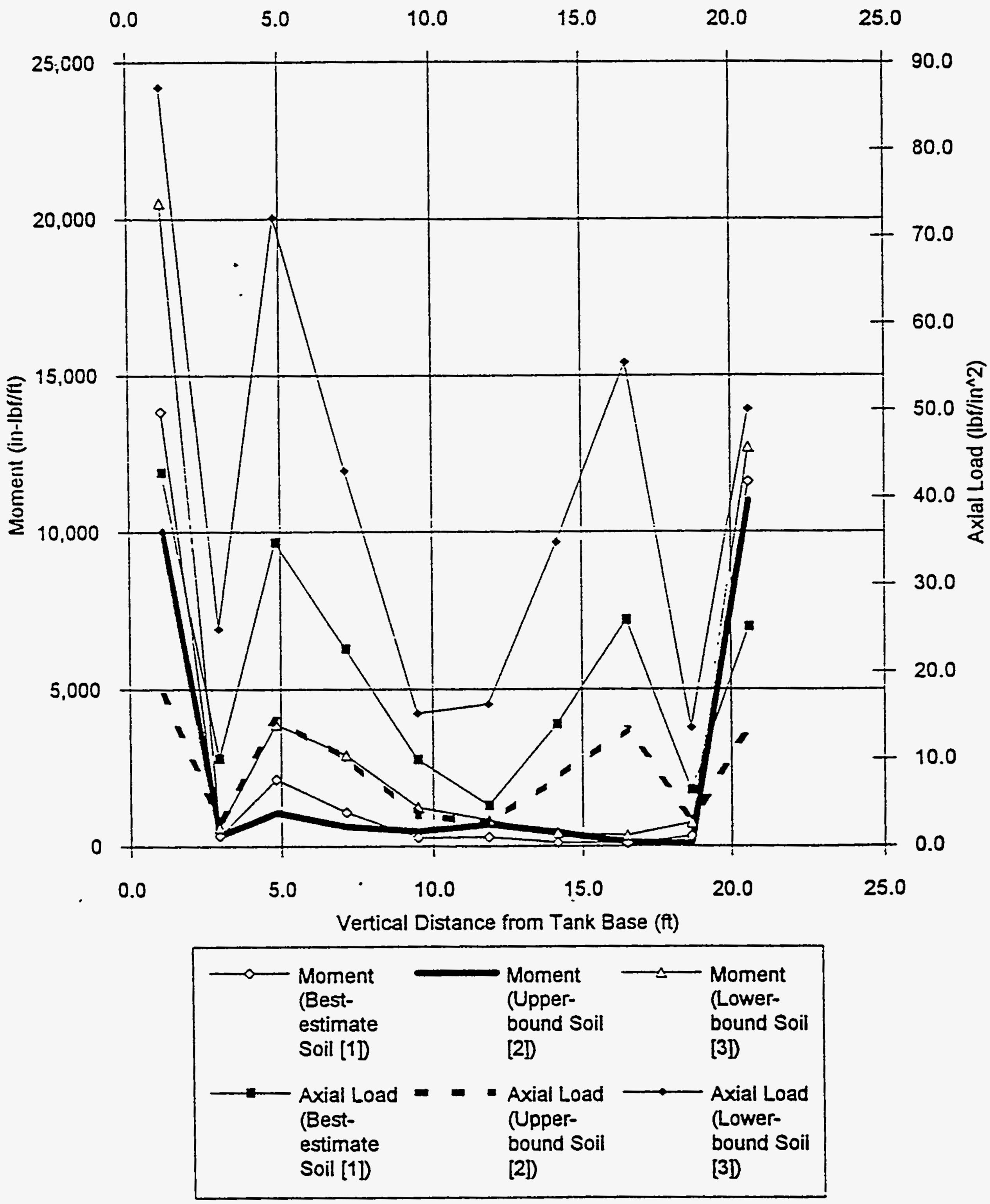
Figure 6.2-3. Meridional Seismic Response of Tank Wall at 180° Meridian from Horizontal Excitation: Effects of Soil Properties Variation.



Note: [1] = Run ID "Q7pnt4", [2] = Run ID "QHI", [3] = Run ID "cmot50 QLOWpnt4".

qhi\CWALLI2.XLC

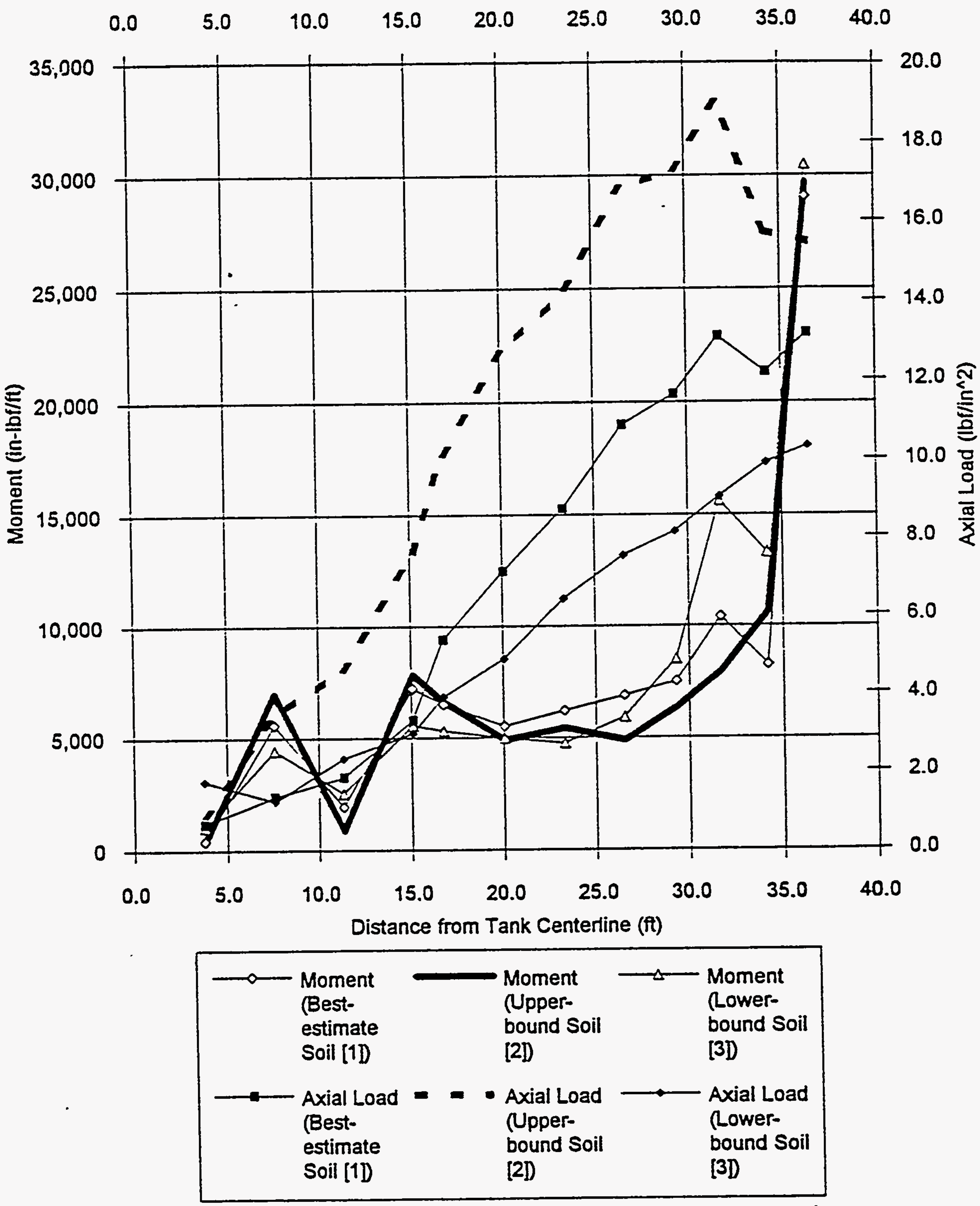
Figure 6.2-4. Circumferential Seismic Response of Tank Wall at 180° Meridian from Horizontal Excitation: Effects of Soil Properties Variation.



Note: [1] = Run ID "Q7pnt4", [2] = Run ID "QHI", [3] = Run ID "cmot50 QLOWpnt4".

qhi\CWALLO2.XLC

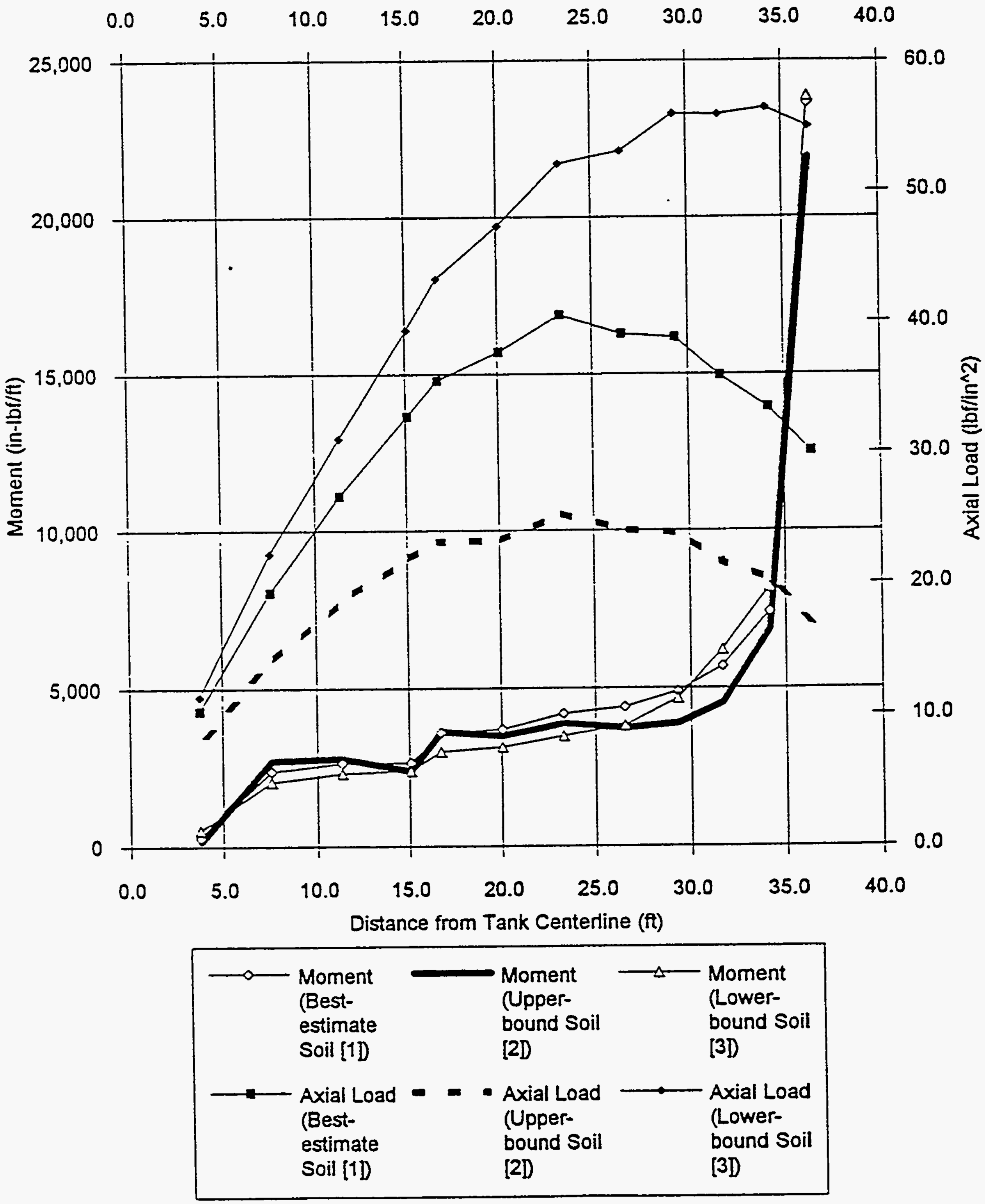
Figure 6.2-5. Meridional Seismic Response of Tank Dome at 180° Meridian from Horizontal Excitation: Effects of Soil Properties Variation.



Note: [1] = Run ID "Q7pnt4", [2] = Run ID "QHI", [3] = Run ID "cmot50 QLOWpnt4".

qhi\CDOMEI2.XLC

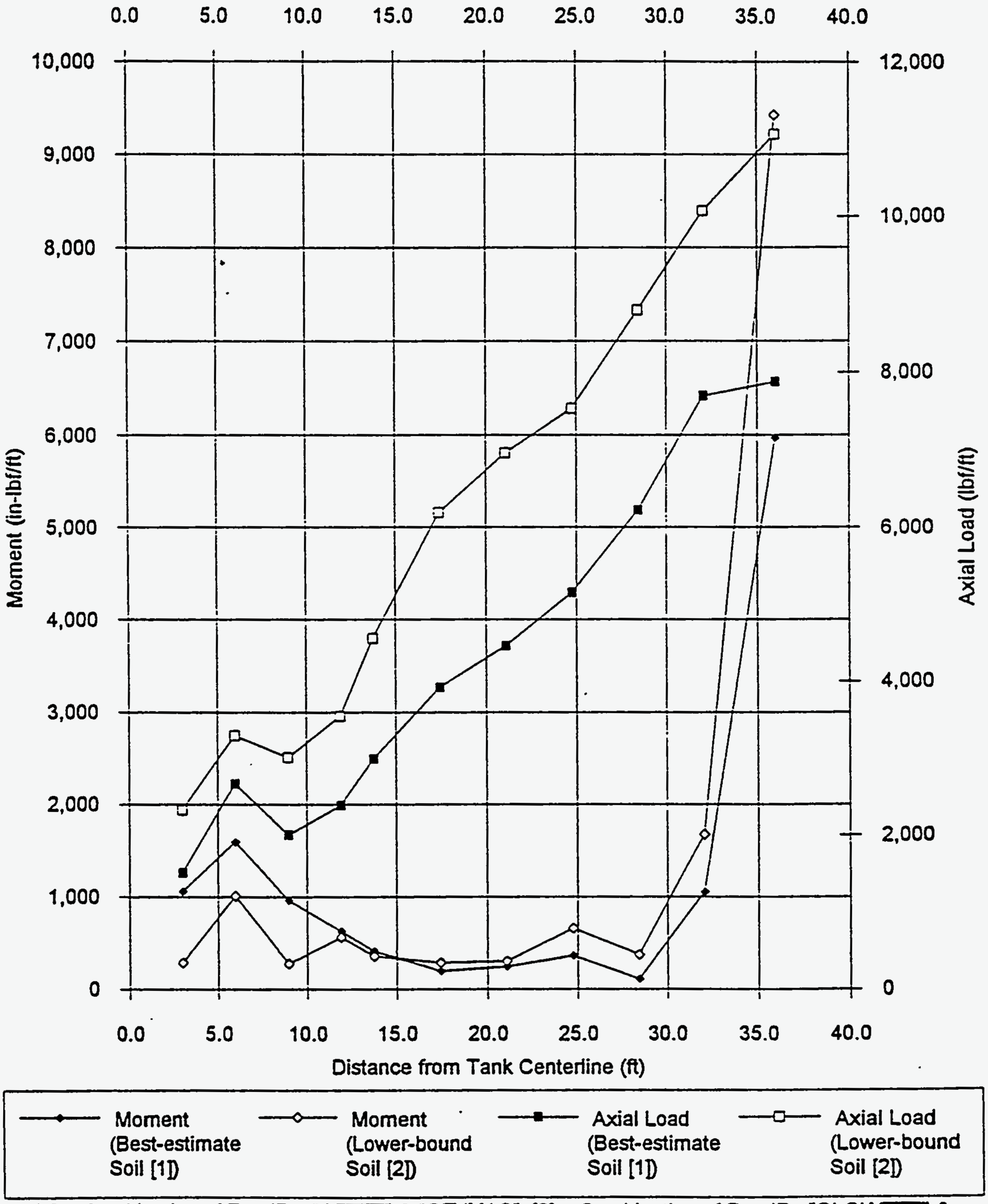
Figure 6.2-6. Circumferential Seismic Response of Tank Dome at 180° Meridian from Horizontal Excitation: Effects of Soil Properties Variation.



Note: [1] = Run ID "Q7pnt4", [2] = Run ID "QHI", [3] = Run ID "cmot50 QLOWpnt4".

qhi\CDOMEO2.XLC

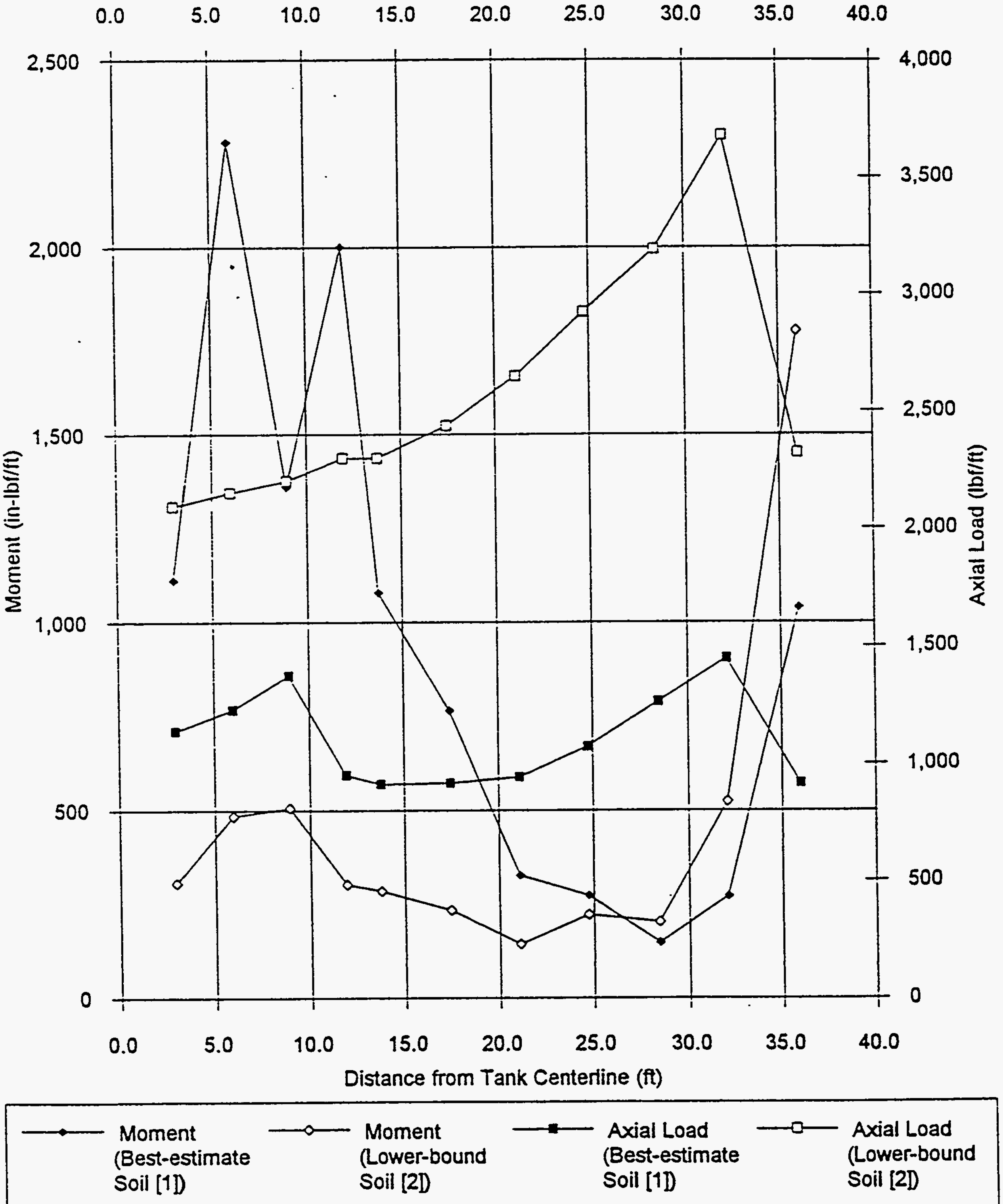
Figure 6.2-7. Total Meridional Seismic Response of Tank Base: Effects of Soil Properties Variation.



Note: [1] = Combination of Run IDs "Q7TTT" & "Q7VMAS", [2] = Combination of Run IDs "QLOWTTT" & "QLOWVLIV".

q7ttt\CBASEI.XLC

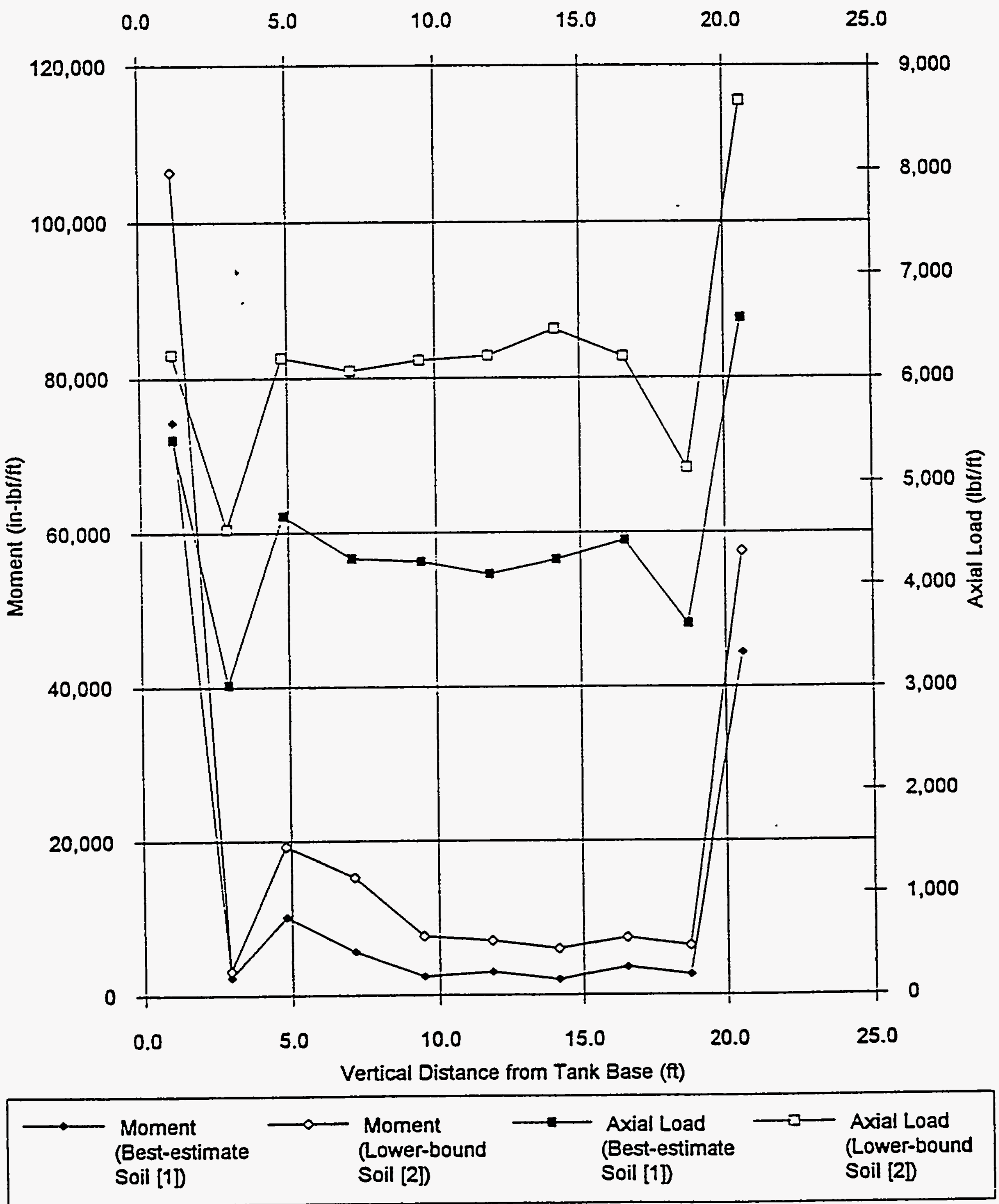
Figure 6.2-8. Total Circumferential Seismic Response of Tank Base: Effects of Soil Properties Variation.



Note: [1] = Combination of Run IDs "Q7TTT" & "Q7VMAS", [2] = Combination of Run IDs "QLOWTTT" & "QLOWVLIV".

q7ttt\CBASEO.XLC

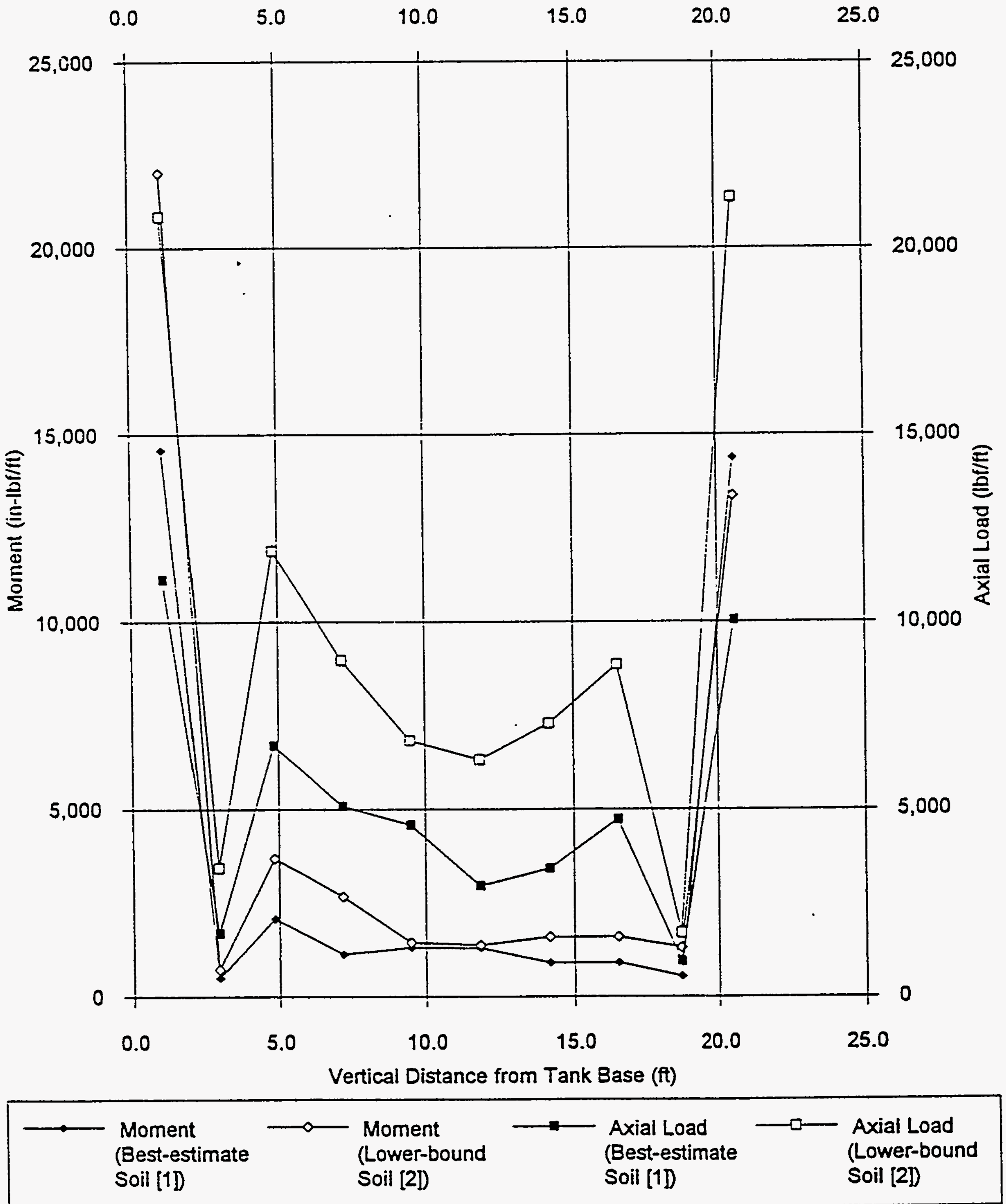
Figure 6.2-9. Total Meridional Seismic Response of Tank Wall: Effects of Soil Properties Variation.



Note: [1] = Combination of Run IDs "Q7TTT" & "Q7VMAS", [2] = Combination of Run IDs "QLOWTTT" & "QLOWVLIV".

q7ttt\CWALLI.XLC

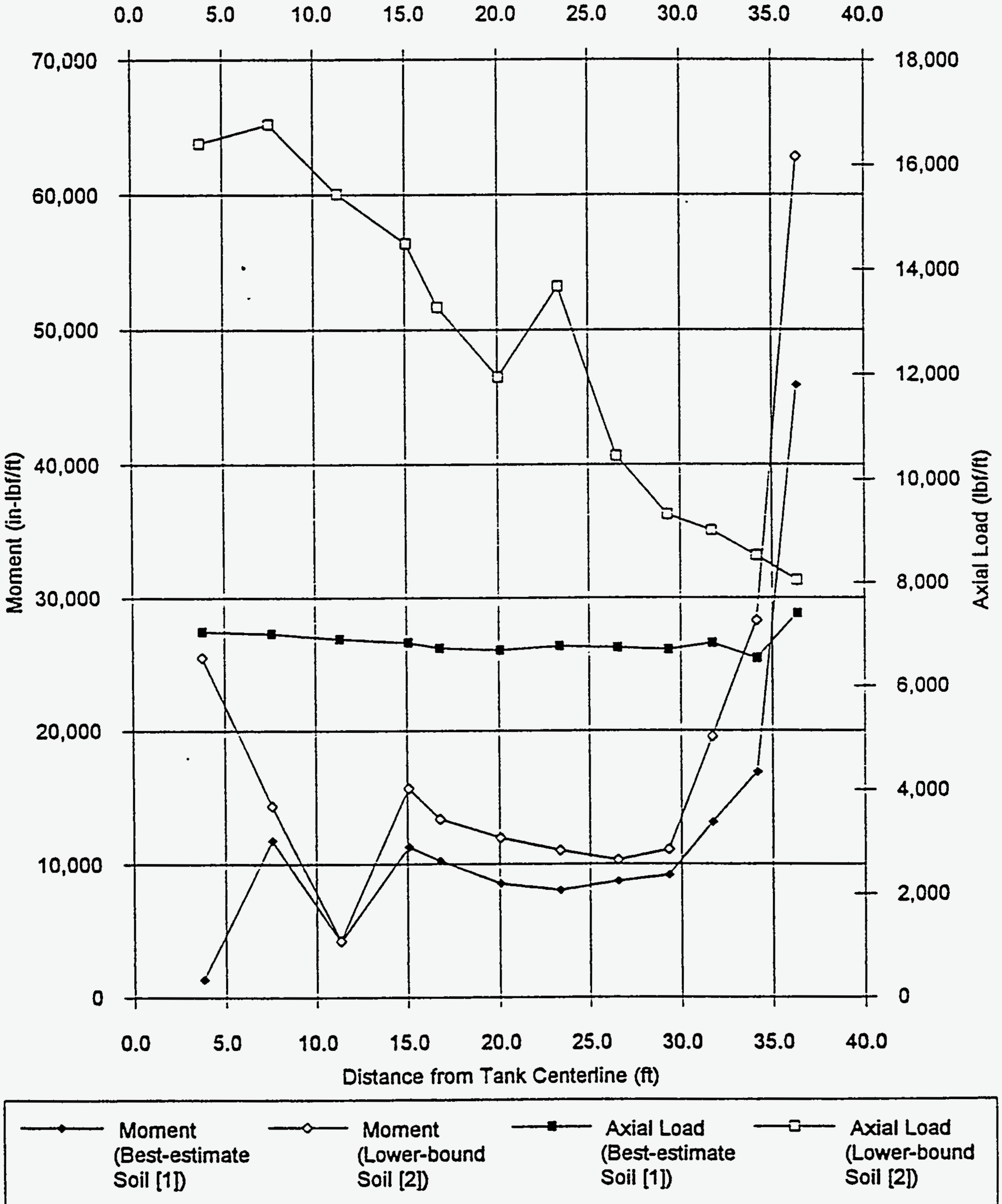
Figure 6.2-10. Total Circumferential Seismic Response of Tank Wall: Effects of Soil Properties Variation.



Note: [1] = Combination of Run IDs "Q7TTT" & "Q7VMAS", [2] = Combination of Run IDs "QLOWTTT" & "QLOWVLIV".

q7ttt\CWALLO.XLC

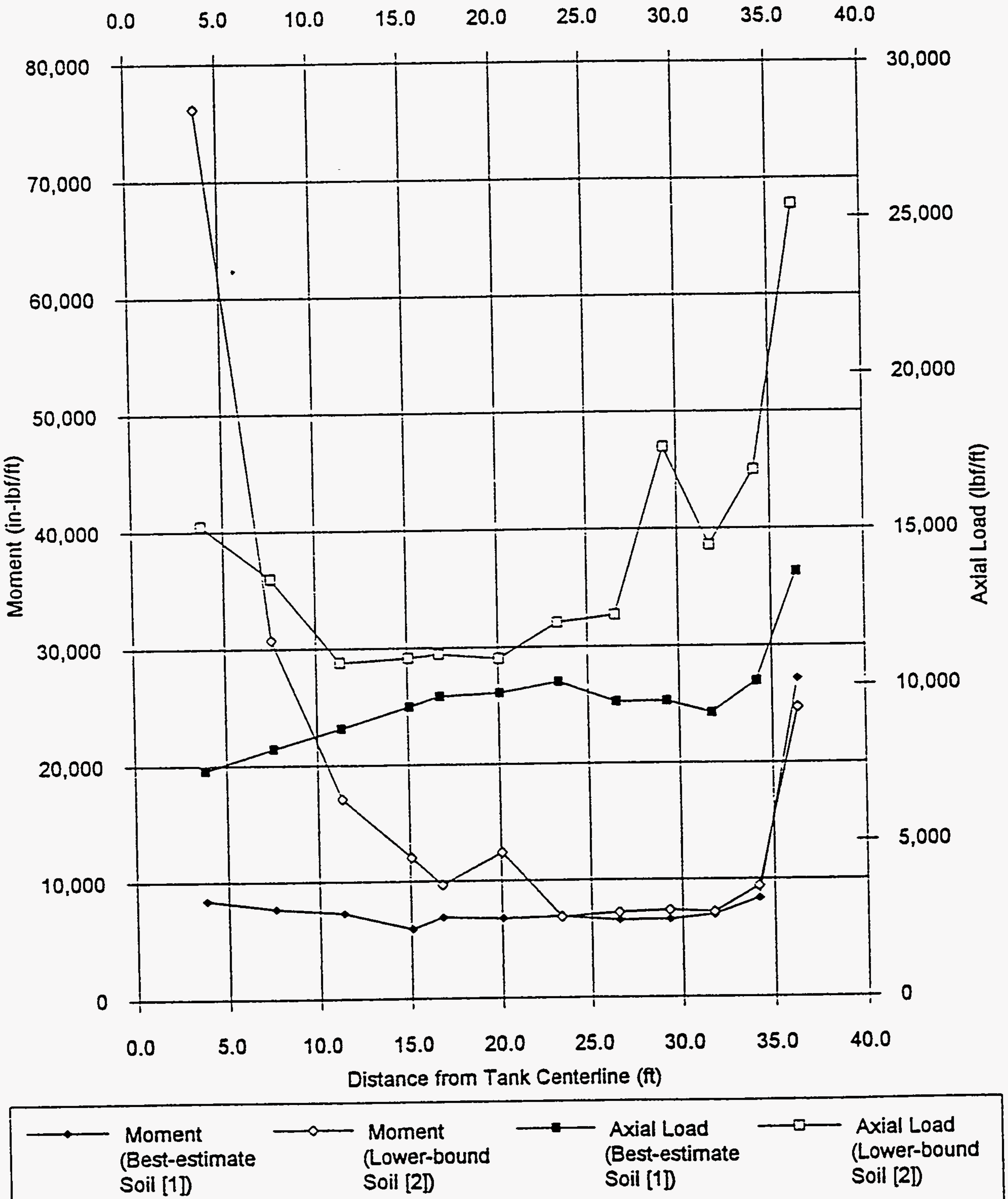
Figure 6.2-11. Total Meridional Seismic Response of Tank Dome: Effects of Soil Properties Variation.



Note: [1] = Combination of Run IDs "Q7TTT" & "Q7VMAS", [2] = Combination of Run IDs "QLOWTTT" & "QLOWVLIV".

q7ttt\CDOMEI.XLC

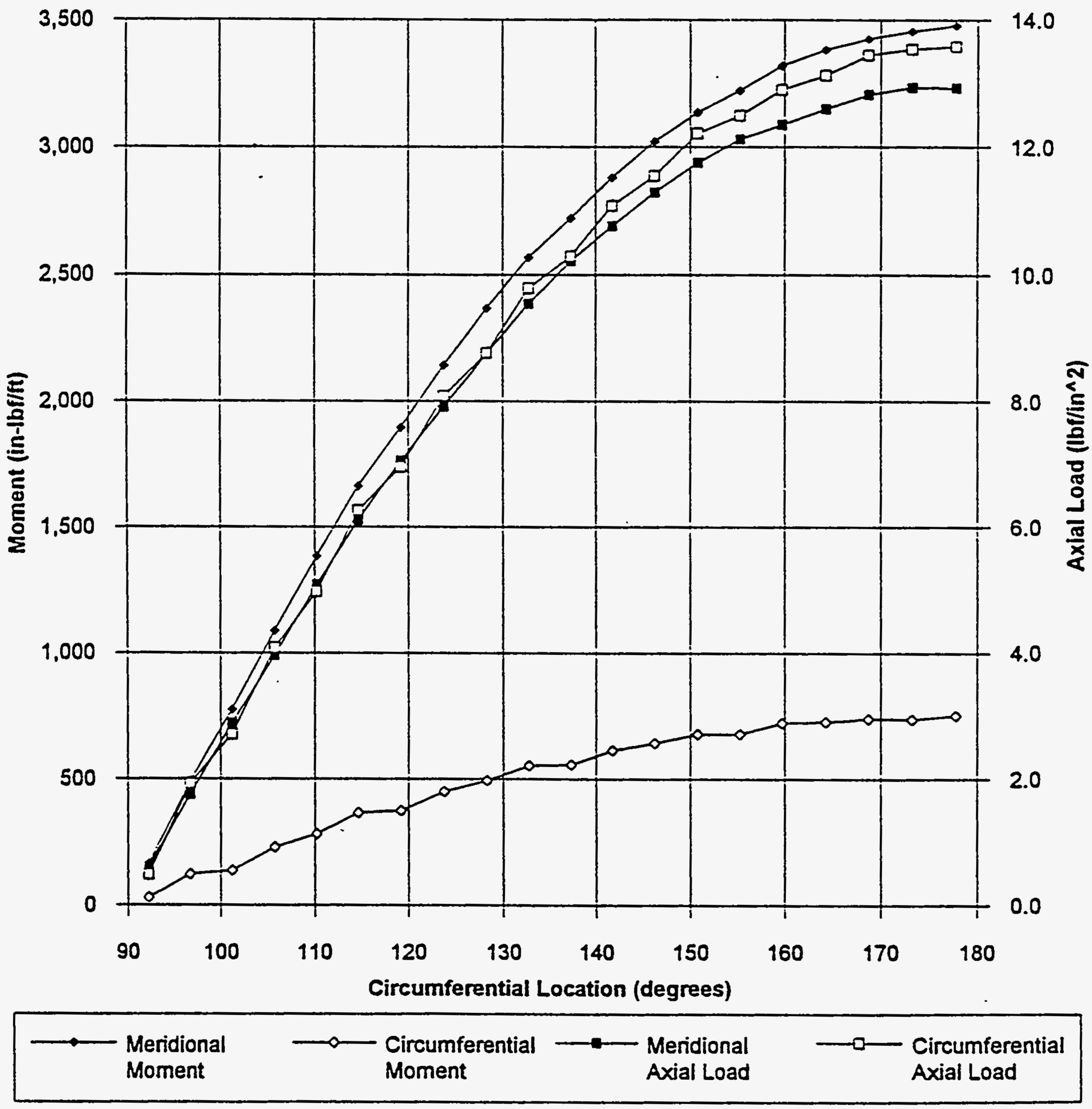
Figure 6.2-12. Total Circumferential Seismic Response of Tank Dome: Effects of Soil Properties Variation.



Note: [1] = Combination of Run IDs "Q7TTT" & "Q7VMAS", [2] = Combination of Run IDs "QLOWTTT" & "QLOWVLIV".

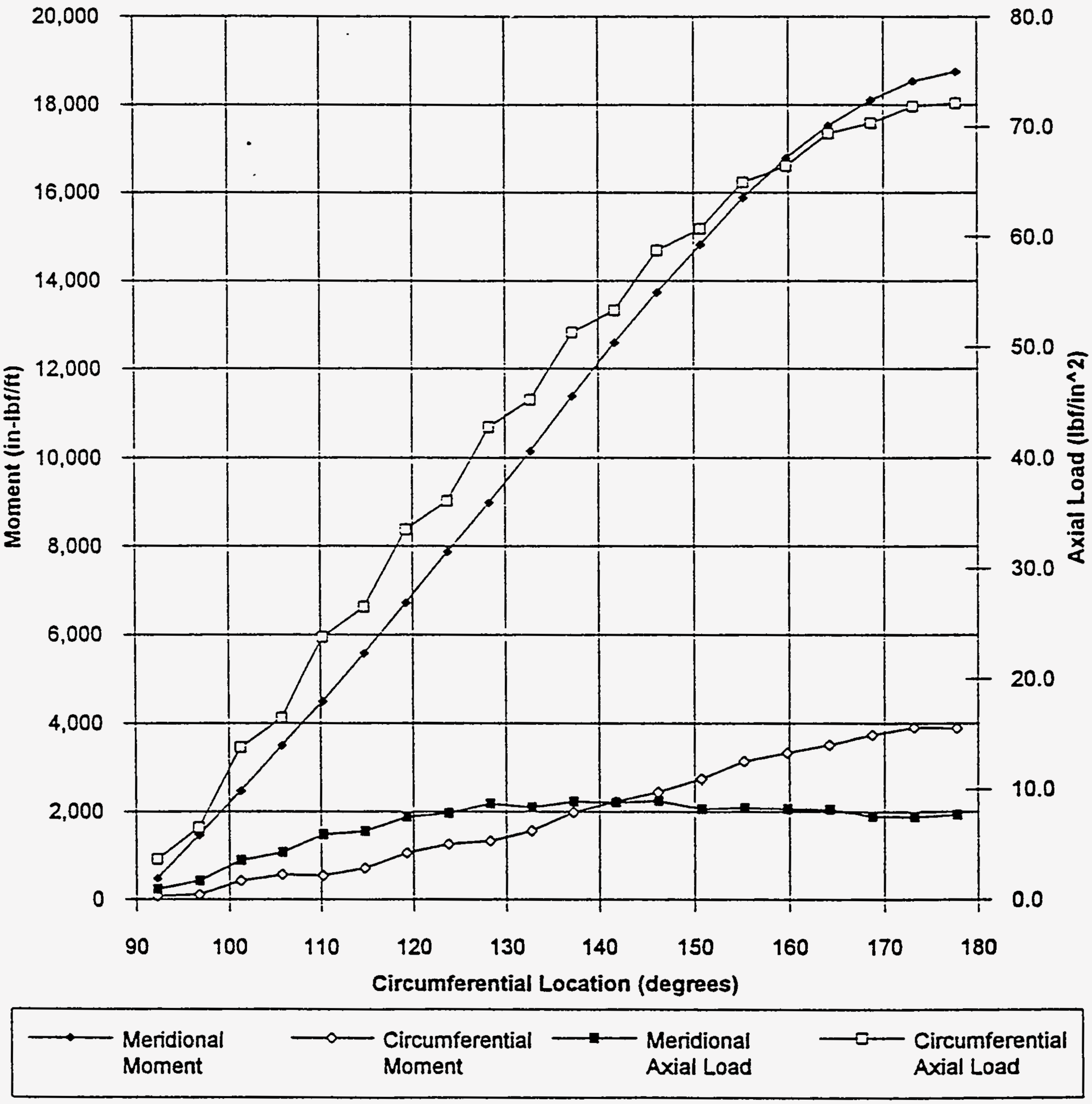
q7ttt\CDOMEO.XLC

Figure 6.2-13. Circumferential Variation of Seismic Response of Tank Wall Near Haunch from Horizontal Excitation Using Lower-Bound Soil Properties (Run ID "cmot50 QLOWpnt4").



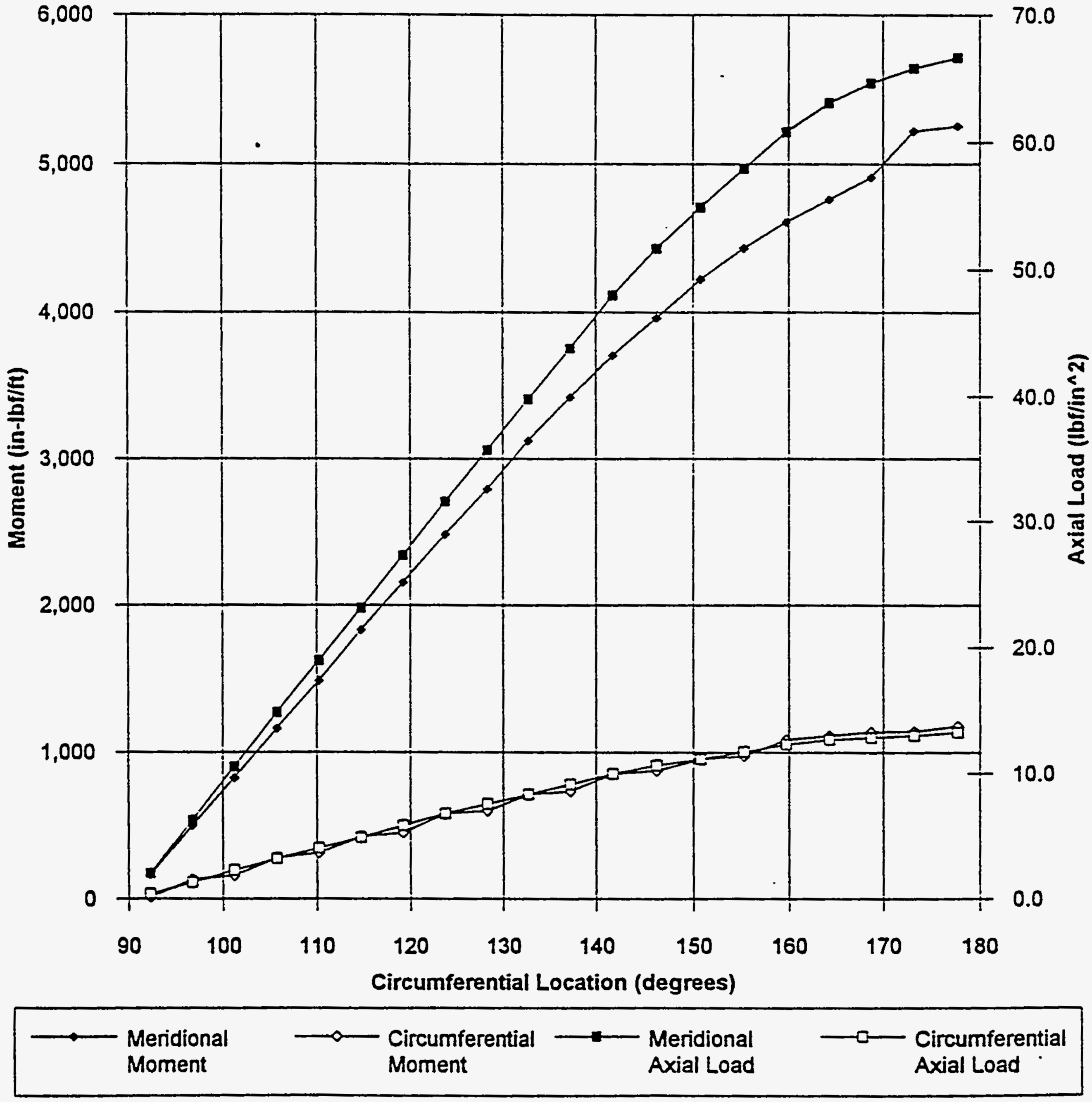
qlow\lanl\cmot50\STRESS1.XLC

Figure 6.2-14. Circumferential Variation of Seismic Response of Tank Wall Near Knuckle from Horizontal Excitation Using Lower-Bound Soil Properties (Run ID "cmot50 QLOWpnt4").



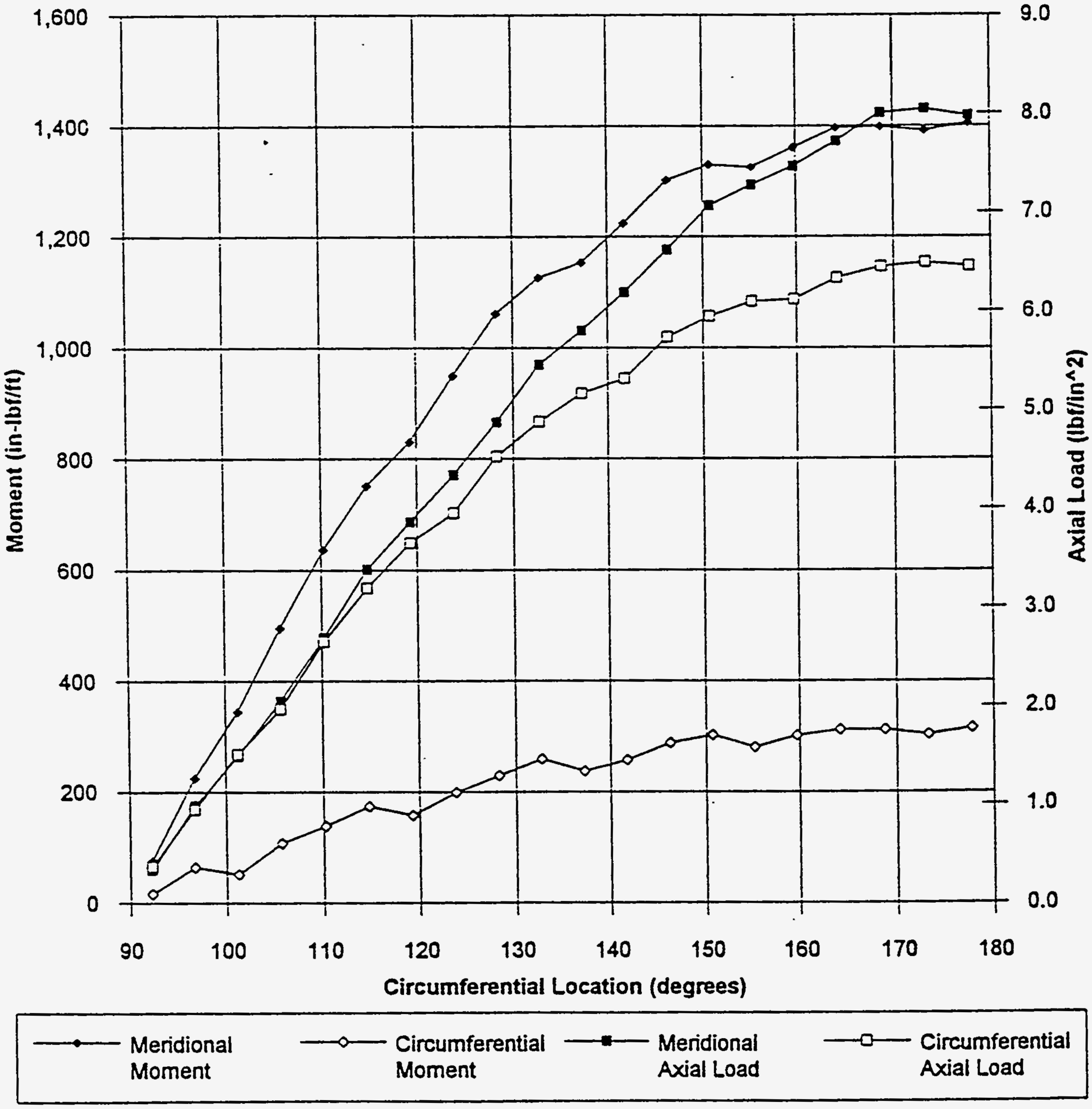
qlow\anl\cmot50\STRESS2.XLC

Figure 6.2-15. Circumferential Variation of Seismic Response of Tank Base Near Knuckle from Horizontal Excitation Using Lower-Bound Soil Properties (Run ID "cmot50 QLOWpnt4").



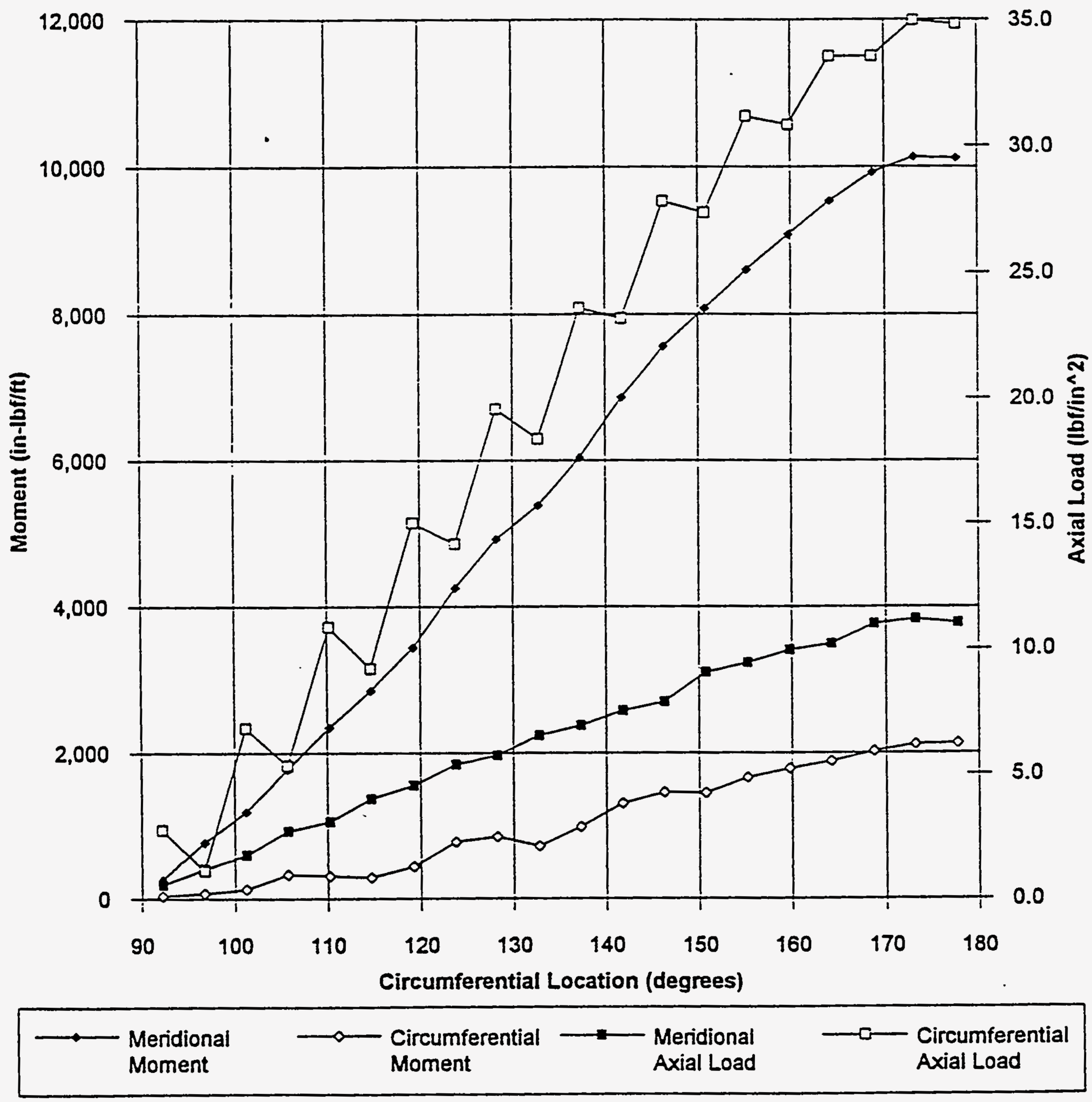
qlow\anl\cmot50\STRESS3.XLC

Figure 6.2-16. Circumferential Variation of Seismic Response of Tank Wall Near Haunch from Horizontal Excitation Using Best-estimate Soil Properties (Run ID "Q7pnt4").



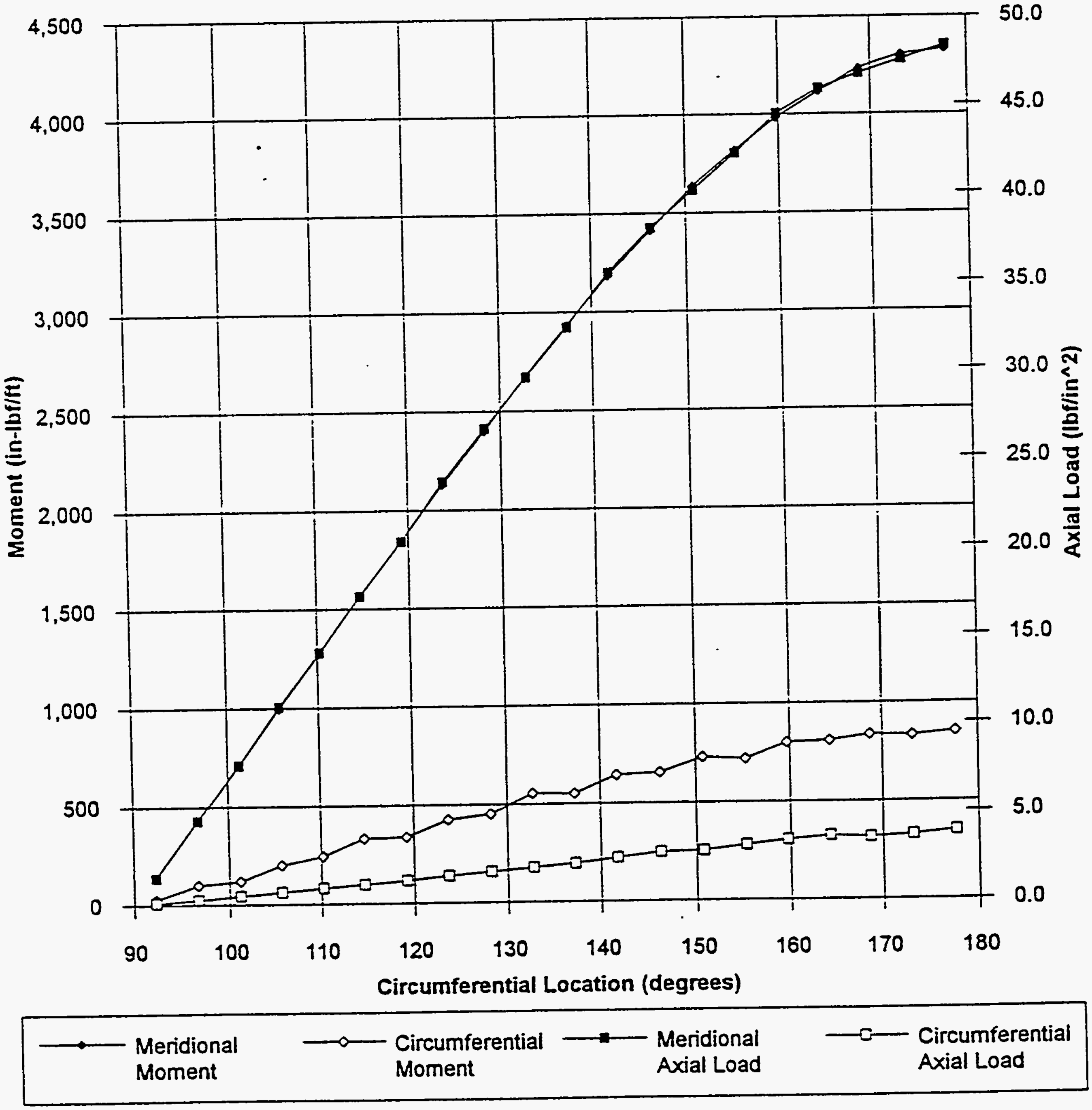
q7\anl\STRESS1.XLC

Figure 6.2-17. Circumferential Variation of Seismic Response of Tank Wall Near Knuckle from Horizontal Excitation Using Best-estimate Soil Properties (Run ID "Q7pnt4").



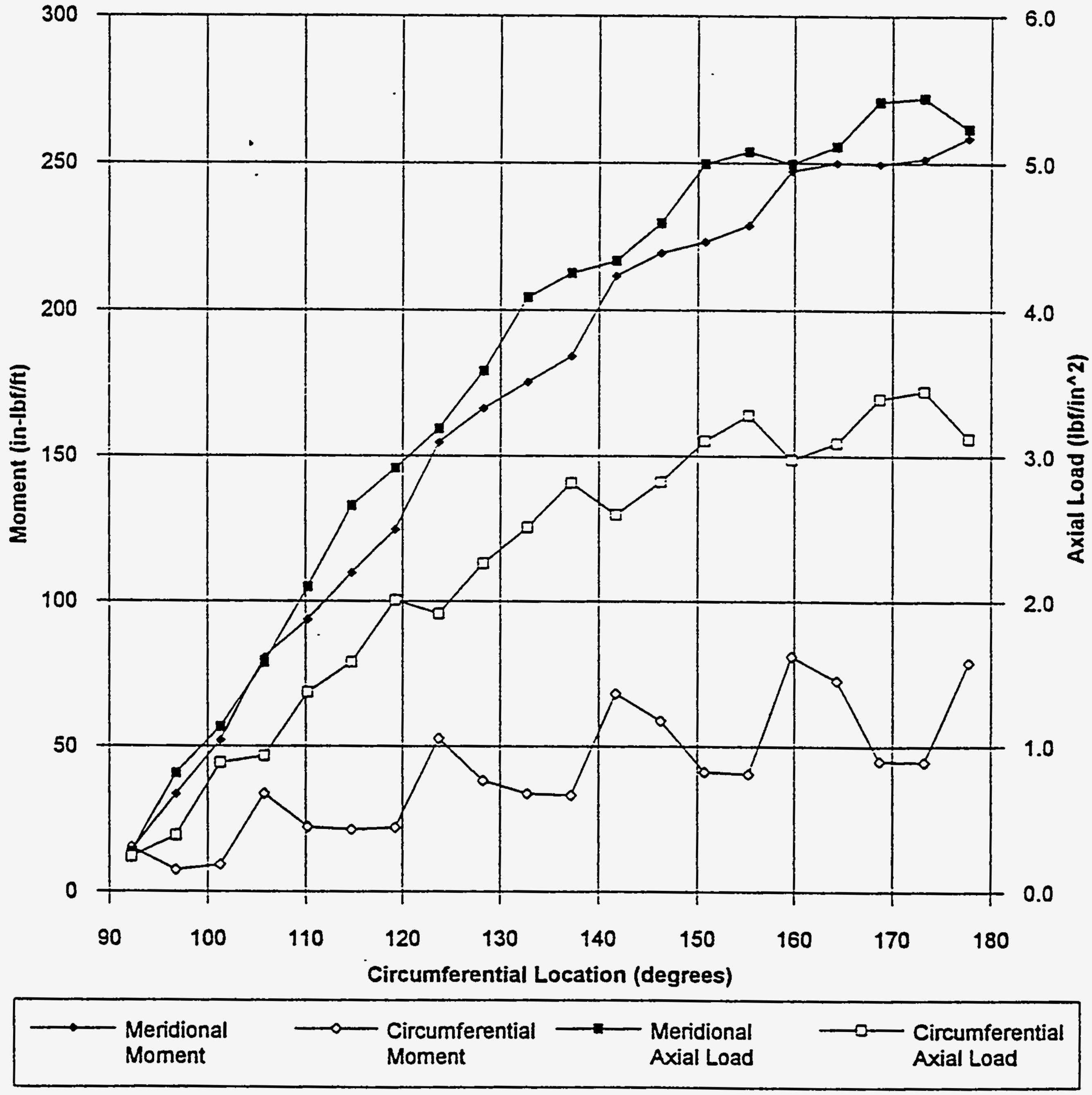
q7\anl\STRESS2.XLC

Figure 6.2-18. Circumferential Variation of Seismic Response of Tank Base Near Knuckle from Horizontal Excitation Using Best-estimate Soil Properties (Run ID "Q7pnt4").



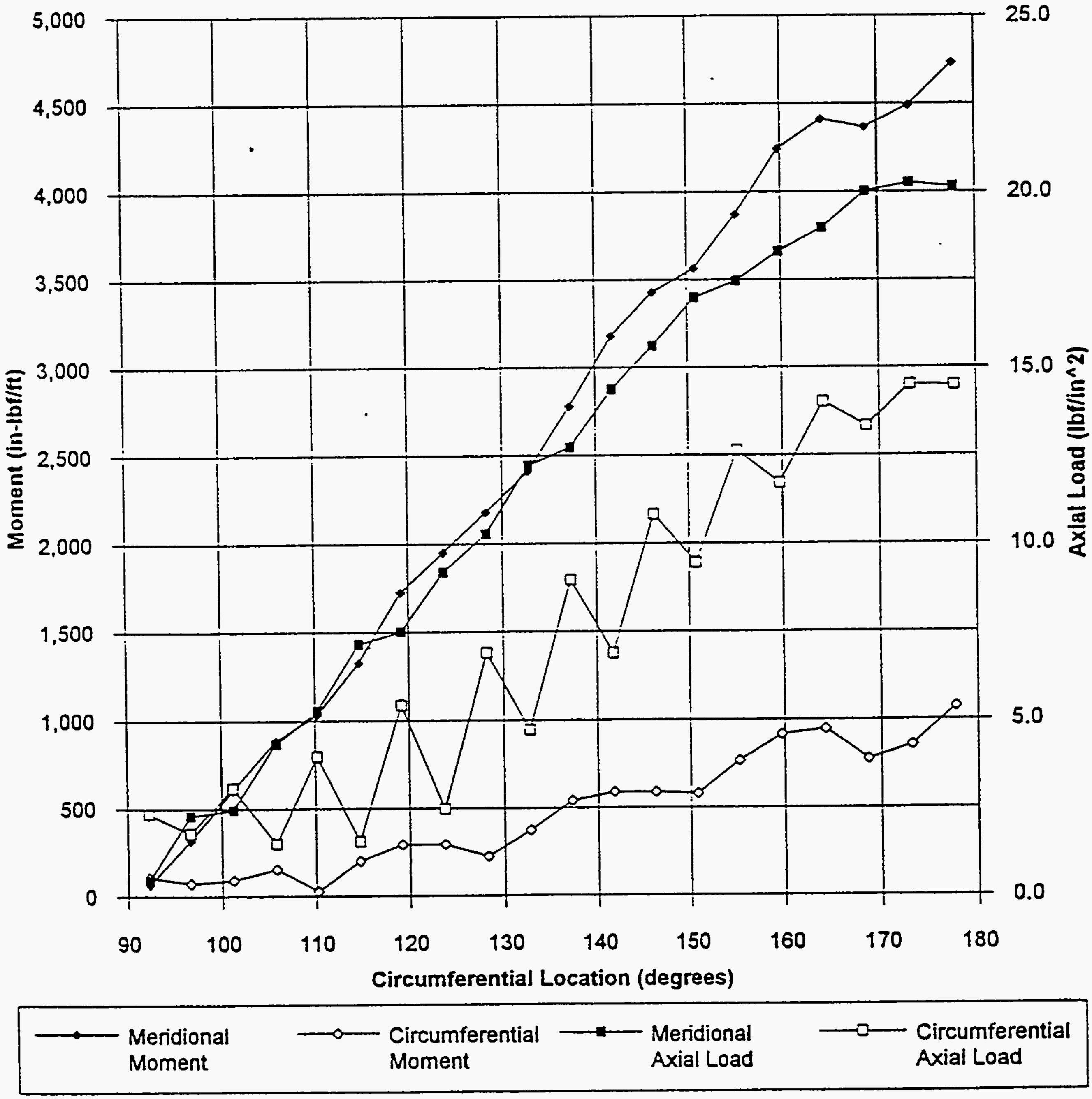
q7\anl\STRESS3.XLC

Figure 6.2-19. Circumferential Variation of Seismic Response of Tank Wall Near Haunch from Horizontal Excitation Using Upper-Bound Soil Properties (Run ID "QHI").



qhi\STRESS2A.XLC

Figure 6.2-20. Circumferential Variation of Seismic Response of Tank Wall Near Knuckle from Horizontal Excitation Using Upper-Bound Soil Properties (Run ID "QHI").



qhi\STRESS2B.XLC

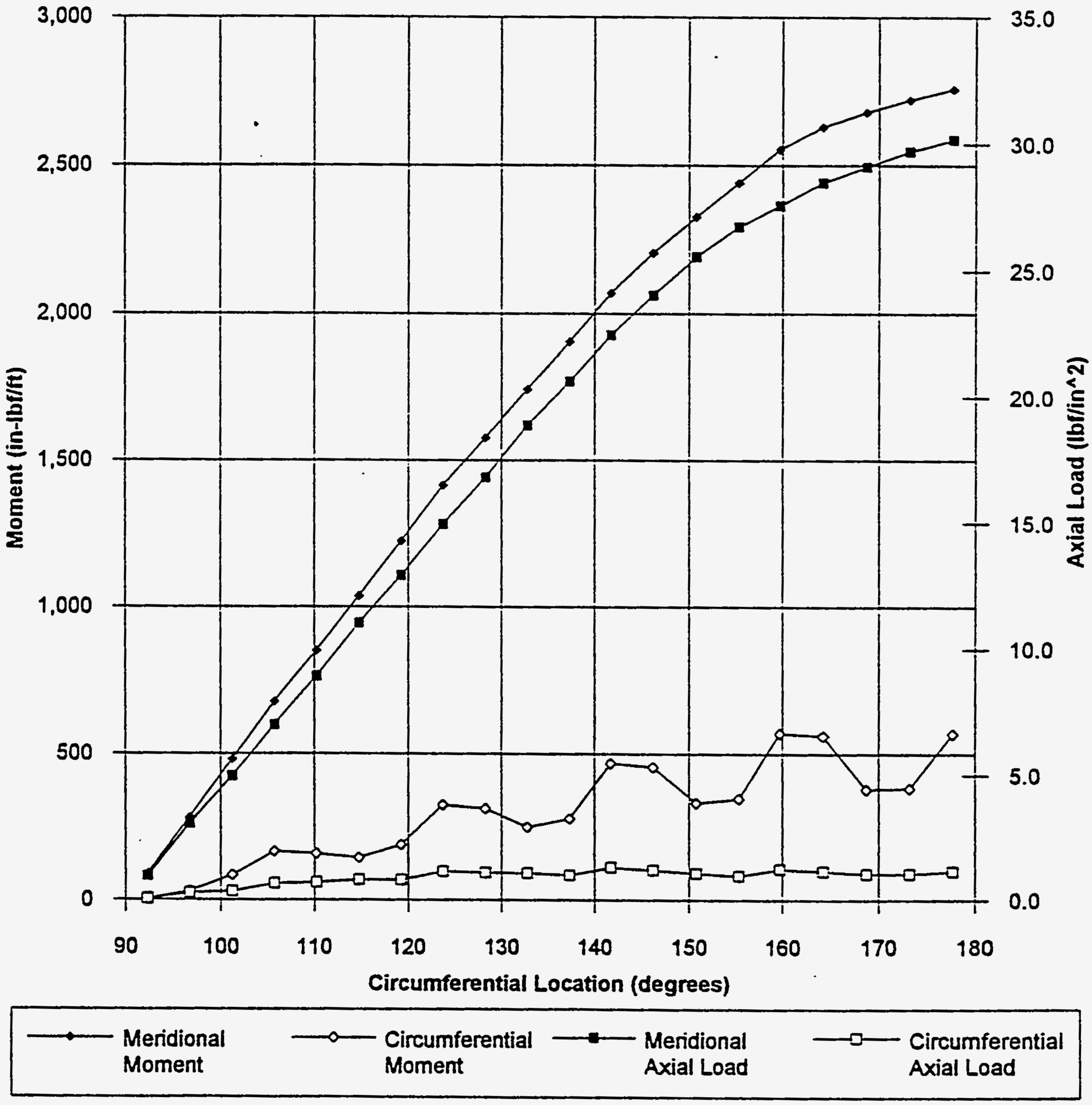
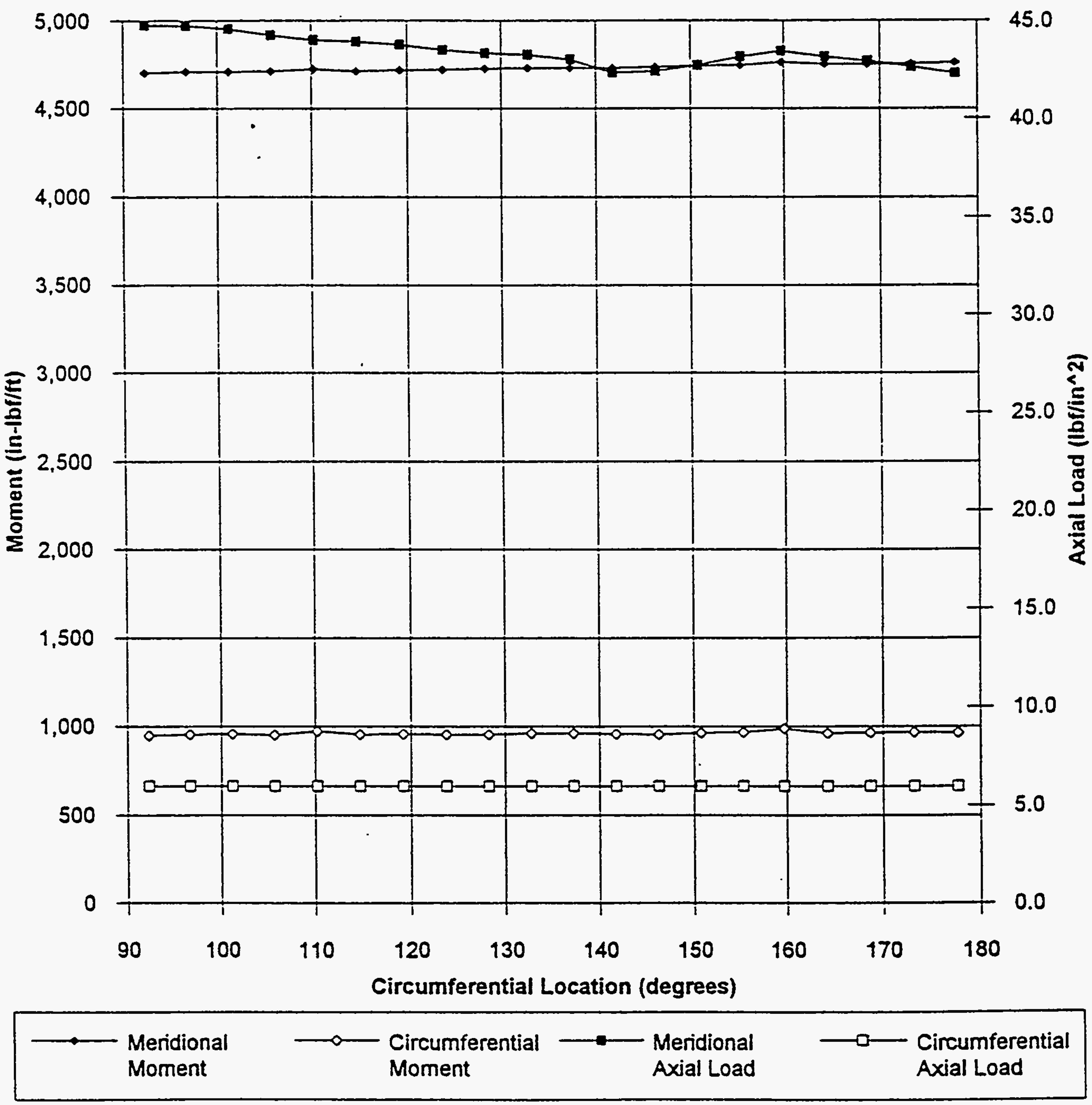


Figure 6.2-21. Circumferential Variation of Seismic Response of Tank Base Near Knuckle from Horizontal Excitation Using Upper-Bound Soil Properties (Run ID "QHI").

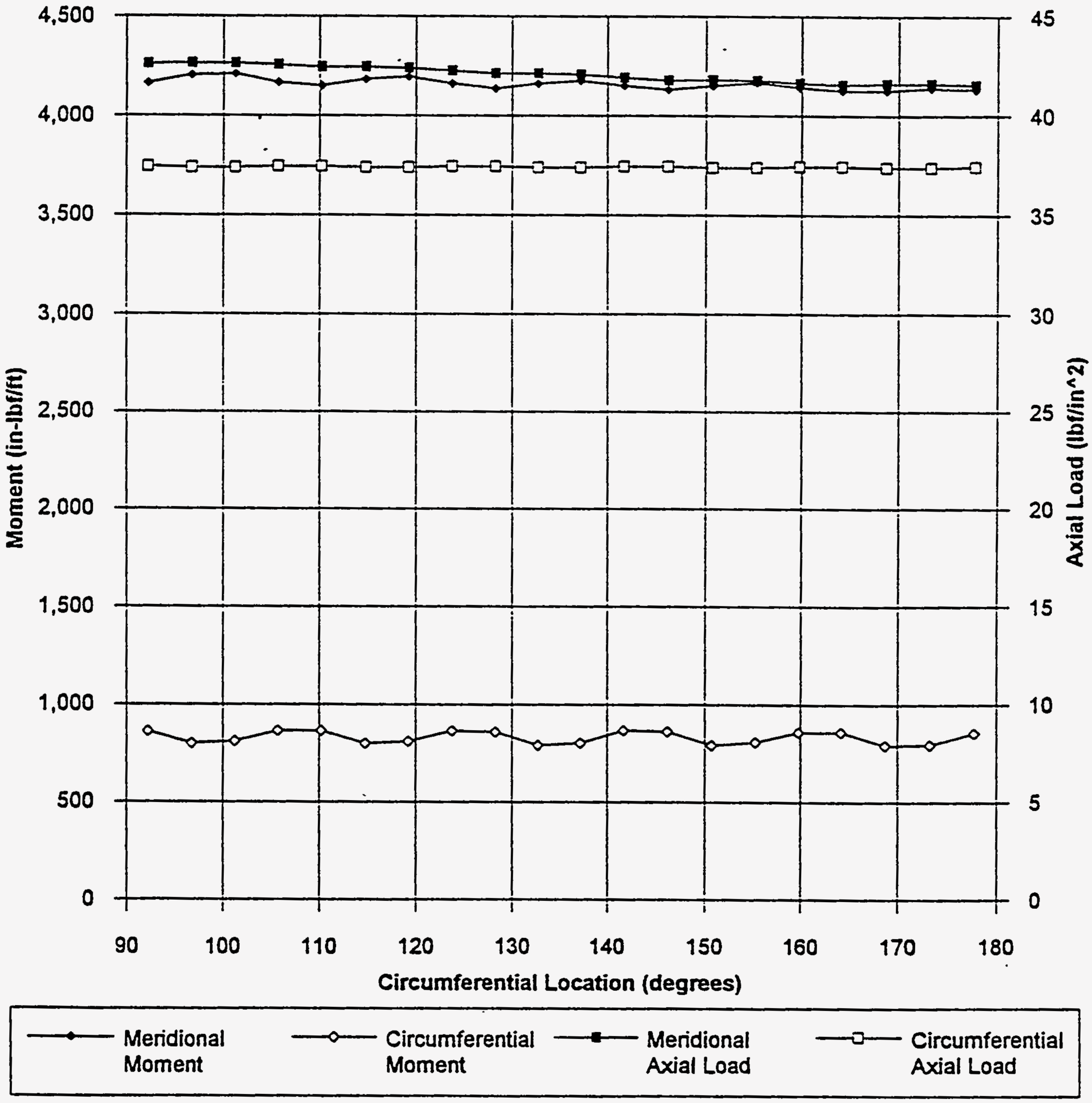
qhi\STRESS2C.XLC

Figure 6.2-22. Circumferential Variation of Seismic Response of Tank Wall Near Haunch from Vertical Excitation Using Lower-Bound Soil Properties (Run ID "QLOWVMAS").



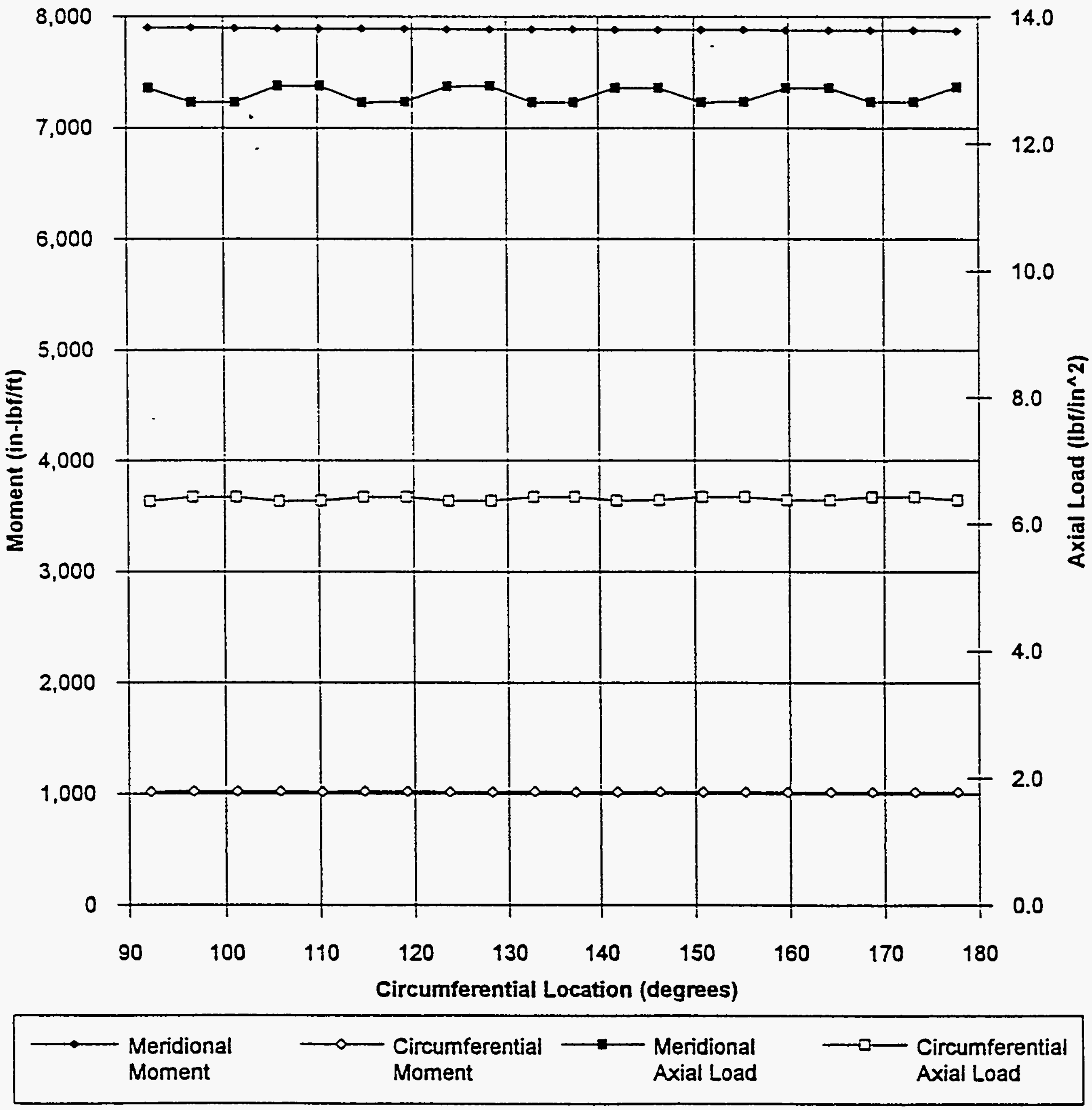
qlow-v\STRESS1.XLC

Figure 6.2-23. Circumferential Variation of Seismic Response of Tank Wall Near Knuckle from Vertical Excitation Using Lower-Bound Soil Properties (Run ID "QLOWVMAS").



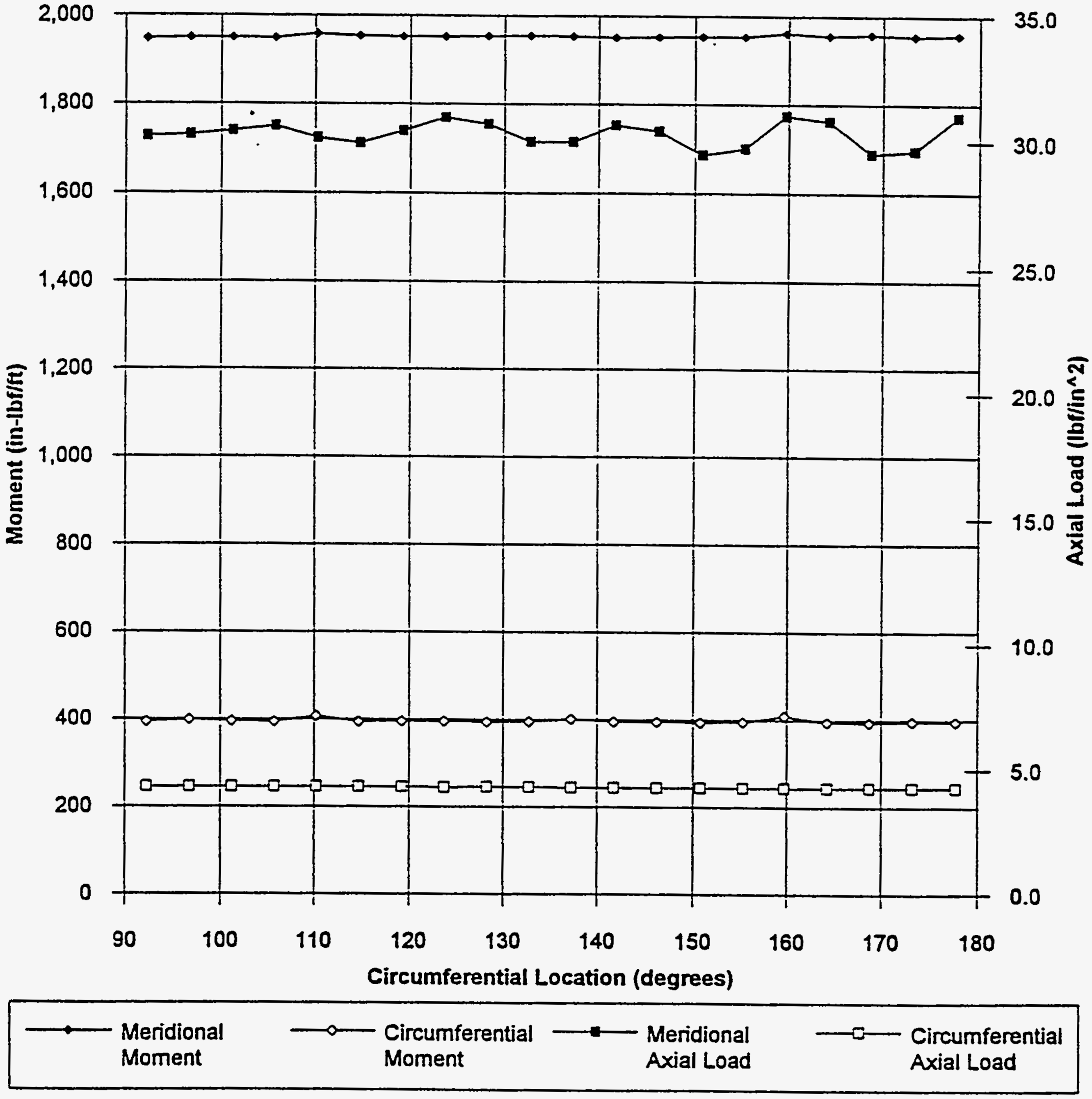
qlow-v\STRESS2.XLC

Figure 6.2-24. Circumferential Variation of Seismic Response of Tank Base Near Knuckle from Vertical Excitation Using Lower-Bound Soil Properties (Run ID "QLOWVMAS").



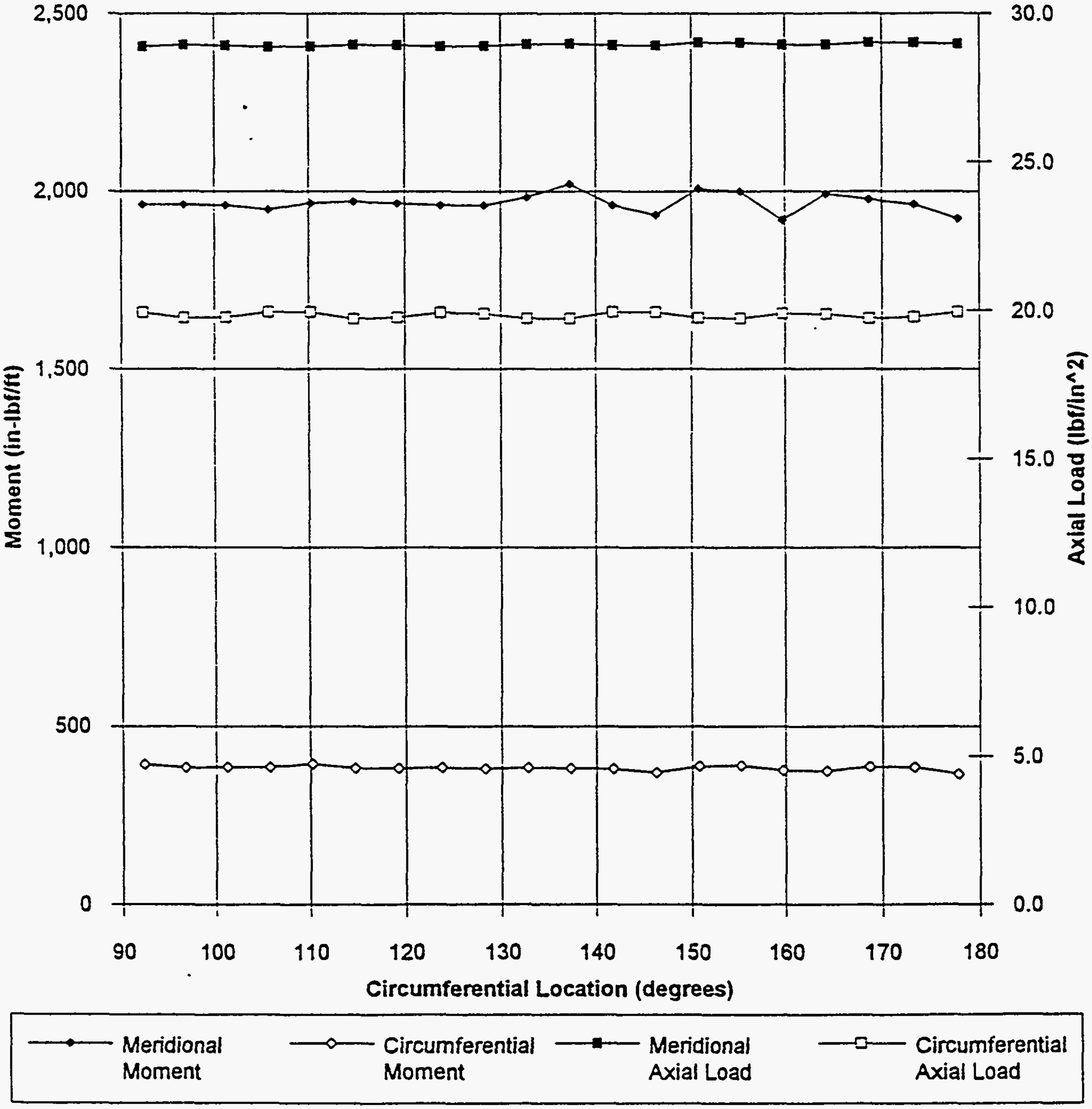
qlow-v\STRESS3.XLC

Figure 6.2-25. Circumferential Variation of Seismic Response of Tank Wall Near Haunch from Vertical Excitation Using Best-estimate Soil Properties (Run ID "Q7VMAS").



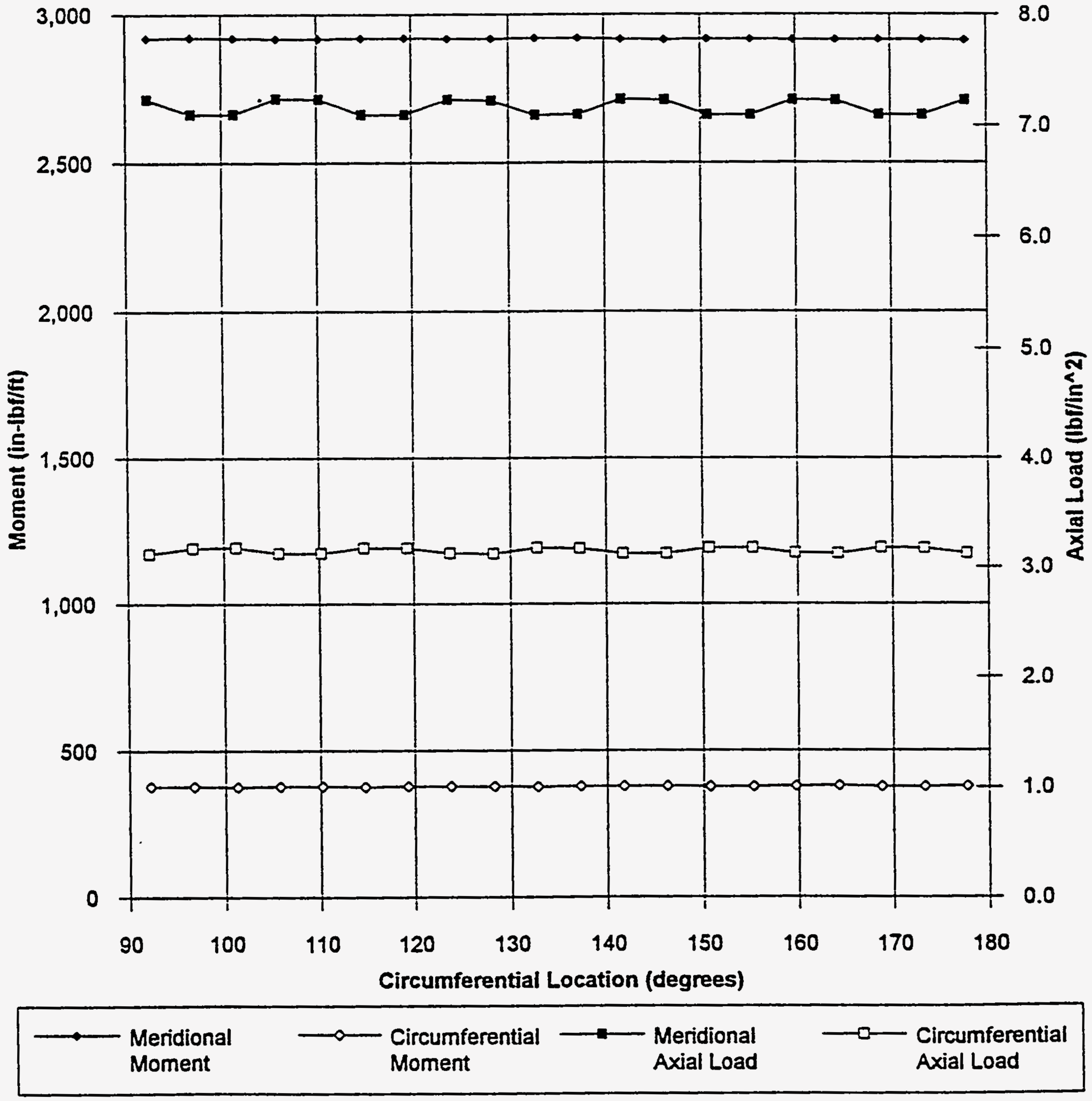
q7v\anl\STRESS1.XLC

Figure 6.2-26. Circumferential Variation of Seismic Response of Tank Wall Near Knuckle from Vertical Excitation Using Best-estimate Soil Properties (Run ID "Q7VMAS").



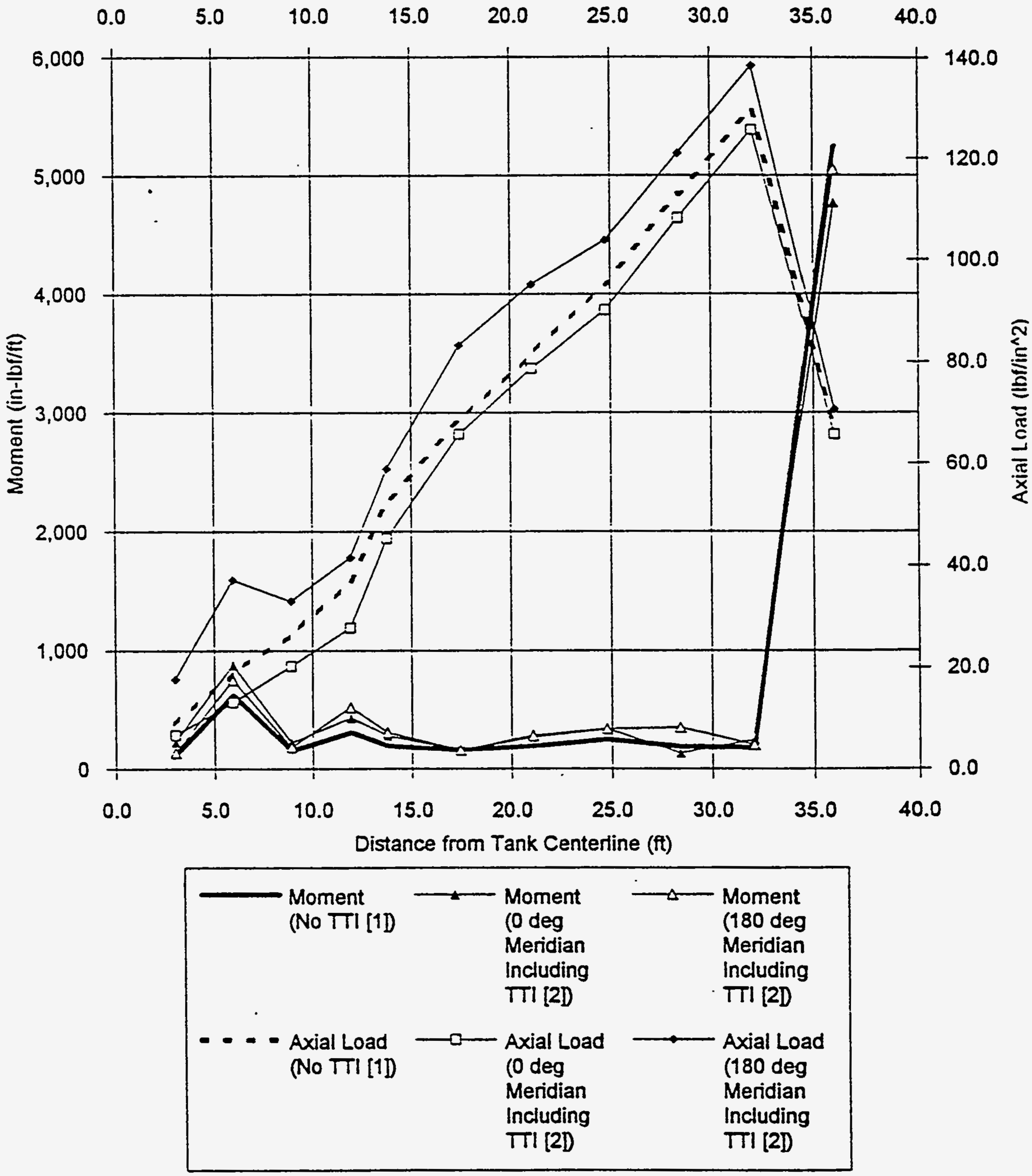
q7v\anl\STRESS2.XLC

Figure 6.2-27. Circumferential Variation of Seismic Response of Tank Base Near Knuckle from Vertical Excitation Using Best-estimate Soil Properties (Run ID "Q7VMAS").



q7v\anl\STRESS3.XLC

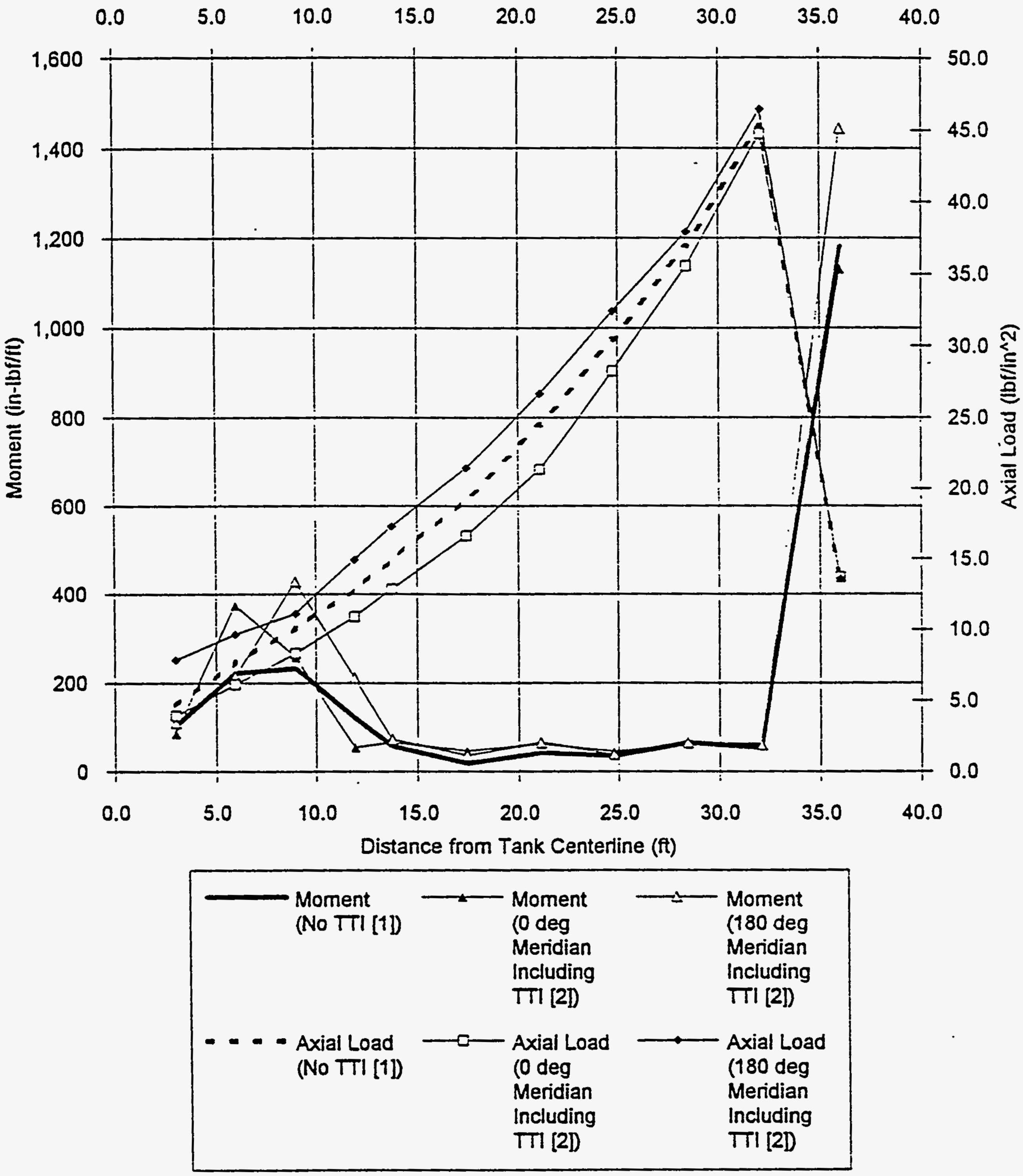
Figure 6.2-28. Meridional Seismic Response of Tank Base at 0°/180° Meridian from Horizontal Excitation Using Lower-Bound Soil Properties: Effects of Tank-to-Tank Interaction.



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = Run ID "TTTLOW".

qlow\anl\cmot50\CBASEI.XL

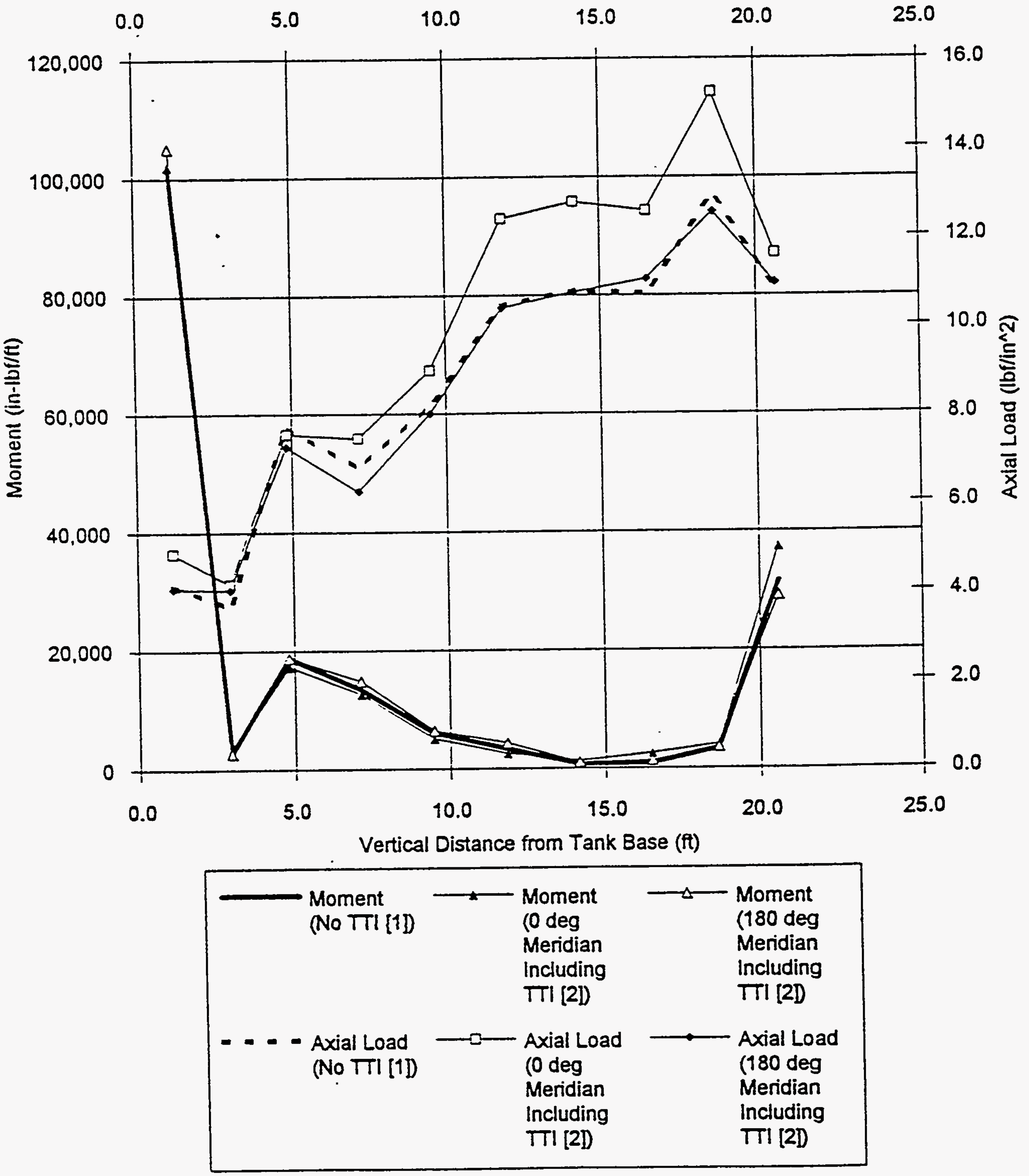
Figure 6.2-29. Circumferential Seismic Response of Tank Base at 0°/180° Meridian from Horizontal Excitation Using Lower-Bound Soil Properties: Effects of Tank-to-Tank Interaction.



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = Run ID "TTTLOW".

qlow\lanl\cmot50\CBASEO.XLC

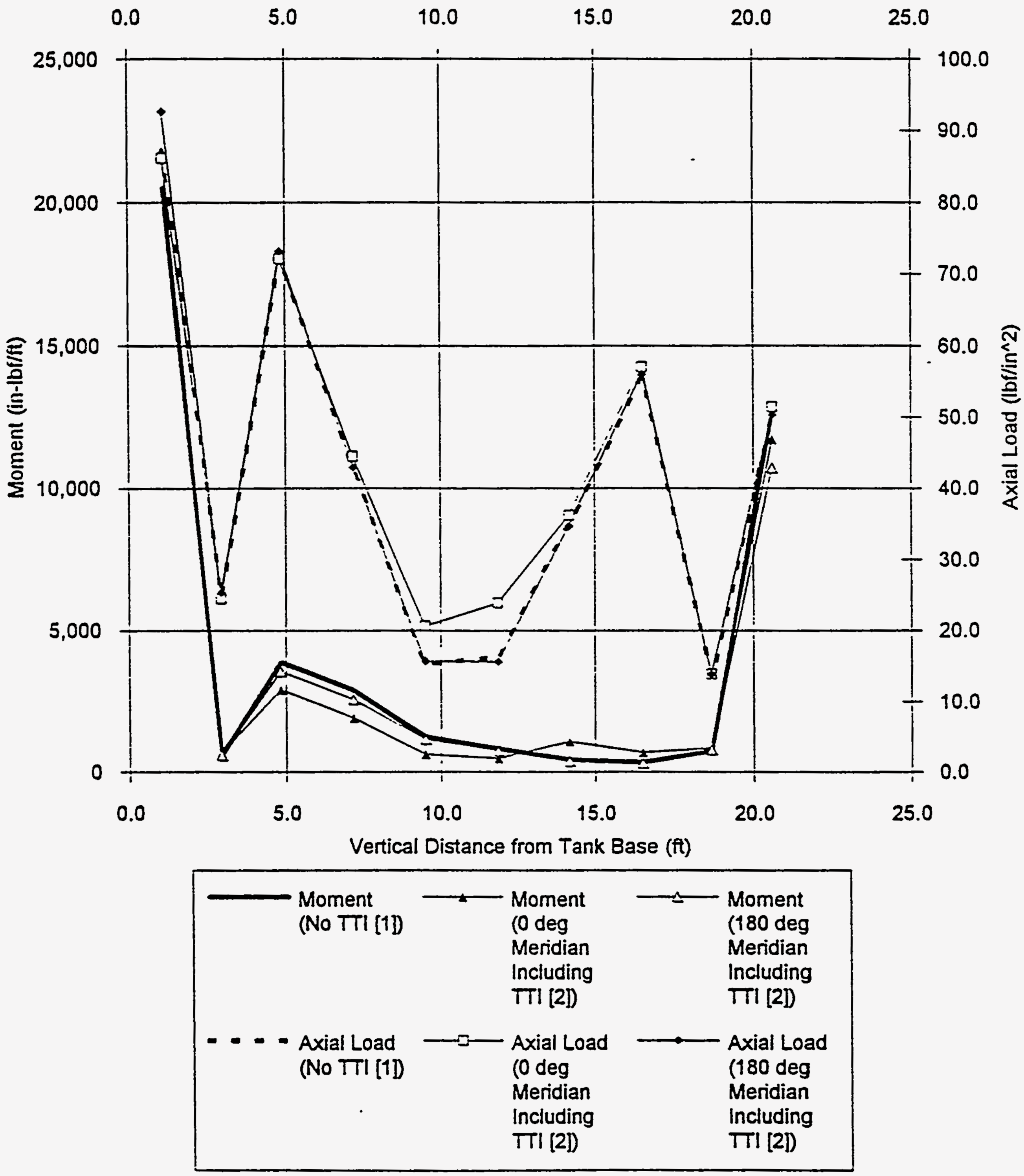
Figure 6.2-30. Meridional Seismic Response of Tank Wall at 0°/180° Meridian from Horizontal Excitation Using Lower-Bound Soil Properties: Effects of Tank-to-Tank Interaction.



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = Run ID "TTTLOW".

qlow\anl\cmot50\CWALLI.XLC

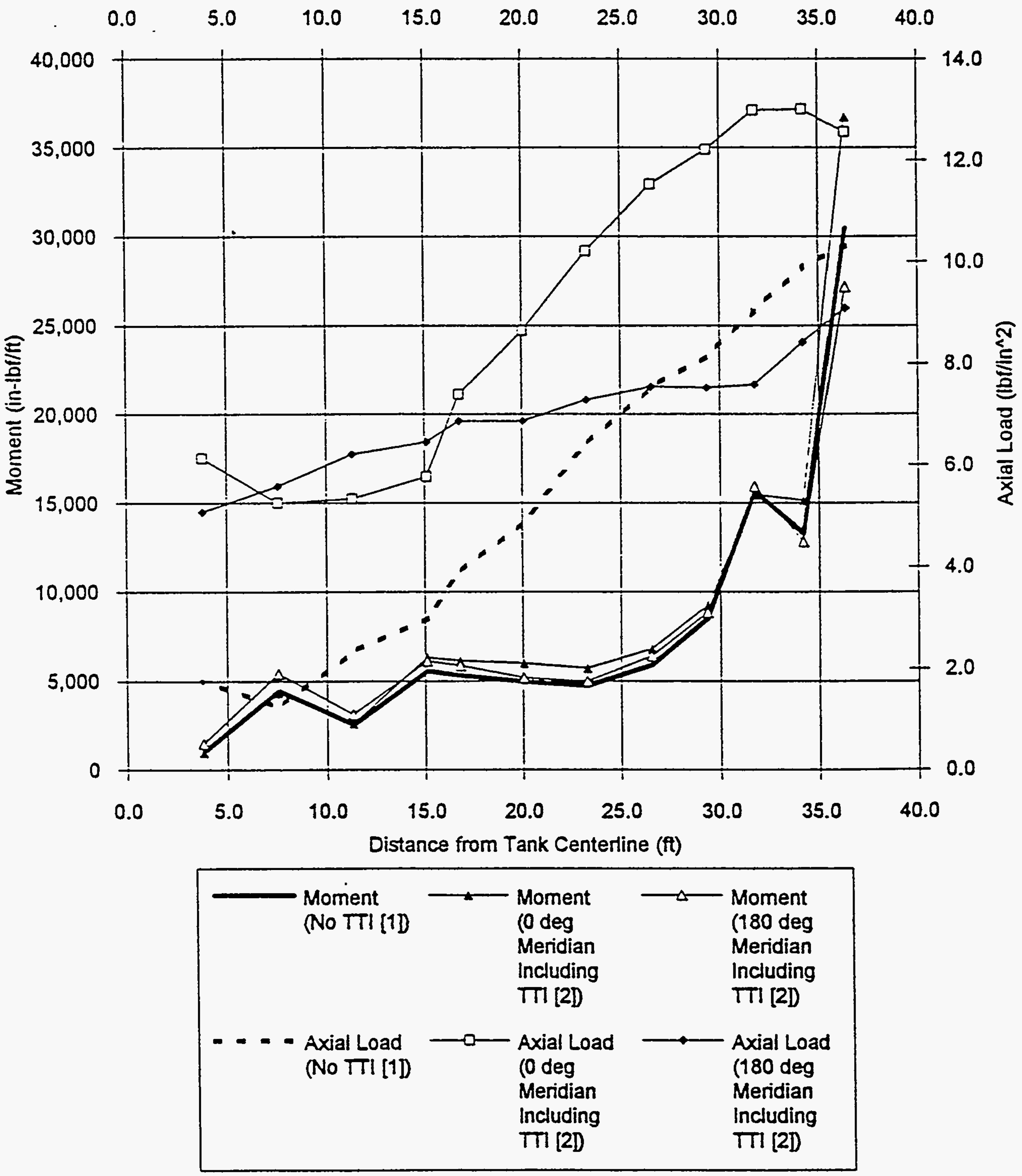
Figure 6.2-31. Circumferential Seismic Response of Tank Wall at 0°/180° Meridian from Horizontal Excitation Using Lower-Bound Soil Properties: Effects of Tank-to-Tank Interaction.



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = Run ID "TTTLOW".

qlow\lanl\cmot50\CWALLO.XLC

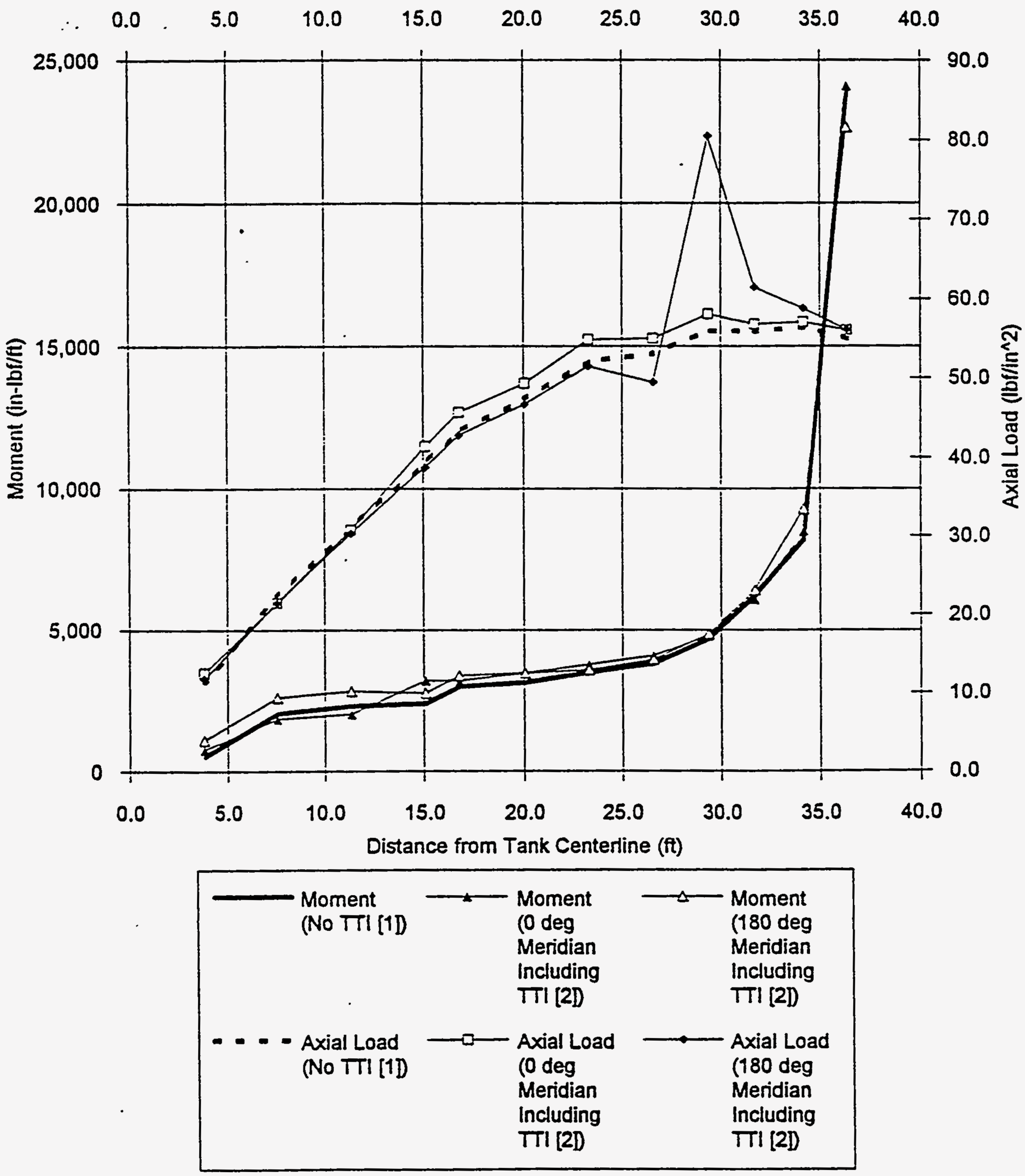
Figure 6.2-32. Meridional Seismic Response of Tank Dome at 0°/180° Meridian from Horizontal Excitation Using Lower-Bound Soil Properties: Effects of Tank-to-Tank Interaction.



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = Run ID "TTTLOW".

qlow\anl\cmot50\CDOMEI.XLC

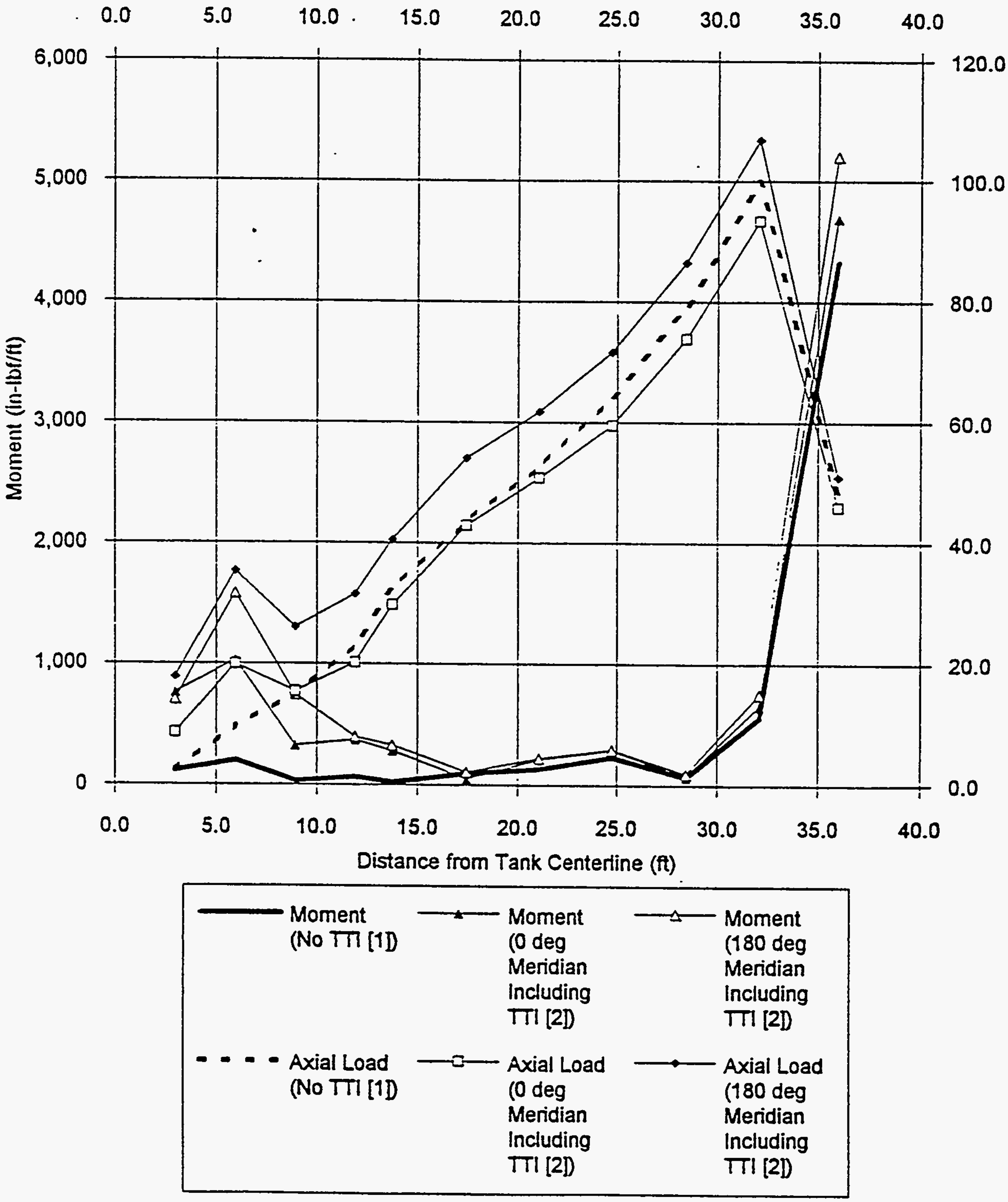
Figure 6.2-33. Circumferential Seismic Response of Tank Dome at 0°/180° Meridian from Horizontal Excitation Using Lower-Bound Soil Properties: Effects of Tank-to-Tank Interaction.



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = Run ID "TTTLOW".

qlow\anl\cmot50\CDOMEO.XLC

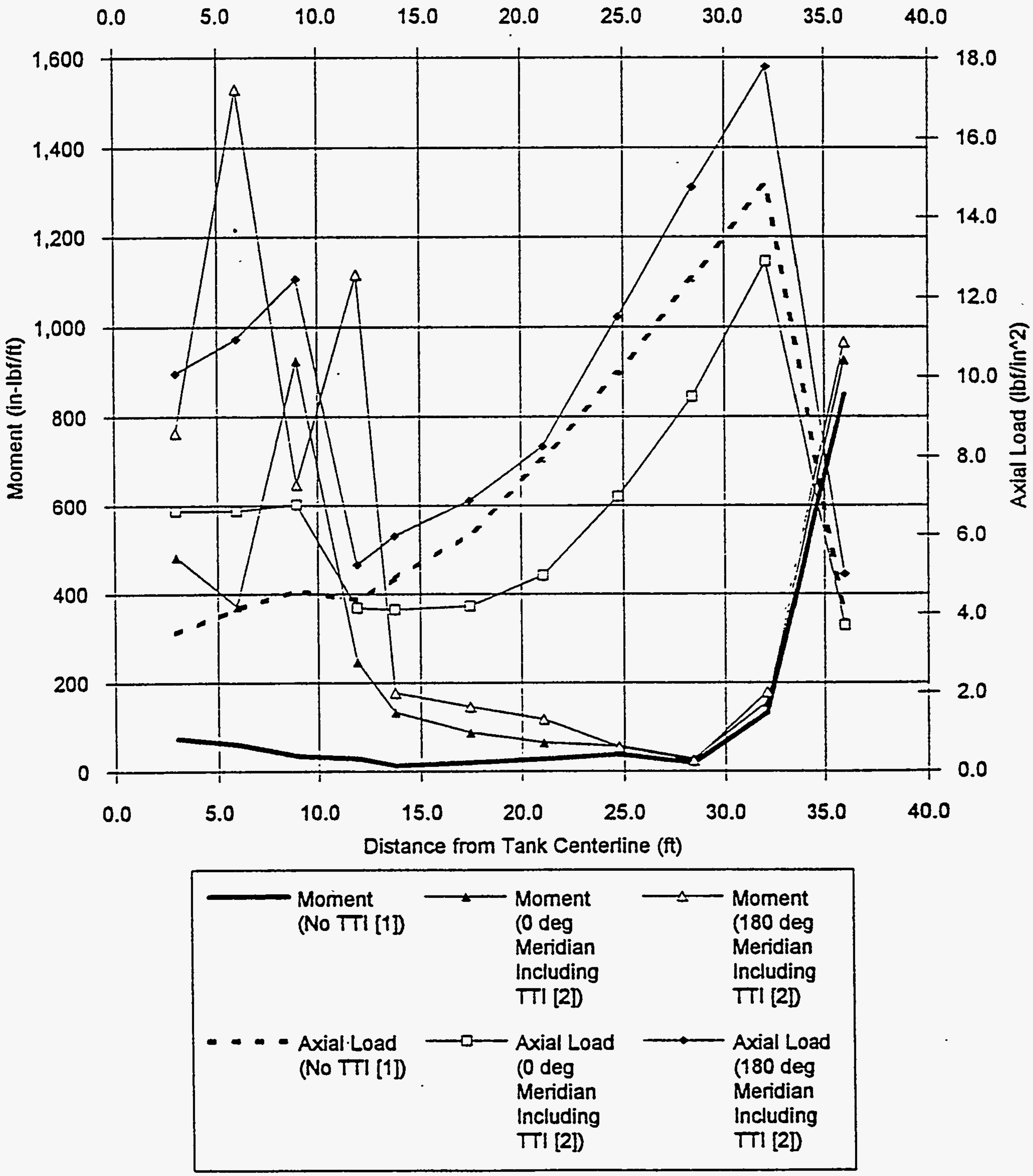
Figure 6.2-34. Meridional Seismic Response of Tank Base at 0°/180° Meridian from Horizontal Excitation Using Best-estimate Soil Properties: Effects of Tank-to-Tank Interaction.



Note: [1] = Run ID "Q7pnt4", [2] = Run ID "Q7TTT".

q7ttt\C2BASEI.XLC

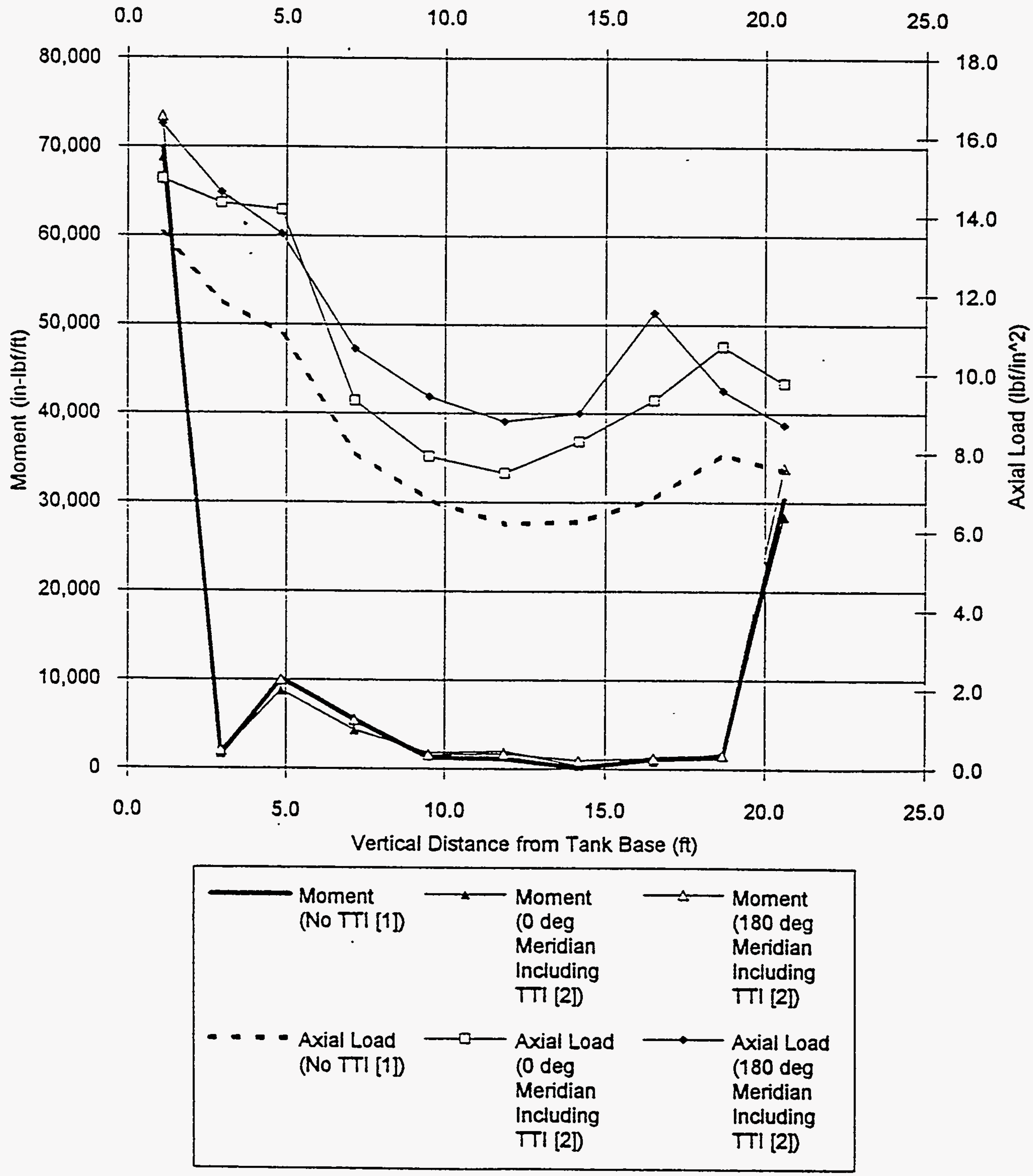
Figure 6.2-35. Circumferential Seismic Response of Tank Base at 0°/180° Meridian from Horizontal Excitation Using Best-estimate Soil Properties: Effects of Tank-to-Tank Interaction.



Note: [1] = Run ID "Q7pnt4", [2] = Run ID "Q7TTT".

q7ttt\C2BASEO.XLC

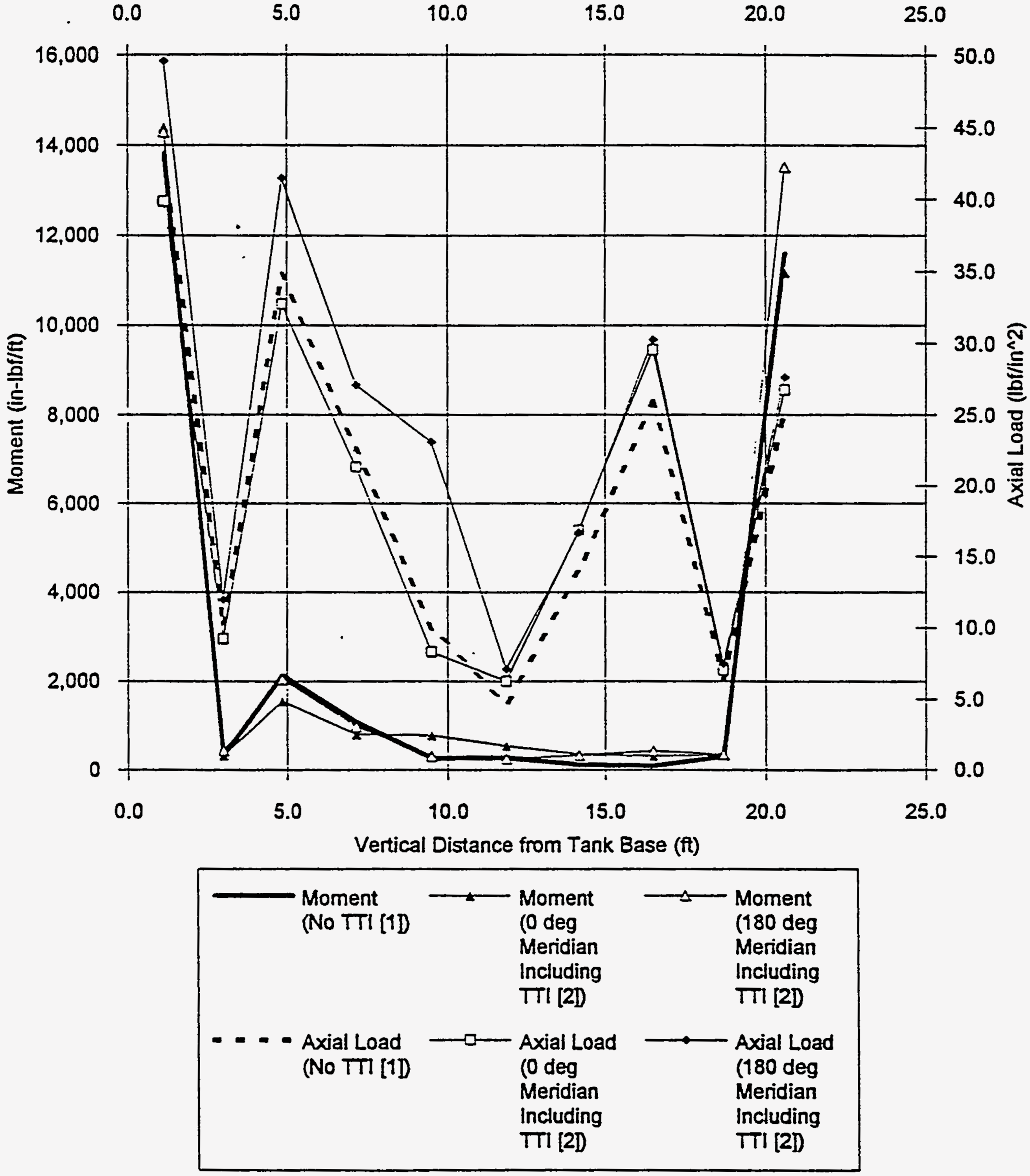
Figure 6.2-36. Meridional Seismic Response of Tank Wall at 0°/180° Meridian from Horizontal Excitation Using Best-estimate Soil Properties: Effects of Tank-to-Tank Interaction.



Note: [1] = Run ID "Q7pnt4", [2] = Run ID "Q7TTT".

q7ttt\C2WALLI.XLC

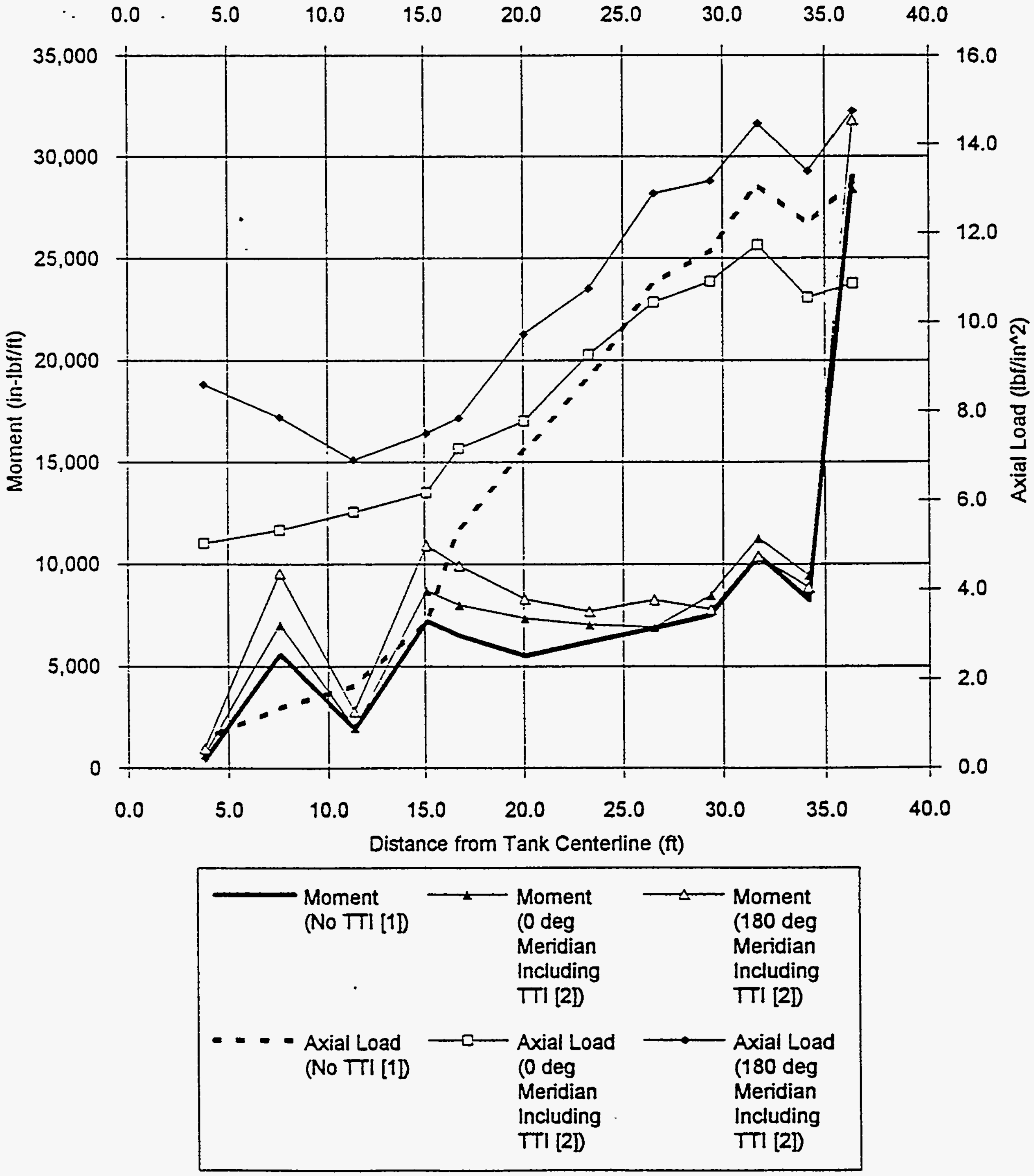
Figure 6.2-37. Circumferential Seismic Response of Tank Wall at 0°/180° Meridian from Horizontal Excitation Using Best-estimate Soil Properties: Effects of Tank-to-Tank Interaction.



Note: [1] = Run ID "Q7pnt4", [2] = Run ID "Q7TTT".

q7ttt\C2WALLO.XLC

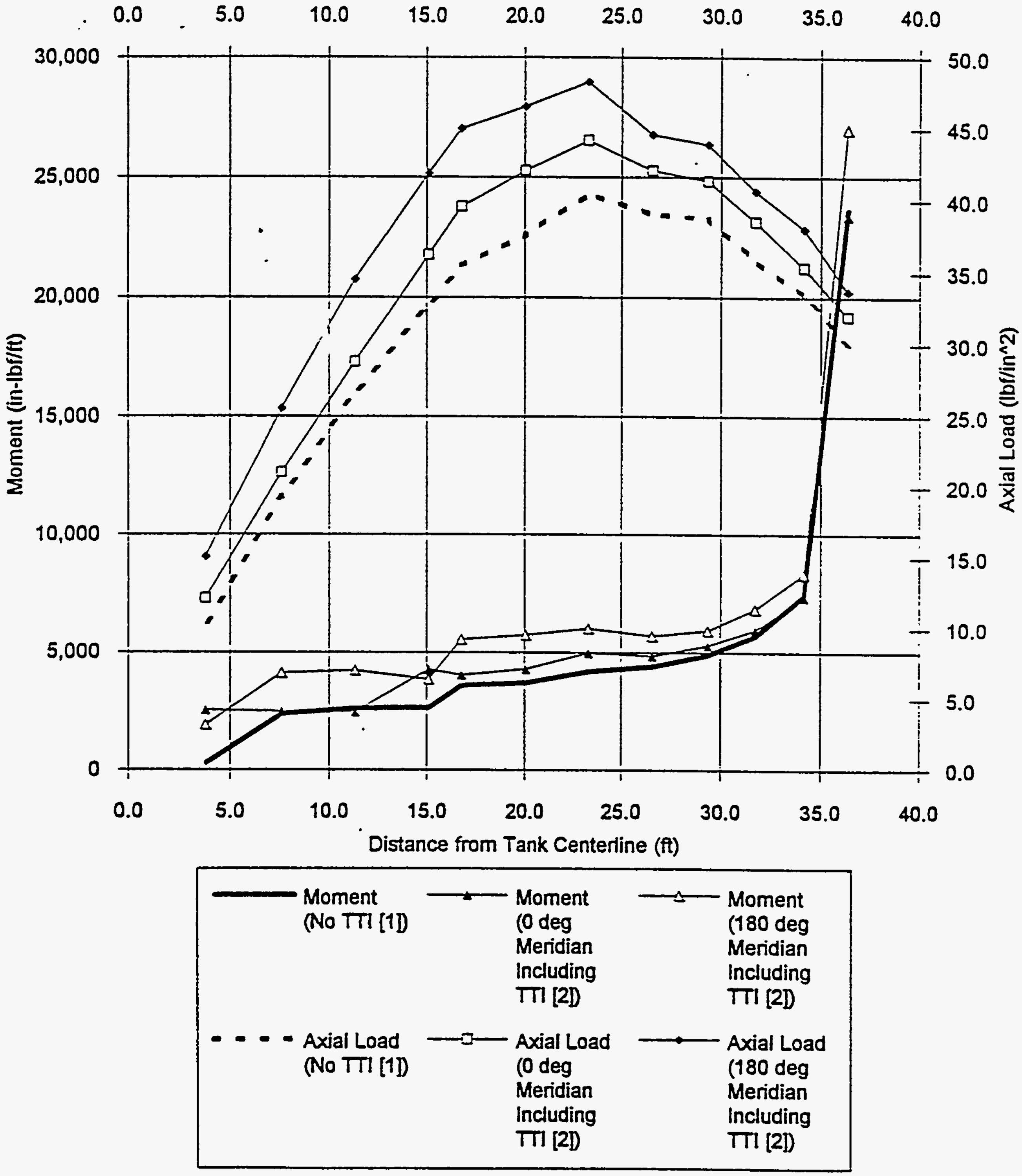
Figure 6.2-38. Meridional Seismic Response of Tank Dome at 0°/180° Meridian from Horizontal Excitation Using Best-estimate Soil Properties: Effects of Tank-to-Tank Interaction.



Note: [1] = Run ID "Q7pnt4", [2] = Run ID "Q7TTT".

q7ttt\C2DOMEI.XLC

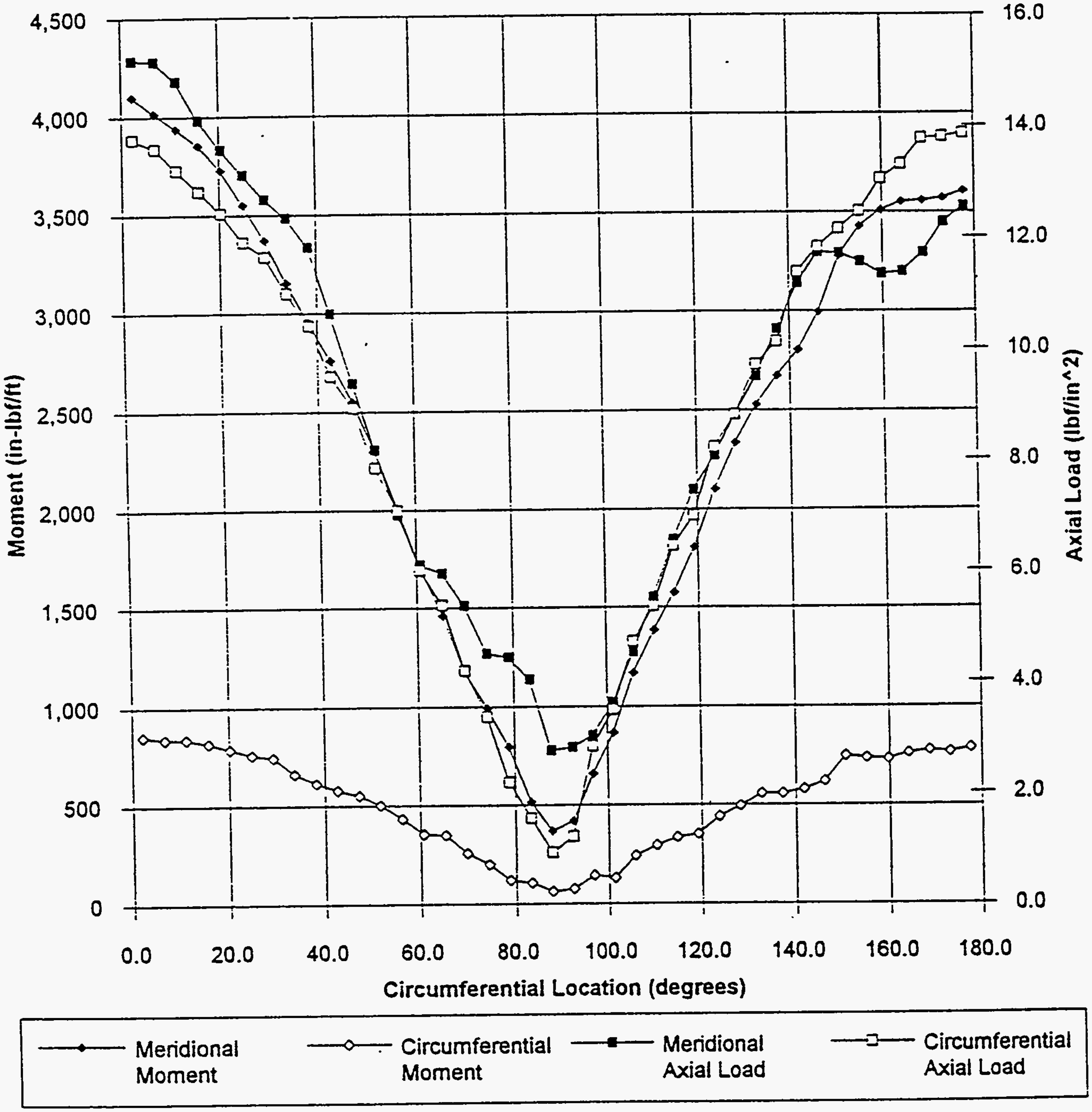
Figure 6.2-39. Circumferential Seismic Response of Tank Dome at 0°/180° Meridian from Horizontal Excitation Using Best-estimate Soil Properties: Effects of Tank-to-Tank Interaction.



Note: [1] = Run ID "Q7pnt4", [2] = Run ID "Q7TTT".

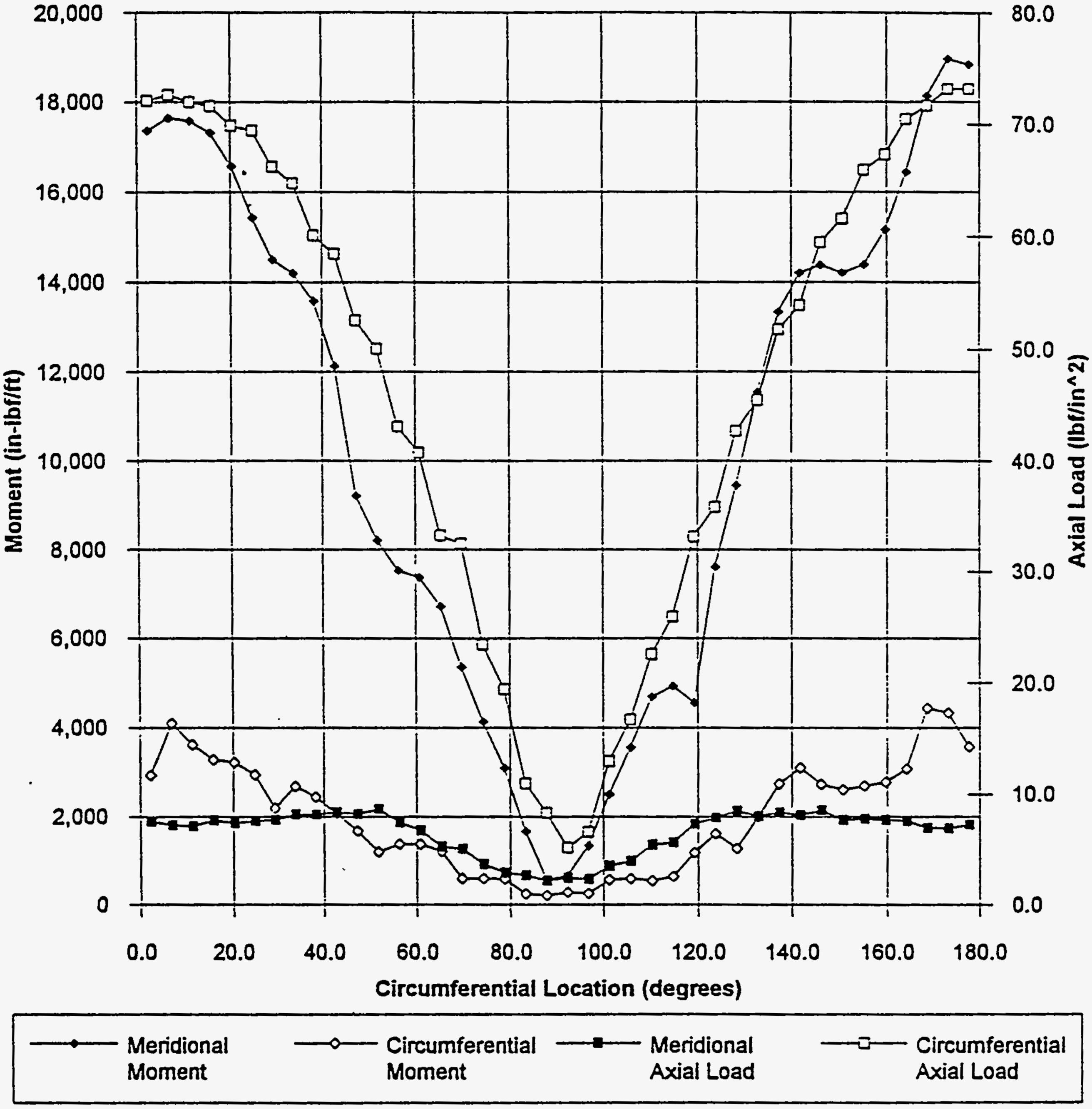
q7ttt\C2DOMEO.XLC

Figure 6.2-40. Circumferential Variation of Seismic Response of Tank Wall Near Haunch from Horizontal Excitation Using Lower-Bound Soil Properties and Including Tank-to-Tank Interaction (Run ID "TTTLOW").



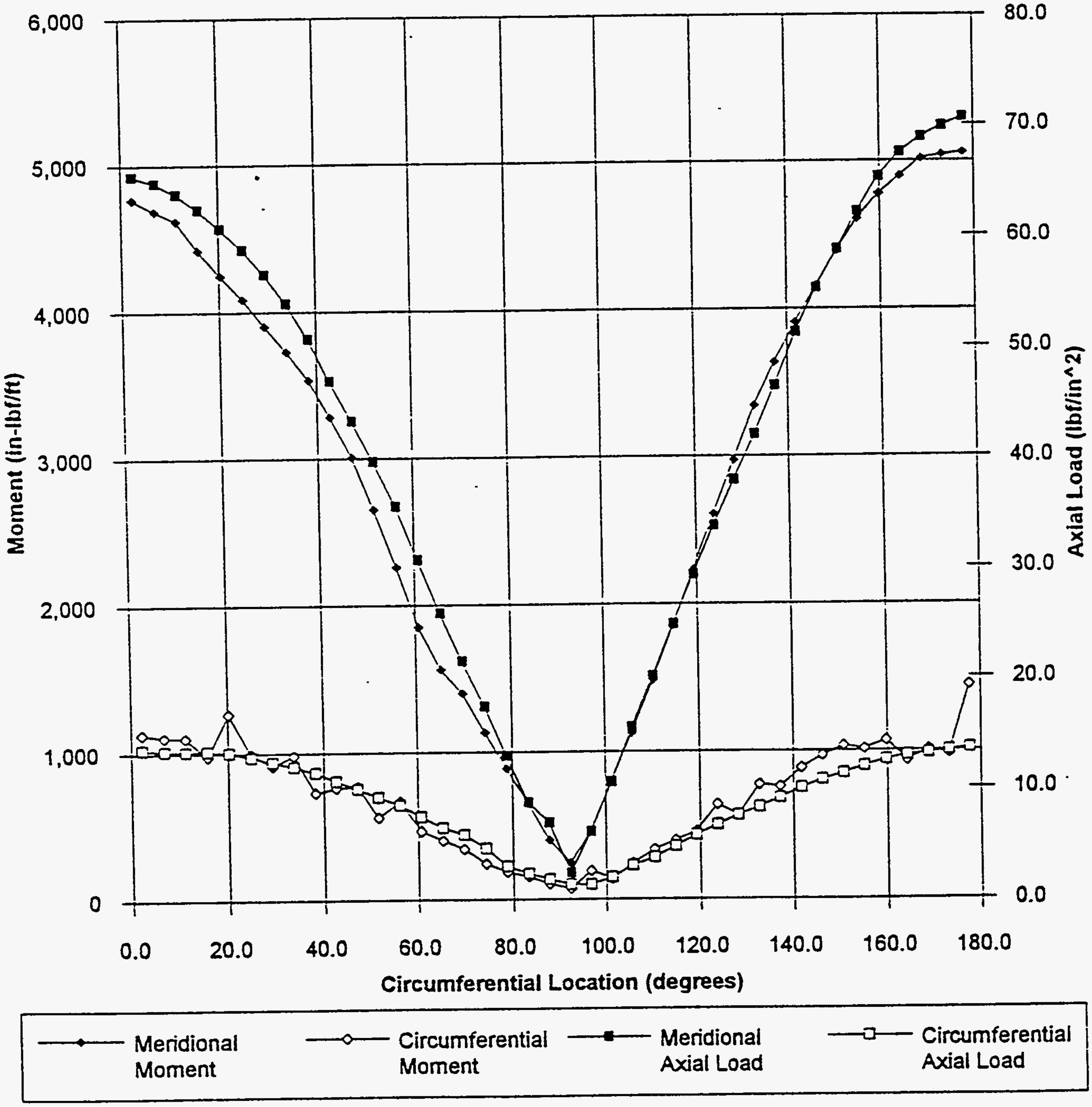
tttlow\STRESS1.XLC

Figure 6.2-41. Circumferential Variation of Seismic Response of Tank Wall Near Knuckle from Horizontal Excitation Using Lower-Bound Soil Properties and Including Tank-to-Tank Interaction (Run ID "TTTLOW").



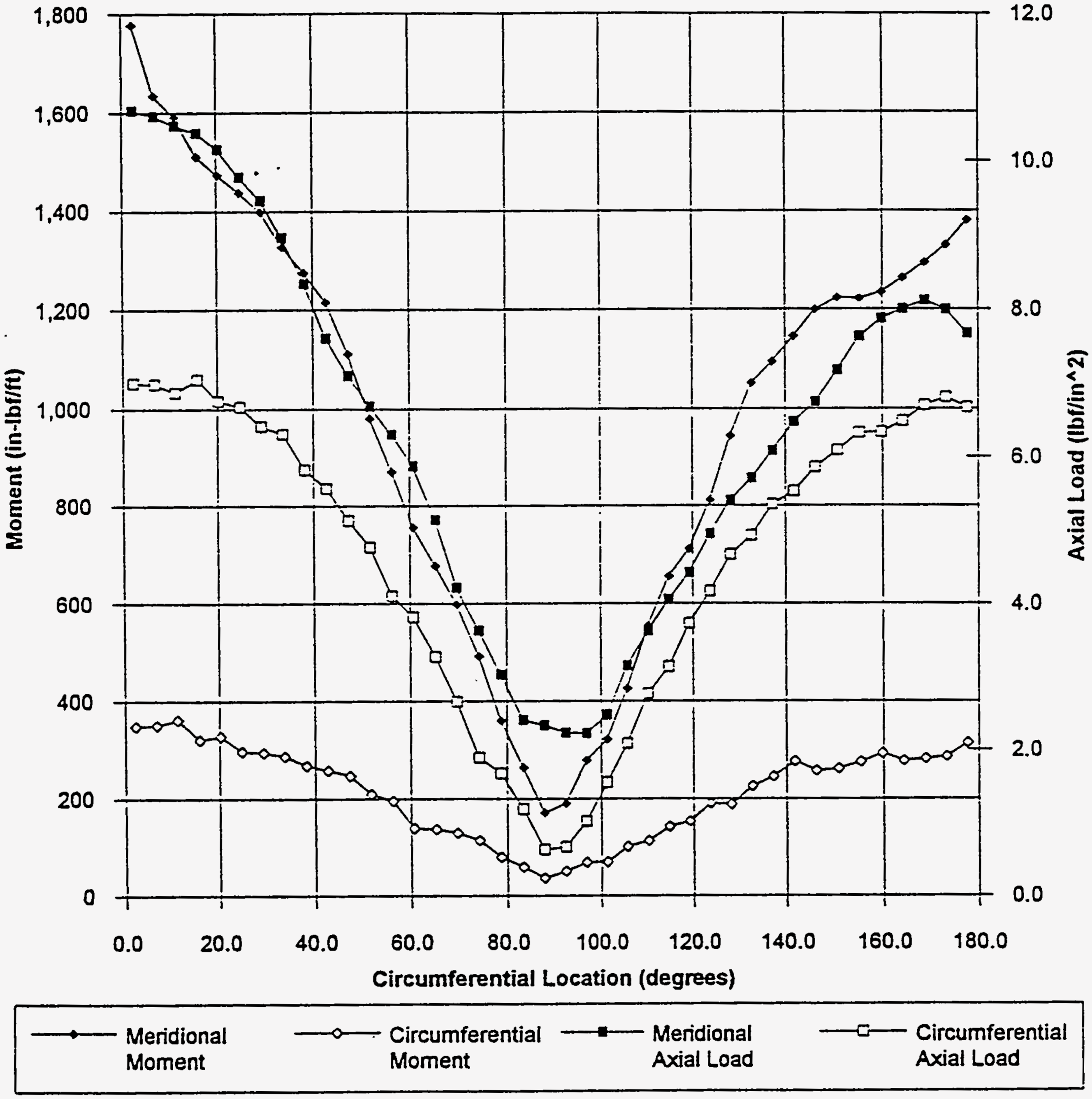
tttlow\STRESS2.XLC

Figure 6.2-42. Circumferential Variation of Seismic Response of Tank Base Near Knuckle from Horizontal Excitation Using Lower-Bound Soil Properties and Including Tank-to-Tank Interaction (Run ID "TTTLOW").



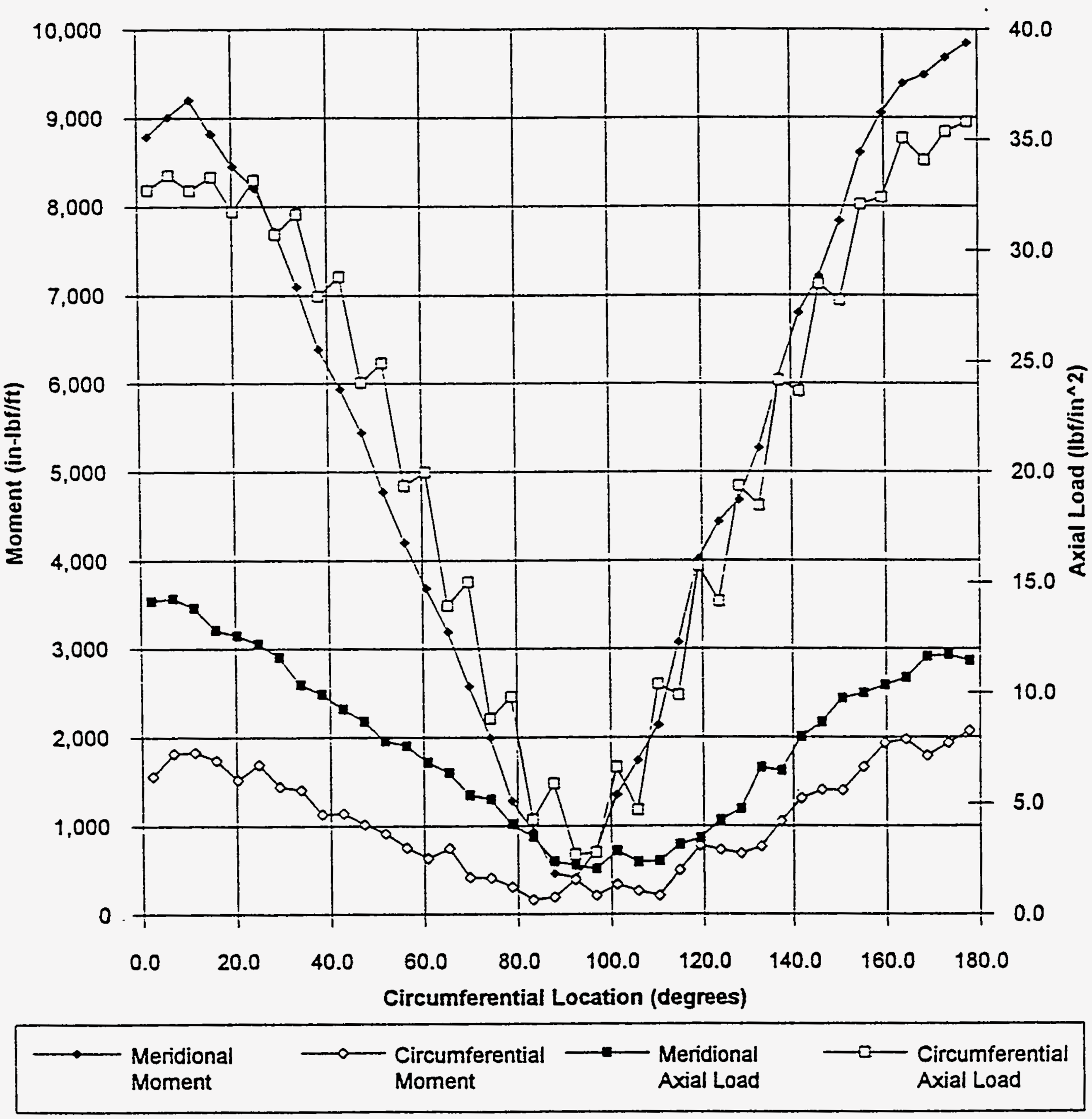
tttlow\STRESS3.XLC

Figure 6.2-43. Circumferential Variation of Seismic Response of Tank Wall Near Haunch from Horizontal Excitation Using Best-estimate Soil Properties and Including Tank-to-Tank Interaction (Run ID "Q7TTT").



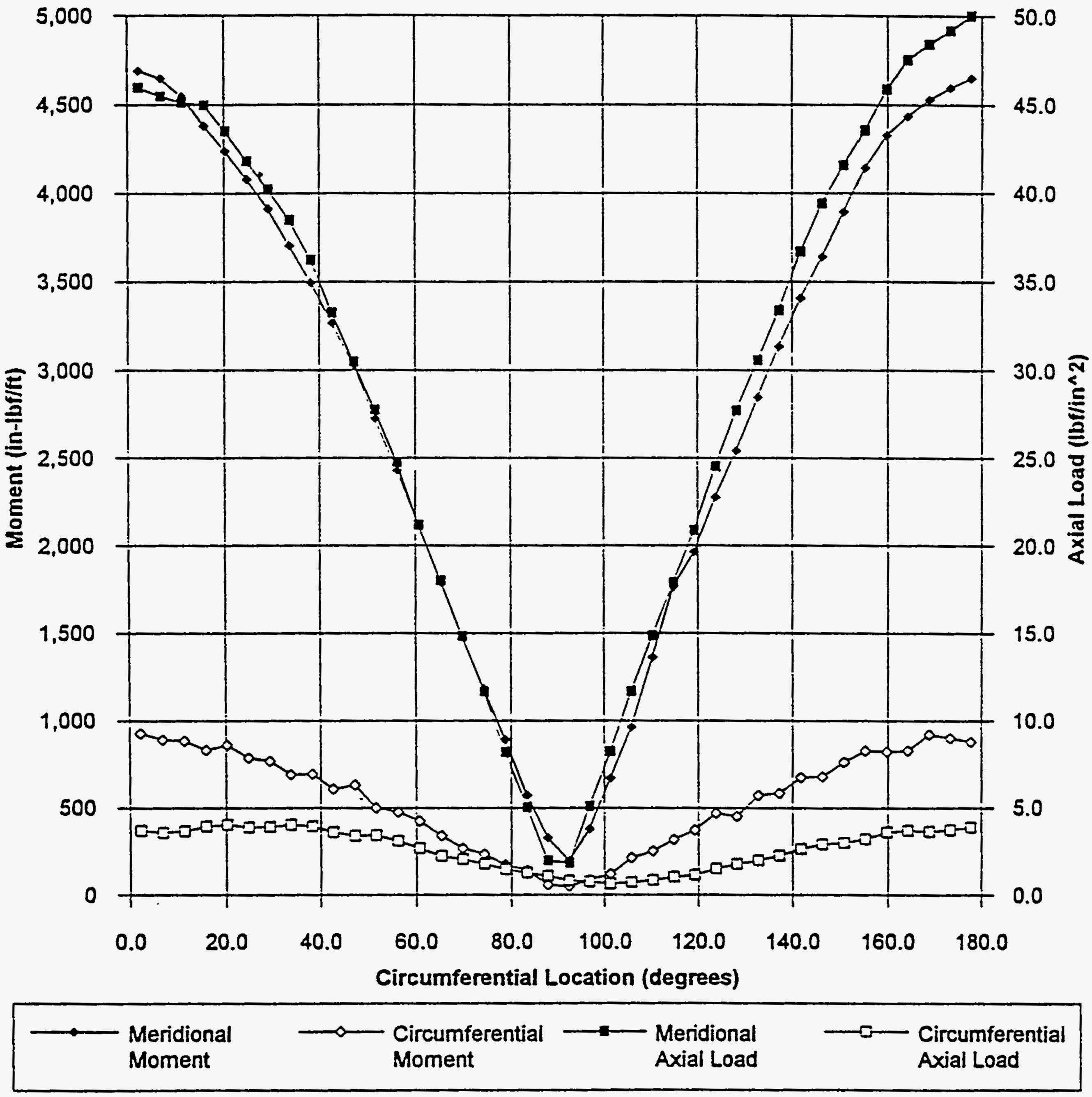
q7ttt\STRESS1.XLC

Figure 6.2-44. Circumferential Variation of Seismic Response of Tank Wall Near Knuckle from Horizontal Excitation Using Best-estimate Soil Properties and Including Tank-to-Tank Interaction (Run ID "Q7TTT").



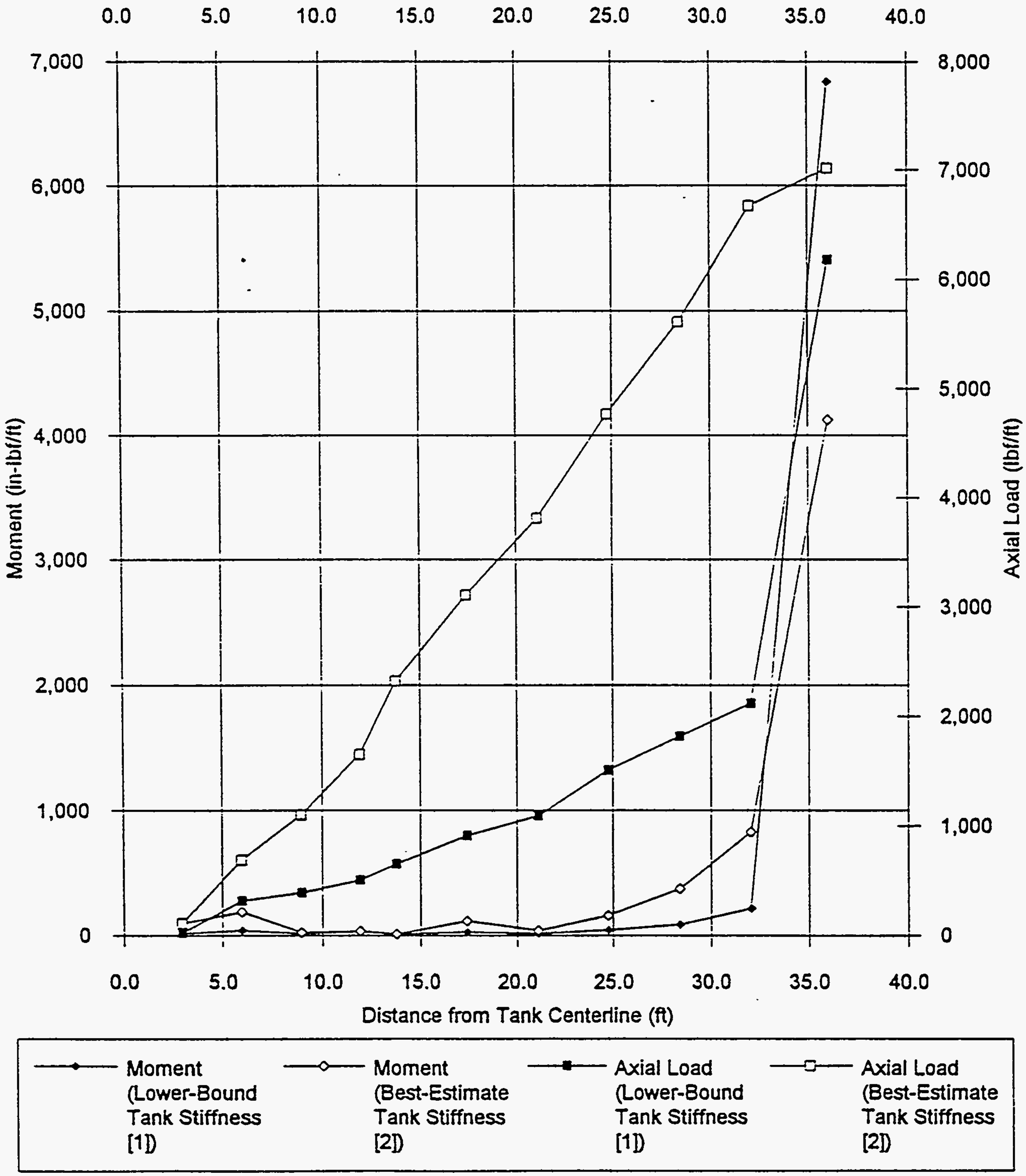
q7ttt\STRESS2.XLC

Figure 6.2-45. Circumferential Variation of Seismic Response of Tank Base Near Knuckle from Horizontal Excitation Using Best-estimate Soil Properties and Including Tank-to-Tank Interaction (Run ID "Q7TTT").



q7ttt\STRESS3.XLC

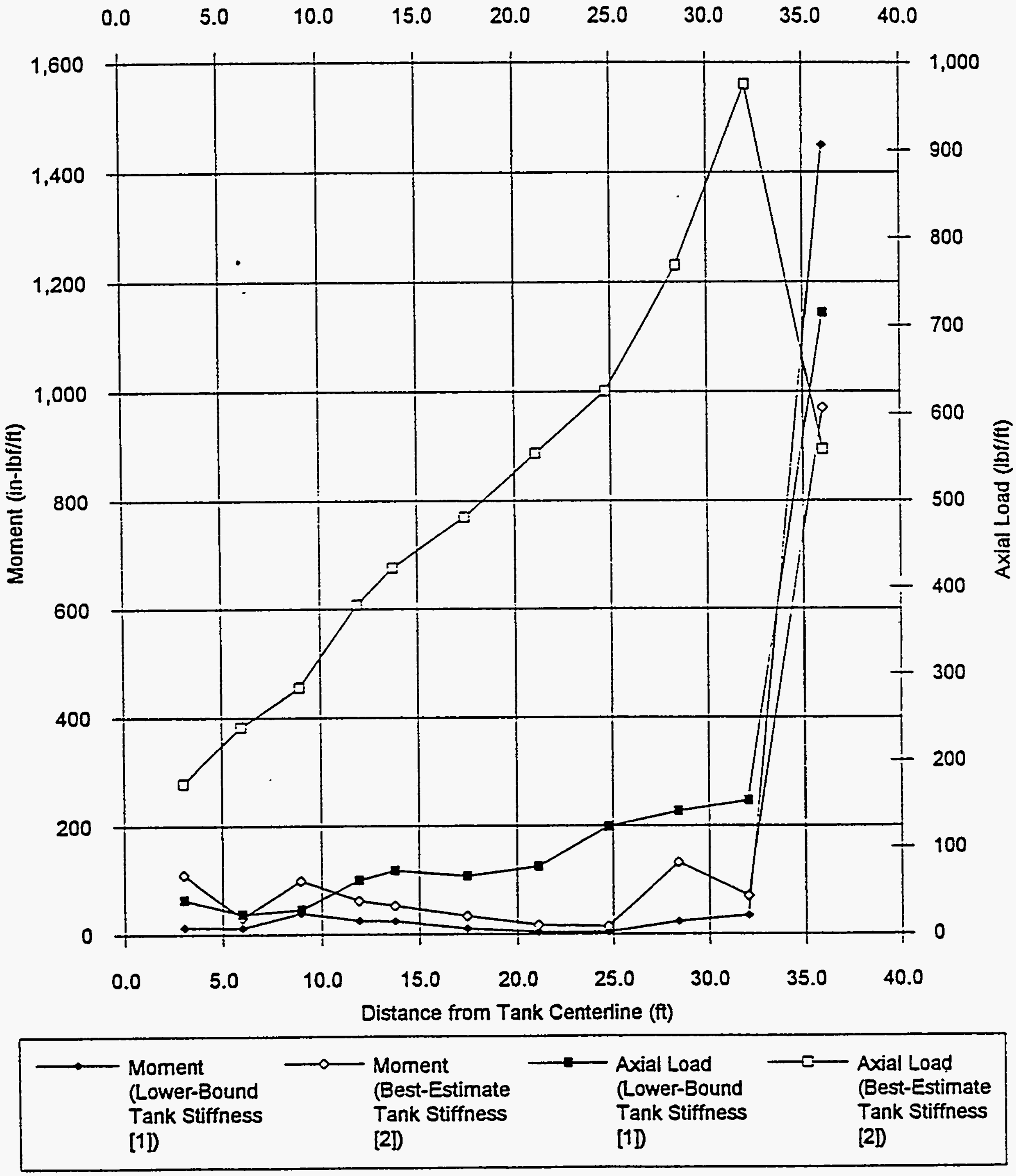
Figure 6.2-46. Meridional Seismic Response of Tank Base at 180° Meridian from Horizontal Excitation Using Best-estimate Soil Properties: Effects of Tank Stiffness.



Note: [1] = Run ID "Q9", [2] = Run ID "Q8".

q9\CBASEI.XLC

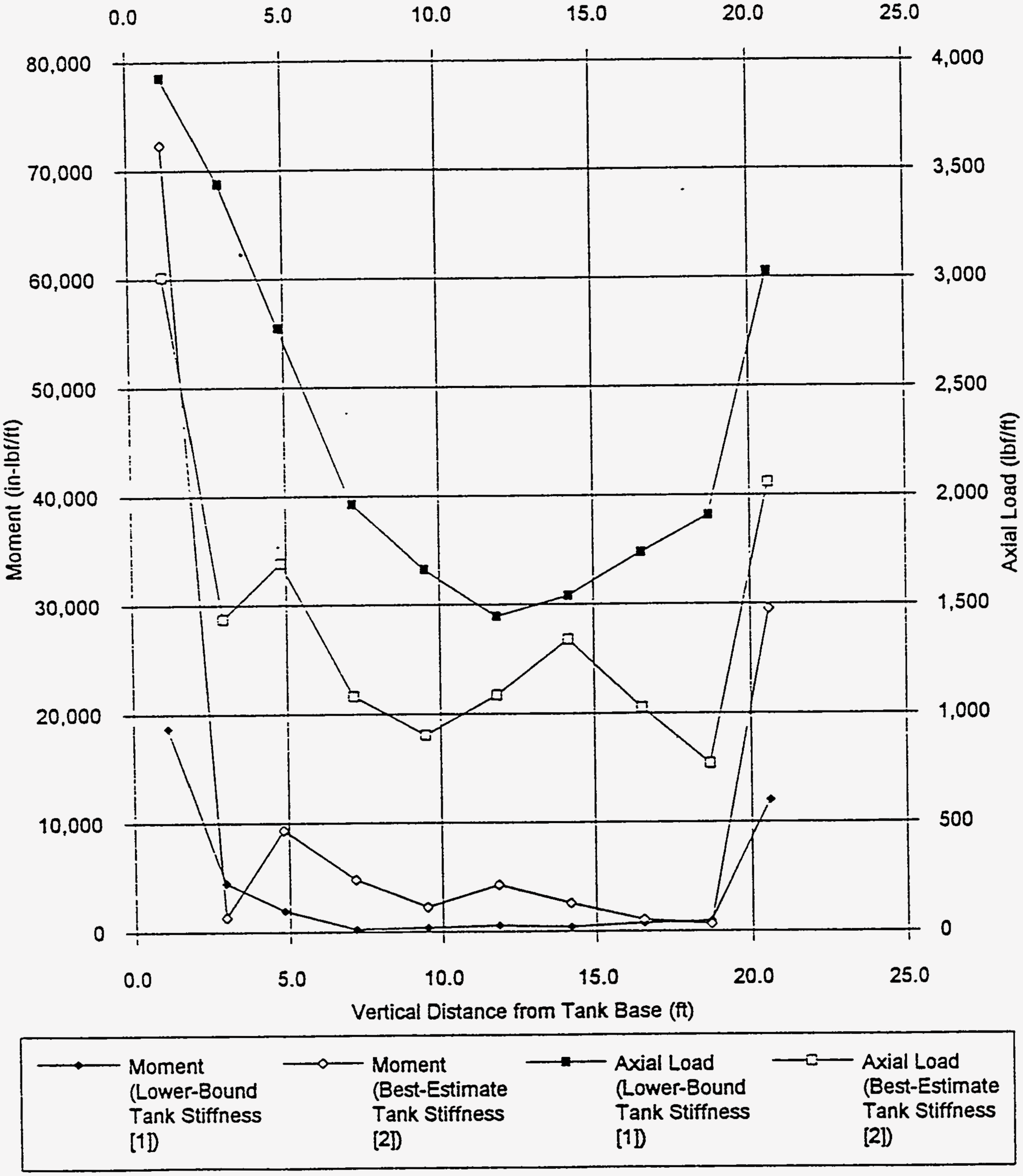
Figure 6.2-47. Circumferential Seismic Response of Tank Base at 180° Meridian from Horizontal Excitation Using Best-estimate Soil Properties: Effects of Tank Stiffness.



Note: [1] = Run ID "Q9", [2] = Run ID "Q8".

q9\CBASEO.XLC

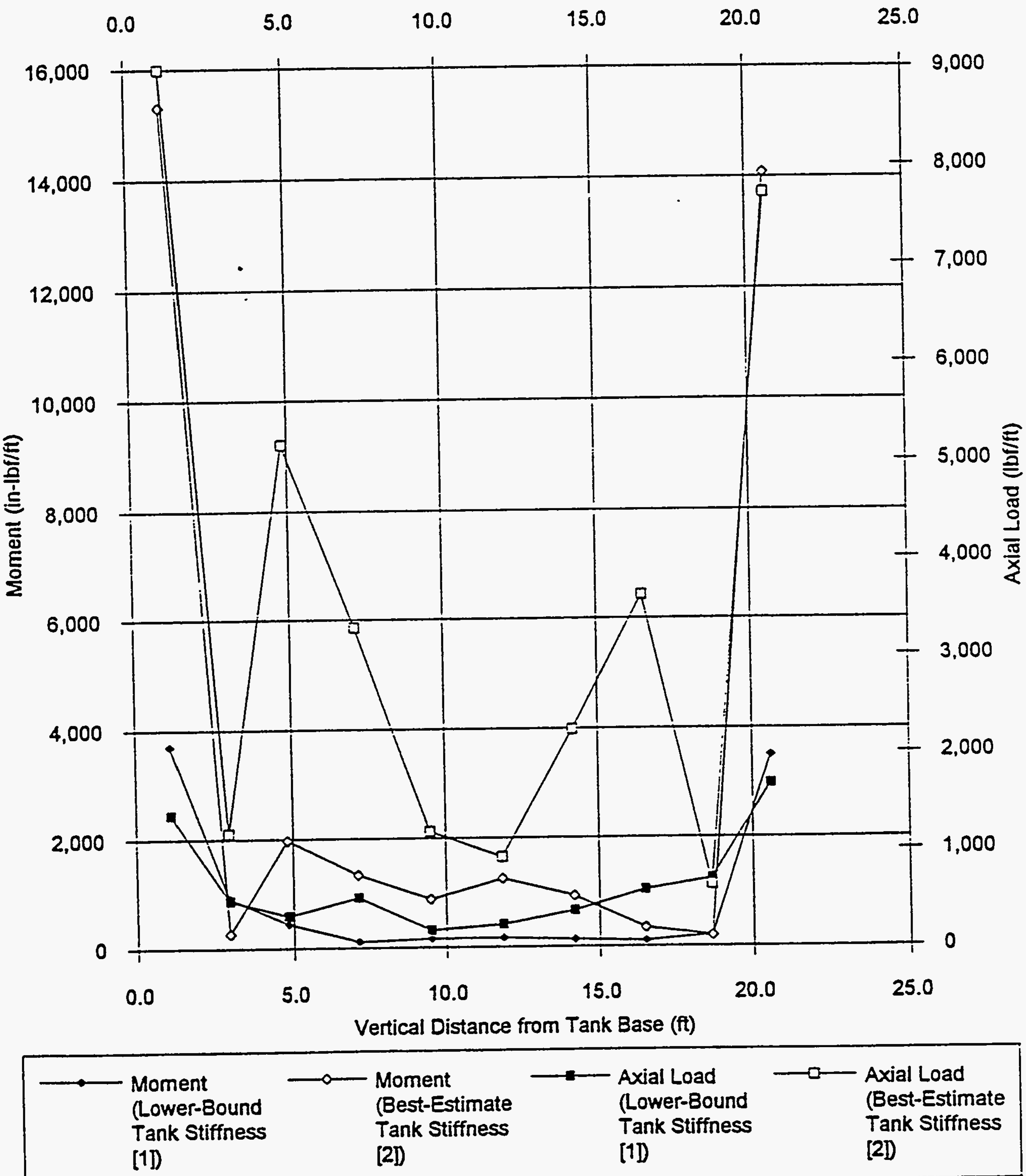
Figure 6.2-48. Meridional Seismic Response of Tank Wall at 180° Meridian from Horizontal Excitation Using Best-estimate Soil Properties: Effects of Tank Stiffness.



Note: [1] = Run ID "Q9", [2] = Run ID "Q8".

q9\CWALLI.XLC

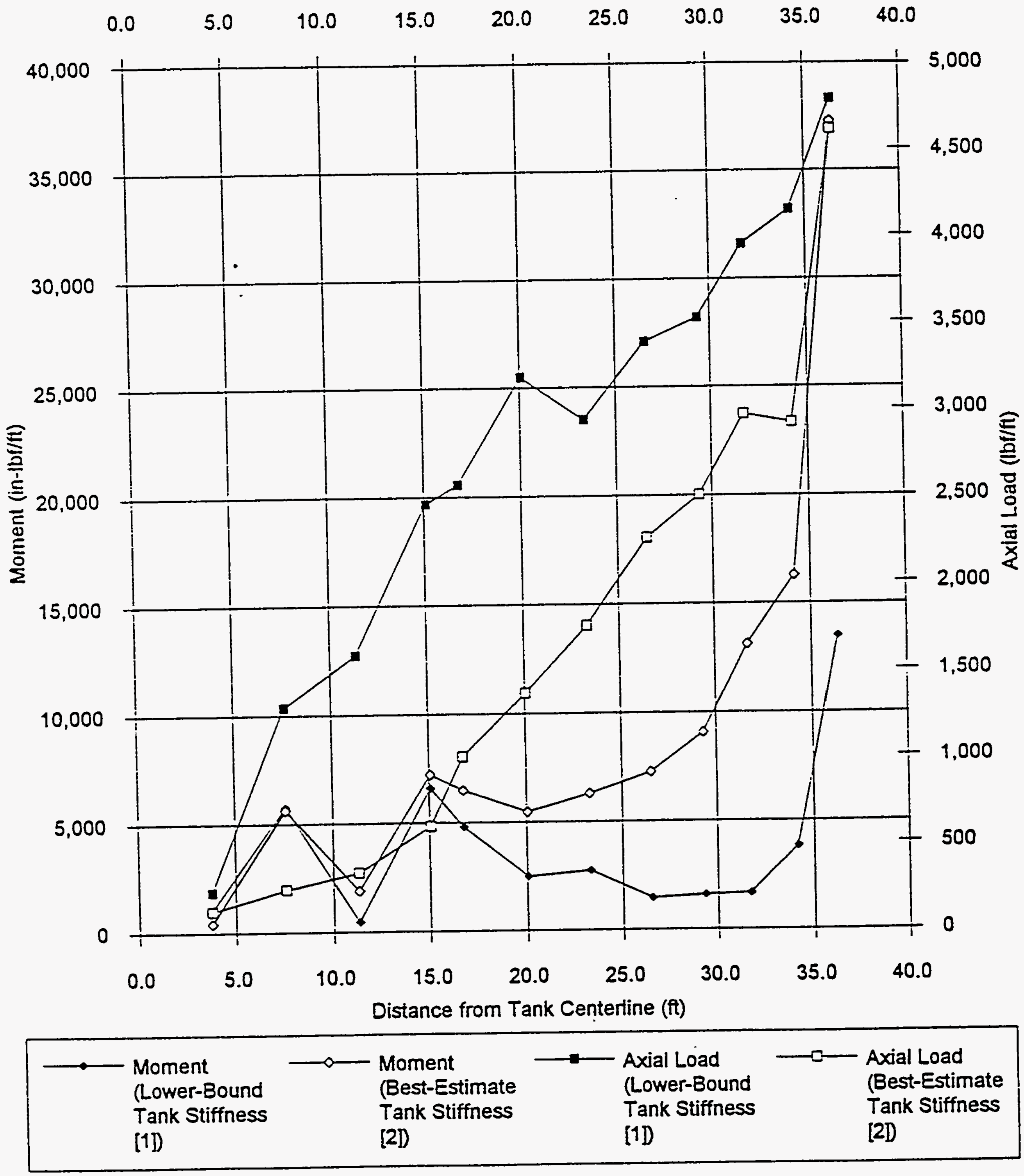
Figure 6.2-49. Circumferential Seismic Response of Tank Wall at 180° Meridian from Horizontal Excitation Using Best-estimate Soil Properties: Effects of Tank Stiffness.



Note: [1] = Run ID "Q9", [2] = Run ID "Q8".

q9\CWALLO.XLC

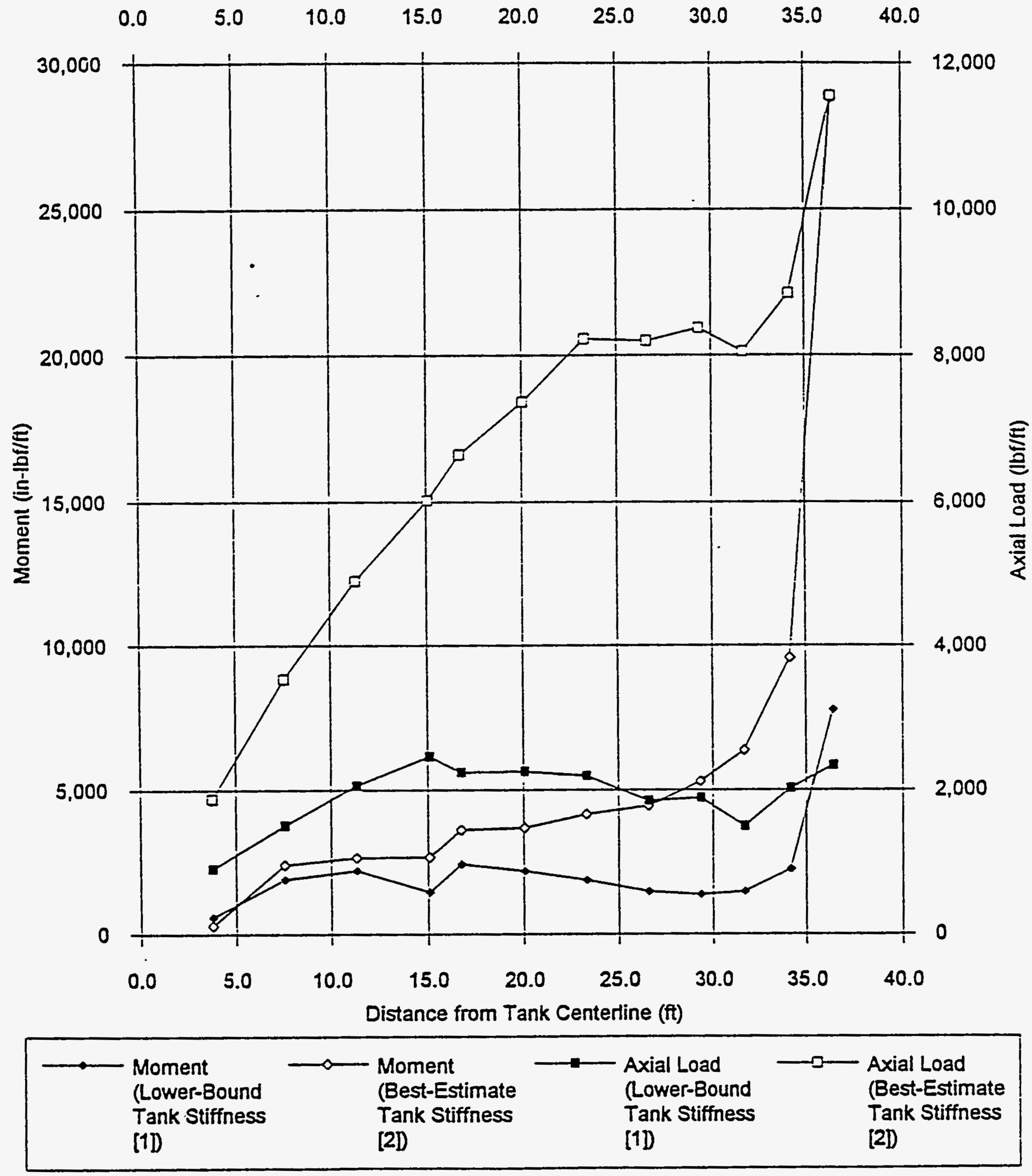
Figure 6.2-50. Meridional Seismic Response of Tank Dome at 180° Meridian from Horizontal Excitation Using Best-estimate Soil Properties: Effects of Tank Stiffness.



Note: [1] = Run ID "Q9", [2] = Run ID "Q8".

q9\CDOMEI.XLC

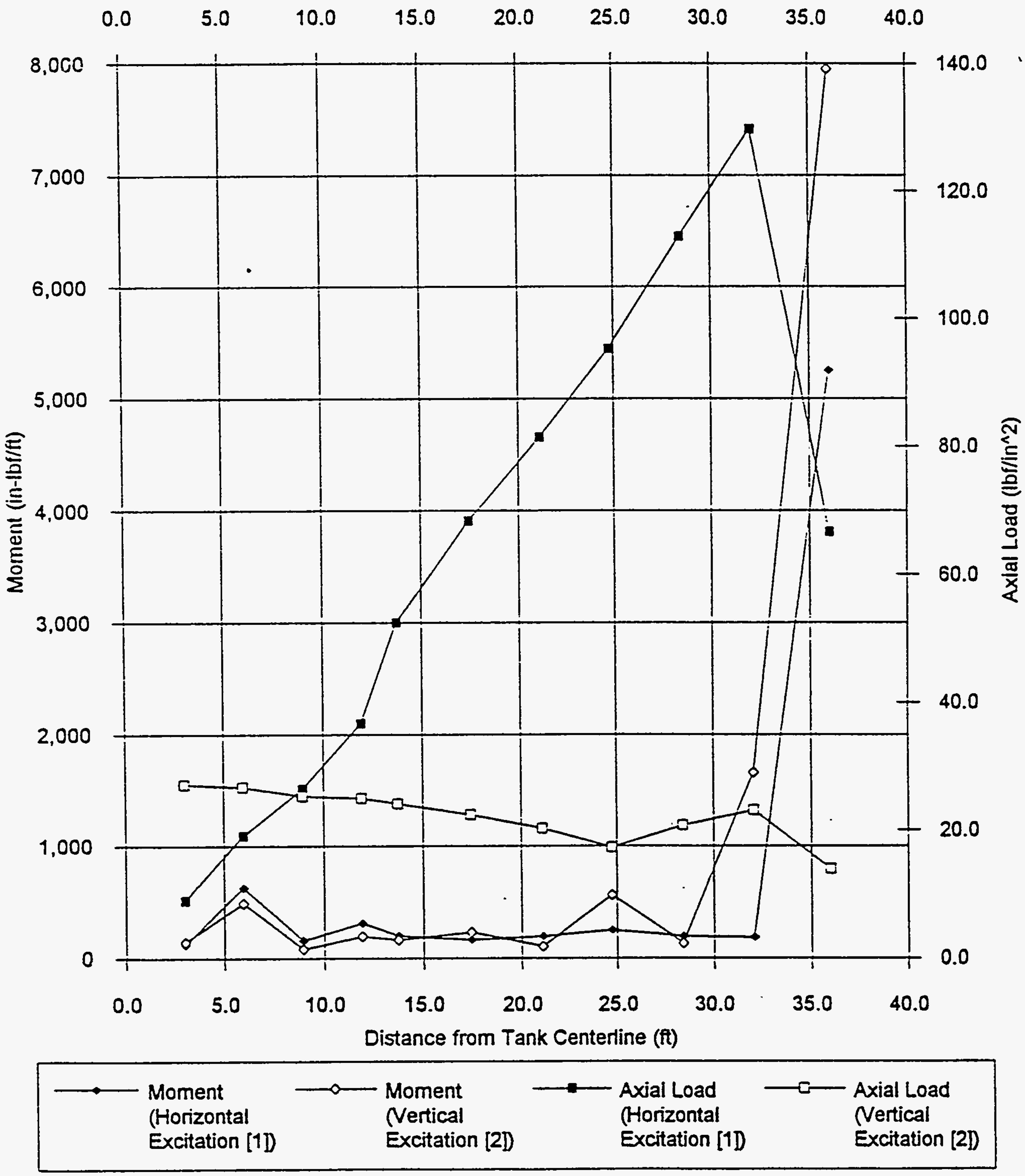
Figure 6.2-51. Circumferential Seismic Response of Tank Dome at 180° Meridian from Horizontal Excitation Using Best-estimate Soil Properties: Effects of Tank Stiffness.



Note: [1] = Run ID "Q9", [2] = Run ID "Q8".

q9\CDOMEO.XLC

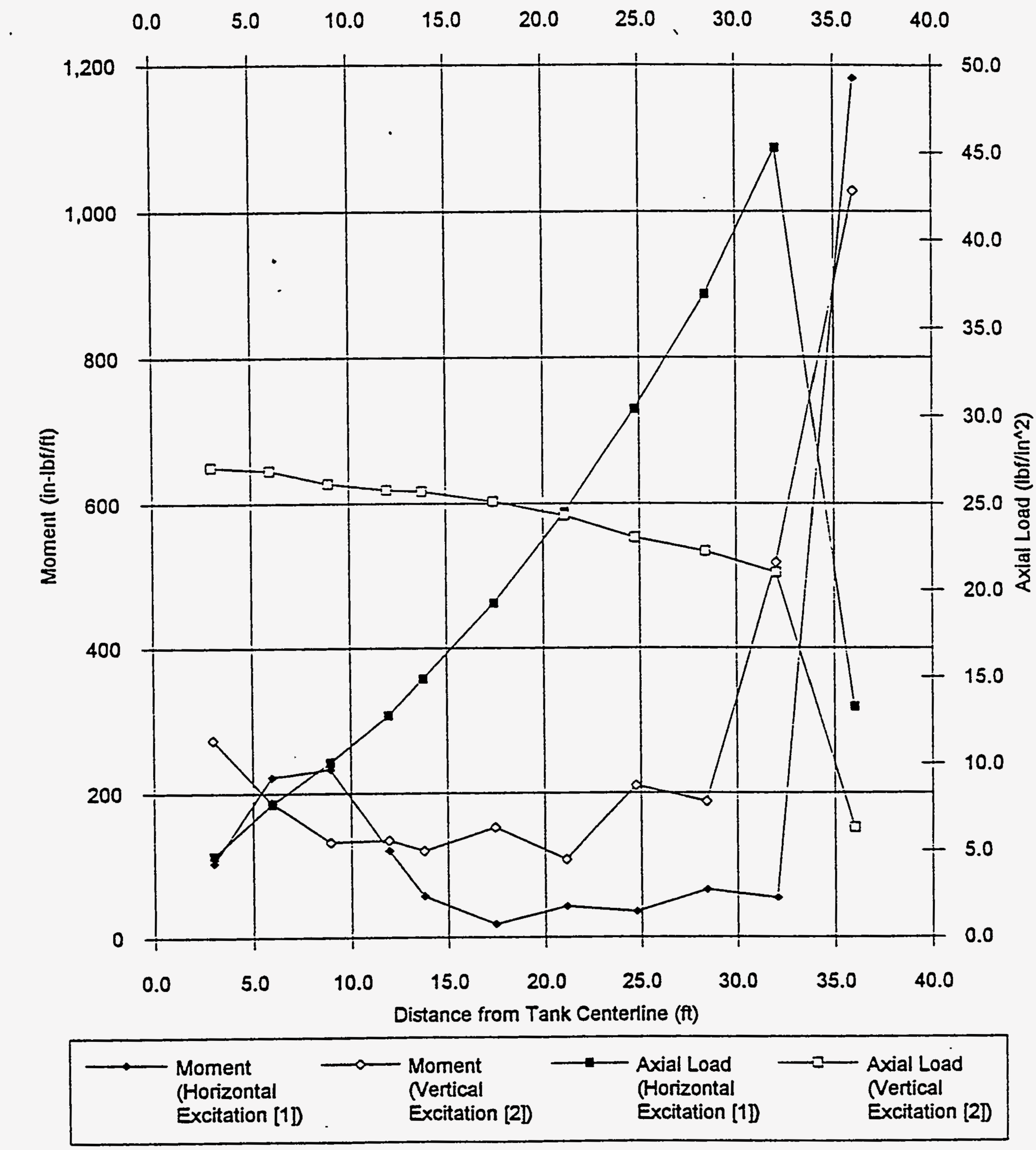
Figure 6.2-52. Meridional Seismic Response of Tank Base at 180° Meridian Using Lower-Bound Soil Properties: Effects of Excitation Direction.



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = Run ID "QLOWVLIV".

qlow-v\h-vs-v\CBASEI.XLC

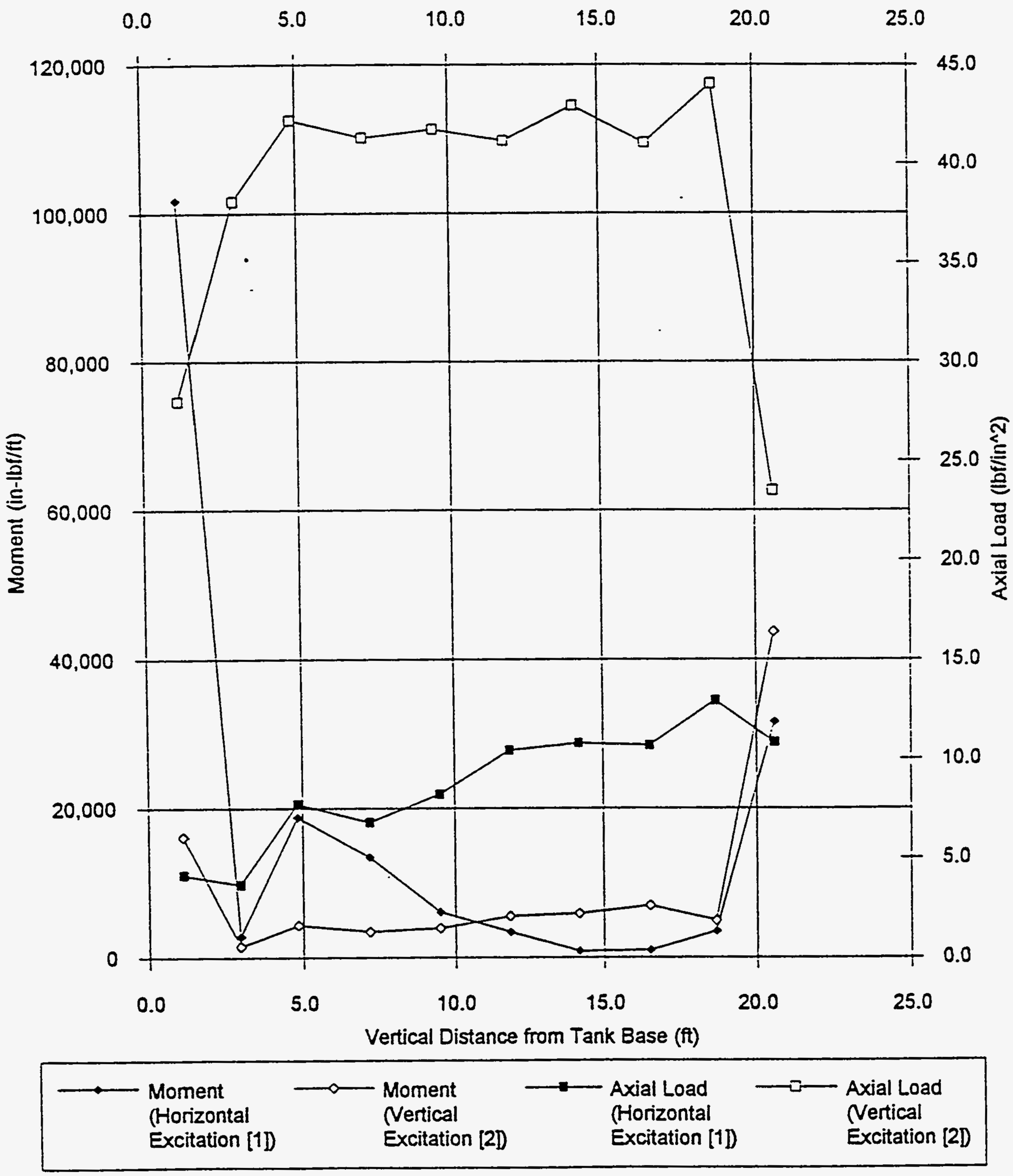
Figure 6.2-53. Circumferential Seismic Response of Tank Base at 180° Meridian Using Lower-Bound Soil Properties: Effects of Excitation Direction.



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = Run ID "QLOWVLIV".

qlow-v\h-vs-v\CBASEO.XLC

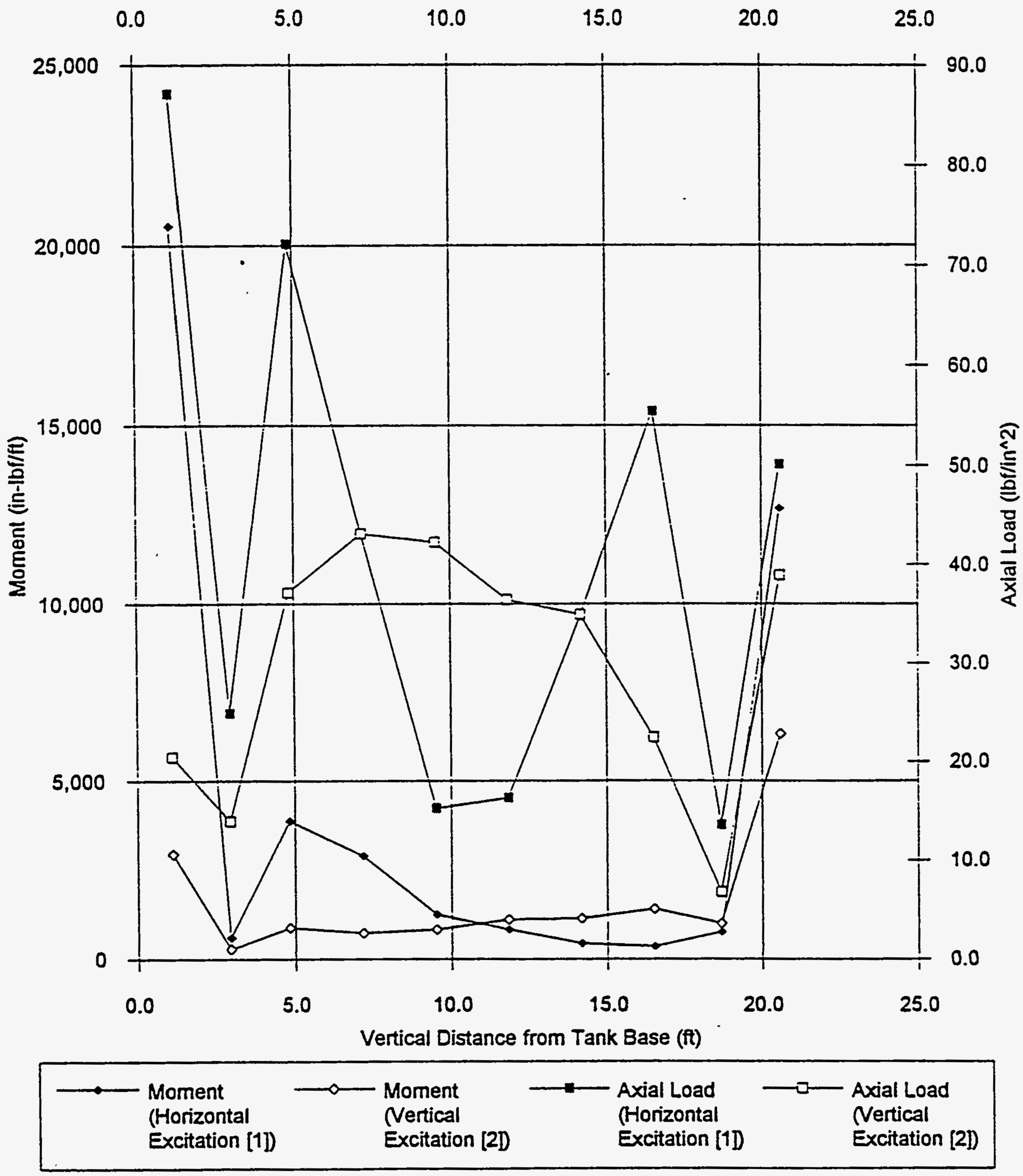
Figure 6.2-54. Meridional Seismic Response of Tank Wall at 180° Meridian Using Lower-Bound Soil Properties: Effects of Excitation Direction.



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = Run ID "QLOWVLIV".

qlow-v\h-vs-v\CWALLI.XLC

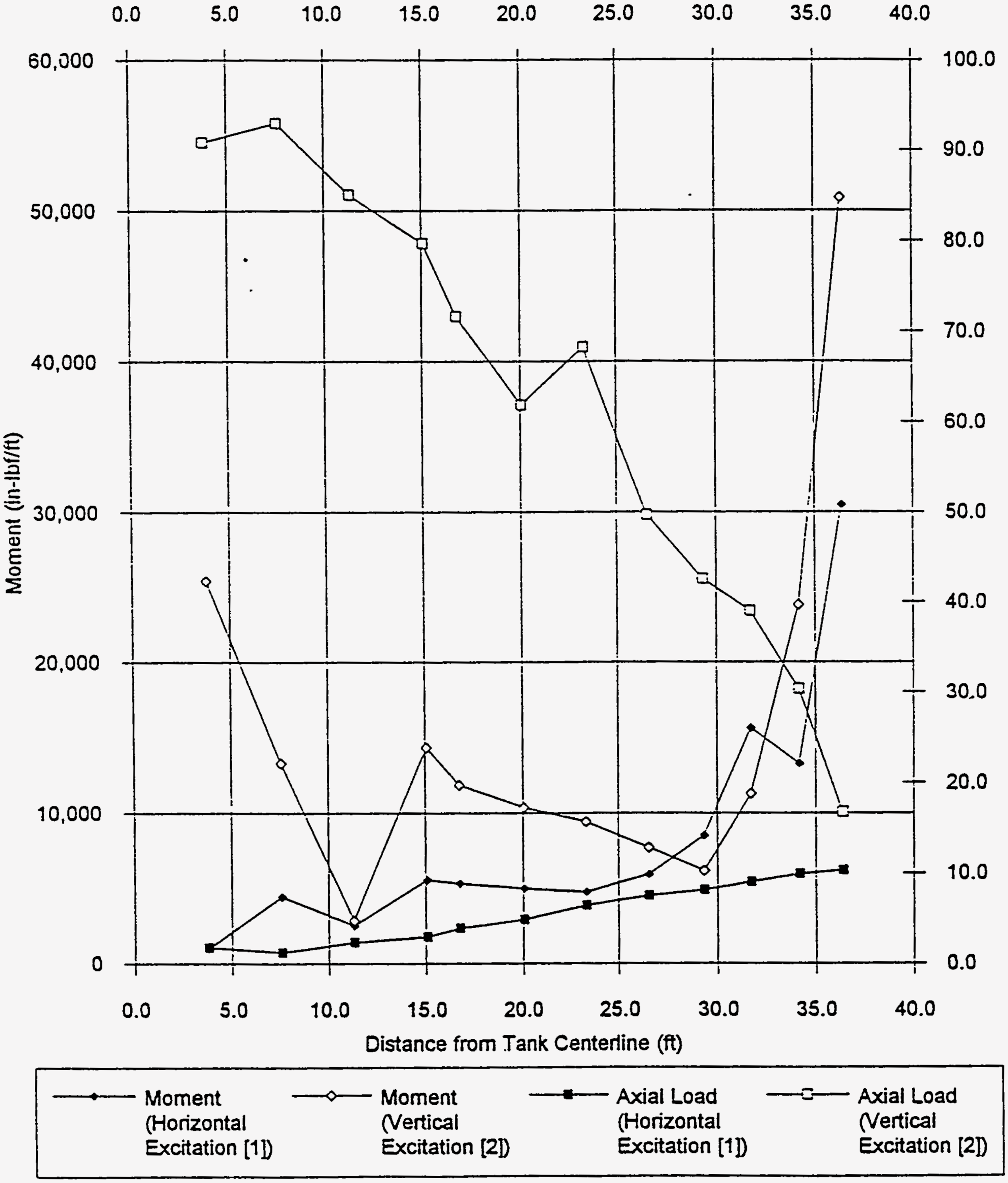
Figure 6.2-55. Circumferential Seismic Response of Tank Wall at 180° Meridian Using Lower-Bound Soil Properties: Effects of Excitation Direction.



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = Run ID "QLOWVLIV".

qlow-v\h-vs-v\CWALLO.XLC

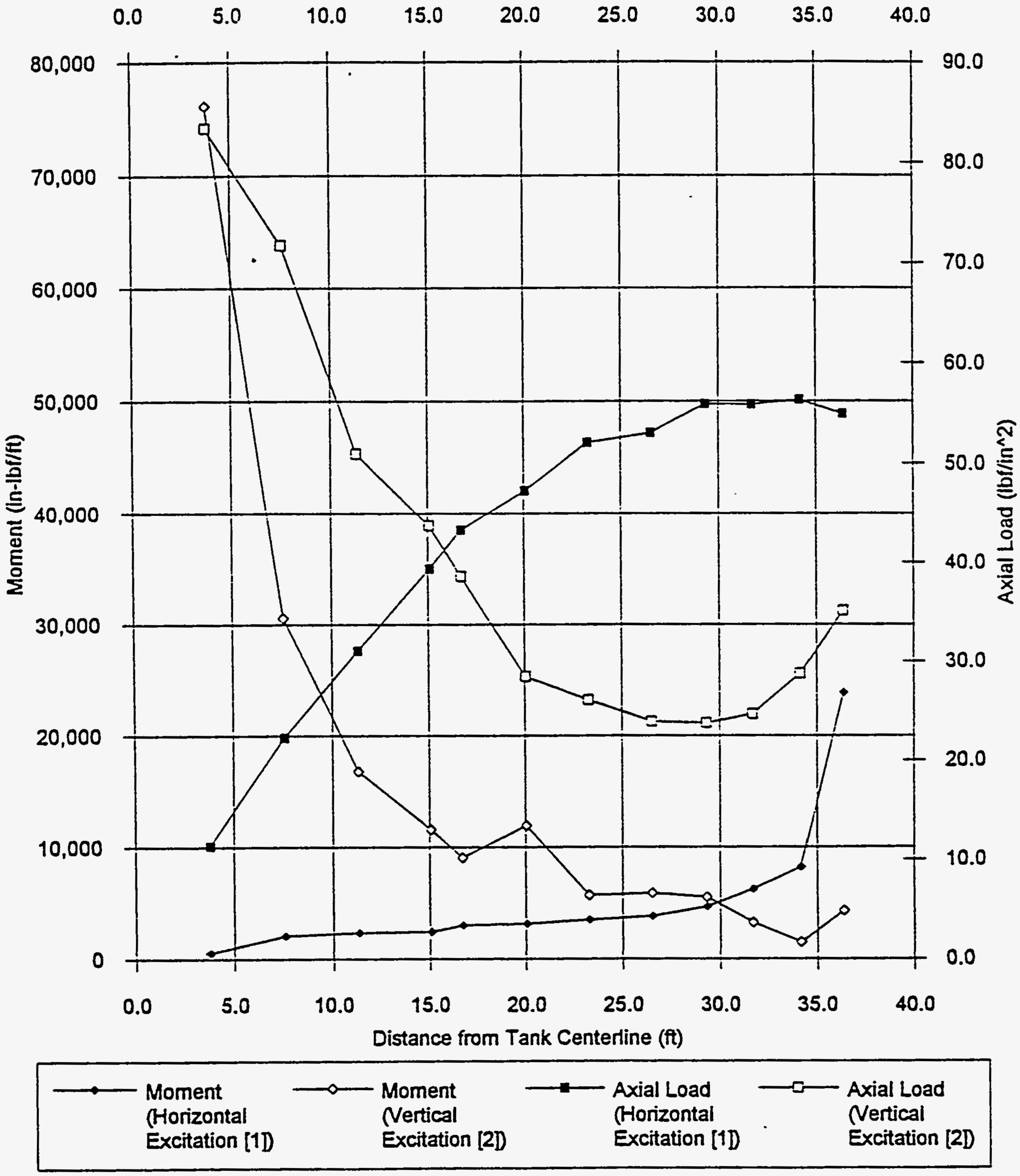
Figure 6.2-56. Meridional Seismic Response of Tank Dome at 180° Meridian Using Lower-Bound Soil Properties: Effects of Excitation Direction.



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = Run ID "QLOWVLIV".

qlow-v\h-vs-v\CDOMEI.XLC

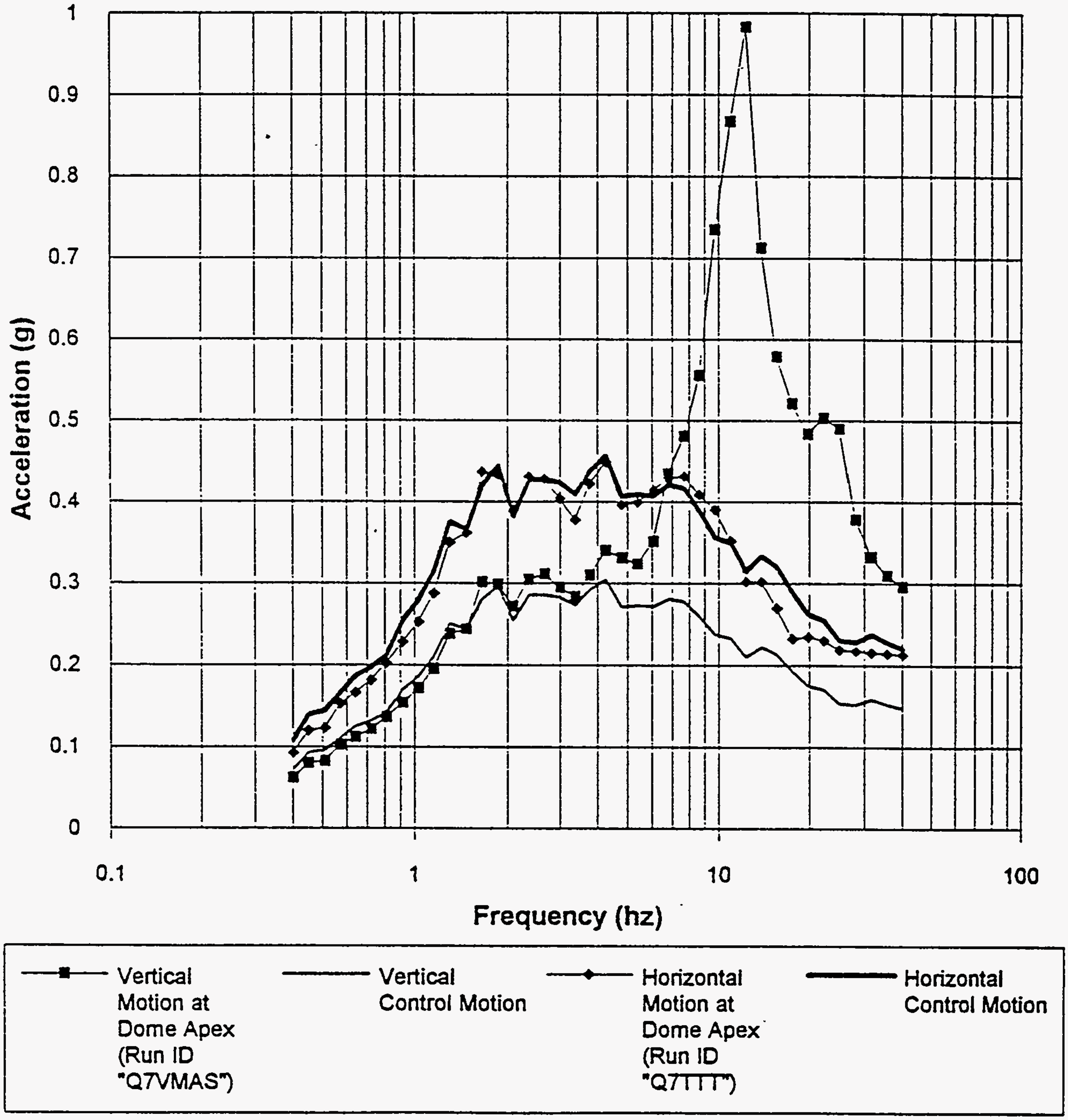
Figure 6.2-57. Circumferential Seismic Response of Tank Dome at 180° Meridian Using Lower-Bound Soil Properties: Effects of Excitation Direction.



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = Run ID "QLOWVLIV".

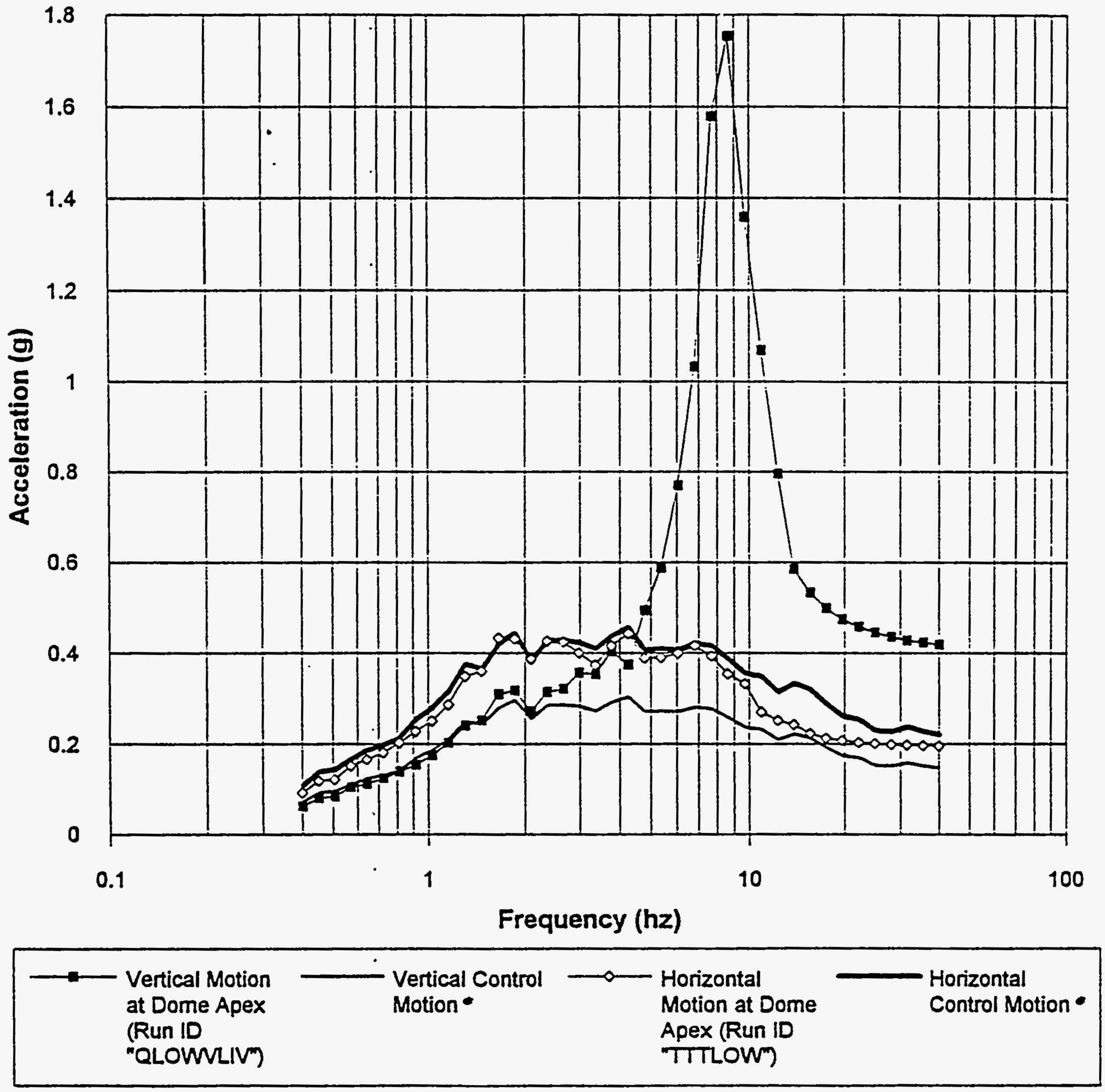
qlow-v\h-vs-v\CDOMEO.XLC

Figure 6.2-58. Response Spectra (0.2 *g* Earthquake/7% Damping/ Best-Estimate Soil Properties.



q7v\anl\RESPBE.XLC

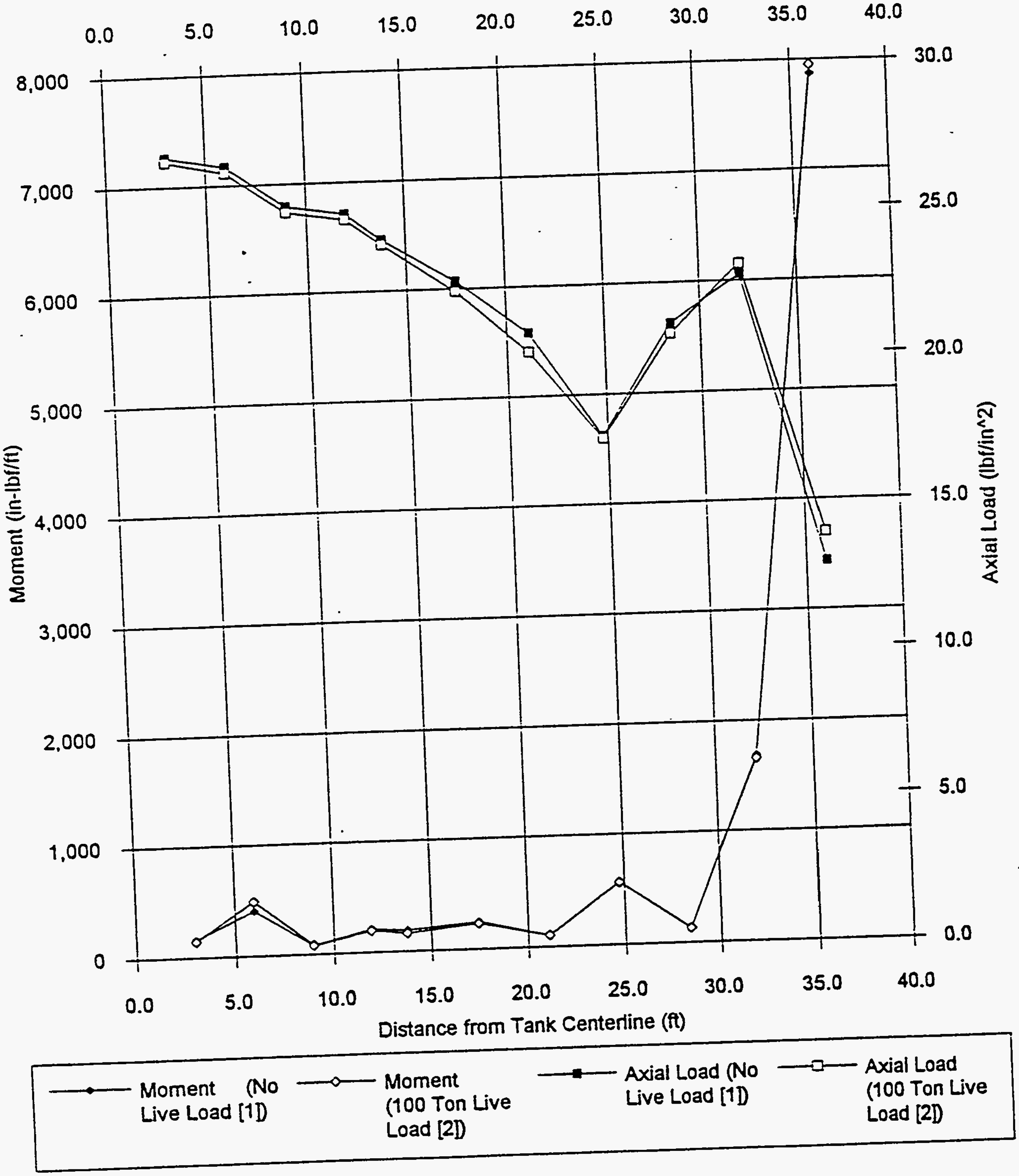
Figure 6.2-59. Response Spectra (0.2 *g* Earthquake/7% Damping/ Lower-Bound Soil Properties.



• Control motion is applied at outcrop of first competent soil layer.

q7v\anl\RESPLB.XLC

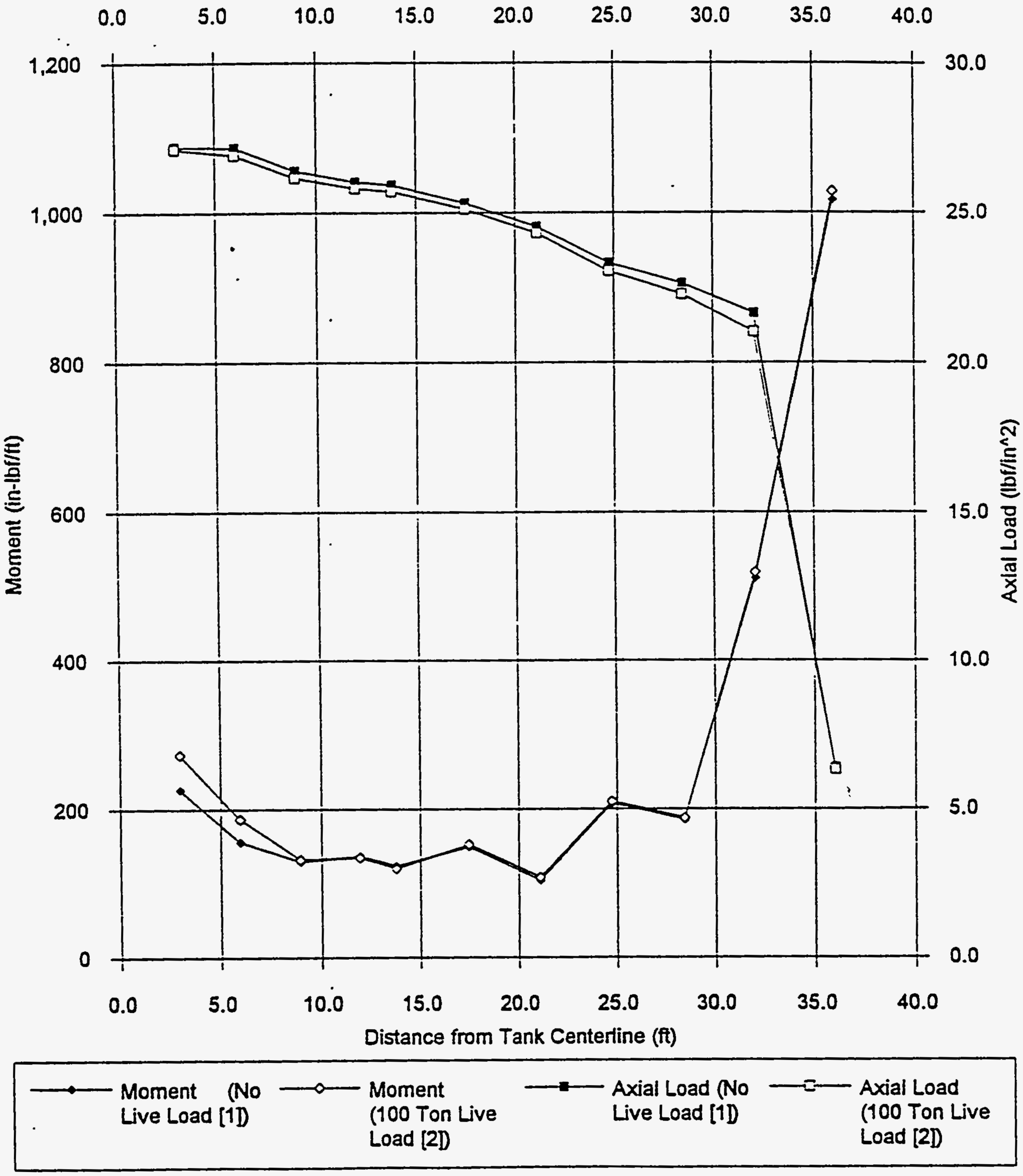
Figure 6.2-60. Meridional Seismic Response of Tank Base from Vertical Excitation Using Lower-Bound Soil Properties: Effects of 100-Ton Live Load.



Note: [1] = Run ID "QLOWVMAS", [2] = Run ID "QLOWVLIV".

qlow-v\CBASEI.XLC

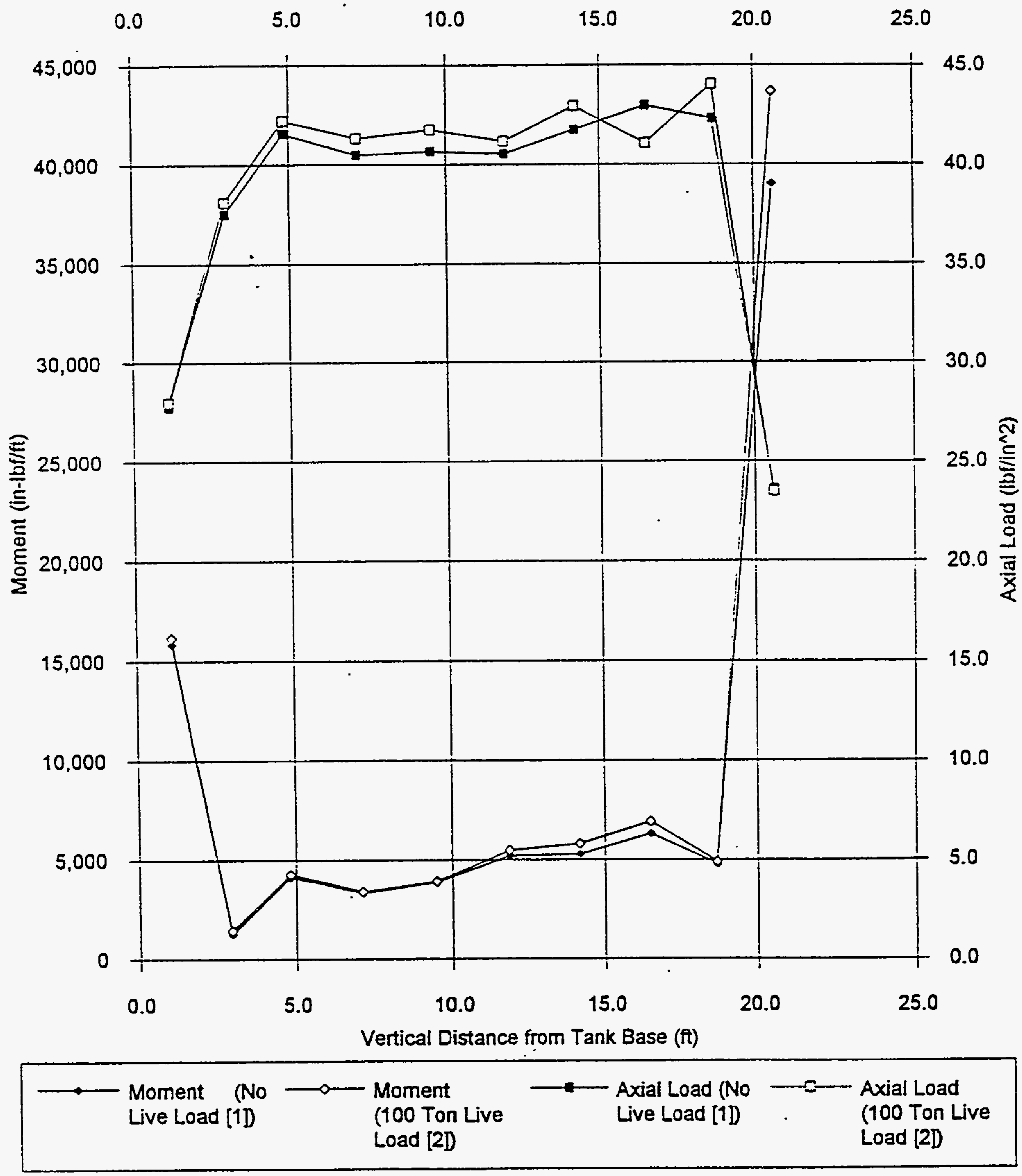
Figure 6.2-61. Circumferential Seismic Response of Tank Base from Vertical Excitation Using Lower-Bound Soil Properties: Effects of 100-Ton Live Load.



Note: [1] = Run ID "QLOWVMAS", [2] = Run ID "QLOWVLIV".

qlow-v\CBASEO.XLC

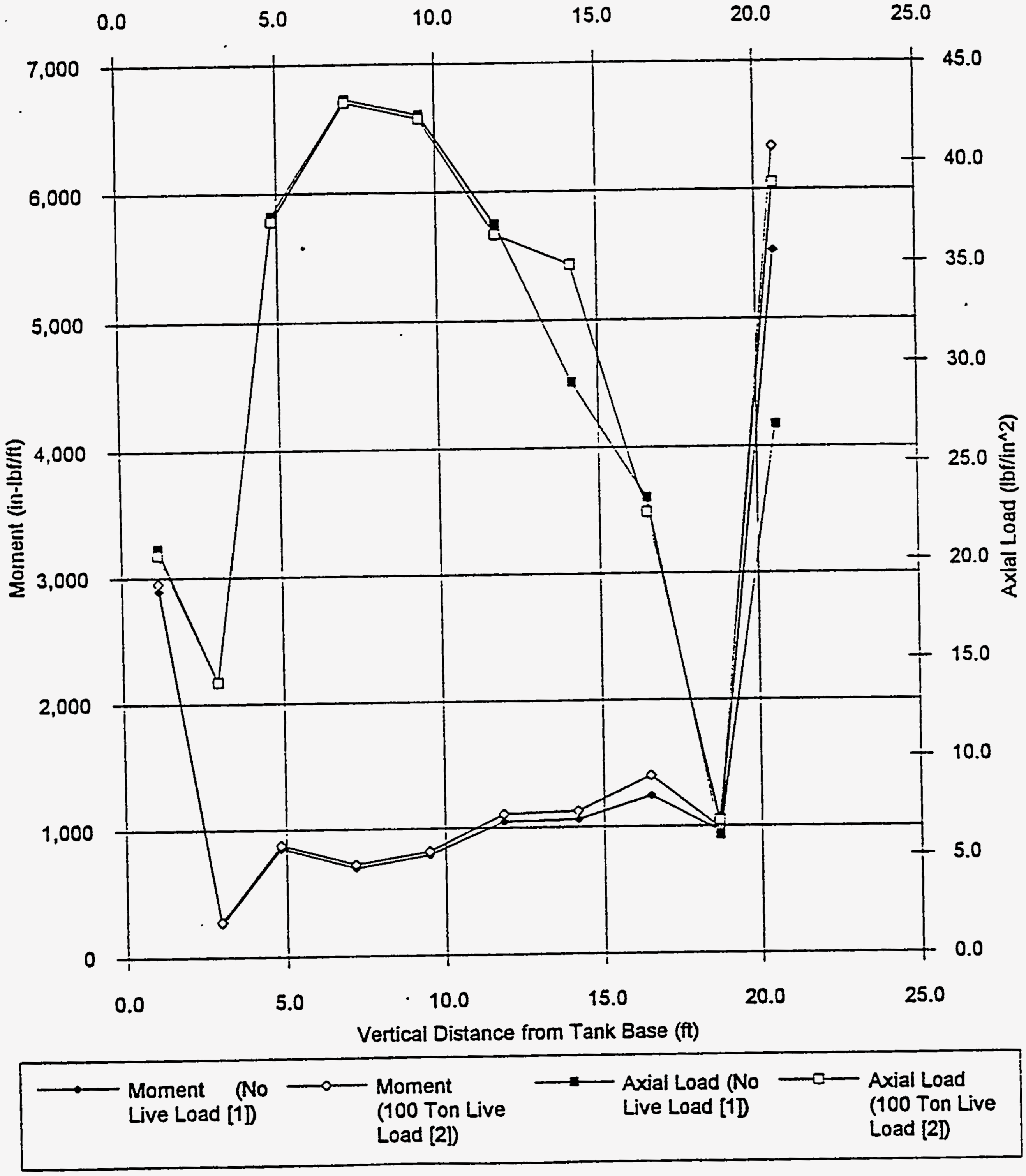
Figure 6.2-62. Meridional Seismic Response of Tank Wall from Vertical Excitation Using Lower-Bound Soil Properties: Effects of 100-Ton Live Load.



Note: [1] = Run ID "QLOWVMAS", [2] = Run ID "QLOWVLIV".

qlow-v\CWALLI.XLC

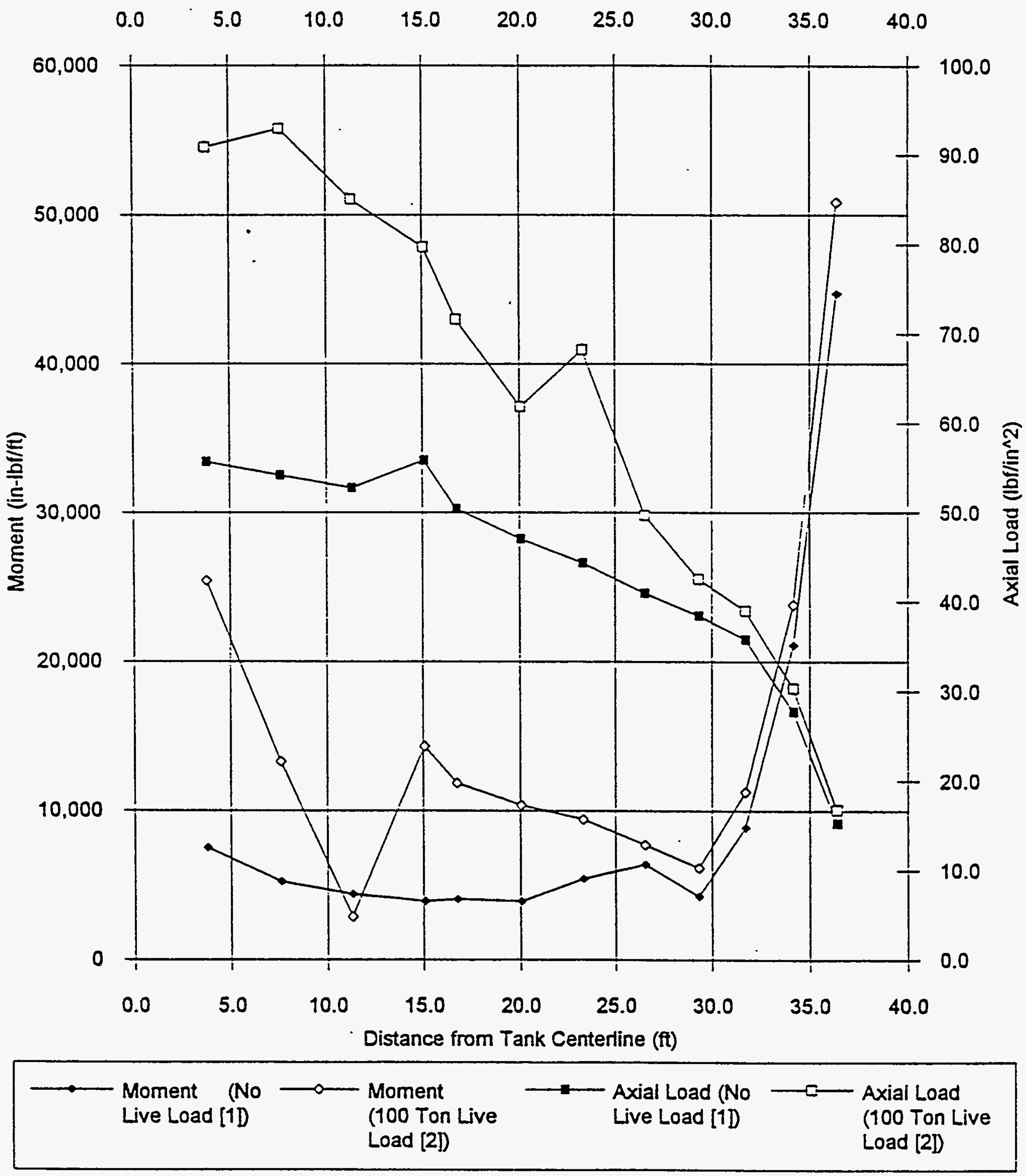
Figure 6.2-63. Circumferential Seismic Response of Tank Wall from Vertical Excitation Using Lower-Bound Soil Properties: Effects of 100-Ton Live Load.



Note: [1] = Run ID "QLOWVMAS", [2] = Run ID "QLOWVLIV".

qlow-v\CWALLO.XLC

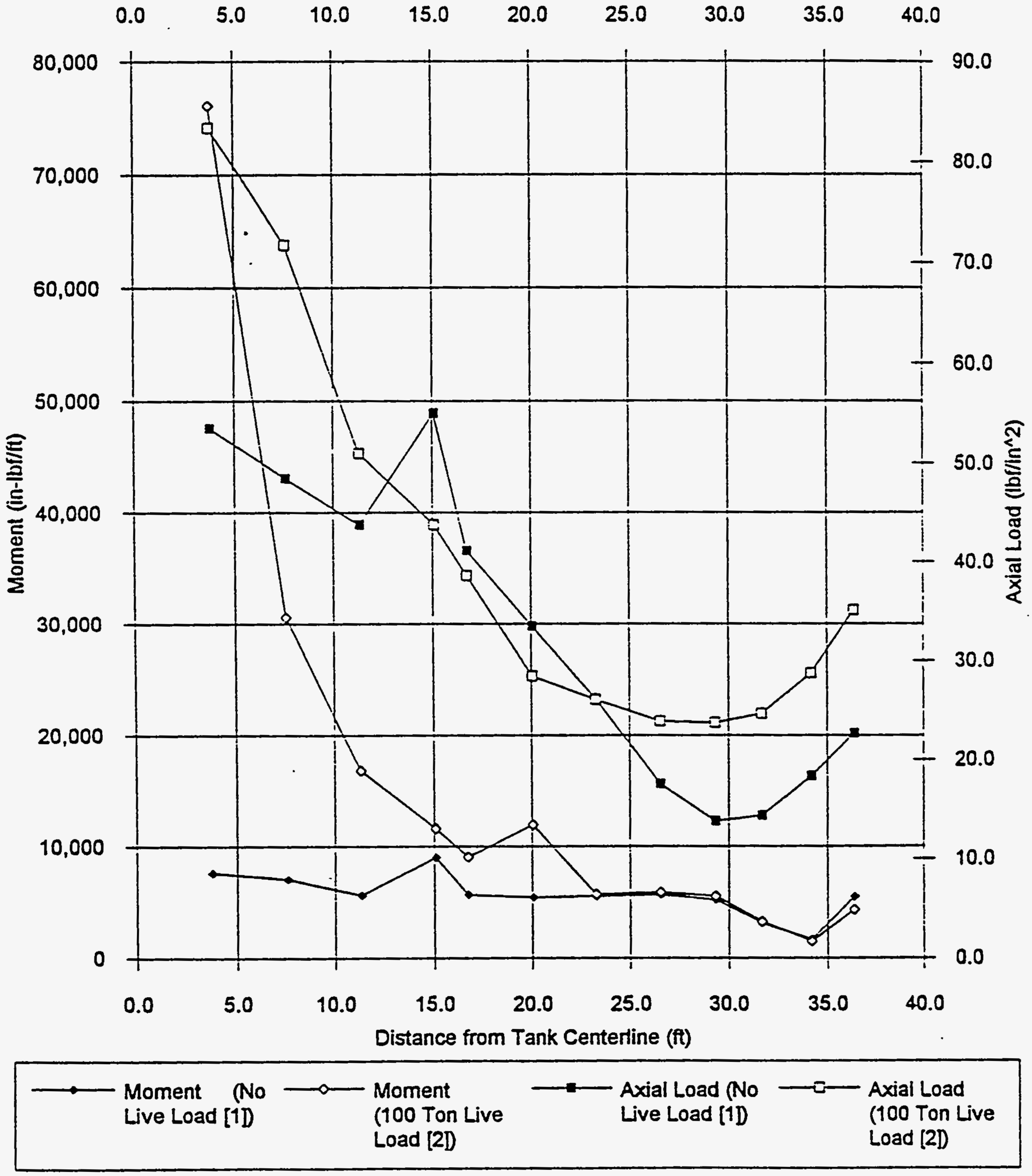
Figure 6.2-64. Meridional Seismic Response of Tank Dome from Vertical Excitation Using Lower-Bound Soil Properties: Effects of 100-Ton Live Load.



Note: [1] = Run ID "QLOWVMAS", [2] = Run ID "QLOWVLIV".

qlow-v\CDOMEI.XLC

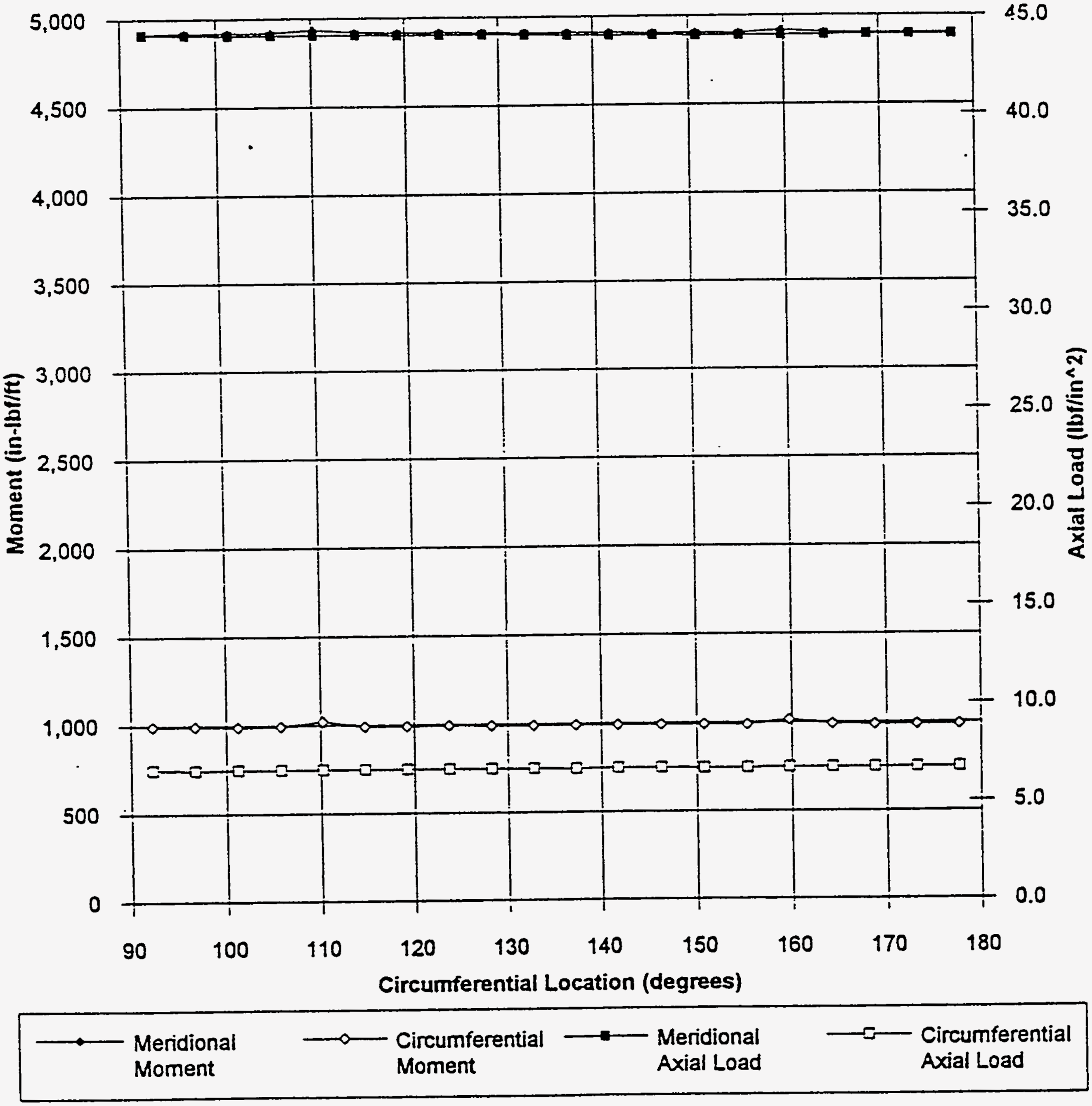
Figure 6.2-65. Circumferential Seismic Response of Tank Dome from Vertical Excitation Using Lower-Bound Soil Properties: Effects of 100-Ton Live Load.



Note: [1] = Run ID "QLOWVMAS", [2] = Run ID "QLOWVLIV".

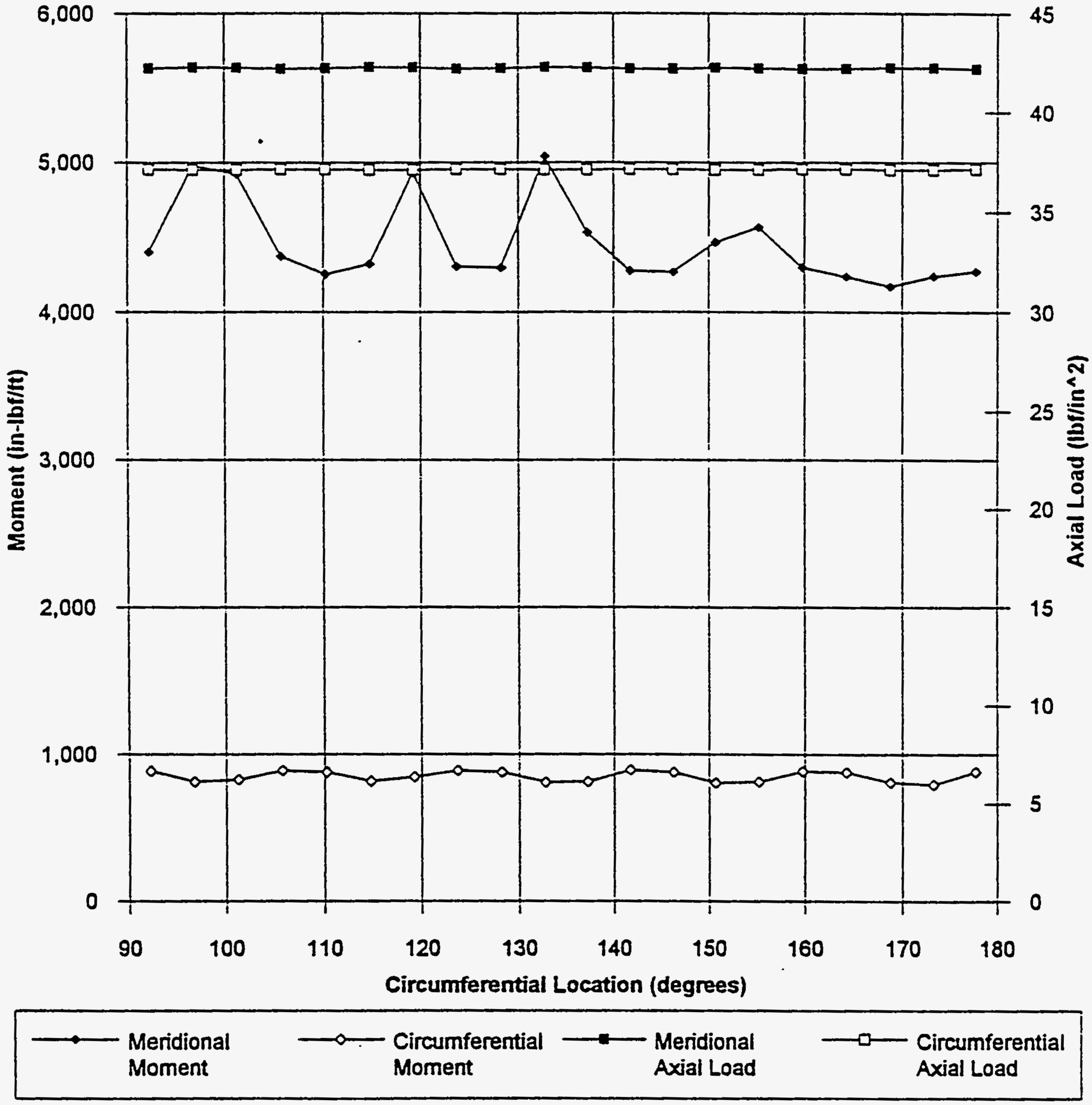
qlow-v\CDOMEO.XLC

Figure 6.2-66. Circumferential Variation of Seismic Response of Tank Wall Near Haunch from Vertical Excitation Using Lower-Bound Soil Properties and Including 100-Ton Live Load (Run ID "QLOWVLIV").



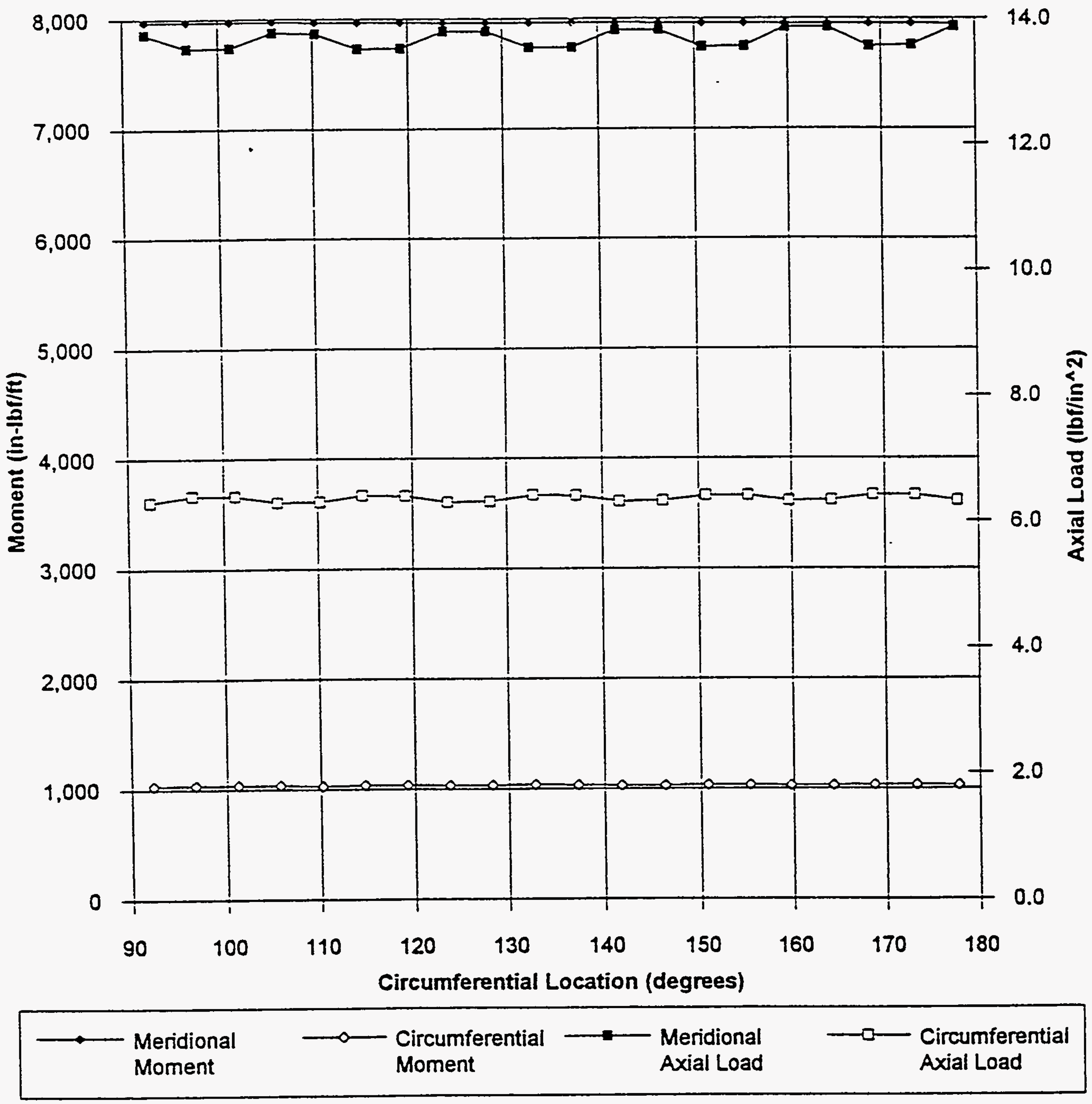
qlow-v\STRS1LIV.XLC

Figure 6.2-67. Circumferential Variation of Seismic Response of Tank Wall Near Knuckle from Vertical Excitation Using Lower-Bound Soil Properties and Including 100-Ton Live Load (Run ID "QLOWVLIV").



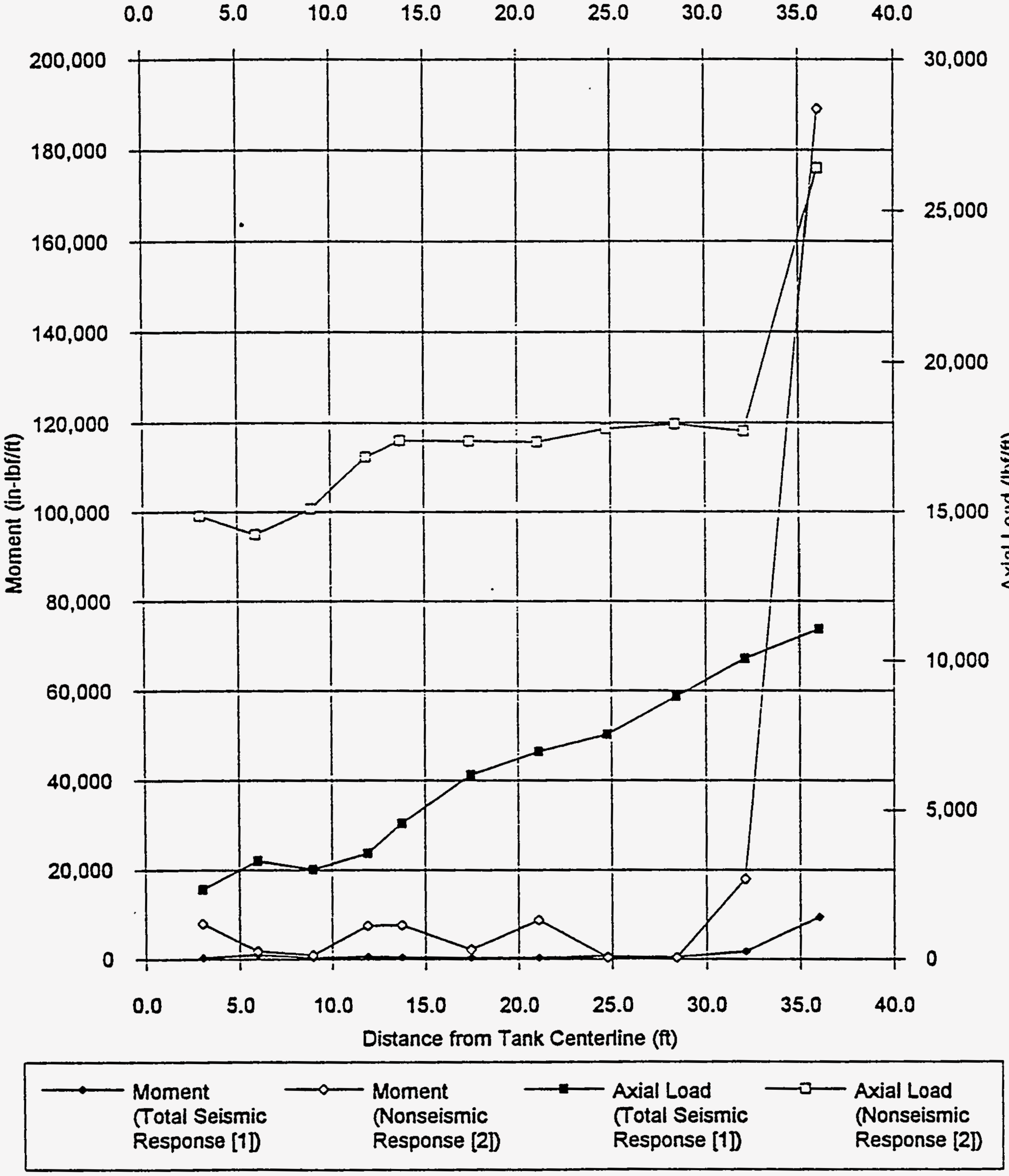
qlow-v\STRS2LIV.XLC

Figure 6.2-68. Circumferential Variation of Seismic Response of Tank Base Near Knuckle from Vertical Excitation Using Lower-Bound Soil Properties and Including 100-Ton Live Load (Run ID "QLOWVLIV").



qlow-v\STRS3LIV.XLC

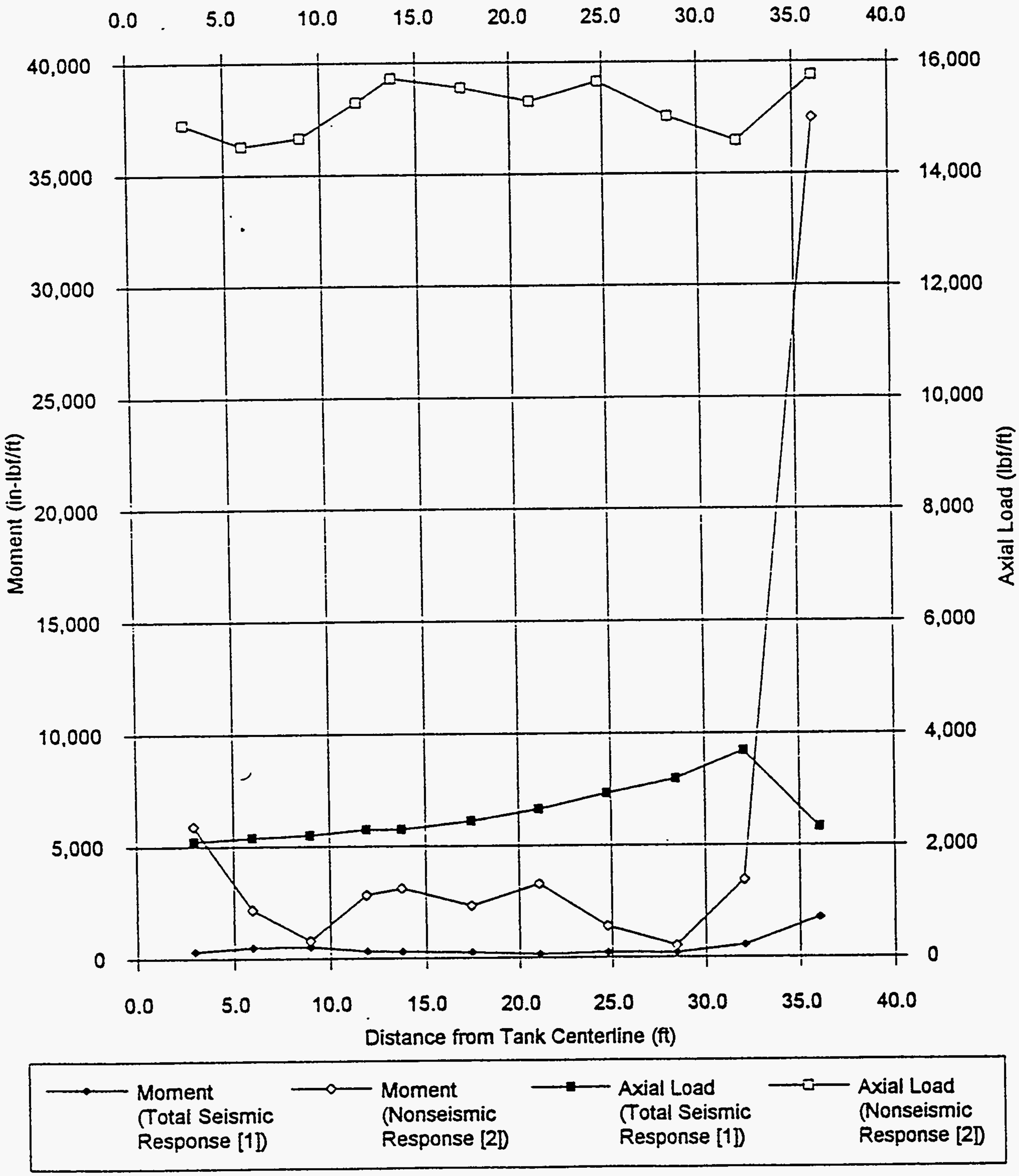
Figure 6.2-69. Meridional Moment and Axial Load Along Tank Base: Total Seismic Response vs. Nonseismic Response.



Note: [1] = Combination of Run IDs "TTTLOW" & "QLOWVLIV", [2] = Nonseismic Load Case 1a.

nonseis3\CBASEI.XLC

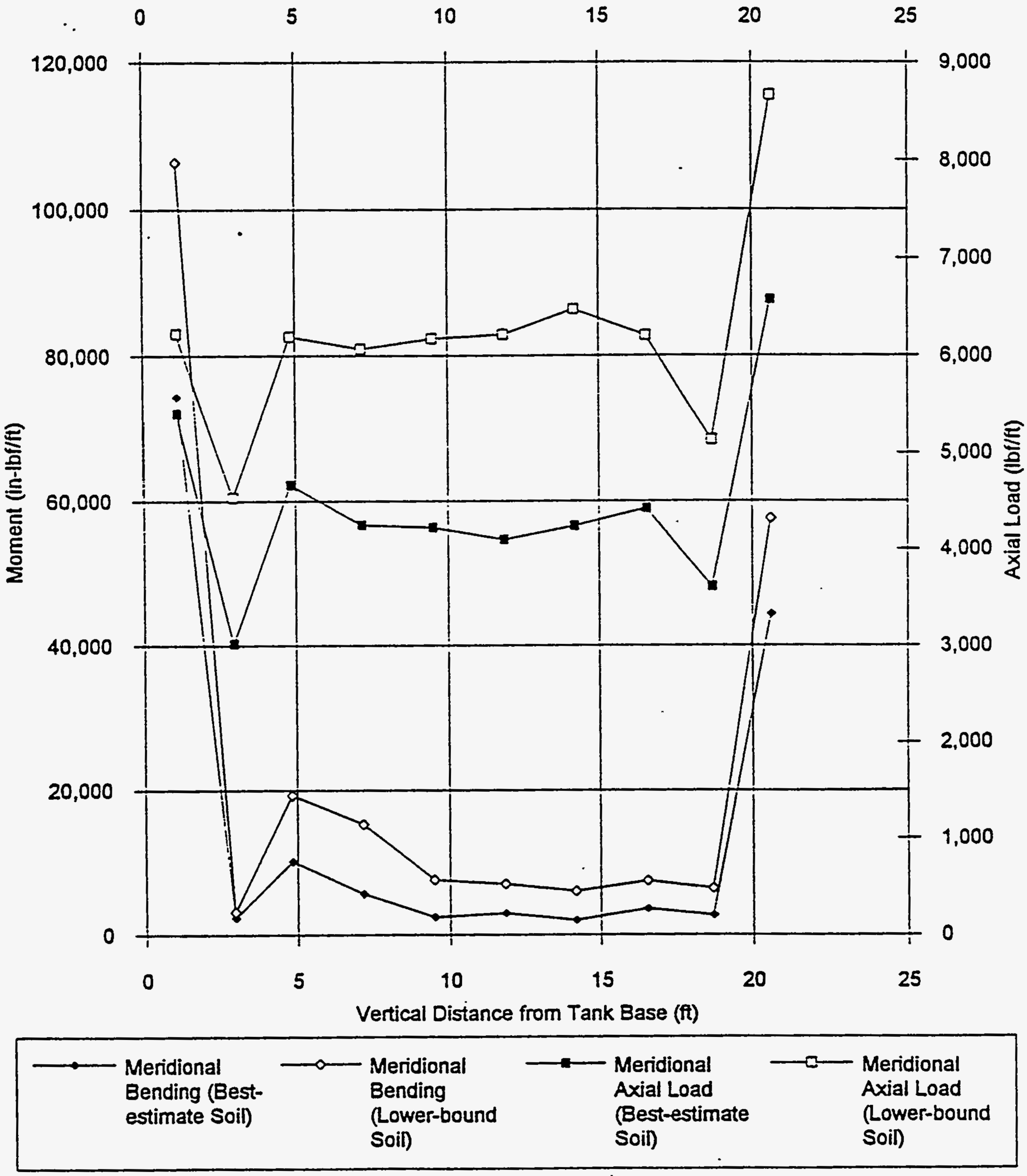
Figure 6.2-70. Circumferential Moment and Axial Load Along Tank Base: Total Seismic Response vs. Nonseismic Response.



Note: [1] = Combination of Run IDs "TTTLOW" & "QLOWVLIV", [2] = Nonseismic Load Case 1a.

nonseis3\CBASEO.XLC

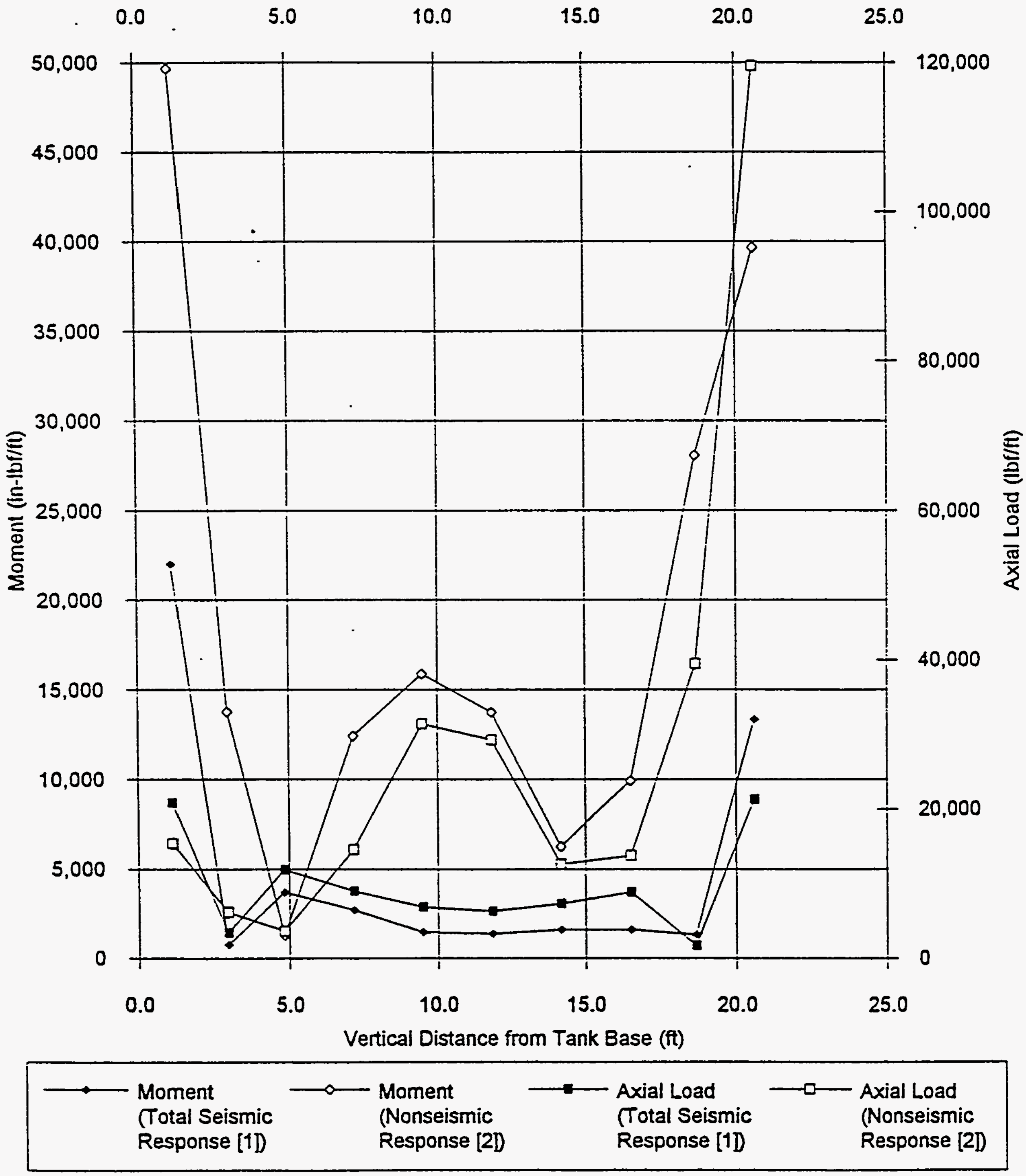
Figure 6.2-71. Meridional Moment and Axial Load Along Tank Wall: Total Seismic Response vs. Nonseismic Response.



Note: [1] = Combination of Run IDs "TTTLOW" & "QLOWVLIV", [2] = Nonseismic Load Case 1a.

nonseis3\CWALLI.XLC

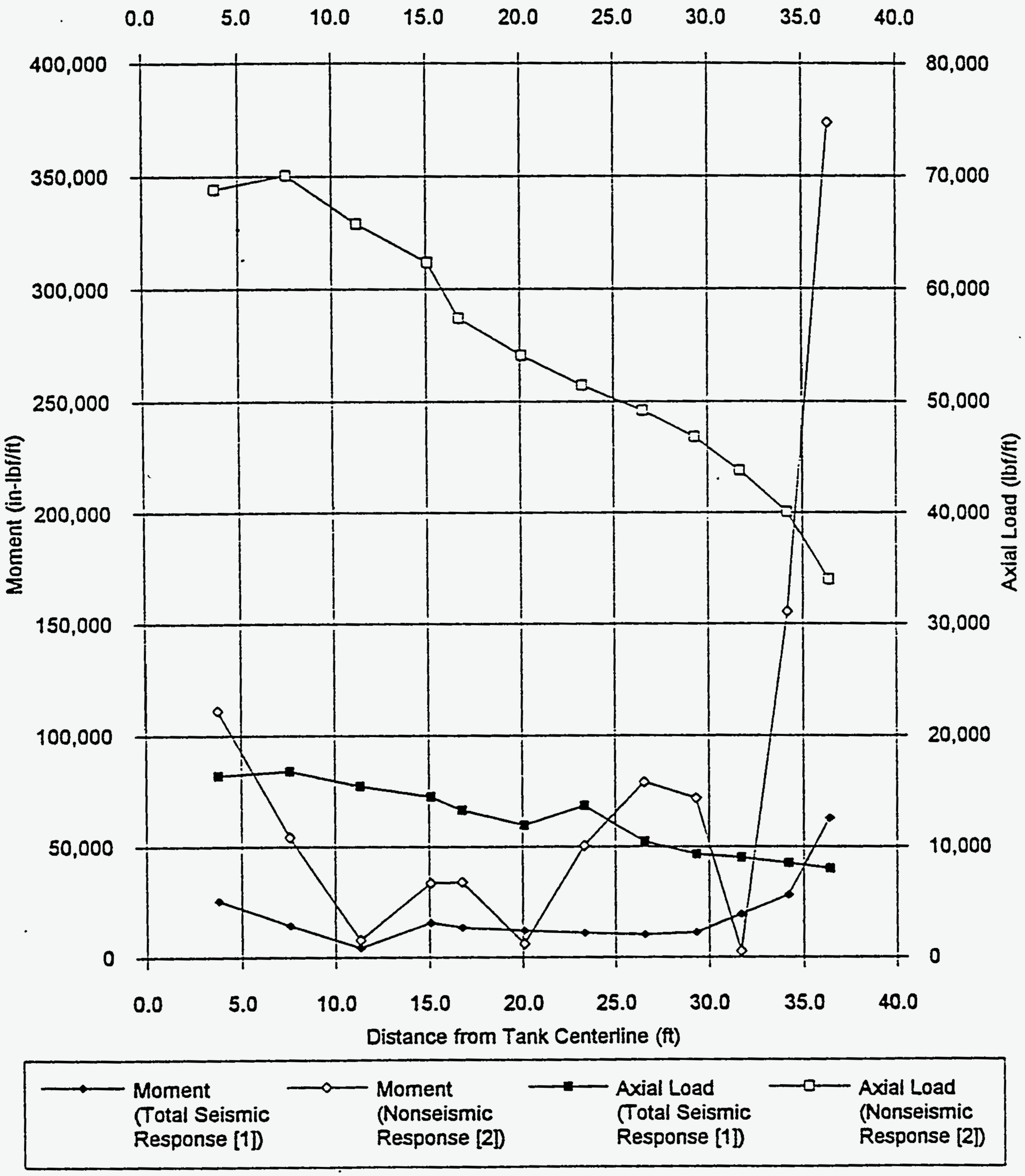
Figure 6.2-72. Circumferential Moment and Axial Load Along Tank Wall: Total Seismic Response vs. Nonseismic Response.



Note: [1] = Combination of Run IDs "TTTLOW" & "QLOWVLIV", [2] = Nonseismic Load Case 1a.

nonseis3\CWALLO.XLC

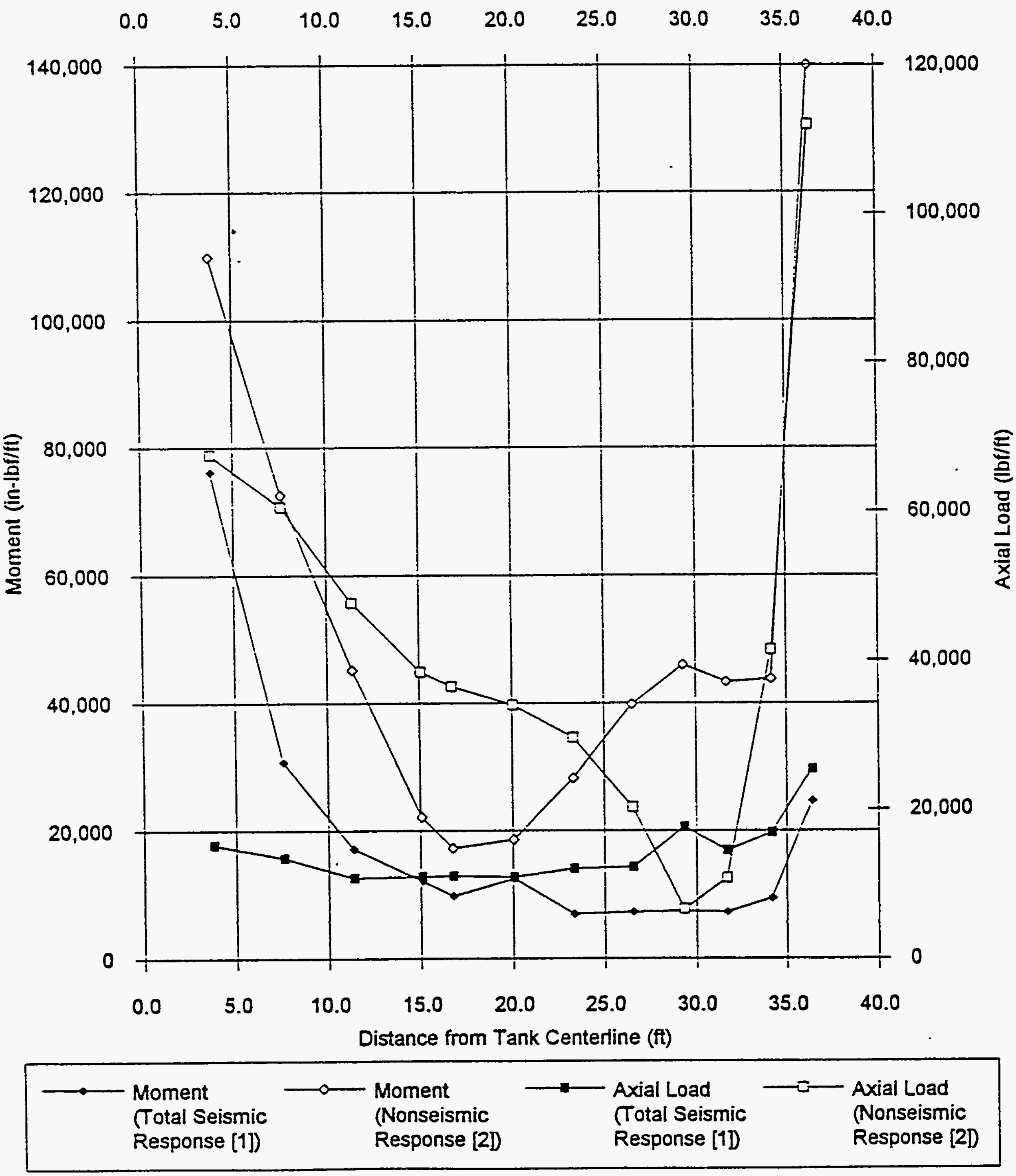
Figure 6.2-73. Circumferential Moment and Axial Load Along Tank Wall: Total Seismic Response vs. Nonseismic Response.



Note: [1] = Combination of Run IDs "TTTLOW" & "QLOWVLIV", [2] = Nonseismic Load Case 1a.

nonseis3\CDOMEI.XLC

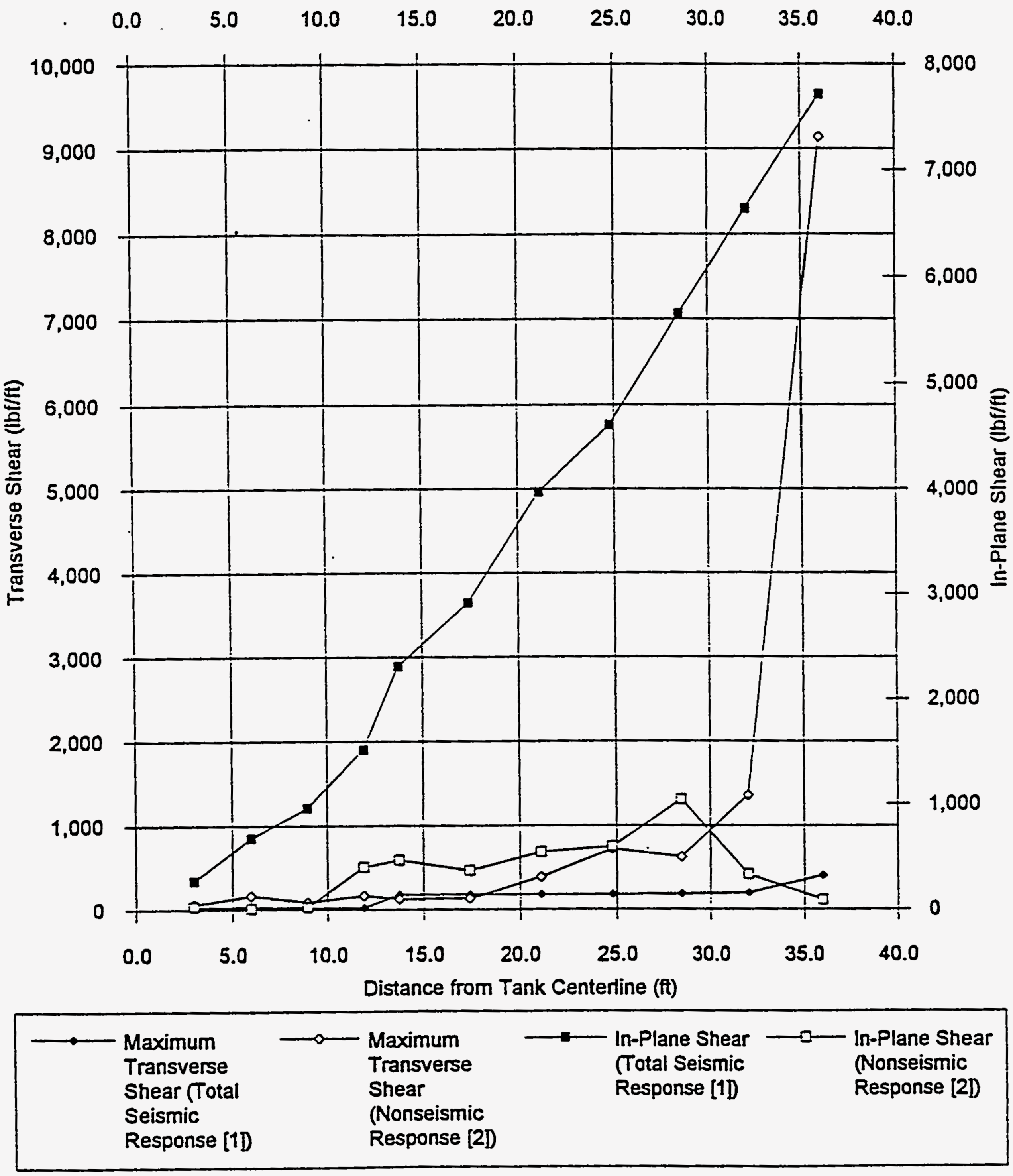
Figure 6.2-74. Meridional Moment and Axial Load Along Tank Dome: Total Seismic Response vs. Nonseismic Response.



Note: [1] = Combination of Run IDs "TTTLOW" & "QLOWVLIV", [2] = Nonseismic Load Case 1a.

nonseis3\CDOMEO.XLC

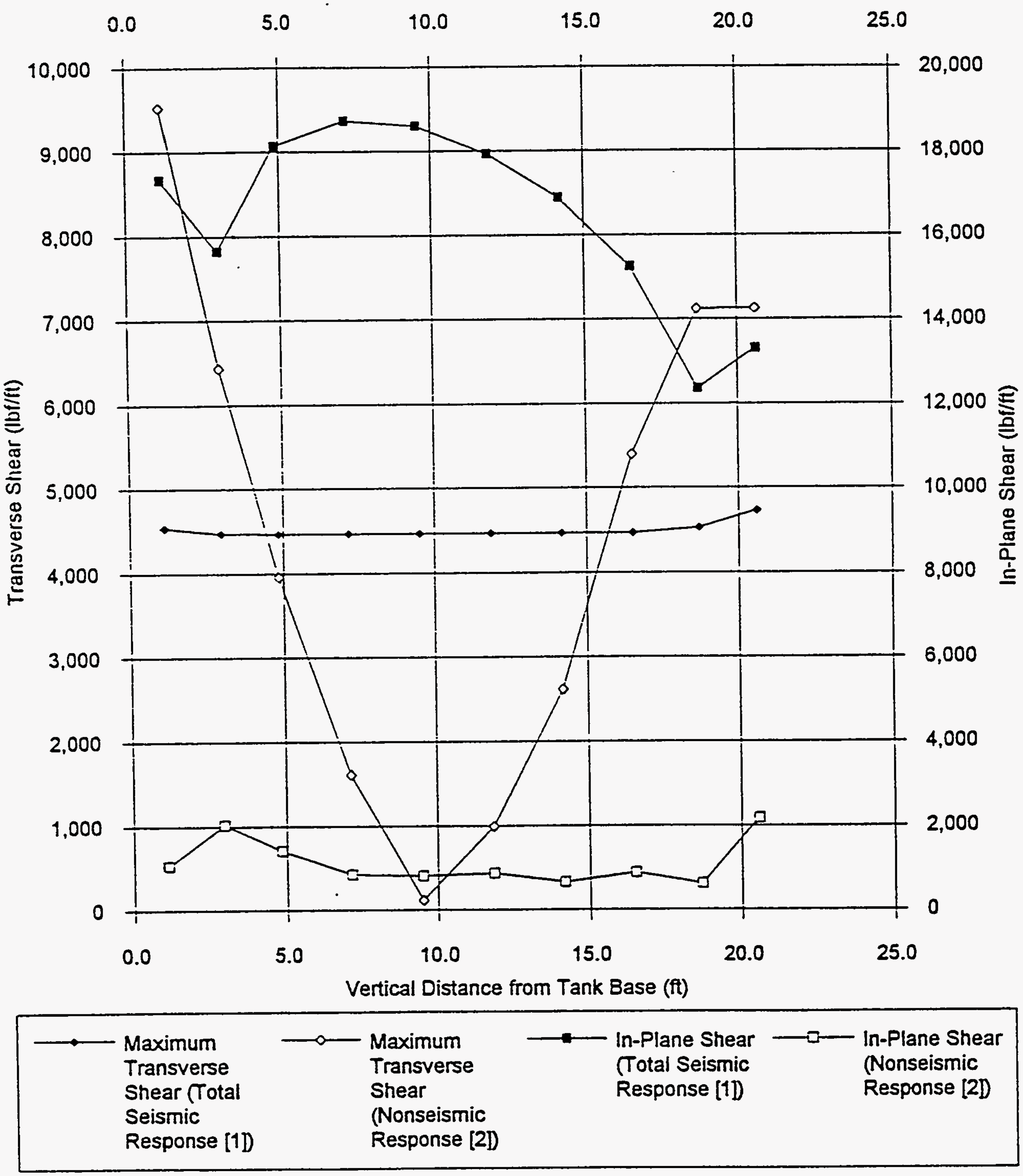
Figure 6.2-75. Circumferential Moment and Axial Load Along Tank Dome: Total Seismic Response vs. Nonseismic Response.



Note: [1] = Combination of Run IDs "TTTLOW" & "QLOWVLIV", [2] = Nonseismic Load Case 1a.

nonseis3\CBASES.XLC

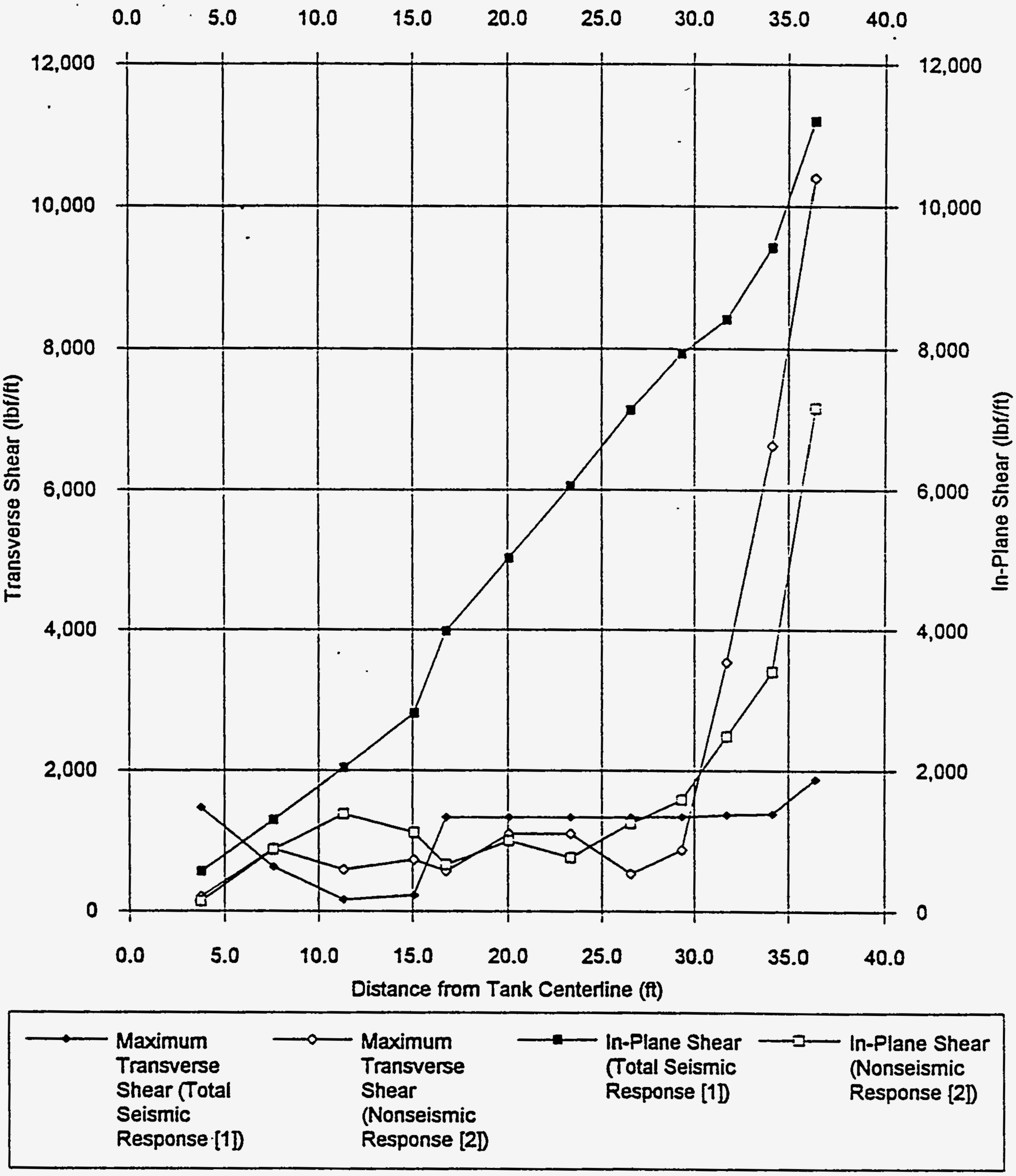
Figure 6.2-76. Transverse and In-Plane Shear Along Tank Base: Total Seismic Response vs. Nonseismic Response.



Note: [1] = Combination of Run IDs "TTTLOW" & "QLOWVLIV", [2] = Nonseismic Load Case 1a.

nonseis3\CWALLS.XLC

Figure 6.2-77. Transverse and In-Plane Shear Along Tank Dome: Total Seismic Response vs. Nonseismic Response.



Note: [1] = Combination of Run IDs "TTTLOW" & "QLOWVLIV", [2] = Nonseismic Load Case 1a.

nonseis3\CDOMES.XLC

Table 6.2-1. Effect of Soil Property Variation (Best-estimate Tank Stiffness).

		Bending Moments (kip-ft/ft)			
Location	Direction	Lower-Bound Soil Properties	Best-Estimate Soil Properties	Upper-Bound Soil Properties	Governing Case
Base	Merid.	0.438	0.361	0.230	L-B (+21%)
Base	Circumf.	0.098	0.071	0.047	L-B (+39%)
Wall	Merid.	8.478	5.829	4.103	L-B (+45%)
Wall	Circumf.	1.711	1.153	0.916	L-B (+48%)
Dome	Merid.	2.539	2.420	2.475	L-B (+5%)
Dome	Circumf.	1.988	1.970	1.826	L-B (+1%)

Notes:
1. Response is from the horizontal excitation.
2. Tabulated bending moments are the peak values within the region specified at the 180 deg meridian.
3. Percentage in parentheses is relative to best-estimate soil response.

Table 6.2-2. Effect of Tank-to-Tank Interaction (Lower-Bound Soil Properties).

		Bending Moments (kip-ft/ft)		
Location	Direction	With TTI	Without TTI	Ratio
Base	Meridional	0.421	0.438	0.96
Base	Circumferential	0.120	0.098	1.22
Wall	Meridional	8.760	8.478	1.03
Wall	Circumferential	1.816	1.711	1.06
Dome	Meridional	3.061	2.539	1.21
Dome	Circumferential	2.009	1.988	1.01

Notes:
1. Response is from the horizontal excitation.
2. Tabulated bending moments are the peak values within the region specified.
3. Moments are along the 180 degree meridian for the "without TTI" case.
4. For the "with TTI" case, moments from the 0 degree meridian and 180 degree meridian are considered.

Table 6.2-3. Effect of Tank-to-Tank Interaction
(Best-estimate Soil Properties).

		Bending Moments (kip-ft/ft)		
Location	Direction	With TTI	Without TTI	Ratio
Base	Meridional	0.434	0.361	1.20
Base	Circumferential	0.128	0.071	1.80
Wall	Meridional	6.122	5.829	1.05
Wall	Circumferential	1.201	1.153	1.04
Dome	Meridional	2.651	2.420	1.10
Dome	Circumferential	2.250	1.970	1.14

Notes:
1. Response is from the horizontal excitation.
2. Tabulated bending moments are the peak values within the region specified.
3. Moments are along the 180 degree meridian for the "without TTI" case.
4. For the "with TTI" case, moments from the 0 degree meridian and 180 degree meridian are considered.

Table 6.2-4. Effect of Tank Stiffness (Best-estimate Soil Properties).

		Bending Moments (kip-ft/ft)		
Location	Direction	Lower-Bound Tank Stiffness	Best-Estimate Tank Stiffness	Ratio
Base	Merid.	0.570	0.344	1.66
Base	Circumf.	0.121	0.081	1.49
Wall	Merid.	1.559	6.029	0.26
Wall	Circumf.	0.309	1.276	0.24
Dome	Merid.	1.125	3.107	0.36
Dome	Circumf.	0.647	2.399	0.27

Notes:

1. Response is from the horizontal excitation.
2. Tabulated bending moments are the peak values within the region specified along the 180 d

Table 6.2-5. Comparison of Response: Horizontal Excitation vs. Vertical Excitation (Lower-Bound Soil Properties).

		Bending Moments (kip-ft/ft)	
Location	Direction	Horizontal Excitation	Vertical Excitation
Base	Merid.	0.44	0.66
Base	Circumf.	0.10	0.09
Wall	Merid.	8.48	3.64
Wall	Circumf.	1.71	0.53
Dome	Merid.	2.54	4.24
Dome	Circumf.	1.99	6.35

Notes:
1. Tabulated bending moments are the peak values within the region specified at the 180 deg. meridian.
2. Vertical excitation amplitude is two-thirds horizontal excitation amplitude.
3. Tank-to-tank interaction is not considered.

Table 6.2-6. Effect of 100-Ton Live-Load Mass (Lower-Bound Soil Properties).

		Bending Moments (kip-ft/ft)		
Location	Direction	Without 100-Ton Live Load	With 100-Ton Live Load	Ratio
Base	Merid.	0.656	0.662	1.01
Base	Circumf.	0.085	0.086	1.01
Wall	Merid.	3.252	3.640	1.12
Wall	Circumf.	0.461	0.528	1.15
Dome	Merid.	3.725	4.236	1.14
Dome	Circumf.	0.751	6.346	8.46

Notes:
1. Response is from the vertical excitation.
2. Tabulated bending moments are the peak values within the region specified.
3. Live load is placed directly over dome apex.

7.0 NONSEISMIC ANALYSIS

The contribution of nonseismic loads (gravity and thermal) to overall response is calculated in a separate static, nonlinear finite-element analysis. Details of the model are provided in Section 7.2.

7.1 NONSEISMIC LOADS

Nonseismic loads applicable to the seismic evaluation are as follows:

- D, deadweight of the tank
- F, hydrostatic waste load
- H, lateral earth pressure (all load associated with deadweight of soil outside the vertical projection of the dome)
- T, in situ temperature
- L_1, soil overburden (deadweight of soil directly over the dome)
- L_2, 40-lbf/ft^2 distributed live load on the ground surface
- L_3, 100-ton concentrated live load on the ground surface (location not fixed)
- L_4, 85-ton crane load on the ground surface (located no closer than 20 ft outside the tank wall).

In the nonseismic tank evaluations (Julyk 1994; Marlow 1994; Wallace 1994), load combinations were determined with the objective of maximizing particular modes of response. Using this same philosophy, three arrangements of nonseismic loads as defined in Table 7.1-1 are developed for the seismic evaluation.

The locations for application of the concentrated 100 ton live load and 85 ton crane load are shown in Figure 7.1-1 and are defined as follows:

- Point A, Soil surface directly over the dome apex (node 377)
- Point B, Soil surface over the tank wall (node 1902)
- Point C, Soil surface, 19.5 ft beyond the tank wall (node 6033)

The three nonseismic load cases differ only in the live loads L_2, L_3, and L_4.

- Load case 1a is an axisymmetric condition intended to maximize vertical load on the dome and minimize lateral load on the wall, thus maximizing dome deflection and wall flexure. The 100 ton live load is directly over the dome apex, the distributed live load is included, and the crane load is omitted.

- Load case 1b is intended to maximize axial force on the tank wall at the 0° meridian. The 100 ton live load is directly over the wall at the 0° meridian, the distributed live load is included, and the crane load is applied 19.5 ft outside the wall at the 0° meridian.

- Load case 2 is intended to maximize lateral pressure on the tank wall at the 0° meridian, minimize dome overburden, and maximize vertical load on the top surface of the footing by placing the concentrated live loads 19.5 ft outside the tank wall. The distributed live load is omitted to minimize dome load; the omission reduces the lateral wall load and vertical footing load slightly.

Wallace (1994) defines an additional nonseismic load case, load case 3, in which ACI load factors are maximized for all loads. The distinction of load case 3 from other nonseismic load cases is less apparent in a seismic evaluation than in a nonseismic evaluation because nonseismic loads are factored only in the latter case. In a seismic evaluation, load case 3 is distinct from Load case 1b only in the location of the 100-ton live load (point A in load case 3 and point B in Load case 1b). Load case 3 is distinct from load case 1a only in that the 85-ton crane load is included in Load case 3 but not in load case 1a. These differences in live load are small relative to total nonseismic load. Tank demands resulting from load case 3 would not fall significantly outside the envelope of demands from load cases 1a and 1b; therefore, Load case 3 is not included in the seismic evaluation.

As described in Section 8.2, each of the three nonseismic load cases described above are combined with seismic loads to obtain total load states for the seismic evaluation.

7.2 NONSEISMIC RESPONSE

The nonseismic finite-element model is from the three-dimensional (3-D), nonseismic tank analysis of Marlow (1994). For convenience in combining nonseismic and seismic components of response, the finite-element mesh of the tank in the nonseismic model was generated to coincide with the finite-element mesh of the tank in the seismic (SASSI) model. The following is Marlow's description of the nonseismic model.

> The analytical model . . . is a 3-D finite-element model of one-half of the tank and surrounding soil with symmetry boundary conditions. The analysis is performed with ABAQUS version 4.9 [(HKS 1989)], a general-purpose [nonlinear] finite-element computer program. The user-defined material subroutine of the ANACAP-U [(James 1993)] concrete analysis package was used to model the constitutive behavior of the concrete. . . .
>
> The tank is modelled with four-noded thin-shell elements. The ABAQUS element type is S4R5. The shell elements are reinforced with the ABAQUS rebar subelements. In ABAQUS version 4.9, the transverse shear forces in an S4R5 element are available. The initial temperature distribution in the tank shell is a uniform 70 °F.
>
> In the center of the dome and in the center of the tank base, the four-noded elements are collapsed to form triangular elements. The elements were collapsed in these regions to maintain compatibility between the model described here and another model being used in a seismic analysis of C106. The collapsed elements

are not as accurate as quadrilateral elements. However, the stiffness of the center of the dome is not affected greatly by the collapsed elements, as discussed in Section 4.1.2. The center of the tank base is not significant in this analysis. Any inaccuracy introduced by the triangular elements in this area may be safely ignored.

The half-cylinder region of soil surrounding the tank is modelled with eight-noded brick elements, many of which are degenerate. Because detailed soil stresses are of minor importance to the goals of this effort, there is a clear benefit in using these degenerate elements as means to allow transition from the detailed mesh of the tank to the coarse mesh of the surrounding soil. The soil region extends to a depth of 1,405 in. The radius of the half-cylinder is 967 in., a radius chosen to correspond to the radius of the soil region used in the C106 in situ analysis (Julyk 1994).

The ANACAP-U concrete material properties vary by position. The values used for the modulus, the compressive strength, and the tensile strength are the lower-bound degraded properties obtained from the C106 in situ analysis (Julyk 1994). The properties are assigned directly rather than produced during an application of a thermal history. The density and coefficient of thermal expansion of the concrete also is taken directly from the C106 in situ analysis.

Specification of the transverse shear stiffness of the shell elements is required because the concrete material is not linearly elastic. The value of 10^6 lbf/in was chosen on the basis of previous work (Dyrness 1991). The element type S4R5 is intended for thin-shell applications. The transverse shear stiffness acts as a penalty function for this element. Thus, the results are insensitive to the actual value of the transverse shear stiffness (HKS 1989b).

The soil is modelled with the Drucker-Prager plasticity model. The parameters that define the constitutive behavior are taken directly from the C106 in situ analysis. The soil has a field-variable dependence, which is documented in Appendix A [of (Marlow 1994)]. The geostatic stress state in the soil is created by specifying an initial stress state with the ABAQUS command *INITIAL CONDITIONS. The determination of the appropriate stress state is documented in Appendix A [of (Marlow 1994)]. The first step of each ABAQUS analysis brings the soil into a state of equilibrium under the applied gravitational acceleration.

The steel rebar material is modelled as an elastic-plastic material with isotropic hardening. The modulus is temperature dependent as is the post-yield behavior. The yield stress varies from 38,000 lbf/in^2 at 70 °F to 32,585 lbf/in^2 at 400 °F. The constitutive model for the rebar in Marlow 1994 is taken directly from the C106 in situ analysis [see Julyk 1994].

Table 7.2-1 describes spreadsheets and ABAQUS input and output files used in calculating and compiling demands from nonseismic loads. The files are provided in Appendix M.

The ABAQUS input file, LOAD1.abdat that generates the model and applies the tank deadweight and soil deadweight (load steps 1 and 2), is not provided in Appendix M but is documented in the analysis supporting the long-reach manipulator (LRM) procurement (Marlow 1994). The temperature, waste load, and live loads are added in load step 3 defined in the input file PPS-1A.abdat, PPS-1B.abdat, or PPS-2.abdat. Thus, use is made of the binary restart file from the LRM analysis (LOAD1.res).

ABAQUS reports shell-element forces and moments in the local element coordinate system. For the ACI code evaluation, section demands must be in the principal directions of the tank (circumferential and meridional). The convention for the ABAQUS local coordinate system is such that the local element axes at the 0°, 90°, and 180° meridians of the model are generally well aligned with the principal tank directions. The general correlation of local axes to global axes is indicated in Figure 7.2-1 where the +1, -1, and +2 global axes are equivalent to the 0°, 180°, and 90° meridians, respectively. Exceptions arise for two haunch elements on the 0° meridian (elements 1317 and 1321) and the corresponding elements on the 180° meridian (elements 384 and 388) which have local coordinate systems that do not align with the tank principal directions. At these locations, a transformation is made via MathCad (Appendix K) to convert the ABAQUS response from the local element coordinate system to the principal directions of the tank. The transformed demands are included in the spreadsheets listed in Appendix M.

Figure 7.1-1
Concentrated Live Load Application Points

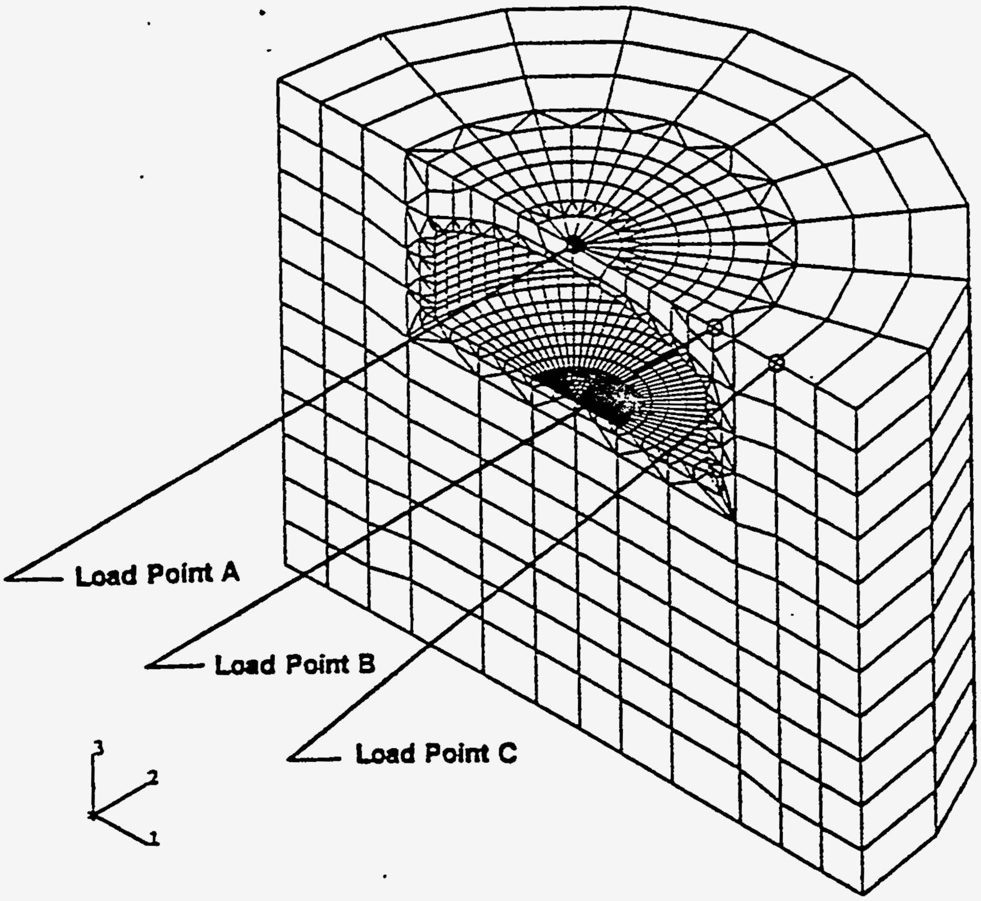


Figure 7.2-1. ABAQUS Local Element Coordinate System.

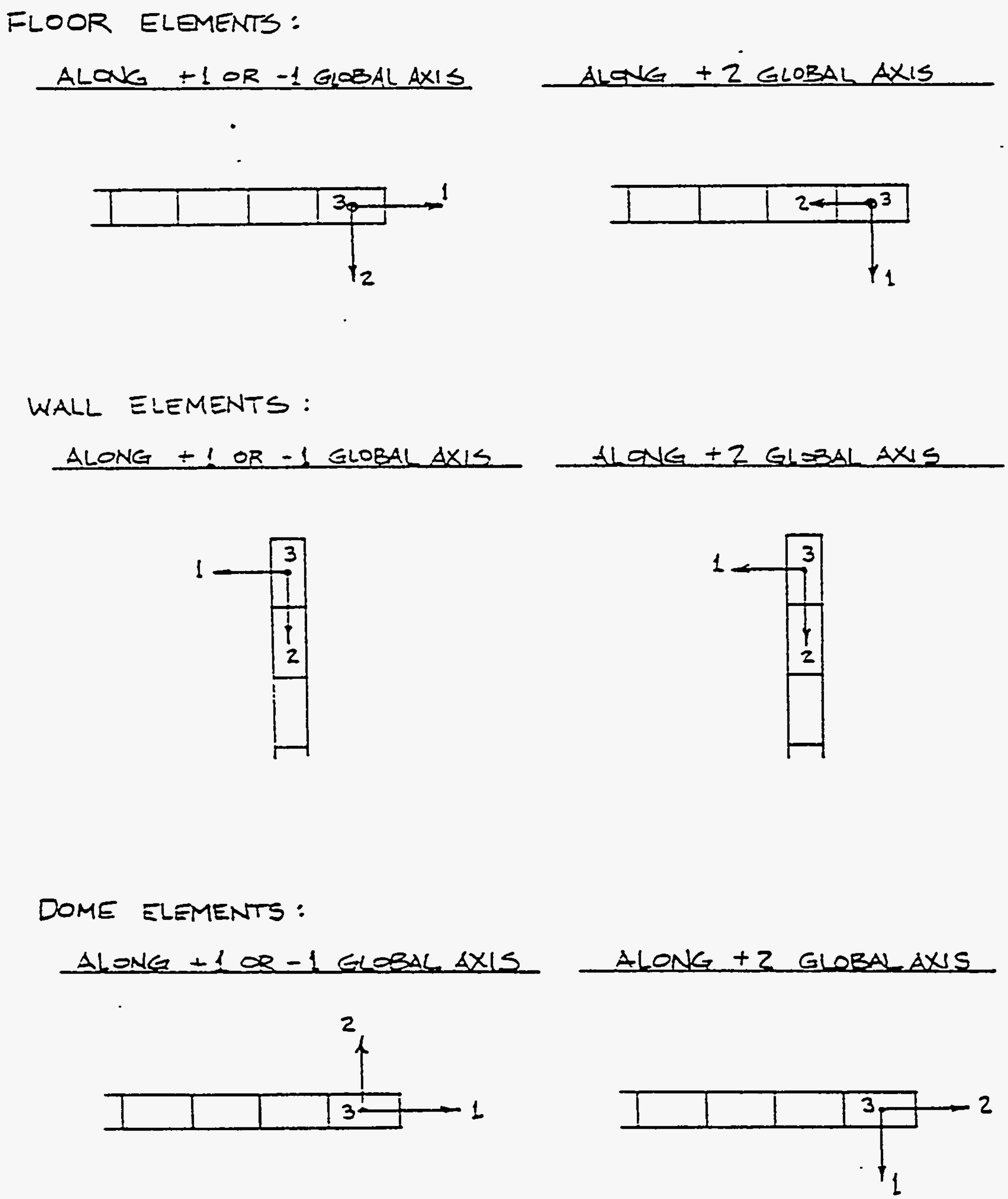


Table 7.1-1. Load Factors for Nonseismic Load Combinations.

Load Case	D	F	H	T	L_1	L_2	L_3	L_4
1a	1	1	1	1	1	1	1 @ A*	0
1b	1	1	1	1	1	1	1 @ B*	1 @ C*
2	1	1	1	1	1	0	1 @ C*	1 @ C*

* A, B, and C refer to locations shown in Figure 7.1-1.

Table 7.2-1. File Descriptions for Determination of Nonseismic Demands.

File Name	Description
PPS-U1A.abdat	ABAQUS input file to add temperature, waste load, and load case 1a live loads (restarts from binary file LOAD1.res).
PPS-U1B.abdat	ABAQUS input file to add temperature, waste load, and load case 1b live loads (restarts from binary file LOAD1.res).
PPS-U2.abdat	ABAQUS input file to add temperature, waste load, and load case 1b live loads (restarts from binary file LOAD1.res).
PPS-U1AP.abdat	ABAQUS input file to extract load case 1a element demands (restarts from binary file PPS-U1A.res).
PPS-U1BP.abdat	ABAQUS input file to extract load case 1b element demands (restarts from binary file PPS-U1B.res).
PPS-U2P.abdat	ABAQUS input file to extract load case 2 element demands (restarts from binary file PPS-U2.res).
PPS-U1AP.about	ABAQUS output file containing nonseismic load case 1a element demands.
PPS-U1BP.about	ABAQUS output file containing nonseismic load case 1b element demands.
PPS-U2P.about	ABAQUS output file containing nonseismic load case 2 element demands.
PPS-U1AP.xls	Spreadsheet containing demands reported in PPS-U1AP.about.
PPS-U1BP.xls	Spreadsheet containing demands reported in PPS-U1BP.about.
PPS-U2P.xls	Spreadsheet containing demands reported in PPS-U2P.about.

8.0 STRUCTURAL ACCEPTANCE CRITERIA

Capacities of the tank structural components (tank sections) are determined as described in Section 8.1. Section 8.2 discusses the methodology for combining seismic and nonseismic demands to obtain total section demands against which the section capacities are evaluated.

8.1 CAPACITIES

Capacities of reinforced concrete tank sections are computed on the basis of the strength design approach presented in ACI 349-90 (ACI 1990). The relevant sections of ACI 349-90 and the equations contained therein are discussed in Section 9.2. In accordance with BNL 52361 (Bandyopadhyay et al. 1993), material properties used in computing the code-based capacities are "based on 95% exceedance values estimated from tests of the actual materials used at the facility." The computations consider degradation of concrete and reinforcement from long-term exposure to elevated temperatures.

Capacities of the steel risers are calculated conservatively on the basis of the allowable stress design approach presented in the AISC code (AISC 1989). The BNL 52361 guidelines (Bandyopadhyay et al. 1993) allow the use of plastic design capacities (estimated as 1.7 times the allowable stress design capacities); however, this increase factor is not considered in the riser evaluation. The riser evaluation approach is discussed in detail in Section 9.3.

8.2 LOAD COMBINATIONS

Per UCRL-15910 (Kennedy et al. 1990) and BNL 52361 (Bandyopadhyay et al. 1993), total demand is the combination of unfactored nonseismic demand and inelastic seismic demand. According to UCRL-15910, inelastic seismic demand is calculated as the elastic seismic demand divided by the inelastic demand-capacity ratio F_μ where F_μ may be taken conservatively as one. The UCRL-15910 load combination is in fundamental agreement with Section 9.2 of ACI 349-90 (ACI 1990) in that all load factors are, in effect, unity. However, per Section 9.2.3 of ACI 349-90, load factors are subject to reduction when the effects of one load counteract the effects of other load(s). In such cases, ACI prescribes use of a minimum load factor equal to 0.9 if the counteracting load is always present in combination with the other loads. Otherwise, the minimum load factor for the counteracting load is zero. Because any given load in the tank analysis may be counteracting for some measures of tank response and additive for others, the ACI prescription of the 10% load reduction is somewhat ambiguous. Further, the UCRL-15910 guidelines do not address such a reduction; therefore, calculations herein do not implement 10% load reduction.

In summary tank response from thermal and gravity (nonseismic) loads is determined via nonlinear methods (ABAQUS with nonlinear material descriptions) while seismic response is calculated via a linear approach (SASSI with relatively simple material descriptions). The two sets of responses are combined to obtain the overall response. This operation is shown on the spreadsheet in Appendix E (*total.xls*), which sums demands from one of the three nonseismic load combinations (load cases 1a, 1b, and 2) with the total seismic demand. Modifying the "links" in the spreadsheet allows a different nonseismic load combination to be considered in combination with the total seismic demand. For example, linking *total.xls* to *PPS-U1B.xls* (Appendix M) and to *combin.xls* (Appendix D), sums demand from nonseismic load case 1b with total seismic demand. Shears and moments are combined absolutely (values are unsigned). In combining membrane forces, the algebraic sign of the nonseismic contribution is retained. At each section, both negative and positive values of the seismic membrane force are added to the nonseismic membrane force to obtain the minimum and maximum combined membrane forces.

Mass associated with live loads generally is not considered in the seismic analyses; however, the 100-ton live load is considered as a lumped mass in one instance. In the seismic analysis for vertical excitation using lower-bound soil properties, the 100-ton live-load mass is placed directly over the dome apex as a worst-case scenario for evaluating the effect of live load on seismic response. Comparing seismic response with and without the live-load mass (Figures 6.2-60 to 6.2-65) clearly indicates that the effect of the live-load mass is significant only near the center of the dome. While there is a disparity in combining results from the vertical excitation seismic analysis, which includes a centrally positioned 100-ton live-load mass, with results from either of the nonseismic load cases 1b or 2 (which place the 100-ton live load off-center), these combinations nonetheless are considered in the seismic evaluation. The error associated with this disparity is insignificant in all areas of the tank except in the central portion of the dome, where the approach is conservative.

9.0 STRUCTURAL EVALUATION

9.1 EVALUATION SUMMARY

All reinforced concrete section capacities are based on the in situ, time- and temperature-degraded concrete compressive strengths calculated in the in situ tank analysis (Julyk 1994). The Julyk analysis used the Hanford lower-bound concrete model (James 1993). The lower-bound in situ concrete compressive strengths range from approximately 3,400 lbf/in^2 in the tank base to 4,500 lbf/in^2 in the haunch and dome.

The worst-case seismic condition is based on lower-bound soil properties and includes tank-to-tank interaction and impulsive hydrodynamic waste effects. Seismic demands computed with lower-bound soil properties (run IDs "TTTLOW" and "QLOWVLIV" in Appendix O) were combined with demands from three different nonseismic load combinations to obtain total demands for the evaluation. Both positive and negative values of the seismic demands were considered in the evaluation. Moment/axial load interaction, transverse shear, in-plane shear, and twisting moment were evaluated at critical tank sections. Construction joints also were evaluated. ACI 349-90 (ACI 1990) requirements were satisfied in all cases. Appendix L provides results of a generally non-controlling tank evaluation where best-estimate soil properties were used in computing the seismic contribution to the total demand.

The steel risers evaluation considered demand from seismic loads only; and AISC (AISC 1989) acceptance criteria were satisfied. Effects of nonseismic loads on the risers were assumed to be negligible.

9.2 TANK EVALUATION

The ACI code-based capacities of the reinforced concrete tank sections are computed in Sections 9.2.1 to 9.2.5. In addition, total demands, having been calculated as described in foregoing sections, are evaluated against these capacities.

9.2.1 Moment/Axial Force Evaluation

Interaction of axial load capacity and bending moment capacity is calculated according to ACI 349, Section 10 (ACI 1990), with elastic-perfectly-plastic behavior assumed for the rebar. In accordance with Section 14.4 of ACI, ACI Section 10 provisions are appropriate for a wall with combined flexure and axial load. A typical interaction diagram for axial load capacity (P) and moment capacity (M) of a section is illustrated in Figure 9.2.1-1. The heavy line enclosing the shaded area in the figure represents the code-dictated capacity of a tied section. Although the tank does not have ties, Section 14.3.3 of ACI 349 states that vertical reinforcement in walls need not be enclosed by lateral ties if the vertical reinforcement area is less than 0.01 times the gross concrete area. As this criterion is met at all tank sections, the provisions for combined flexure and axial load in a tied section are applicable. Any point on the example M-P interaction diagram that falls inside the shaded area represents an acceptable section demand.

Several key points on any M-P interaction curve are calculated readily. Point D represents the code limit for axial compression in columns with nominally zero bending moment and is given by

$$\alpha\phi P_{n0} = 0.8(0.7)[0.85f_c(A_g - A_s - A_s') + f_y(A_s + A_s')],$$

where α = factor to account for a small eccentricity of the load
= 0.8
ϕ = capacity reduction factor for a tied compression member
= 0.7
P_{n0} = nominal axial load strength at zero eccentricity (lbf)
f_c = in situ compressive strength of the concrete (lbf/in^2)
A_g = gross area of the section (in^2)
A_s = area of rebar at the "tensile" face (in^2)
A_s' = area of rebar at the "compressive" face (in^2)
f_y = yield strength of the rebar adjusted for temperature (lbf/in^2).

The α factor is applicable to columns but is less relevant for sections in a shell structure. Therefore, point O, representing the quantity ϕP_{n0}, is an appropriate allowable for axial compression without bending. Point E is the code limit for axial tension with nominally zero bending moment. This tensile limit is $\phi(A_s+A_s')f_y = 0.9(A_s+A_s')f_y$. Point b, or the "balance point," corresponds to the balanced loading condition for the section where crushing of the concrete ($\epsilon_u = 0.003$) and yield of the tensile rebar ($\epsilon_y = f_y/E_s$ where f_y and Young's modulus of the rebar E_s are adjusted for temperature) occur simultaneously. Figure 9.2.1-3 illustrates this balanced condition. The nominal balance point is determined as follows:

Calculate the depth to the neutral axis c_b from similar triangles and the strain profile,

$$c_b = 0.003d/(0.003 + f_y/E_s).$$

Then, using the concrete compression stress block approximation (where β_1 is calculated in accordance with Section 10 of ACI 349) and the degraded (in situ) concrete compressive strength f_c, algebraically sum steel and concrete forces to determine the nominal balanced axial load P_b. Sum moments about the plastic centroid to determine the nominal balanced bending moment M_b. The plastic centroid of a section is the location of the resultant load that would give a uniform strain across the section (no bending). For a symmetric section, the plastic centroid lies at the geometric centroid. For an unsymmetric section subjected to net axial compression, the location of the plastic centroid, as measured from the centroid of the steel designated A_s in Figure 9.2.1-2, may be computed as follows:

$$x_p = [0.85f_cbh(h/2 - d') + A_s'f_y(d - d'')] / [0.85f_cbh + (A_s'+ A_s)f_y].$$

This expression reduces to $x_p = h/2 - d'$, i.e., the location of the geometric centroid, in the case of a symmetric section where $A_s = A_s'$ and $d' = d''$.

The balanced axial load and moment are calculated as follows (Figure 9.2.1-3):

$$P_b = \Sigma F = C_c + C_s - T$$

$$= 0.85f_c b(\beta_1 c_b) + A_s'f_s' - A_s f_y$$

where

$$f_s' = E_s \cdot 0.003(c_b - d'')/c_b \leq f_y.$$

When the "compression" reinforcement is located within the concrete compression block, f_s' is reduced by the quantity $0.85f_c$ to account indirectly for a reduction in the area of the concrete compression block equal to A_s'. Likewise, when the "tension" reinforcement is located within the concrete compression block, f_y in the above expression is increased by the quantity $0.85f_c$ to account indirectly for a reduction in the area of the concrete compression block equal to A_s.

Summing moments about the plastic centroid,

$$M_b = C_c(d - x_p - \beta_1 c_b/2) + C_s(d - x_p - d'') + T(x_p).$$

Point B on the M-P interaction diagram in Figure 9.2.1-1 is determined by reducing the balanced axial load and moment by the ϕ factor = 0.7. Connecting the points O, B, and E with straight lines forms a crude but conservative M-P capacity envelope for the section.

In lieu of using the conservative three-point approximation, the M-P interaction curve may be generated in rigorous fashion with the following step-by-step approach:

Arbitrarily select a location of the neutral axis (c > 0). Assuming a linear strain profile with $\epsilon_u = 0.003$, calculate the rebar strain(s). Using Hooke's Law, calculate rebar stress from the rebar strain and Young's modulus adjusted for temperature (as strains are small, neglect strain hardening). Concrete stress is $0.85f_c$ and the concrete compression stress block is $a=\beta_1 c$ deep. If the "compression" steel is within the concrete compression block, reduce the steel stress f_s' by $0.85f_c$. If the "tensile" steel is within the concrete compression block, increase the steel stress f_s by $0.85f_c$. Sum concrete and steel forces to get P_n and sum moments about the plastic centroid to get M_n. Apply the appropriate ϕ factors to P_n and M_n to obtain a point on the interaction diagram. For P_n greater than $(0.1f_c A_g)/0.7$, ϕ is 0.7 and, for P_n less than zero, ϕ is 0.9. For other values of P_n, ϕ may be determined by linear interpolation.

Axial forces and bending moments, in the meridional and circumferential directions, resulting from seismic loads are obtained directly from the SASSI printed output. The axial forces SXX and SYY are multiplied by the shell thickness to obtain units of force per unit length. Both positive and negative values of seismic demands are considered, i.e., the seismic forces and moments are considered to act in either direction. Printed seismic forces and moments are the maximum values calculated through time and do not necessarily occur simultaneously; however, the peak values are always considered acting together.

Calculated shell-element demands are reported at the geometric centroid of the shell; therefore, in accordance with MacGregor (1988), moment capacities are determined more appropriately by summing forces about the geometric centroid rather than the plastic centroid of the section. Accordingly, the term "plastic centroid" in the foregoing discussion is replaced with "geometric centroid" in calculating tank section capacities. Thus, the dimension x_p is calculated as h/2 - d' for symmetric *and* unsymmetric sections.

Spreadsheets as described in Table 9.2.1-1 are used in calculating combined moment and axial load (M-P) capacities at discrete "capacity sections." These spreadsheets are provided in Appendix F. Locations of capacity sections along a tank meridian are shown in Figure 9.2.1-4. Element numbers associated with each capacity section are provided in Table 9.2.1-2 (meridional direction) and Table 9.2.1-3 (circumferential direction).

For meridional capacity sections 2, 4a, 4, 5, 6, and 6a and circumferential capacity sections 2, 4, 5, and 6, a reduced area of reinforcement is considered in calculating the M-P capacity envelopes. As described in Section 9.2.3, the reduction in reinforcement is applied so that minimum in-plane shear reinforcement requirements are satisfied.

The M-P capacity envelope and demands for each capacity section are plotted in the figures listed in Table 9.2.1-4. To reiterate, lower-bound soil properties are used in computing the seismic contribution to the plotted demands in these figures. For reference, the EXCEL files that generate the M-P diagrams are listed in Tables 9.2.1-5 (meridional direction) and 9.2.1-6 (circumferential direction).

In summary, all sections meet ACI 349-90 criteria for combined moment and axial load; however, several sections warrant further discussion.

At meridional capacity section 4a (Figures 9.2.1-10, 9.2.1-32, and 9.2.1-54), demand points corresponding to *tensile* seismic axial load fall marginally outside the capacity envelope; however, longitudinal reinforcement has been reduced conservatively in the M-P capacity calculation to provide minimum in-plane shear reinforcement. If the meridional rather than the circumferential axial load is used to calculate in-plane shear capacity, in-plane shear reinforcement is not required, and the full area of meridional reinforcement may be considered in the calculation of the M-P capacity envelope. In this case, the demands are well within the capacity envelope (Figures 9.2.1-11, 9.2.1-33, and 9.2.1-55).

Figures 9.2.1-21, 9.2.1-43, and 9.2.1-65 appear to indicate that a number of demands exceed the capacity envelope at circumferential capacity sections 4, 5, and/or 6. The demands labeled "bottom of wall" correspond to capacity section 4 and are thus acceptable. The demands labeled "haunch" correspond to capacity section 6 where the capacity calculation considers only a portion of the circumferential reinforcement. The circumferential steel in the most lightly reinforced haunch element consists of twelve 1¼-in. square bars.

The area of circumferential reinforcement not considered in the capacity calculation is as follows:

$$(A_s)_{supp} = (A_s)_{haunch} - (A_s)_{capacity\ section\ 6}$$

$$= [12(1.25)^2 \times 12/23.8] - (0.72 + 0.72)$$

$$= 8.01\ in^2/ft$$

where the width of the haunch element is 23.8 in. The tensile capacity associated with the "supplemental" area of reinforcement is as follows:

$$T_{supp} = 0.9(A_s)_{supp}f_y = 0.9(8.01)38,000 = 273,900\ lbf/ft.$$

This minimum additional tensile capacity in the haunch is clearly larger than the margin by which the haunch axial load demand exceeds the capacity section 6 capacity envelope. Therefore, the circumferential haunch demands are acceptable by this simple, rational approach. To confirm the validity of this simple evaluation of supplemental tensile capacity, a refined capacity curve is calculated for the "weakest" haunch element at capacity section 6a. Located just above the upper wall construction joint, the weakest element is considered conservatively to be 12-in. thick with five 1¼-in. square bars along each face. Figure 9.2.1-71 shows that the refined circumferential capacity curve for the weakest haunch element envelops the worst-case haunch demands from Figure 9.2.1-43. This confirms the conclusion of the simple approach, i.e., that the circumferential demands of the upper wall/haunch region are acceptable.

A similar set of M-P diagrams associated with seismic demands computed with best-estimate soil properties rather than lower-bound soil properties is provided in Appendix L. The best-estimate soil-properties case does not control.

9.2.2 Transverse Shear Evaluation

The SASSI code does not report nodal forces or transverse shear for shell elements; therefore, an approximate method based on element equilibrium is used to calculate transverse shears in the tank. The details of the method and the seismic transverse shears obtained via the approach are reported in Appendix G. Seismic transverse shears are computed only for the controlling seismic condition (lower-bound soil properties).

For elements subject to axial compression and shear (ACI 349, Section 11.3.1.2):

$$\phi V_n = \phi 2bd(f_c)^{1/2}[1+(N_u/2000hb)]$$

where ϕ = strength reduction factor = 0.85
V_n = nominal shear load strength (lbf)
b = width of section (in)
d = distance from compressive face to centroid of tensile reinforcement (in)
N_u = compression force in the element (positive value, lbf)
h = thickness of the element (in).

For elements subject to axial tension and shear (ACI 349, Section 11.3.2.3):

$$\phi V_n = \phi 2bd(f_c)^{1/2}[1+(N_u/500hb)]$$

where

N_u = tension force in the element (negative value, lbf).

For capacity sections used to qualify more than one element along a meridian, a conservative approach is used whereby the minimum axial load (N_u) within the range of elements is considered to minimize capacities and the evaluation is made against the maximum shear demand within the same range of elements. Figure 9.2.1-4 identifies the tank capacity locations. Table 9.2.2-1 correlates element numbers to the capacity locations.

Transverse shear capacities using section parameters given in Table 9.2.2-2 are calculated and compared to demands in the spreadsheet *shear.xls* given in Tables 9.2.2-3 to 9.2.2-5. Each table addresses a different nonseismic load case contributing to the total demand. All demands are less than the computed capacities for all load combinations.

9.2.3 In-Plane Shear Evaluation

The in-plane shear capacity is calculated according to the in-plane shear provisions for walls (ACI 349-90, Section 11.10.6, Equation 11-32):

$$\phi V_c = \phi\{3.3(f_c)^{1/2}hd+N_u d/4(l_w)\}$$

where

ϕ = strength reduction factor = 0.85
d = width of element = 12 in.
N_u = minimum factored axial load (positive for compression, lbf)
l_w = width of element = 12 in.

Equation 11-32 is used because bending moment about the short axis of the shell cross section is negligible; therefore, Equation 11-33 does not apply, and d, the distance from the extreme compression fiber to the centroid of the longitudinal steel, may reasonably be considered equal to the length of the "wall" (width of the shell element).

In ACI 349-90, Section 11.10.8, $\phi V_c/2$ is identified as the maximum shear allowed without shear reinforcing requirements. The spreadsheet *twist.xls* in Tables 9.2.3-1 to 9.2.3-3 provides the in-plane shear demands and the associated capacities. Each table addresses a different nonseismic load case contributing to the total demand. For most sections, the demand is less than $\phi V_c/2$ and is therefore acceptable. For the remaining sections, in-plane shear demand exceeds $\phi V_c/2$ but is less than ϕV_c. For those sections, a minimum area of longitudinal reinforcement equal to 0.0025 bt is required per ACI 349-90, Sections 11.10.9.2 and 11.10.9.4, where b is the width of the element and t is the element thickness. This minimum area of in-plane shear reinforcement is subtracted from the total area of longitudinal reinforcement when calculating the capacity envelopes for combined bending and axial load (M-P diagrams).

9.2.4 Twisting Moment Evaluation

Twisting moments (MXY) are reported by ABAQUS and SASSI for the tank shell elements. This twisting moment can be likened to torsion in a beam. The threshold below which torsion may be neglected is calculated according to ACI 349-90, Section 11.6.1:

$$T_{threshold} = \phi 0.5(f_c)^{1/2} x^2 y$$

where

ϕ = strength reduction factor = 0.85
x = thickness of element (in)
y = width of element = 12 in.

Twisting moment in the tank shell sections is evaluated via the spreadsheet *twist.xls* provided in Tables 9.2.3-1 to 9.2.3-3. Each table addresses a different nonseismic load case contributing to the total demand. In these tables, the element twisting demands are compared with the threshold values of twisting moment. All demands are less than the threshold values and therefore can be neglected.

9.2.5 Construction Joint Evaluation

Shear-friction capacity at a construction joint is calculated according to ACI 349, Section 11.7.4.1:

$$\phi V_n = \phi A_v f_y \mu$$

where

ϕ = strength reduction factor = 0.85
A_v = area of shear-friction reinforcement (in^2)
f_y = yield stress of the reinforcement (lbf/in^2)
μ = coefficient of friction = 0.6.

Further, according to ACI 349, Section 11.7.5, the following restrictions on shear-friction capacity apply:

$$\phi V_n < \phi(0.2)(f_c)(A_c)$$
$$\phi V_n < \phi(800)(A_c)$$

where A_c = area of concrete resisting shear transfer = 12t (in^2)
t = shell thickness (in).

<u>Upper Wall</u>

For the construction joint located in the wall at a distance 16 ft-8 in. from the top of the footing;

A_v = 2(0.44) = 0.88 in^2
f_y = 38,000 lbf/in^2
f_c = 4418 lbf/in^2
A_c = 12(12) = 144 in^2.

Thus, the shear-friction capacity is 17,054 lbf.

Transverse shear demands at the upper construction joint (capacity section 6) are reported in Tables 9.2.2-3 to 9.2.2-5:

Nonseismic load case 1a + seismic (lower-bound soil): 9,866 lbf
Nonseismic load case 1b + seismic (lower-bound soil): 10,218 lbf
Nonseismic load case 2 + seismic (lower-bound soil): 9,712 lbf.

Demands are less than the capacities; therefore, the upper construction joint in the tank wall is acceptable.

Lower Wall

For the construction joint at the base of the wall,

A_v = 2(0.44) = 0.88 in^2
f_y = 37,631 lbf/in^2
f'_c = 3899 lbf/in^2
A_c = 12(12) = 144 in^2.

Thus, the shear-friction capacity is 16,889 lbf.

Transverse shear demands at the lower construction joint (capacity section 4a) are reported in Tables 9.2.2-3 to 9.2.2-5:

Nonseismic load case 1a + seismic (lower-bound soil): 14,067 lbf
Nonseismic load case 1b + seismic (lower-bound soil): 14,390 lbf
Nonseismic load case 2 + seismic (lower-bound soil): 14,310 lbf.

Demands are less than the capacities; therefore, the construction joint at the base of the wall is acceptable.

9.3 RISER EVALUATION

Demands in the risers from nonseismic loads are assumed to be small and are neglected. Seismic demands on the risers are computed by SASSI with the pits and risers modeled as described in Section 5.3.4 and consider only best-estimate soil properties. The total seismic demand in each riser is calculated as the SRSS of the demand from vertical excitation and maximum of the demands from the two horizontal excitations. Only the worst of the two horizontal excitations need be considered, as the risers are modeled as beams with axisymmetric cross sections.

Capacities of the risers are based on the provisions given in AISC (AISC 1989). The allowable shear stress is calculated according to AISC, Section F4:

$$F_v = 0.4F_y \cdot 1.33$$

where

F_y = yield strength of the riser steel = 30,000 lbf/in^2.

In accordance with AISC Section A5.2, an increase factor equal to 1.33 is included in the allowables for seismic load combinations.

The allowable axial stress (tension or compression) is calculated per AISC, Section E2:

$$F_a = 0.6F_y \cdot 1.33.$$

In determining the compression allowable, the risers are assumed to be supported continuously in the lateral direction by the soil.

The allowable bending stress for a compact circular section is calculated per AISC, Section F3:

$$F_b = 0.66F_y \cdot 1.33.$$

The section is compact if the diameter-to-thickness ratio is less than $3300/F_y$ (AISC, Section B5).

When axial stress demand is less than or equal to 15% of the axial stress limit, a linear interaction equation for combined bending and axial load is used in accordance with AISC, Section H1.

Capacities are calculated in the spreadsheet *risers.xls* shown in Table 9.3-1. This spreadsheet also tabulates the three sets (three excitation directions) of seismic demands computed by SASSI and combines them to obtain the total seismic demands. Demand forces and moments are transformed into corresponding stresses. Demand-to-capacity stress ratios for shear and combined moment and axial load are shown to be less than unity; therefore, the risers are acceptable. The effect of soil property variation on riser demands is not an issue because the residual capacities of the risers are large.

Figure 9.2.1-1. Typical Moment-Axial Load Interaction Diagram.

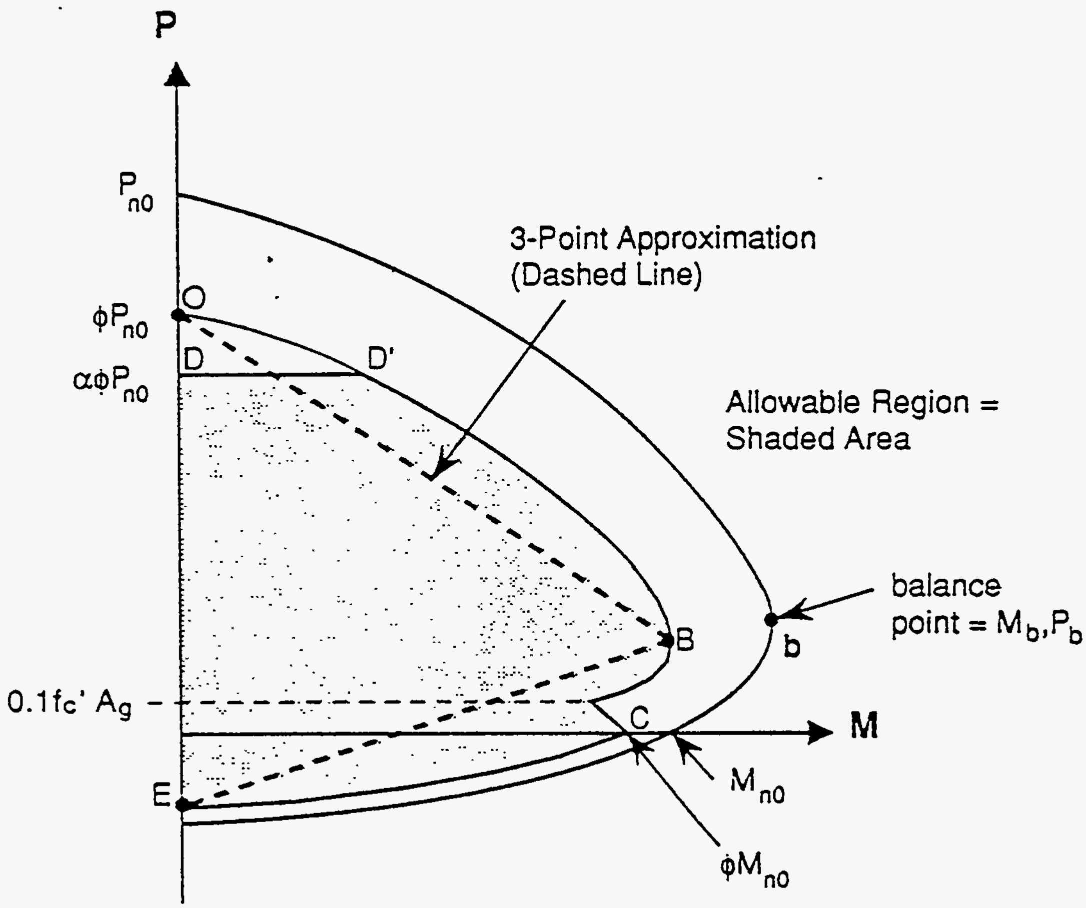


Figure 9.2.1-2. Axial Compression with No Bending.

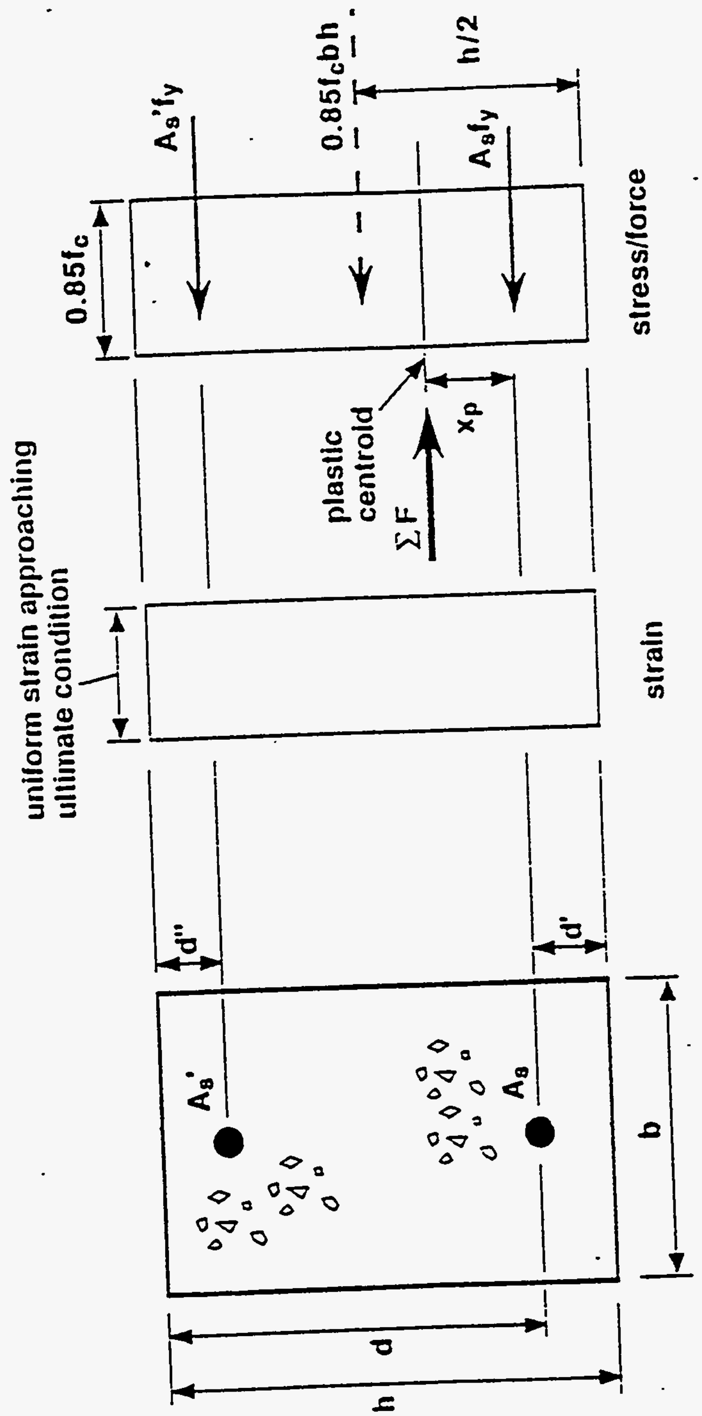


Figure 9.2.1-3. Balanced Condition for Combined Bending and Axial Compression.

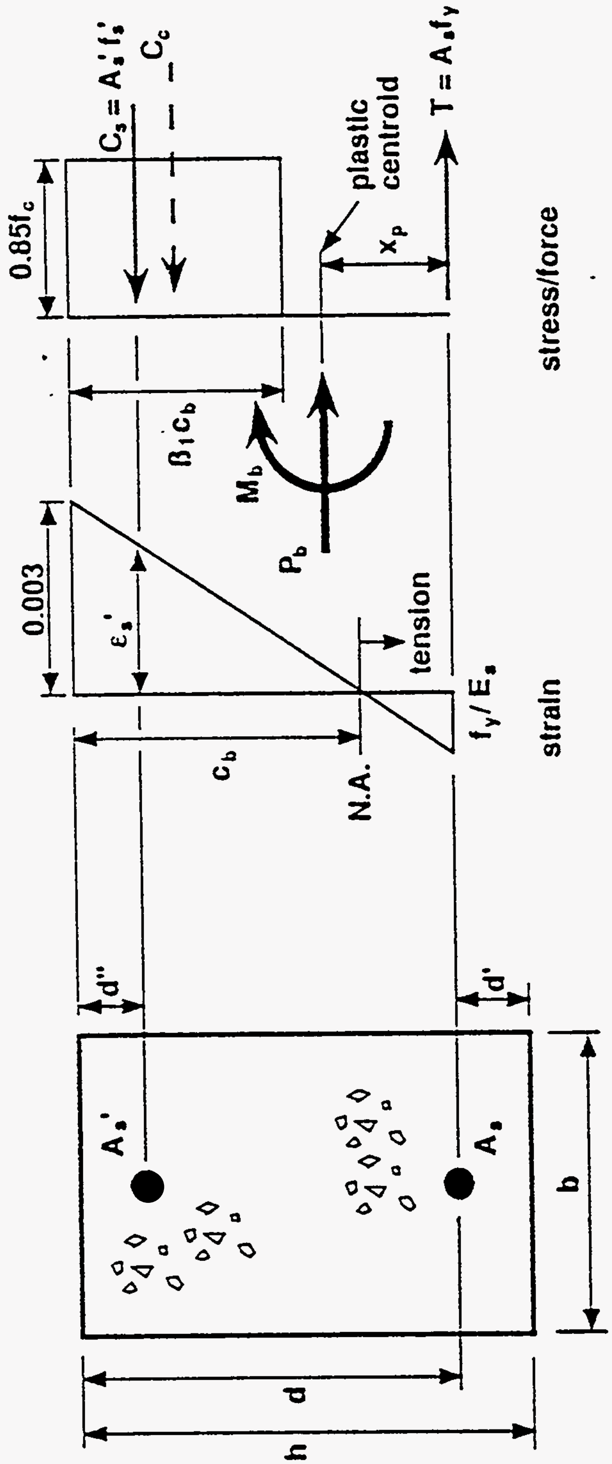


Figure 9.2.1-4. Capacity Sections for American Concrete Institute Code Evaluation.

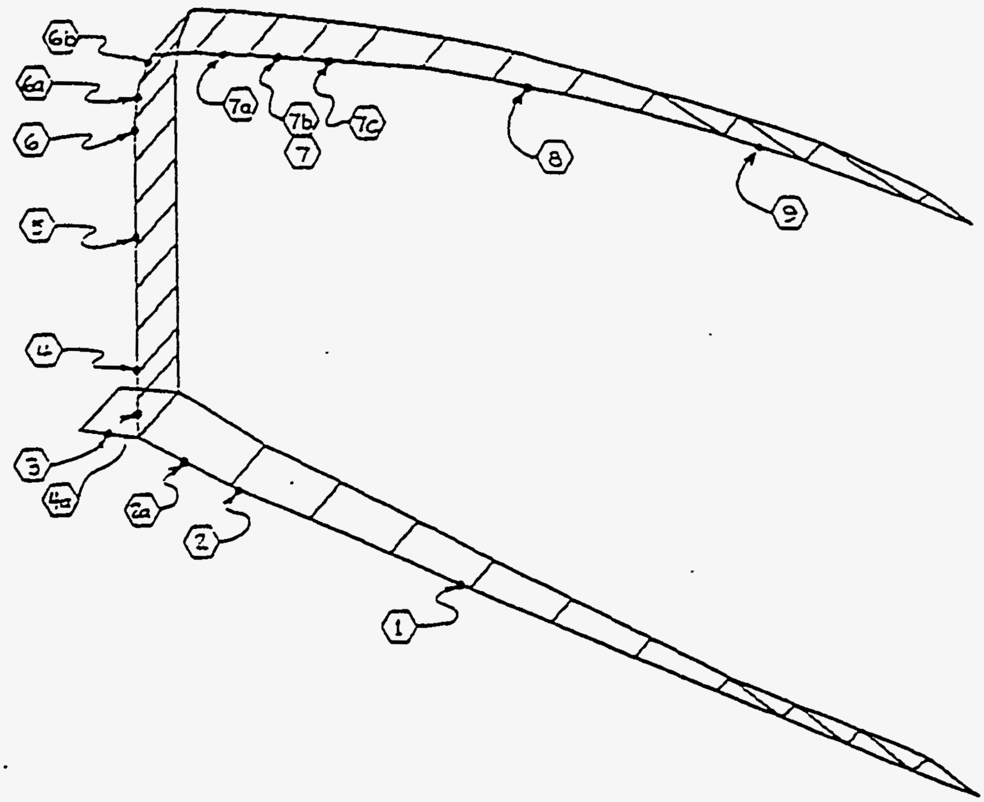
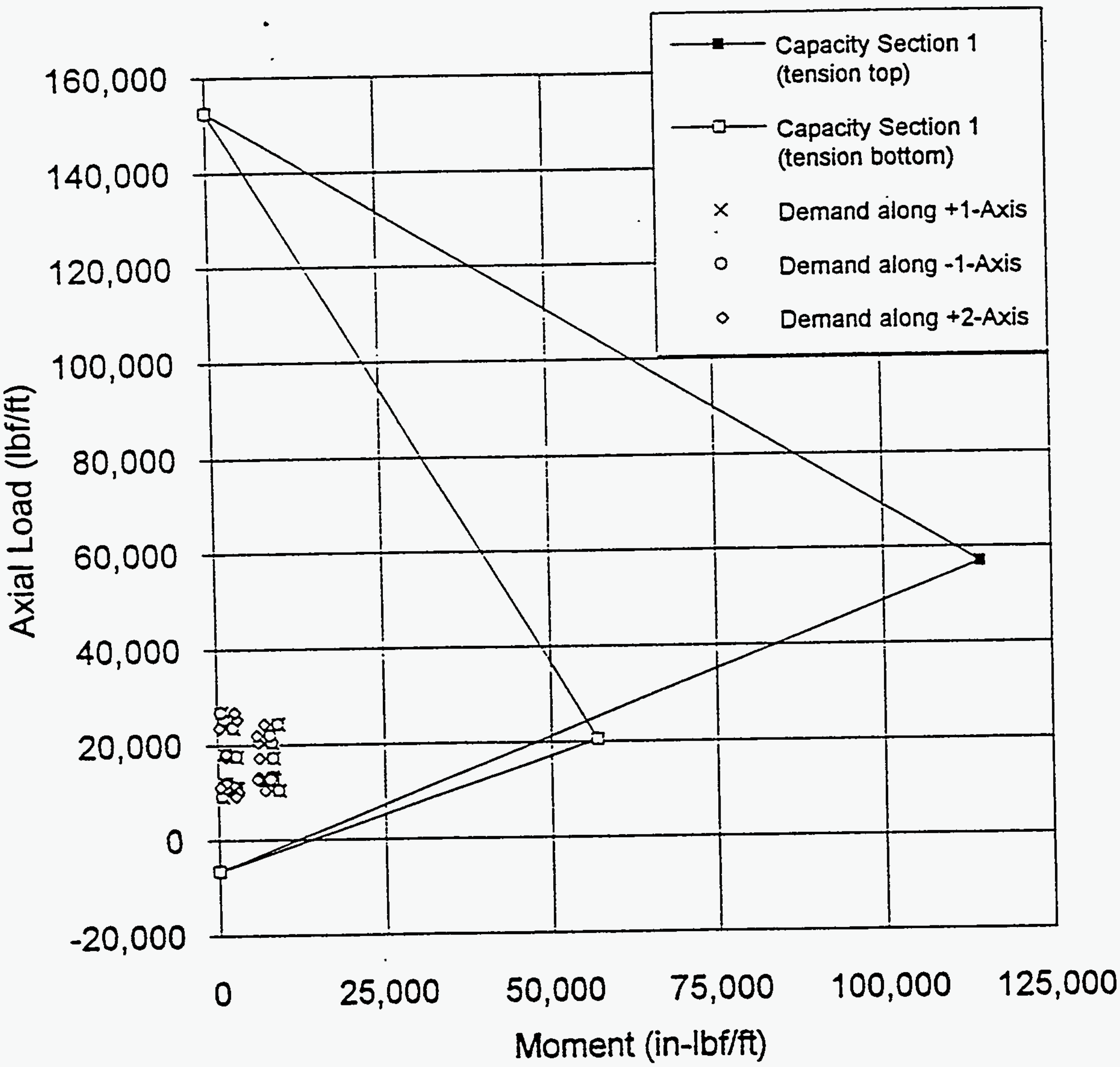
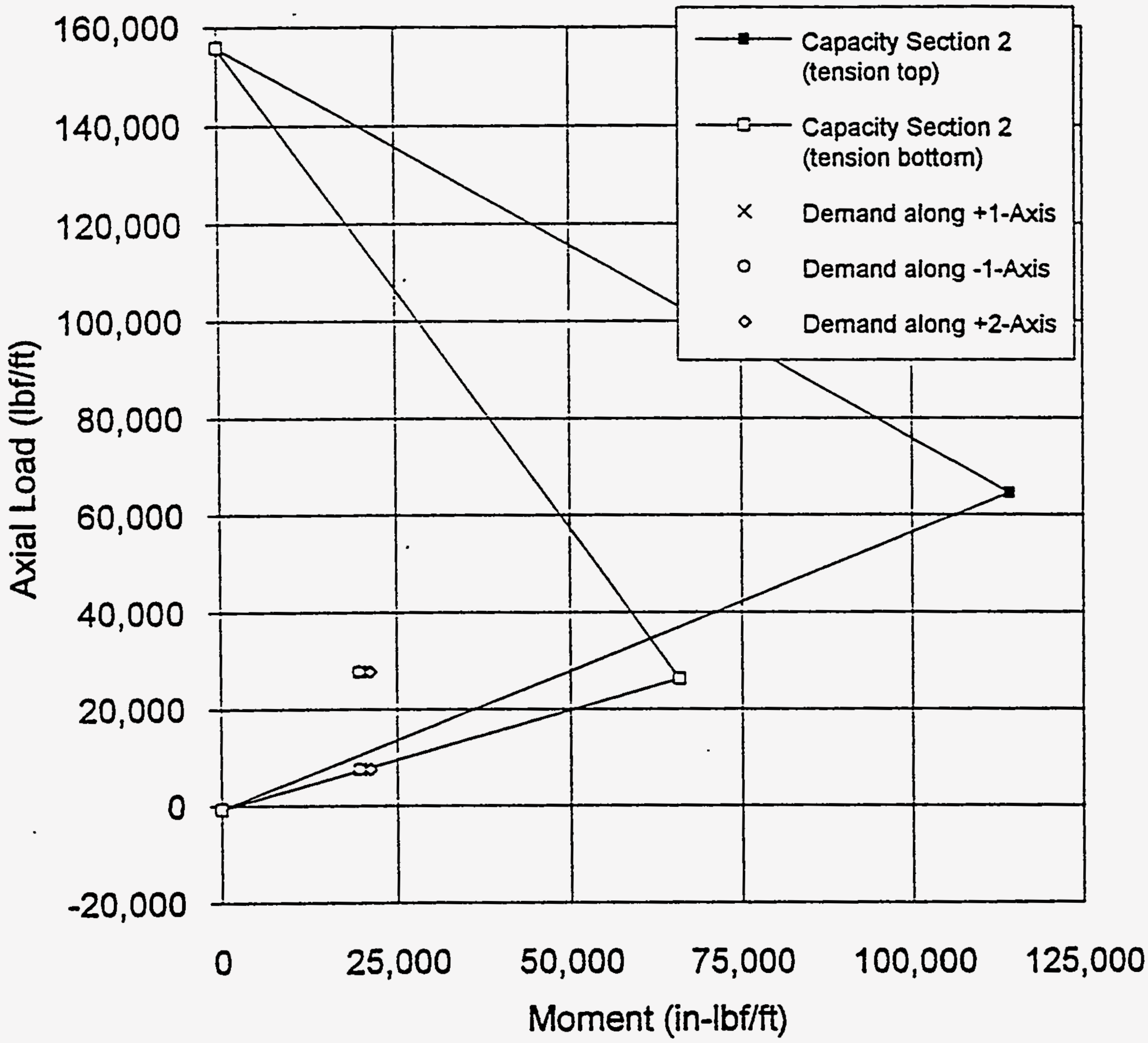


Figure 9.2.1-5. Meridional Moment-Axial Load Interaction Diagram for Inner Base Sections: Nonseismic (Load Case 1a) + Seismic (Lower-Bound Soil Properties).



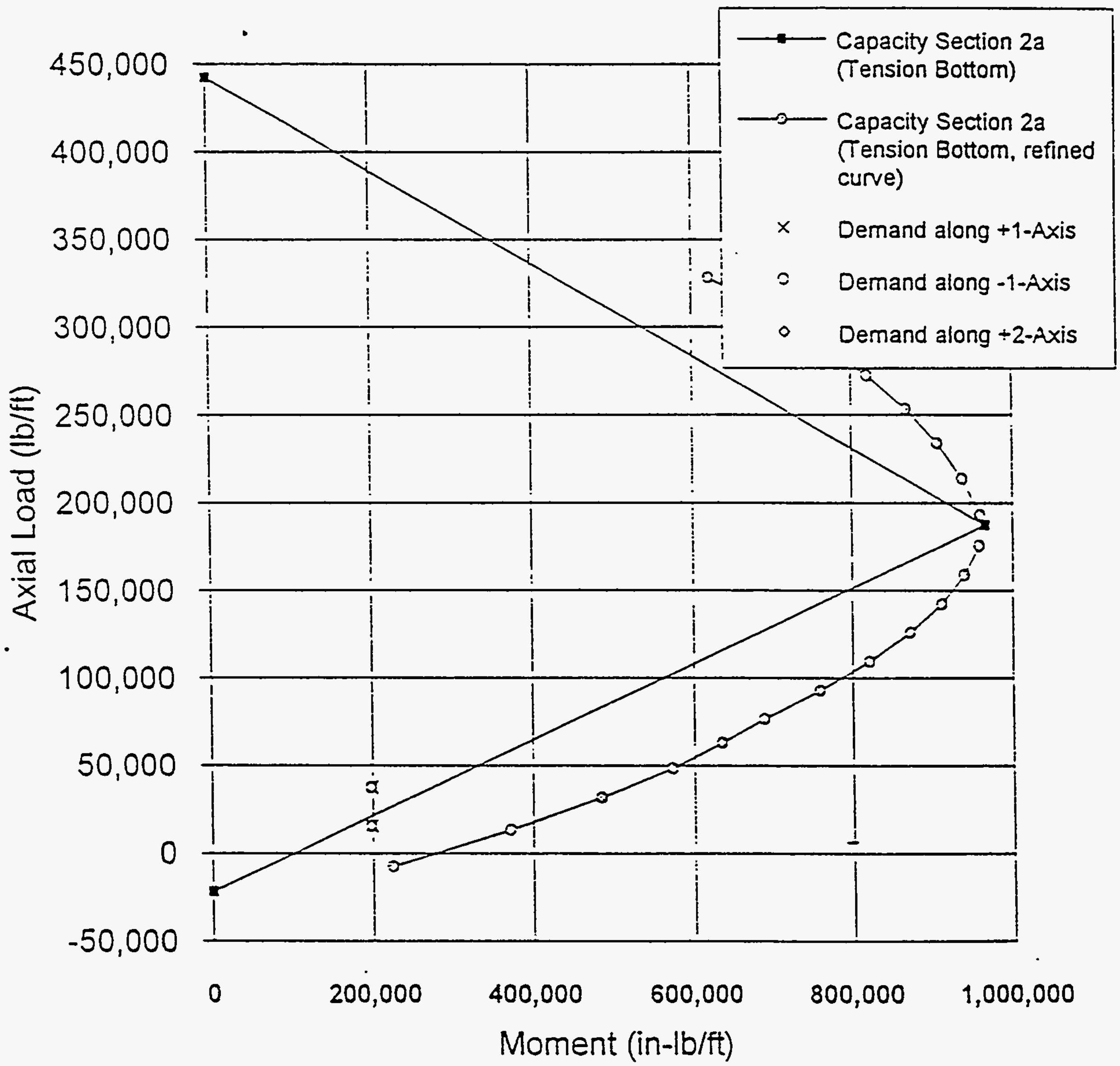
M1-1.XLC

Figure 9.2.1-6. Meridional Moment-Axial Load Interaction Diagram for Outer Base Sections: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound SoilProperties).



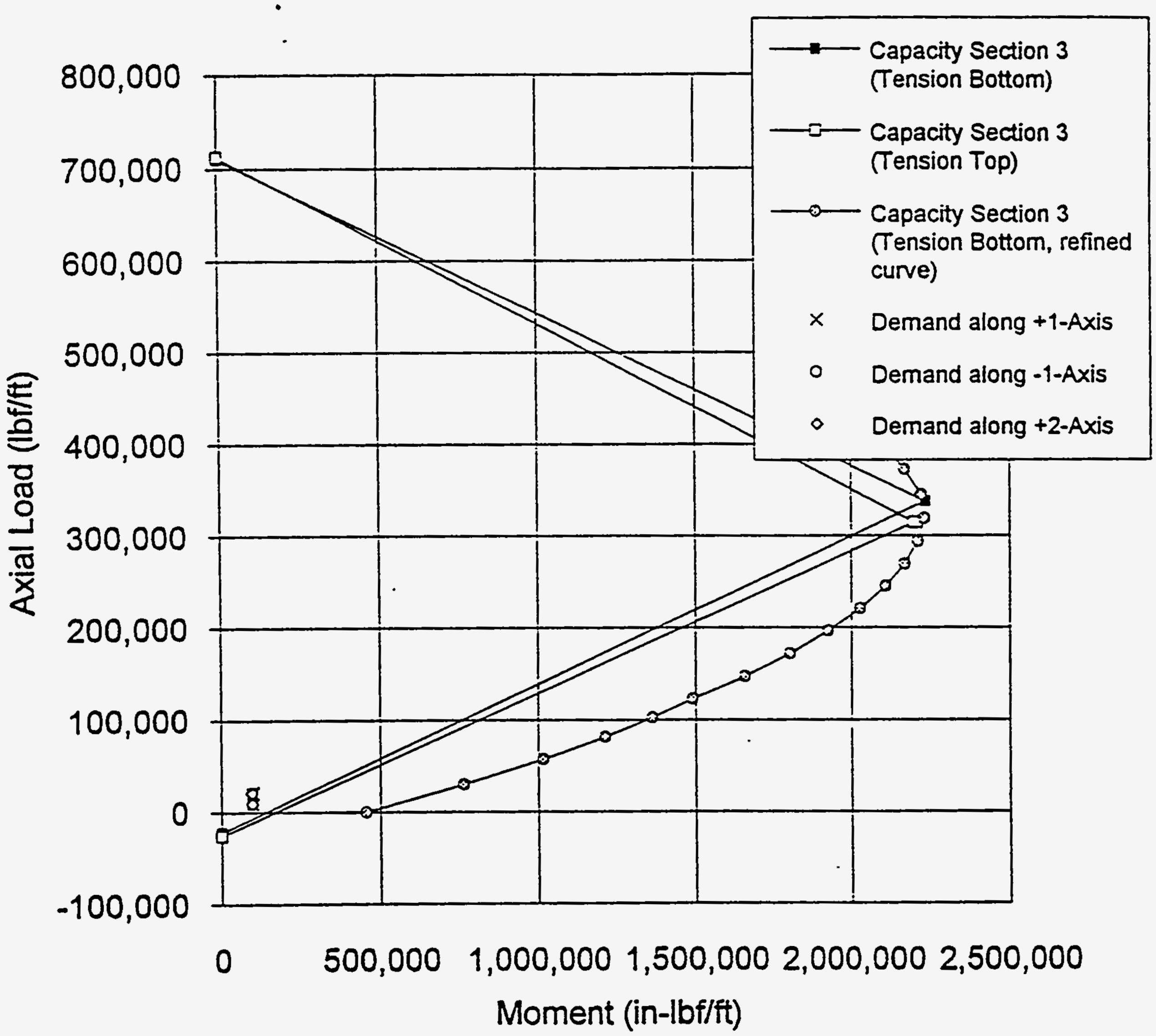
M1-2.XLC

Figure 9.2.1-7. Meridional Moment-Axial Load Interaction Diagram for Floor/Wall Interface Section: Nonseismic (Load Case 1a) Plus Sesimic (Lower-Bound Soil Properties).



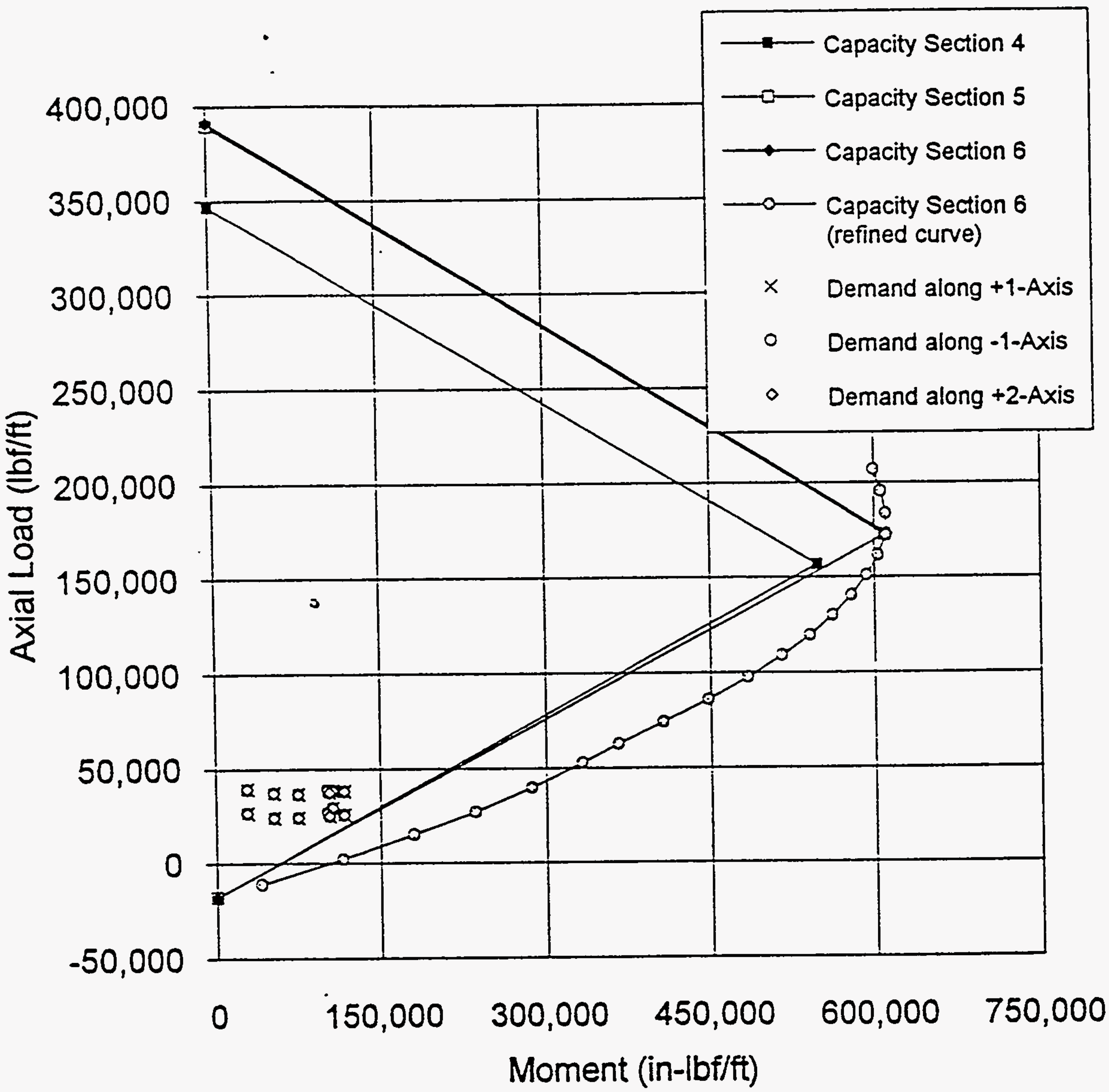
M1-2A.XLC

Figure 9.2.1-8. Meridional Moment-Axial Load Interaction Diagram for Footing Section: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



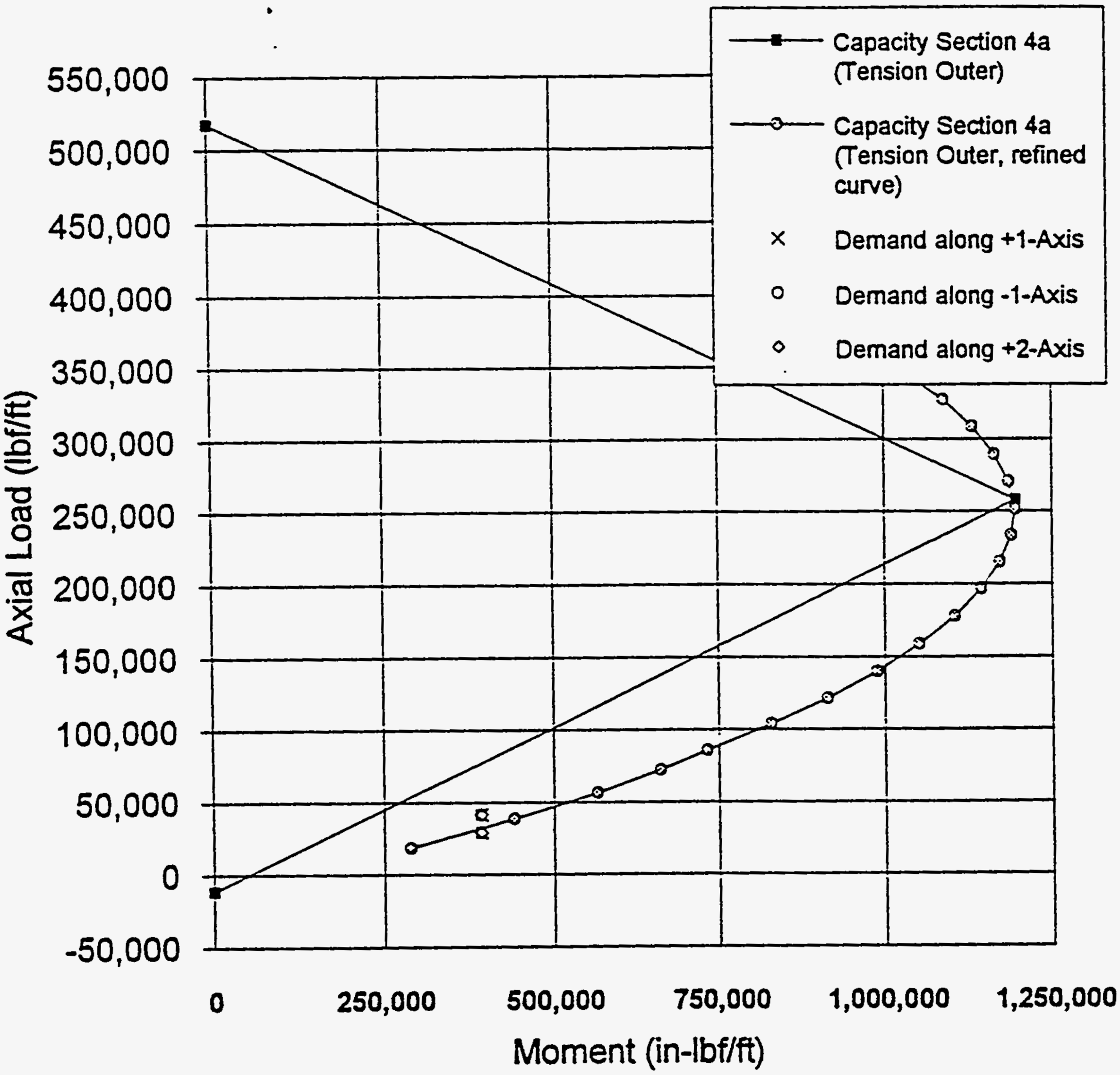
M1-3.XLC

Figure 9.2.1-9. Meridional Moment-Axial Load Interaction Diagram for Inner Base Sections: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



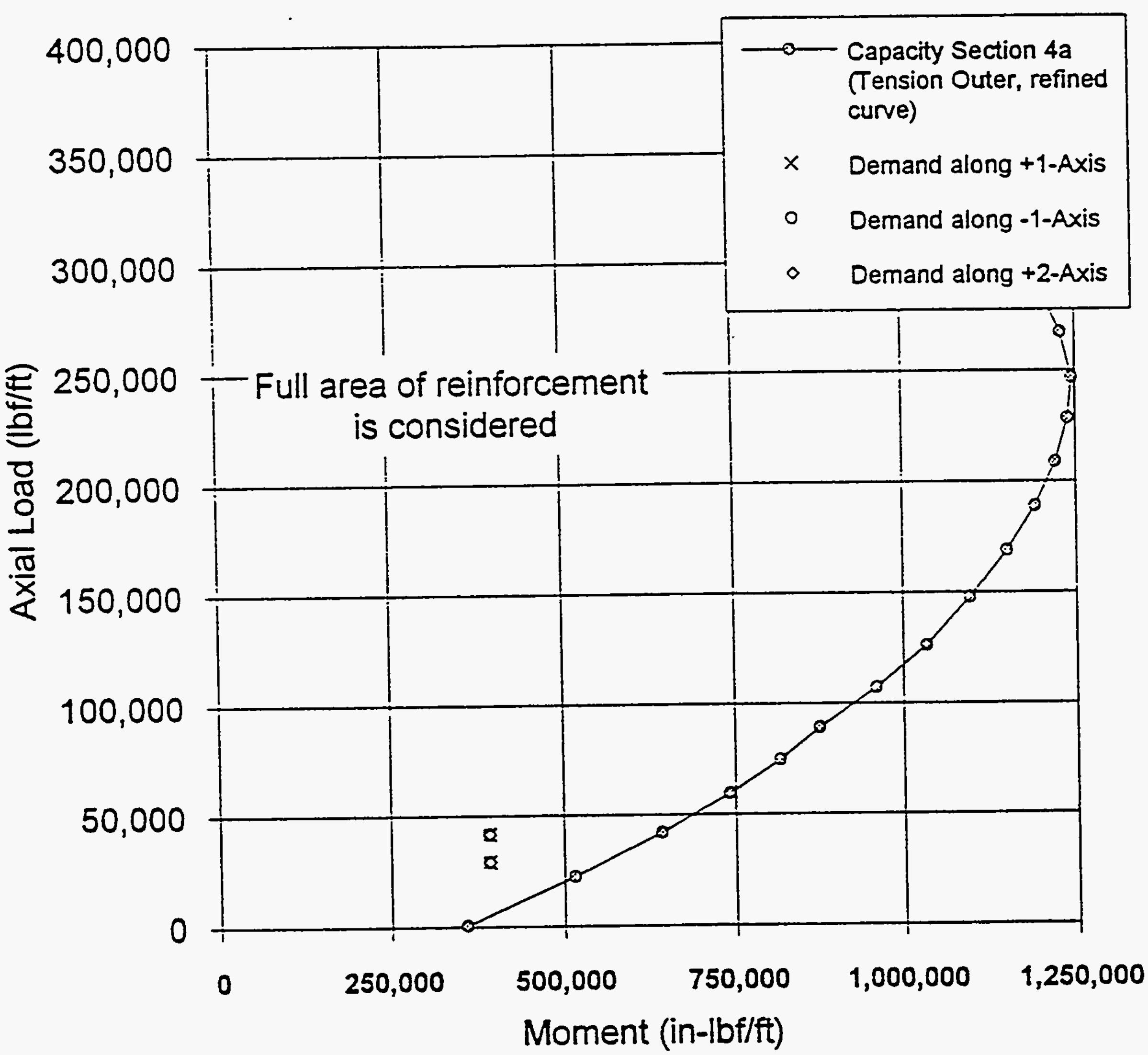
M1-456.XLC

Figure 9.2.1-10. Meridional Moment-Axial Load Interaction Diagram for Lower Wall Sections (Reduced Reinforcement): Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



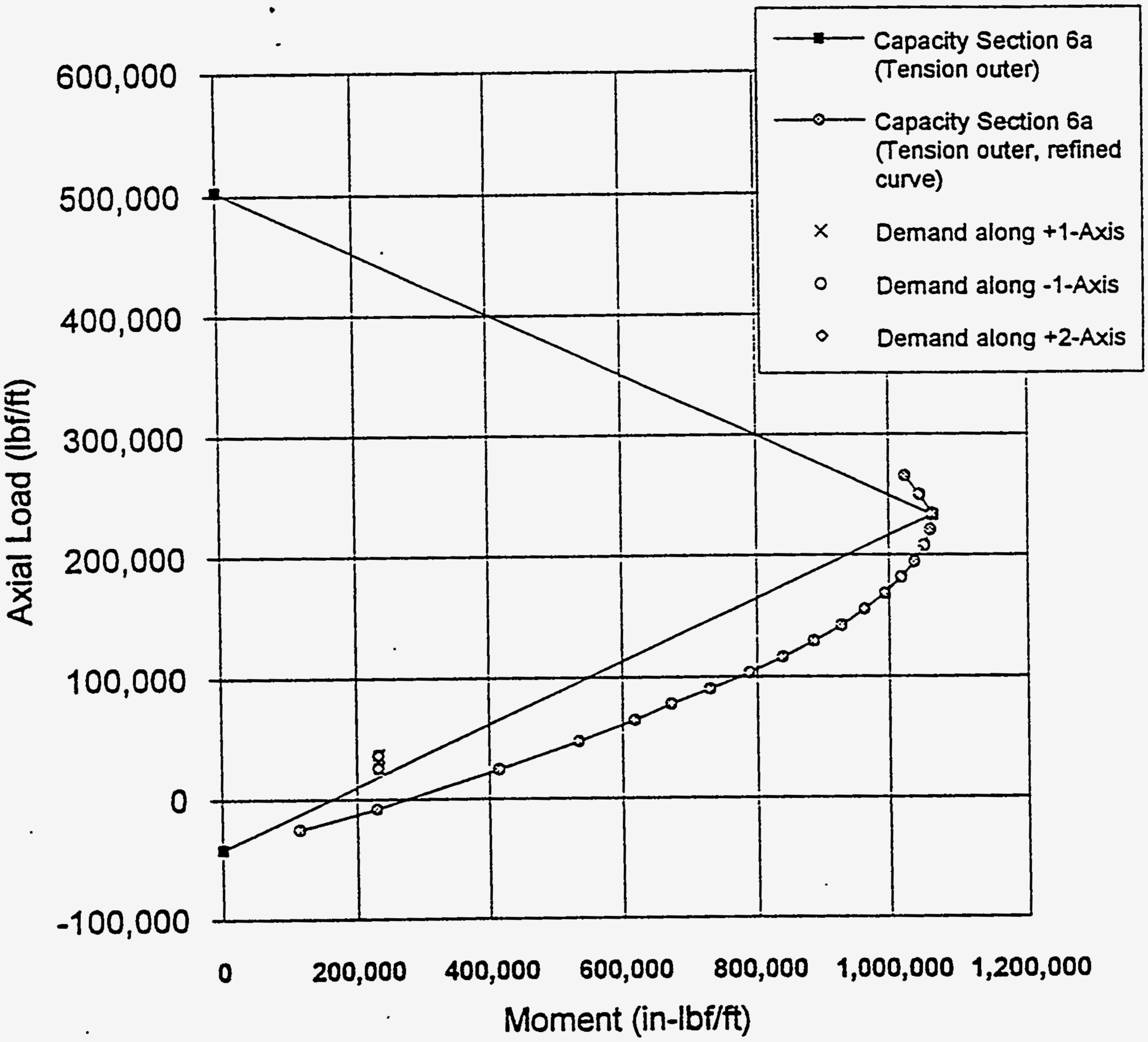
M1-4A.XLC

Figure 9.2.1-11. Meridional Moment-Axial Load Interaction Diagram for Lower Wall Section: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



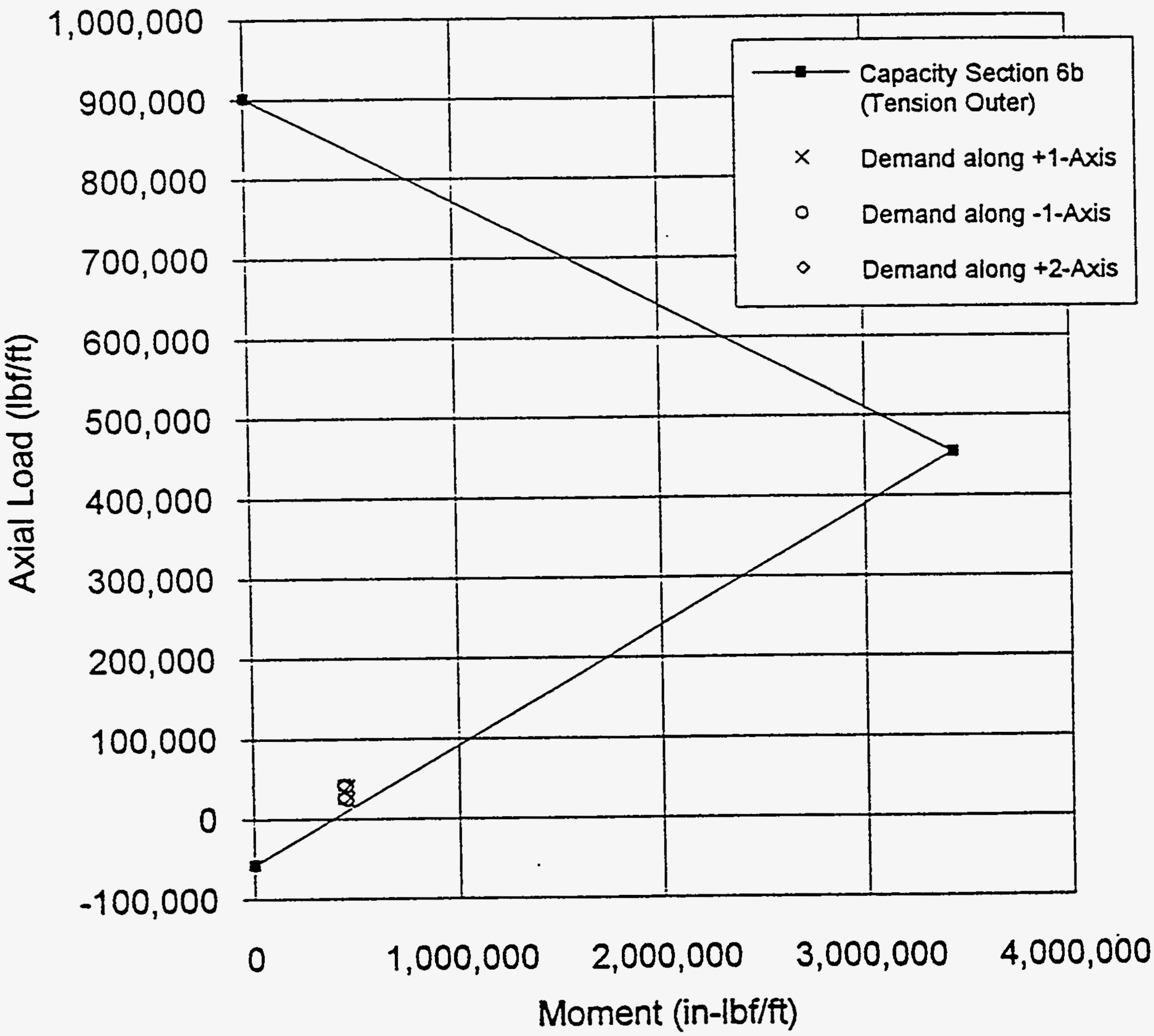
M1-4A-2.XLC

Figure 9.2.1-12. Meridional Moment-Axial Load Interaction Diagram for Wall/Haunch Interface Section: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



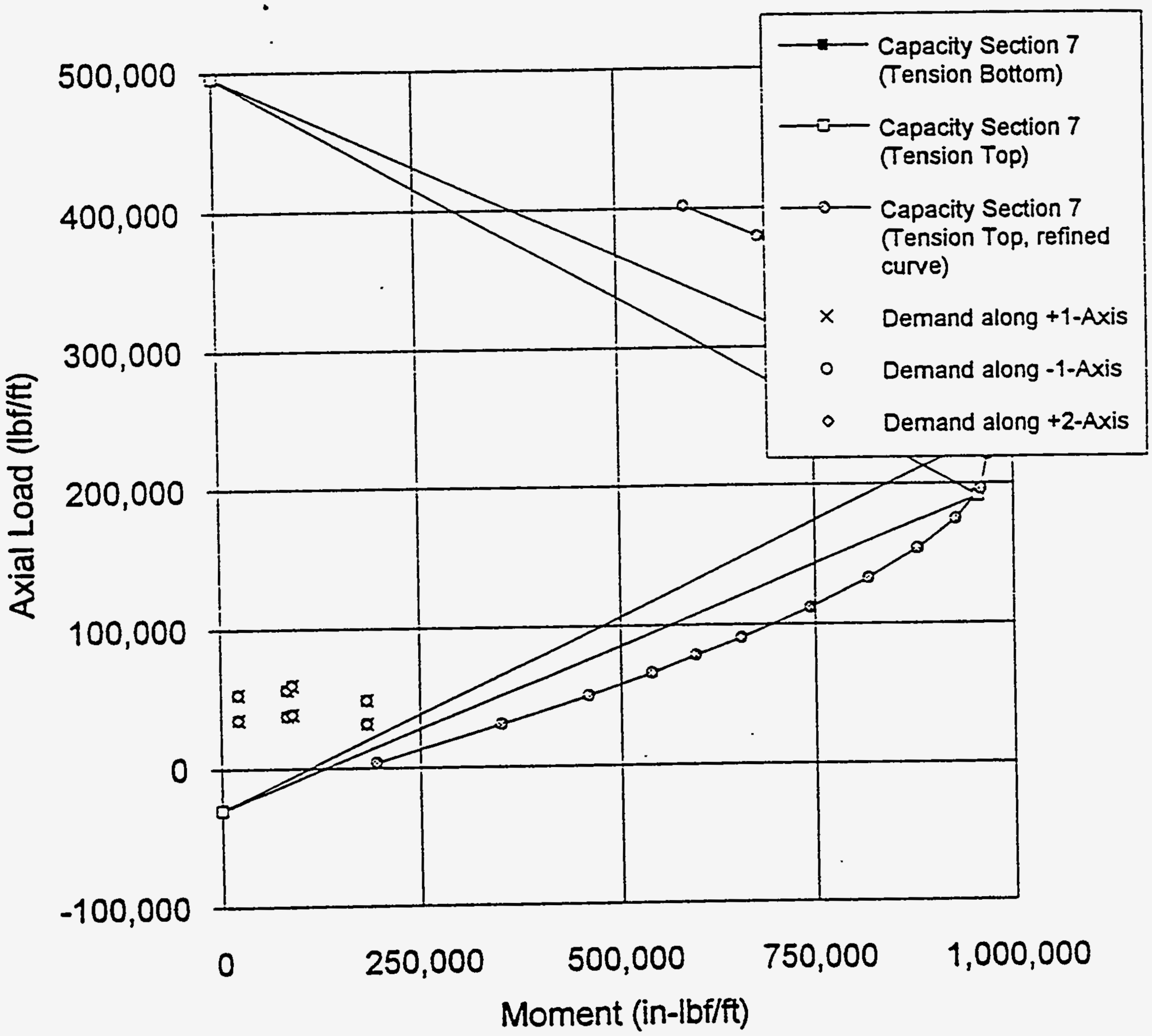
M1-6A.XLC

Figure 9.2.1-13. Meridional Moment-Axial Load Interaction Diagram for Haunch Section: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



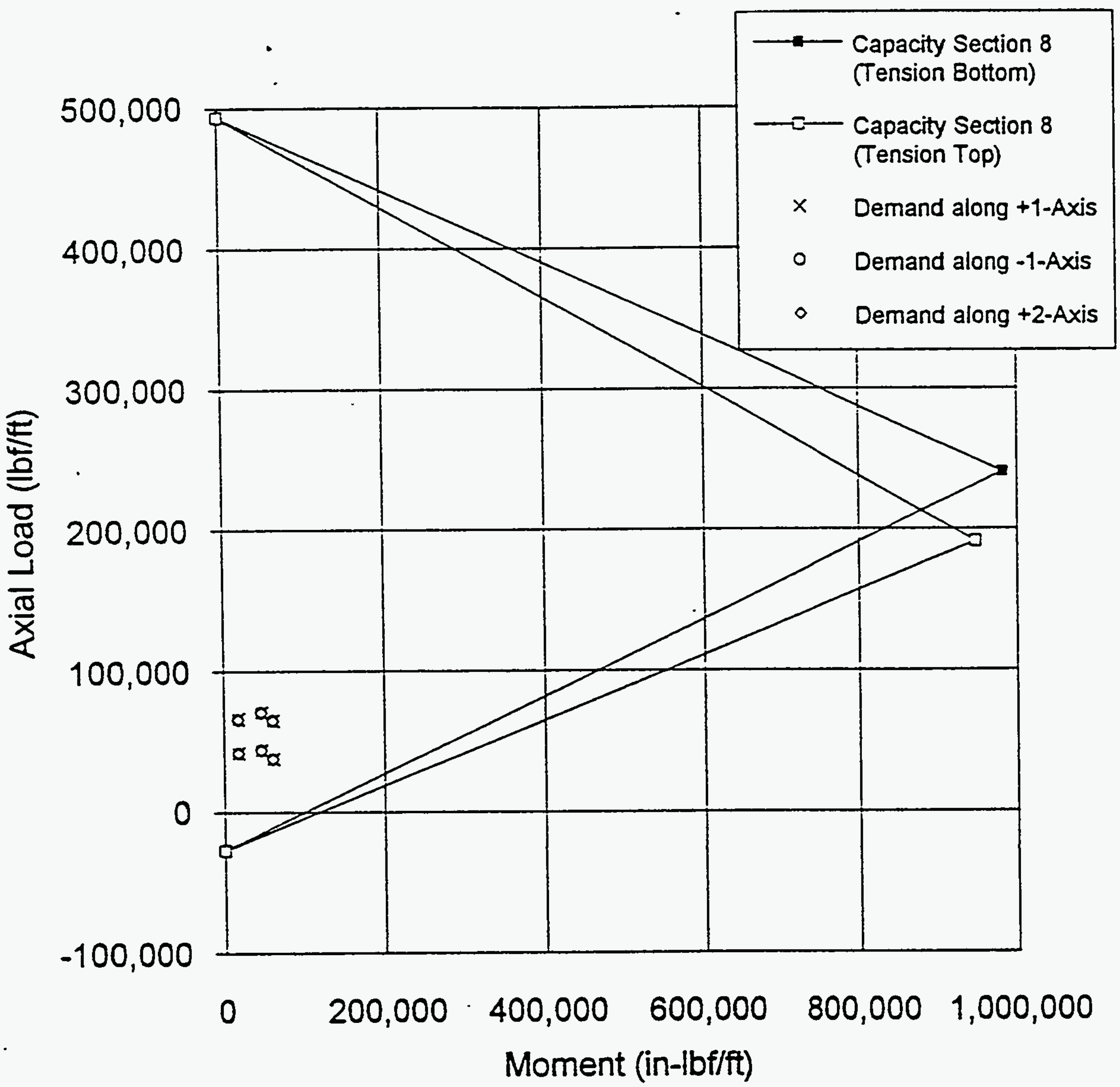
M1-6B.XLC

Figure 9.2.1-14. Meridional Moment-Axial Load Interaction Diagram for Haunch/Dome Interface Section: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



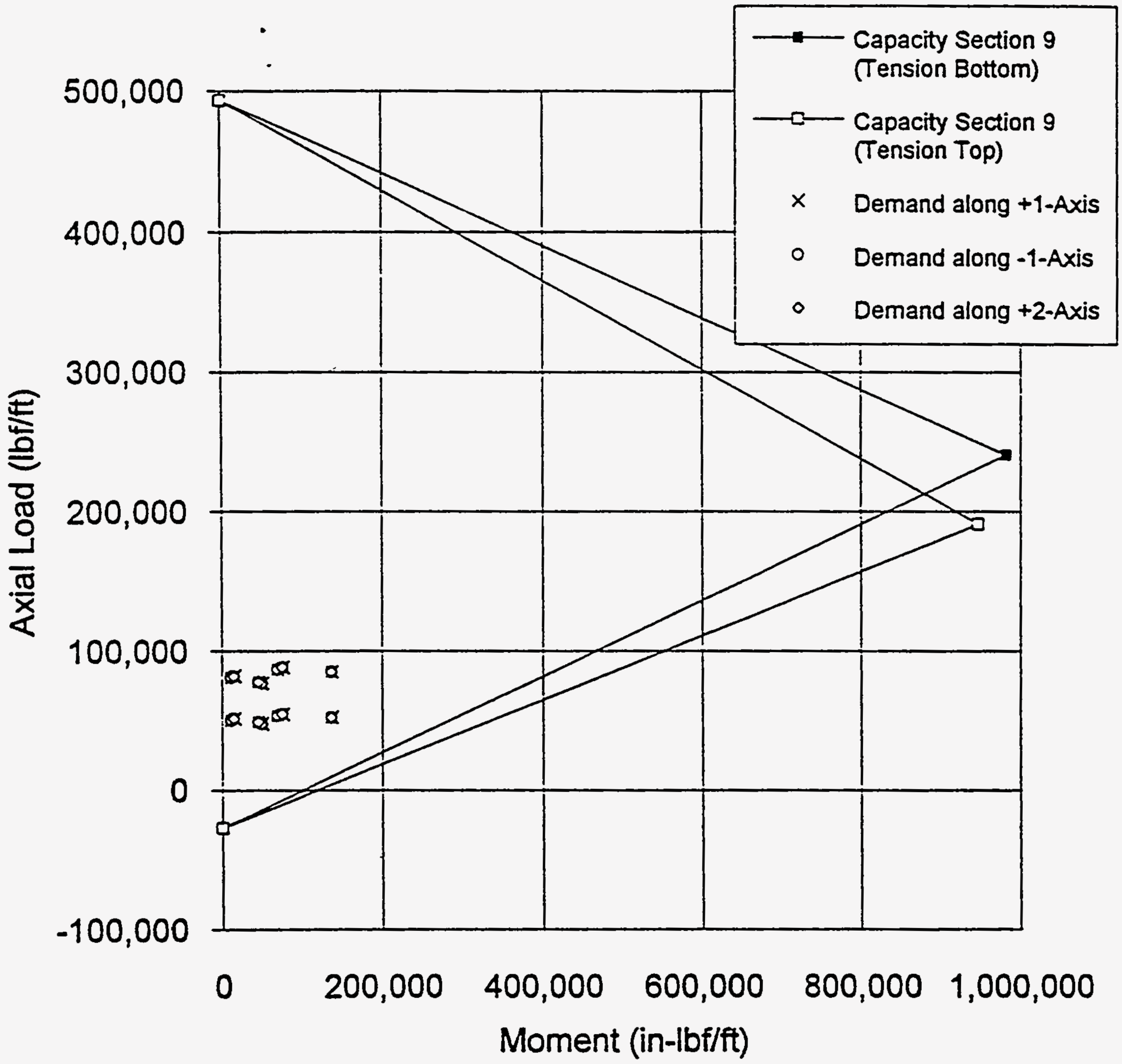
M1-7.XLC

Figure 9.2.1-15. Meridional Moment-Axial Load Interaction Diagram for Intermediate Dome Sections: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



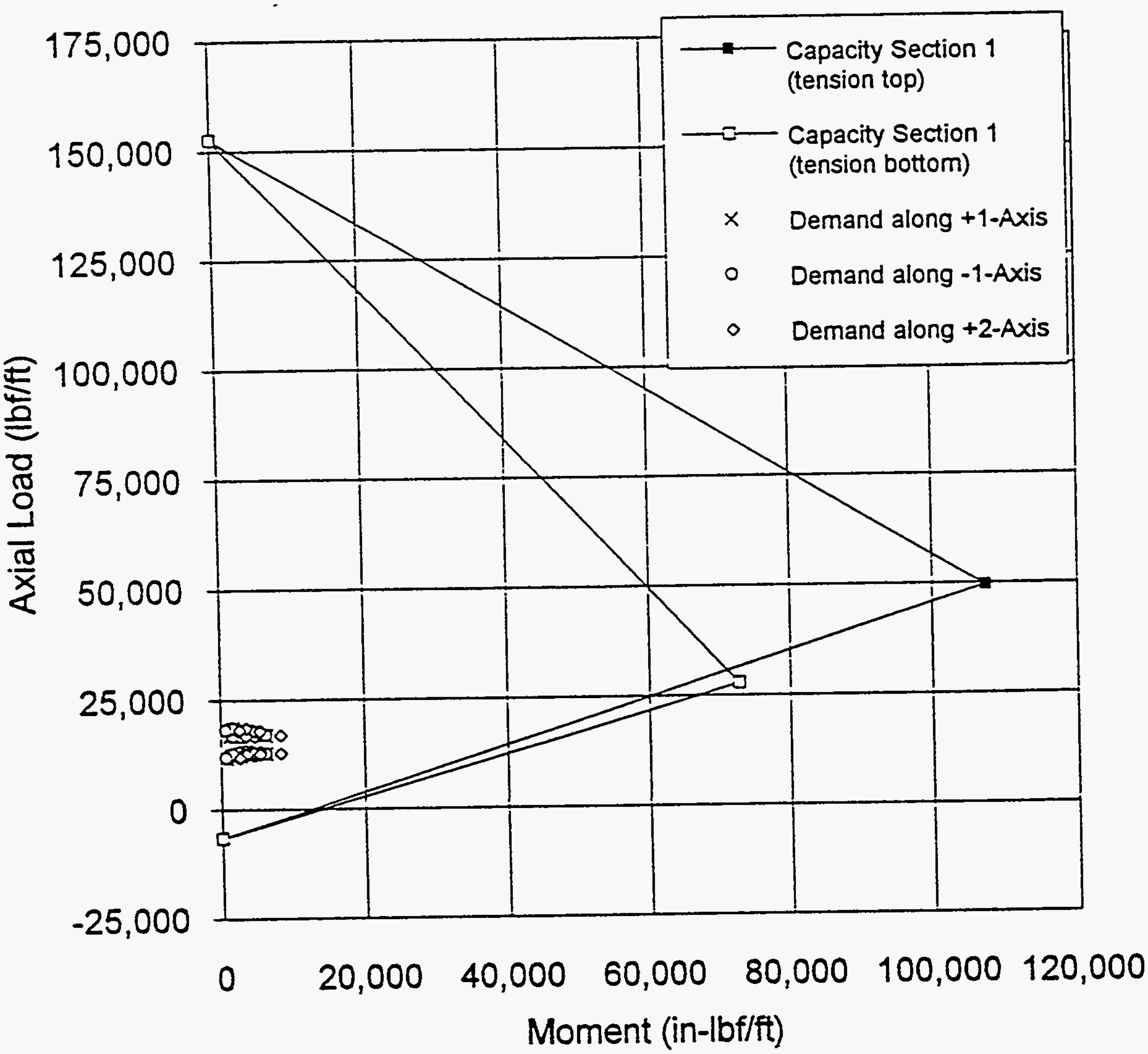
M1-8.XLC

Figure 9.2.1-16. Meridional Moment-Axial Load Interaction Diagram for Dome Sections Near Apex: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



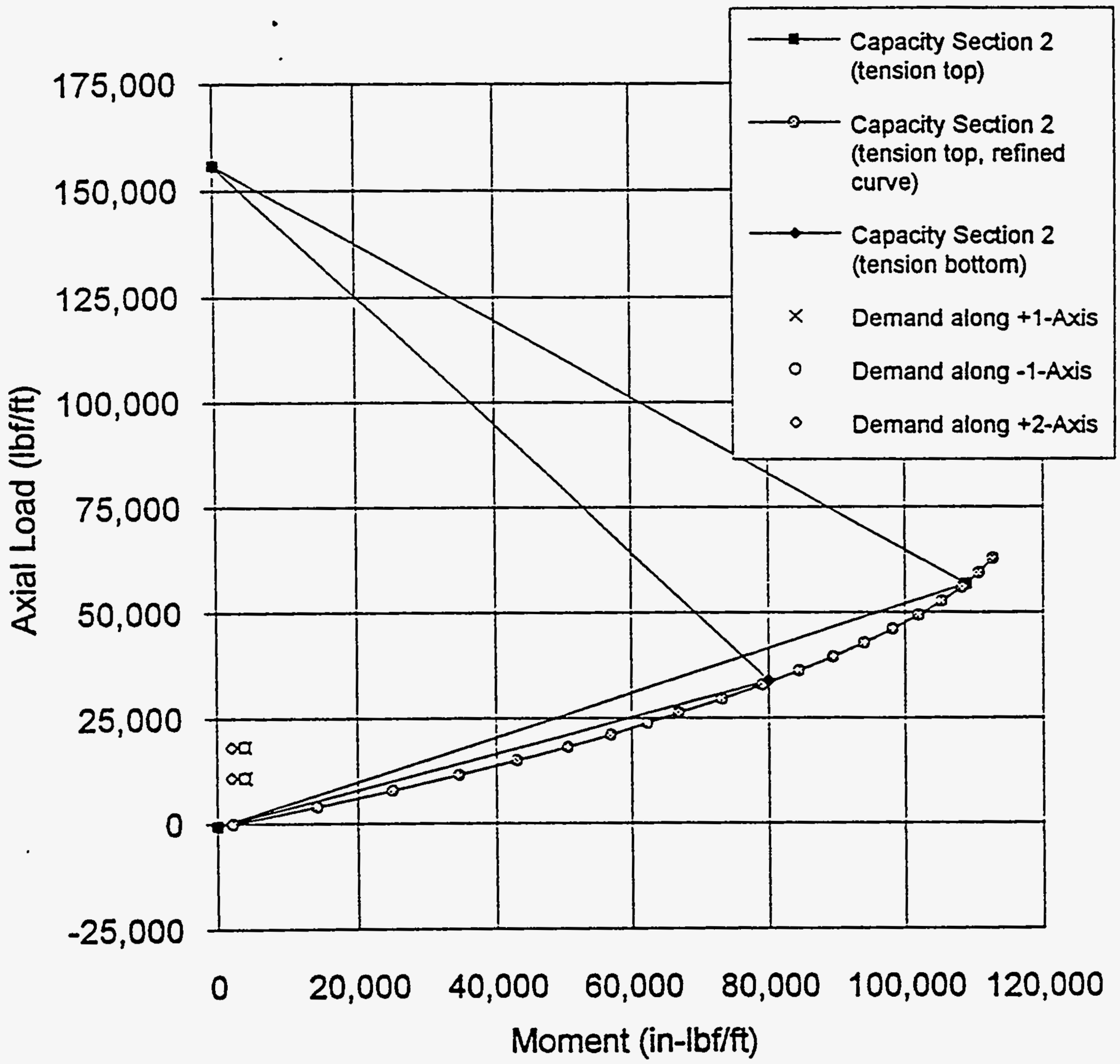
M1-9.XLC

Figure 9.2.1-17. Circumferential Moment-Axial Load Interaction Diagram for Inner Base Sections: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



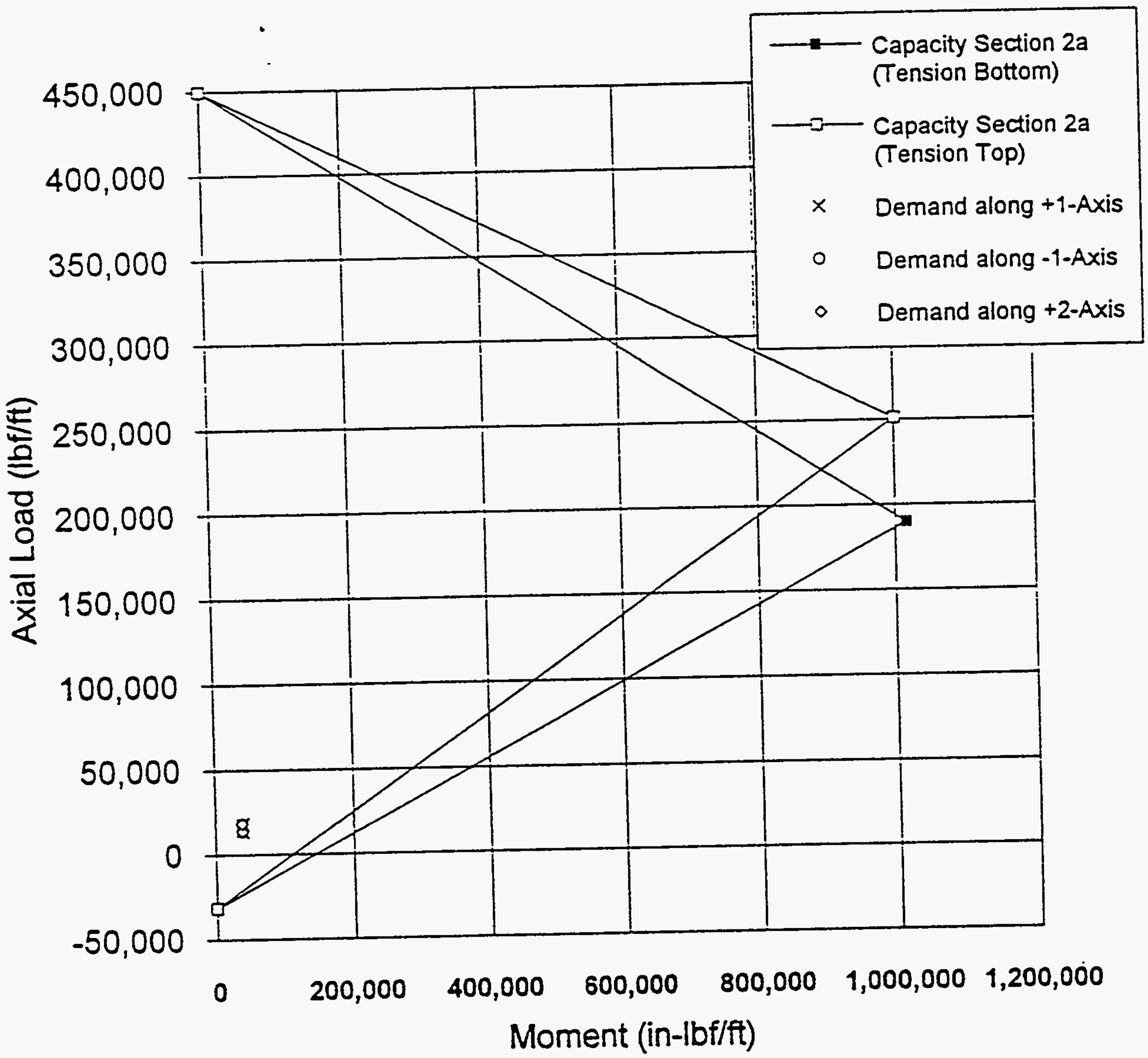
C1-1.XLC

Figure 9.2.1-18. Circumferential Moment-Axial Load Interaction Diagram for Outer Base Sections: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



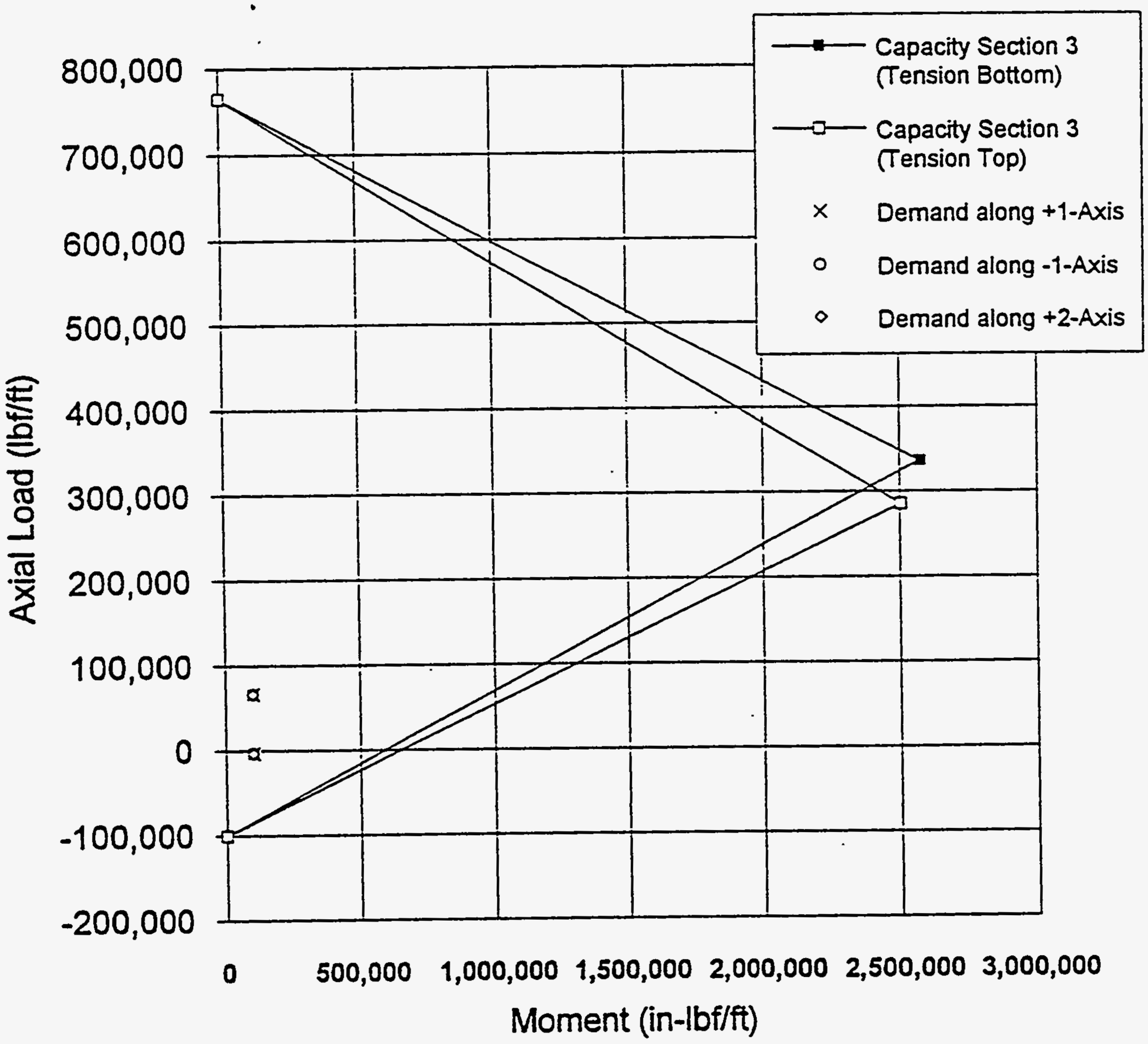
C1-2.XLC

Figure 9.2.1-19. Circumferential Moment-Axial Load Interaction Diagram for Base/Wall Interface Section: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



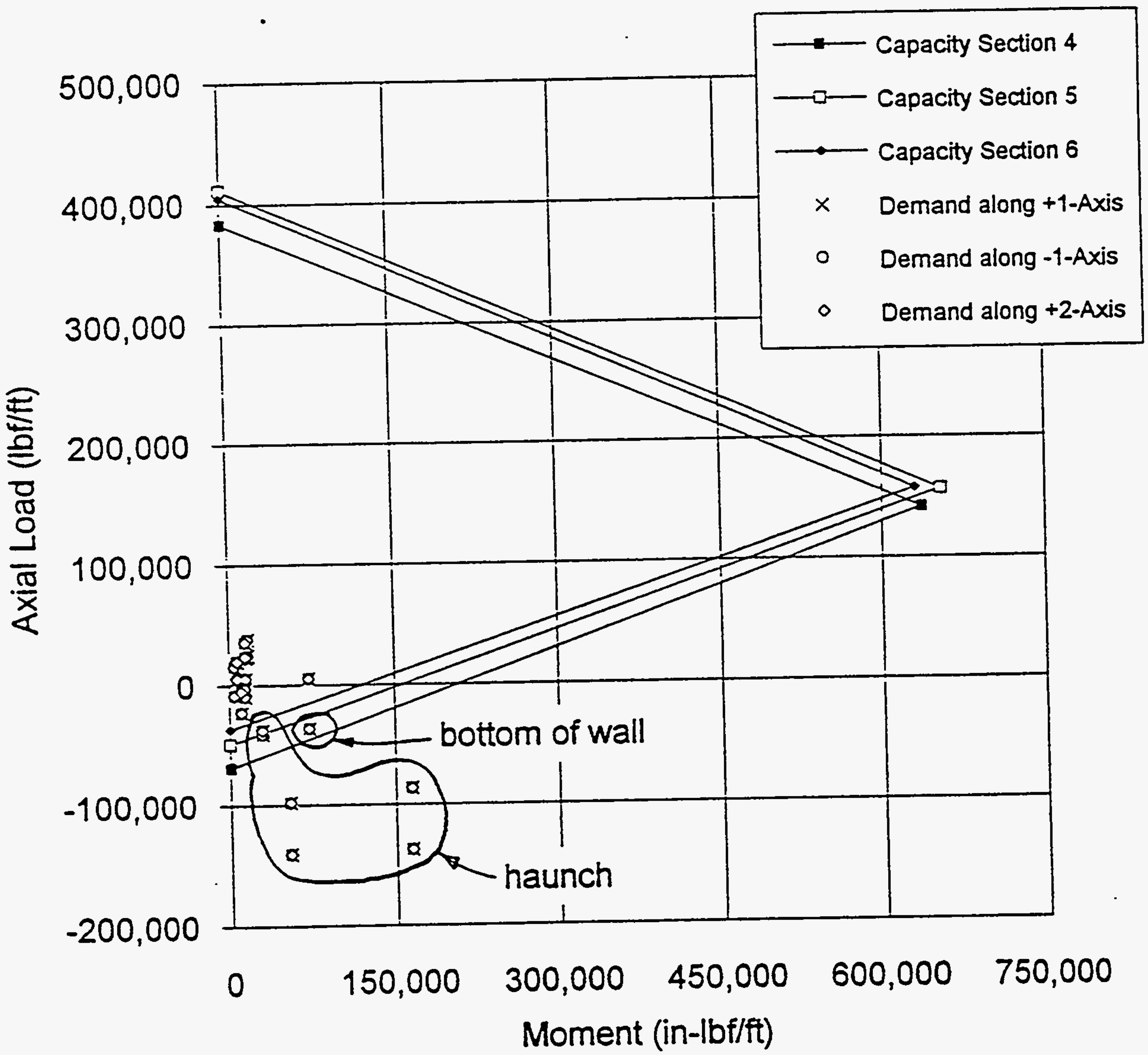
C1-2A.XLC

Figure 9.2.1-20. Circumferential Moment-Axial Load Interaction Diagram for Footing Section: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



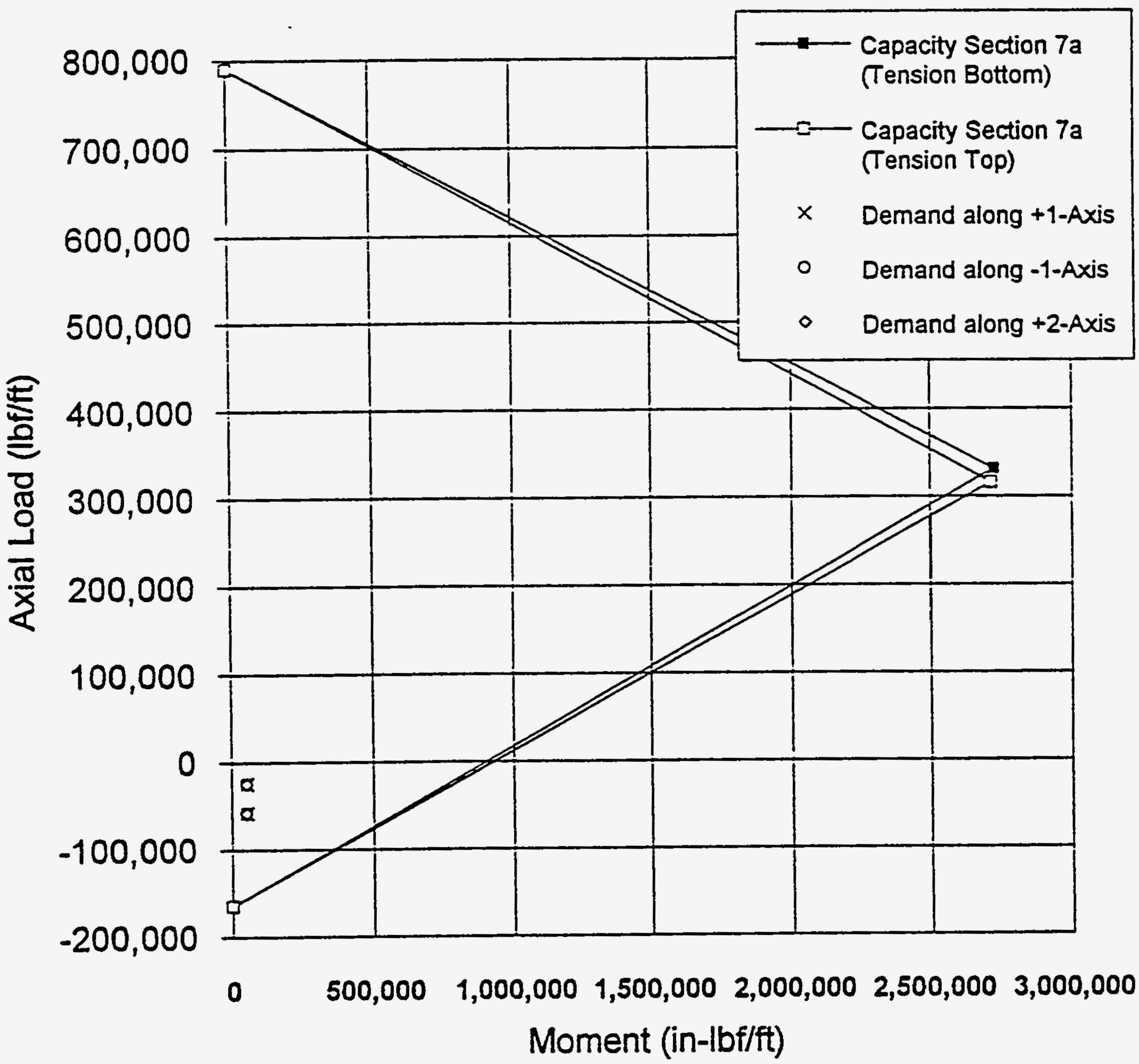
C1-3.XLC

Figure 9.2.1-21. Circumferential Moment-Axial Load Interaction Diagram for 12-Inch Thick Wall Sections: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



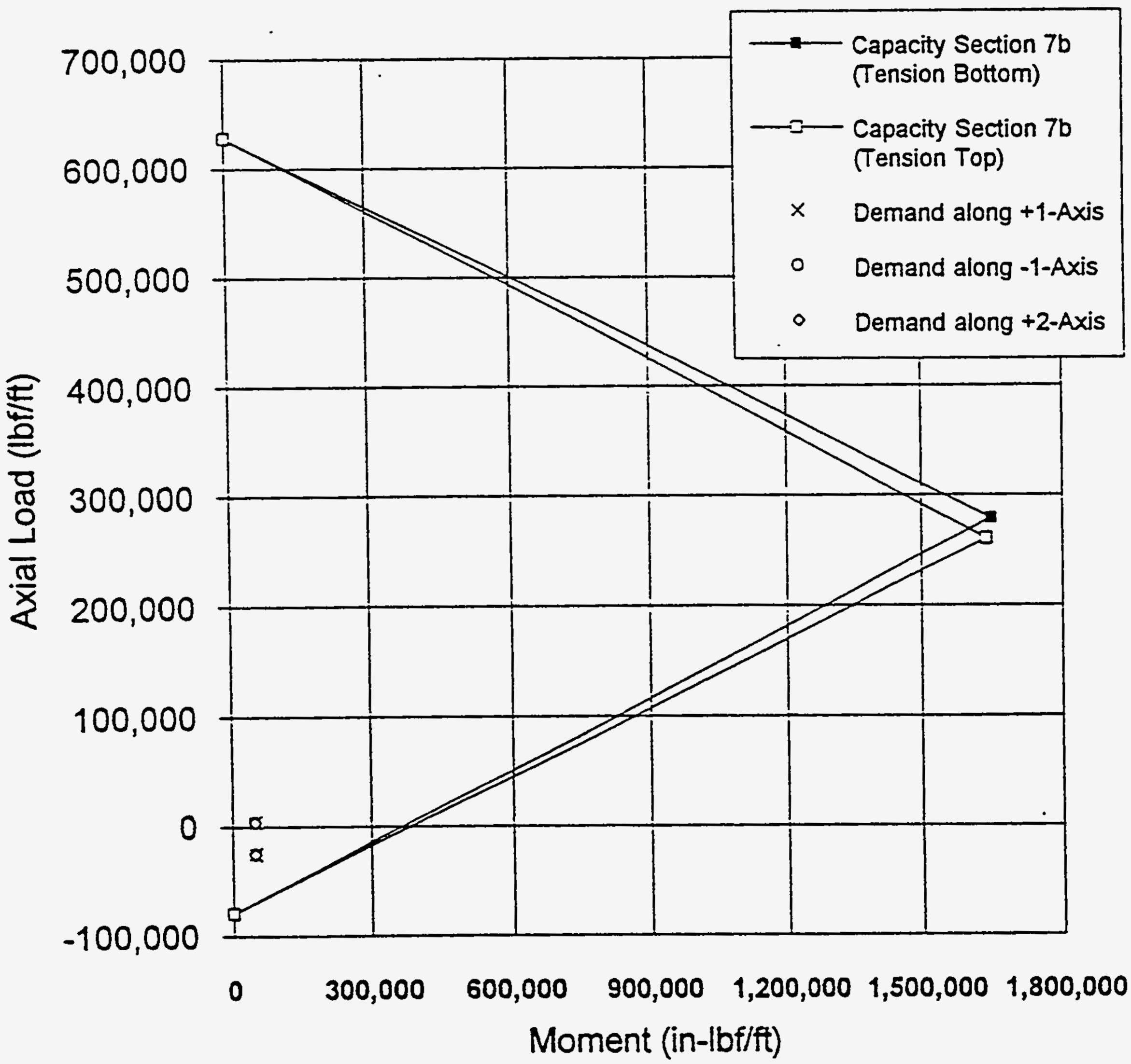
C1-456.XLC

Figure 9.2.1-22. Circumferential Moment-Axial Load Interaction Diagram for Haunch Section: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



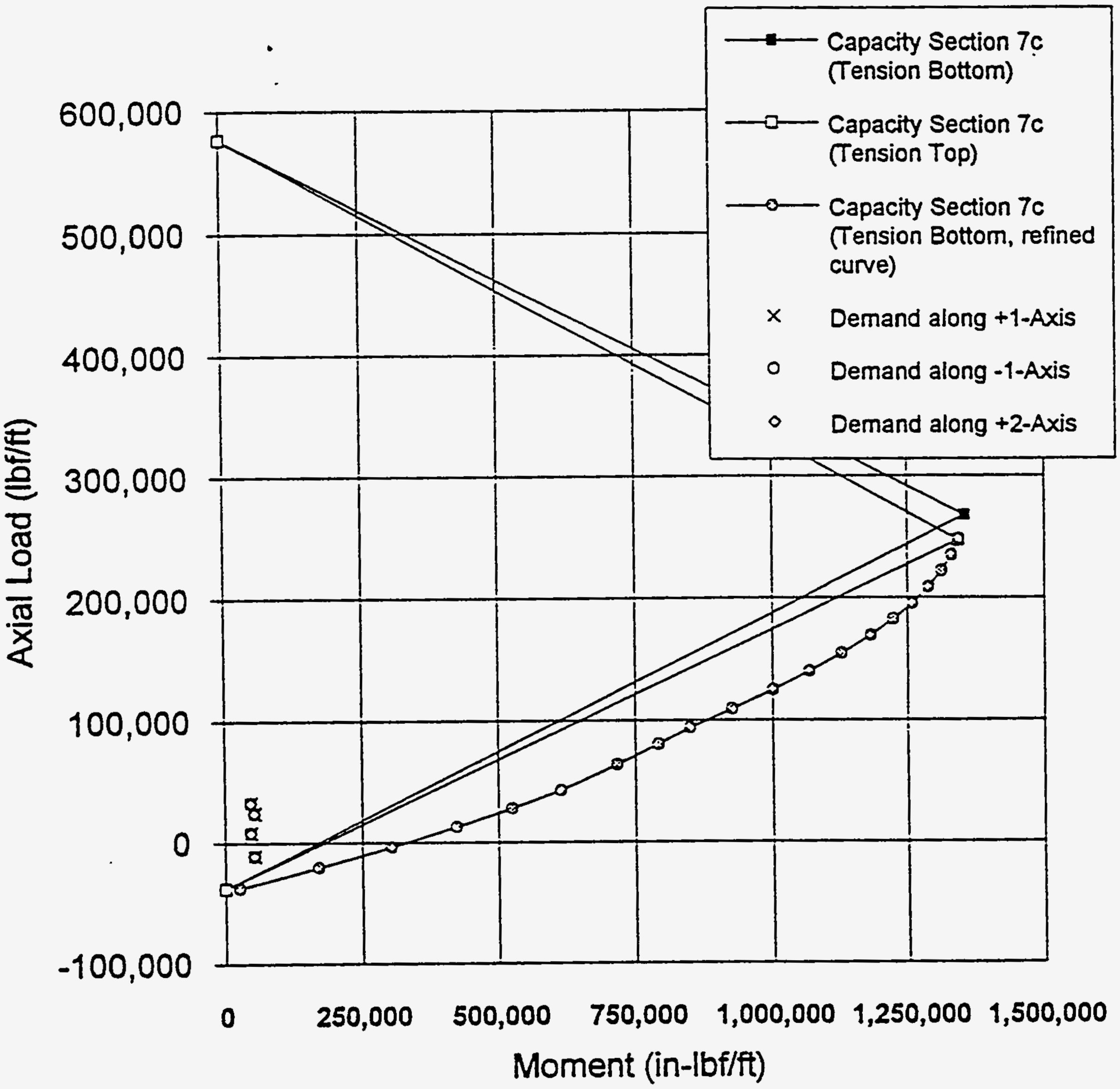
C1-7A.XLC

Figure 9.2.1-23. Circumferential Moment-Axial Load Interaction Diagram for Haunch/Dome Interface Section: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



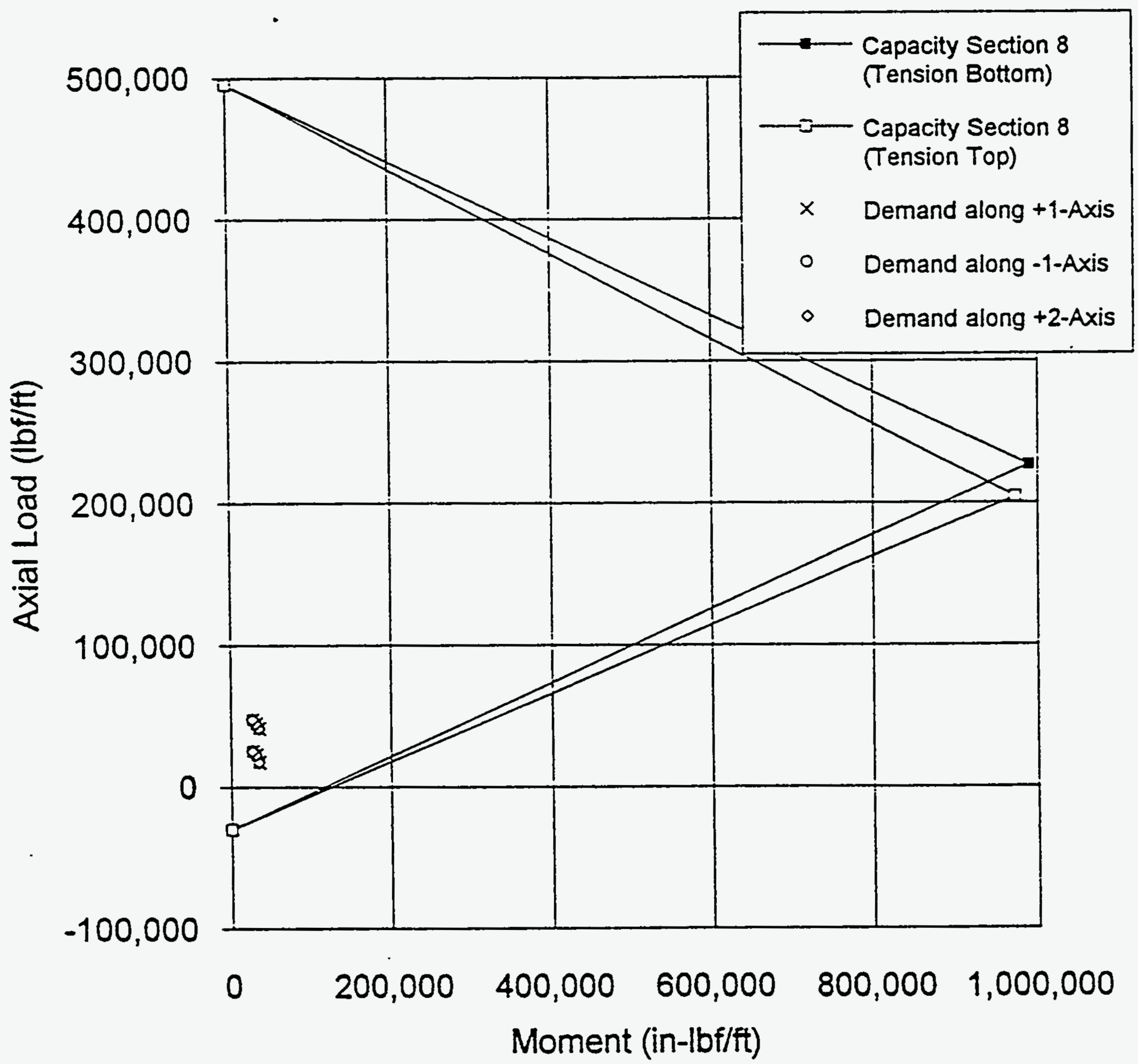
C1-7B.XLC

Figure 9.2.1-24. Circumferential Moment-Axial Load Interaction Diagram for Outer Dome Section: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



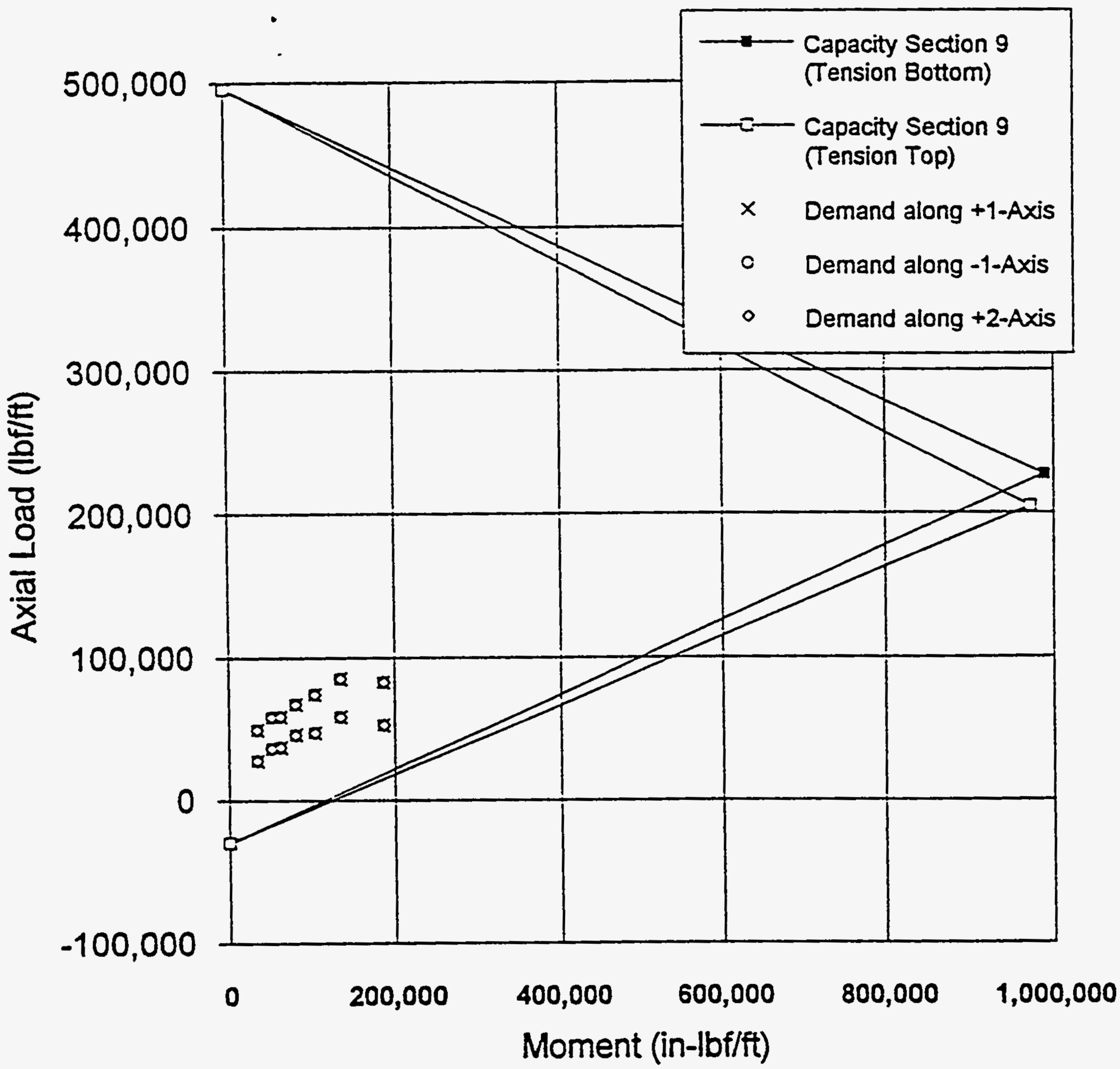
C1-7C.XLC

Figure 9.2.1-25. Circumferential Moment-Axial Load Interaction Diagram for Intermediate Dome Sections: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



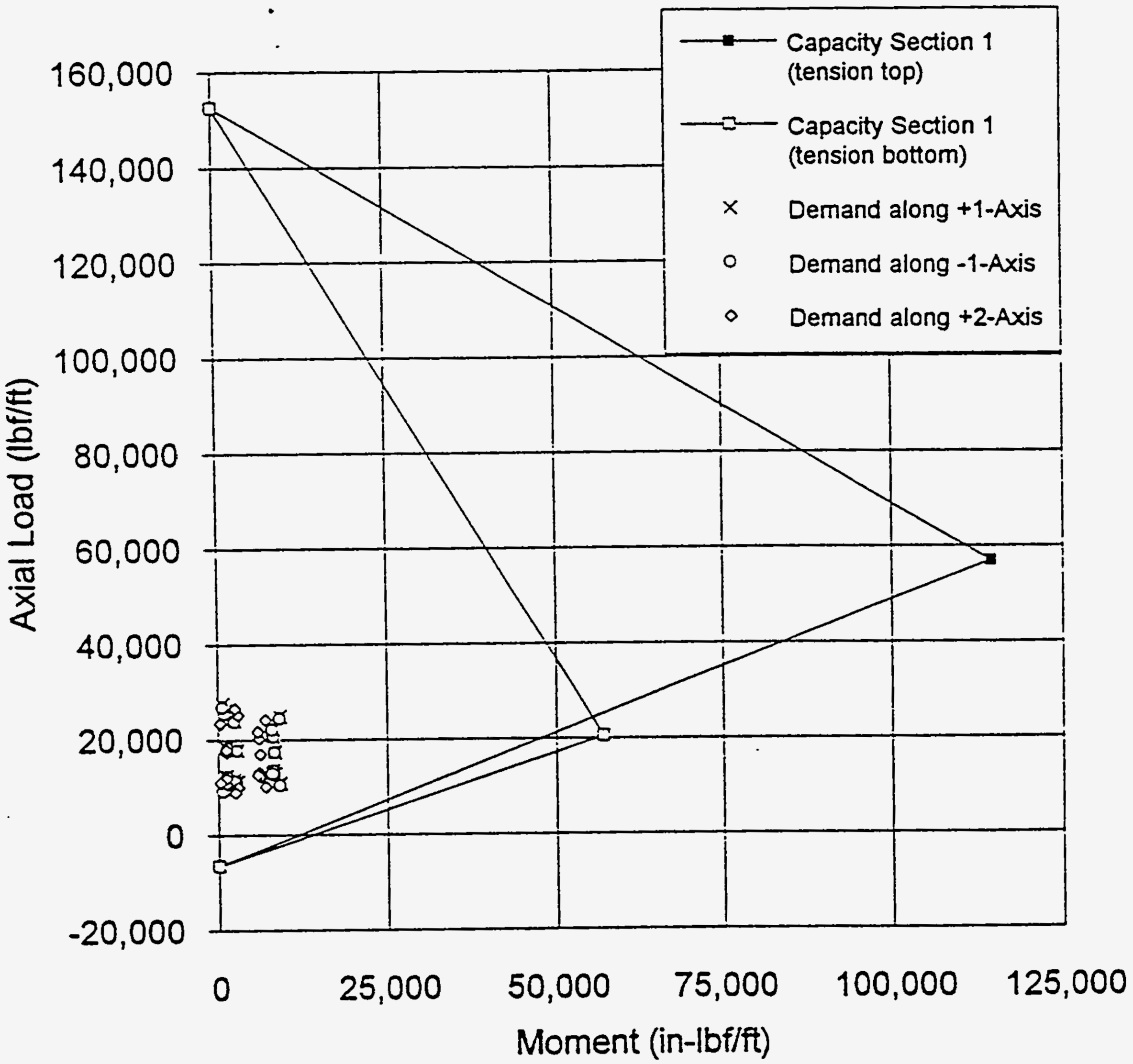
C1-8.XLC

Figure 9.2.1-26. Circumferential Moment-Axial Load Interaction Diagram for Dome Sections Near Apex: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).



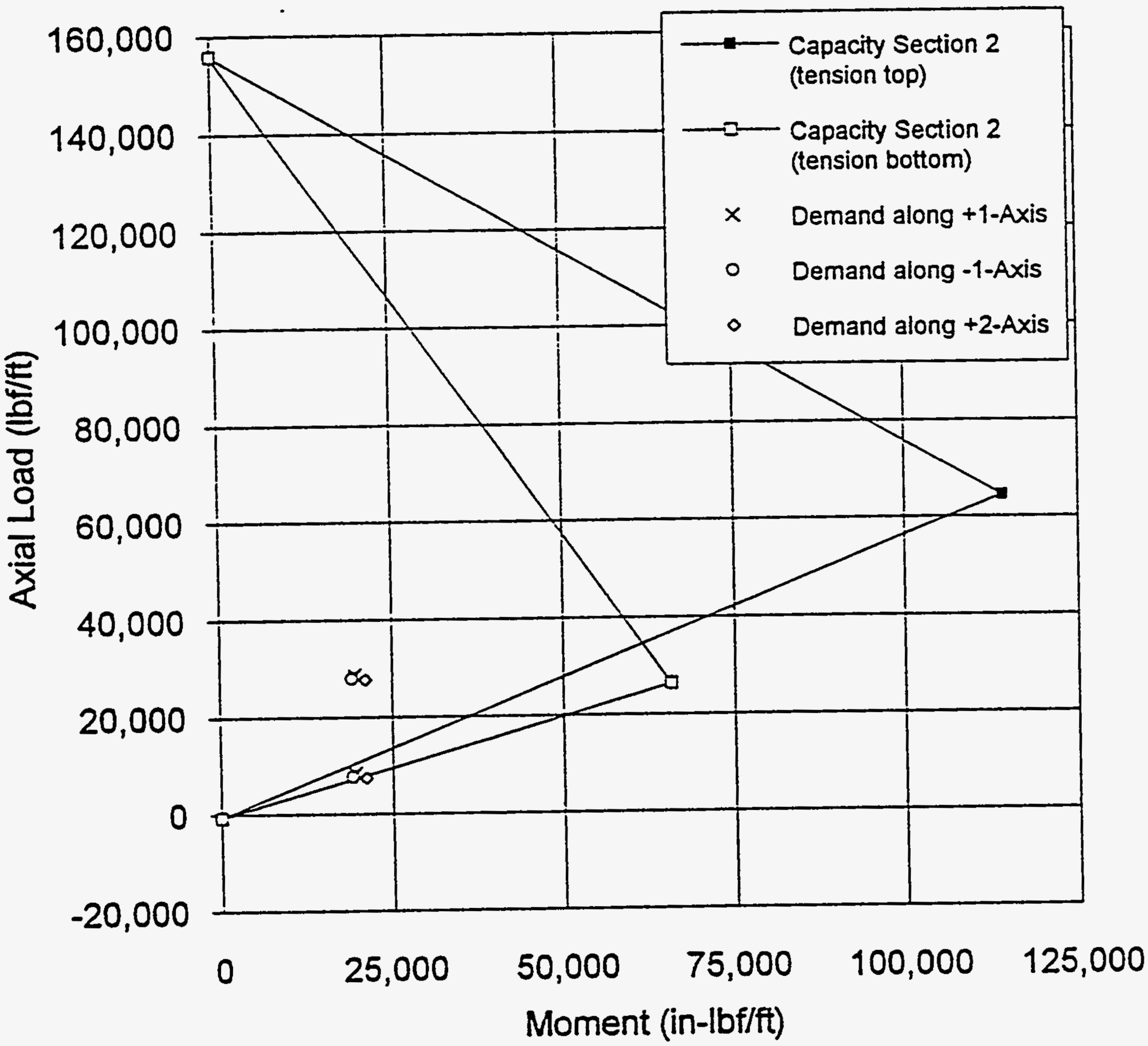
C1-9.XLC

Figure 9.2.1-27. Meridional Moment-Axial Load Interaction Diagram for Inner Base Sections: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



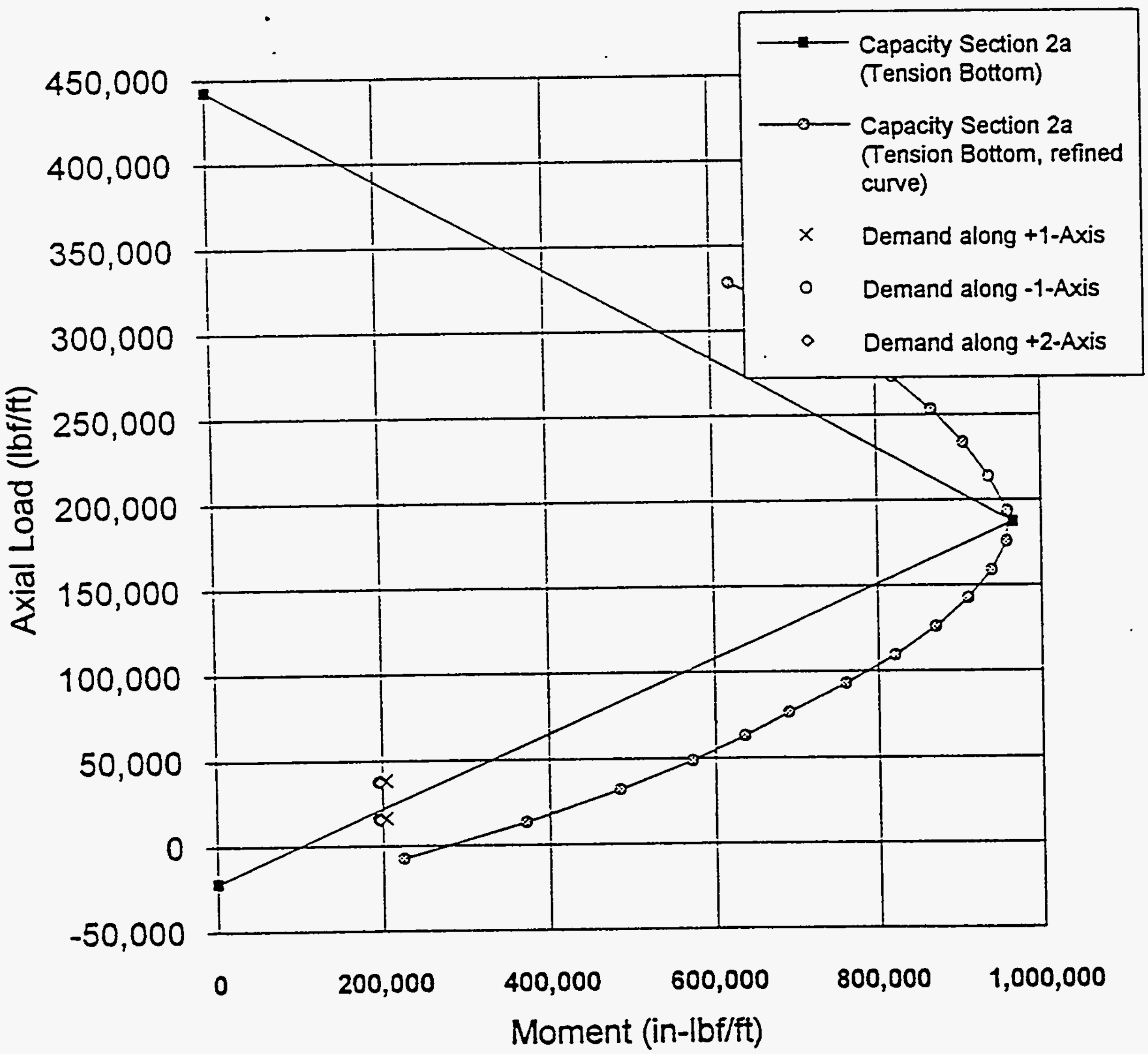
M1-1.XLC

Figure 9.2.1-28. Meridional Moment-Axial Load Interaction Diagram for Outer Base Sections: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



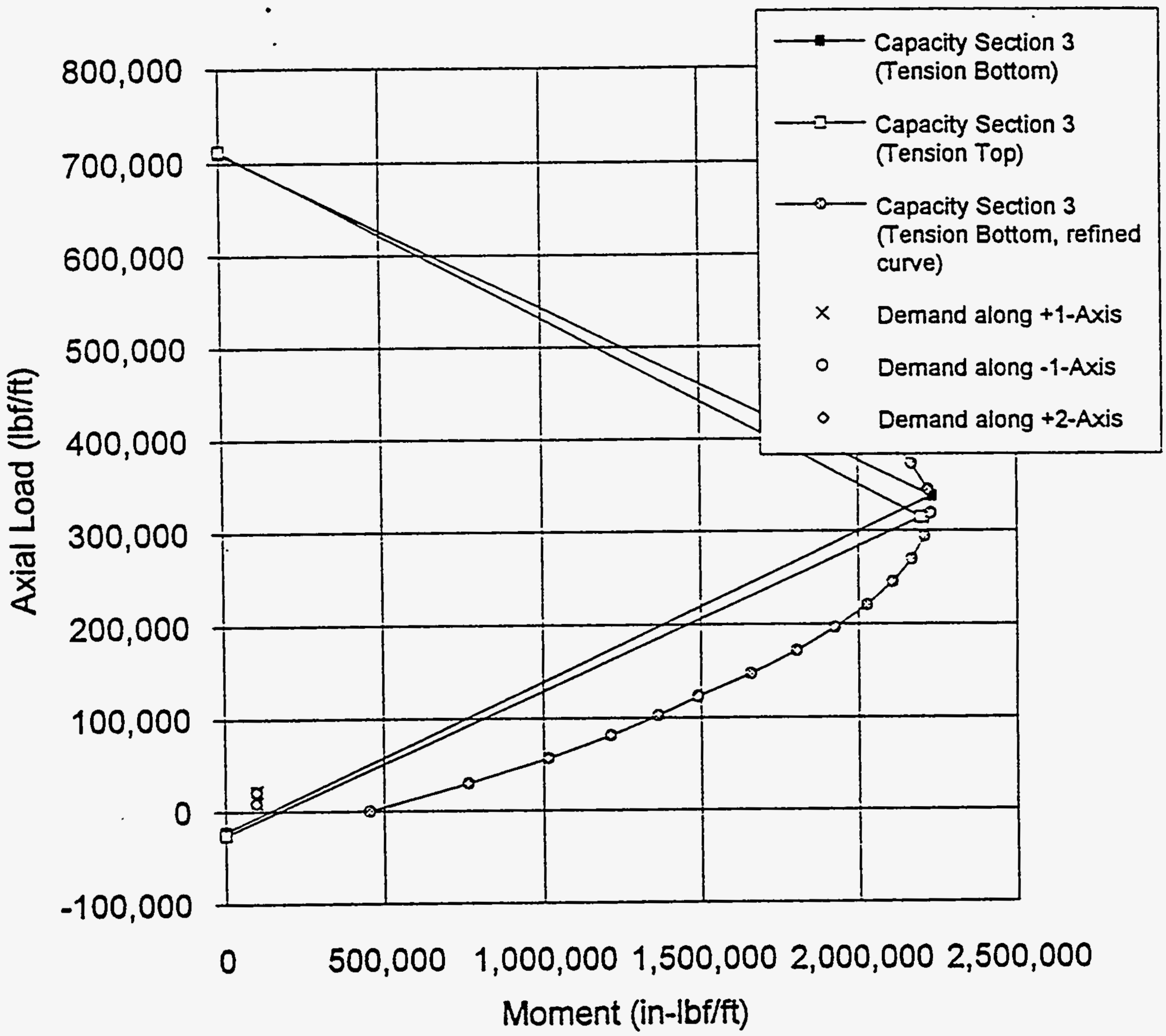
M1-2.XLC

Figure 9.2.1-29. Meridional Moment-Axial Load Interaction Diagram for Base/Wall Interface Section: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



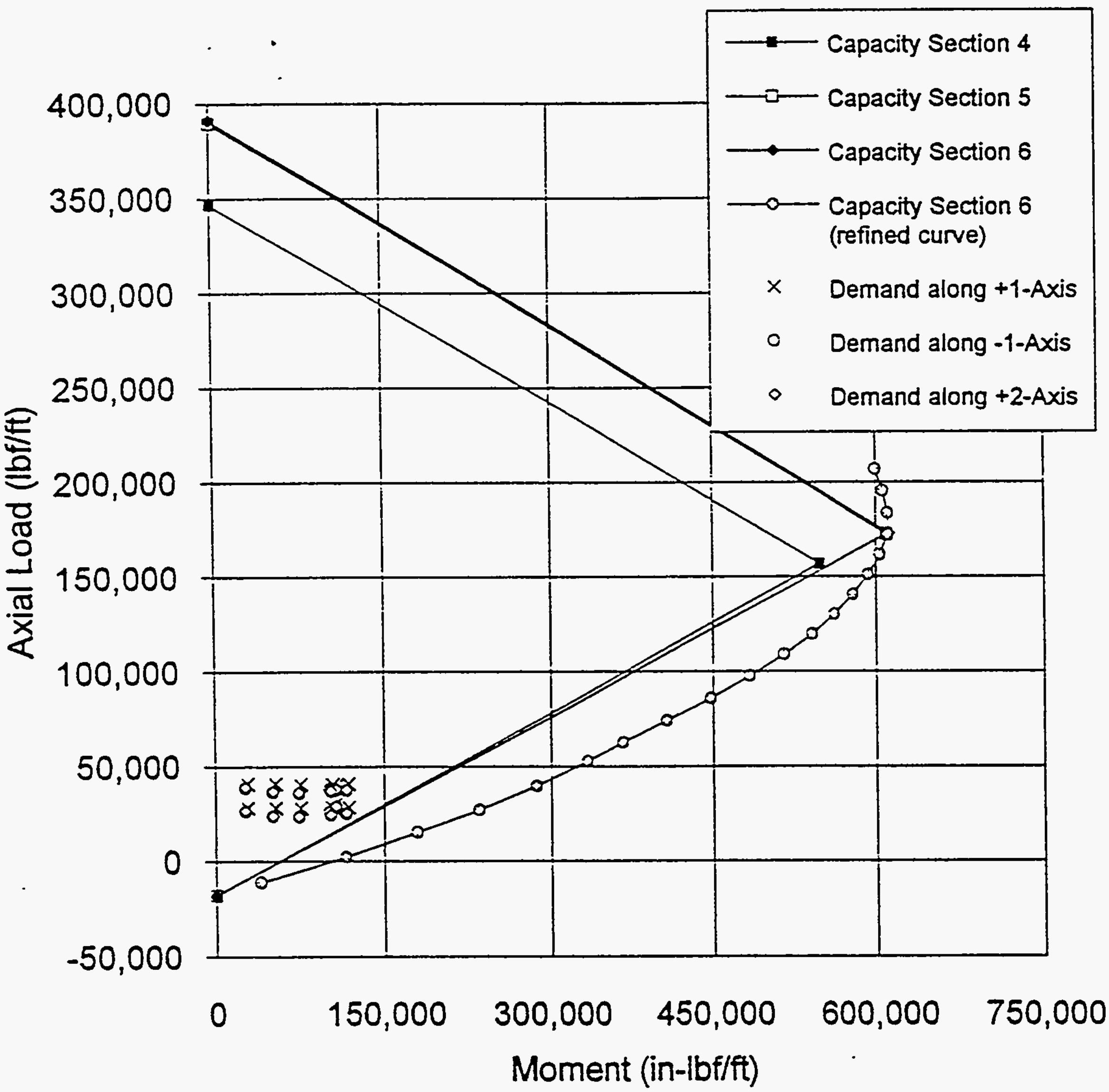
M1-2A.XLC

Figure 9.2.1-30. Meridional Moment-Axial Load Interaction Diagram for Footing Section: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).

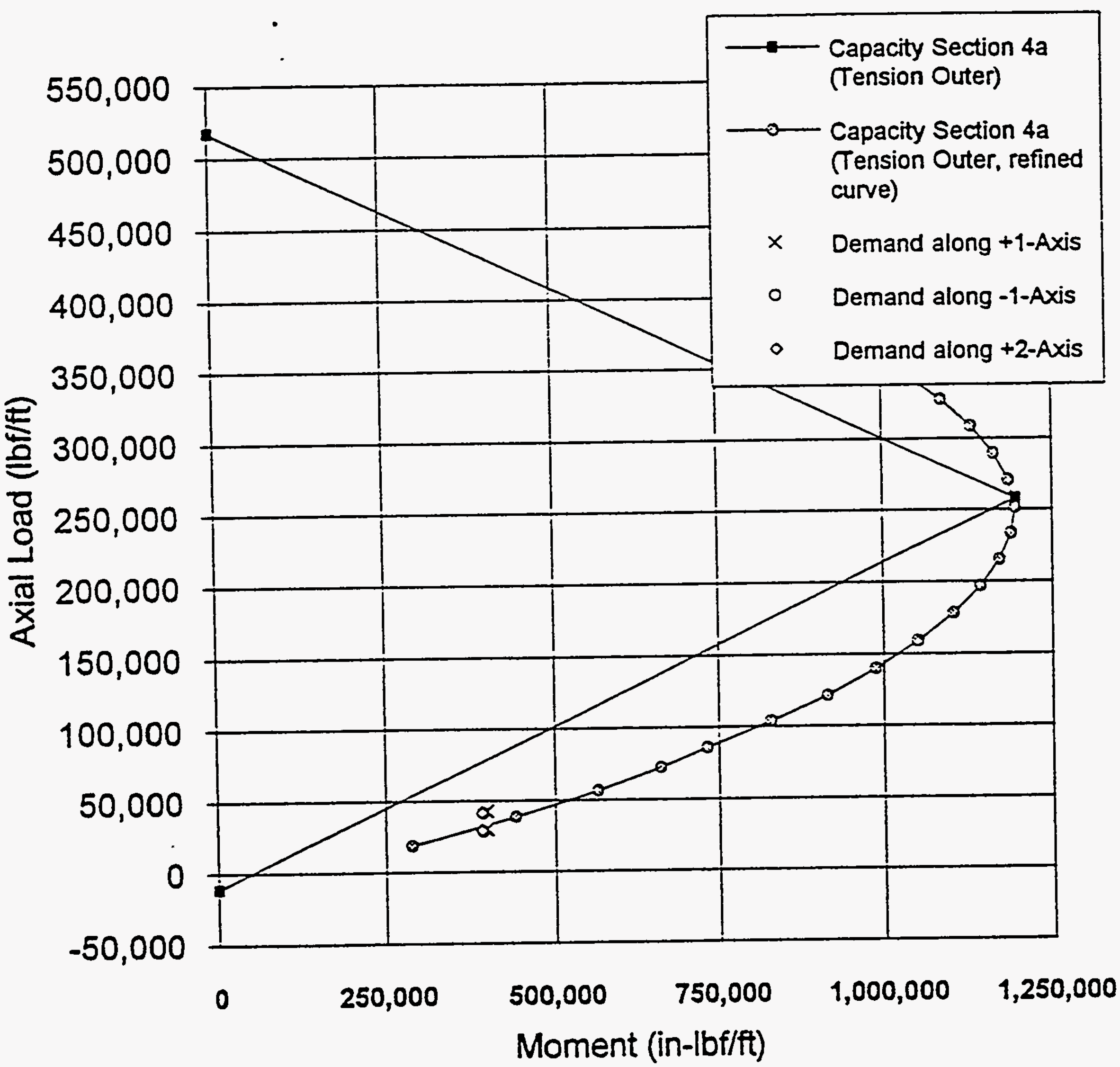


M1-3.XLC

Figure 9.2.1-31. Meridional Moment-Axial Load Interaction Diagram for 12-In.-Thick Wall Sections: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).

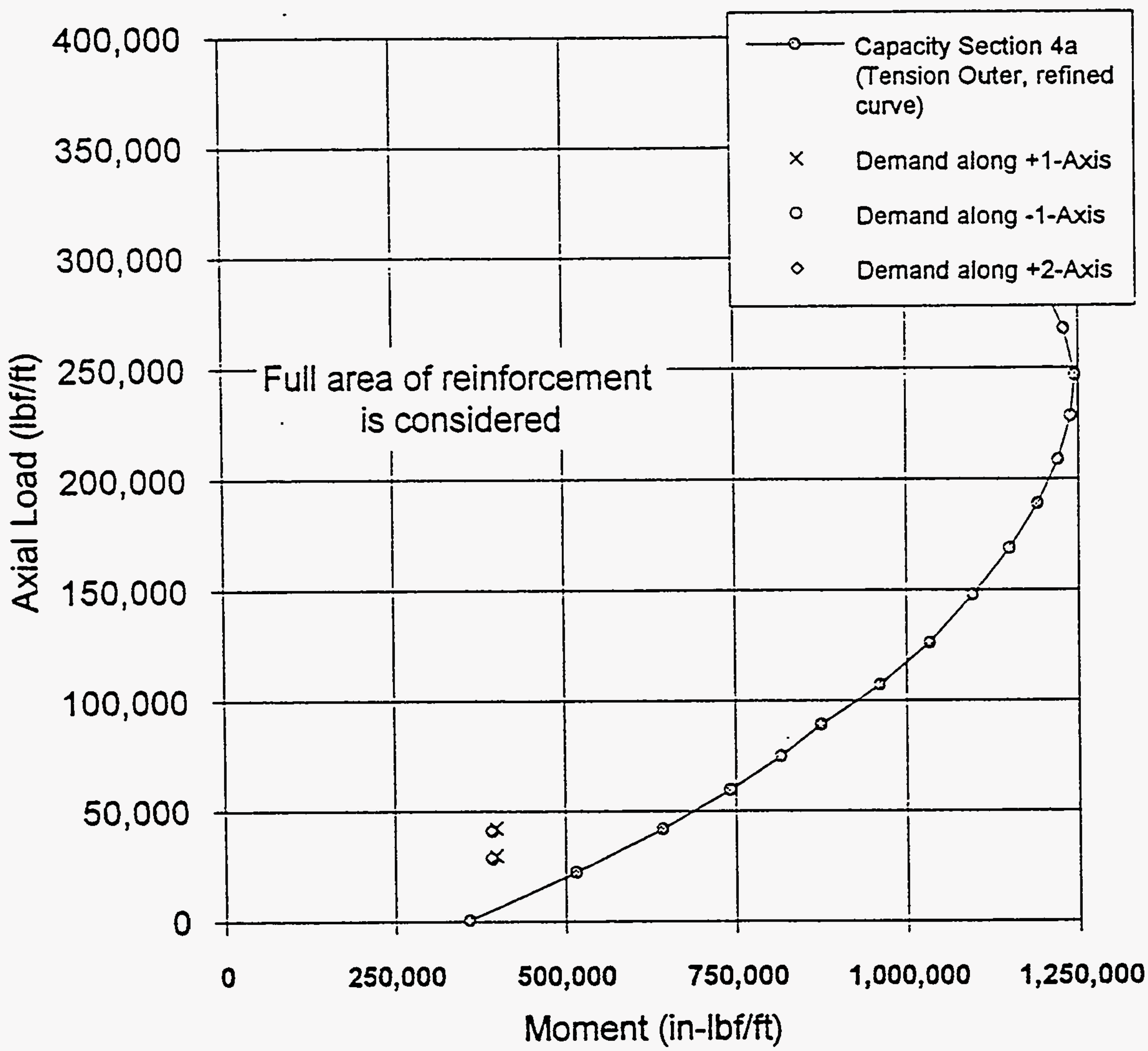


M1-456.XLC


Capacity Section 4a (Tension Outer)
Capacity Section 4a (Tension Outer, refined curve)
Demand along +1-Axis
Demand along -1-Axis
Demand along +2-Axis
550,000
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
-50,000
Axial Load (lbf/ft)
0
250,000
500,000
750,000
1,000,000
1,250,000
Moment (in-lbf/ft)

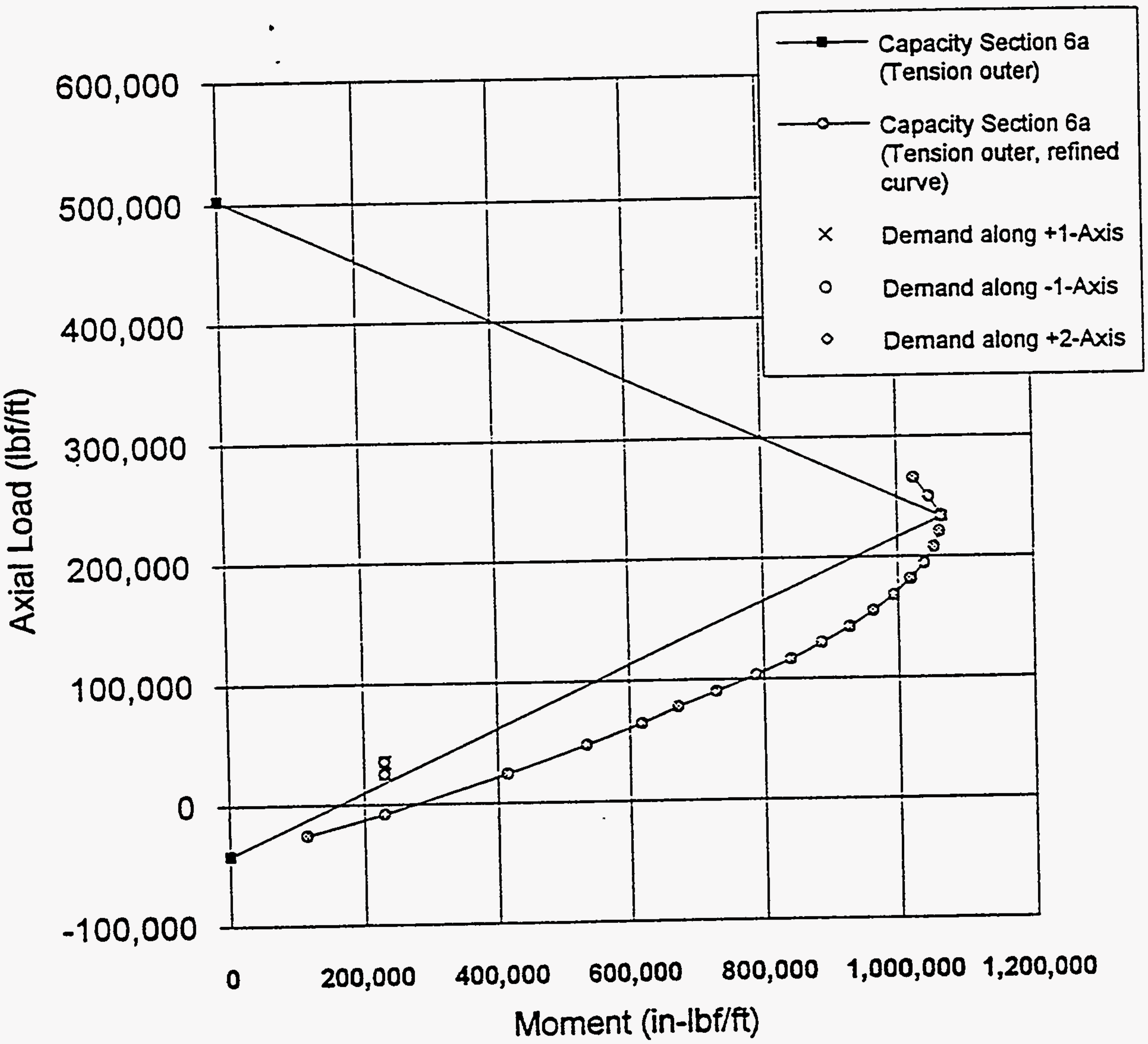
M1-4A.XLC

Figure 9.2.1-33. Meridional Moment-Axial Load Interaction Diagram for Lower Wall Section: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



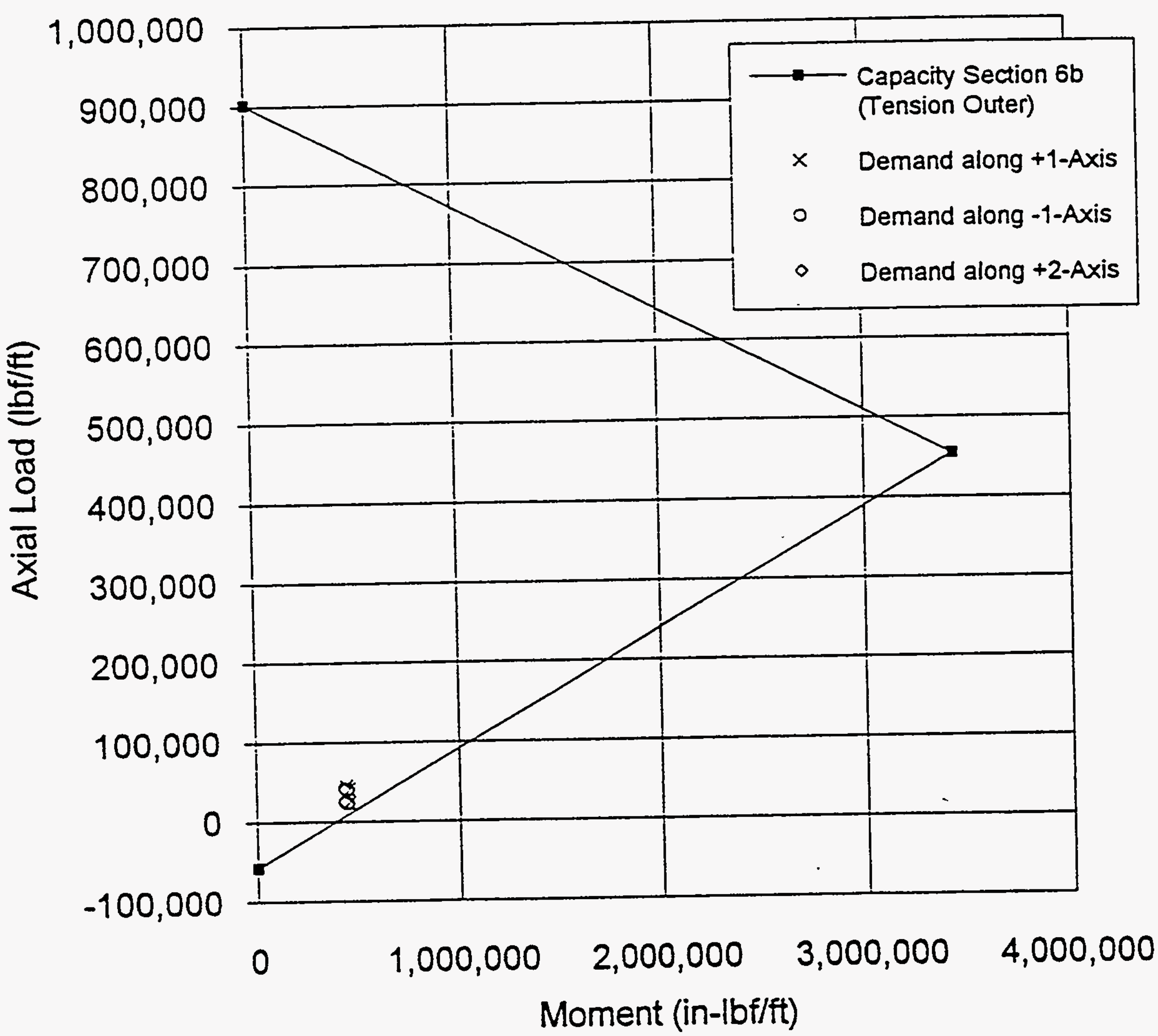
M1-4A-2.XLC

Figure 9.2.1-34. Meridional Moment-Axial Load Interaction Diagram for Wall/Haunch Interface Section: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



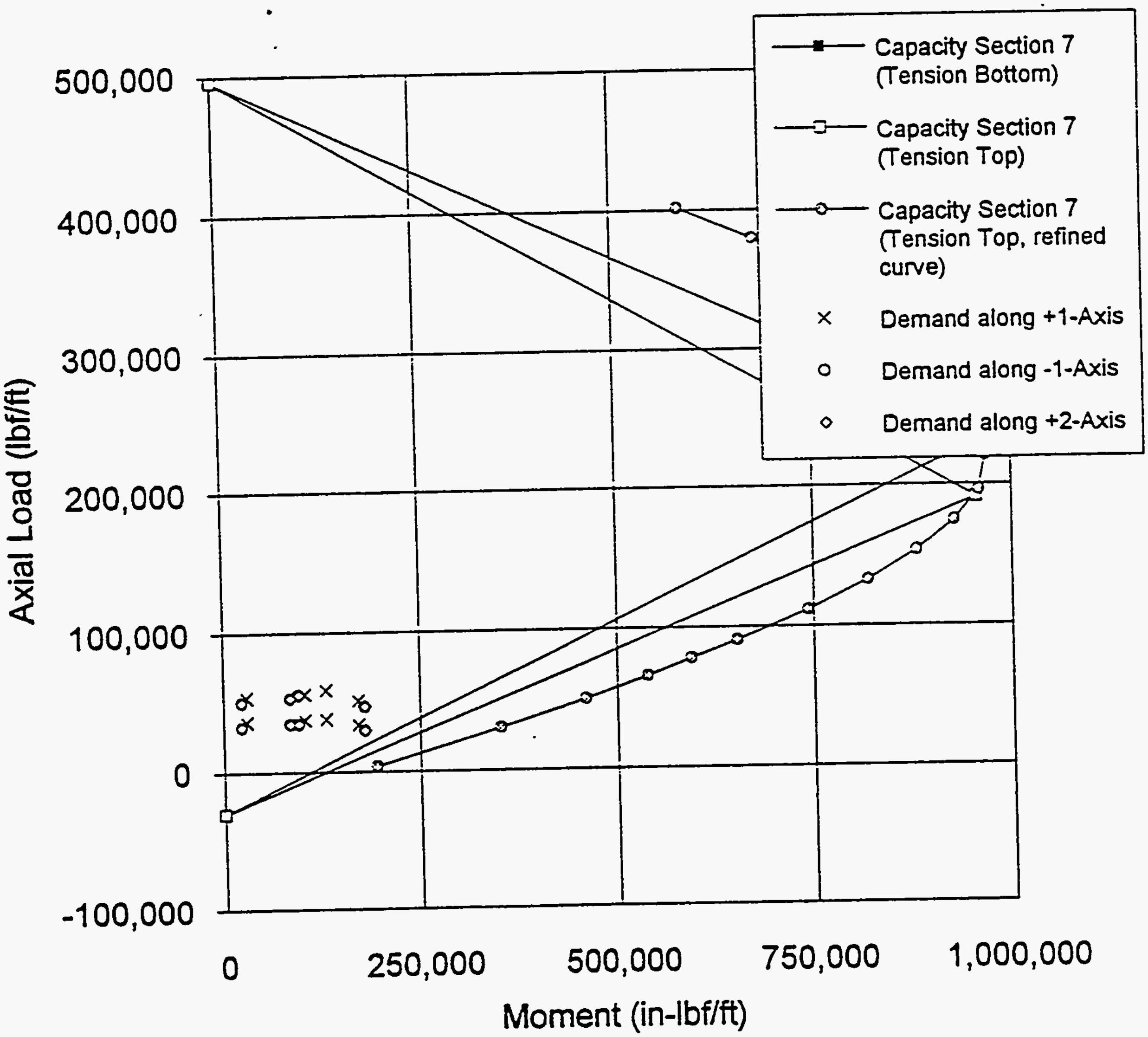
M1-6A.XLC

Figure 9.2.1-35. Meridional Moment-Axial Load Interaction Diagram for Haunch Section: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



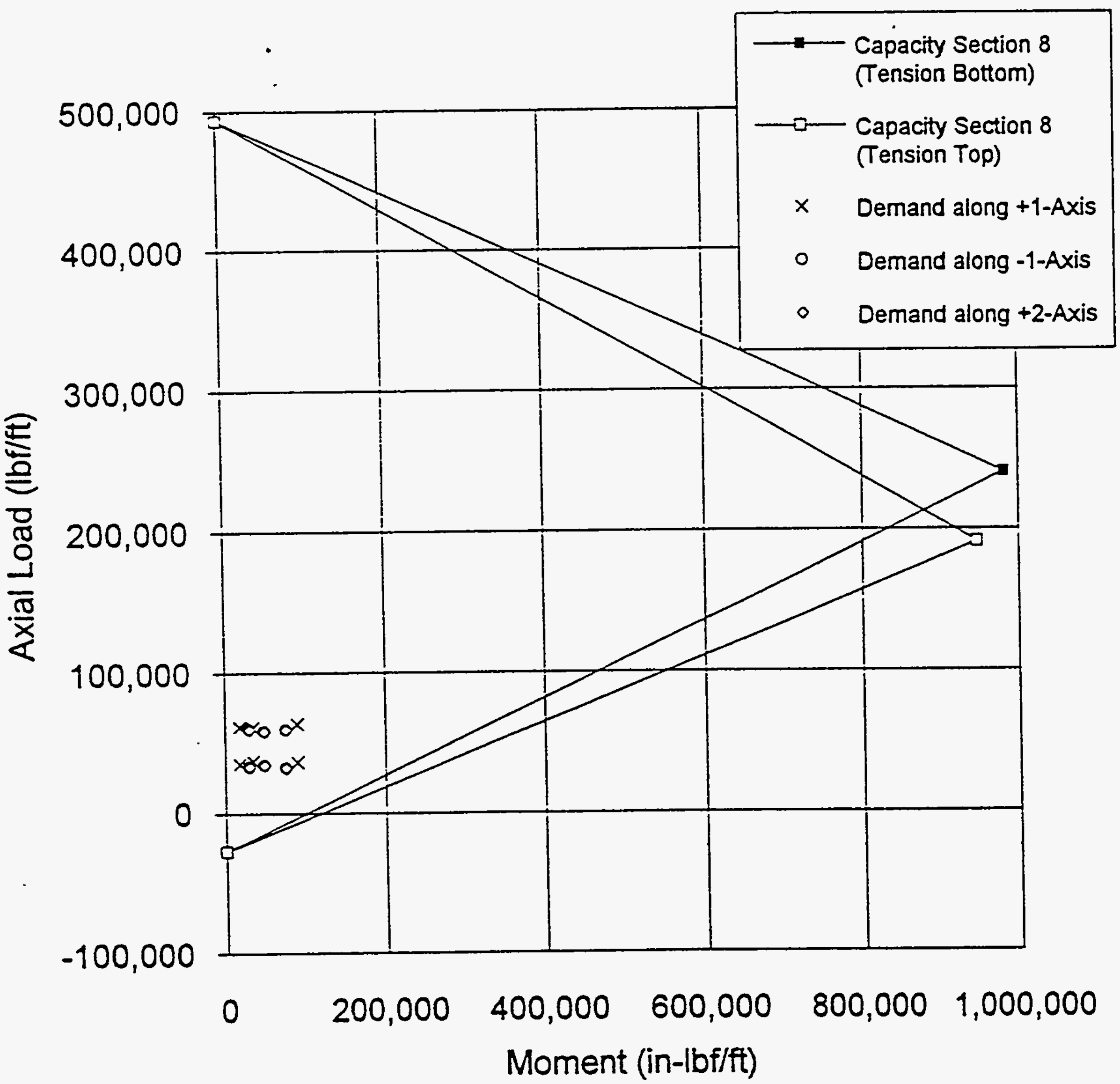
M1-6B.XLC

Figure 9.2.1-36. Meridional Moment-Axial Load Interaction Diagram for Haunch/Dome Interface Section: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



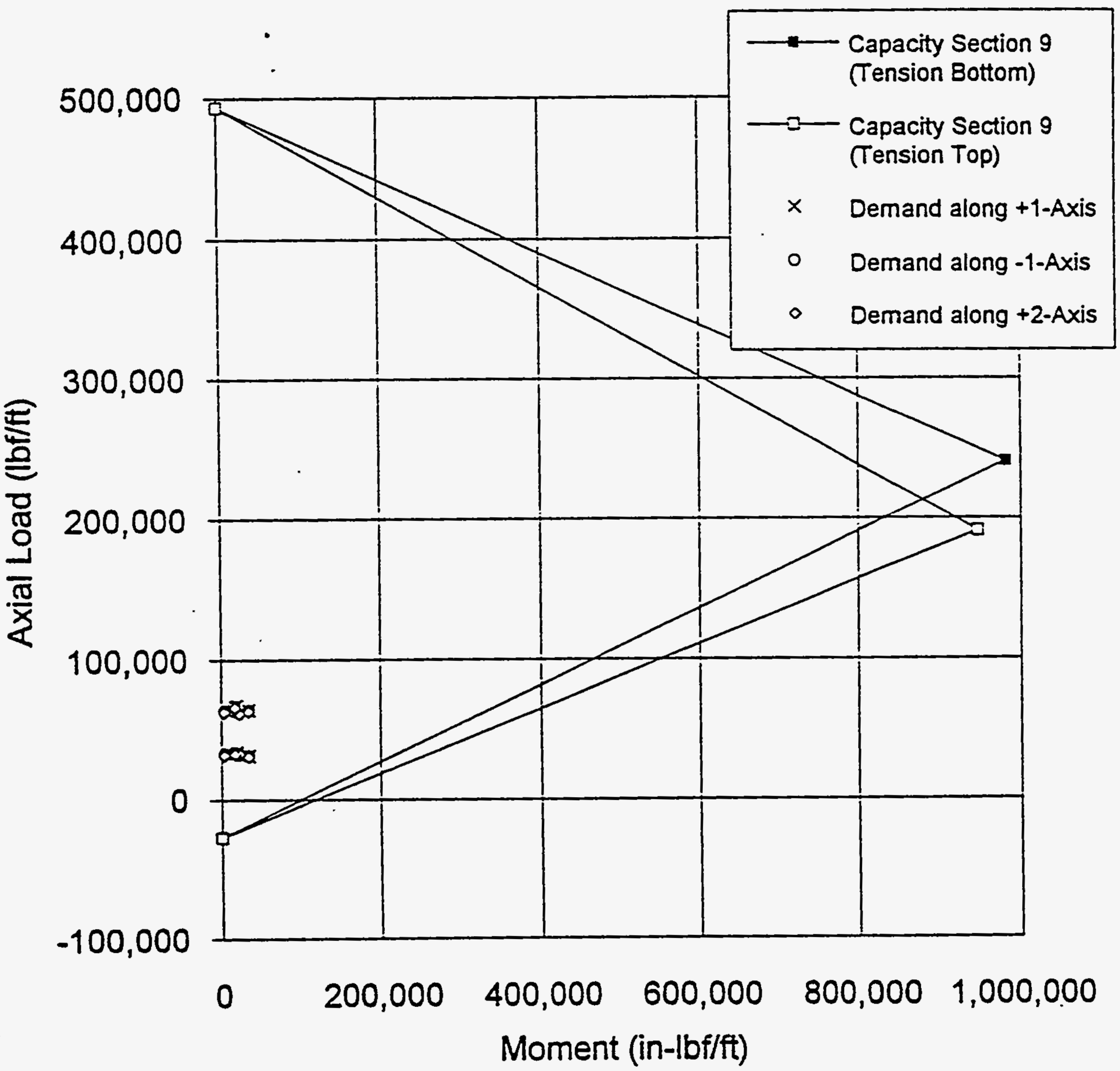
M1-7.XLC

Figure 9.2.1-37. Meridional Moment-Axial Load Interaction Diagram for Intermediate Dome Sections: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



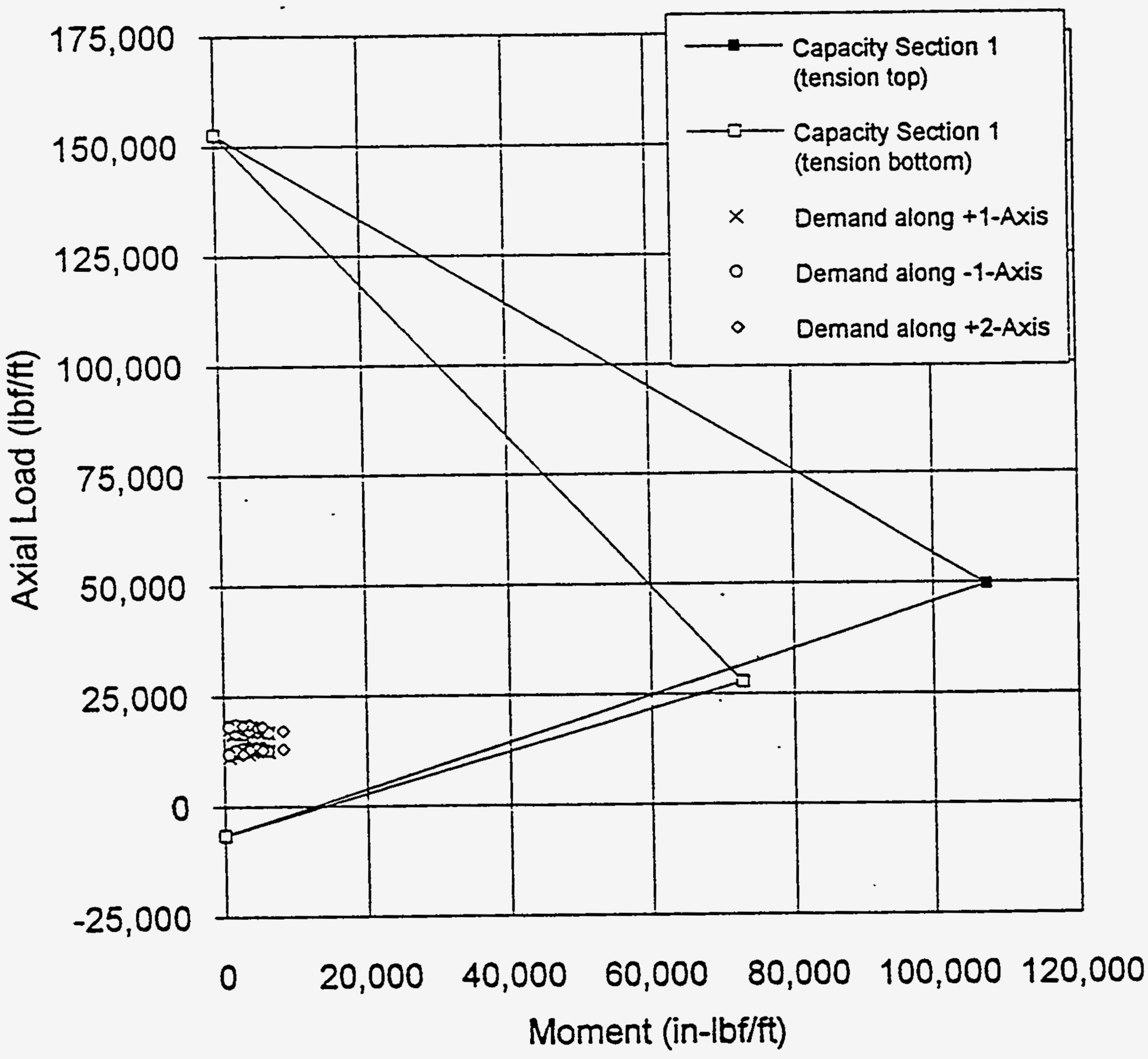
M1-8.XLC

Figure 9.2.1-38. Meridional Moment-Axial Load Interaction Diagram for Dome Sections Near Apex: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



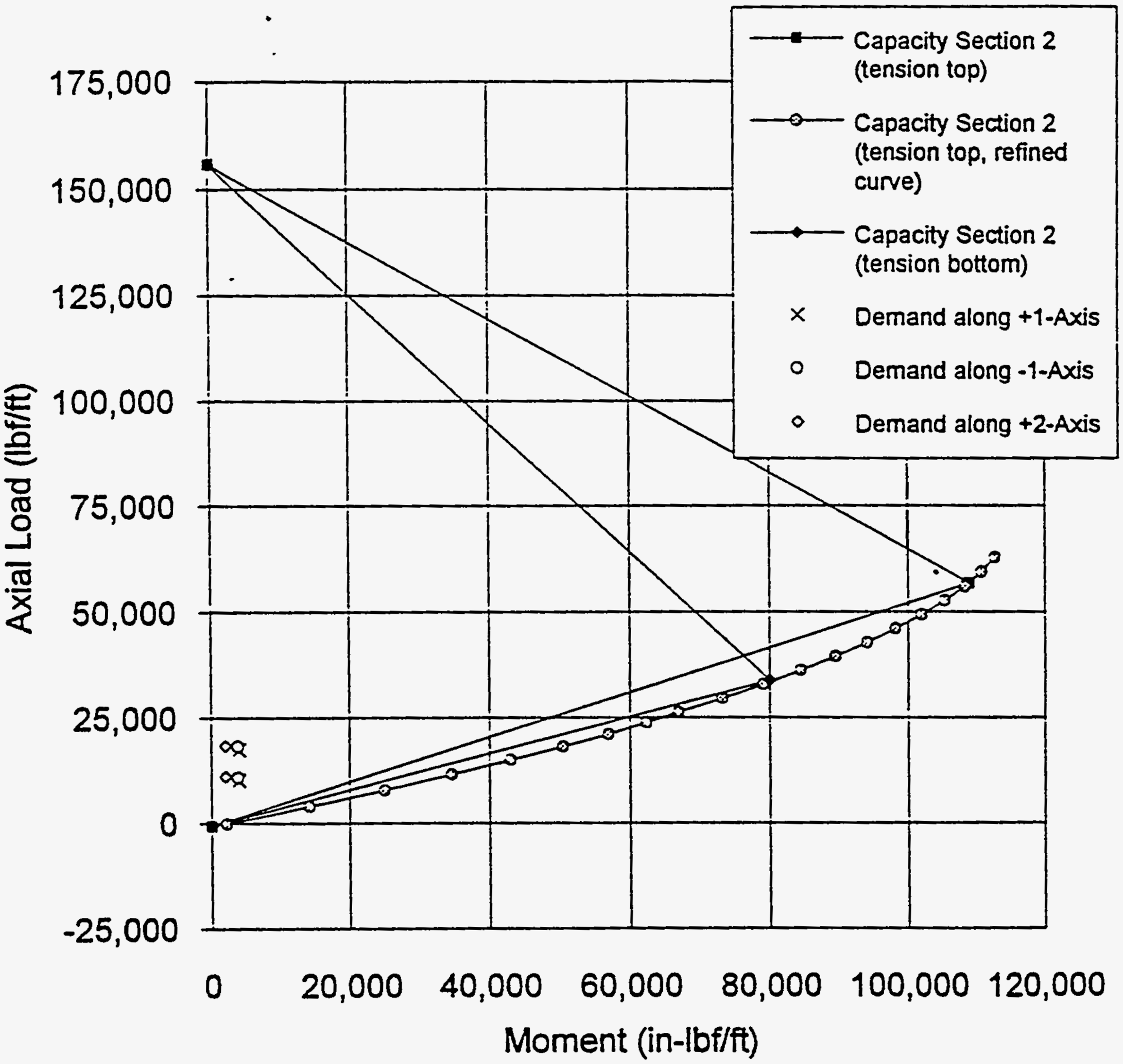
M1-9.XLC

Figure 9.2.1-39. Meridional Moment-Axial Load Interaction Diagram for Inner Base Sections: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



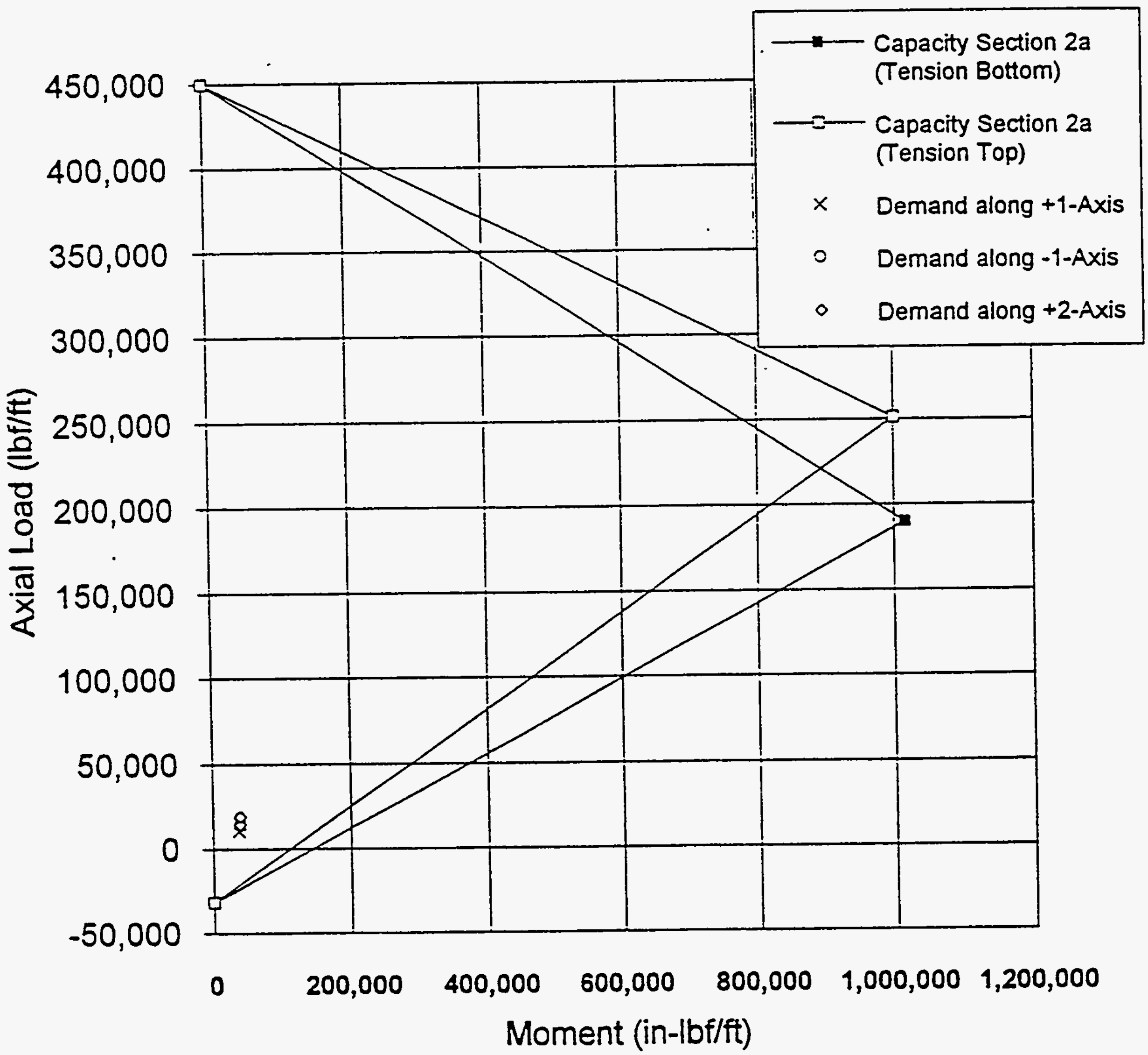
C1-1.XLC

Figure 9.2.1-40. Circumferential Moment-Axial Load Interaction Diagram for Outer Base Sections: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



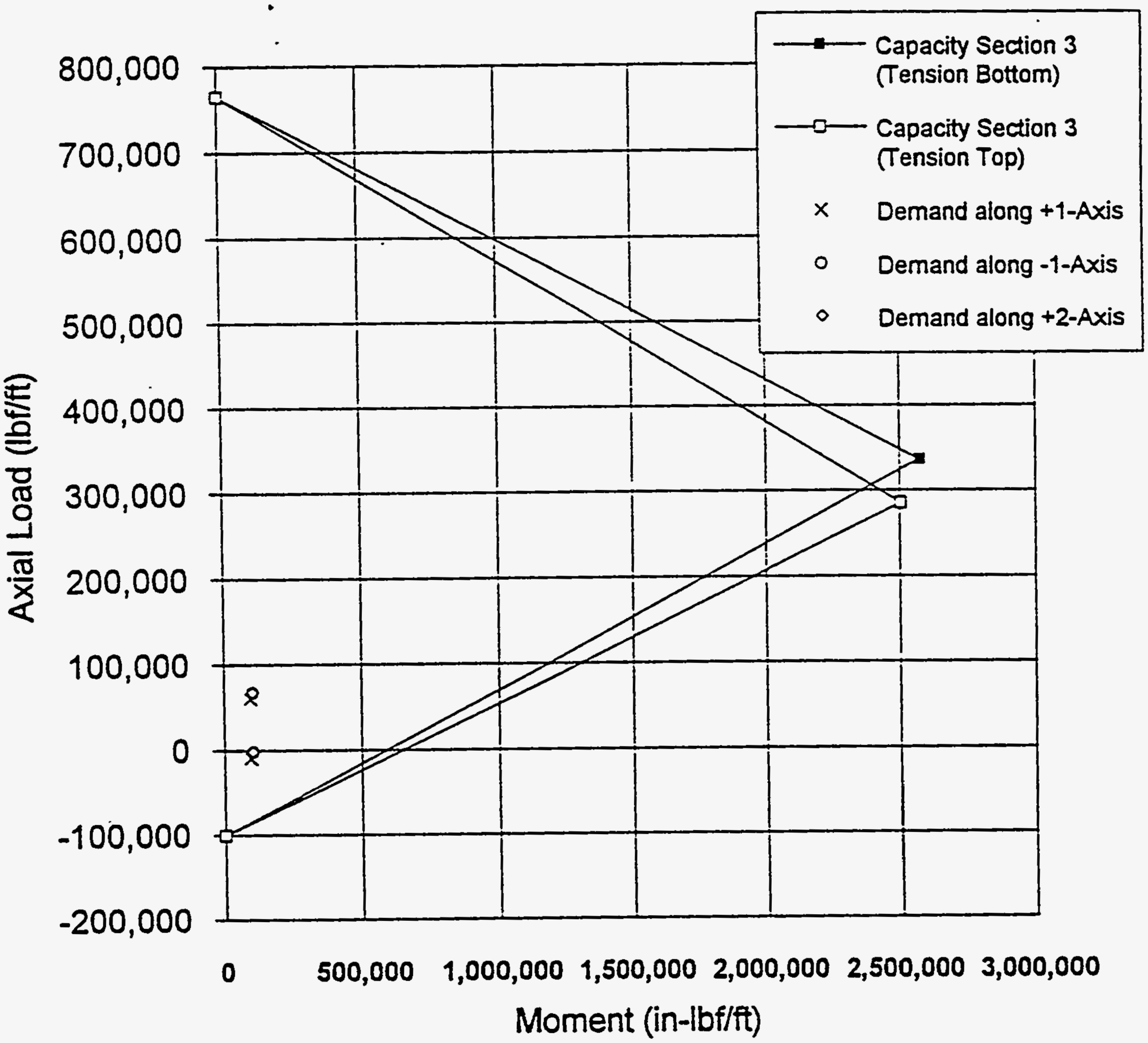
C1-2.XLC

Figure 9.2.1-41. Circumferential Moment-Axial Load Interaction Diagram for Base/Wall Interface Section: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



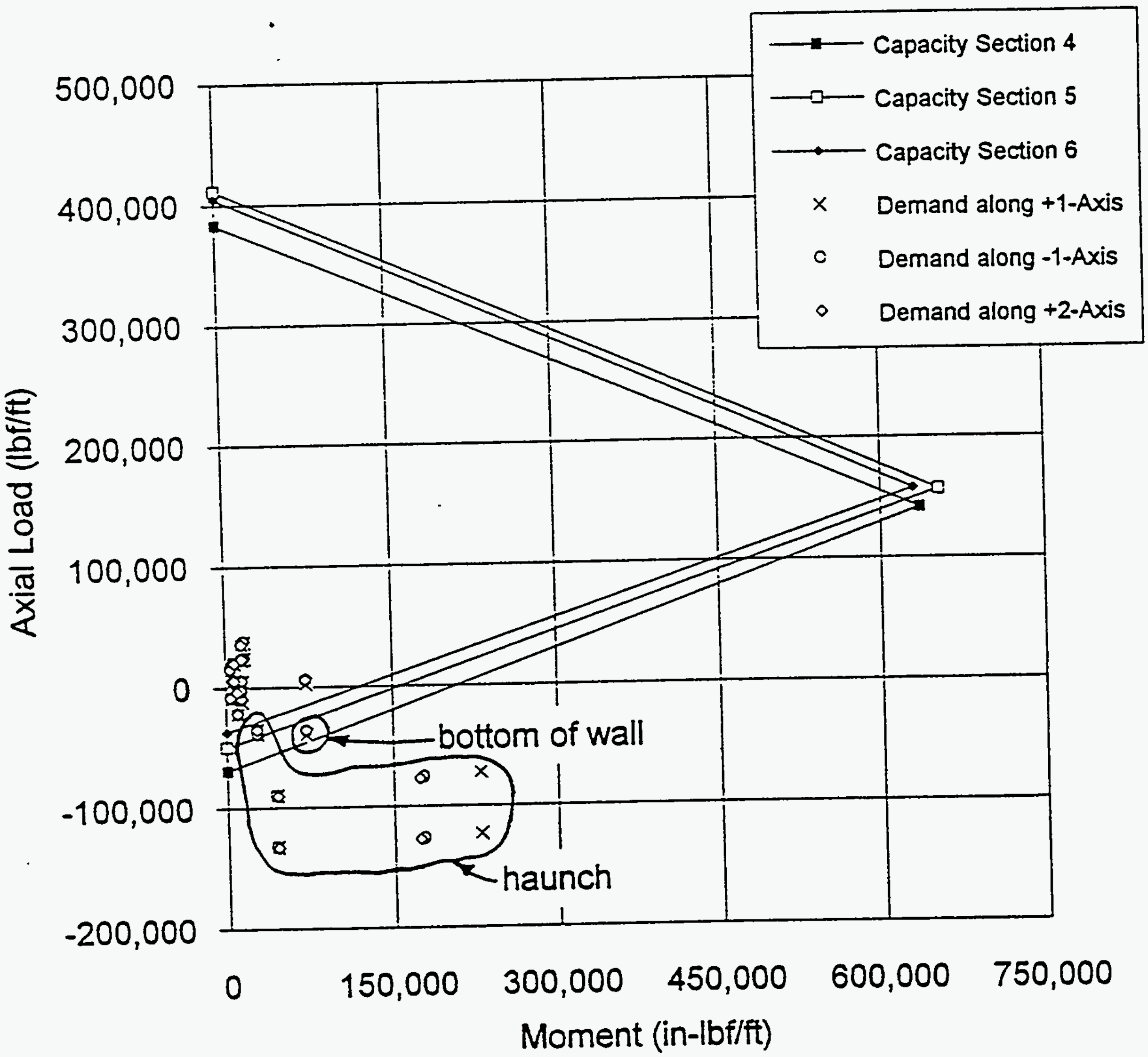
C1-2A.XLC

Figure 9.2.1-42. Circumferential Moment-Axial Load Interaction Diagram for Footing Section: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



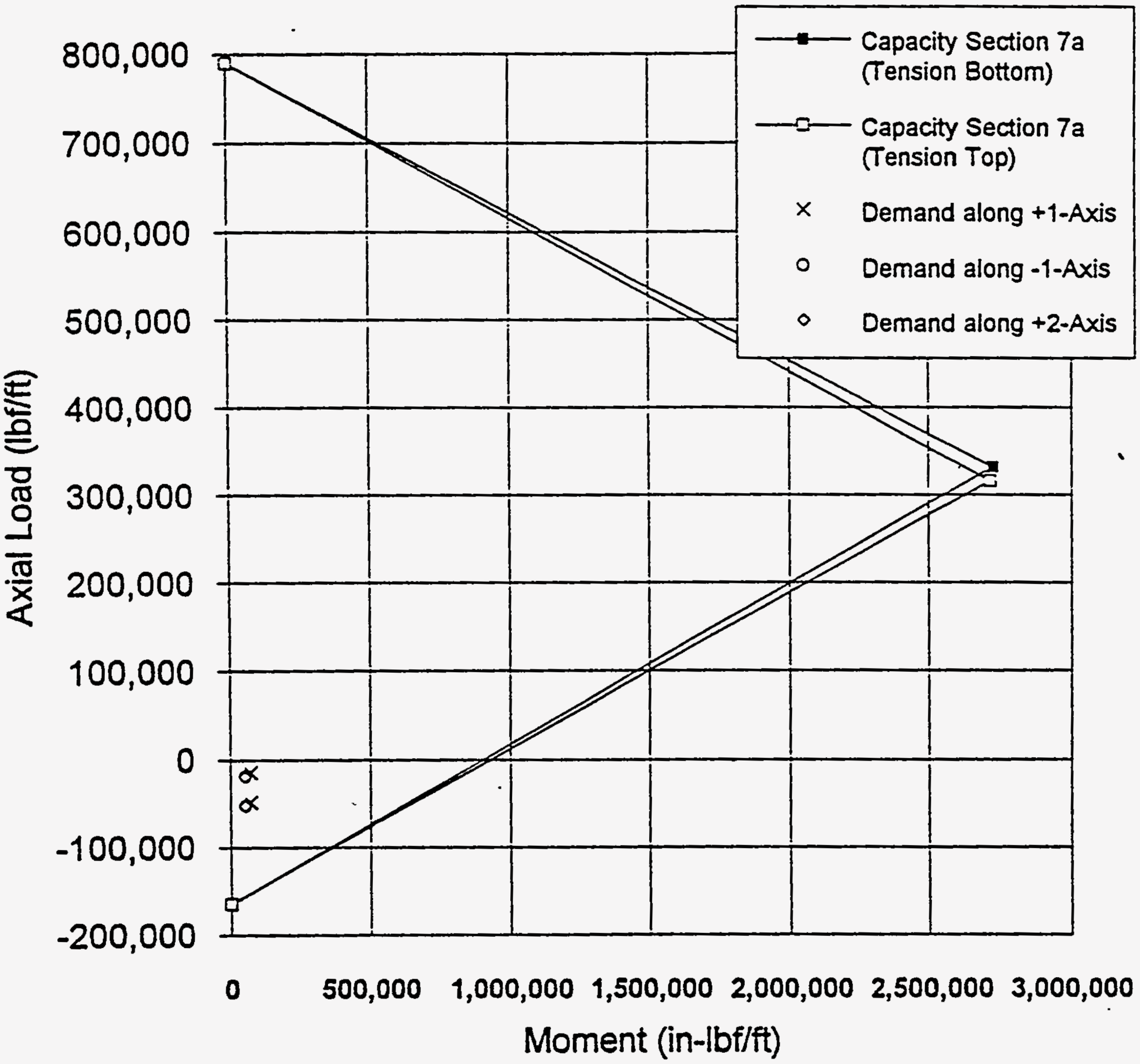
C1-3.XLC

Figure 9.2.1-43. Circumferential Moment-Axial Load Interaction Diagram for 12-Inch Thick Wall Sections: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



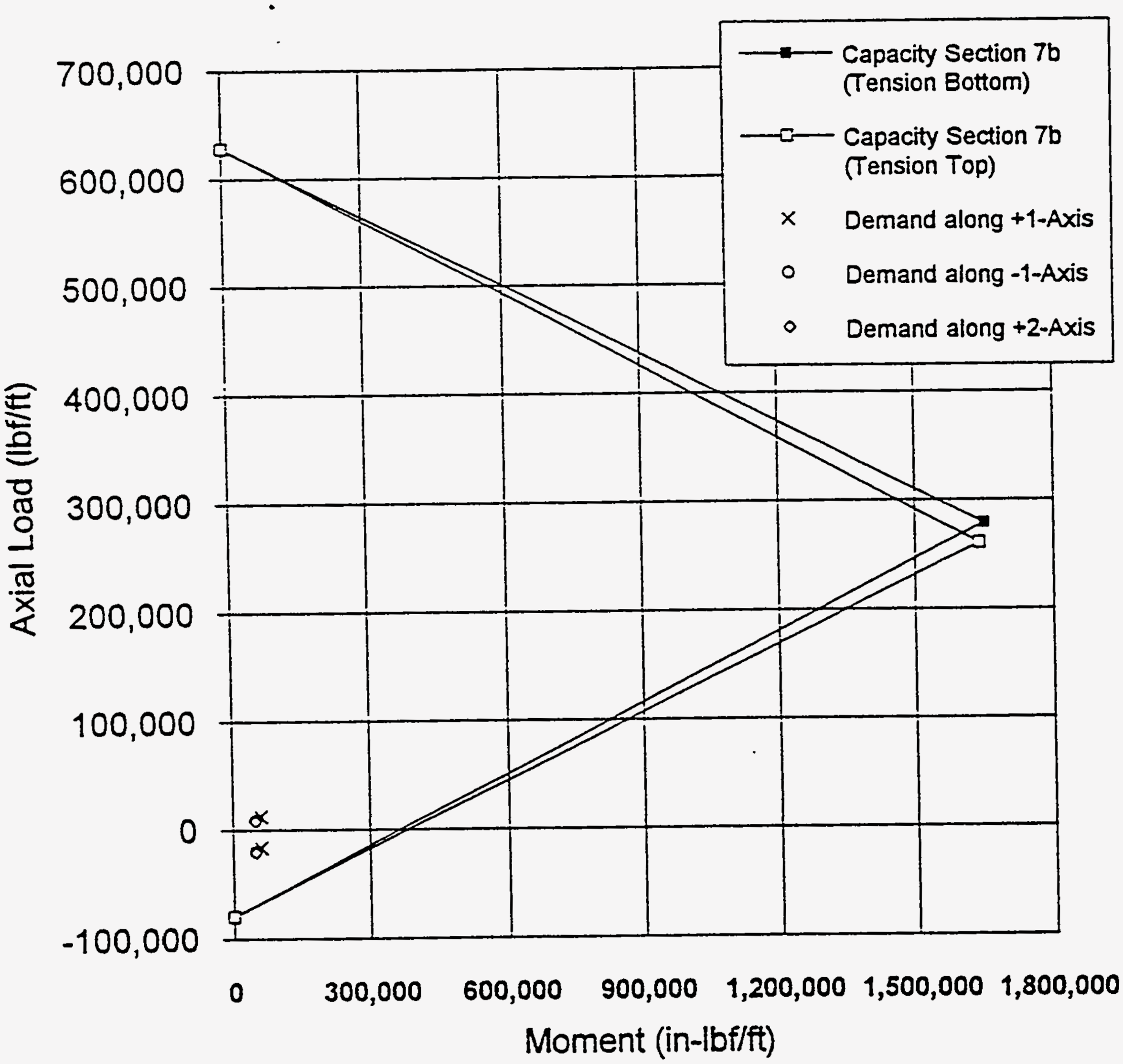
C1-456.XLC

Figure 9.2.1-44. Circumferential Moment-Axial Load Interaction Diagram for Haunch Section: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



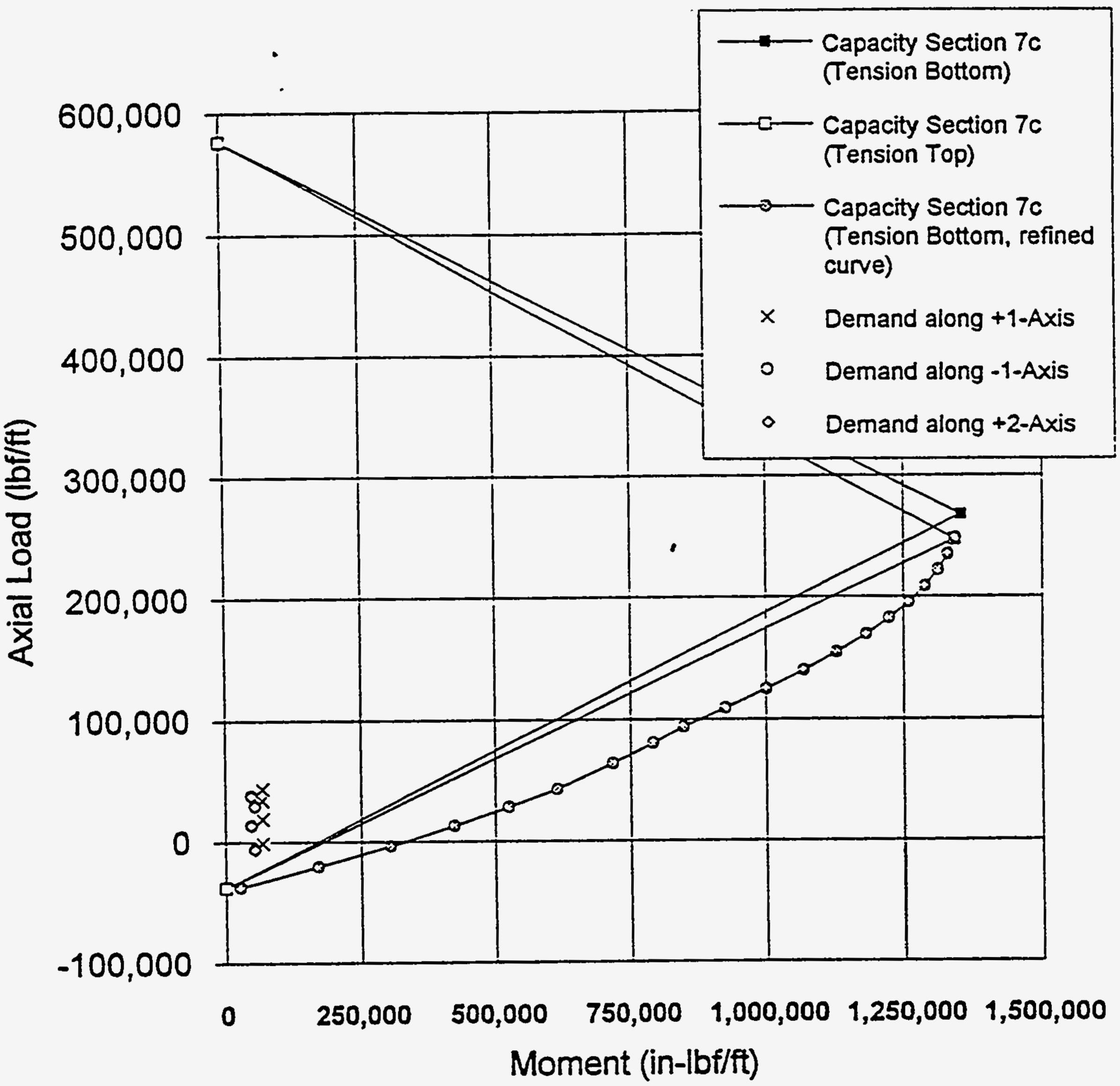
C1-7A.XLC

Figure 9.2.1-45. Circumferential Moment-Axial Load Interaction Diagram for Haunch/Dome Interface Section: Nonseismic (Load Case 1b) Plust Seismic (Lower-Bound Soil Properties).



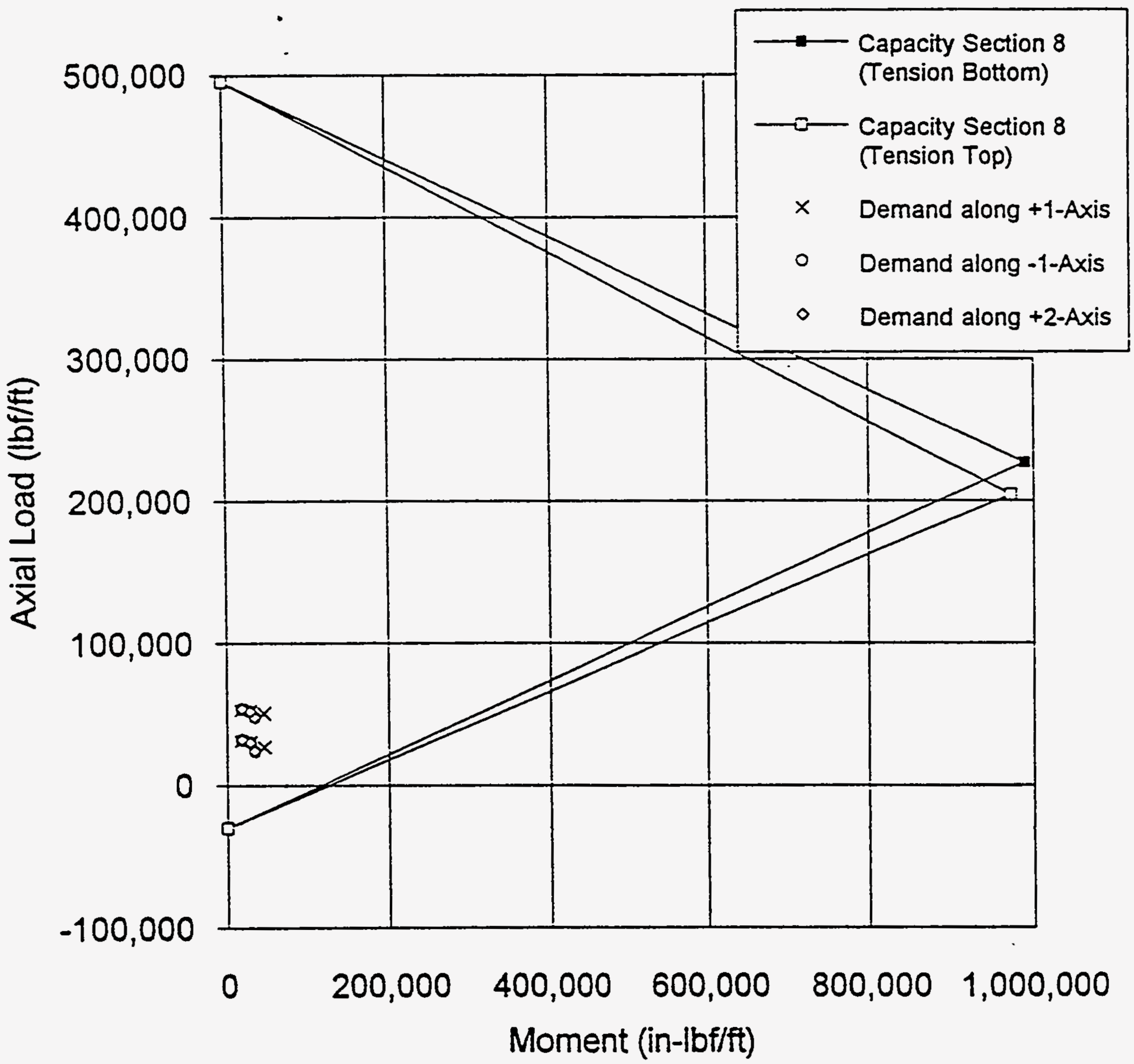
C1-7B.XLC

Figure 9.2.1-46. Circumferential Moment-Axial Load Interaction Diagram for Outer Dome Section: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



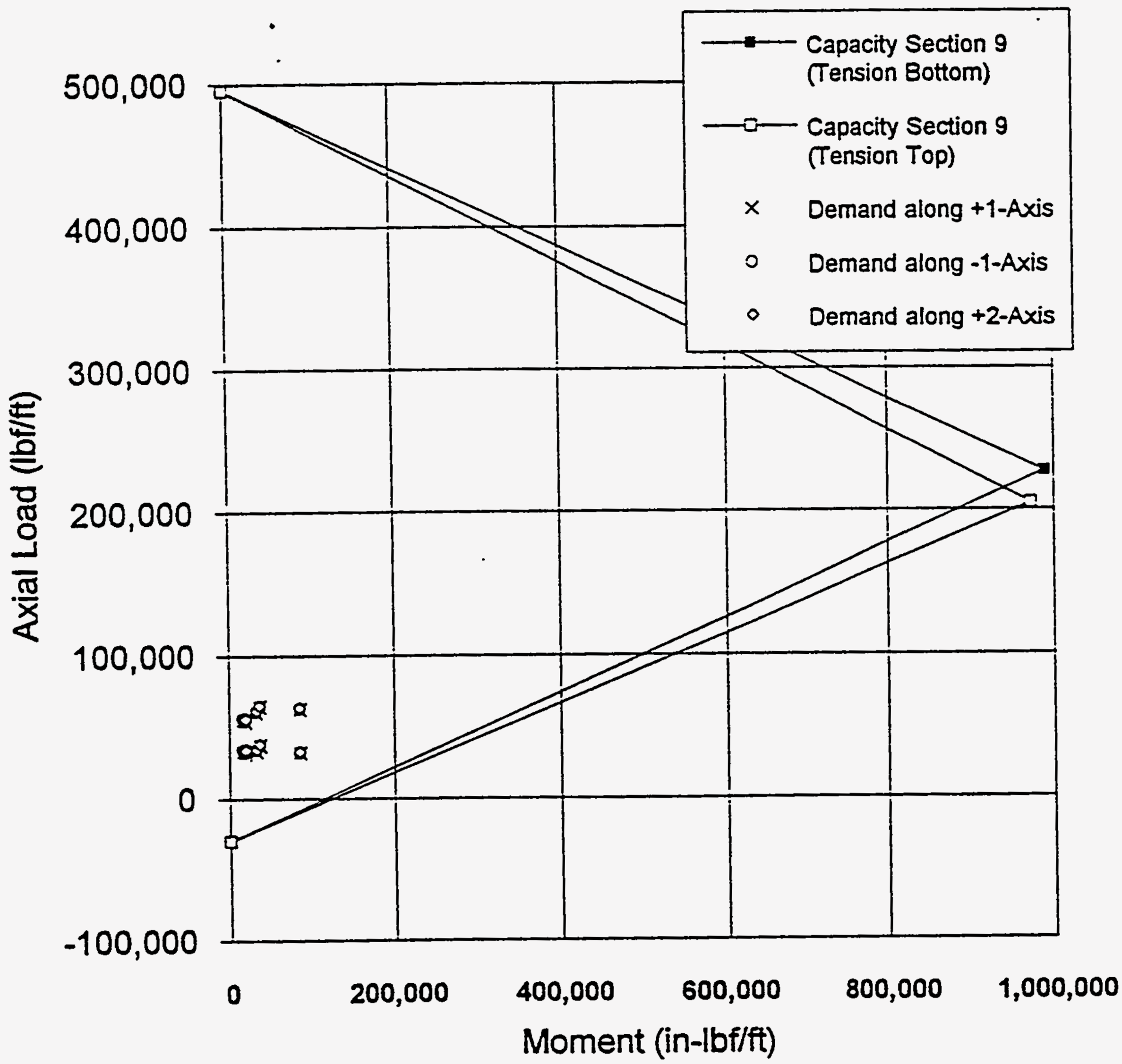
C1-7C.XLC

Figure 9.2.1-47. Circumferential Moment-Axial Load Interaction Diagram for Intermediate Dome Sections: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



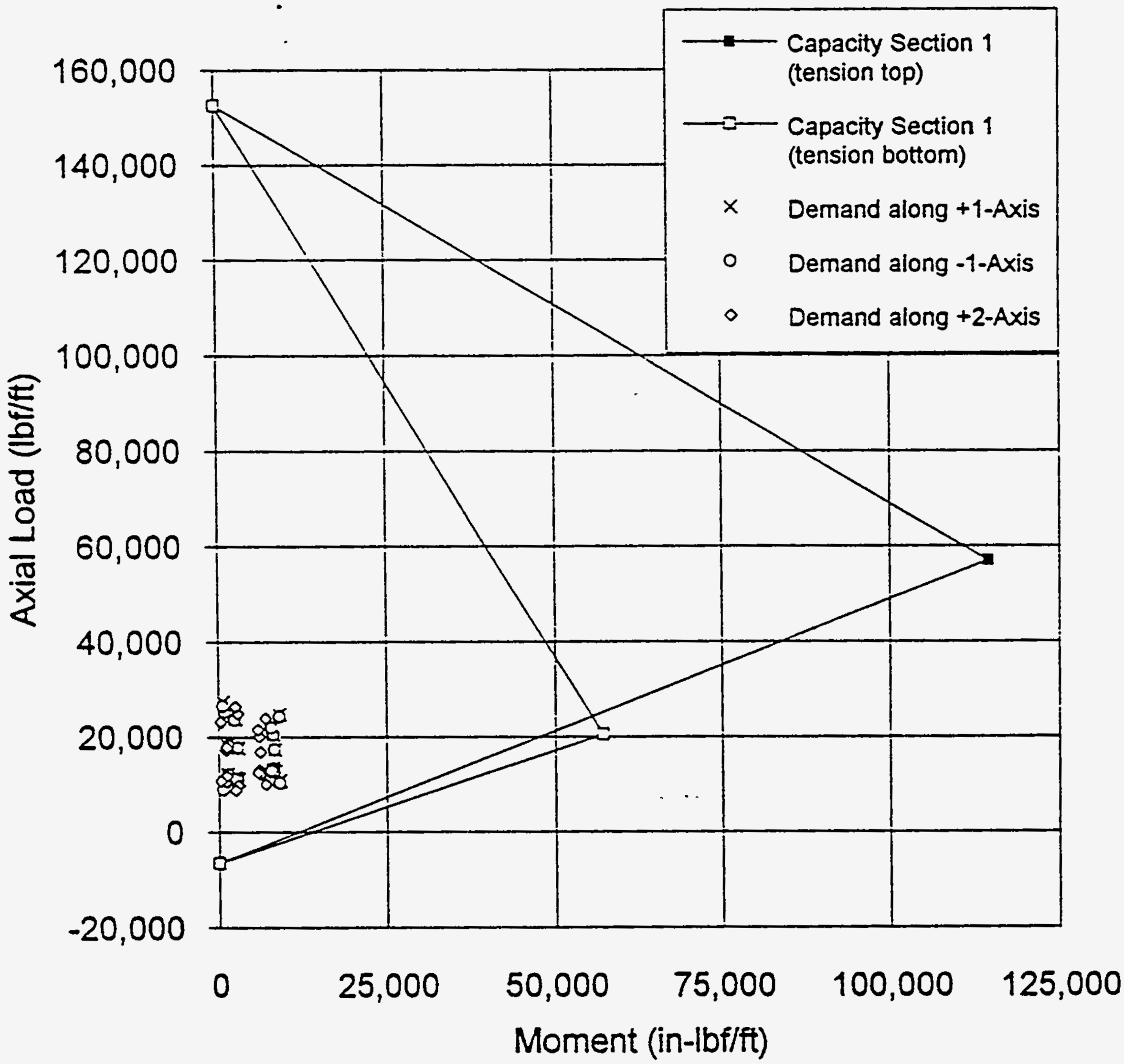
C1-8.XLC

Figure 9.2.1-48. Circumferential Moment-Axial Load Interaction Diagram for Dome Sections Near Apex: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



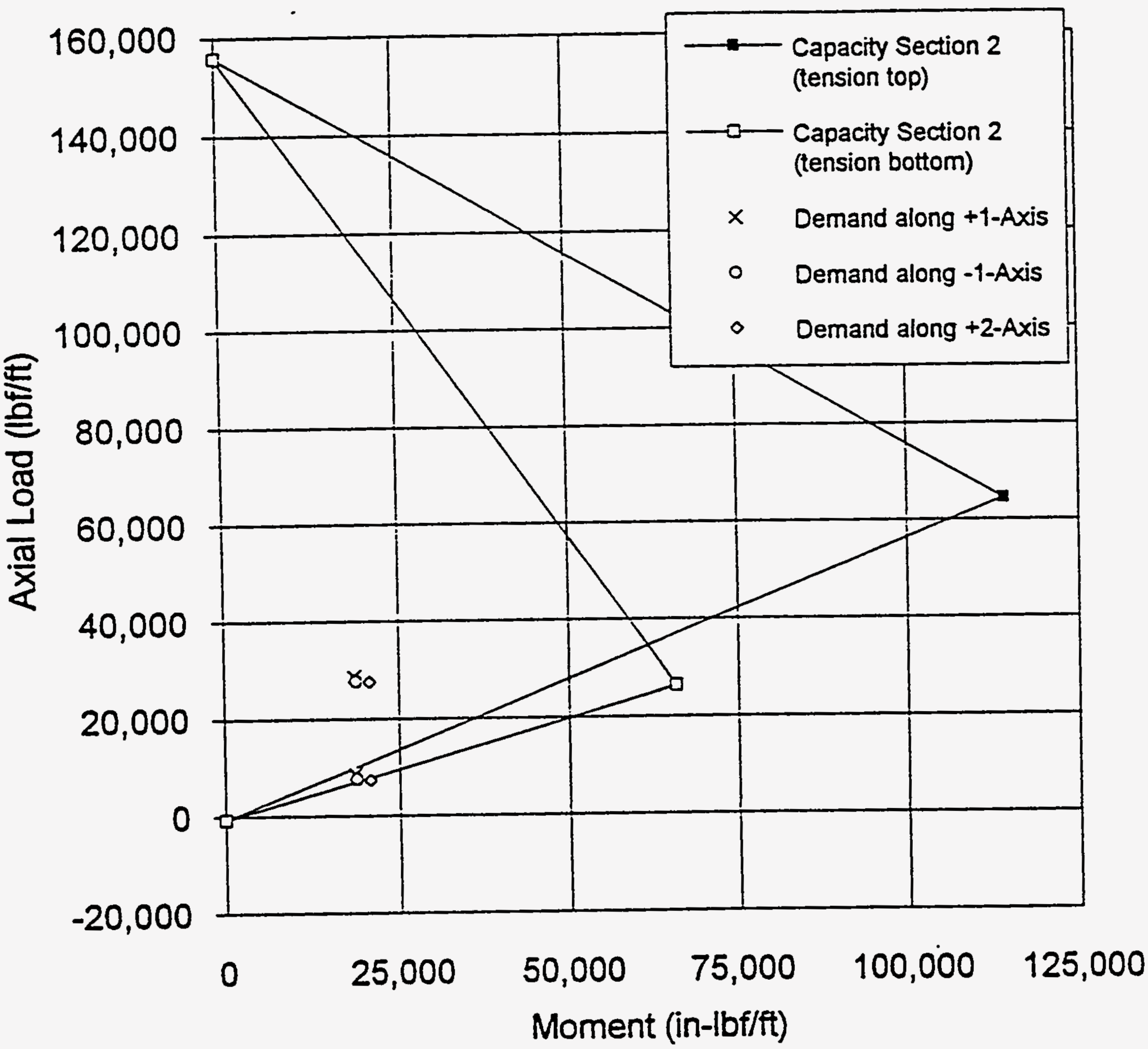
C1-9.XLC

Figure 9.2.1-49. Meridional Moment-Axial Load Interaction Diagram for Inner Base Sections: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



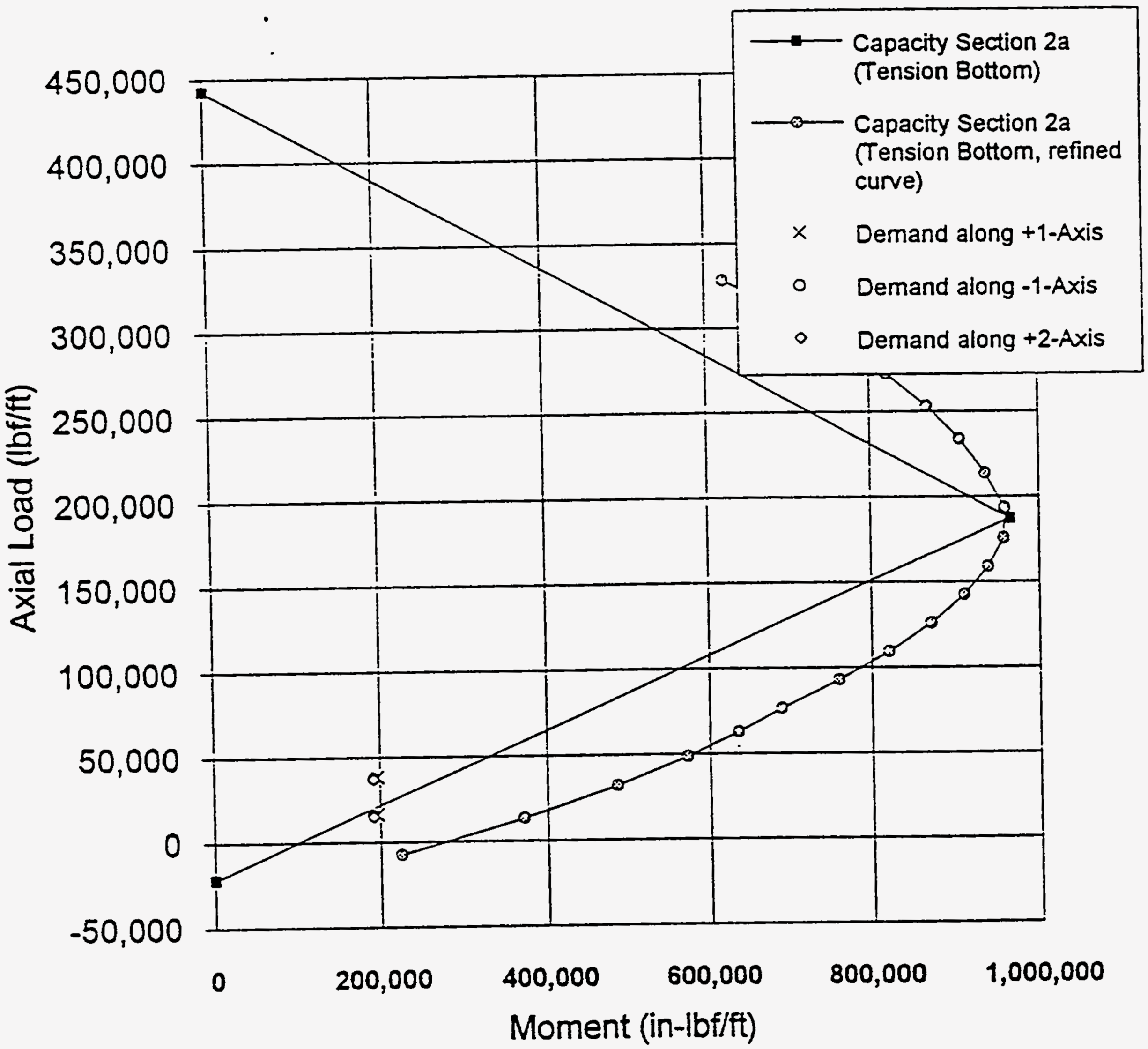
M1-1.XLC

Figure 9.2.1-50. Meridional Moment-Axial Load Interaction Diagram for Outer Base Sections: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



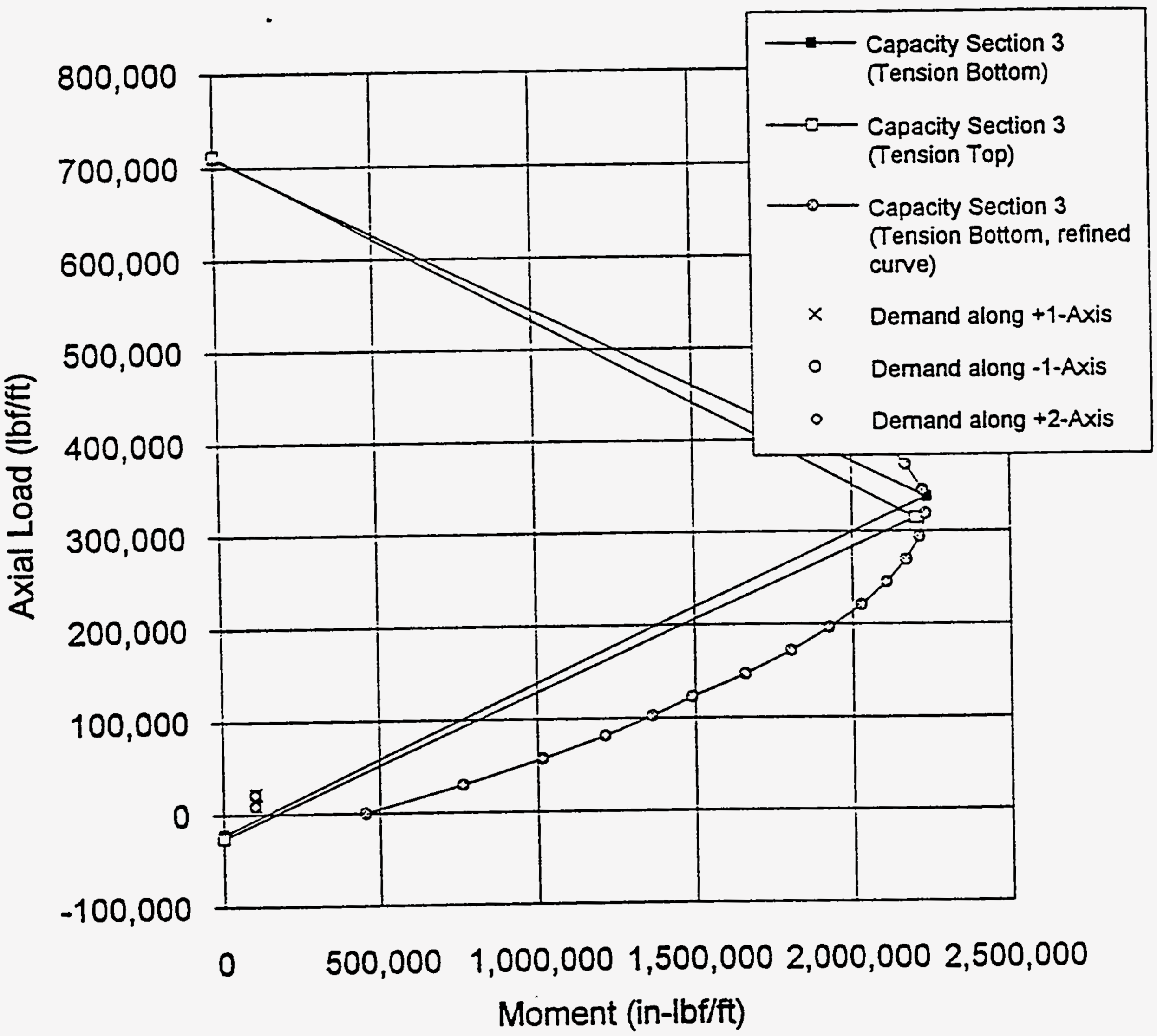
M1-2.XLC

Figure 9.2.1-51. Meridional Moment-Axial Load Interaction Diagram for Base/Wall Section: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



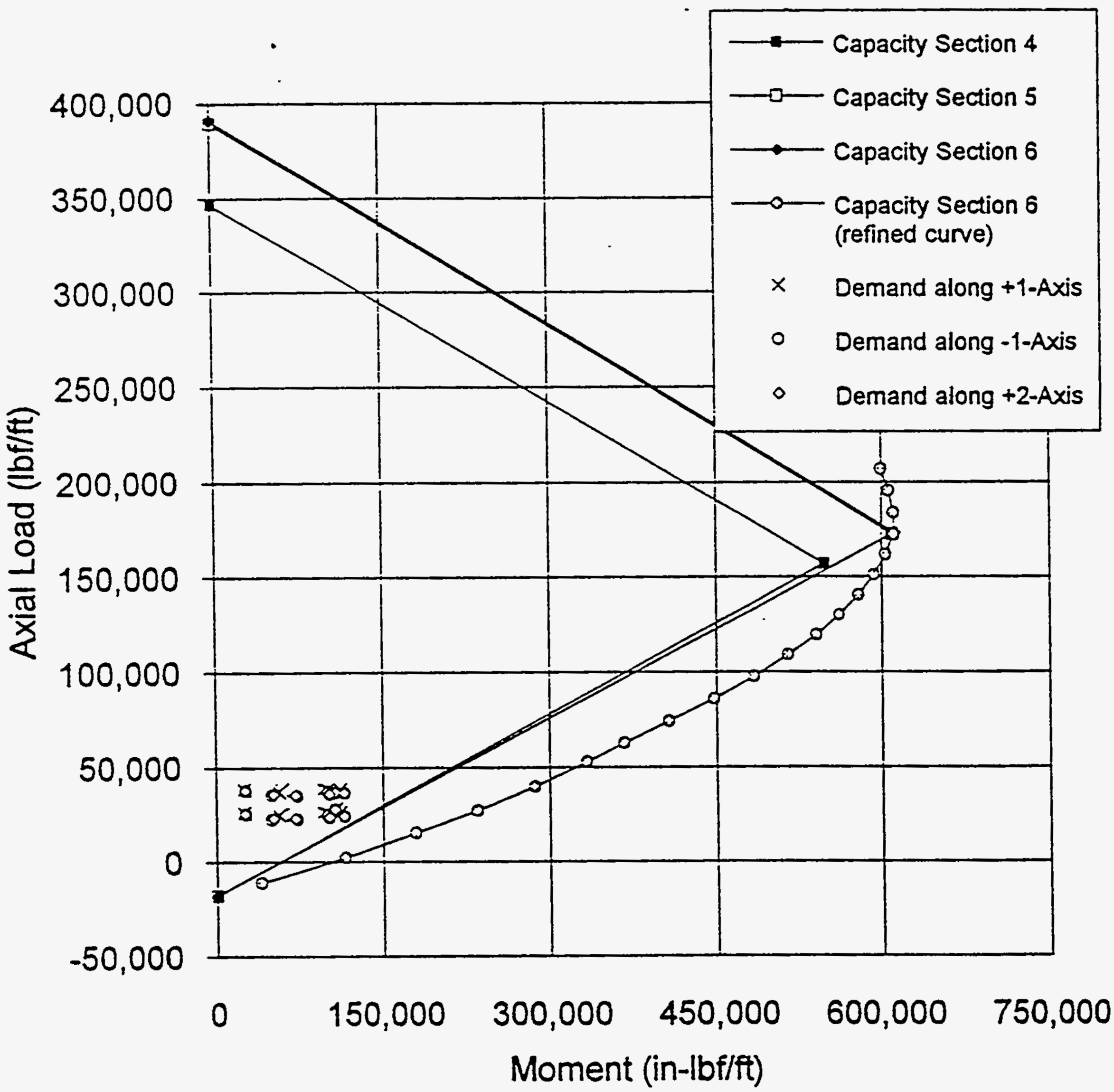
M1-2A.XLC

Figure 9.2.1-52. Meridional Moment-Axial Load Interaction Diagram for Footing Section: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



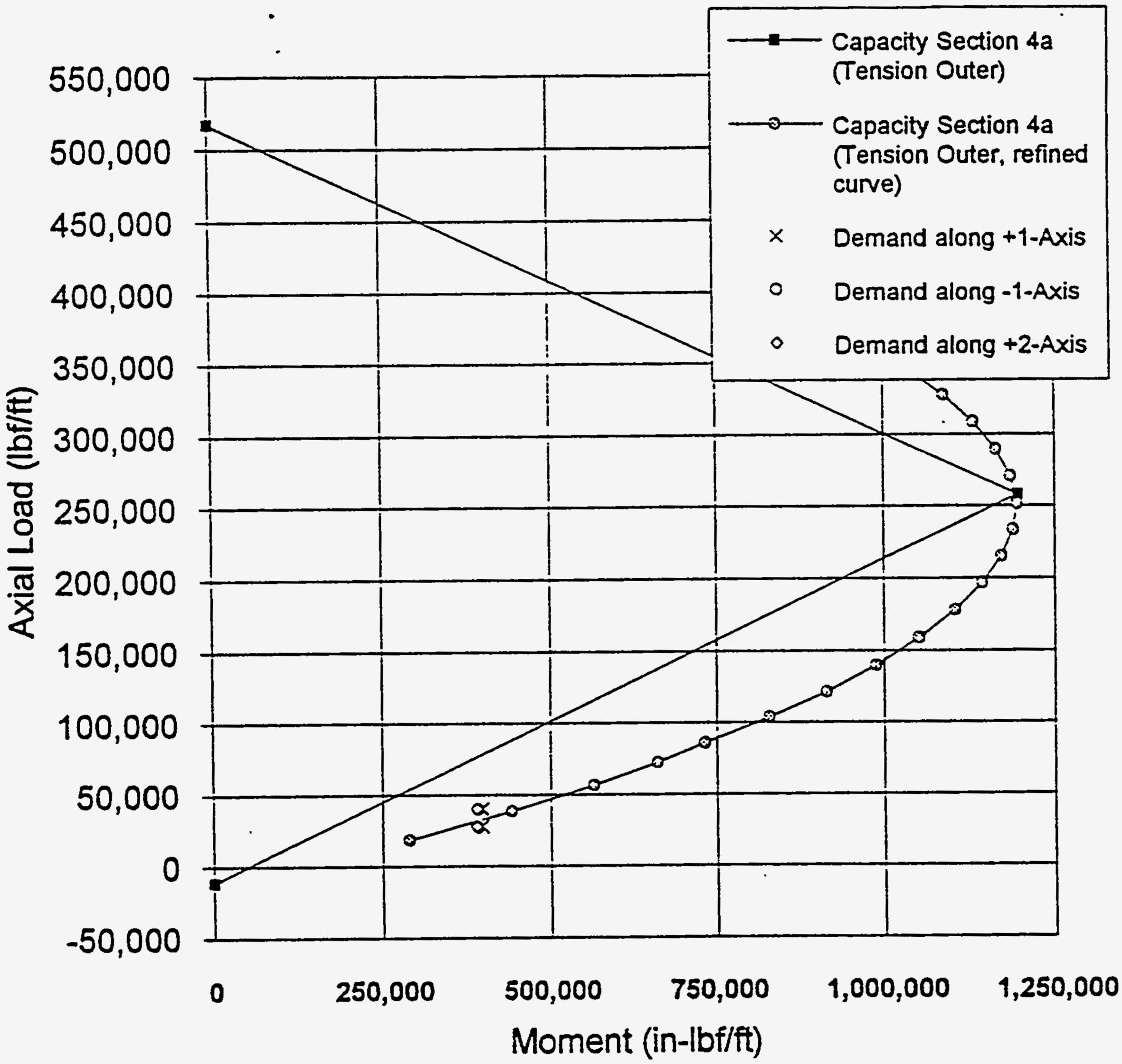
M1-3.XLC

Figure 9.2.1-53. Meridional Moment-Axial Load Interaction Diagram for 12-In.-Thick Wall Sections: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



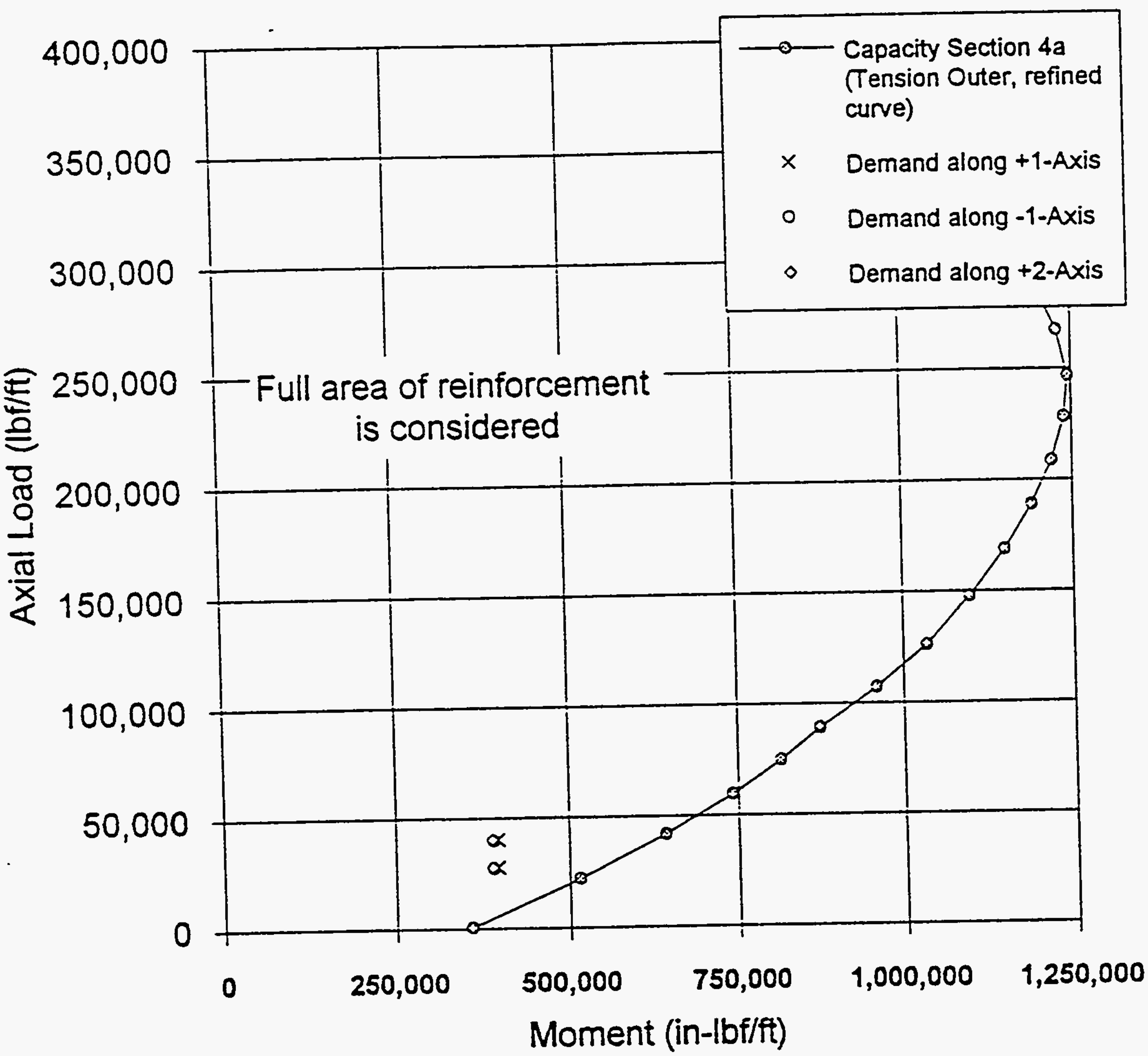
M1-456.XLC

Figure 9.2.1-54. Meridional Moment-Axial Load Interaction Diagram for Lower Wall Section (Reduced Reinforcement): Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



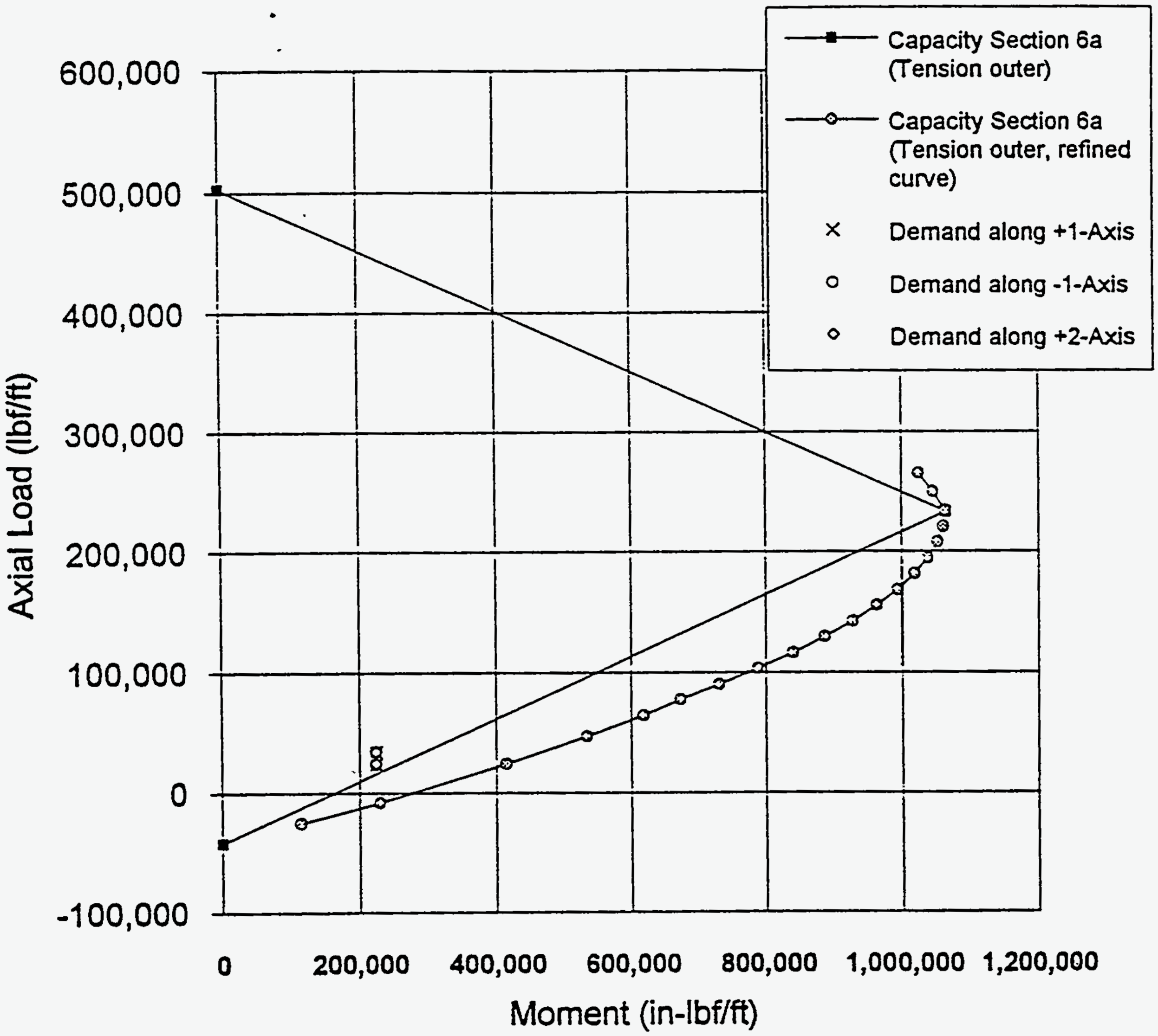
M1-4A.XLC

Figure 9.2.1-55. Meridional Moment-Axial Load Interaction Diagram for Lower Wall Section: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



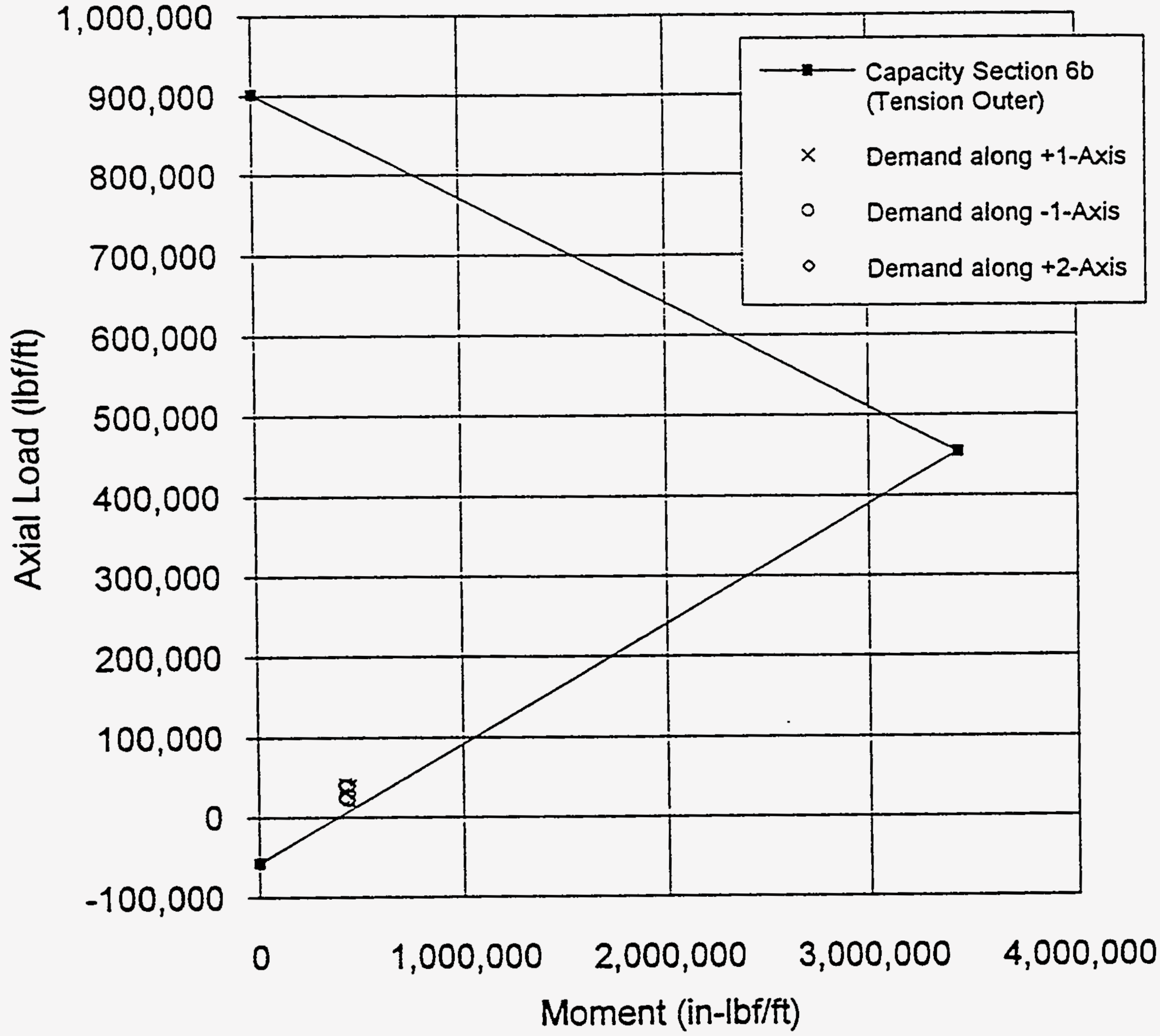
M1-4A-2.XLC

Figure 9.2.1-56. Meridional Moment-Axial Load Interaction Diagram for Wall/Haunch Interface Section: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



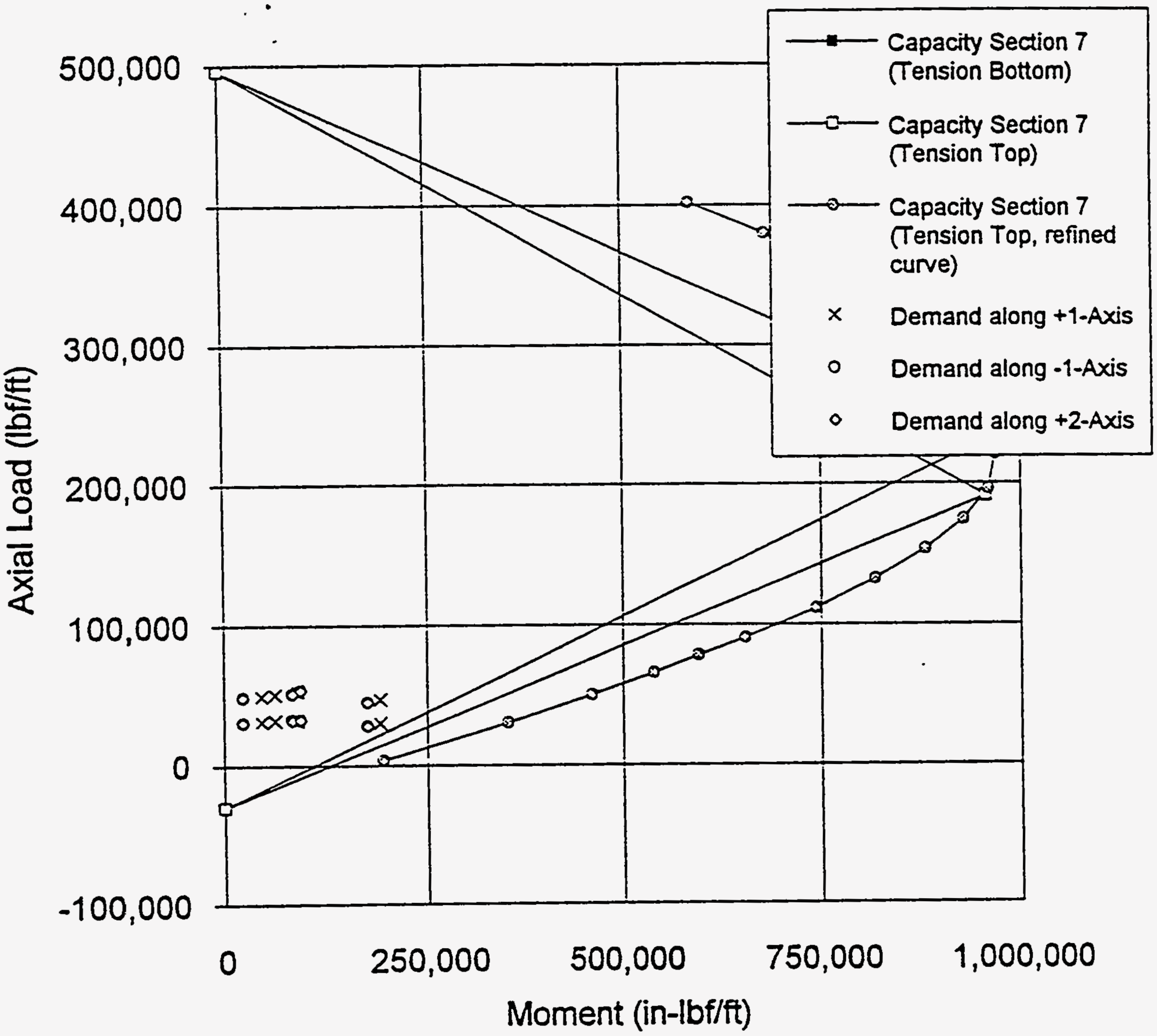
M1-6A.XLC

Figure 9.2.1-57. Meridional Moment-Axial Load Interaction Diagram for Haunch Section: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



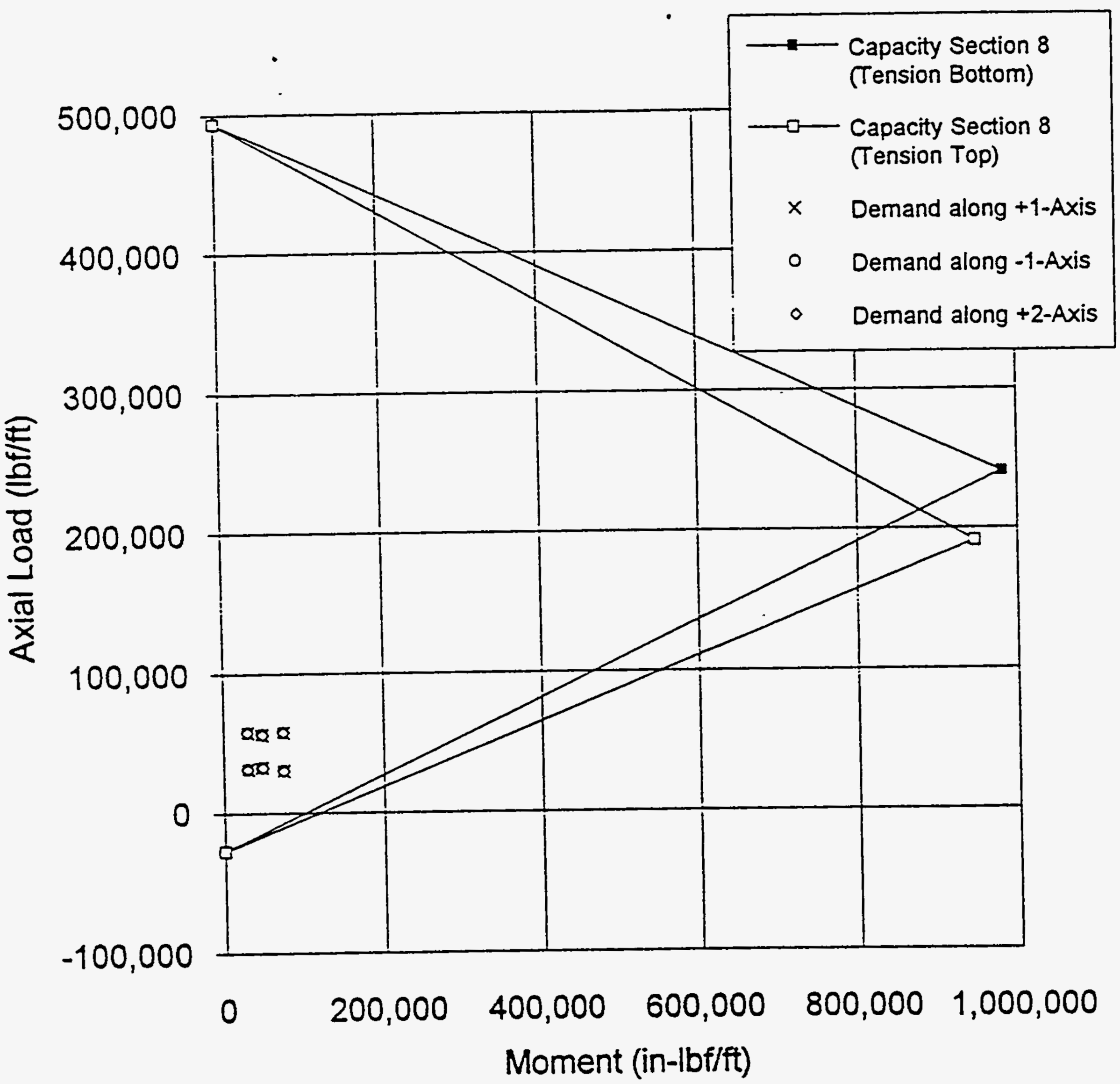
M1-6B.XLC

Figure 9.2.1-58. Meridional Moment-Axial Load Interaction Diagram for Haunch/Dome Interface Section: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



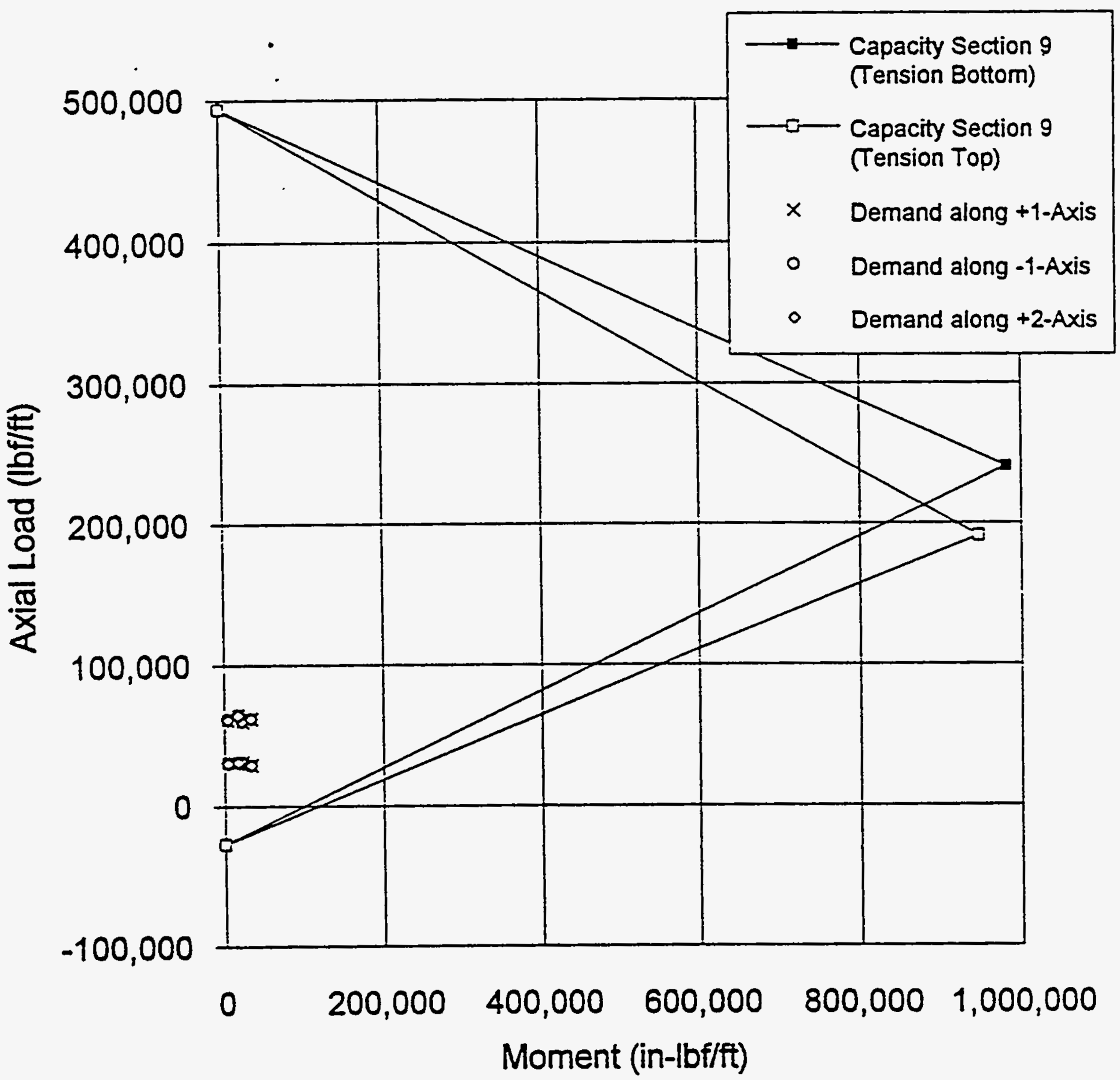
M1-7.XLC

Figure 9.2.1-59. Meridional Moment-Axial Load Interaction Diagram for Intermediate Dome Sections: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



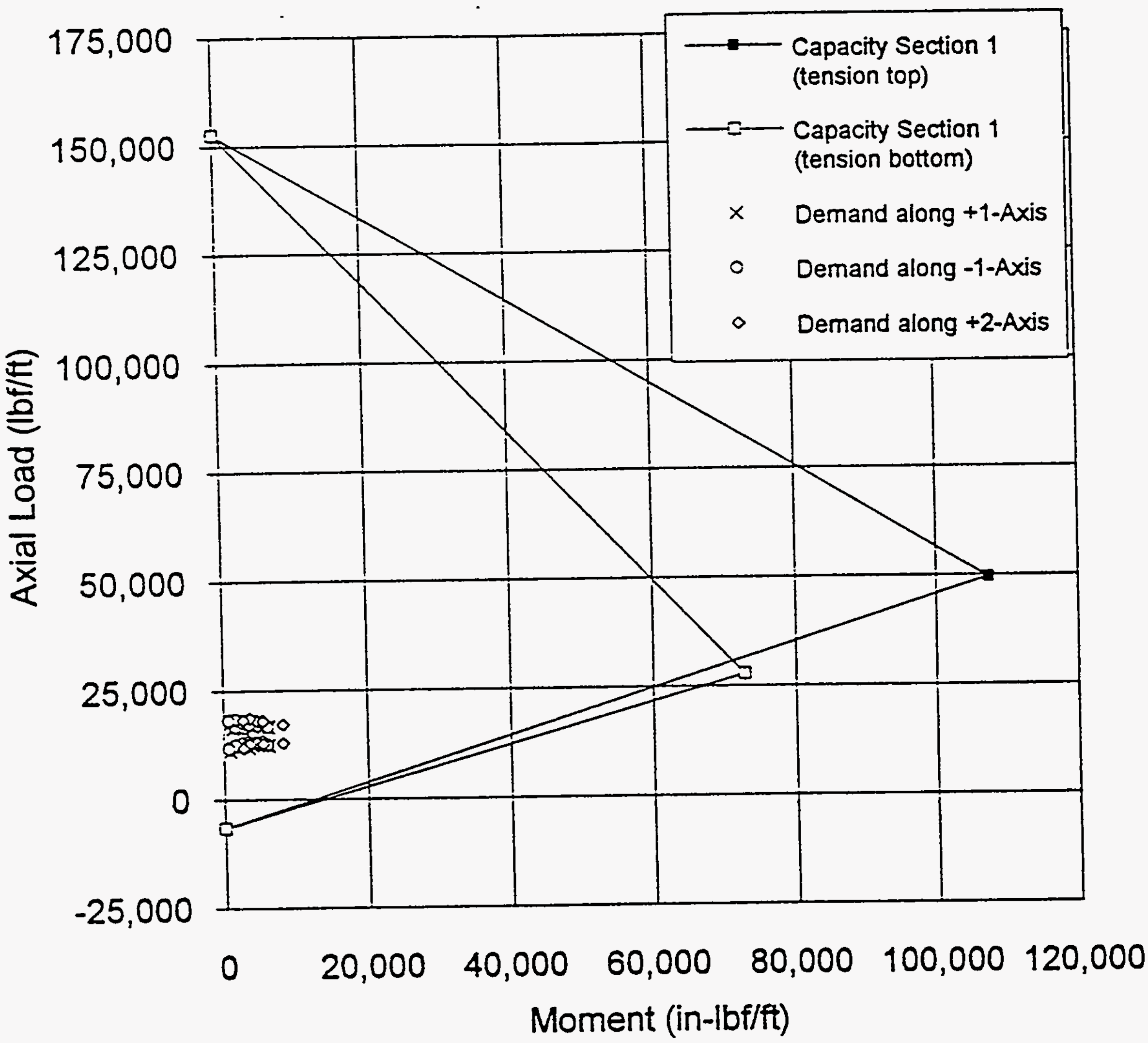
M1-8.XLC

Figure 9.2.1-60. Meridional Moment-Axial Load Interaction Diagram for Dome Sections Near Apex: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



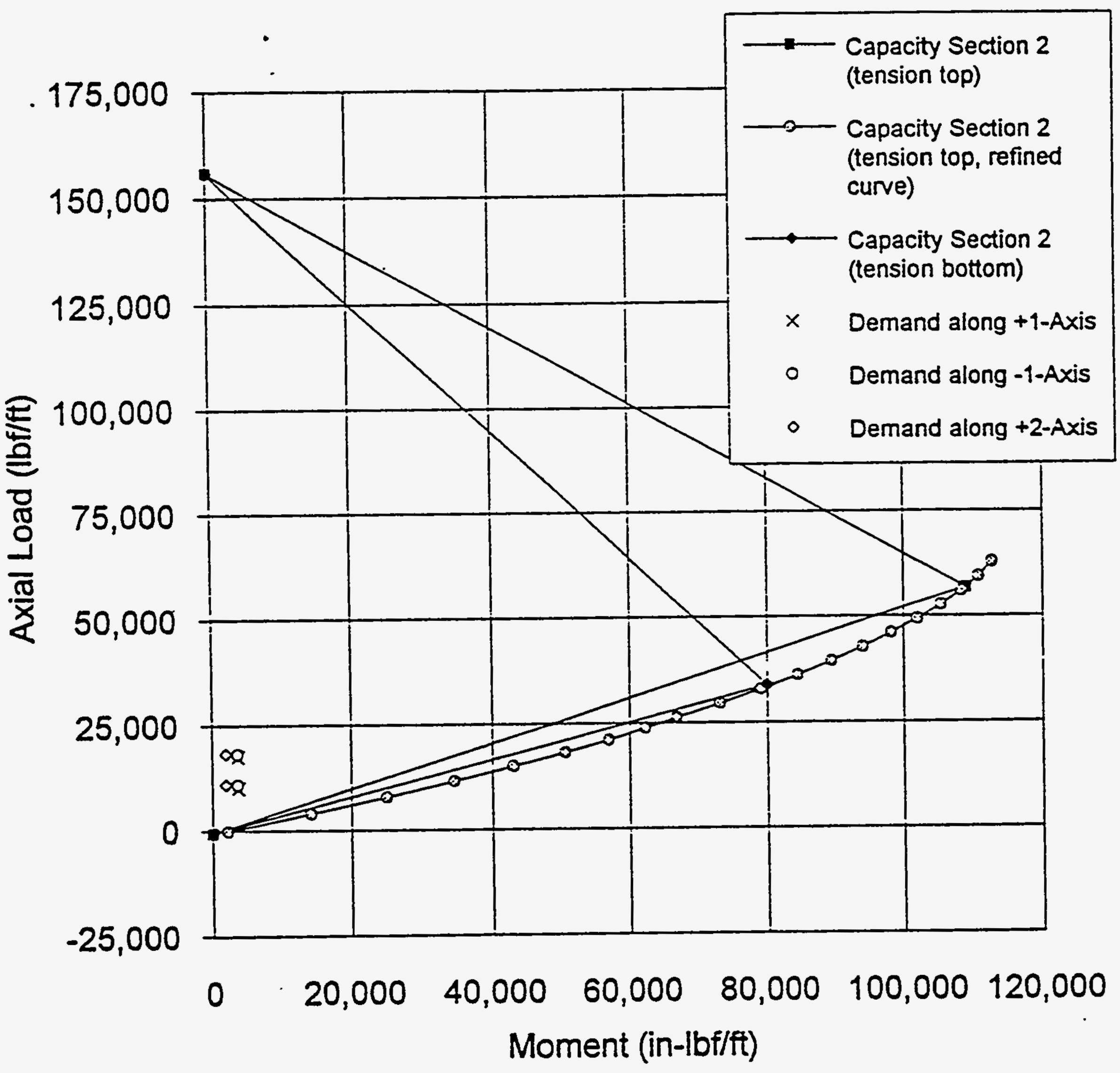
M1-9.XLC

Figure 9.2.1-61. Circumferential Moment-Axial Load Interaction Diagram for Inner Base Sections: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



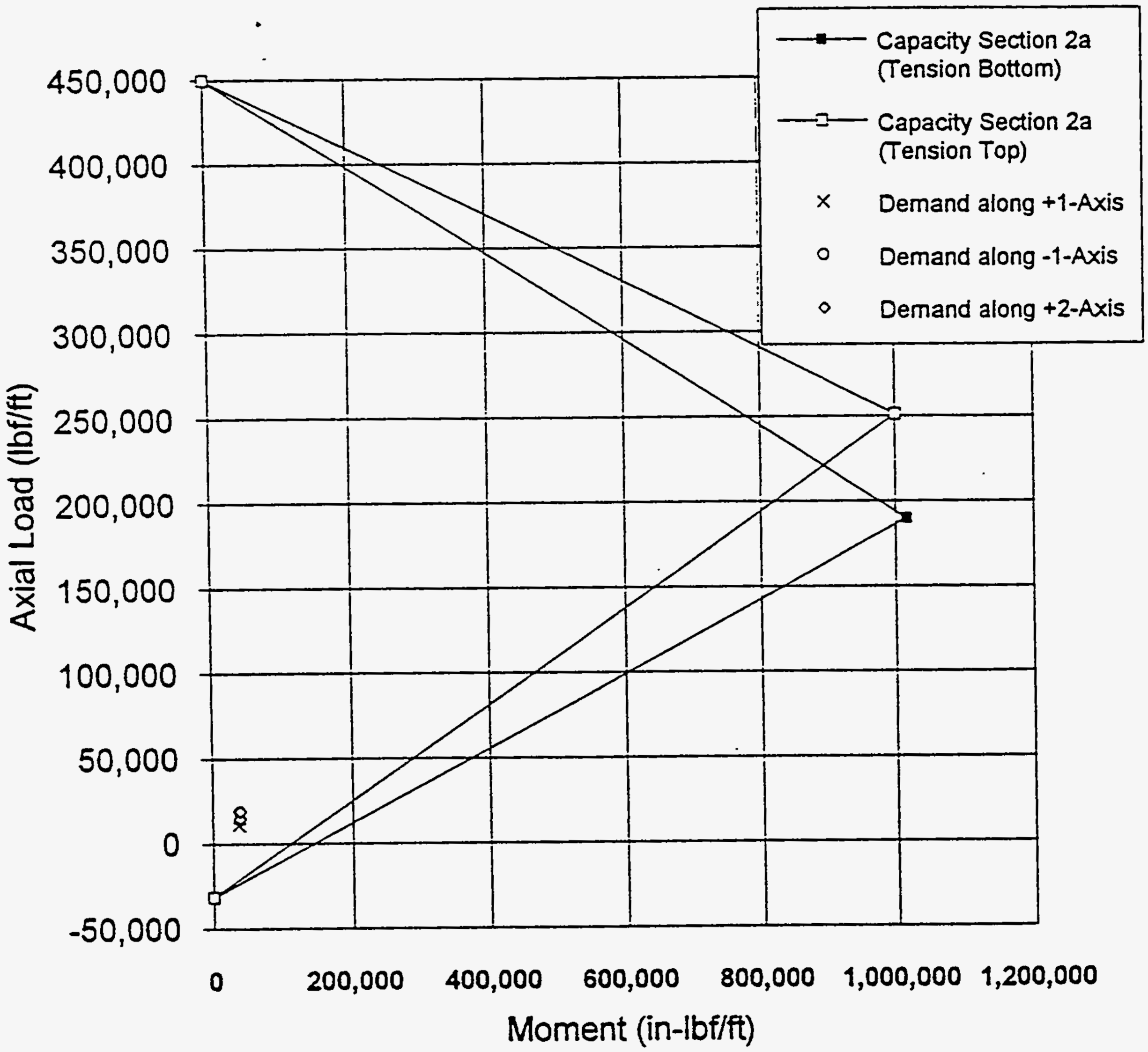
C1-1.XLC

Figure 9.2.1-62. Circumferential Moment-Axial Load Interaction Diagram for Outer Base Sections: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



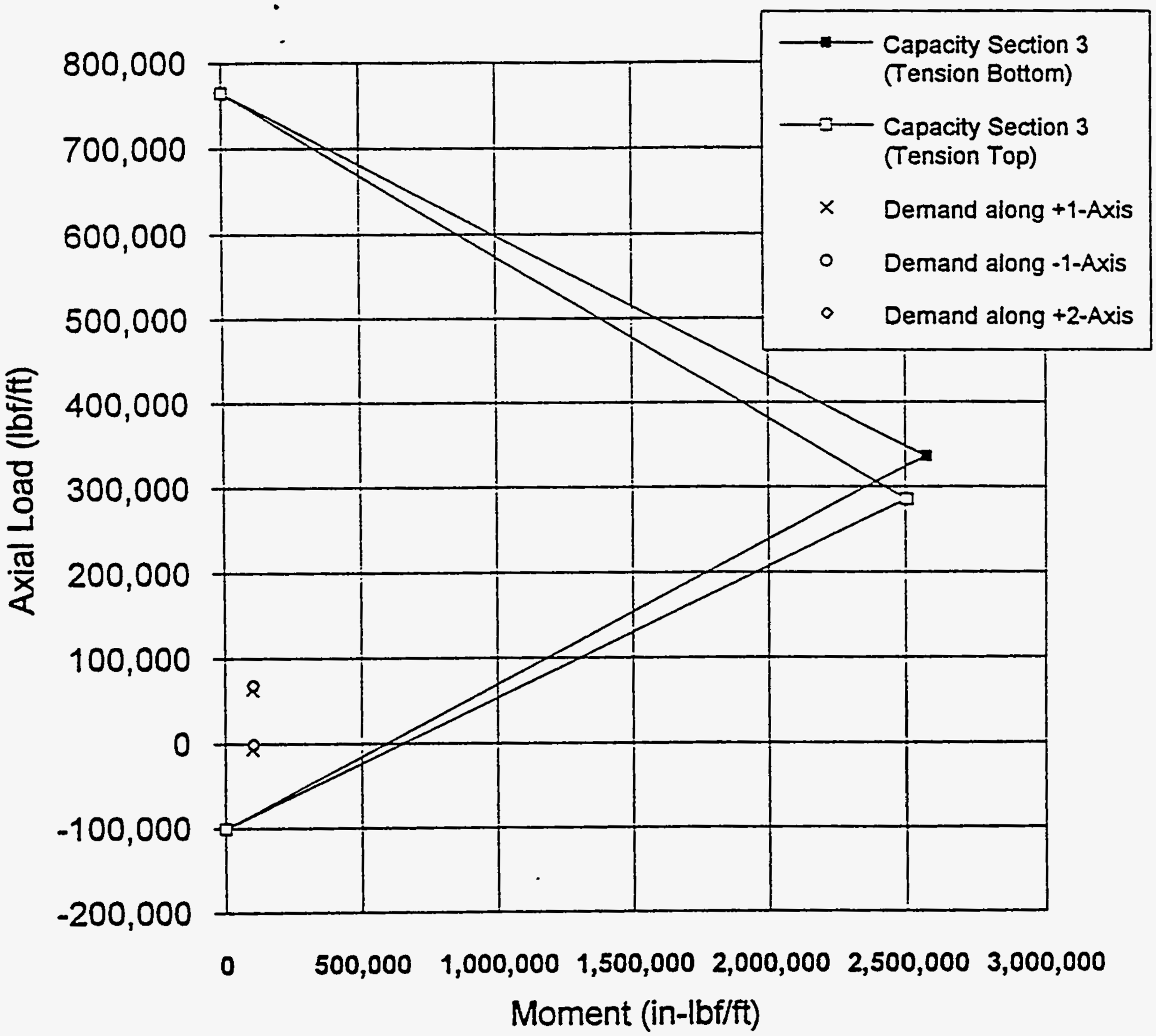
C1-2.XLC

Figure 9.2.1-63. Circumferential Moment-Axial Load Interaction Diagram for Base/Wall Interface Section: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



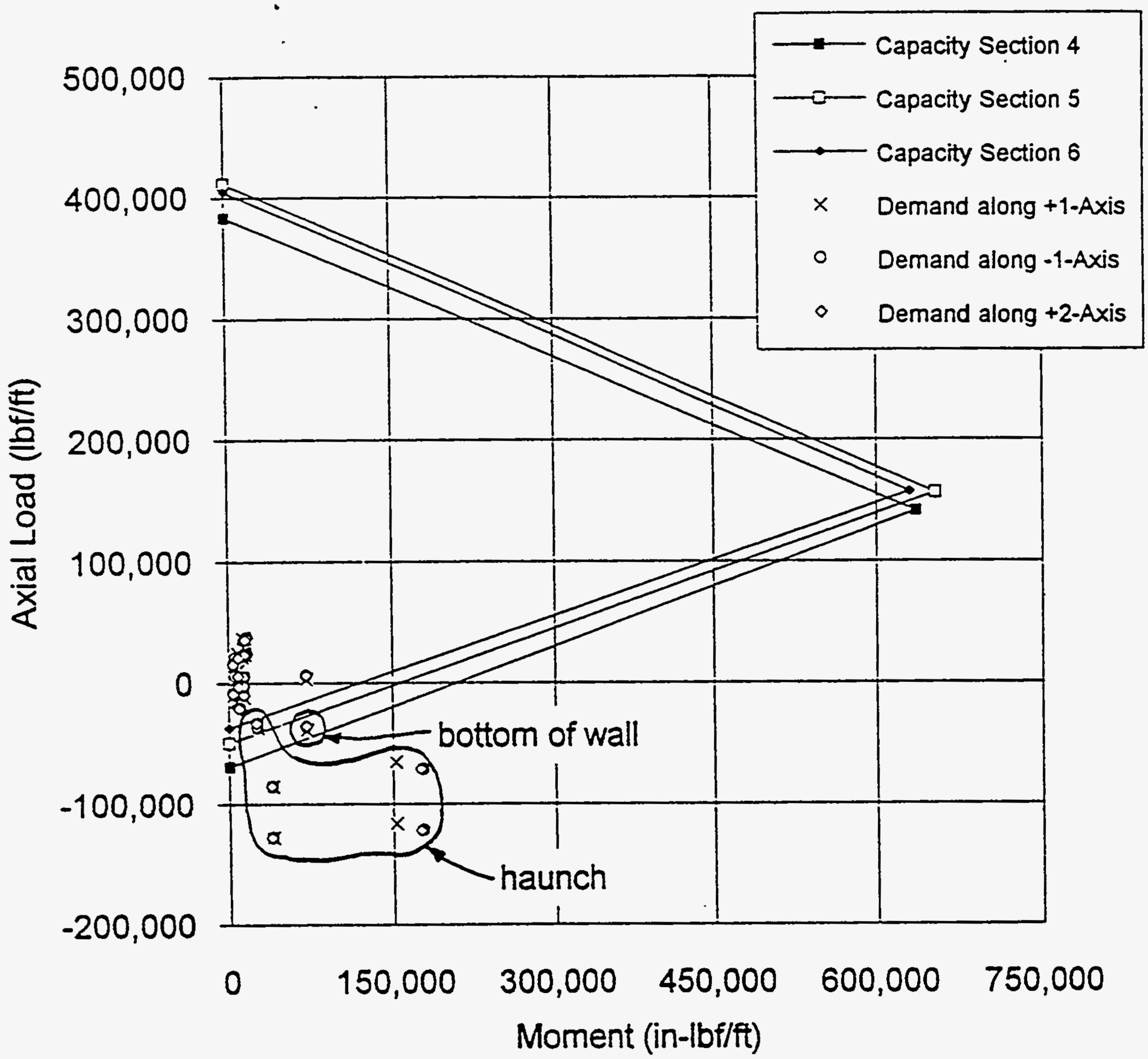
C1-2A.XLC

Figure 9.2.1-64. Circumferential Moment-Axial Load Interaction Diagram for Footing Section: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



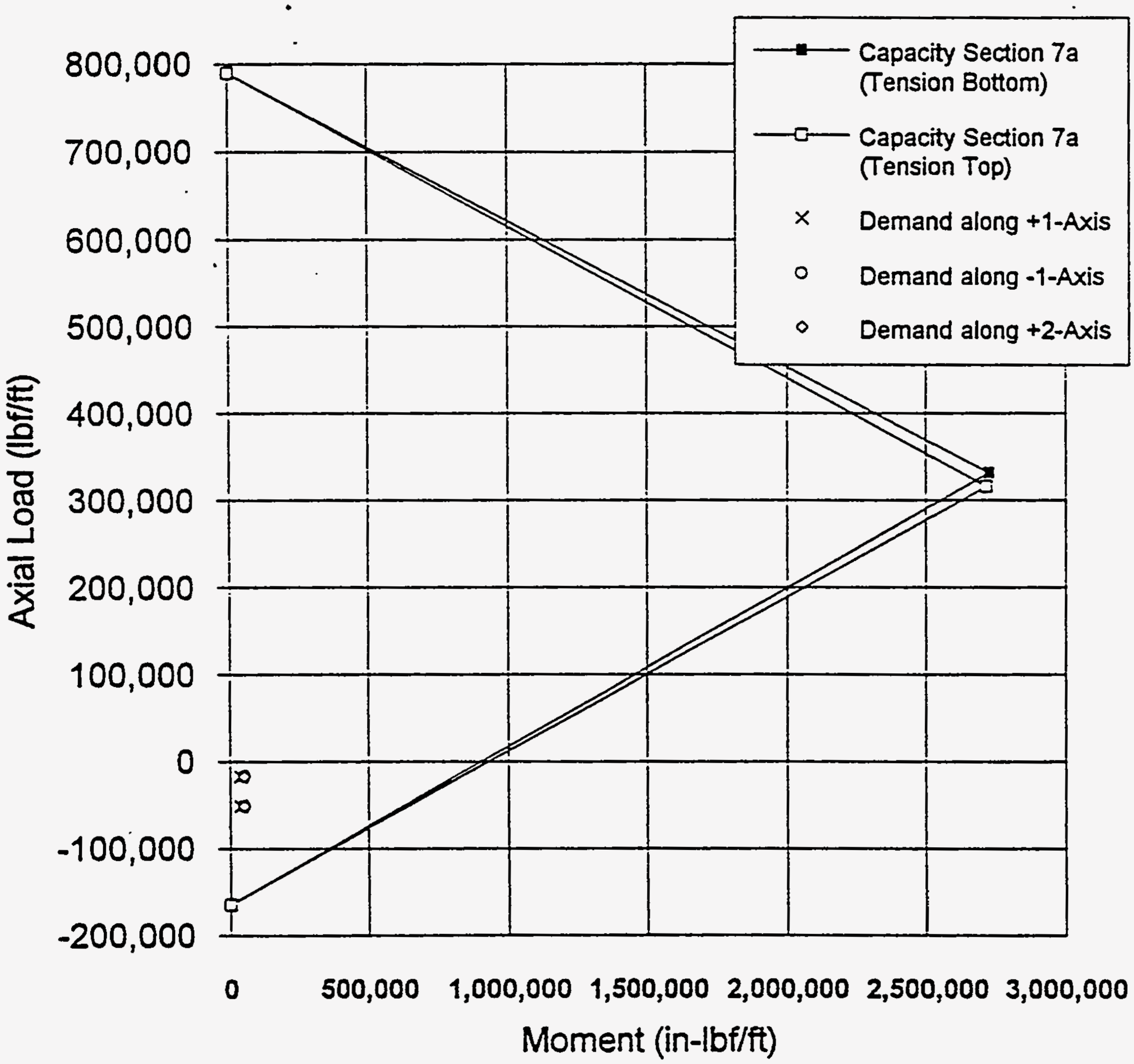
C1-3.XLC

Figure 9.2.1-65. Circumferential Moment-Axial Load Interaction Diagram for 12-Inch Thick Wall Sections: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



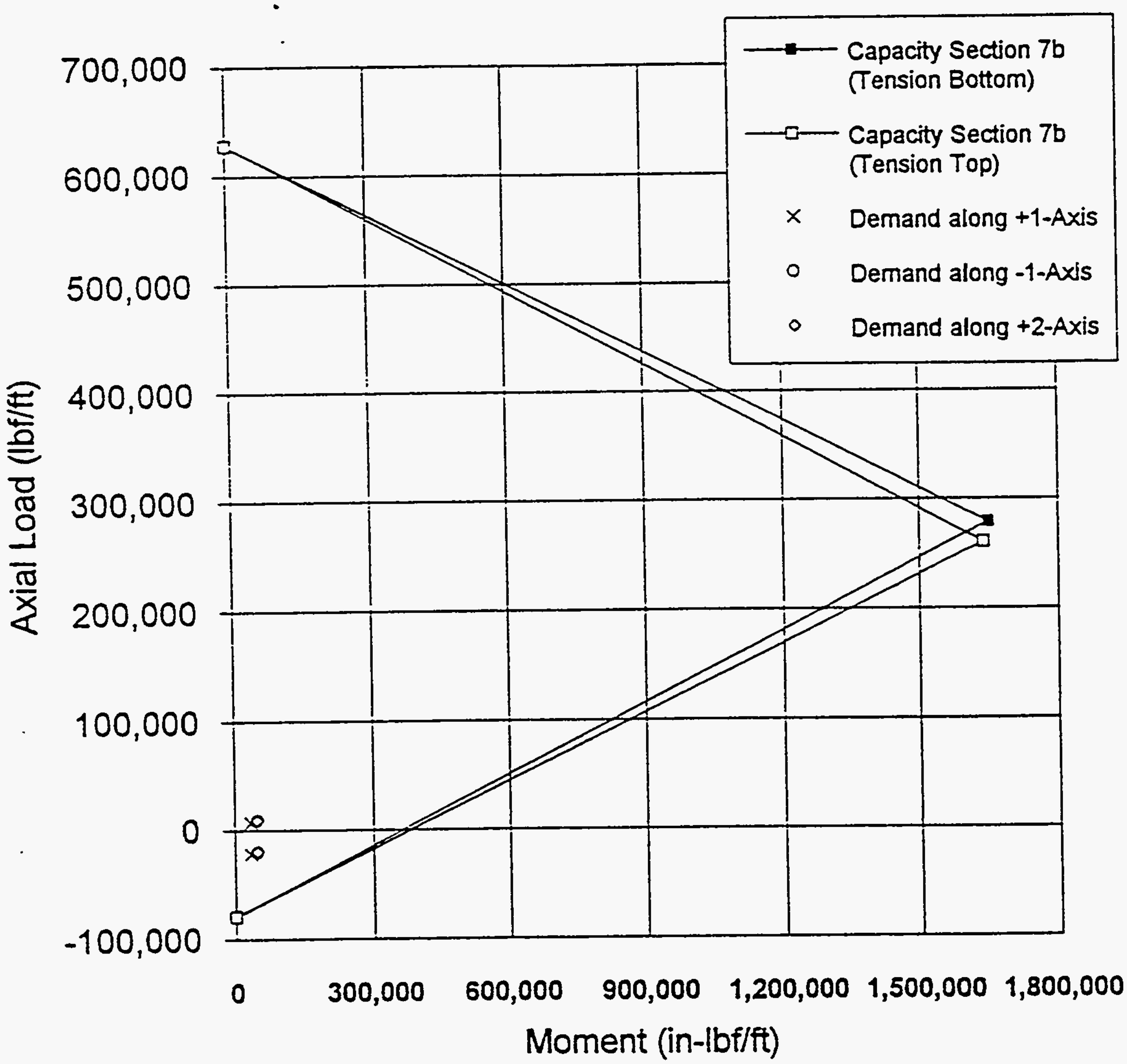
C1-456.XLC

Figure 9.2.1-66. Circumferential Moment-Axial Load Interaction Diagram for Haunch Section: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



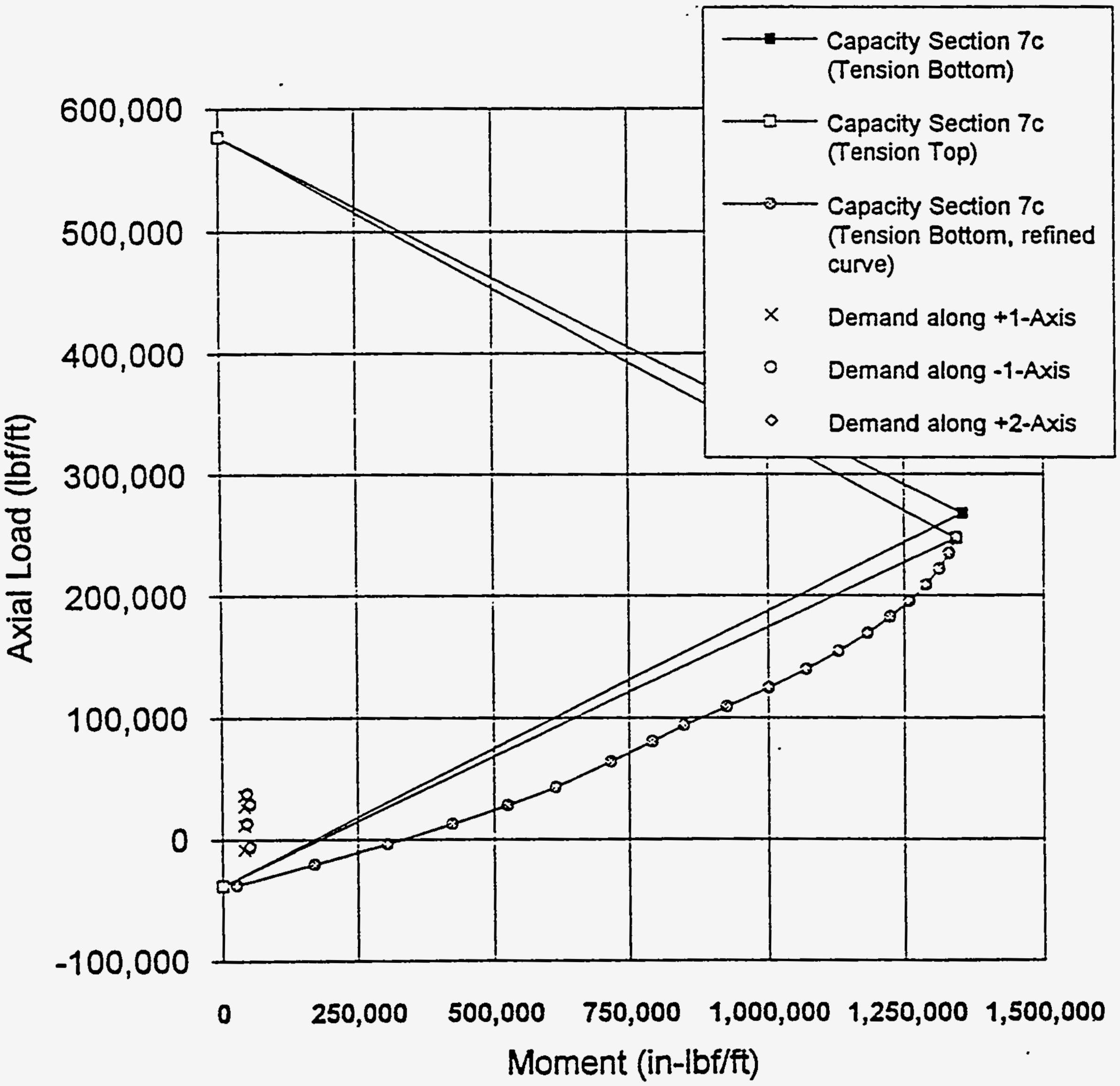
C1-7A.XLC

Figure 9.2.1-67. Circumferential Moment-Axial Load Interaction Diagram for Haunch/Dome Interface Section: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



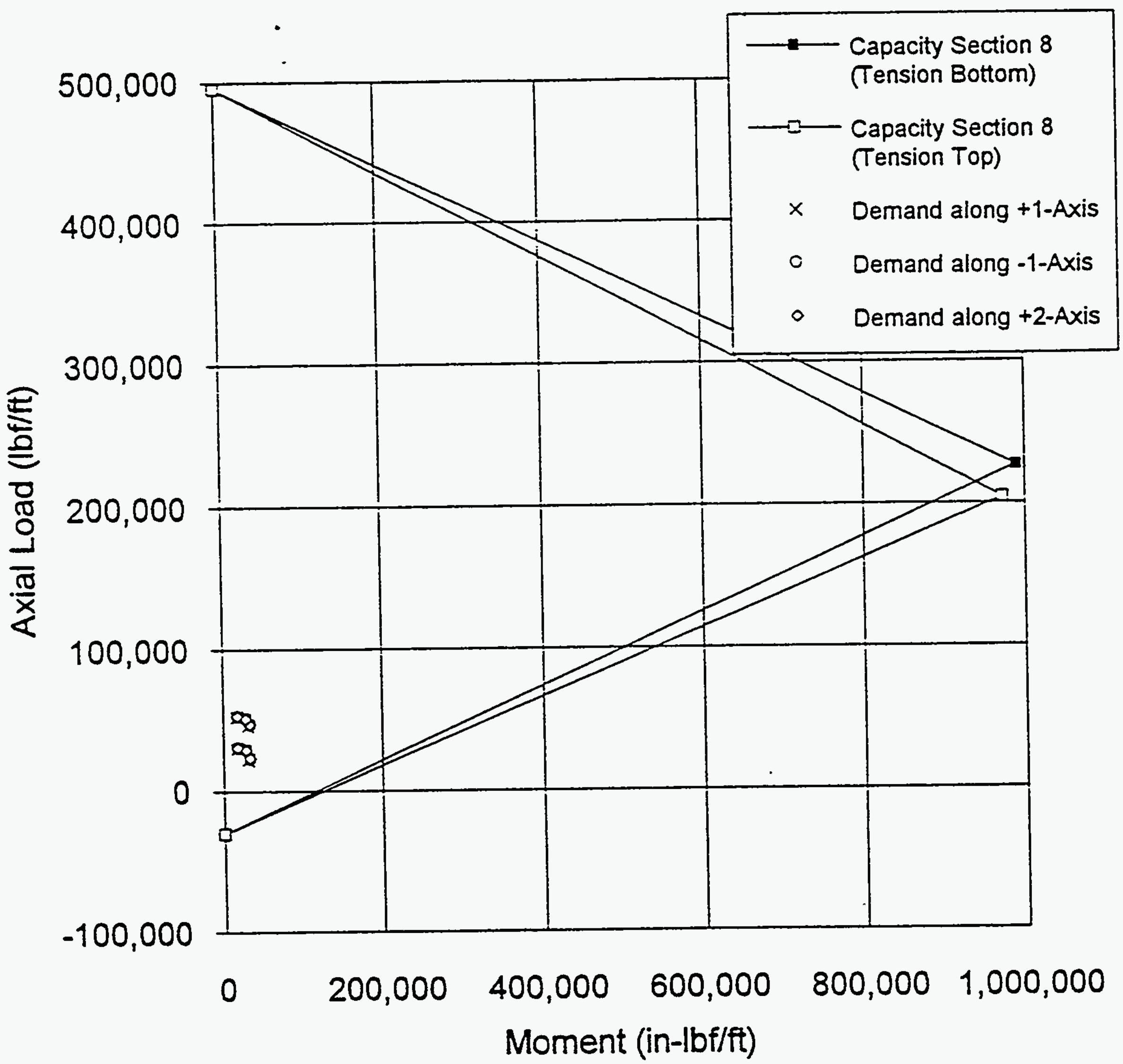
C1-7B.XLC

Figure 9.2.1-68. Circumferential Moment-Axial Load Interaction Diagram for Outer Dome Section: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



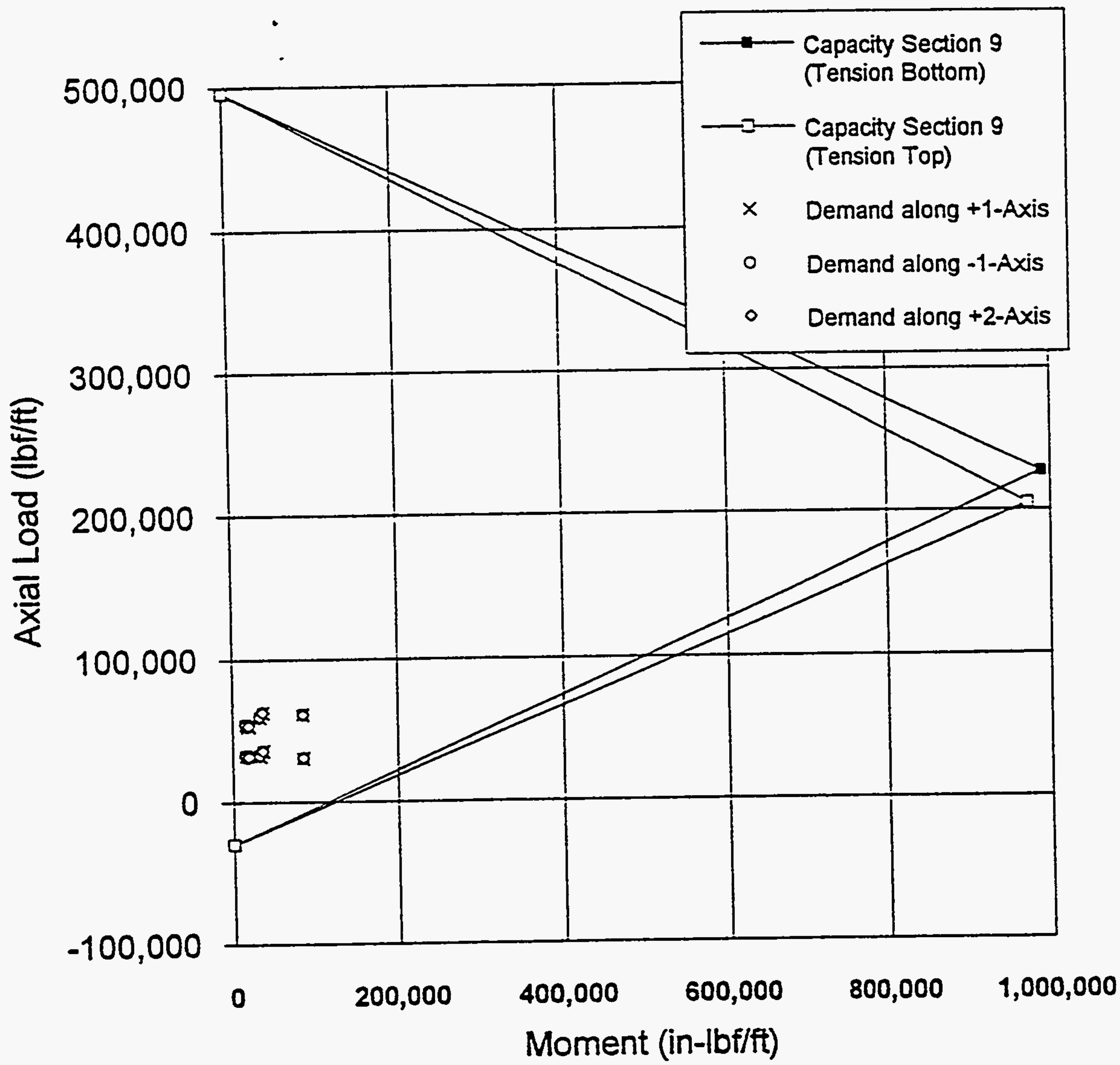
C1-7C.XLC

Figure 9.2.1-69. Circumferential Moment-Axial Load Interaction Diagram for Intermediate Dome Sections: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



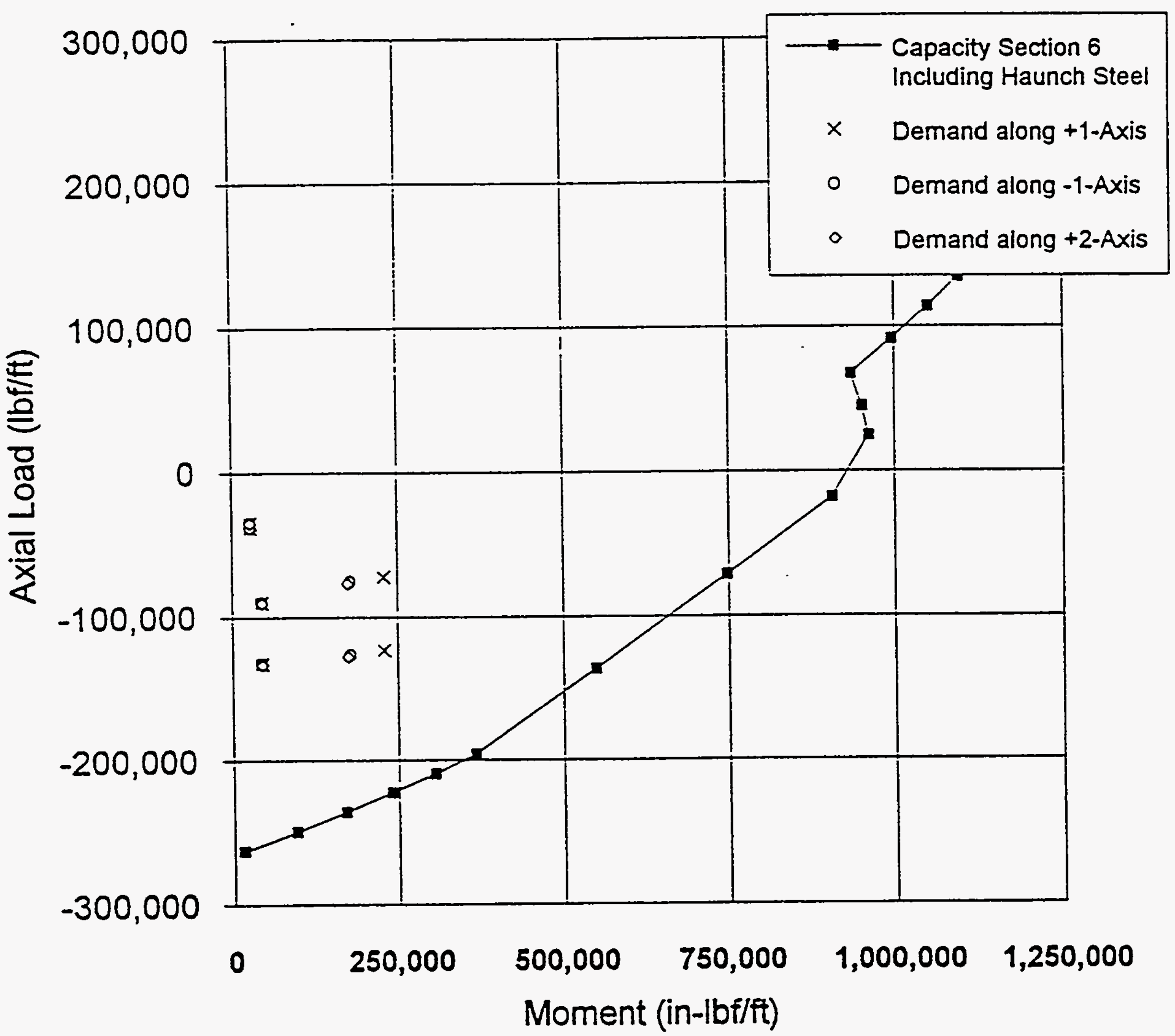
C1-8.XLC

Figure 9.2.1-70. Circumferential Moment-Axial Load Interaction Diagram for Dome Sections Near Apex: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).



C1-9.XLC

Figure 9.2.1-71. Circumferential Moment-Axial Load Interaction Diagram for Upper Wall and Haunch Sections: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).



C1-6HAU.XLC

Table 9.2.1-1. Spreadsheets for Calculating Moment/Axial Capacities.

File Name	Description
LBCAP_IP.xls	Calculates three key capacity points for meridional M-P interaction diagrams at each capacity section.
LBINT_IP.xls	Summarizes and groups LBCAP_IP.xls M-P capacity data for plotting.
LBCAP_OP.xls	Calculates three key capacity points for circumferential M-P interaction diagrams at each capacity section.
LBINT_OP.xls	Summarizes and groups LBCAP_OP.xls M-P capacity data for plotting.
SEC2ABOT.xls	Calculates refined meridional capacity curve at capacity section 2a, with bottom steel in tension.
SECT3BOT.xls	Calculates refined meridional capacity curve at capacity section 3, with bottom steel in tension.
SEC4AOUT.xls	Calculates refined meridional capacity curve at capacity section 4a, with outer steel in tension.
SEC4A-2.xls	Calculates refined meridional capacity curve at capacity section 4a, with outer steel in tension (total steel considered).
SECT6.xls	Calculates refined meridional capacity curve at capacity section 6.
SEC6AOUT.xls	Calculates refined meridional capacity curve at capacity section 6a, with outer steel in tension.
SEC7TOP.xls	Calculates refined meridional capacity curve at capacity section 7, with top steel in tension.
SEC2TOP.xls	Calculates refined circumferential capacity curve at capacity section 2, with top steel in tension.
SEC7CBOT.xls	Calculates refined circumferential capacity curve at capacity section 7c, with bottom steel in tension.
SECT6CIR.xls	Calculates refined circumferential capacity curve at "weakest" haunch element (capacity section 6a).

Table 9.2.1-2. Correlation of Capacity Locations to Demand Locations for Meridional Moment-Axial Load Loads.

Capacity Section	Element Numbers (1/2 Model)		
	Positive 1-Axis (0° Meridian)	Negative 1-Axis (180° Meridian)	Positive 2-Axis (90° Meridian)
Base			
1	289, 291, 295, 301, 1257, 1261, 1265, 1269, 1273	1, 4, 9, 16, 324, 328, 332, 336, 340	161, 164, 169, 176, 844, 848, 852, 856, 860
2	1277	344	864
2a	1281	348	868
Footing			
3	1357	424	944
Wall			
4a	1285	352	872
4, 5, 6	1289, 1293, 1297, 1301, 1305, 1309, 1313	356, 360, 364, 368, 372, 376, 380	876, 880, 884, 888, 892, 896, 900
Haunch			
6a	1317	384	904
6b	1321, 1325	388, 392	908, 912
Dome			
7	1329, 1333, 1337, 1341	396, 400, 404, 408	916, 920, 924, 928
8	1345, 1349, 1353	412, 416, 420	932, 936, 940
9	308, 305, 314, 312, 318, 317, 320	23, 19, 28, 25, 31, 29, 32	183, 179, 188, 185, 191, 189, 192

Table 9.2.1-3. Correlation of Capacity Locations to Demand Locations for Circumferential Moment-Axial Load Loads.

Capacity Section	Element Numbers (1/2 Model)		
	Positive 1-Axis (0° Meridian)	Negative 1-Axis (180° Meridian)	Positive 2-Axis (90° Meridian)
Base			
1	289, 291, 295, 301, 1257, 1261, 1265, 1269, 1273	1, 4, 9, 16, 324, 328, 332, 336, 340	161, 164, 169, 176, 844, 848, 852, 856, 860
2	1277	344	864
2a	1281	348	868
Footing			
3	1357	424	944
Wall			
4, 5, 6	1285, 1289, 1293, 1297, 1301, 1305, 1309, 1313, 1317, 1321, 1325	352, 356, 360, 364, 368, 372, 376, 380, 384, 388, 392	872, 876, 880, 884, 888, 892, 896, 900, 904, 908, 912
Dome			
7a	1329	396	916
7b	1333	400	920
7c	1337, 1341	404, 408	924, 928
8	1345, 1349, 1353	412, 416, 420	932, 936, 940
9	308, 305, 314, 312, 318, 317, 320	23, 19, 28, 25, 31, 29, 32	183, 179, 188, 185, 191, 189, 192

Table 9.2.1-4. Figure Numbers for Moment-Axial Load Diagrams.

	Meridional Direction	Circumferential Direction
Nonseismic Load Case 1a Plus Seismic (Lower-Bound Soil Properties)	Figures 9.2.1-5 to 9.2.1-16	Figures 9.2.1-17 to 9.2.1-26
Nonseismic Load Case 1b Plus Seismic (Lower-Bound Soil Properties)	Figures 9.2.1-27 to 9.2.1-38	Figures 9.2.1-39 to 9.2.1-48
Nonseismic Load Case 2 Plus Seismic (Lower-Bound Soil Properties)	Figures 9.2.1-49 to 9.2.1-60	Figures 9.2.1-61 to 9.2.1-70

Table 9.2.1-5. Plot Files for Meridional Moment-Axial Load Diagrams.

File Name	Capacity Section
M1-1.xlc	1
M1-2.xlc *	2
M1-2A.xlc	2a
M1-3.xlc	3
M1-4A.xlc *	4a
M1-4A-2.xlc	4a
M1-456.xlc *	4, 5, and 6
M1-6A.xlc *	6a
M1-6B.xlc	6b
M1-7.xlc	7
M1-8.xlc	8
M1-9.xlc	9

*Capacities shown are based on total reinforcement minus minimum reinforcement for in-plane shear.

Table 9.2.1-6. Plot Files for Circumferential Moment-Axial Load Diagrams.

File Name	Capacity Sections
Cl-1.xlc	1
Cl-2.xlc *	2
Cl-2A.xlc	2a
Cl-3.xlc	3
Cl-456.xlc *	4, 5, and 6
Cl-7A.xlc	7a
Cl-7B.xlc	7b
Cl-7C.xlc	7c
Cl-8.xlc	8
Cl-9.xlc	9

* Capacities shown are based on total reinforcement minus minimum reinforcement for in-plane shear.

Table 9.2.2-1. Correlation of Capacity Locations to Demand Locations for Shear Loads.

Capacity Section	Element Numbers (1/2 Model)		
	Positive 1-Axis (0° Meridian)	Negative 1-Axis (180° Meridian)	Positive 2-Axis (90° Meridian)
Base			
1	289, 291, 295, 301, 1257, 1261, 1265, 1269, 1273	1, 4, 9, 16, 324, 328, 332, 336, 340	161, 164, 169, 176, 844, 848, 852, 856, 860
2	1277	344	864
2a	1281	348	868
Footing			
3	1357	424	944
Wall			
4a	1285	352	872
4, 5, 6	1289, 1293, 1297, 1301, 1305, 1309, 1313	356, 360, 364, 368, 372, 376, 380	876, 880, 884, 888, 892, 896, 900
Haunch			
6a	1317	384	904
6b	1321, 1325	388, 392	908, 912
Dome			
7	1329, 1333, 1337, 1341	396, 400, 404, 408	916, 920, 924, 928
8	1345, 1349, 1353	412, 416, 420	932, 936, 940
9	308, 305, 314, 312, 318, 317, 320	23, 19, 28, 25, 31, 29, 32	183, 179, 188, 185, 191, 189, 192

Table 9.2.2-2. Sections for Determination of Transverse Shear Capacity.

Section	h	Meridional		Circumferential		b	fc
		d'	d	d'	d		
	[in]	[in]	[in]	[in]	[in]	[in]	[lbf/in^2]
1	6	1.75	4.25	2.25	3.75	12	3451
2	6	1.75	4.25	2.25	3.75	12	3625
2a (bot)	16.49	3.13	13.36	4	12.49	12	3625
3 (bot)	24	3.13	20.87	4	20	12	4049
3 (top)	24	6.25	17.75	7	17	12	4049
4a	18.3	2.375	15.925	3.1875	15.1125	12	3899
4	12	2.375	9.625	3.1875	8.8125	12	3899
5	12	2.375	9.625	3.1875	8.8125	12	4399
6	12	2.375	9.625	3.1875	8.8125	12	4418
6a	15	2	13	3	12	12	4418
6b	27.29	2	25.29	3	24.29	12	4418
7 (in)	15	1.625	13.375	2.375	12.625	12	4431
7 (out)	15	4.375	10.625	3.625	11.375	12	4431
8 (in)	15	1.625	13.375	2.375	12.625	12	4428
8 (out)	15	4.375	10.625	3.625	11.375	12	4428
9 (in)	15	1.625	13.375	2.375	12.625	12	4429
9 (out)	15	4.375	10.625	3.625	11.375	12	4429

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Table 9.2.2-3. Evaluation of Transverse Shear: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).

	POSITIVE 1-AXIS				NEGATIVE 1-AXIS			
	Meridional		Circumferential		Meridional		Circumferential	
Section	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Nu (min.) [lbf/ft]	Shear Cap. [lbf]
1	9,155	5,417	11,832	4,863	9,143	5,417	11,844	4,864
2	7,656	5,498	10,901	4,955	7,656	5,498	10,913	4,955
2a (bot)	15,338	17,045	13,434	15,861	15,338	17,045	13,434	15,861
3 (bot)	9,274	27,527	-3,560	25,320	9,274	27,527	-3,560	25,320
3 (top)	9,274	23,412	-3,560	21,522	9,274	23,412	-3,560	21,522
4a	29,005	21,625	-36,237	12,897	29,005	21,625	-36,237	12,897
4	26,717	13,398	-9,624	9,725	26,717	13,398	-9,622	9,725
5	24,318	14,123	5,320	12,144	24,318	14,123	5,320	12,144
6	24,264	14,151	-22,664	8,188	24,264	14,151	-22,664	8,188
6a	25,710	18,886	-41,176	8,827	25,710	18,886	-41,176	8,827
6b	23,368	35,515	-140,855	4,603	23,368	35,515	-140,855	4,603
7 (in)	31,541	19,754	-58,269	6,044	31,529	19,753	-58,269	6,044
7 (out)	31,541	15,692	-58,269	5,446	31,529	15,692	-58,269	5,446
8 (in)	37,762	20,061	17,601	17,976	37,750	20,060	17,601	17,976
8 (out)	37,762	15,936	17,601	16,196	37,750	15,936	17,601	16,196
9 (in)	47,839	20,571	27,520	18,450	47,839	20,571	27,496	18,449
9 (out)	47,839	16,342	27,520	16,624	47,839	16,342	27,496	16,623

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Table 9.2.2-3. Evaluation of Transverse Shear: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties) (cont).

	POSITIVE 2-AXIS				Elements along the Positive 1-Axis			
	Meridional		Circumferential		Meridional		Circumferential	
Section	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Demand [lbf/ft]	Capacity [lbf/ft]	Demand [lbf/ft]	Capacity [lbf/ft]
1	9,155	5,417	11,808	4,863	900	5,417	672	4,863
2	7,668	5,498	10,865	4,953	1,558	5,498	598	4,955
2a (bot)	15,338	17,045	13,482	15,863	9,542	17,045	508	15,861
3 (bot)	9,262	27,527	-3,488	25,333	4,773	27,527	2,395	25,320
3 (top)	9,262	23,412	-3,488	21,533	4,773	23,412	2,395	21,522
4a	29,017	21,626	-36,213	12,902	14,061	21,625	975	12,897
4	26,717	13,398	-9,609	9,727	10,906	13,398	577	9,725
5	24,330	14,123	5,308	12,143	7,087	14,123	562	12,144
6	24,276	14,151	-22,664	8,188	9,866	14,151	453	8,188
6a	25,770	18,889	-41,200	8,823	11,648	18,886	584	8,827
6b	23,438	35,519	-140,875	4,599	12,278	35,515	945	4,603
7 (in)	31,589	19,756	-58,317	6,035	8,023	19,754	713	6,044
7 (out)	31,589	15,694	-58,317	5,438	8,023	15,692	713	5,446
8 (in)	37,762	20,061	17,589	17,976	2,445	20,061	573	17,976
8 (out)	37,762	15,936	17,589	16,196	2,445	15,936	573	16,196
9 (in)	47,839	20,571	27,496	18,449	1,678	20,571	1,207	18,450
9 (out)	47,839	16,342	27,496	16,623	1,678	16,342	1,207	16,624

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Table 9.2.2-3. Evaluation of Transverse Shear: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties) (cont).

	Elements along the Negative 1-Axis				Elements along the Positive 2-Axis			
	Meridional		Circumferential		Meridional		Circumferential	
Section	Demand [lbf/ft]	Capacity [lbf/ft]	Demand [lbf/ft]	Capacity [lbf/ft]	Demand [lbf/ft]	Capacity [lbf/ft]	Demand [lbf/ft]	Capacity [lbf/ft]
1	900	5,417	671	4,864	895	5,417	671	4,863
2	1,558	5,498	598	4,955	1,537	5,498	596	4,953
2a (bot)	9,542	17,045	508	15,861	9,567	17,045	519	15,863
3 (bot)	4,773	27,527	2,395	25,320	4,772	27,527	2,394	25,333
3 (top)	4,773	23,412	2,395	21,522	4,772	23,412	2,394	21,533
4a	14,061	21,625	975	12,897	14,067	21,626	1,005	12,902
4	10,905	13,398	577	9,725	10,908	13,398	586	9,727
5	7,086	14,123	562	12,144	7,087	14,123	562	12,143
6	9,866	14,151	453	8,188	9,866	14,151	457	8,188
6a	11,648	18,886	584	8,827	11,648	18,889	631	8,823
6b	12,278	35,515	945	4,603	12,285	35,519	838	4,599
7 (in)	8,023	19,753	713	6,044	8,025	19,756	663	6,035
7 (out)	8,023	15,692	713	5,446	8,025	15,694	663	5,438
8 (in)	2,450	20,060	572	17,976	2,448	20,061	569	17,976
8 (out)	2,450	15,936	572	16,196	2,448	15,936	569	16,196
9 (in)	1,718	20,571	1,135	18,449	1,706	20,571	1,117	18,449
9 (out)	1,718	16,342	1,135	16,623	1,706	16,342	1,117	16,623

Table 9.2.2-4. Evaluation of Transverse Shear: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).

	POSITIVE 1-AXIS				NEGATIVE 1-AXIS			
	Meridional		Circumferential		Meridional		Circumferential	
Section	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Nu (min.) [lbf/ft]	Shear Cap. [lbf].	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Nu (min.) [lbf/ft]	Shear Cap. [lbf]
1	9,911	5,444	11,244	4,845	9,179	5,418	11,820	4,863
2	8,496	5,528	10,169	4,931	7,704	5,499	10,925	4,955
2a (bot)	16,358	17,088	10,494	15,748	15,302	17,044	13,710	15,872
3 (bot)	9,622	27,544	-9,428	24,262	9,358	27,531	-2,480	25,515
3 (top)	9,622	23,426	-9,428	20,623	9,358	23,415	-2,480	21,687
4a	29,869	21,665	-39,285	12,363	28,237	21,590	-35,925	12,952
4	28,437	13,471	-11,301	9,464	25,949	13,365	-9,565	9,734
5	28,146	14,296	5,920	12,169	23,502	14,086	5,932	12,169
6	28,236	14,331	-21,896	8,315	23,436	14,113	-21,380	8,401
6a	24,890	18,846	-38,336	9,340	24,890	18,846	-38,336	9,340
6b	22,428	35,466	-132,455	6,293	22,428	35,466	-132,455	6,293
7 (in)	33,821	19,869	-48,429	7,919	29,549	19,653	-52,521	7,139
7 (out)	33,821	15,784	-48,429	7,135	29,549	15,612	-52,521	6,432
8 (in)	35,111	19,927	27,009	18,424	32,314	19,786	23,865	18,274
8 (out)	35,111	15,830	27,009	16,600	32,314	15,718	23,865	16,465
9 (in)	31,616	19,753	31,444	18,637	31,496	19,747	32,237	18,675
9 (out)	31,616	15,692	31,444	16,792	31,496	15,687	32,237	16.826

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Table 9.2.2-4. Evaluation of Transverse Shear: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties) (cont).

	POSITIVE 2-AXIS				Elements along the Positive 1-Axis			
	Meridional		Circumferential		Meridional		Circumferential	
Section	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Demand [lbf/ft]	Capacity [lbf/ft]	Demand [lbf/ft]	Capacity [lbf/ft]
1	8,951	5,410	12,048	4,870	902	5,444	673	4,845
2	7,464	5,491	11,117	4,961	1,557	5,528	593	4,931
2a (bot)	15,134	17,037	14,358	15,897	9,728	17,088	512	15,748
3 (bot)	9,214	27,524	-1,760	25,644	4,759	27,544	2,425	24,262
3 (top)	9,214	23,410	-1,760	21,798	4,759	23,426	2,425	20,623
4a	28,909	21,621	-35,373	13,049	14,390	21,665	983	12,363
4	26,357	13,383	-9,164	9,797	11,038	13,471	574	9,464
5	23,886	14,103	5,992	12,172	6,932	14,296	520	12,169
6	23,808	14,130	-21,392	8,399	10,218	14,331	466	8,315
6a	25,194	18,861	-38,404	9,328	11,499	18,846	589	9,340
6b	22,778	35,485	-133,183	6,146	13,484	35,466	1,071	6,293
7 (in)	29,717	19,662	-52,989	7,050	8,064	19,869	822	7,919
7 (out)	29,717	15,619	-52,989	6,352	8,064	15,784	822	7,135
8 (in)	32,206	19,781	24,057	18,283	3,516	19,927	573	18,424
8 (out)	32,206	15,714	24,057	16,473	3,516	15,830	573	16,600
9 (in)	30,620	19,703	32,776	18,701	1,643	19,753	1,164	18,637
9 (out)	30,620	15,652	32,776	16,849	1,643	15,692	1,164	16,792

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Table 9.2.2-4. Evaluation of Transverse Shear: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties) (cont).

	Elements along the Negative 1-Axis				Elements along the Positive 2-Axis			
	Meridional		Circumferential		Meridional		Circumferential	
Section	Demand [lbf/ft]	Capacity [lbf/ft]	Demand [lbf/ft]	Capacity [lbf/ft]	Demand [lbf/ft]	Capacity [lbf/ft]	Demand [lbf/ft]	Capacity [lbf/ft]
1	898	5,418	666	4,863	894	5,410	670	4,870
2	1,531	5,499	591	4,955	1,540	5,491	601	4,961
2a (bot)	9,417	17,044	501	15,872	9,535	17,037	508	15,897
3 (bot)	4,974	27,531	2,369	25,515	4,786	27,524	2,397	25,644
3 (top)	4,974	23,415	2,369	21,687	4,786	23,410	2,397	21,798
4a	14,063	21,590	968	12,952	14,004	21,621	1,000	13,049
4	10,914	13,365	573	9,734	10,876	13,383	593	9,797
5	7,075	14,086	564	12,169	7,055	14,103	552	12,172
6	9,781	14,113	459	8,401	9,810	14,130	466	8,399
6a	11,499	18,846	589	9,340	11,534	18,861	610	9,328
6b	12,042	35,466	932	6,293	12,073	35,485	843	6,146
7 (in)	7,902	19,653	708	7,139	7,916	19,662	661	7,050
7 (out)	7,902	15,612	708	6,432	7,916	15,619	661	6,352
8 (in)	2,245	19,786	547	18,274	2,248	19,781	545	18,283
8 (out)	2,245	15,718	547	16,465	2,248	15,714	545	16,473
9 (in)	1,681	19,747	1,114	18,675	1,678	19,703	1,137	18,701
9 (out)	1,681	15,687	1,114	16,826	1,678	15,652	1,137	16,849

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Table 9.2.2-5. Evaluation of Transverse Shear: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).

Section	POSITIVE 1-AXIS				NEGATIVE 1-AXIS			
	Meridional		Circumferential		Meridional		Circumferential	
	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Nu (min.) [lbf/ft]	Shear Cap. [lbf]
1	9,863	5,442	11,148	4,842	8,987	5,411	11,748	4,861
2	8,544	5,530	10,097	4,929	7,548	5,494	10,853	4,953
2a (bot)	16,238	17,083	10,866	15,762	15,026	17,032	13,770	15,875
3 (bot)	9,850	27,554	-6,836	24,729	9,214	27,524	-1,688	25,657
3 (top)	9,850	23,435	-6,836	21,020	9,214	23,410	-1,688	21,809
4a	27,697	21,565	-38,685	12,468	27,217	21,543	-35,673	12,996
4	26,073	13,370	-11,406	9,447	24,977	13,324	-9,574	9,733
5	25,566	14,179	10,456	12,356	22,470	14,039	6,088	12,176
6	24,780	14,174	-14,575	9,530	22,404	14,066	-20,603	8,530
6a	23,850	18,795	-36,516	9,670	23,850	18,795	-36,516	9,670
6b	21,378	35,411	-127,955	7,198	21,378	35,411	-127,955	7,198
7 (in)	30,149	19,684	-51,021	7,425	28,277	19,589	-51,045	7,421
7 (out)	30,149	15,636	-51,021	6,690	28,277	15,561	-51,045	6,686
8 (in)	30,478	19,693	21,969	18,184	30,610	19,700	22,977	18,232
8 (out)	30,478	15,644	21,969	16,384	30,610	15,650	22,977	16,427
9 (in)	29,252	19,634	30,592	18,597	29,228	19,633	30,677	18,601
9 (out)	29,252	15,597	30,592	16,755	29,228	15,596	30,677	16,759

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Table 9.2.2-5. Evaluation of Transverse Shear: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties) (cont).

	POSITIVE 2-AXIS				Elements along the Positive 1-Axis			
	Meridional		Circumferential		Meridional		Circumferential	
Section	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Nu (min.) [lbf/ft]	Shear Cap. [lbf]	Demand [lbf/ft]	Capacity [lbf/ft]	Demand [lbf/ft]	Capacity [lbf/ft]
1	8,783	5,404	11,916	4,866	885	5,442	648	4,842
2	7,332	5,486	10,985	4,957	1,489	5,530	573	4,929
2a (bot)	14,846	17,025	14,442	15,901	9,350	17,083	486	15,762
3 (bot)	9,046	27,517	-1,148	25,755	5,207	27,554	2,364	24,729
3 (top)	9,046	23,403	-1,148	21,892	5,207	23,435	2,364	21,020
4a	27,709	21,565	-35,277	13,066	14,310	21,565	960	12,468
4	25,181	13,332	-9,352	9,767	10,939	13,370	560	9,447
5	22,914	14,059	6,124	12,177	6,390	14,179	484	12,356
6	22,896	14,089	-20,499	8,547	9,712	14,174	482	9,530
6a	24,318	18,818	-36,268	9,714	11,325	18,795	585	9,670
6b	21,830	35,435	-127,855	7,218	11,731	35,411	906	7,198
7 (in)	28,289	19,590	-51,069	7,416	6,776	19,684	575	7,425
7 (out)	28,289	15,562	-51,069	6,682	6,776	15,636	575	6,690
8 (in)	30,466	19,693	23,181	18,242	2,256	19,693	546	18,184
8 (out)	30,466	15,644	23,181	16,436	2,256	15,644	546	16,384
9 (in)	29,192	19,631	30,713	18,602	1,650	19,634	1,160	18,597
9 (out)	29,192	15,595	30,713	16,761	1,650	15,597	1,160	16,755

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Table 9.2.2-5. Evaluation of Transverse Shear: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties) (cont).

	Elements along the Negative 1-Axis				Elements along the Positive 2-Axis			
	Meridional		Circumferential		Meridional		Circumferential	
Section	Demand [lbf/ft]	Capacity [lbf/ft]	Demand [lbf/ft]	Capacity [lbf/ft]	Demand [lbf/ft]	Capacity [lbf/ft]	Demand [lbf/ft]	Capacity [lbf/ft]
1	892	5,411	656	4,861	886	5,404	659	4,866
2	1,507	5,494	581	4,953	1,507	5,486	592	4,957
2a (bot)	9,222	17,032	494	15,875	9,305	17,025	496	15,901
3 (bot)	5,155	27,524	2,342	25,657	5,022	27,517	2,354	25,755
3 (top)	5,155	23,410	2,342	21,809	5,022	23,403	2,354	21,892
4a	13,992	21,543	959	12,996	13,932	21,565	989	13,066
4	10,871	13,324	567	9,733	10,824	13,332	592	9,767
5	7,038	14,039	570	12,176	6,995	14,059	549	12,177
6	9,638	14,066	460	8,530	9,686	14,089	495	8,547
6a	11,325	18,795	585	9,670	11,380	18,818	572	9,714
6b	11,756	35,411	924	7,198	11,772	35,435	844	7,218
7 (in)	7,739	19,589	703	7,421	7,736	19,590	662	7,416
7 (out)	7,739	15,561	703	6,686	7,736	15,562	662	6,682
8 (in)	2,223	19,700	547	18,232	2,227	19,693	544	18,242
8 (out)	2,223	15,650	547	16,427	2,227	15,644	544	16,436
9 (in)	1,658	19,633	1,117	18,601	1,661	19,631	1,112	18,602
9 (out)	1,658	15,596	1,117	16,759	1,661	15,595	1,112	16,761

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Table 9.2.3-1. Evaluation of In-Plane Shear and Twisting Moment: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties).

Elements Along the Positive 1-Axis

d=lw=12"

ELEMENT	fc [lbf/in^2]	Thickness [in]	Mend. P (min.) [lbf/ft]	Circum. P (min.) [lbf/ft]	min. Nu [lbf/ft]	phi*Vc Eqn 11-32 [lbf/ft]	phi*Vc/2 [lbf/ft]	In-plane shear [lbf/ft]	T threshold [in-lbf/ft]	Twist. moment [in-lbf/ft]
floor elements										
289	3317	6.00	12,538	12,798	12,538	14,296	7,148	300	10,574	45
291	3321	6.00	10,952	12,357	10,952	13,966	6,983	685	10,581	146
295	3330	6.00	12,104	12,450	12,104	14,226	7,113	988	10,594	197
301	3343	6.00	13,314	12,988	12,988	14,437	7,218	1,920	10,616	285
1257	3361	6.00	12,852	13,420	12,852	14,439	7,219	2,779	10,643	136
1261	3382	6.00	11,206	13,113	11,206	14,126	7,063	3,286	10,677	167
1265	3421	6.00	10,393	12,650	10,393	14,021	7,010	4,513	10,738	96
1269	3456	6.00	10,257	12,724	10,257	14,053	7,026	5,205	10,794	322
1273	3519	6.00	9,155	11,832	9,155	13,925	6,963	6,691	10,891	487
1277	3610	6.00	7,656	10,901	7,656	13,760	6,880	6,971	11,031	445
1281	3747	16.49	15,338	13,434	13,434	36,831	18,416	7,799	84,889	7,835
wall elements										
1285	3795	18.30	29,005	-36,237	-36,237	30,245	15,122	18,385	105,212	8,658
1289	3912	12.30	29,350	-9,624	-9,624	23,849	11,924	17,663	48,256	1,596
1293	4073	12.00	26,889	-8,319	-8,319	24,009	12,004	19,541	46,867	2,584
1297	4327	12.00	26,717	5,649	5,649	27,771	13,886	19,566	48,310	2,297
1301	4403	12.00	25,820	24,599	24,599	32,028	16,014	19,406	48,728	2,333
1305	4413	12.00	25,131	22,990	22,990	31,718	15,859	18,802	48,786	1,880
1309	4433	12.00	24,318	5,320	5,320	28,023	14,012	17,538	48,896	1,716
1313	4443	12.00	24,264	-22,664	-22,664	22,106	11,053	16,131	48,949	2,112
haunch elements										
1317	4480	15.00	25,710	-41,176	-41,176	25,044	12,522	12,975	76,805	840
1321	4526	27.29	23,368	-140,855	-140,855	31,865	15,932	15,480	255,519	8,563
1325	4533	31.62	25,913	-137,338	-137,338	42,470	21,235	18,359	343,291	35,394
dome elements										
1329	4506	21.31	31,541	-58,269	-58,269	35,768	17,884	12,810	155,465	13,358
1333	4492	18.08	34,829	-25,200	-25,200	35,433	17,717	10,897	111,734	4,012
1337	4492	17.38	37,499	-11,023	-11,023	36,865	18,433	9,509	103,247	2,971
1341	4492	16.91	38,713	7,991	7,991	39,846	19,923	8,391	97,738	3,271
1345	4499	16.38	37,762	17,601	17,601	40,720	20,360	6,815	91,777	2,789
1349	4502	15.83	42,121	23,096	23,096	40,659	20,329	6,027	85,748	2,608
1353	4504	15.28	44,099	25,482	25,482	39,932	19,966	4,637	79,913	2,994
308	4513	15.00	47,839	27,520	27,520	39,766	19,883	3,930	77,086	3,652
305	4513	15.00	48,703	36,208	36,208	41,612	20,806	3,268	77,086	8,432
314	4514	15.00	50,319	36,932	36,932	41,770	20,885	3,412	77,096	4,006
312	4514	15.00	51,219	45,740	45,740	43,642	21,821	2,696	77,096	7,278
318	4507	15.00	53,308	47,042	47,042	43,891	21,946	2,175	77,034	6,045
317	4507	15.00	54,748	58,058	54,748	45,529	22,764	1,338	77,034	12,324
320	4508	15.00	52,412	52,373	52,373	45,029	22,515	708	77,045	4,824
footing element										
1357	4136	24.00	9,274	-3,560	-3,560	51,199	25,599	8,213	188,928	22,224

Table 9.2.3-1. Evaluation of In-Plane Shear and Twisting Moment: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties) (cont).

Elements Along the Negative 1-Axis

ELEMENT	fc [lbf/in^2]	Thickness [in]	Merid. P (min.) [lbf/ft]	Circum. P (min.) [lbf/ft]	min. Nu [lbf/ft]	phi*Vc Eqn 11-32 [lbf/ft]	phi*Vc/2 [lbf/ft]	In-plane shear [lbf/ft]	T threshold [in-lbf/ft]	Twist. moment [in-lbf/ft]
floor elements										
1	3317	6.00	12,526	12,822	12,526	14,293	7,146	273	10,574	42
4	3321	6.00	10,988	12,393	10,988	13,973	6,987	685	10,581	128
9	3330	6.00	12,092	12,462	12,092	14,223	7,112	970	10,594	169
16	3343	6.00	13,338	13,000	13,000	14,439	7,220	1,913	10,616	289
324	3361	6.00	12,828	13,420	12,828	14,434	7,217	2,777	10,643	127
328	3382	6.00	11,194	13,113	11,194	14,124	7,062	3,287	10,677	165
332	3421	6.00	10,393	12,638	10,393	14,021	7,010	4,514	10,738	96
336	3456	6.00	10,257	12,724	10,257	14,053	7,026	5,205	10,794	320
340	3519	6.00	9,143	11,844	9,143	13,923	6,961	6,690	10,891	488
344	3610	6.00	7,656	10,913	7,656	13,760	6,880	6,971	11,031	447
348	3747	16.49	15,338	13,434	13,434	36,831	18,416	7,799	84,889	7,832
wall elements										
352	3795	18.30	29,005	-36,237	-36,237	30,245	15,122	18,385	105,212	8,660
356	3912	12.30	29,350	-9,622	-9,622	23,849	11,924	17,663	48,256	1,595
360	4073	12.00	26,877	-8,318	-8,318	24,009	12,005	19,541	46,867	2,584
364	4327	12.00	26,717	5,649	5,649	27,771	13,886	19,566	48,310	2,297
368	4403	12.00	25,820	24,611	24,611	32,030	16,015	19,406	48,728	2,333
372	4413	12.00	25,131	22,990	22,990	31,718	15,859	18,802	48,786	1,880
376	4433	12.00	24,318	5,320	5,320	28,023	14,012	17,538	48,896	1,716
380	4443	12.00	24,264	-22,564	-22,664	22,106	11,053	16,131	48,949	2,113
haunch elements										
384	4480	15.00	25,710	-41,176	-41,176	25,044	12,522	12,975	76,805	840
388	4526	27.29	23,368	-140,855	-140,855	31,865	15,932	15,480	255,519	8,563
392	4533	31.62	25,913	-137,326	-137,326	42,473	21,236	18,359	343,291	35,394
dome elements										
396	4506	21.31	31,529	-58,269	-58,269	35,768	17,884	12,810	155,465	13,356
400	4492	18.08	34,817	-25,195	-25,195	35,434	17,717	10,896	111,734	4,011
404	4492	17.38	37,487	-11,021	-11,021	36,866	18,433	9,509	103,247	2,974
408	4492	16.91	38,713	8,003	8,003	39,848	19,924	8,390	97,738	3,272
412	4499	16.38	37,750	17,601	17,601	40,720	20,360	6,814	91,777	2,792
416	4502	15.83	42,097	23,096	23,096	40,659	20,329	6,025	85,748	2,590
420	4504	15.28	44,099	25,470	25,470	39,930	19,965	4,639	79,913	2,994
23	4513	15.00	47,839	27,496	27,496	39,761	19,880	3,923	77,086	3,644
19	4513	15.00	48,691	36,184	36,184	41,607	20,803	3,276	77,086	8,412
28	4514	15.00	50,259	36,908	36,908	41,765	20,883	3,436	77,096	3,995
25	4514	15.00	51,183	45,716	45,716	43,637	21,819	2,690	77,096	7,290
31	4507	15.00	53,344	47,030	47,030	43,889	21,944	2,190	77,034	6,042
29	4507	15.00	54,736	58,046	54,736	45,526	22,763	1,339	77,034	12,408
32	4508	15.00	52,376	52,349	52,349	45,024	22,512	762	77,045	4,859
footing element										
424	4136	24.00	9,274	-3,560	-3,560	51,199	25,599	8,213	188,928	22,224

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Table 9.2.3-1. Evaluation of In-Plane Shear and Twisting Moment: Nonseismic (Load Case 1a) Plus Seismic (Lower-Bound Soil Properties) (cont).

Elements Along the Positive 2-Axis

ELEMENT	fc [lbf/in^2]	Thickness [in]	Merid. P (min.) [lbf/ft]	Circum. P (min.) [lbf/ft]	min. Nu [lbf/ft]	phi*Vc Eqn 11-32 [lbf/ft]	phi*Vc/2 [lbf/ft]	In-plane shear [lbf/ft]	T threshold [in-lbf/ft]	Twist. moment [in-lbf/ft]
floor elements										
161	3317	6.00	12,526	12,810	12,526	14,293	7,146	290	10,574	47
164	3321	6.00	10,976	12,369	10,976	13,971	6,985	684	10,581	139
169	3330	6.00	12,104	12,450	12,104	14,226	7,113	972	10,594	175
176	3343	6.00	13,314	13,000	13,000	14,439	7,220	1,909	10,616	286
844	3361	6.00	12,840	13,420	12,840	14,436	7,218	2,774	10,643	133
848	3382	6.00	11,206	13,101	11,206	14,126	7,063	3,286	10,677	168
852	3421	6.00	10,393	12,638	10,393	14,021	7,010	4,509	10,738	98
856	3456	6.00	10,257	12,700	10,257	14,053	7,026	5,202	10,794	320
860	3519	6.00	9,155	11,808	9,155	13,925	6,963	6,684	10,891	489
864	3610	6.00	7,668	10,865	7,668	13,763	6,881	6,968	11,031	445
868	3747	16.49	15,338	13,482	13,482	36,841	18,421	7,817	84,889	7,539
wall elements										
872	3795	18.30	29,017	-36,213	-36,213	30,250	15,125	18,376	105,212	8,860
876	3912	12.30	29,362	-9,609	-9,609	23,852	11,926	17,659	48,256	1,641
880	4073	12.00	26,889	-8,318	-8,318	24,009	12,005	19,539	46,867	2,530
884	4327	12.00	26,717	5,649	5,649	27,771	13,886	19,569	48,310	2,311
888	4403	12.00	25,820	24,599	24,599	32,028	16,014	19,406	48,728	2,324
892	4413	12.00	25,143	22,990	22,990	31,718	15,859	18,802	48,786	1,887
896	4433	12.00	24,330	5,308	5,308	28,021	14,010	17,543	48,896	1,732
900	4443	12.00	24,276	-22,664	-22,664	22,106	11,053	16,122	48,949	2,143
haunch elements										
904	4480	15.00	25,770	-41,200	-41,200	25,039	12,520	13,397	76,805	1,913
908	4526	27.29	23,438	-140,875	-140,875	31,860	15,930	14,220	255,519	15,800
912	4533	31.62	26,069	-137,458	-137,458	42,445	21,222	16,911	343,291	30,330
dome elements										
916	4506	21.31	31,589	-58,317	-58,317	35,757	17,879	12,218	155,465	11,895
920	4492	18.08	34,853	-25,230	-25,230	35,427	17,713	10,551	111,734	3,761
924	4492	17.38	37,511	-11,042	-11,042	36,861	18,431	9,281	103,247	2,830
928	4492	16.91	38,725	7,979	7,979	39,843	19,921	8,250	97,738	3,086
932	4499	16.38	37,762	17,589	17,589	40,717	20,359	6,738	91,777	2,718
936	4502	15.83	42,109	23,084	23,084	40,656	20,328	5,978	85,748	2,567
940	4504	15.28	44,099	25,458	25,458	39,927	19,964	4,604	79,913	2,915
183	4513	15.00	47,839	27,496	27,496	39,761	19,880	3,900	77,086	3,687
179	4513	15.00	48,691	36,196	36,196	41,609	20,805	3,243	77,086	8,354
188	4514	15.00	50,283	36,920	36,920	41,768	20,884	3,408	77,096	3,986
185	4514	15.00	51,195	45,716	45,716	43,637	21,819	2,680	77,096	7,231
191	4507	15.00	53,320	47,030	47,030	43,889	21,944	2,185	77,034	6,041
189	4507	15.00	54,724	58,058	54,724	45,524	22,762	1,316	77,034	12,376
192	4508	15.00	52,376	52,361	52,361	45,027	22,513	731	77,045	4,873
footing element										
944	4136	24.00	9,262	-3,488	-3,488	51,214	25,607	8,237	188,928	22,308

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Table 9.2.3-2. Evaluation of In-Plane Shear and Twisting Moment: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties).

Elements Along the Positive 1-Axis d=lw=12"

ELEMENT	fc [lbf/in^2]	Thickness [in]	Merid. P (min.) [lbf/ft]	Circum. P (min.) [lbf/ft]	min. Nu [lbf/ft]	phi*Vc Eqn 11-32 [lbf/ft]	phi*Vc/2 [lbf/ft]	In-plane shear [lbf/ft]	T threshold [in-lbf/ft]	Twist. moment [in-lbf/ft]
floor elements										
289	3317	6.00	12,778	12,570	12,570	14,302	7,151	295	10,574	44
291	3321	6.00	11,228	12,093	11,228	14,024	7,012	686	10,581	145
295	3330	6.00	12,392	12,162	12,162	14,238	7,119	991	10,594	191
301	3343	6.00	13,626	12,664	12,664	14,368	7,184	1,932	10,616	288
1257	3361	6.00	13,212	13,048	13,048	14,480	7,240	2,788	10,643	140
1261	3382	6.00	11,662	12,705	11,662	14,223	7,112	3,300	10,677	167
1265	3421	6.00	10,933	12,182	10,933	14,135	7,068	4,524	10,738	101
1269	3456	6.00	10,917	12,184	10,917	14,193	7,097	5,232	10,794	315
1273	3519	6.00	9,911	11,244	9,911	14,086	7,043	6,701	10,891	490
1277	3610	6.00	8,496	10,169	8,496	13,939	6,969	6,999	11,031	457
1281	3747	16.49	16,358	10,494	10,494	36,206	18,103	7,764	84,889	7,347
wall elements										
1285	3795	18.30	29,869	-39,285	-39,285	29,597	14,799	18,719	105,212	8,755
1289	3912	12.30	30,538	-11,301	-11,301	23,492	11,746	17,416	48,256	1,577
1293	4073	12.00	28,437	-9,601	-9,601	23,736	11,868	19,907	46,867	2,452
1297	4327	12.00	28,877	4,833	4,833	27,598	13,799	19,239	48,310	2,169
1301	4403	12.00	28,484	24,311	24,311	31,967	15,983	19,810	48,728	2,467
1305	4413	12.00	28,371	23,194	23,194	31,761	15,881	18,409	48,786	1,653
1309	4433	12.00	28,146	5,920	5,920	28,151	14,075	18,094	48,896	1,423
1313	4443	12.00	28,236	-21,896	-21,896	22,269	11,135	15,793	48,949	1,973
haunch elements										
1317	4480	15.00	24,890	-38,336	-38,336	25,648	12,824	13,019	76,805	845
1321	4526	27.29	22,428	-132,455	-132,455	33,650	16,825	15,371	255,519	8,611
1325	4533	31.62	28,289	-123,034	-123,034	45,510	22,755	17,946	343,291	40,230
dome elements										
1329	4506	21.31	33,821	-48,429	-48,429	37,859	18,929	12,696	155,465	14,284
1333	4492	18.08	36,041	-16,303	-16,303	37,324	18,662	10,425	111,734	5,267
1337	4492	17.38	37,259	-1,223	-1,223	38,948	19,474	9,246	103,247	2,098
1341	4492	16.91	38,017	18,935	18,935	42,171	21,086	7,806	97,738	3,848
1345	4499	16.38	36,442	27,009	27,009	42,719	21,359	6,104	91,777	5,284
1349	4502	15.83	37,465	30,248	30,248	42,179	21,089	5,052	85,748	3,085
1353	4504	15.28	35,111	30,990	30,990	41,103	20,551	4,002	79,913	1,923
308	4513	15.00	34,123	31,444	31,444	40,600	20,300	2,998	77,086	3,829
305	4513	15.00	34,255	32,992	32,992	40,929	20,464	2,913	77,086	3,898
314	4514	15.00	33,579	33,260	33,260	40,990	20,495	2,113	77,096	3,338
312	4514	15.00	33,447	32,720	32,720	40,875	20,438	2,252	77,096	3,016
318	4507	15.00	33,376	33,326	33,326	40,977	20,488	1,352	77,034	5,444
317	4507	15.00	33,856	37,154	33,856	41,089	20,545	1,536	77,034	7,147
320	4508	15.00	31,616	31,961	31,616	40,618	20,309	642	77,045	4,840
footing element										
1357	4136	24.00	9,622	-9,428	-9,428	49,952	24,976	7,999	188,928	22,212

Table 9.2.3-2. Evaluation of In-Plane Shear and Twisting Moment: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties) (cont).

Elements Along the Negative 1-Axis

ELEMENT	fc [lbf/in^2]	Thickness [in]	Merid. P (min.) [lbf/ft]	Circum. P (min.) [lbf/ft]	min. Nu [lbf/ft]	phi*Vc Eqn 11-32 [lbf/ft]	phi*Vc/2 [lbf/ft]	In-plane shear [lbf/ft]	T threshold [in-lbf/ft]	Twist. moment [in-lbf/ft]
floor elements										
1	3317	6.00	12,742	12,642	12,642	14,318	7,159	273	10,574	42
4	3321	6.00	11,180	12,237	11,180	14,014	7,007	683	10,581	128
9	3330	6.00	12,260	12,330	12,260	14,259	7,130	969	10,594	169
16	3343	6.00	13,482	12,892	12,892	14,417	7,208	1,907	10,616	287
324	3361	6.00	12,960	13,312	12,960	14,462	7,231	2,771	10,643	126
328	3382	6.00	11,302	13,029	11,302	14,147	7,073	3,282	10,677	165
332	3421	6.00	10,465	12,578	10,465	14,036	7,018	4,505	10,738	95
336	3456	6.00	10,305	12,676	10,305	14,063	7,032	5,198	10,794	318
340	3519	6.00	9,179	11,820	9,179	13,930	6,965	6,677	10,891	482
344	3610	6.00	7,704	10,925	7,704	13,771	6,885	6,968	11,031	439
348	3747	16.49	15,302	13,710	13,710	36,890	18,445	7,815	84,889	7,728
wall elements										
352	3795	18.30	28,237	-35,925	-35,925	30,311	15,156	18,386	105,212	8,639
356	3912	12.30	28,594	-9,565	-9,565	23,861	11,931	17,618	48,256	1,596
360	4073	12.00	26,133	-8,358	-8,358	24,001	12,000	19,538	46,867	2,608
364	4327	12.00	25,949	5,565	5,565	27,753	13,877	19,552	48,310	2,281
368	4403	12.00	25,040	24,599	24,599	32,028	16,014	19,398	48,728	2,375
372	4413	12.00	24,351	23,194	23,194	31,761	15,881	18,803	48,786	1,937
376	4433	12.00	23,502	5,932	5,932	28,153	14,077	17,530	48,896	1,759
380	4443	12.00	23,436	-21,380	-21,380	22,379	11,189	16,120	48,949	2,105
haunch elements										
384	4480	15.00	24,890	-38,336	-38,336	25,648	12,824	13,019	76,805	845
388	4526	27.29	22,428	-132,455	-132,455	33,650	16,825	15,371	255,519	8,611
392	4533	31.62	24,521	-126,346	-126,346	44,806	22,403	17,785	343,291	35,694
dome elements										
396	4506	21.31	29,549	-52,521	-52,521	36,989	18,494	12,506	155,465	13,269
400	4492	18.08	32,273	-20,379	-20,379	36,457	18,229	10,554	111,734	3,971
404	4492	17.38	34,259	-6,062	-6,062	37,919	18,960	9,169	103,247	3,080
408	4492	16.91	34,513	13,547	13,547	41,026	20,513	7,973	97,738	3,517
412	4499	16.38	32,314	23,865	23,865	42,051	21,025	6,402	91,777	3,348
416	4502	15.83	34,561	30,092	30,092	42,145	21,073	5,303	85,748	2,323
420	4504	15.28	33,443	31,890	31,890	41,294	20,647	4,001	79,913	2,035
23	4513	15.00	33,031	32,296	32,296	40,781	20,390	3,123	77,086	3,936
19	4513	15.00	33,151	33,748	33,151	40,962	20,481	3,037	77,086	3,881
28	4514	15.00	32,811	34,052	32,811	40,895	20,447	2,223	77,096	3,286
25	4514	15.00	32,679	33,296	32,679	40,867	20,433	2,352	77,096	2,874
31	4507	15.00	33,076	33,974	33,076	40,924	20,462	1,380	77,034	5,519
29	4507	15.00	33,496	37,430	33,496	41,013	20,506	1,470	77,034	6,942
32	4508	15.00	31,496	32,237	31,496	40,593	20,296	598	77,045	4,764
footing element										
424	4136	24.00	9,358	-2,480	-2,480	51,428	25,714	8,239	188,928	22,092

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Table 9.2.3-2. Evaluation of In-Plane Shear and Twisting Moment: Nonseismic (Load Case 1b) Plus Seismic (Lower-Bound Soil Properties) (cont).

Elements Along the Positive 2-Axis

ELEMENT	fc [lbf/in^2]	Thickness [in]	Merid. P (min.) [lbf/ft]	Circum. P (min.) [lbf/ft]	min. Nu [lbf/ft]	phi*Vc Eqn 11-32 [lbf/ft]	phi*Vc/2 [lbf/ft]	In-plane shear [lbf/ft]	T threshold [in-lbf/ft]	Twist. moment [in-lbf/ft]
floor elements										
161	3317	6.00	12,322	13,038	12,322	14,250	7,125	297	10,574	56
164	3321	6.00	10,772	12,597	10,772	13,928	6,964	679	10,581	145
169	3330	6.00	11,900	12,678	11,900	14,183	7,091	982	10,594	175
176	3343	6.00	13,122	13,204	13,122	14,465	7,233	1,916	10,616	290
844	3361	6.00	12,636	13,648	12,636	14,393	7,196	2,772	10,643	131
848	3382	6.00	11,002	13,317	11,002	14,083	7,041	3,277	10,677	172
852	3421	6.00	10,189	12,866	10,189	13,977	6,989	4,525	10,738	97
856	3456	6.00	10,053	12,928	10,053	14,010	7,005	5,165	10,794	323
860	3519	6.00	8,951	12,048	8,951	13,882	6,941	6,728	10,891	490
864	3610	6.00	7,464	11,117	7,464	13,720	6,860	6,904	11,031	456
868	3747	16.49	15,134	14,358	14,358	37,027	18,514	7,740	84,889	7,940
wall elements										
872	3795	18.30	28,909	-35,373	-35,373	30,429	15,214	17,992	105,212	8,617
876	3912	12.30	29,098	-9,164	-9,164	23,946	11,973	18,019	48,256	1,487
880	4073	12.00	26,637	-7,986	-7,986	24,080	12,040	19,185	46,367	2,529
884	4327	12.00	26,357	5,841	5,841	27,812	13,906	19,886	48,310	2,315
888	4403	12.00	25,448	24,767	24,767	32,064	16,032	19,137	48,728	2,372
892	4413	12.00	24,699	23,290	23,290	31,782	15,891	19,055	48,786	1,716
896	4433	12.00	23,886	5,992	5,992	28,166	14,083	17,318	48,896	1,623
900	4443	12.00	23,808	-21,392	-21,392	22,376	11,188	16,393	48,949	2,207
haunch elements										
904	4480	15.00	25,194	-38,404	-38,404	25,634	12,817	13,099	76,805	1,552
908	4526	27.29	22,778	-133,183	-133,183	33,495	16,747	13,774	255,519	15,422
912	4533	31.62	24,809	-127,522	-127,522	44,556	22,278	16,115	343,291	30,318
dome elements										
916	4506	21.31	29,717	-52,989	-52,989	36,890	18,445	11,586	155,465	11,435
920	4492	18.08	32,345	-20,567	-20,567	36,418	18,209	9,873	111,734	3,504
924	4492	17.38	34,283	-6,133	-6,133	37,904	18,952	8,592	103,247	3,105
928	4492	16.91	34,477	13,619	13,619	41,041	20,521	7,464	97,738	3,431
932	4499	16.38	32,206	24,057	24,057	42,092	21,046	6,157	91,777	3,343
936	4502	15.83	34,345	30,404	30,404	42,212	21,106	5,191	85,748	2,332
940	4504	15.28	33,107	32,298	32,298	41,381	20,690	4,360	79,913	2,039
183	4513	15.00	32,539	32,776	32,539	40,832	20,416	2,875	77,086	3,988
179	4513	15.00	32,659	34,324	32,659	40,858	20,429	2,950	77,086	3,948
188	4514	15.00	32,211	34,628	32,211	40,767	20,384	2,167	77,096	3,394
185	4514	15.00	32,043	33,944	32,043	40,732	20,366	2,091	77,096	2,761
191	4507	15.00	32,272	34,646	32,272	40,753	20,376	1,421	77,034	5,684
189	4507	15.00	32,668	38,234	32,668	40,837	20,418	1,589	77,034	7,079
192	4508	15.00	30,620	33,017	30,620	40,407	20,203	685	77,045	4,919
footing element										
944	4136	24.00	9,214	-1,760	-1,760	51,581	25,791	8,510	188,928	21,840

Table 9.2.3-3. Evaluation of In-Plane Shear and Twisting Moment: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties).

Elements Along the Positive 1-Axis d=tw=12"

ELEMENT	fc [lbf/in^2]	Thickness [in]	Merid. P (min.) [lbf/ft]	Circum. P (min.) [lbf/ft]	min. Nu [lbf/ft]	phi*Vc Eqn 11-32 [lbf/ft]	phi*Vc/2 [lbf/ft]	In-plane shear [lbf/ft]	T threshold [in-lbf/ft]	Twist. moment [in-lbf/ft]
floor elements										
289	3317	6.00	12,718	12,474	12,474	14,282	7,141	292	10,574	42
291	3321	6.00	11,192	11,985	11,192	14,017	7,008	685	10,581	144
295	3330	6.00	12,356	12,042	12,042	14,213	7,106	994	10,594	184
301	3343	6.00	13,542	12,532	12,532	14,340	7,170	1,920	10,616	272
1257	3361	6.00	13,128	12,916	12,916	14,452	7,226	2,774	10,643	139
1261	3382	6.00	11,590	12,561	11,590	14,208	7,104	3,288	10,677	162
1265	3421	6.00	10,873	12,062	10,873	14,123	7,061	4,505	10,738	107
1269	3456	6.00	10,881	12,076	10,881	14,185	7,093	5,218	10,794	294
1273	3519	6.00	9,863	11,148	9,863	14,076	7,038	6,666	10,891	492
1277	3610	6.00	8,544	10,097	8,544	13,949	6,975	7,014	11,031	454
1281	3747	16.49	16,238	10,866	10,866	36,285	18,143	7,784	84,889	7,015
wall elements										
1285	3795	18.30	27,697	-38,685	-38,685	29,725	14,862	18,585	105,212	8,582
1289	3912	12.30	28,246	-11,406	-11,406	23,470	11,735	17,333	48,256	1,360
1293	4073	12.00	26,073	-10,227	-10,227	23,603	11,802	19,773	46,867	2,545
1297	4327	12.00	26,585	3,873	3,873	27,394	13,697	19,172	48,310	2,081
1301	4403	12.00	26,108	24,059	24,059	31,913	15,957	19,641	48,728	2,511
1305	4413	12.00	25,935	24,790	24,790	32,101	16,050	18,292	48,786	1,595
1309	4433	12.00	25,566	10,456	10,456	29,114	14,557	17,865	48,896	1,825
1313	4443	12.00	24,780	-14,575	-14,575	23,825	11,912	15,958	48,949	2,501
haunch elements										
1317	4480	15.00	23,850	-36,516	-36,516	26,035	13,017	13,003	76,805	930
1321	4526	27.29	21,378	-127,955	-127,955	34,606	17,303	15,283	255,519	8,570
1325	4533	31.52	25,325	-115,978	-115,978	47,009	23,505	16,933	343,291	31,230
dome elements										
1329	4506	21.31	30,149	-51,021	-51,021	37,308	18,654	11,820	155,465	9,980
1333	4492	18.08	31,649	-21,975	-21,975	36,118	18,059	10,222	111,734	4,044
1337	4492	17.38	32,423	-8,222	-8,222	37,460	18,730	9,141	103,247	2,052
1341	4492	16.91	32,581	11,663	11,663	40,626	20,313	8,002	97,738	2,663
1345	4499	16.38	30,478	21,969	21,969	41,648	20,824	6,366	91,777	3,214
1349	4502	15.83	32,653	28,124	28,124	41,727	20,864	5,302	85,748	2,146
1353	4504	15.28	31,415	30,066	30,066	40,906	20,453	3,985	79,913	1,899
308	4513	15.00	30,919	30,592	30,592	40,419	20,209	3,122	77,086	3,990
305	4513	15.00	31,087	32,068	31,087	40,524	20,262	2,977	77,086	3,879
314	4514	15.00	30,735	32,360	30,735	40,454	20,227	2,160	77,096	3,284
312	4514	15.00	30,579	31,664	30,579	40,420	20,210	2,317	77,096	2,919
318	4507	15.00	30,808	32,294	30,808	40,442	20,221	1,373	77,034	5,506
317	4507	15.00	31,264	35,798	31,264	40,539	20,269	1,516	77,034	6,874
320	4508	15.00	29,252	30,653	29,252	40,116	20,058	626	77,045	4,775
footing element										
1357	4136	24.00	9,850	-6,836	-6,836	50,503	25,251	8,137	188,928	21,456

Table 9.2.3-3. Evaluation of In-Plane Shear and Twisting Moment: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties) (cont).

Elements Along the Negative 1-Axis

ELEMENT	fc [lbf/in^2]	Thickness [in]	Mend. P (min.) [lbf/ft]	Circum. P (min.) [lbf/ft]	min. Nu [lbf/ft]	phi*Vc Eqn 11-32 [lbf/ft]	phi*Vc/2 [lbf/ft]	In-plane shear [lbf/ft]	T threshold [in-lbf/ft]	Twist. moment [in-lbf/ft]
floor elements										
1	3317	6.00	12,682	12,546	12,546	14,297	7,149	275	10,574	42
4	3321	6.00	11,132	12,153	11,132	14,004	7,002	683	10,581	128
9	3330	6.00	12,200	12,246	12,200	14,246	7,123	969	10,594	168
16	3343	6.00	13,386	12,796	12,796	14,396	7,198	1,898	10,616	277
324	3361	6.00	12,852	13,216	12,852	14,439	7,219	2,762	10,643	121
328	3382	6.00	11,182	12,933	11,182	14,121	7,061	3,274	10,677	163
332	3421	6.00	10,333	12,482	10,333	14,008	7,004	4,493	10,738	91
336	3456	6.00	10,149	12,580	10,149	14,030	7,015	5,187	10,794	313
340	3519	6.00	8,987	11,748	8,987	13,889	6,945	6,662	10,891	473
344	3610	6.00	7,548	10,853	7,548	13,737	6,869	6,966	11,031	431
348	3747	16.49	15,026	13,770	13,770	36,902	18,451	7,816	84,889	7,554
wall elements										
352	3795	18.30	27,217	-35,673	-35,673	30,365	15,182	18,380	105,212	8,623
356	3912	12.30	27,598	-9,574	-9,574	23,859	11,929	17,568	48,256	1,602
360	4073	12.00	25,137	-8,568	-8,568	23,956	11,978	19,512	46,867	2,637
364	4327	12.00	24,977	5,145	5,145	27,664	13,832	19,533	48,310	2,248
368	4403	12.00	24,044	24,131	24,044	31,910	15,955	19,356	48,728	2,415
372	4413	12.00	23,343	22,918	22,918	31,703	15,851	18,797	48,786	2,008
376	4433	12.00	22,470	6,088	6,088	28,186	14,093	17,482	48,896	1,783
380	4443	12.00	22,404	-20,603	-20,603	22,544	11,272	16,103	48,949	2,100
haunch elements										
384	4480	15.00	23,850	-36,516	-36,516	26,035	13,017	13,003	76,805	930
388	4526	27.29	21,378	-127,955	-127,955	34,606	17,303	15,283	255,519	8,570
392	4533	31.62	23,489	-121,726	-121,726	45,788	22,894	17,551	343,291	35,190
dome elements										
396	4506	21.31	28,277	-51,045	-51,045	37,303	18,651	12,367	155,465	13,077
400	4492	18.08	30,857	-19,933	-19,933	36,552	18,276	10,495	111,734	3,907
404	4492	17.38	32,747	-6,200	-6,200	37,890	18,945	9,089	103,247	3,057
408	4492	16.91	32,917	12,971	12,971	40,904	20,452	7,944	97,738	3,500
412	4499	16.38	30,610	22,977	22,977	41,862	20,931	6,354	91,777	3,321
416	4502	15.83	32,785	28,988	28,988	41,911	20,955	5,292	85,748	2,334
420	4504	15.28	31,595	30,642	30,642	41,029	20,514	3,985	79,913	2,031
23	4513	15.00	31,075	30,988	30,988	40,503	20,251	3,110	77,086	3,932
19	4513	15.00	31,195	32,308	31,195	40,547	20,273	3,020	77,086	3,851
28	4514	15.00	30,759	32,588	30,759	40,459	20,229	2,198	77,096	3,260
25	4514	15.00	30,627	31,808	30,627	40,431	20,215	2,327	77,096	2,879
31	4507	15.00	30,856	32,438	30,856	40,452	20,226	1,360	77,034	5,525
29	4507	15.00	31,276	35,834	31,276	40,541	20,271	1,483	77,034	6,864
32	4508	15.00	29,228	30,677	29,228	40,111	20,055	602	77,045	4,767
footing element										
424	4136	24.00	9,214	-1,688	-1,688	51,596	25,798	8,236	188,928	21,852

Table 9.2.3-3. Evaluation of In-Plane Shear and Twisting Moment: Nonseismic (Load Case 2) Plus Seismic (Lower-Bound Soil Properties) (cont).

Stress Allowables (lbf/in^2):

Fy	Shear: 1.33(0.4)Fy	Axial: 1.33(0.6)Fy	Bending: 1.33(0.66)Fy	D/t limit 3300/Fy
30,000	15,960	23,940	26,334	110

Riser	Beam No.	O.D. [in]	Thickness,t [in]	Area [in^2]	Section Modulus [in^3]	D/t Ratio	Compact?
4" in Pump/Sluicing Pits	1	4.5	0.237	3.17	3.21	19.0	yes
12" in Pump/Sluicing Pits	2	12.75	0.406	15.75	47.1	31.4	yes
36" in Pump Pit	3	36.75	0.375	42.85	772	98.0	yes
12" in Heel Pit	4	12.75	0.406	15.75	47.1	31.4	yes

Seismic Forces and Moments (lbf, inches):

		Raw output from STRESS Module						Total Seismic
		1-Direc.	2-Direc.	3-Direc.	1-Direc.	2-Direc.	3-Direc.	Demand
4" Riser in Pump/Sluicing Pits	P1	0	0	0	0	0	0	0
	P2	0	2	1	0	4	3	5
	P3	-1	0	0	-1	0	0	1
	M1	0	0	0	0	0	0	0
	M2	33	0	0	65	0	0	65
	M3	0	110	76	0	220	153	268
12" Riser in Pump/Sluicing Pits	P1	0	0	0	0	0	0	0
	P2	0	73	50	0	145	101	177
	P3	-22	0	0	-43	0	0	43
	M1	0	0	0	0	0	0	0
	M2	1,262	0	0	2,524	0	0	2,524
	M3	0	4,251	2,947	0	8,502	5,894	10,345
36" Riser in Pump Pit	P1	0	0	0	0	0	0	0
	P2	0	1,657	861	0	3,314	1,721	3,734
	P3	-40	0	0	-81	0	0	81
	M1	0	0	0	0	0	0	0
	M2	1,426	0	0	2,852	0	0	2,852
	M3	0	58,640	30,460	0	117,280	60,920	132,158
12" Riser in Heel Pit	P1	0	0	0	0	0	0	0
	P2	0	685	0	0	2,738	0	2,738
	P3	-704	0	0	-2,816	0	0	2,816
	M1	0	0	0	0	0	0	0
	M2	14,430	0	0	57,720	0	0	57,720
	M3	0	14,030	0	0	56,120	0	56,120

	Stress Demands (lbf/in^2)			Demand-Capacity Ratio	
Riser	Shear Stress	Axial Stress	Bending Stress	Shear	Moment/Axial
4" in Pump/Sluicing Pits	3	0	84	0.00	0.00
12" in Pump/Sluicing Pits	22	0	220	0.00	0.01
36" in Pump Pit	174	0	171	0.01	0.01
12" in Heel Pit	358	0	1,225	0.02	0.05

risers\RISERS.XLS

Table 9.3-1. AISC Code Evaluation of Risers for Seismic Demand.

Elements Along the Positive 2-Axis

ELEMENT	fc [lbf/in^2]	Thickness [in]	Merid. P (min.) [lbf/ft]	Circum. P (min.) [lbf/ft]	min. Nu [lbf/ft]	phi*Vc Eqn 11-32 [lbf/ft]	phi*Vc/2 [lbf/ft]	In-plane shear [lbf/ft]	T threshold [in-lbf/ft]	Twist. moment [in-lbf/ft]
floor elements										
161	3317	6.00	12,226	12,990	12,226	14,229	7,115	302	10,574	57
164	3321	6.00	10,676	12,549	10,676	13,907	6,954	684	10,581	147
169	3330	6.00	11,792	12,618	11,792	14,160	7,080	992	10,594	175
176	3343	6.00	12,990	13,144	12,990	14,437	7,219	1,920	10,616	280
844	3361	6.00	12,492	13,576	12,492	14,362	7,181	2,744	10,643	129
848	3382	6.00	10,858	13,245	10,858	14,052	7,026	3,284	10,677	168
852	3421	6.00	10,033	12,770	10,033	13,944	6,972	4,490	10,738	99
856	3456	6.00	9,885	12,832	9,885	13,974	6,987	5,168	10,794	315
860	3519	6.00	8,783	11,916	8,783	13,846	6,923	6,680	10,891	490
864	3610	6.00	7,332	10,985	7,332	13,692	6,846	6,934	11,031	439
868	3747	16.49	14,846	14,442	14,442	37,045	18,523	7,758	84,889	7,735
wall elements										
872	3795	18.30	27,709	-35,277	-35,277	30,449	15,224	17,964	105,212	8,527
876	3912	12.30	27,946	-9,352	-9,352	23,906	11,953	17,911	48,256	1,413
880	4073	12.00	25,449	-8,398	-8,398	23,992	11,996	19,184	46,867	2,513
884	4327	12.00	25,181	5,217	5,217	27,679	13,840	19,777	48,310	2,349
888	4403	12.00	24,320	24,119	24,119	31,926	15,963	19,201	48,728	2,545
892	4413	12.00	23,619	22,930	22,930	31,705	15,853	18,912	48,786	1,522
896	4433	12.00	22,914	5,124	6,124	28,194	14,097	17,411	48,896	1,449
900	4443	12.00	22,896	-20,499	-20,499	22,566	11,283	16,298	48,949	2,278
haunch elements										
904	4480	15.00	24,318	-36,268	-36,268	26,087	13,044	13,116	76,805	1,322
908	4526	27.29	21,830	-127,855	-127,855	34,627	17,314	13,706	255,519	14,827
912	4533	31.62	23,753	-122,038	-122,038	45,722	22,861	15,924	343,291	29,850
dome elements										
916	4506	21.31	28,289	-51,069	-51,069	37,298	18,649	11,522	155,465	11,069
920	4492	18.08	30,749	-19,779	-19,779	36,585	18,292	10,006	111,734	3,440
924	4492	17.38	32,591	-6,030	-6,030	37,926	18,963	8,752	103,247	3,002
928	4492	16.91	32,749	13,211	13,211	40,955	20,477	7,766	97,738	3,257
932	4499	16.38	30,466	23,181	23,181	41,906	20,953	6,280	91,777	3,121
936	4502	15.83	32,641	29,192	29,192	41,954	20,977	5,279	85,748	2,168
940	4504	15.28	31,463	30,786	30,786	41,059	20,530	3,984	79,913	1,913
183	4513	15.00	30,943	31,132	30,943	40,493	20,247	3,138	77,086	4,049
179	4513	15.00	31,051	32,404	31,051	40,516	20,258	3,056	77,086	3,967
188	4514	15.00	30,687	32,696	30,687	40,443	20,222	2,200	77,096	3,357
185	4514	15.00	30,531	31,856	30,531	40,410	20,205	2,371	77,096	2,814
191	4507	15.00	30,784	32,486	30,784	40,437	20,218	1,376	77,034	5,579
189	4507	15.00	31,204	35,882	31,204	40,526	20,263	1,463	77,034	8,901
192	4508	15.00	29,192	30,713	29,192	40,103	20,052	613	77,045	4,789
footing element										
944	4136	24.00	9,046	-1,148	-1,148	51,711	25,856	8,476	188,928	21,732

10.0 REFERENCES

ACI, 1990, *Code Requirements for Nuclear Safety-Related Concrete Structures*, ACI 349-90, American Concrete Institute, Detroit, Michigan.

AISC, 1989, *Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design*, American Institute of Steel Construction, Inc., Chicago, Illinois.

ASCE, 1986, *Standard for Seismic Analysis of Safety-Related Nuclear Structures and Commentary on Standard for Seismic Analysis of Safety-Related Nuclear Structures*, ASCE 4-86, American Society of Civil Engineers, New York, New York.

Bander, T. J., 1992, *Thermal History of Tank 241-C-106*, WHC-SD-WM-ER-161, Westinghouse Hanford Company, Richland, Washington.

Bandyopadhyay, K., A. Cornell, C. Costantino, R. Kennedy, C. Miller, and A. Veletsos, 1993, *Seismic Design and Evaluation Guidelines for the Department of Energy High-Level Waste Storage Tanks and Appurtenances*, BNL 52361, Brookhaven National Laboratory, Upton, New York.

Brewster, R. D., 1994, *Hanford Site Tank Farm Facilities Interim Safety Basis*, WHC-SD-WM-ISB-001, Revision OE, Westinghouse Hanford Company, Richland, Washington.

Dames & Moore, 1988, *Report-Geotechnical and Corrosion Investigation-Grout Vaults Hanford, Washington*, prepared by Dames & Moore Consulting Engineers for Kaiser Engineers Hanford, Inc., Contract No. 10805-282-016, DM, Seattle, Washington.

Drawings
1) D1 through D6, 1944, Project 9536, Purchase Order 1451½, Morrison-Bechtel-McCone Construction Drawings, Contract No. 869.
2) H-2-1744, Tank Farm Riser and Nozzle Elevation
3) H-2-37006, C-106 Tank Arrangement, As Built
4) H-2-41190, Piping, Cascade Pump Pit Plan & Sections
5) H-2-41267, Mechanical Equipment - Sub Assembly - Slurry Pump Adaptor Ring
6) H-2-41294, Mechanical Equipment - Plan, Section and Details Heel Jet
7) H-2-41295, Heel Pit Adaptor Ring
8) H-2-41311, Mechanical Equipment - Sub Assembly Sluicing Adapter Ring
9) H-2-41343, Structural Concrete - Plan and Sections - Pump Pit
10) H-2-41344, Structural Concrete - Plan and Sections - Sluicing Pit
11) H-2-41345, Structural Concrete - Plan and Sections - Heel Pit
12) H-2-41368, Structural Construction Sequence - Heel Pit
13) H-2-41371, Structural Steel - Plan and Sections - Alignment Assembly and Leveling Beam Pump Pit

Giller, R. A. and E. O. Weiner, 1991, *Soil Structure Interaction Analysis for the Hanford Site 241-SY-101 Double-Shell Waste Storage Tanks*, WHC-EP-0504, Volume 2, Westinghouse Hanford Company, Richland, Washington.

HKS, 1989, *ABAQUS User's Manual*, Version 4.8 with 4.9 Supplement, Hibbitt, Karlsson & Sorensen, Inc., Pawtucket, Rhode Island.

James, R. J., 1993, *ANACAP-U, ANATECH Concrete Analysis Package Version 92-2.2, User's Manual*, ANA-QA-118, Rev. 3, Anatech Research Corporation, San Diego, California.

Julyk, L. J., et al., 1994, *Tank 241-C-106 Structural Integrity Evaluation for In Situ Conditions*, WHC-SD-W320-ANAL-001, Westinghouse Hanford Company, Richland, Washington.

Kennedy, R. P., S. A. Short, J. R. McDonald, M. W. McCann, R. C. Murray and J. R. Hill, 1990, *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards*, UCRL-15910, Lawrence Livermore National Laboratory, Livermore, California.

Kidder, R. J., 1993, *Single-Shell Tank Interim Safety Equipment List*, WHC-SD-WM-SEL-027, Revision 1, Westinghouse Hanford Company, Richland, Washington.

Lysmer, J., F. Ostadan, M. Tabatabaie, F. Tajirian, and S. Vahdani, 1991a, *SASSI, A System for Analysis of Soil-Structure Interaction, Theoretical Manual*, Geotechnical Engineering Division, Civil Engineering Department, University of California, Berkeley, California.

Lysmer, J., F. Ostadan, M. Tabatabaie, F. Tajirian, and S. Vahdani, 1991b, *SASSI, A System for Analysis of Soil-Structure Interaction, User's Manual*, Geotechnical Engineering Division, Civil Engineering Department, University of California, Berkeley, California.

MacGregor, J. G., 1988, *Reinforced Concrete Mechanics and Design*, Prentice-Hall, Englewood Cliffs, New Jersey.

Marlow, R. S., 1994, *Structural Analysis and Evaluation in Support of the Long Reach Manipulator Procurement Specification*, WHC-SD-W340-ANAL-001, Westinghouse Hanford Company, Richland, Washington.

Milliken, N. J., 1992, *Double-Shell Interim Safety Equipment List*, WHC-SD-WM-SEL-026, Revision 0A, Westinghouse Hanford Company, Richland, Washington.

NUREG, 1989, *Standard Review Plan, NUREG-0800, Rev. 2*, U.S. Nuclear Regulatory Commission, Washington, D.C.

Moore, C. J., 1993, *241-C-106 Preliminary Seismic Evaluation (Phase II-A)* Westinghouse Hanford Company, Richland, Washington.

Schnabel, P. B., J. Lysmer and H. B. Seed, 1972, *SHAKE, A Computer Program for Earthquake Response Analysis of Horizontally Layered Sites*, Report No. EERC 72-12, College of Engineering, University of California, Berkeley, California.

SDC-4.1, 1993, *Hanford Plant Standards, HPS-SDC-4.1, Rev. 12, Standard Arch-Civil Design Criteria Design Loads for Facilities*, U.S. Department of Energy-Richland Operations Office, Richland, Washington.

Seed, H. B., and I. M. Idriss, 1970, *Soil Moduli and Damping Factors for Dynamic Response Analyses*, Report No. EERC 70-10, Earthquake Engineering Research Center, University of California, Berkeley, California.

Wallace, D. A., 1994, *Tank 241-C-106 Structural Evaluation in Support of Project W320 Retrieval Demonstration*, WHC-SD-W320-ANAL-003, Westinghouse Hanford Company, Richland, Washington.

Weiner, E. O., and A. C. Rohay, 1992, *Design Basis Earthquake Time Histories for 1992 SDC-4.1, Revision 12*, WHC-SD-GN-DA-30018, Westinghouse Hanford Company, Richland, Washington.

Winter, G., and A. H. Nilson, 1979, *Design of Concrete Structures*, McGraw-Hill Book Company, New York, New York.

can be used with confidence in modeling tank-to-tank interaction via a half model as described in the next section.

A.1.2 ANTISYMMETRY IN SIMULATING TANK-TO-TANK INTERACTION

An antisymmetry plane must be defined in the soil halfway between two adjacent tanks (Figure A.1.1(b)) to simulate horizontal tank-to-tank interaction via a half tank model. Accordingly, a vertical antisymmetry plane perpendicular to the excitation direction was added to the baseline half model at the midway point between adjacent tanks (50 feet from the tank centroidal axis).

Two analyses were made to ascertain the importance of extending soil elements to the antisymmetry plane such that the antisymmetry plane forms the bounding surface of the finite element mesh on one side. In the first analysis, the finite element mesh stops short of the antisymmetry plane, i.e., no elements interest the antisymmetry plane and thus displacement constraints associated with antisymmetry conditions are not directly imposed (Figure A.1.2-1(a)). In the second analysis, the outer boundary of the finite element mesh was extended to the antisymmetry plane (Figure A.1.2-1(b)) and the appropriate displacement boundary conditions were applied to those nodes which lie on the antisymmetry plane. In both analyses the antisymmetry plane is defined using three reference points as described on p. 5-33 of the SASSI User's Manual (Lysmer 1991b). Comparing the results of the two analyses in Figures A.1.2-2 to A.1.2-8, it is concluded that extending the finite element mesh of the soil to the antisymmetry plane is not warranted since doing so does not significantly affect the computed tank demands.

A.2 MESH REFINEMENT

The use of degenerate solid elements in transitioning from a fine to a coarse mesh in the near-field soil is examined in Section A.2.1. Section A.2.2 addresses the sensitivity of tank response to interaction node spacing.

A.2.1 SOLID ELEMENT TRANSITION ZONE

The solid element used in the SASSI program is an eight-node isoparametric element. The element's isoparametric coordinate system can be distorted to degenerate the brick into a tetrahedron (4-node, 4-face element), a pyramid (5-node, 5-face element), or a wedge (6-node, 5-face element).

Three test problems were analyzed with SASSI to address concerns about the use of these degenerate isoparametric solid elements in transitioning from a fine mesh to a coarse mesh in the near-field soil. The test model is a vertical cantilever of solid elements (140 in. x 108 in. x 480 in. tall) with a layer of shell elements superimposed on one of the 140 in. x 480 in. faces. Two materials are defined: a generic soil for the solid elements and an elastic pseudo-concrete for the shell elements. The control motion at the fixed base of the test cantilever is the same as the horizontal control motion used in the tank analysis.

Baseline Test Model

The baseline test model (Figure A.2.1-1) is made up of 144 (4 x 3 x 12) identical 8-node bricks with 48 (4 x 12) shells along one face. There is a one-to-one correspondence of nodes at the shell-solid interface. As recommended in the SASSI Users' Manual (Lysmer, et al. 1991b), the integration order of the solid elements is set to two.

DK Model - Skipped Nodes

One approach to reducing the number of solid elements (and increasing the node spacing in the soil) is to have disparate element sizes at the shell-solid interface whereby only every second (third, fourth, etc) shell element node is shared with a solid element. The "DK" variation of the test model (Figure A.2.1-2) employs this strategy by skipping every second shell element node. The DK model consists of 36 identical solid elements (2 x 3 x 6) and 48 shell elements (4 x 12) where the shell elements are identical to those of the baseline test model.

CM Model - Degenerate Elements

The "CM" variation of the test model (Figure A.2.1-3) utilizes distorted tetrahedrons and pyramids, similar to those used in the tank analyses, to achieve a mesh density change from the mesh at the shell interface to the coarser mesh at the opposite surface. The solid element mesh is effectively transitioned from a 4-element wide, 12-element-high mesh to a 2-element-wide, 6-element-high mesh. The model has a total of 132 solid elements and 48 shell elements (4 x 12) where the shell elements are identical to those of the baseline test model.

Basic rules consistent with the element formulation were observed for the definition of the degenerate solid elements, i.e., the first three nodes of the element define the plane for the 1 and 2 isoparametric directions, and the normal vector to this plane (defined via the right-hand rule) points toward the interior of the solid element. A higher integration order (4) was used for the degenerate elements.

Results and Conclusions

Forces and moments in the shells and peak accelerations resulting from the three test models are given in Table A.2.1-1. It is evident that the degenerate transition elements are valid and are at least as accurate as skipping every second shell element node as a means of reducing the soil mesh density. Either method gives approximately the same results as the baseline test model (generally less than 10% difference where response is significant). It may be deduced that skipping more than every other shell element node using the "node-skipping" approach would result in a less favorable comparison with the degenerate element approach.

A.2.2 SPACING OF INTERACTION NODES

This section examines the effect of interaction node spacing on horizontal seismic tank demands. The coarse quarter model is constructed from the baseline quarter model by stripping away the outer layer of near-field soil elements in the "structure" thereby reducing the volume of "excavated soil" while increasing the number of interaction nodes from 95 to 558. Figure A.2.2-1 shows the coarse and baseline finite element meshes of the tank and near-field soil. Table A.2.2-1 provides a tabular comparison of the soil layers defined in the baseline and coarse models.

The proper radius of the "central zone" (R) specified by the analyst in SASSI's POINT module is dependent on the horizontal spacing of interaction nodes; therefore, the value of R is greater for the coarse model than for the baseline model (130 in. vs. 72 in.). This radius is used in calculating the axisymmetric point load solution for each analysis frequency at the surface of each soil layer in the embedment zone. Theoretical details are provided in the SASSI documentation (Lysmer, et al. 1991a and 1991b). Sensitivity analyses not documented herein revealed that the computed tank response is somewhat sensitive to the radius of the central zone; however, the sensitivity is insignificant when the radius falls within the range of values recommended by Lysmer, i.e., 85% to 100% of the average horizontal spacing of interaction nodes.

Although analysis frequencies greater than 13 Hz are permitted for the baseline model according to the one-fifth wavelength rule (Section 5.3.2), the 13 Hz cutoff frequency is retained to minimize differences in the two analyses. Although the two cases employ the same frequency range, there are 12 analysis frequencies within that range for the coarse model and only 7 analysis frequencies in the range for the baseline model. As reported in Section A.4, the sensitivity to the number of analysis frequencies is negligible.

Figures A.2.2-2 to A.2.2-7 compare tank demands computed by the coarse and baseline models. Differences in the results of the two models are sometimes significant with the coarse model results usually (but not always) being conservative. The mesh refinement of the baseline model is recommended to avoid undue conservatism (or possible unconservatism) in the seismic analyses.

A.3 MATERIAL PROPERTIES

Sensitivities of computed tank response to the site soil profile, the use of nominal versus in situ concrete section properties, and the consideration of waste in the tank are reported in Sections A.3.1, A.3.2, and A.3.3, respectively.

A.3.1 SOIL

The preliminary C-106 seismic analysis (Moore 1993) employed soil properties developed for the SY-101 seismic analysis (Giller and Weiner 1991) whereas the seismic evaluation documented in this report is based on data from the Grout Vault soil testing report (Dames & Moore 1988). Table A.3.1-1 reveals sizeable differences in the two sets of soil data through the depth of embedment. The sensitivity of tank response to the soil profile and to the control motion (acceleration time history) are examined below.

A SSI analysis of C-106 was made using the SY-101 soil data and control motion (Run Q5). Two additional analyses (Runs Q5.5 and Q6) were made employing soil properties based on Grout Vault soil data. Run Q5.5 is a hybrid case where the free-field strain profile used to develop strain-compatible soil properties is based on an updated control motion (Weiner and Rohay 1992) while the structural response is determined via convolution with the control motion used in the SY-101 analysis. The response spectra shown in Figure A.3.1-1 indicate marked similarity in the two control motions. Run Q6 is entirely consistent in that structural response is determined via convolution with the updated control motion. All three analyses utilize the coarse SASSI model.

Results of Runs Q5, Q5.5, and Q6 are provided in Figures A.3.1-2 to A.3.1-7. Comparison of the results of Runs Q5 and Q5.5 provides an approximate indication of the effect of a change in soil properties without a change in control motion while comparison of the results of Runs Q5.5 and Q6 provides an approximate indication of the effect of a change in control motion without a change in soil properties.

In general, the results of Runs Q5.5 and Q6 are nearly the same while the results of Run Q5 are noticeably larger in comparison with results of Runs Q5.5 and Q6. Not surprisingly, these observations indicate that the structural response is more sensitive to the large differences in soil properties than to the small differences in the control motions. It is recognized that the control motion does affect the SHAKE free-field site analysis and, thus, the strain-compatible soil properties used in SASSI. However, the influence of the control motion on the strain-compatible soil properties is relatively minor.

A.3.2 REINFORCED CONCRETE

In the seismic analyses, the tank is modeled with shell elements of elastic, isotropic material. By "tuning" the thickness and Young's modulus of each shell element, the effect of reinforcement, the state of cracking, and the "true" stiffness of concrete and reinforcement including degradation with time and temperature are taken into account. In effect, the axial and bending stiffnesses of the shell elements are matched with the corresponding stiffnesses of the in situ tank sections as calculated in the nonseismic analysis (Julyk 1994). The effective shell thickness and effective Young's modulus for each shell element are calculated as described in Appendix U.

Two analyses were made using the coarse SASSI model to examine the importance of considering in situ tank section properties when computing tank demands. Run Q2 uses the nominal thickness of each concrete section, assumes the section is uncracked (and unreinforced), and considers a uniform value of Young's modulus equal to 3,000,000 lbf/in^2 in defining the shell element properties. Run Q3 utilizes concrete properties and shell thicknesses which have been "tuned" to correspond to best-estimate, 55 year in situ conditions. Figures A.3.2-1 to A.3.2-6 compare the results of the two analyses. In general, the demands from Run Q3 (in situ properties) are less than those from Run Q2 (nominal virain properties) in the base and the wall of the tank and are approximately unchanged in the dome. The differences are significant enough to warrant the use of in situ tank section properties.

A.3.3 WASTE

The hydrodynamic effect of tank waste due to horizontal seismic excitation consists of impulsive and convective components. Considering the general case of an inviscid liquid inside a tank, the convective (sloshing) component is small relative to the impulsive component (Bandyopadhyay, et al. 1993, Section 4.3.2.4 and Appendix F). As the tank waste is in a highly viscous state, the effect of sloshing is reduced (Bandyopadhyay, et al. 1993). Therefore, only the impulsive effect of the waste is considered. The approach to modeling the impulsive effect of waste is described in Appendix N.

Tank response at the 180° meridian of the coarse SASSI model is used as a basis of comparison between the "empty" and "with waste" conditions. The "empty" condition of the tank in response to a horizontal excitation is simulated in Run Q3 while the "with waste" condition in simulated in Run Q5. Figures A.3.3-1 to A.3.3-6 compare the results of Runs Q3 and Q5. While axial forces are sometimes larger when waste is neglected (Run Q3), the absolute values of moments are always larger when waste is considered (Run Q5). Since the differences are not insignificant, waste mass should be considered in the seismic analyses.

A.4 SSI FREQUENCY SELECTION

The sensitivity of tank response to the SASSI analysis frequencies and maximum (cutoff) frequency chosen by the analyst is addressed below.

A.4.1 NUMBER OF FREQUENCIES WITHIN RANGE

SASSI solves the soil-structure interaction problem at discrete frequencies (selected by the user) and then interpolates to obtain solutions at intermediate frequencies. The closer the spacing of the discrete frequencies, the more precise the interpolation scheme and overall solution. However, beyond a certain number of frequencies, the returns in the form of added solution accuracy are diminished as additional frequencies are selected. The SASSI User's Manual recommends that transfer functions be computed at 10 to 20 discrete frequencies. Analyses used in the evaluation of the tank use from 11 to 19 frequencies with a frequency cutoff of 24 Hz.

Two analyses were made utilizing the coarse SASSI model to investigate the sensitivity of tank response to the number of analysis frequencies within a fixed frequency range. Run Q3 includes 12 analysis frequencies ranging from 0.59 Hz to 13 Hz. Run Q4 utilizes 24 analysis frequencies with a cutoff frequency of 13 Hz effectively halving the interval across which transfer functions must be interpolated. Table A.4.1-1 lists the frequencies used in Runs Q3 and Q4.

As shown in Figures A.4.1-1 to A.4.1-6, the tank demands computed in Runs Q3 and Q4 are nearly identical. Thus, for the set of conditions modeled, 12 frequencies are sufficient to obtain a "proper" solution of response associated with frequencies of 13 Hz and lower.

A.4.2 FREQUENCY RANGE

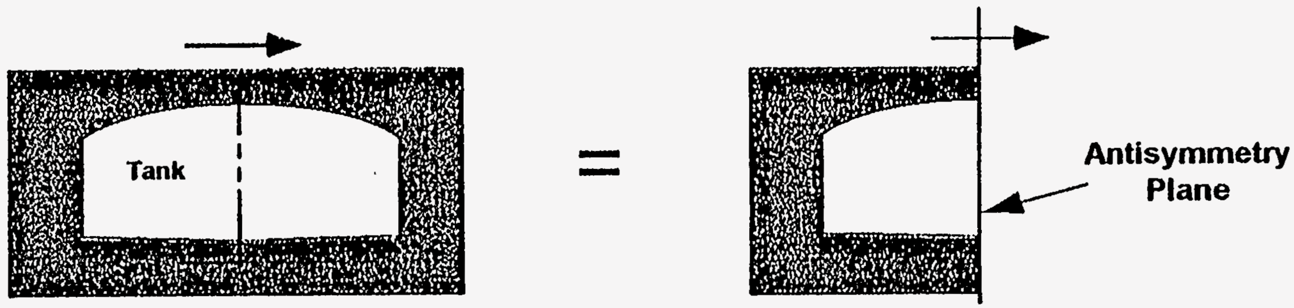
The interaction node spacing in the baseline model is such that transfer functions can be computed at frequencies higher than 13 Hz. A rule of thumb is provided in the SASSI User's Manual (Lysmer, et al. 1991b) for determining the appropriate interaction node spacing for a given frequency cutoff. The rule is stated as follows:

$$f_{NF} \leq \frac{V_s}{5\ (t_{layer})}$$

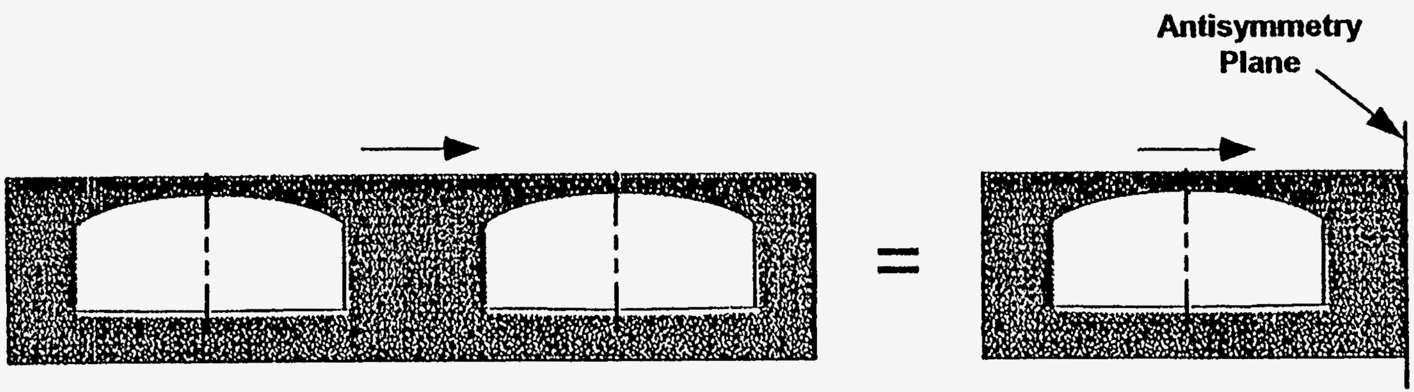
where f_{NF} is the cutoff frequency, V_s is the shear wave speed, and t_{layer} is the soil layer thickness (vertical spacing of interaction nodes). Thus, for the baseline model mesh refinement and lower-bound soil properties, the recommended maximum cutoff frequency is 7,935/(5·77.5) = 20.5 Hz where the wave speed in the top soil layer is 7,935 in/s and the layer thickness is 77.5in. (Table 5.3.2-4).

Table A.4.2-1 and Figures A.4.2-1 to A.4.2-6 summarize results from two analyses which vary only in the number of frequencies and the cutoff frequency. One analysis includes only 7 analysis frequencies with a cutoff frequency of 13 Hz. The second analysis includes 5 additional frequencies less than the 13 cutoff plus 6 more frequencies between 14 and 24 Hz for a total of 18 frequencies between 0.59 and 24 Hz. Both analyses use the baseline SASSI model and consider lower-bound soil properties. The figures suggest that adding more analysis frequencies and extending the cutoff frequency range beyond 13 Hz has negligible influence on the tank response.

Figure A.1.1-1
Use of Anti-Symmetry (Horizontal Excitation)

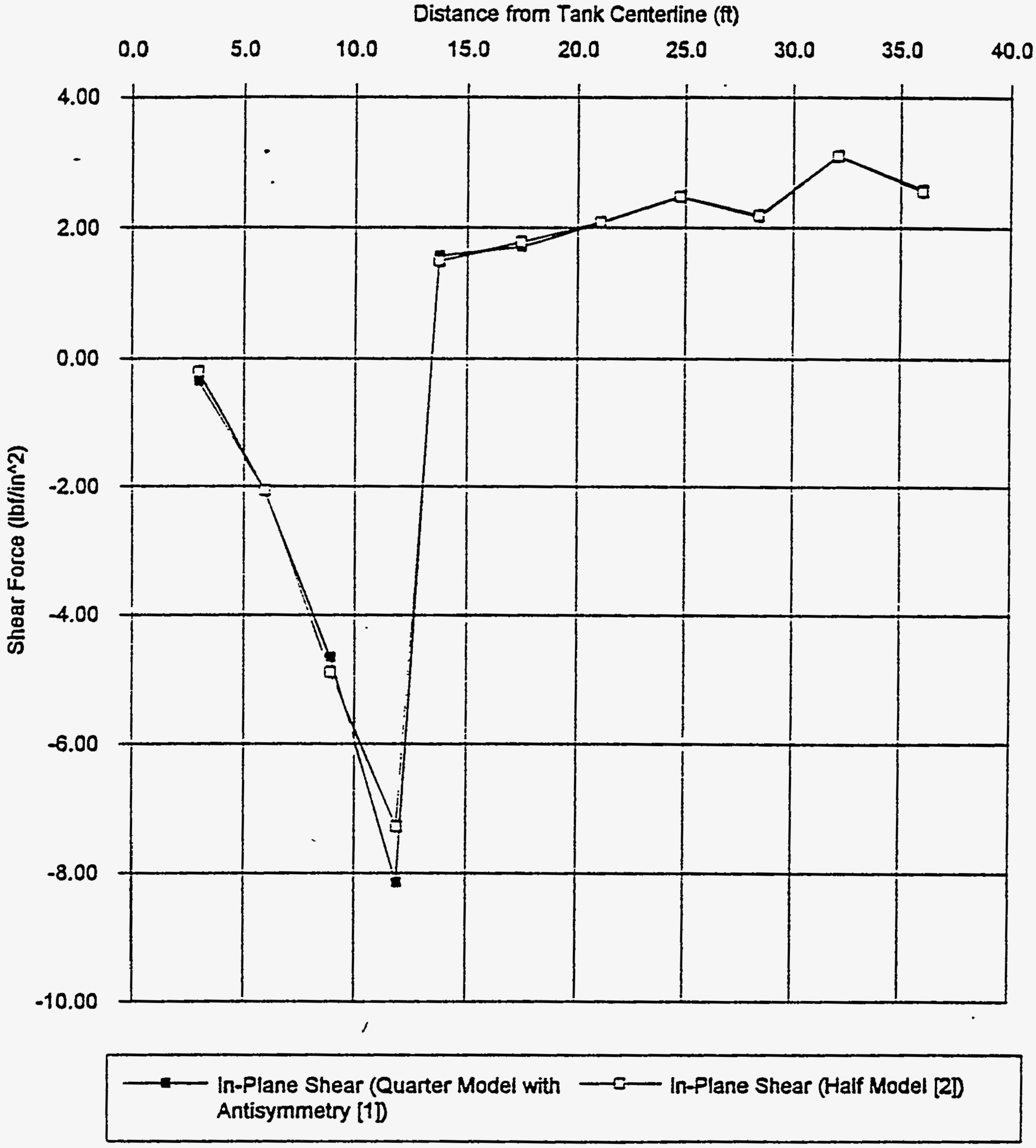


(a) Single Tank



(b) Tank-to-Tank Interaction

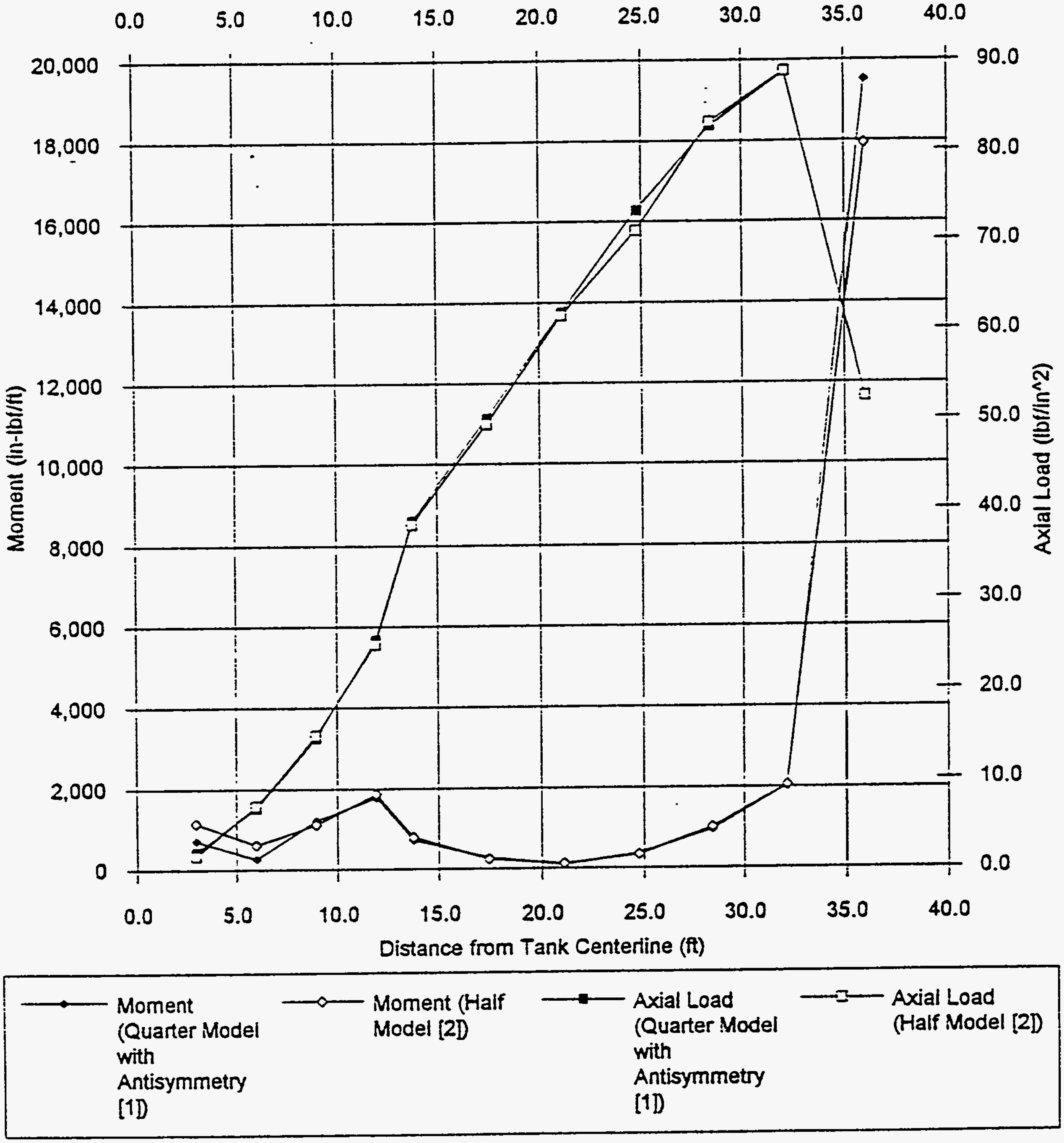
Figure A.1.1-2. Seismic Response (In-Plane Shear) of Tank Base at 180 deg Meridian from Horizontal Excitation: Quarter Model with Antisymmetry Plane vs. Half Model



Note: [1] = Run ID "Q2", [2] = Run ID "9".

q2\C8ASEV.XLC

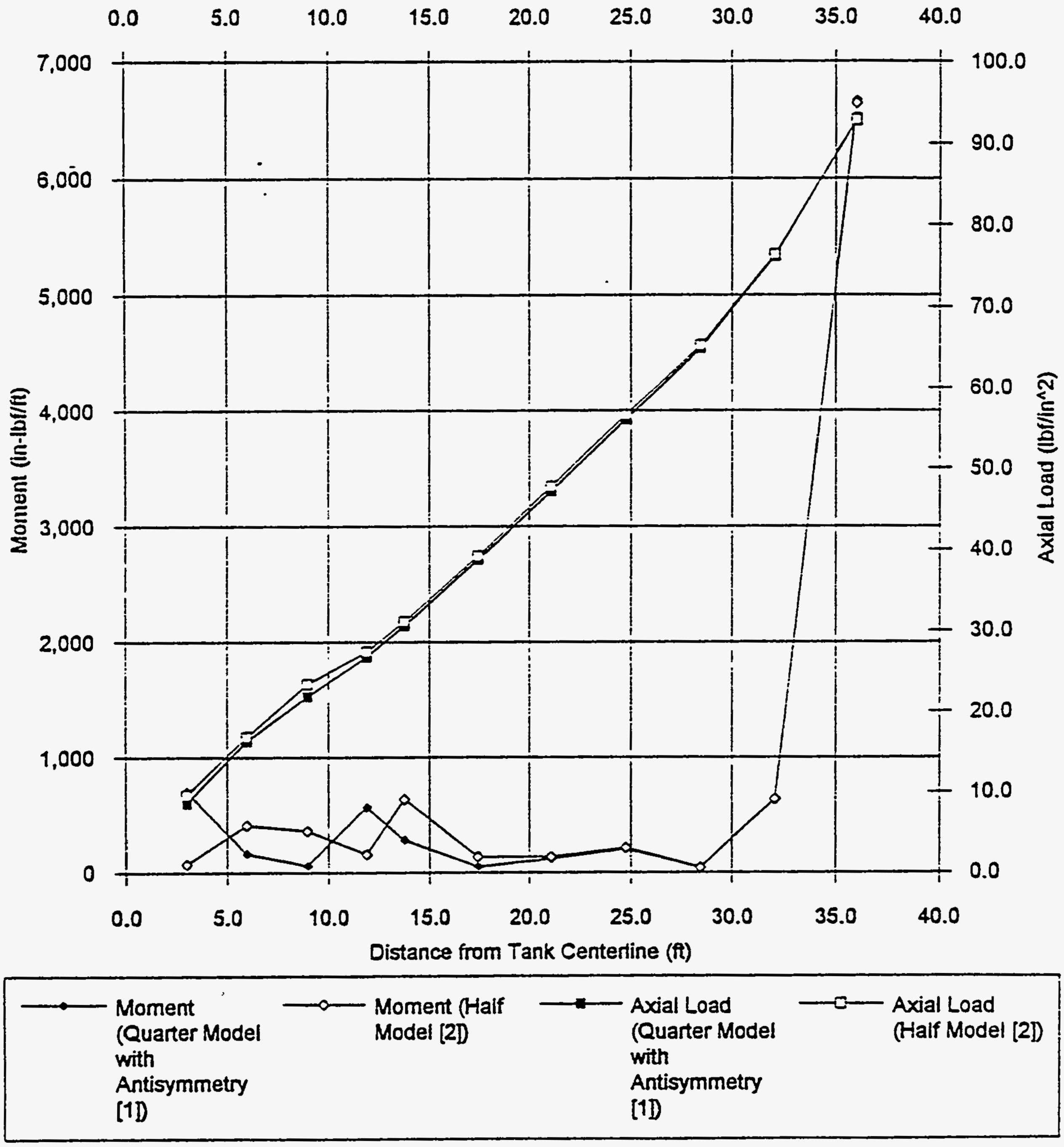
Figure A.1.1-3. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Quarter Model with Antisymmetry Plane vs. Half Model



Note: [1] = Run ID "Q2", [2] = Run ID "9".

q2\CBASEI.XLC

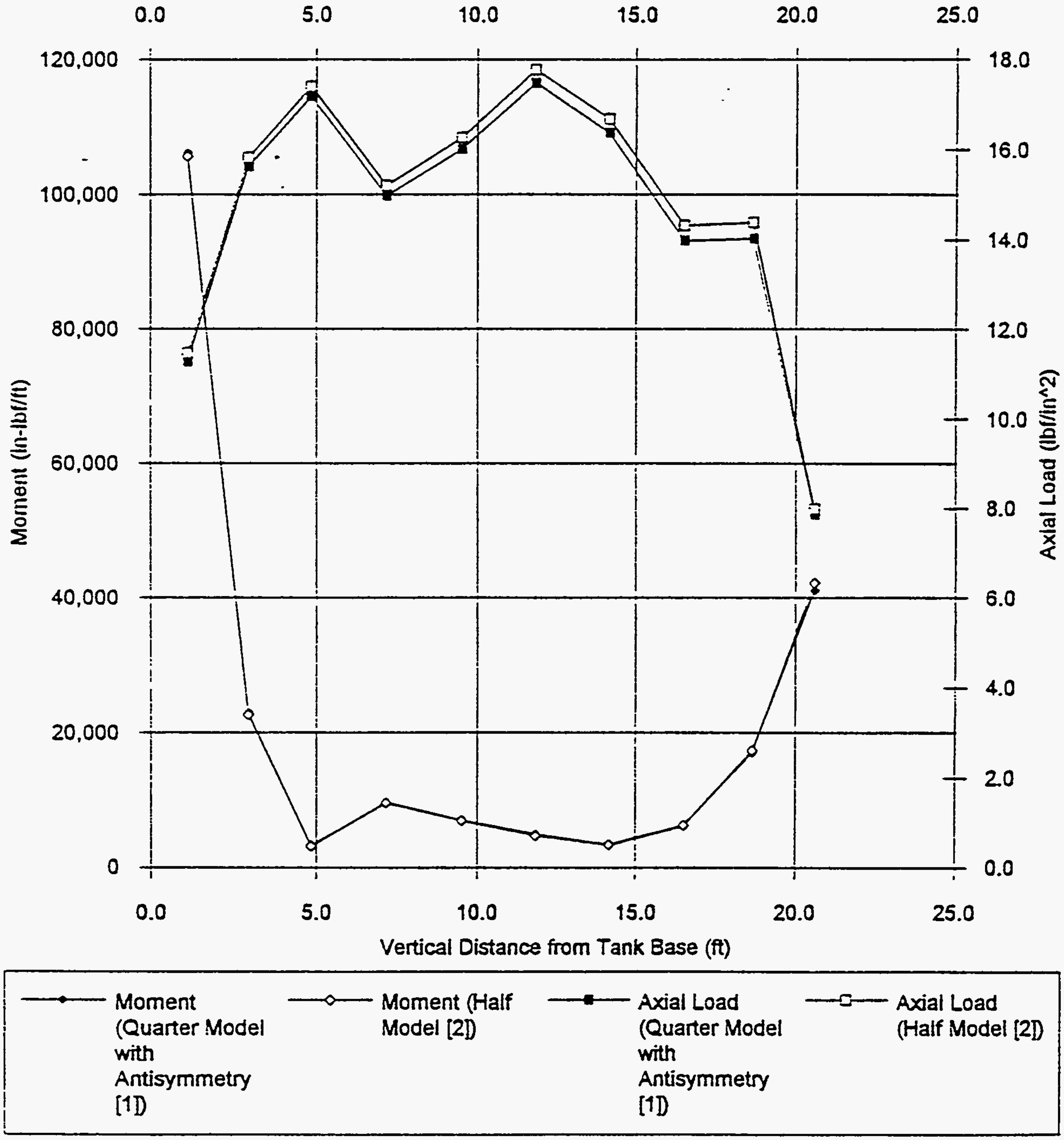
Figure A.1.1-4. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Quarter Model with Antisymmetry Plane vs. Half Model



Note: [1] = Run ID "Q2", [2] = Run ID "9".

q2\C8ASEO.XLC

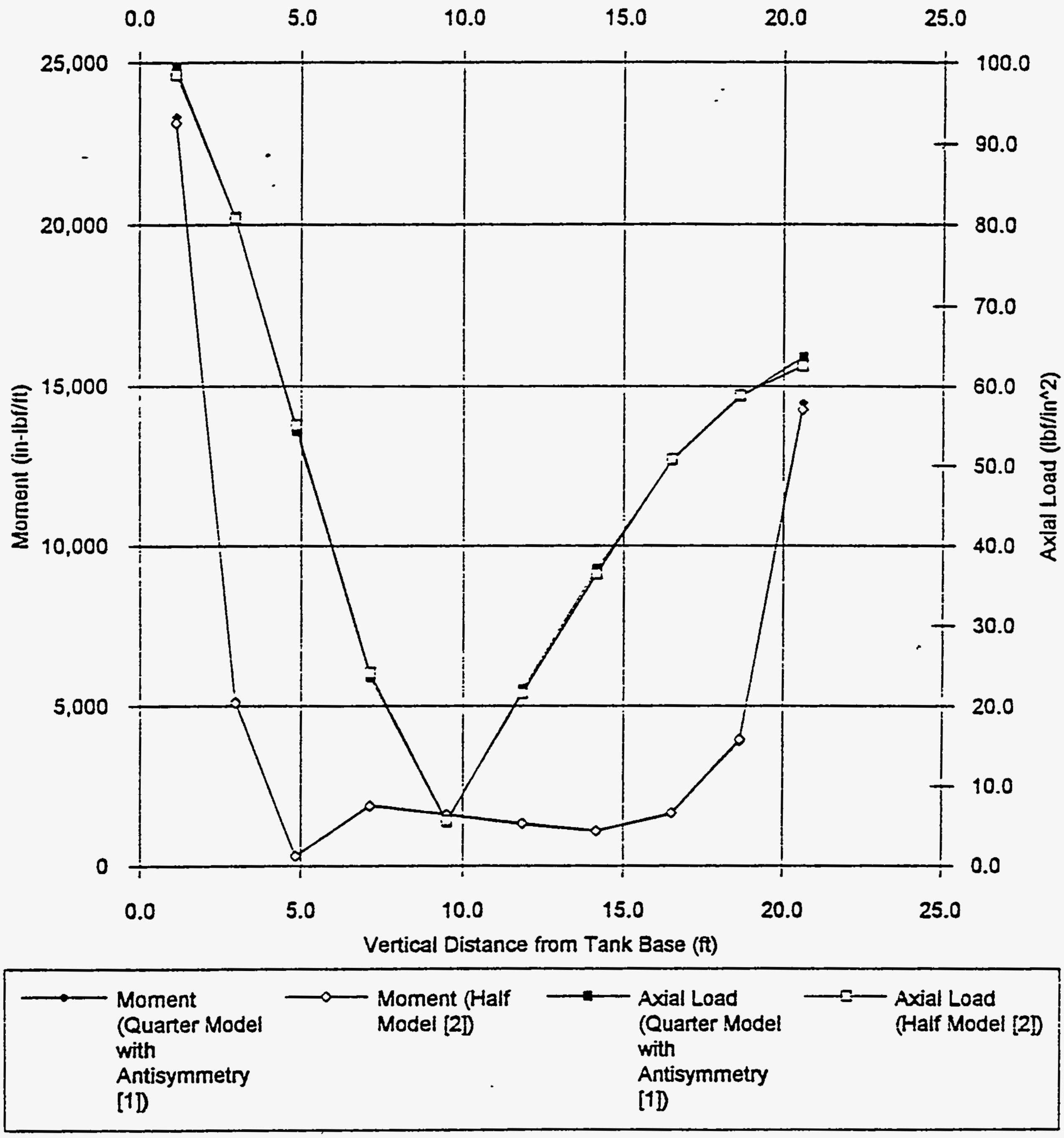
Figure A.1.1-5. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Quarter Model with Antisymmetry Plane vs. Half Model



Note: [1] = Run ID "Q2", [2] = Run ID "9".

q2\CWALLI.XLC

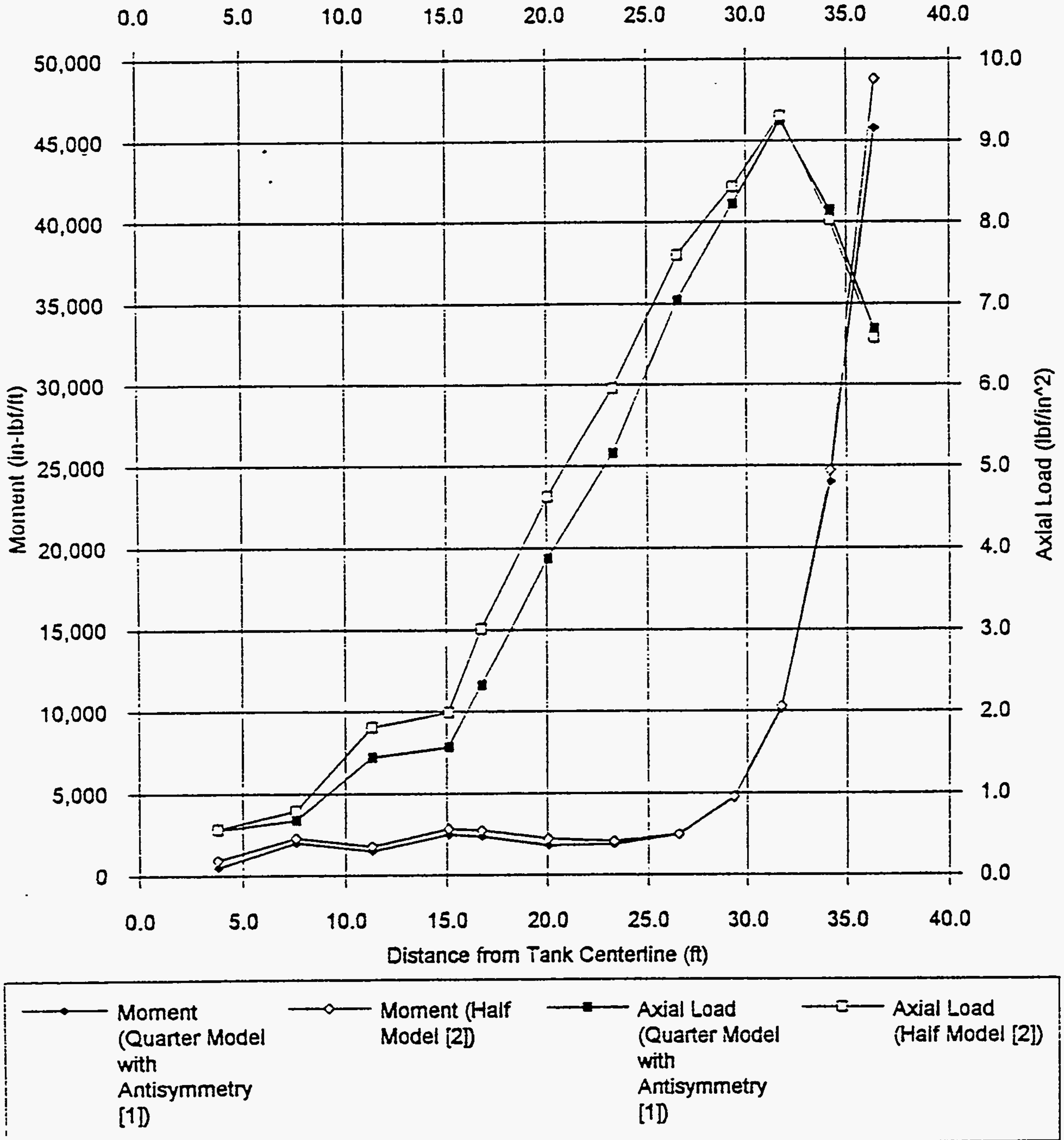
Figure A.1.1-6. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Quarter Model.with Antisymmetry Plane vs. Half Model



Note: [1] = Run ID "Q2", [2] = Run ID "9".

q2\CWALLO.XLC

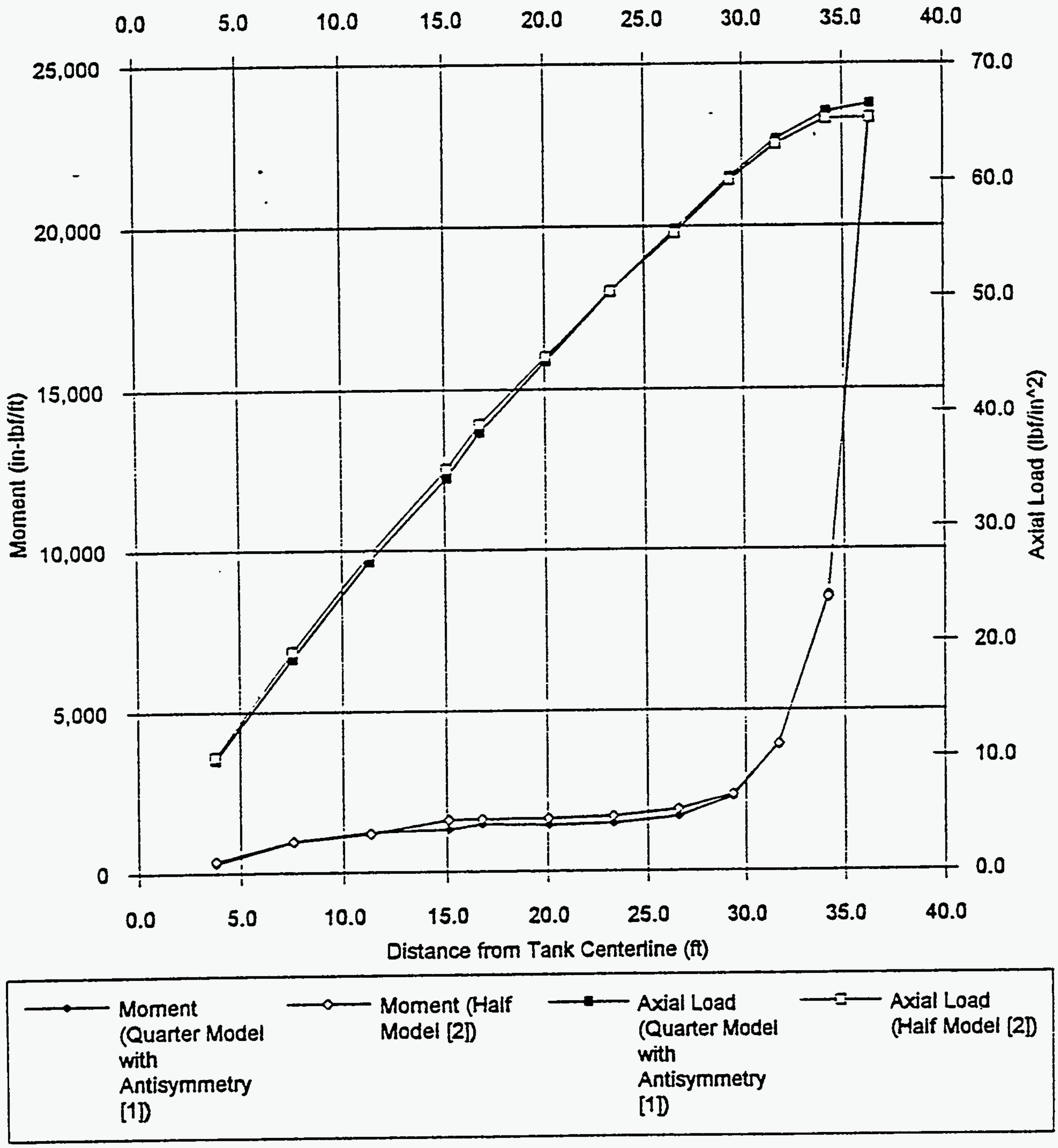
Figure A.1.1-7. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Quarter Model with Antisymmetry Plane vs. Half Model



Note: [1] = Run ID "Q2", [2] = Run ID "9".

q2\CDOMEI.XLC

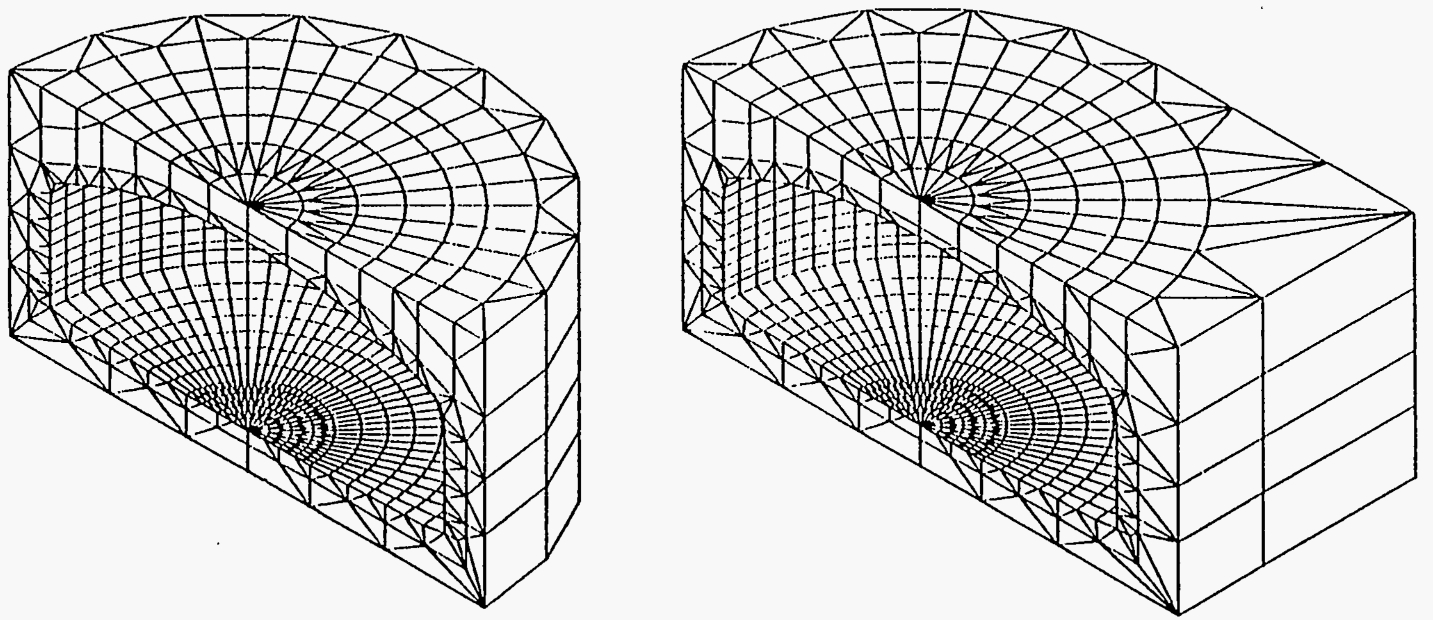
Figure A.1.1-8. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Quarter Model with Antisymmetry Plane vs. Half Model



Note: [1] = Run ID "Q2", [2] = Run ID "9".

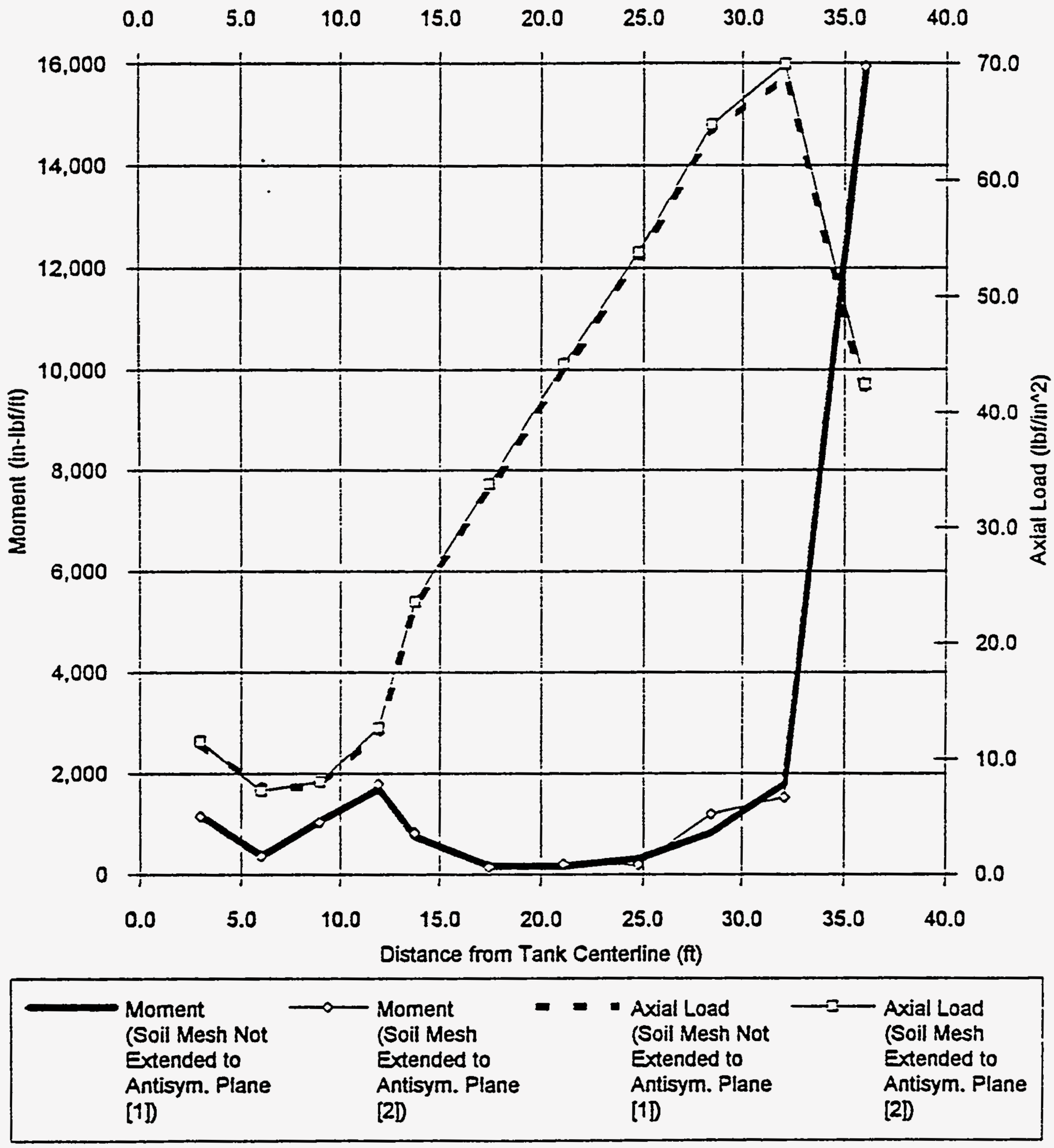
q2\CDOMEO.XLC

Figure A.1.2-1
Tank-to-Tank Interaction using Antisymmetry



(a) Coarse Half Model **(b) Coarse Half Model with Extended Soil Mesh**

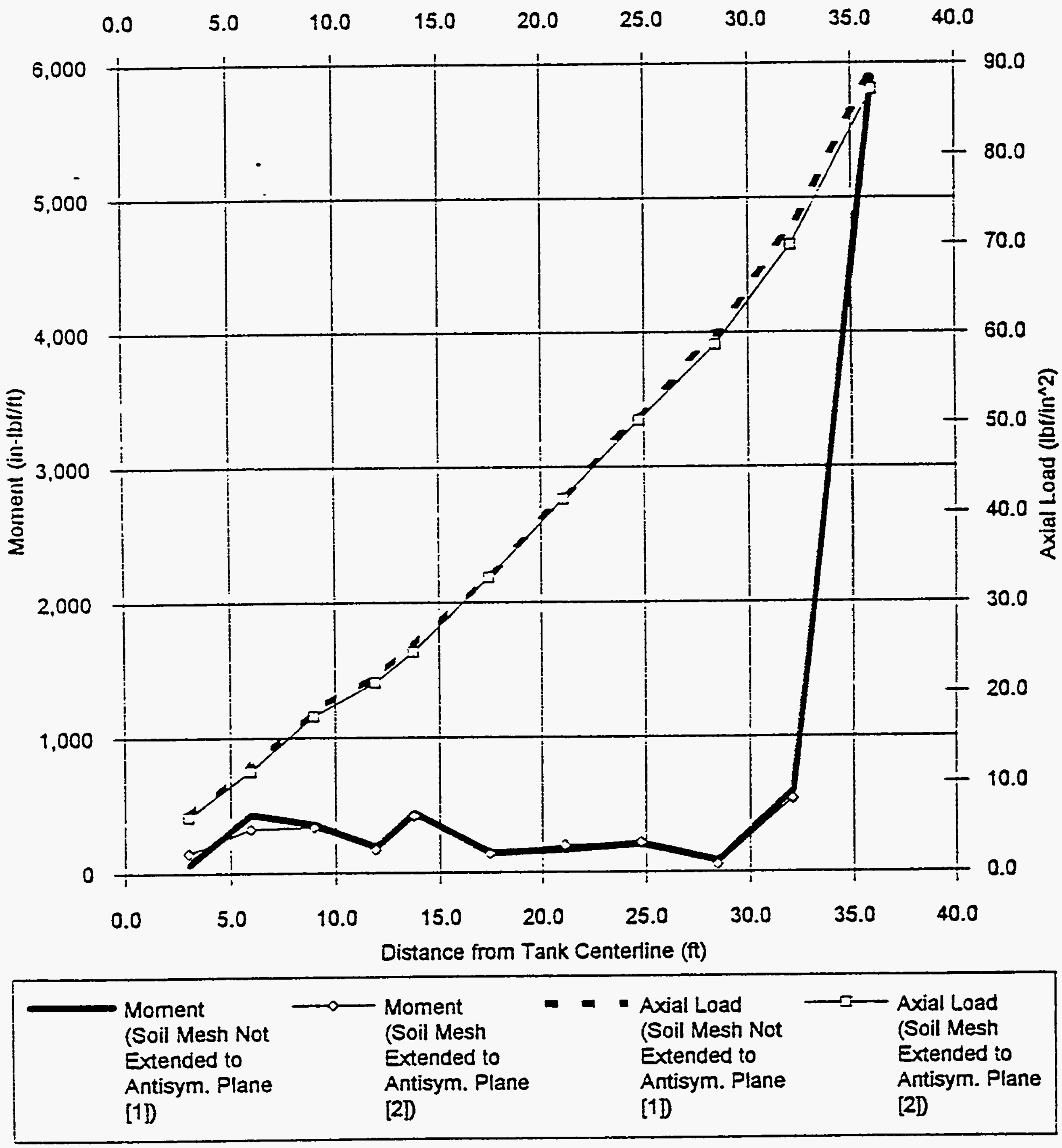
Figure A.1.2-2. Meridional Seismic Response of Tank Base at 0 deg Meridian from Horizontal Excitation: Effect of Extending Soil Mesh to Antisymmetry Plane



Note: [1] = Run ID "9a", [2] = Run ID "9b".

9b\C8ASEI.XLC

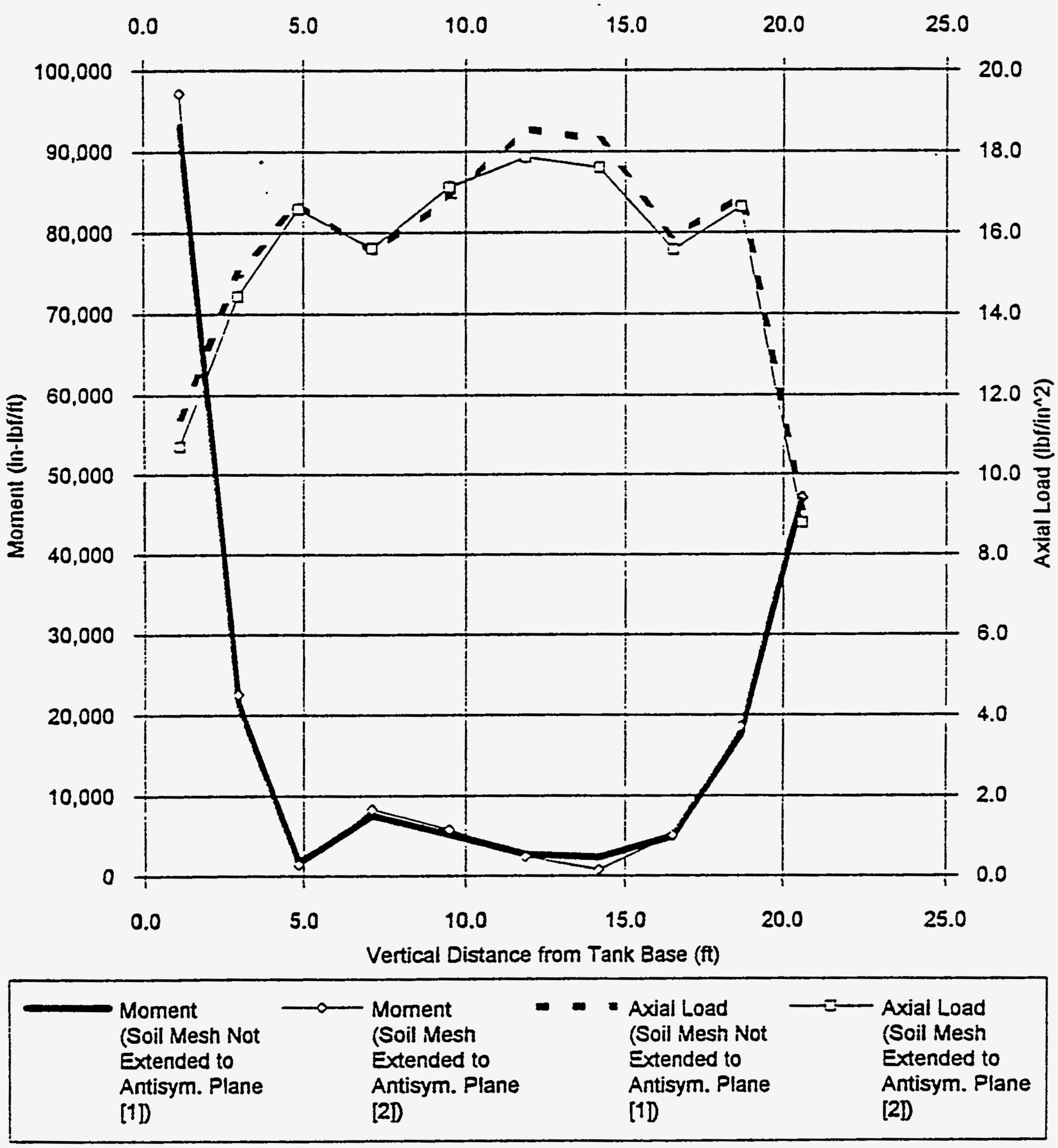
Figure A.1.2-3. Circumferential Seismic Response of Tank Base at 0 deg Meridian from Horizontal Excitation: Effect of Extending Soil Mesh to Antisymmetry Plane



Note: [1] = Run ID "9a", [2] = Run ID "9b".

9b\CBASEO.XLC

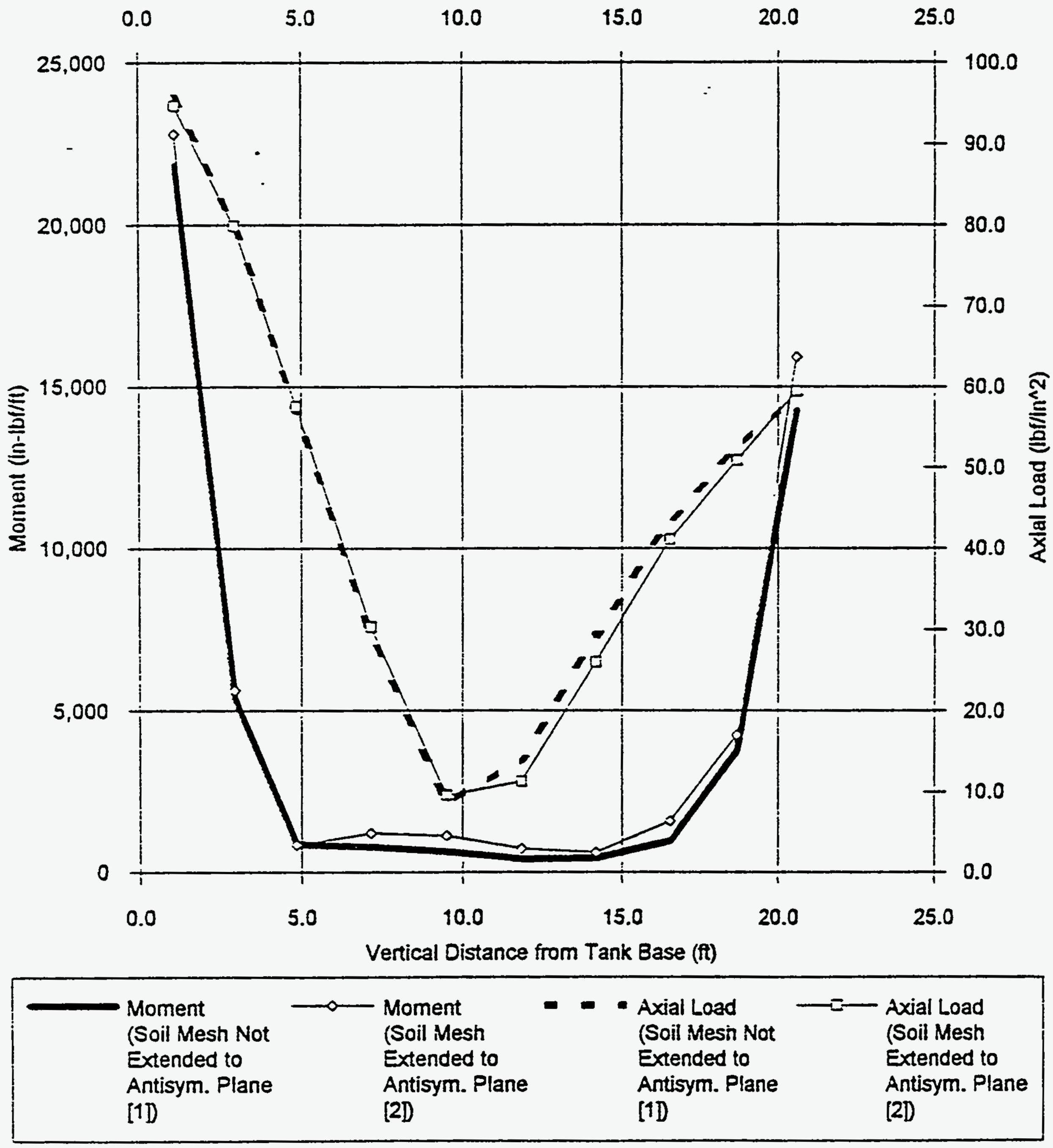
Figure A.1.2-4. Meridional Seismic Response of Tank Wall at 0 deg Meridian from Horizontal Excitation: Effect of Extending Soil Mesh to Antisymmetry Plane



Note: [1] = Run ID "9a", [2] = Run ID "9b".

9b\CWALLI.XLC

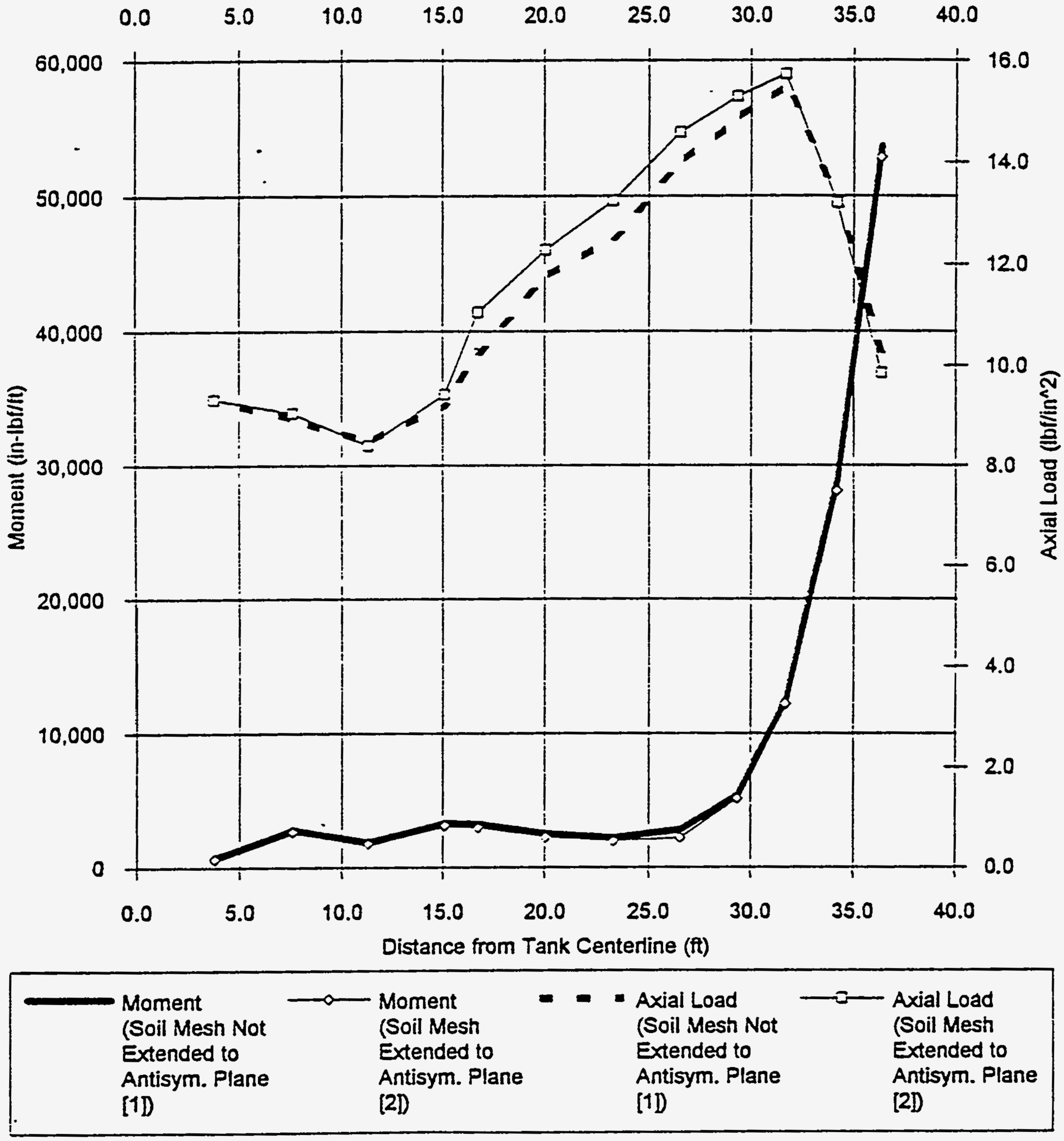
Figure A.1.2-5. Circumferential Seismic Response of Tank Wall at 0 deg Meridian from Horizontal Excitation: Effect of Extending Soil Mesh to Antisymmetry Plane



Note: [1] = Run ID "9a", [2] = Run ID "9b".

9b\CWALLO.XLC

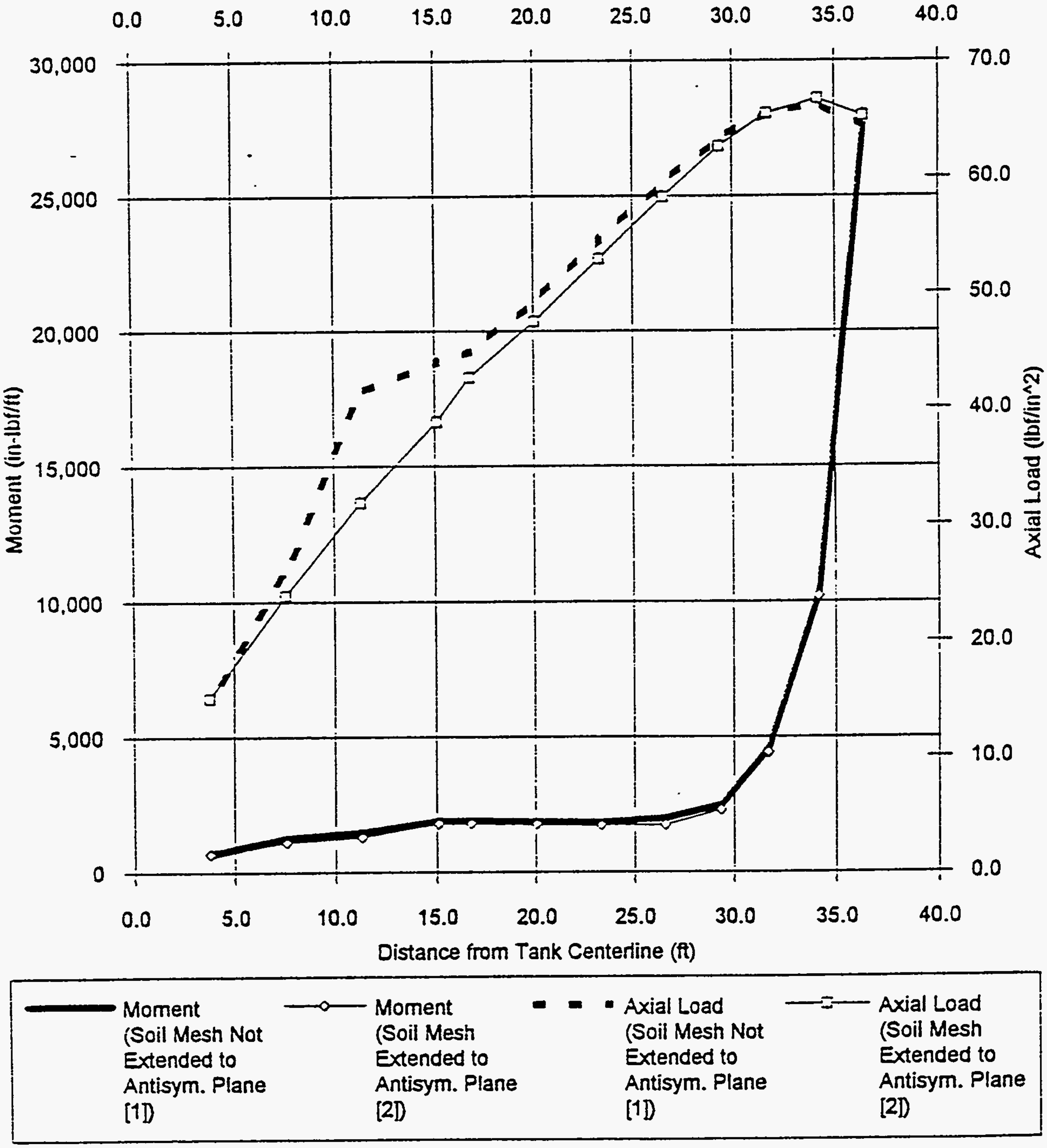
Figure A.1.2-6. Meridional Seismic Response of Tank Dome at 0 deg Meridian from Horizontal Excitation: Effect of Extending Soil Mesh to Antisymmetry Plane



Note: [1] = Run ID "9a", [2] = Run ID "9b".

9b\CDOMEI.XLC

Figure A.1.2-7. Circumferential Seismic Response of Tank Dome at 0 deg Meridian from Horizontal Excitation: Effect of Extending Soil Mesh to Antisymmetry Plane



Note: [1] = Run ID "9a", [2] = Run ID "9b".

9b\CDOMEO.XLC

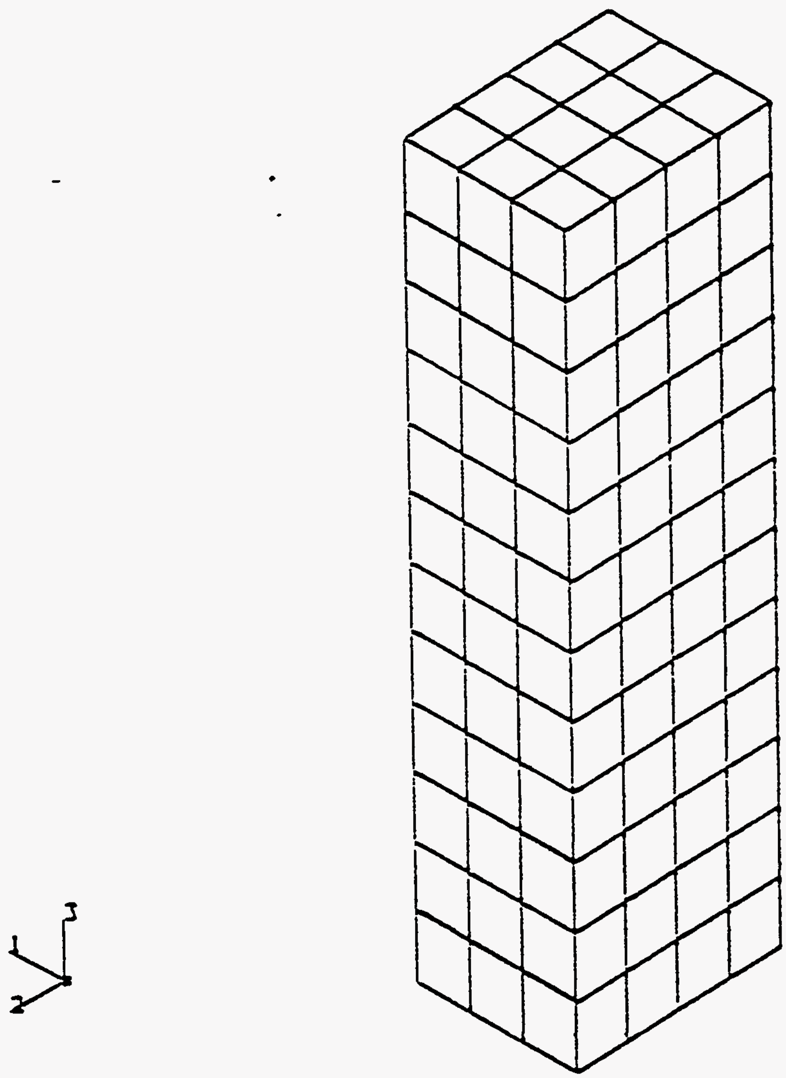


Figure A.2.1-1
Baseline Cantilever Test Model B2a

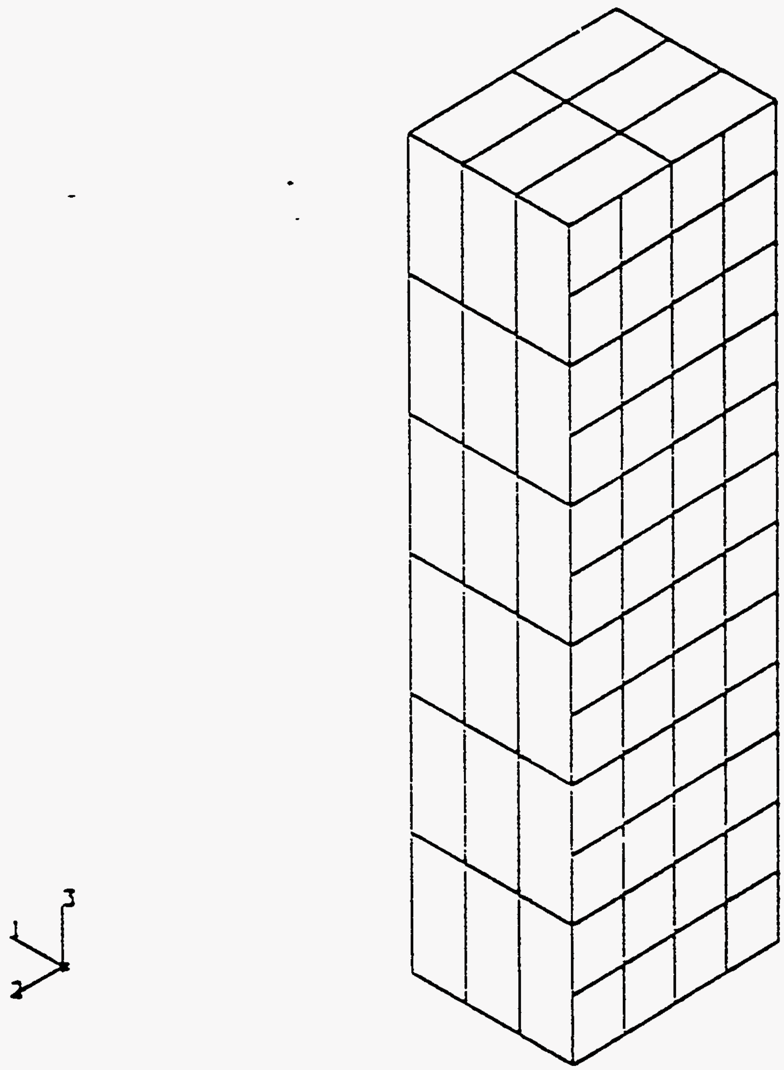


Figure A.2.1-2
Cantilever Test Model DK (Skipped Nodes)

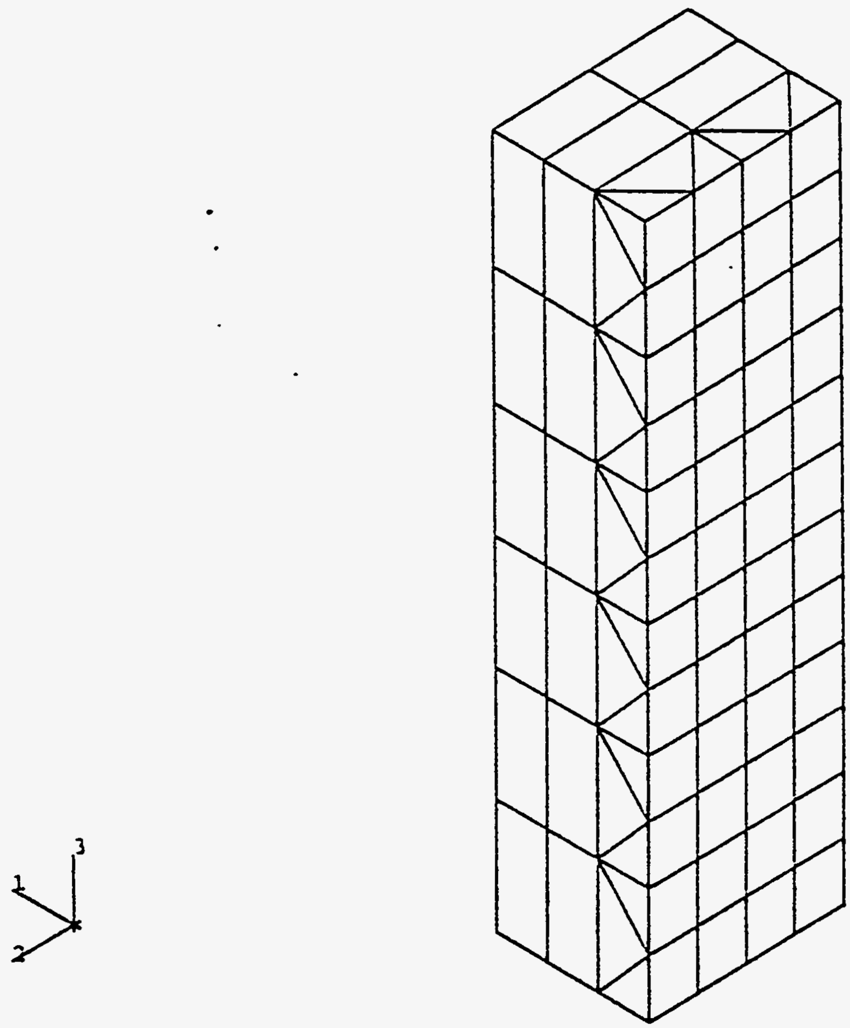
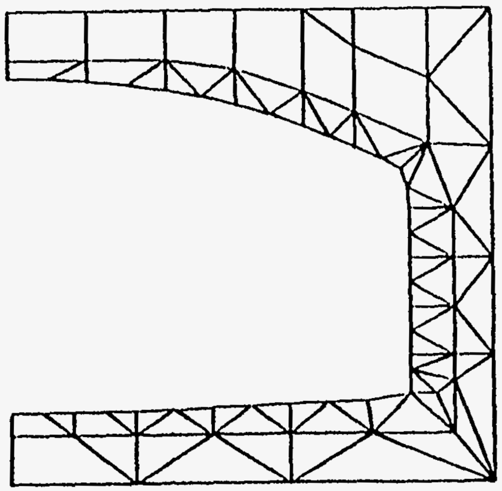
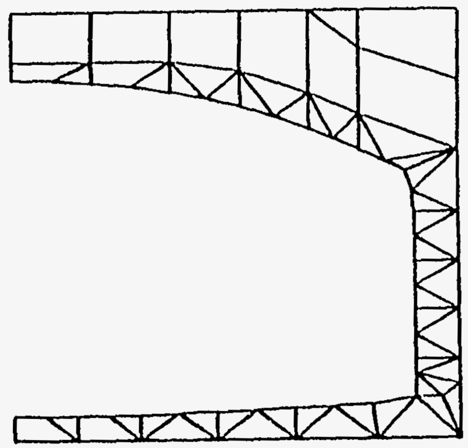


Figure A.2.1-3
Cantilever Test Model CM (Distorted Elements)

Figure A.2.2-1
2-D Slices of 3-D Quarter Models

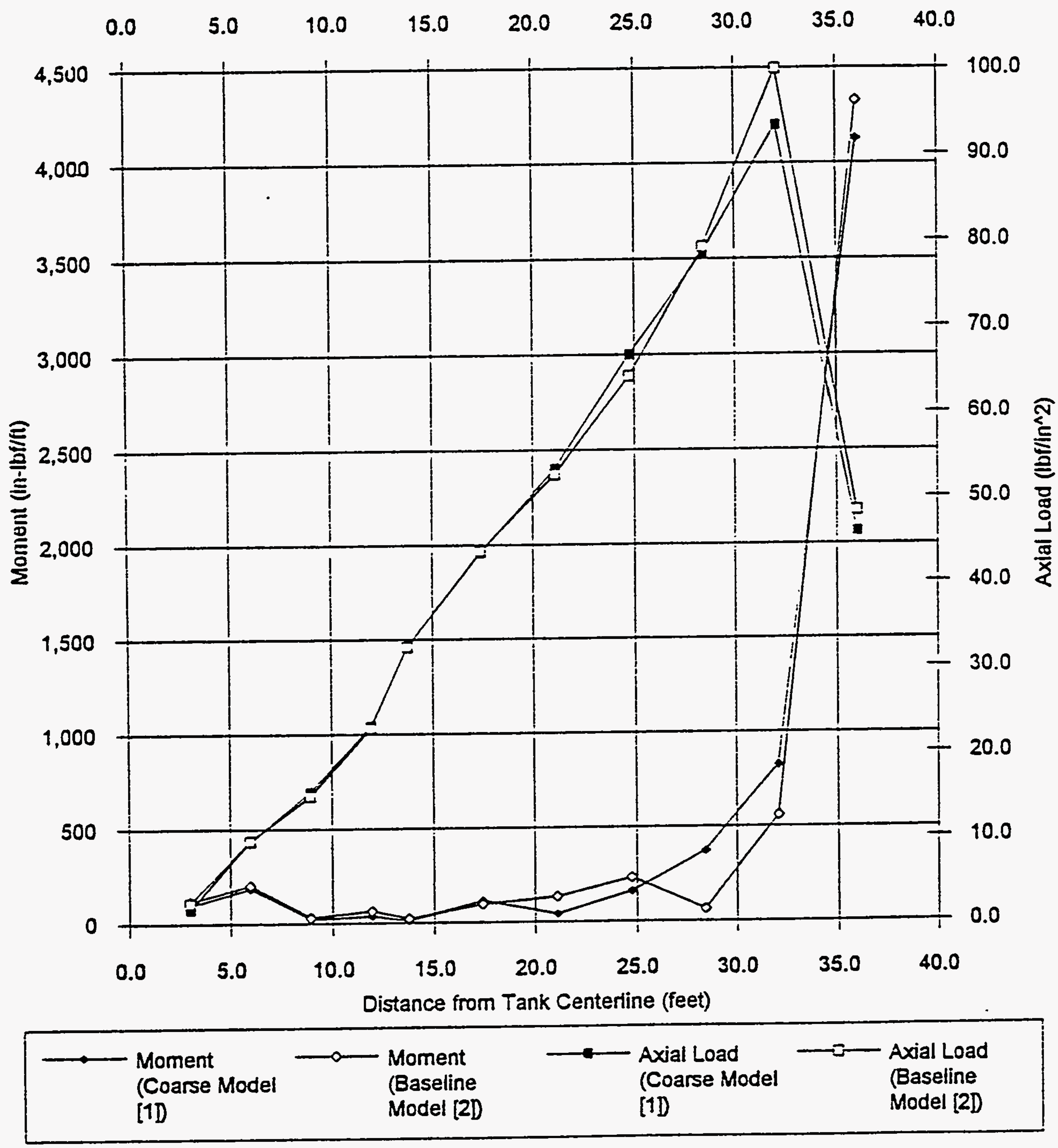


(a) Coarse Model
(95 Interaction Nodes)



(b) Baseline Model
(558 Interaction Nodes)

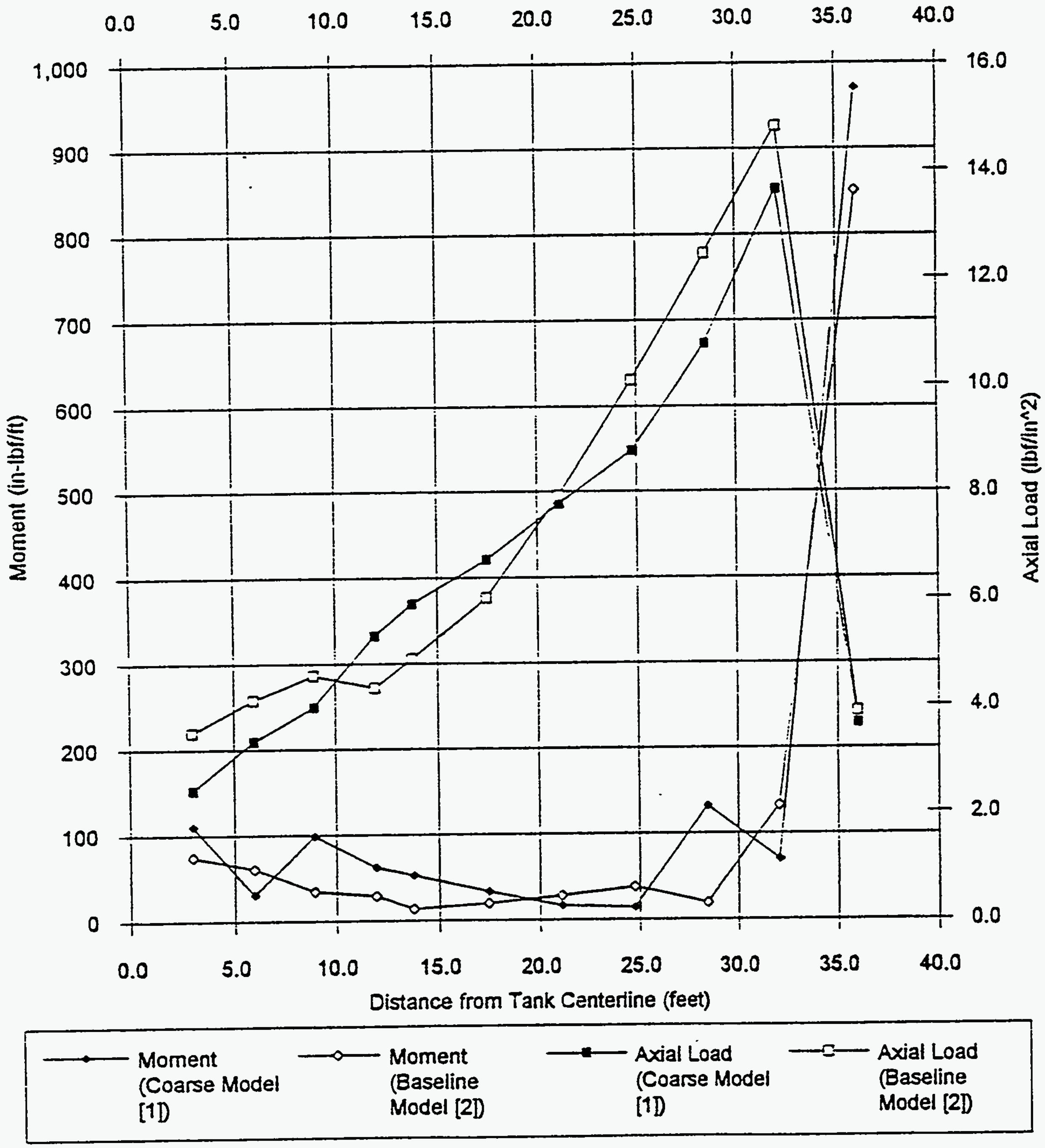
Figure A.2.2-2. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Effect of Interaction Node Spacing



Note: [1] = Run ID "Q8", [2] = Run ID "Q7pnt4".

q7\anl\C3BASEI.XLC

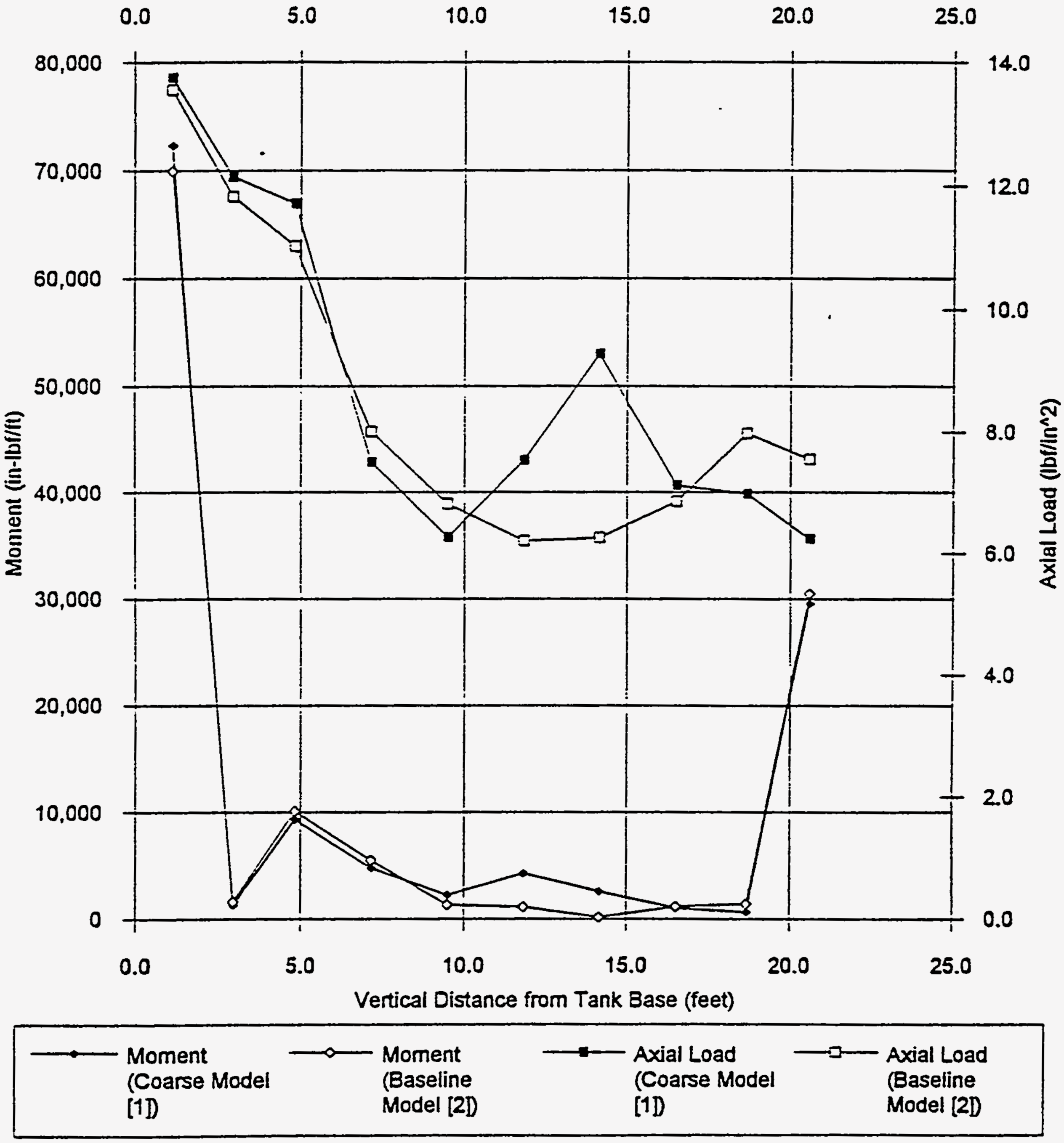
Figure A.2.2-3. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Effect of Interaction Node Spacing



Note: [1] = Run ID "Q8", [2] = Run ID "Q7pnt4".

q7\anl\C3BASEO.XLC

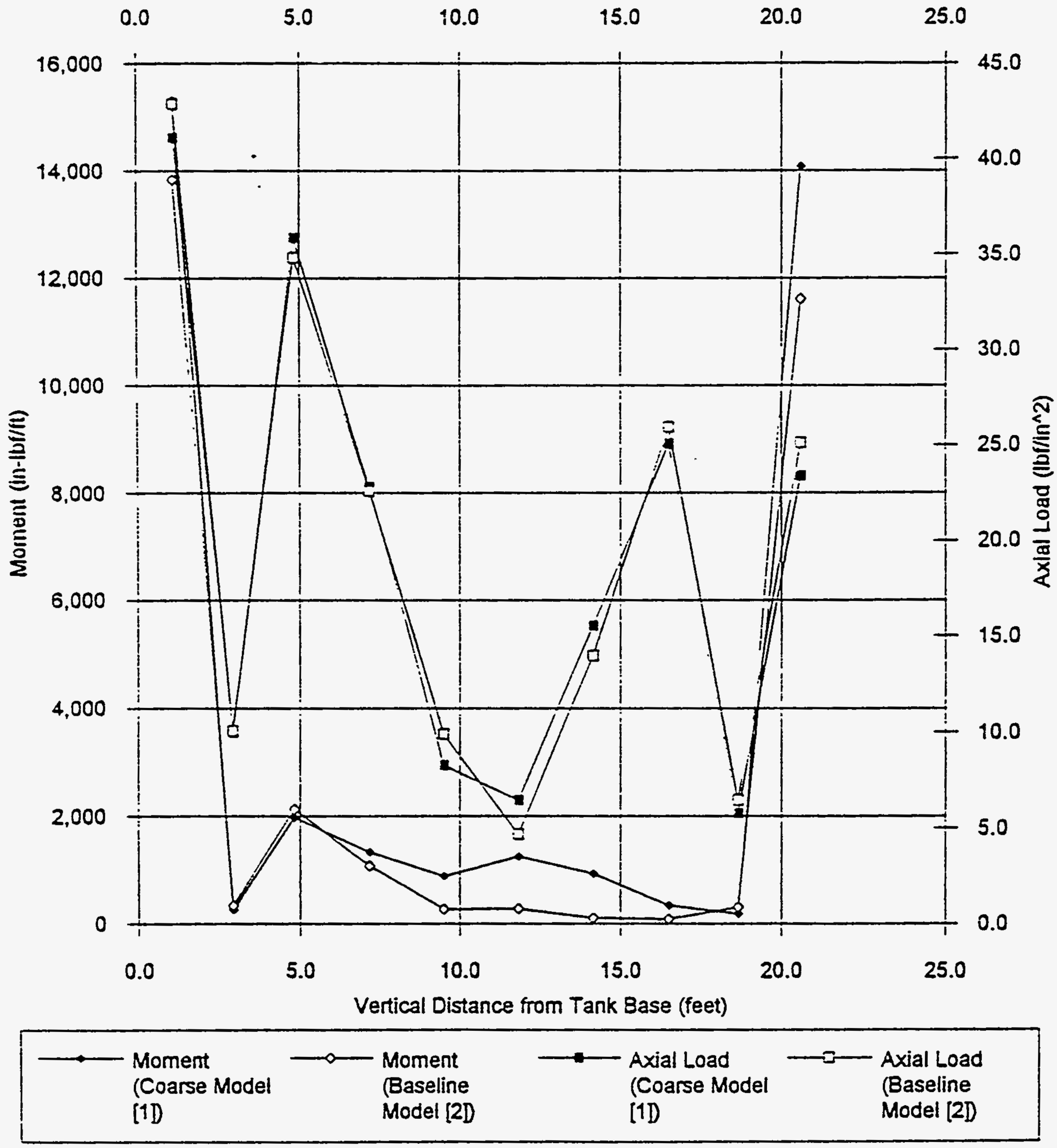
Figure A.2.2-4. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Effect of Interaction Node Spacing



Note: [1] = Run ID "Q8", [2] = Run ID "Q7pnt4".

q7\anl\C3WALLI.XLC

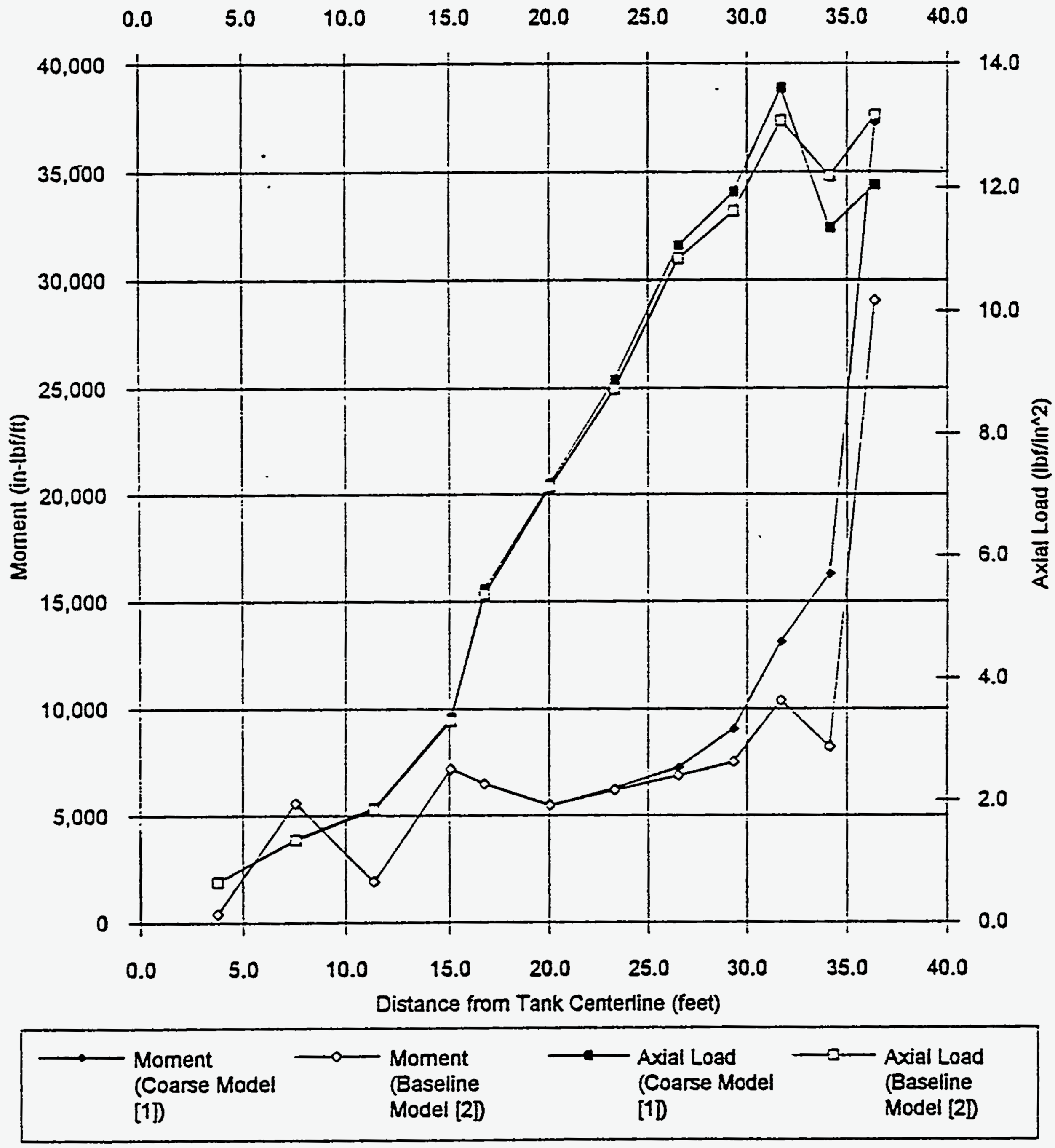
Figure A.2.2-5. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Effect of Interaction Node Spacing



Note: [1] = Run ID "Q8", [2] = Run ID "Q7pnt4".

q7\lanl\C3WALLO.XLC

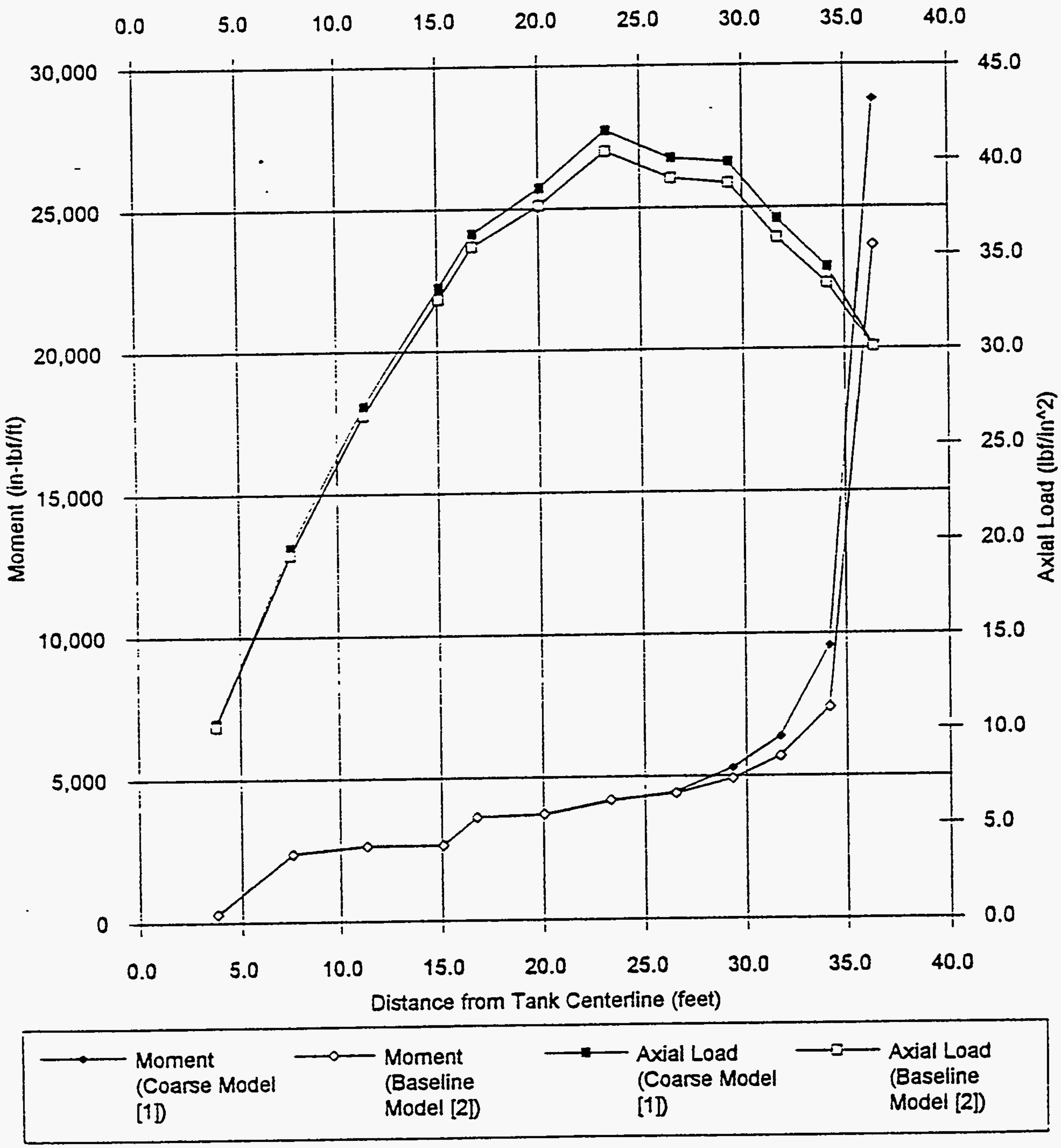
Figure A.2.2-6. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Effect of Interaction Node Spacing



Note: [1] = Run ID "Q8", [2] = Run ID "Q7pnt4".

q7\anl\C3DOMEI.XLC

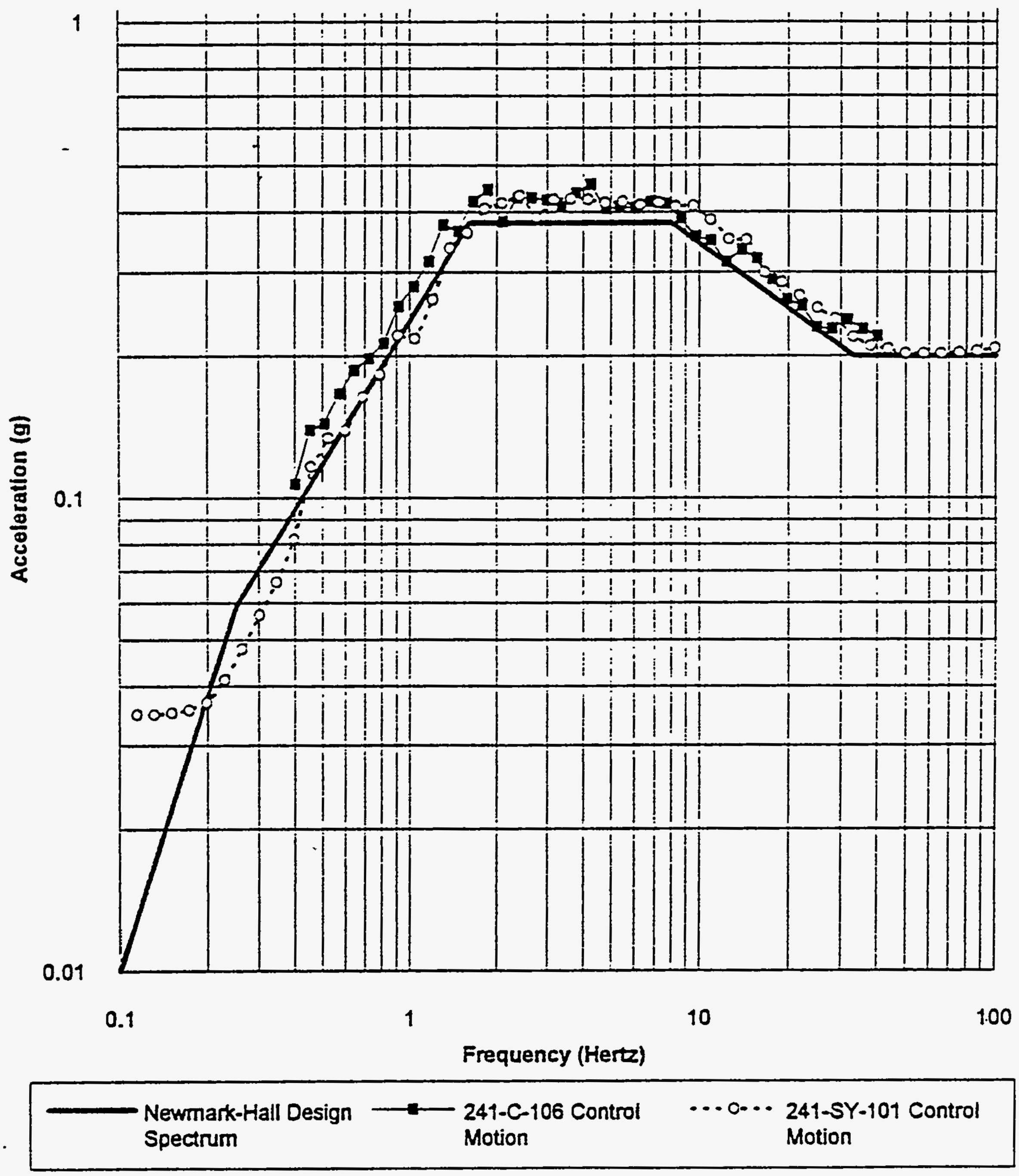
Figure A.2.2-7. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Effect of Interaction Node Spacing



Note: [1] = Run ID "Q8", [2] = Run ID "Q7pnt4".

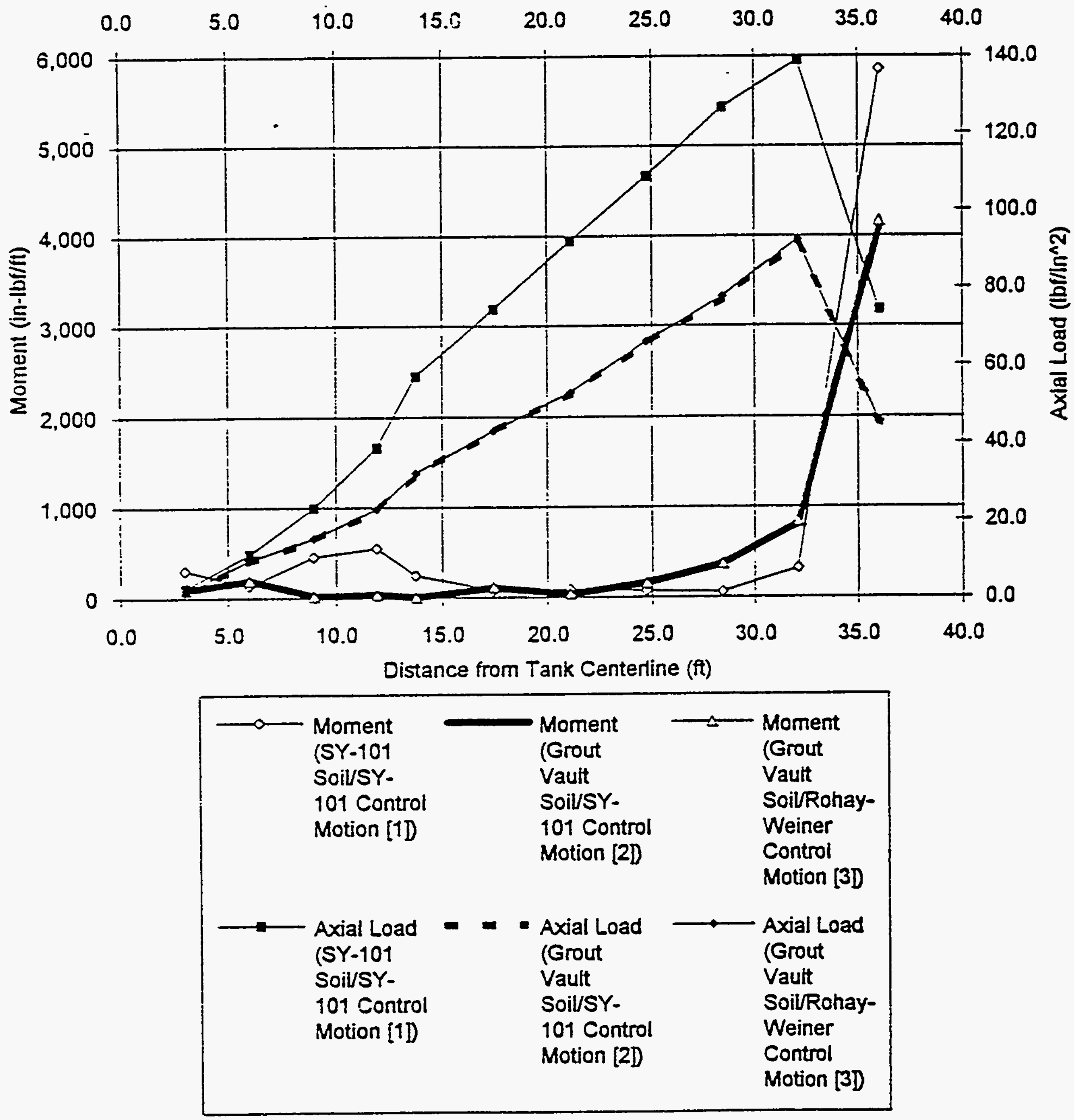
q7\ani\C3DOMEO.XLC

Figure A.3.1-1
Comparison of Horizontal Response Spectra (0.2 g Earthquake/7% Damping)



q7v\lanl\RESSY101.XLC

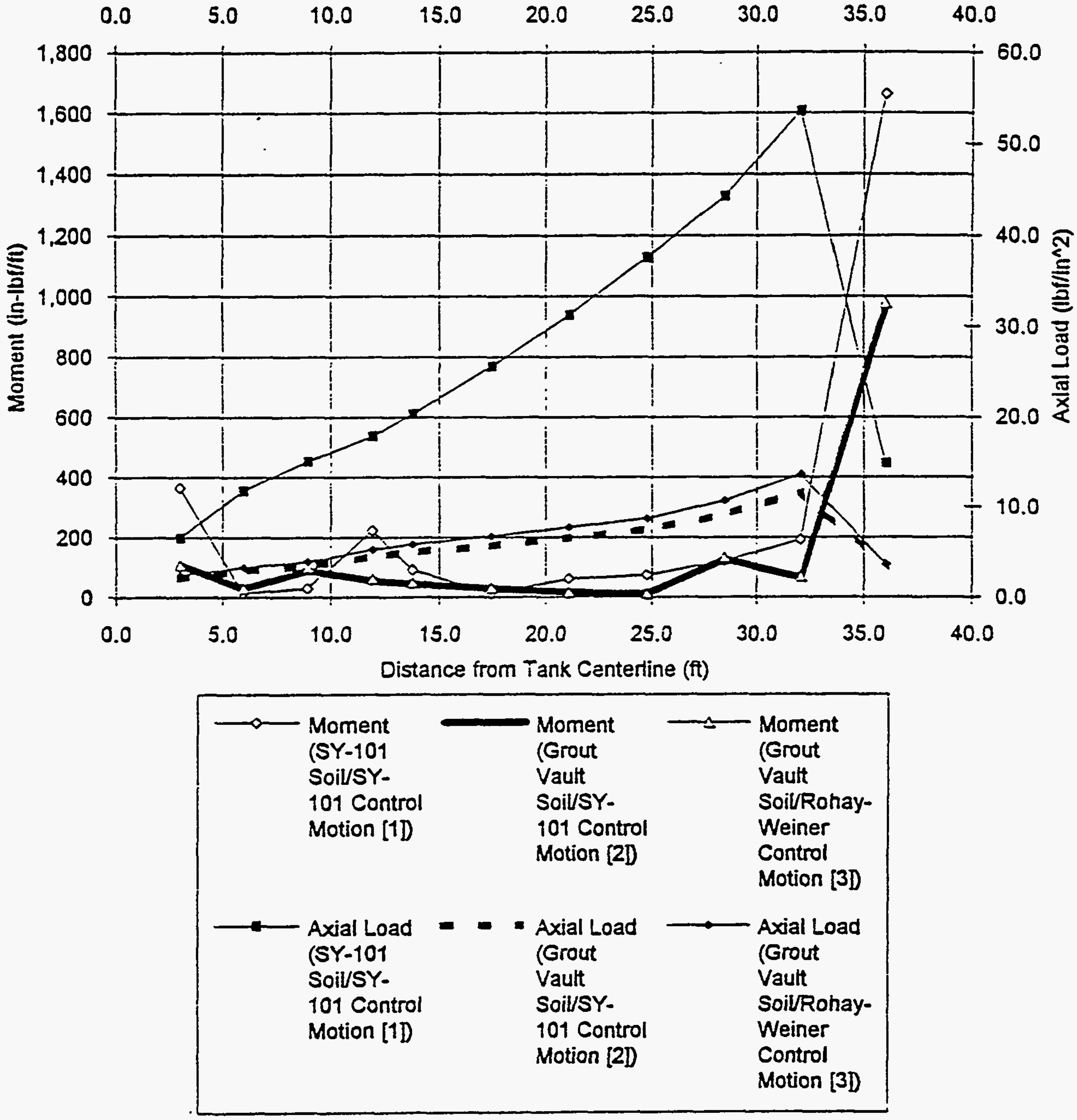
Figure A.3.1-2. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Change in Control Motion and Site Soil Profile



Note: [1] = Run ID "Q5", [2] = Run ID "Q5.5",[3] = Run ID "Q6".

q6\CBASEI.XLC

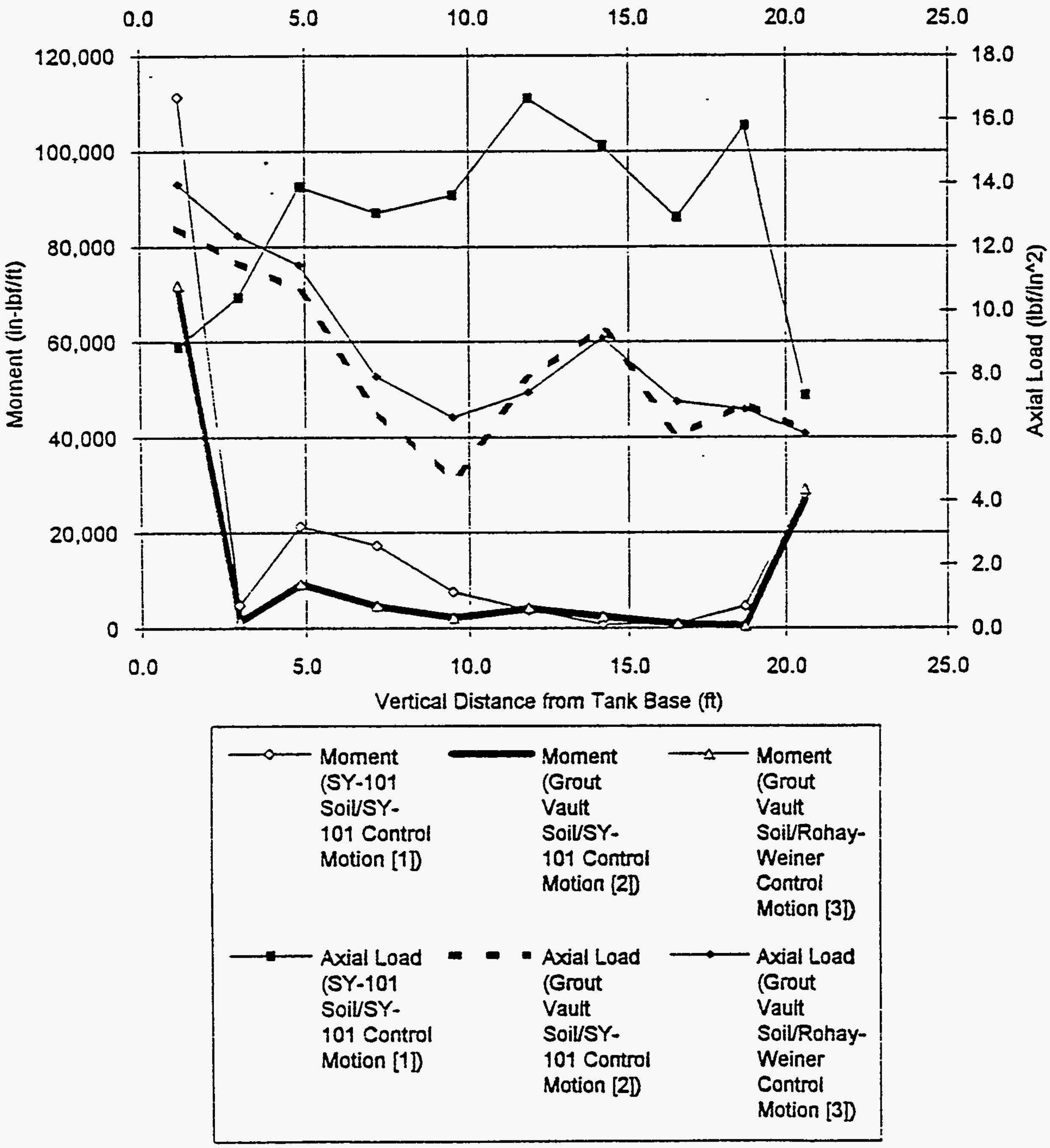
Figure A.3.1-3. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Change in Control Motion and Site Soil Profile



Note: [1] = Run ID "Q5", [2] = Run ID "Q5.5",[3] = Run ID "Q6".

q6\CBASEO.XLC

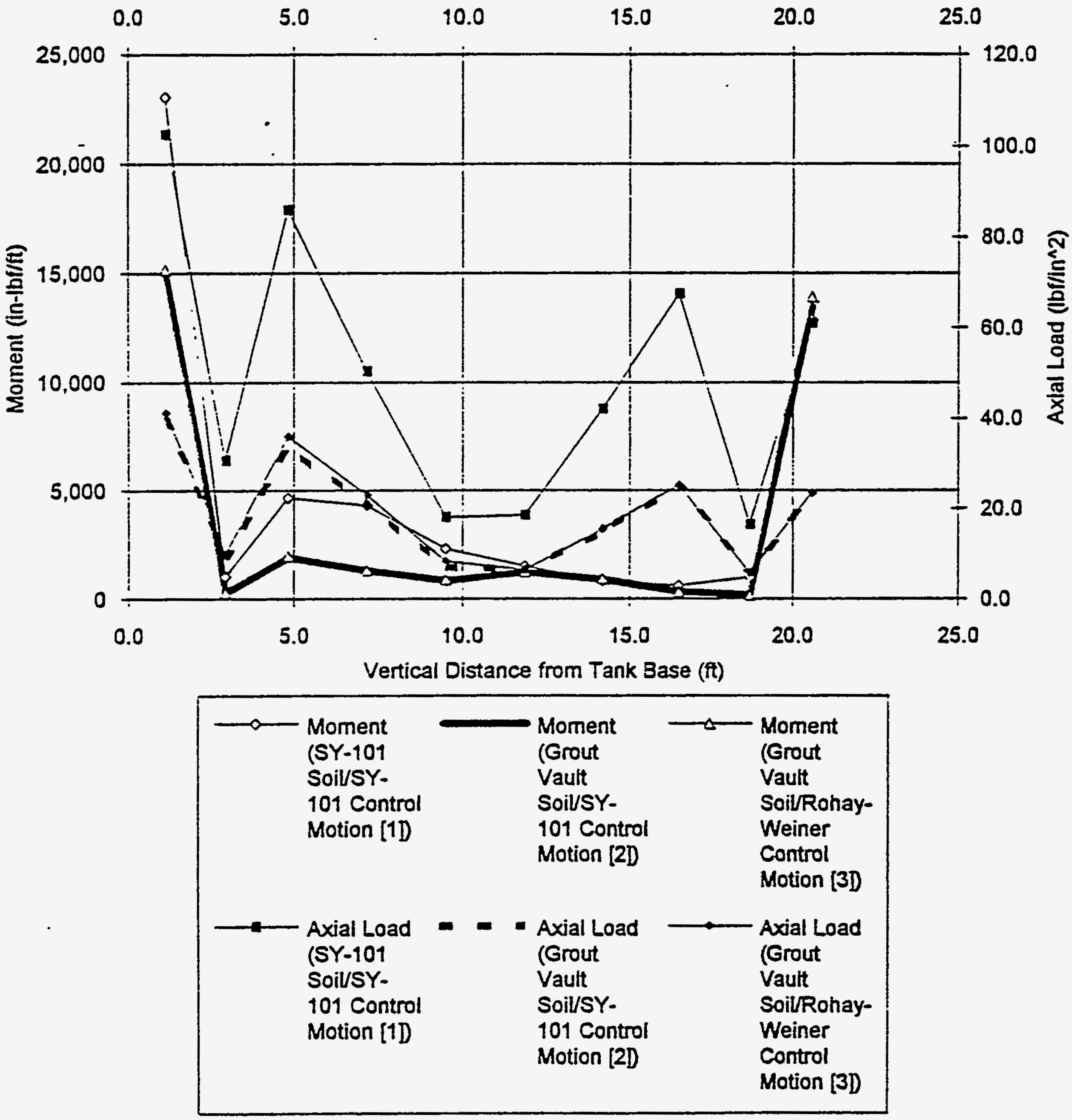
Figure A.3.1-4. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Change in Control Motion and Site Soil Profile



Note: [1] = Run ID "Q5", [2] = Run ID "Q5.5", [3] = Run ID "Q6".

q6\CWALLI.XLC

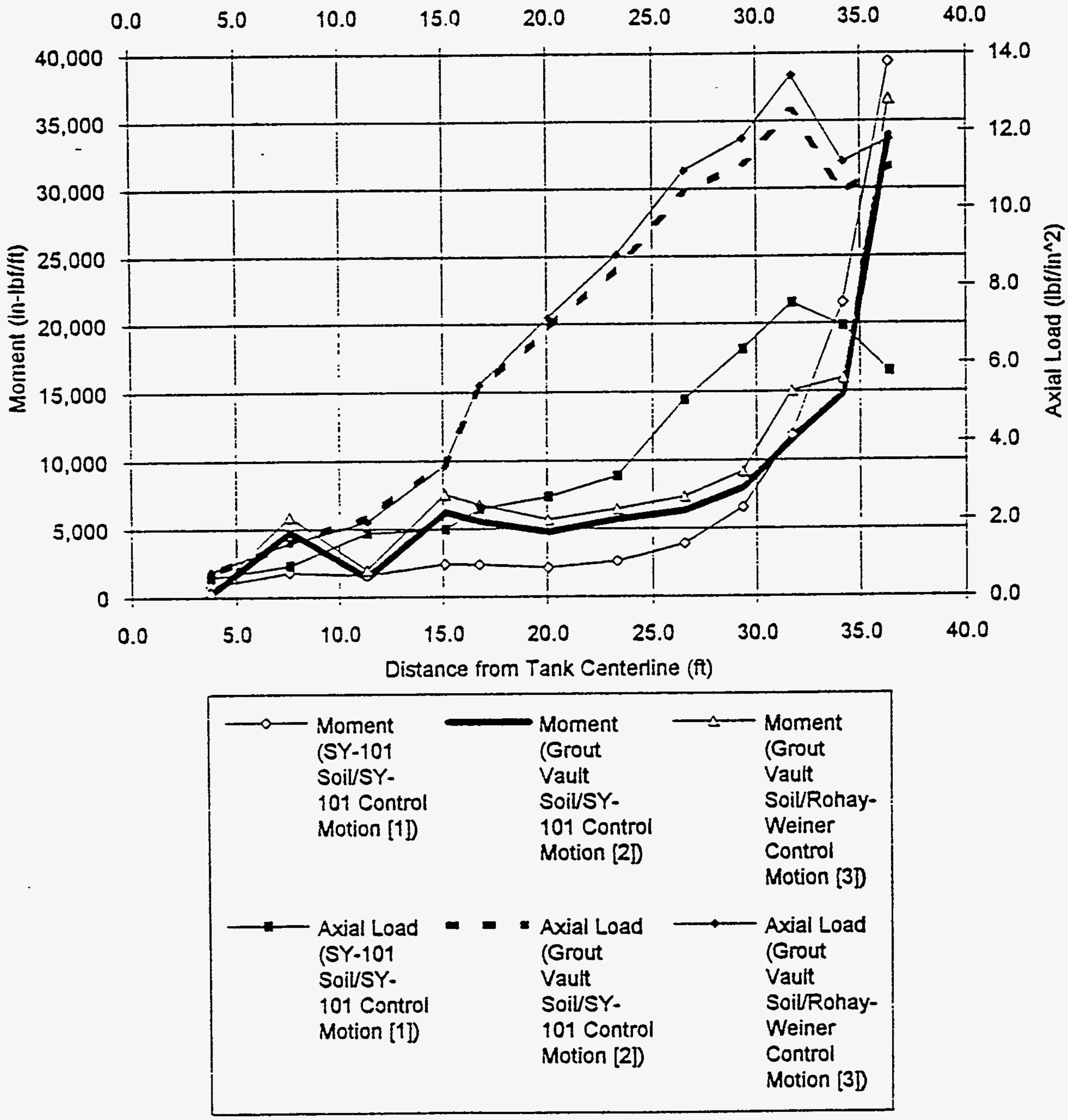
Figure A.3.1-5. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Change in Control Motion and Site Soil Profile



Note: [1] = Run ID "Q5", [2] = Run ID "Q5.5", [3] = Run ID "Q6".

q6\CWALLO.XLC

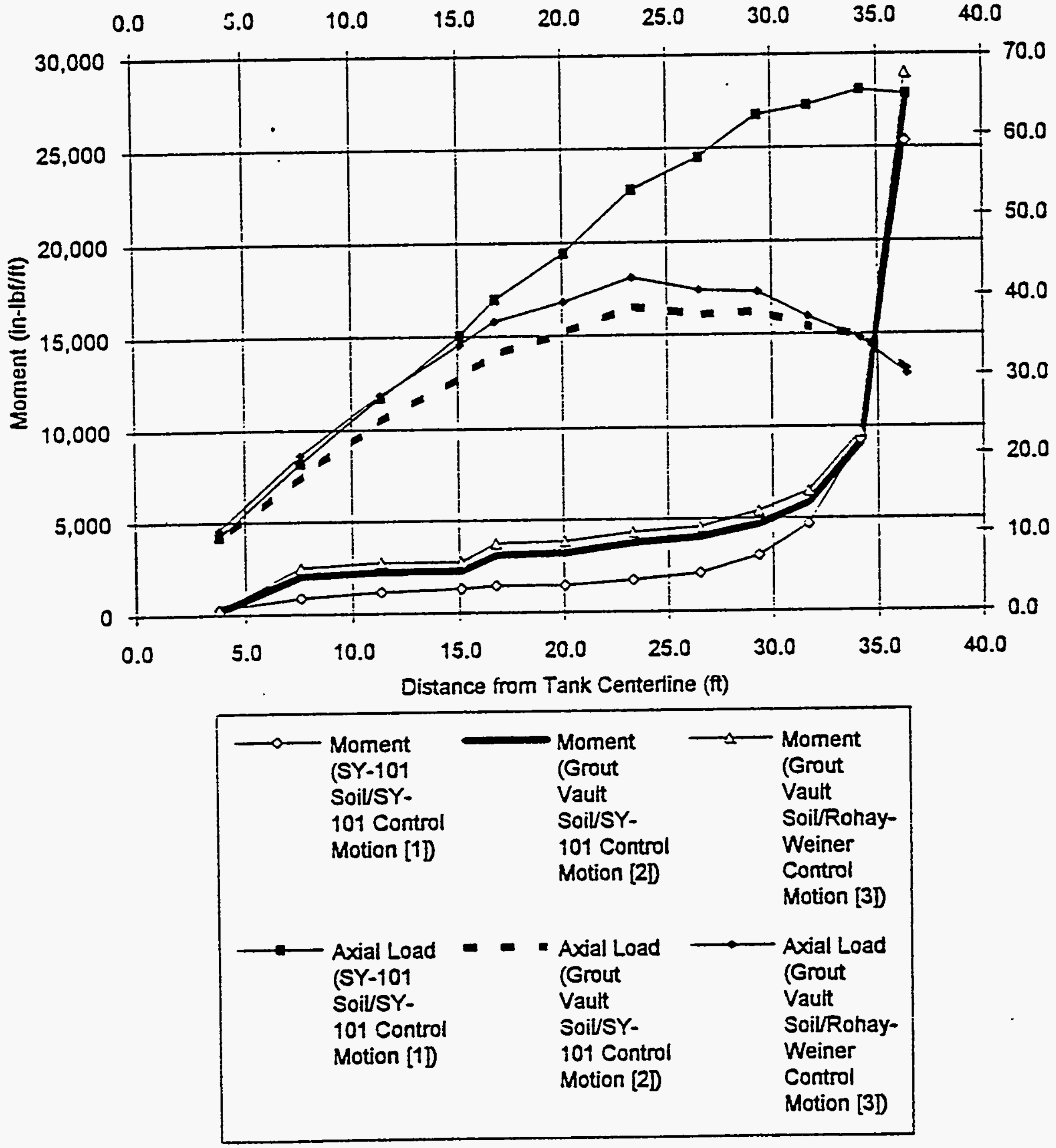
Figure A.3.1-6. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Change in Control Motion and Site Soil Profile



Note: [1] = Run ID "Q5", [2] = Run ID "Q5.5", [3] = Run ID "Q6".

q6\CDOMEI.XLC

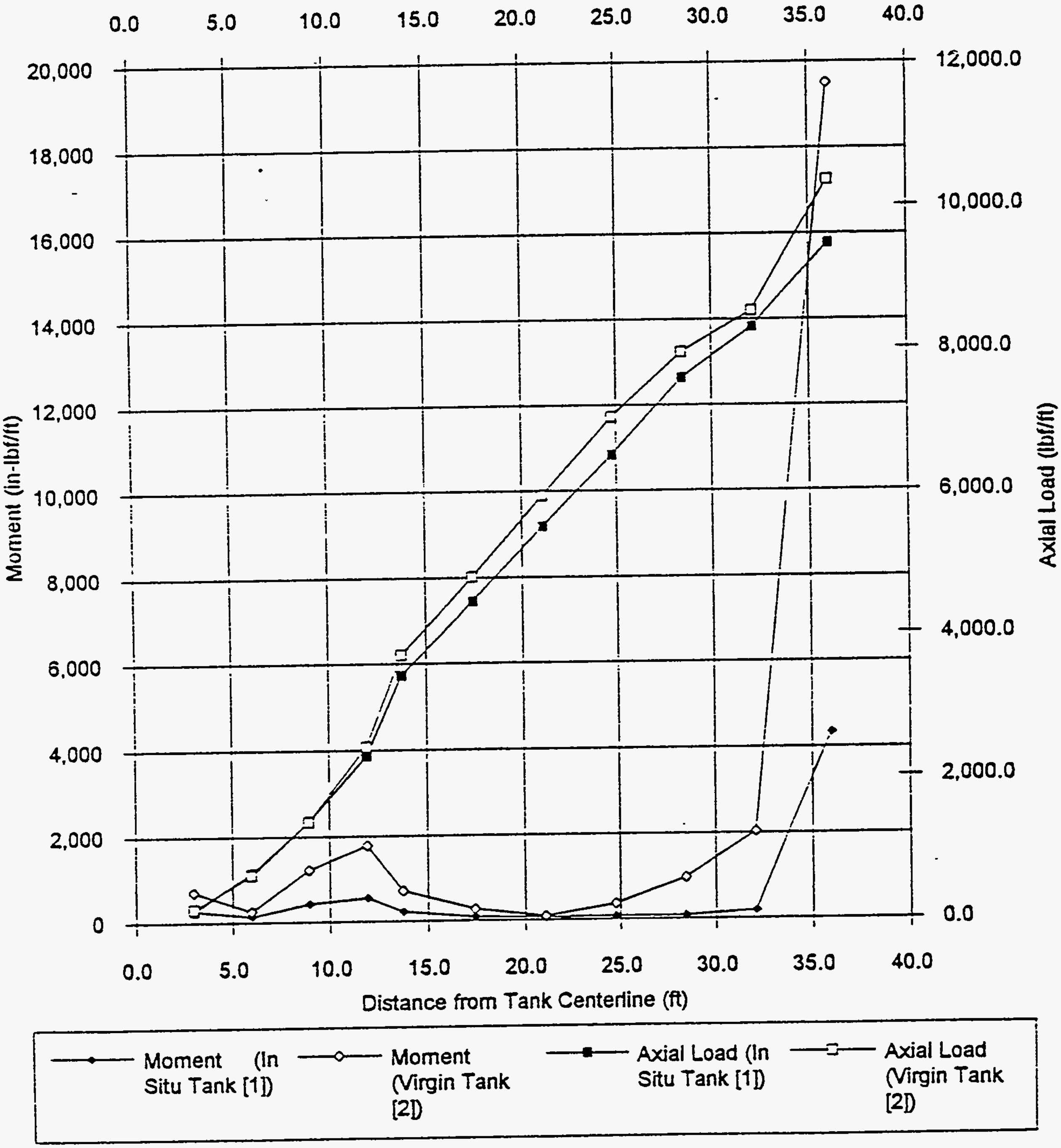
Figure A.3.1-7. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Change in Control Motion and Site Soil Profile



Note: [1] = Run ID "Q5", [2] = Run ID "Q5.5", [3] = Run ID "Q6".

q6\CDOMEO.XLC

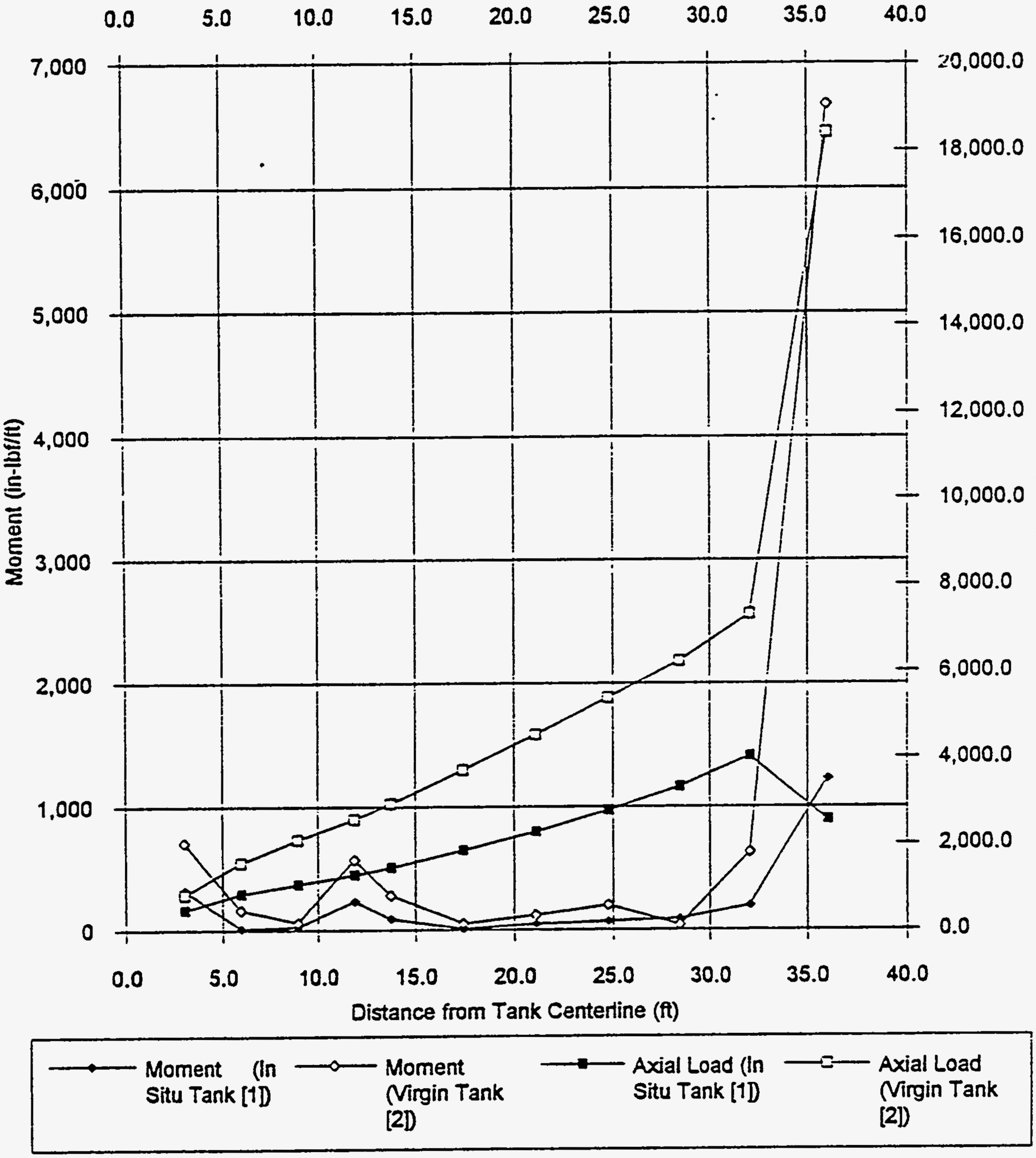
Figure A.3.2-1. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: In Situ Tank vs. Virgin Tank



Note: [1] = Run ID "Q3", [2] = Run ID "Q2".

q3\anl\CBASEI.XLC

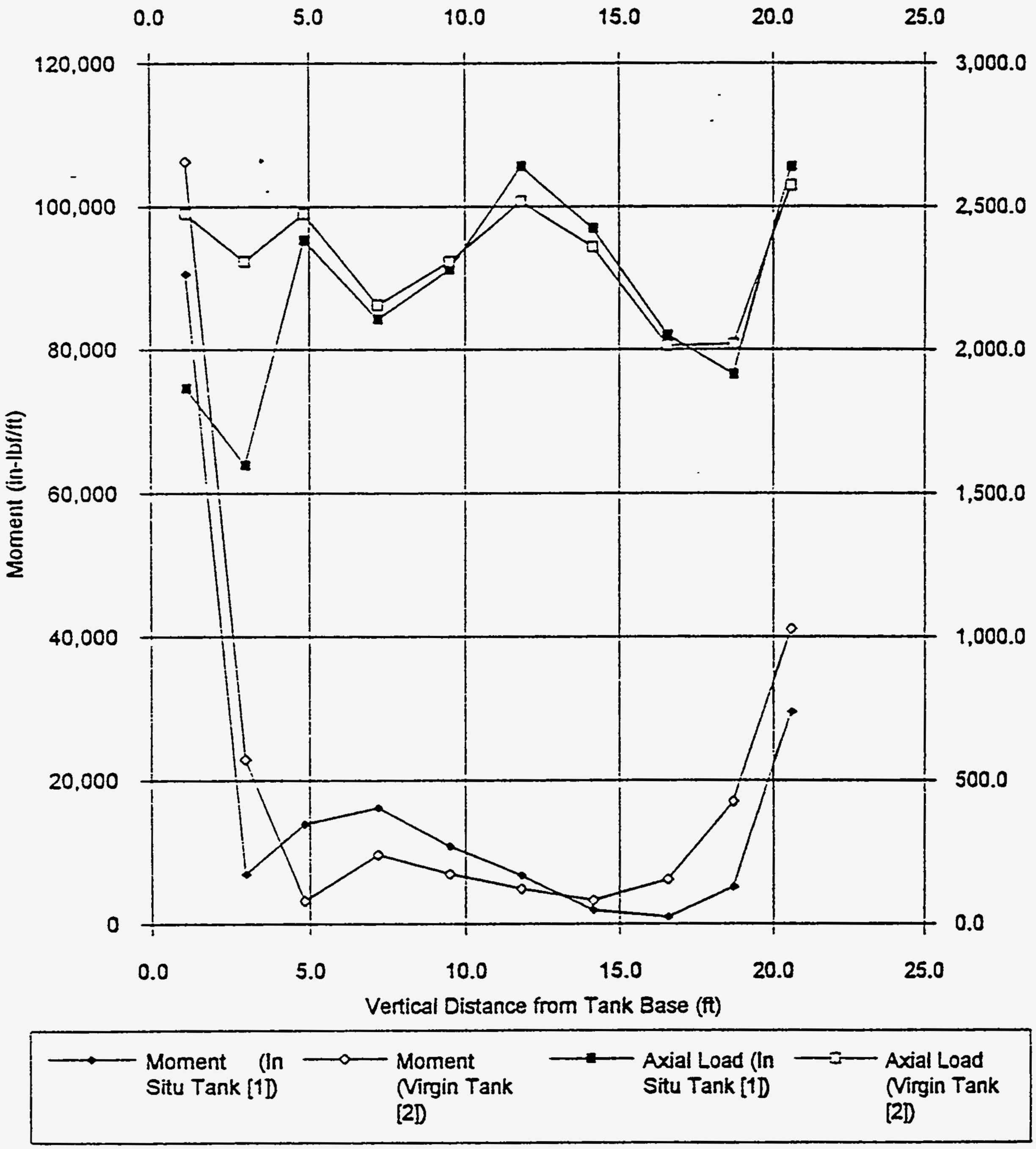
Figure A.3.2-2. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: In Situ Tank vs. Virgin Tank



Note: [1] = Run ID "Q3", [2] = Run ID "Q2".

q3\anl\CBASEO.XLC

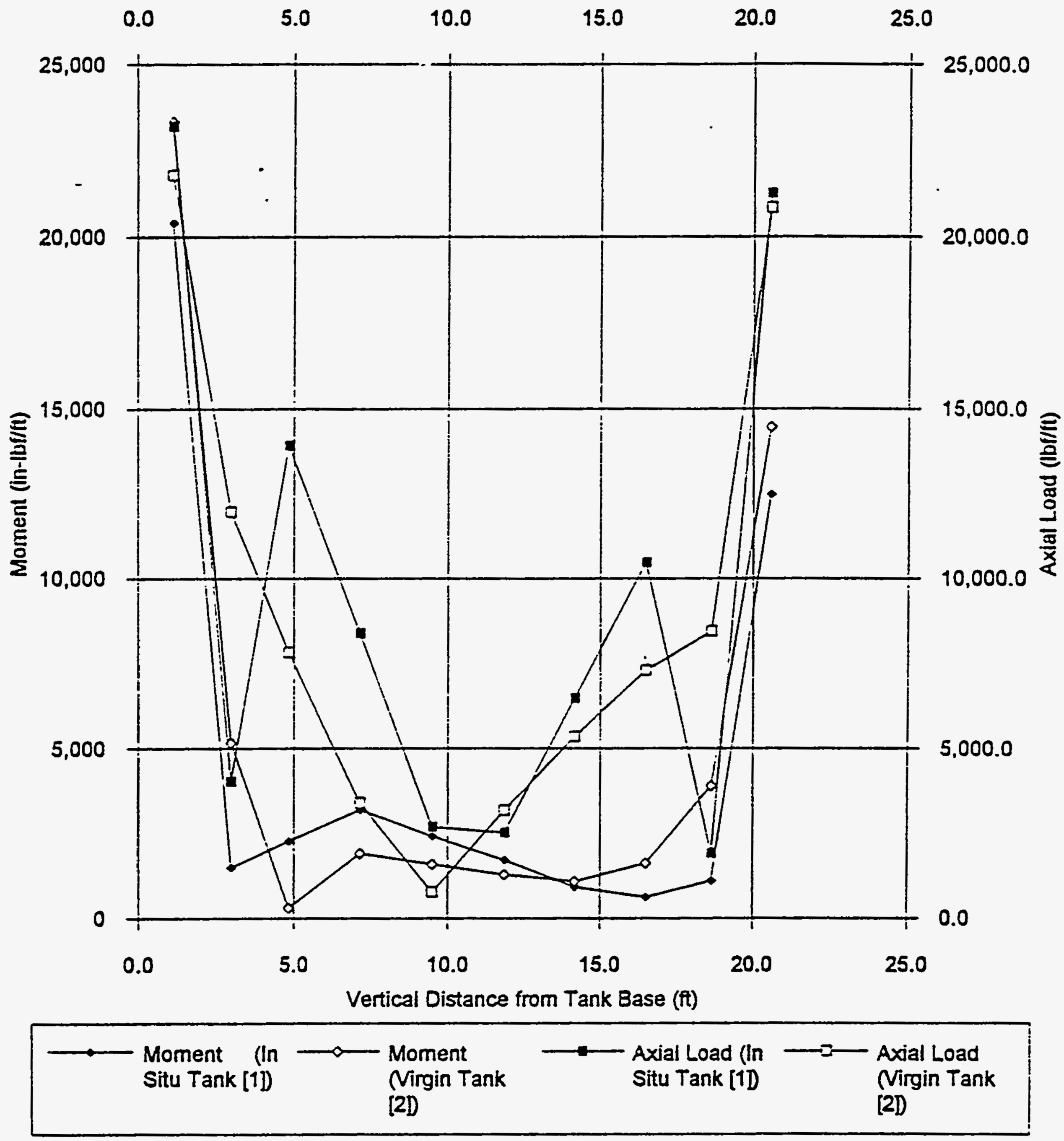
Figure A.3.2-3. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: In Situ Tank vs. Virgin Tank



Note: [1] = Run ID "Q3", [2] = Run ID "Q2".

q3\ani\CWALLI.XLC

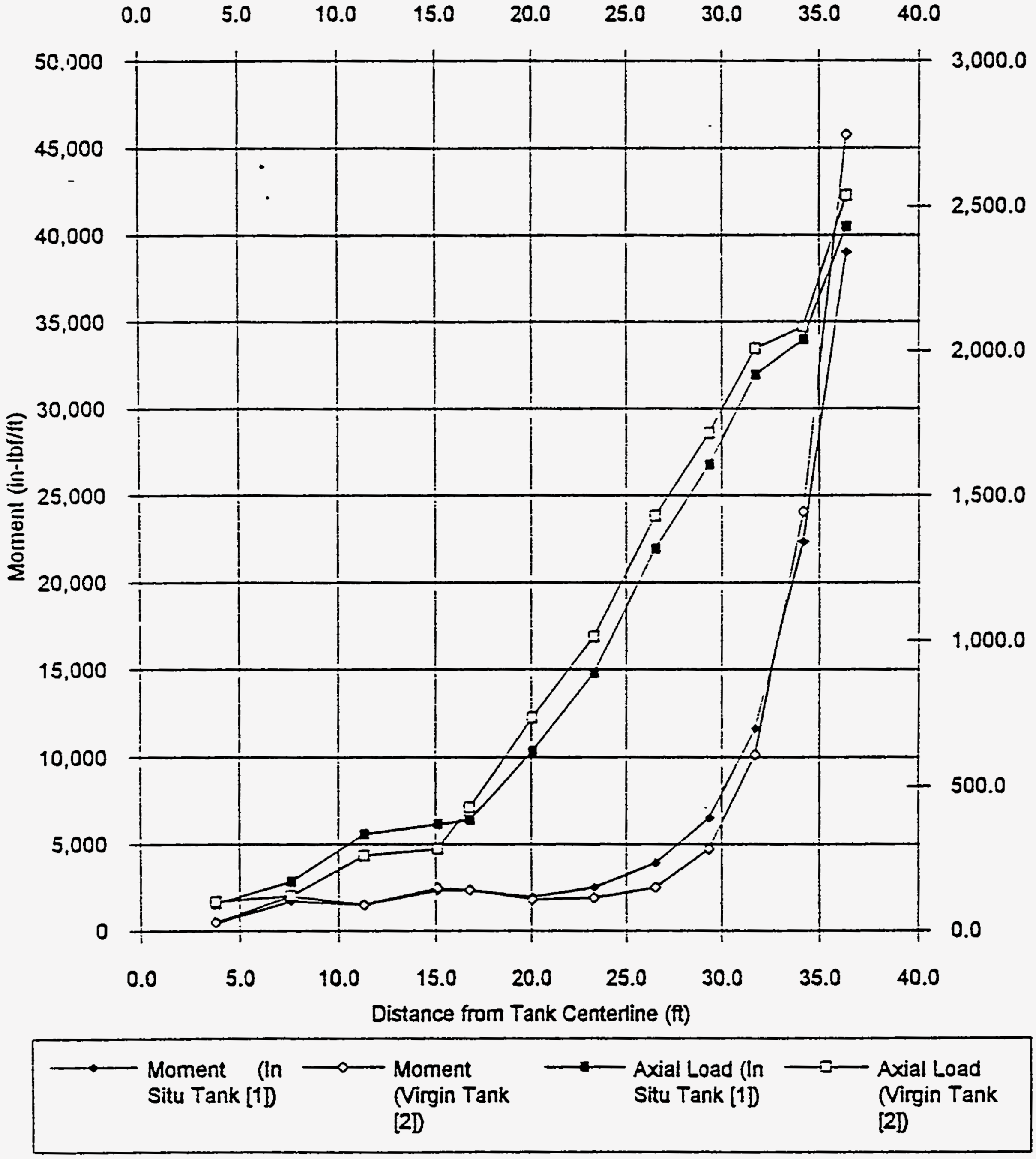
Figure A.3.2-4. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: In Situ Tank vs. Virgin Tank



Note: [1] = Run ID "Q3", [2] = Run ID "Q2".

q3\anl\CWALLO.XLC

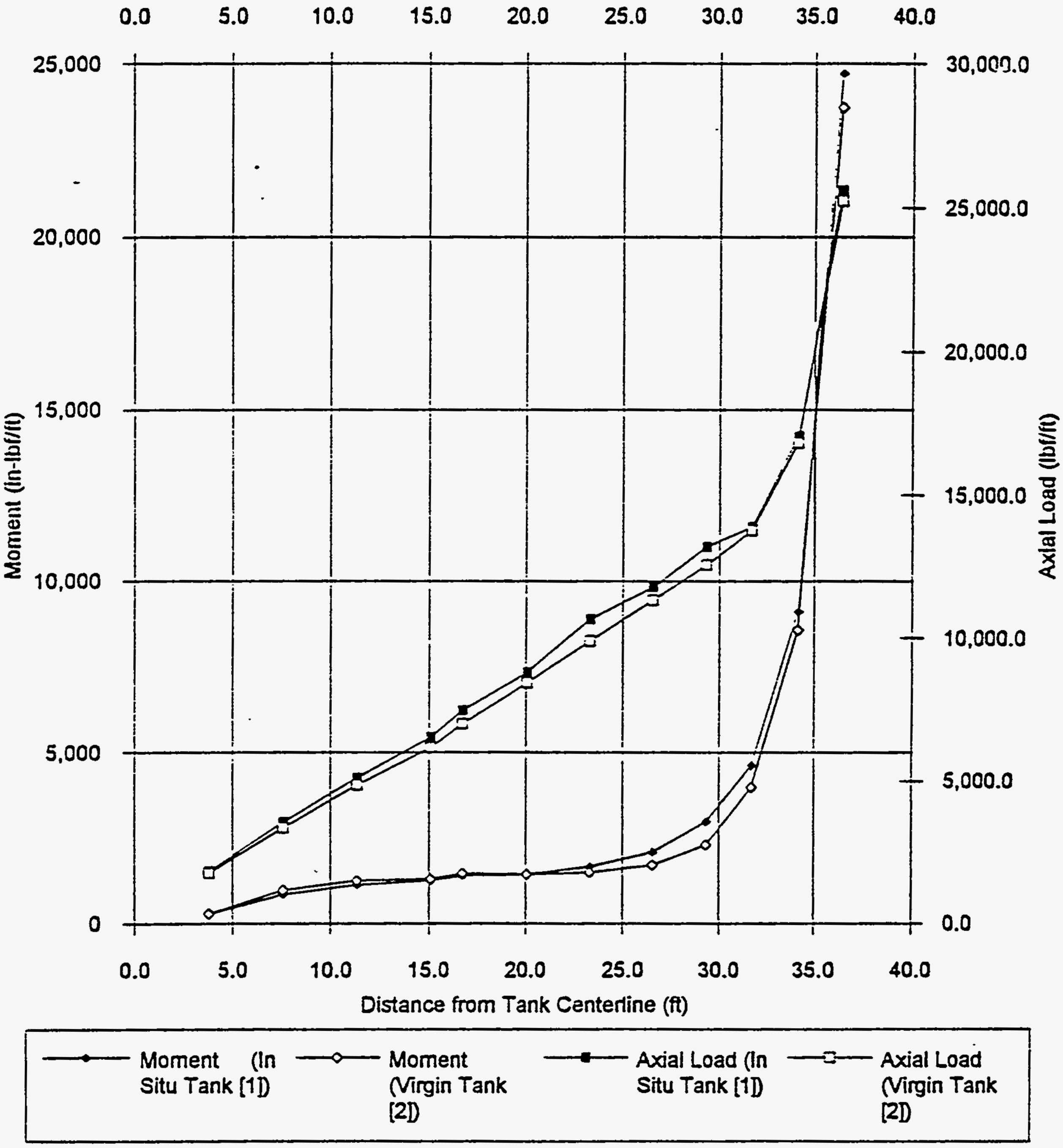
Figure A.3.2-5. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: In Situ Tank vs. Virgin Tank



Note: [1] = Run ID "Q3", [2] = Run ID "Q2".

q3\anl\CDOMEI.XLC

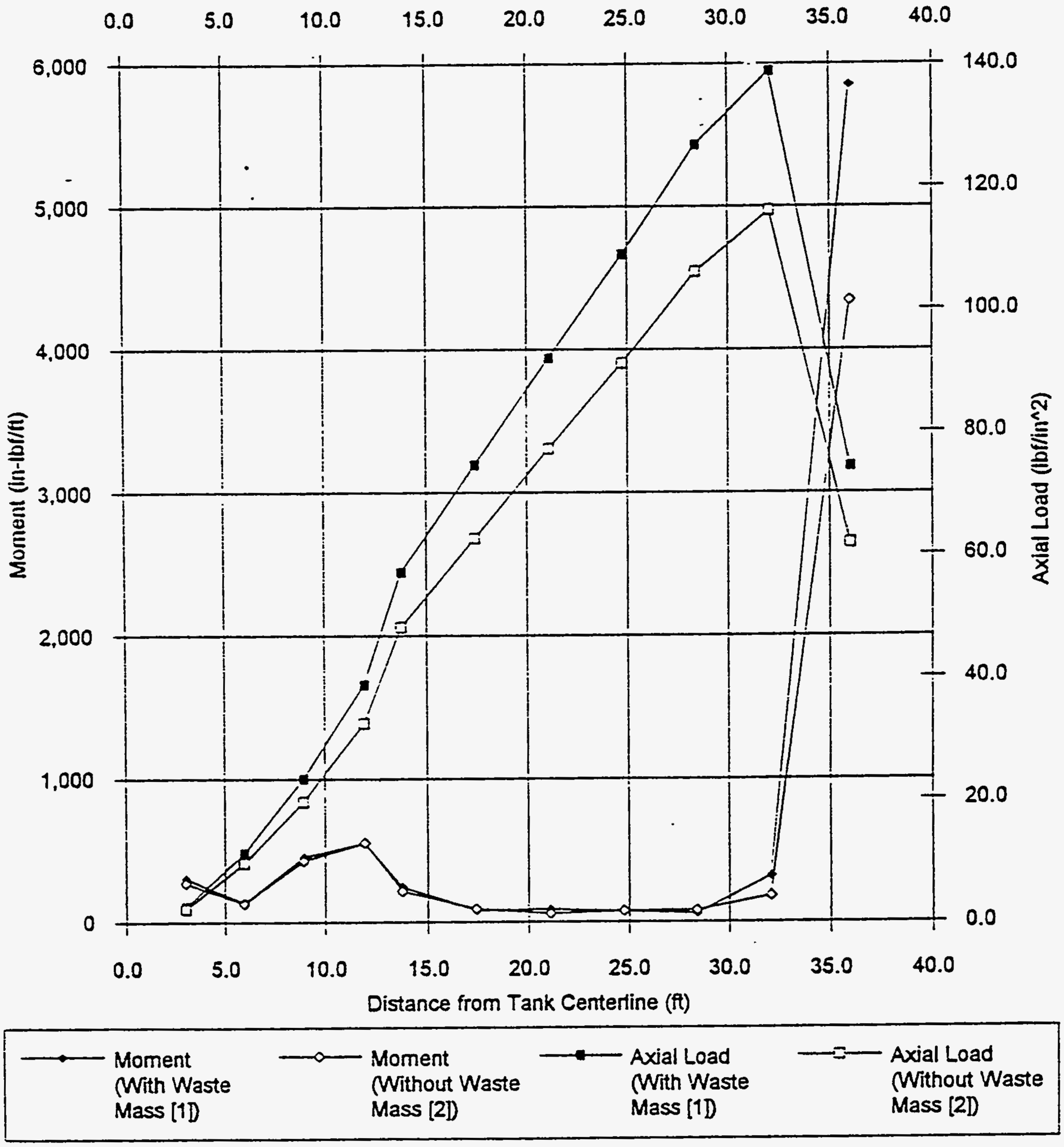
Figure A.3.2-6. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: In Situ Tank vs. Virgin Tank



Note: [1] = Run ID "Q3", [2] = Run ID "Q2".

q3\anl\CDOMEO.XLC

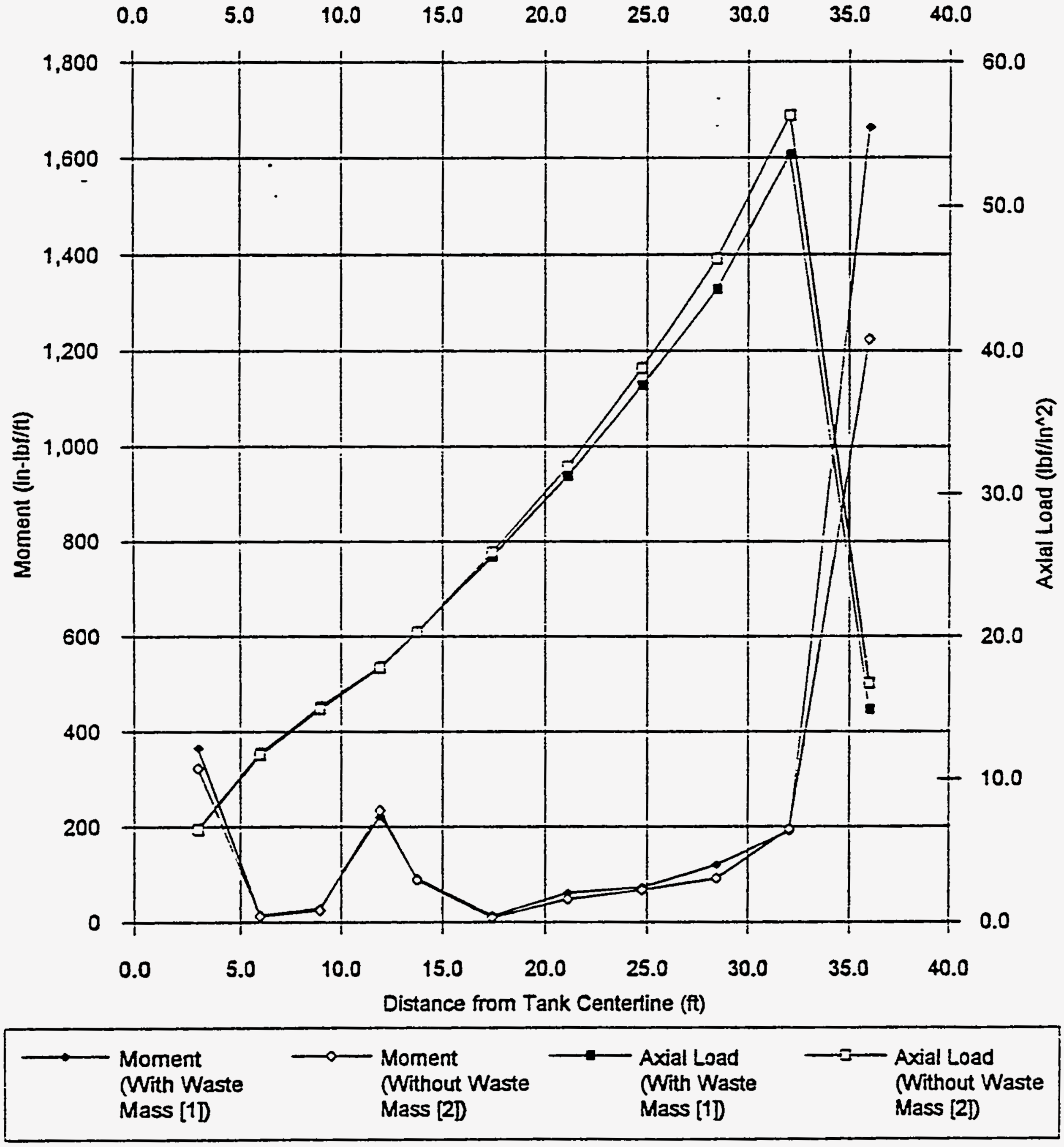
Figure A.3.3-1. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Effect of Waste Mass



Note: [1] = Run ID "Q5", [2] = Run ID "Q3".

q5\CBASEI.XLC

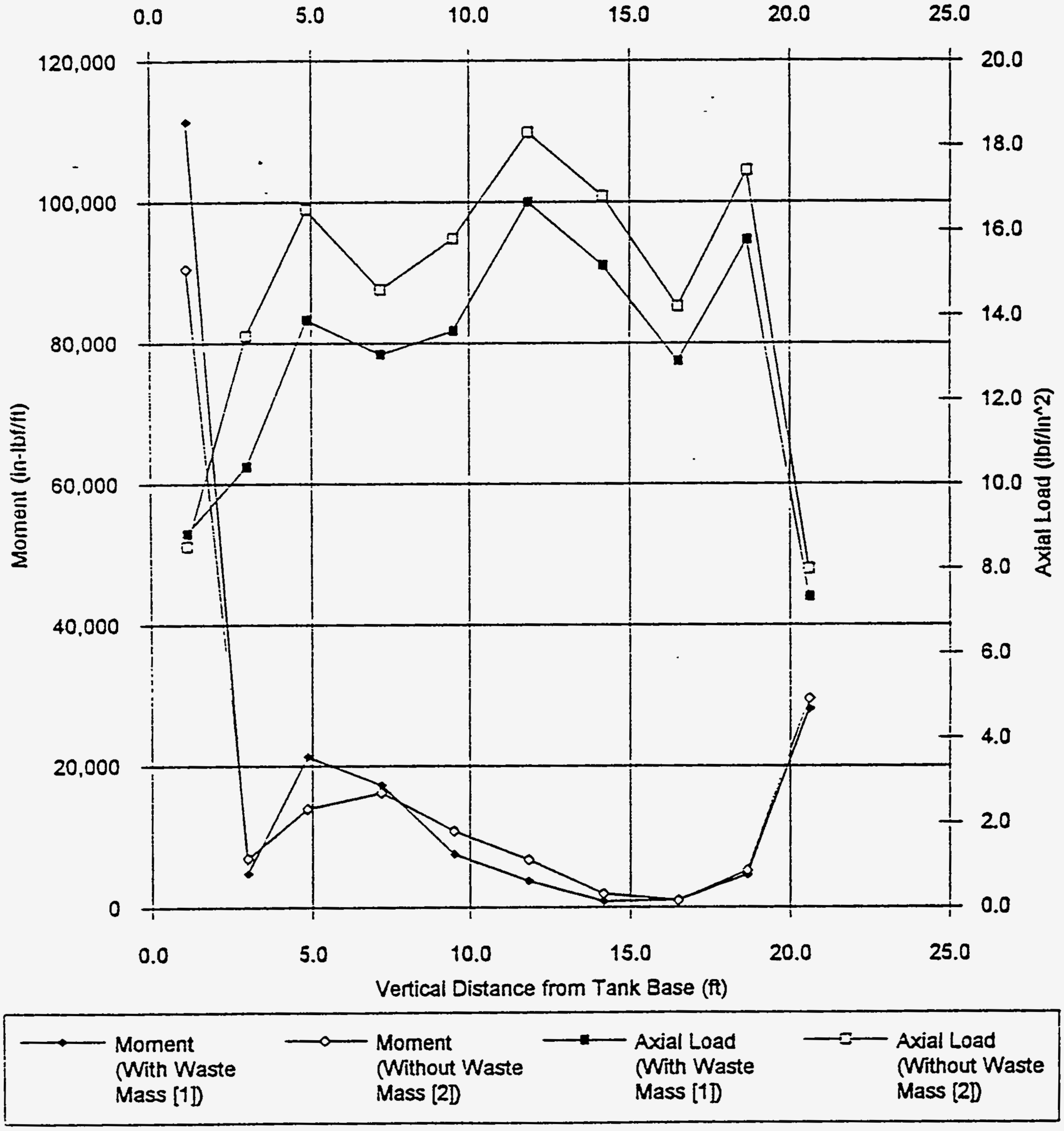
Figure A.3.3-2. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Effect of Waste Mass



Note: [1] = Run ID "Q5", [2] = Run ID "Q3".

q5\CBASEO.XLC

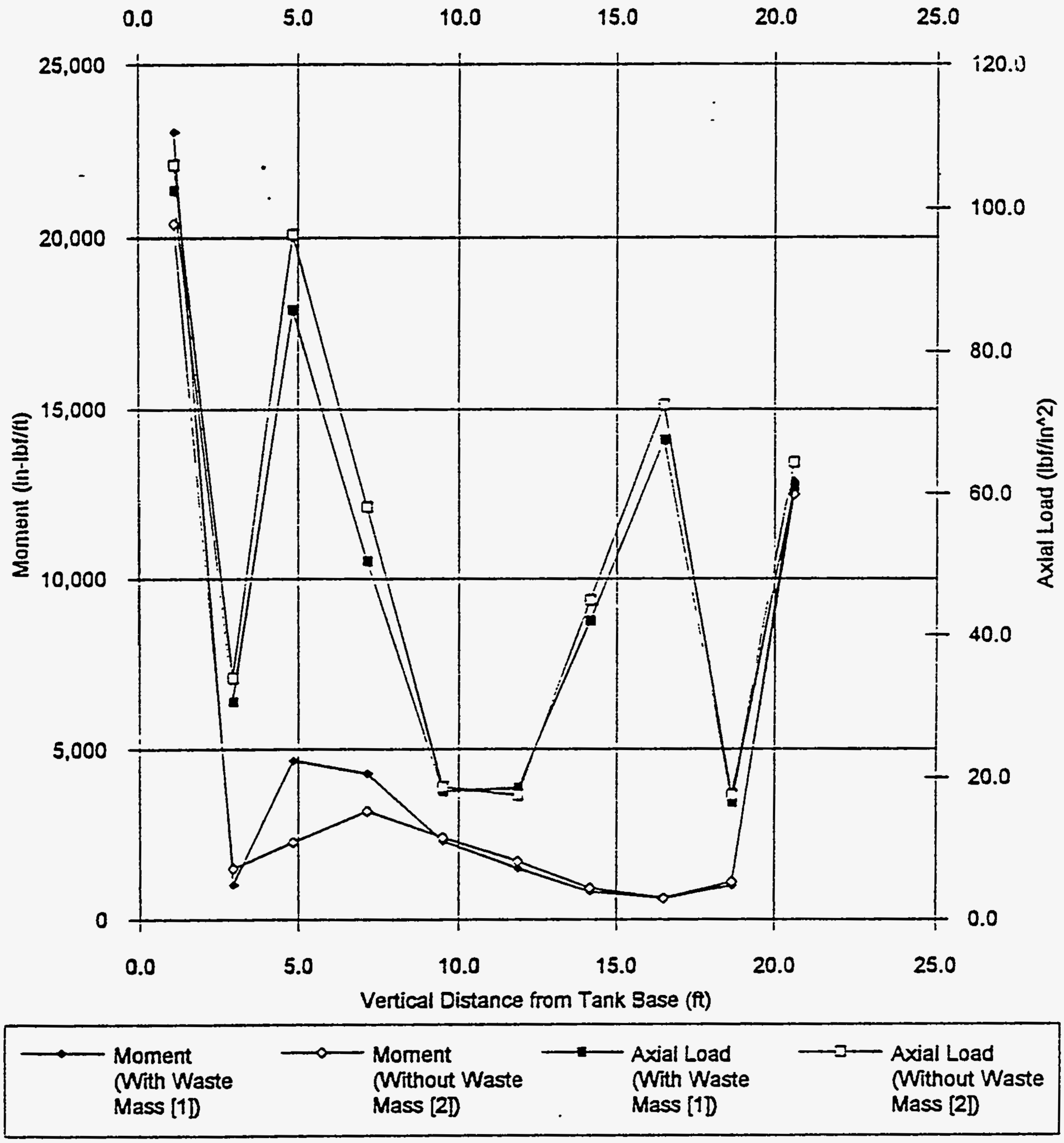
Figure A.3.3-3. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Effect of Waste Mass



Note: [1] = Run ID "Q5", [2] = Run ID "Q3".

q5\CWALLI.XLC

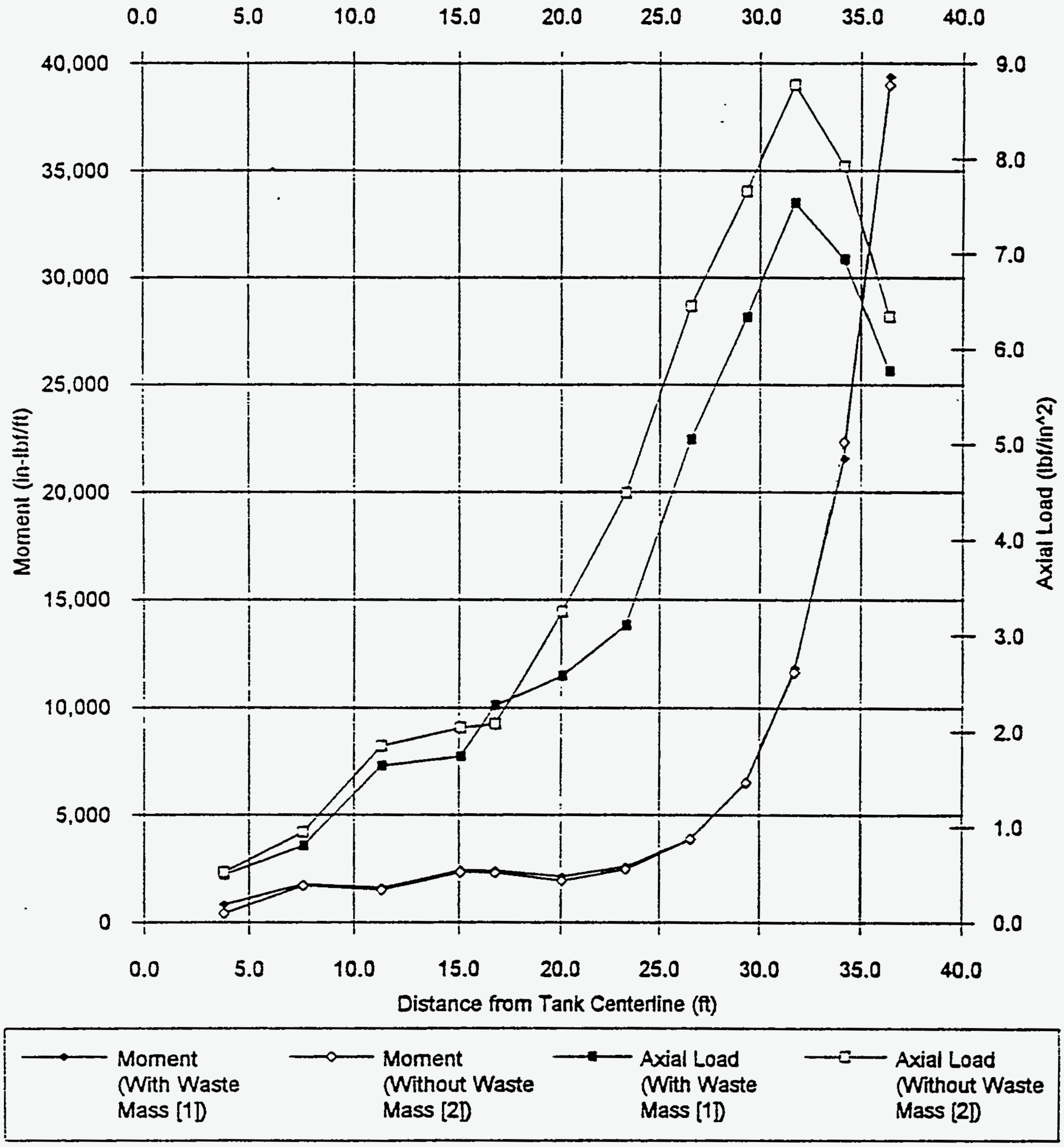
Figure A.3.3-4. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Effect of Waste Mass



Note: [1] = Run ID "Q5", [2] = Run ID "Q3".

q5\CWALLO.XLC

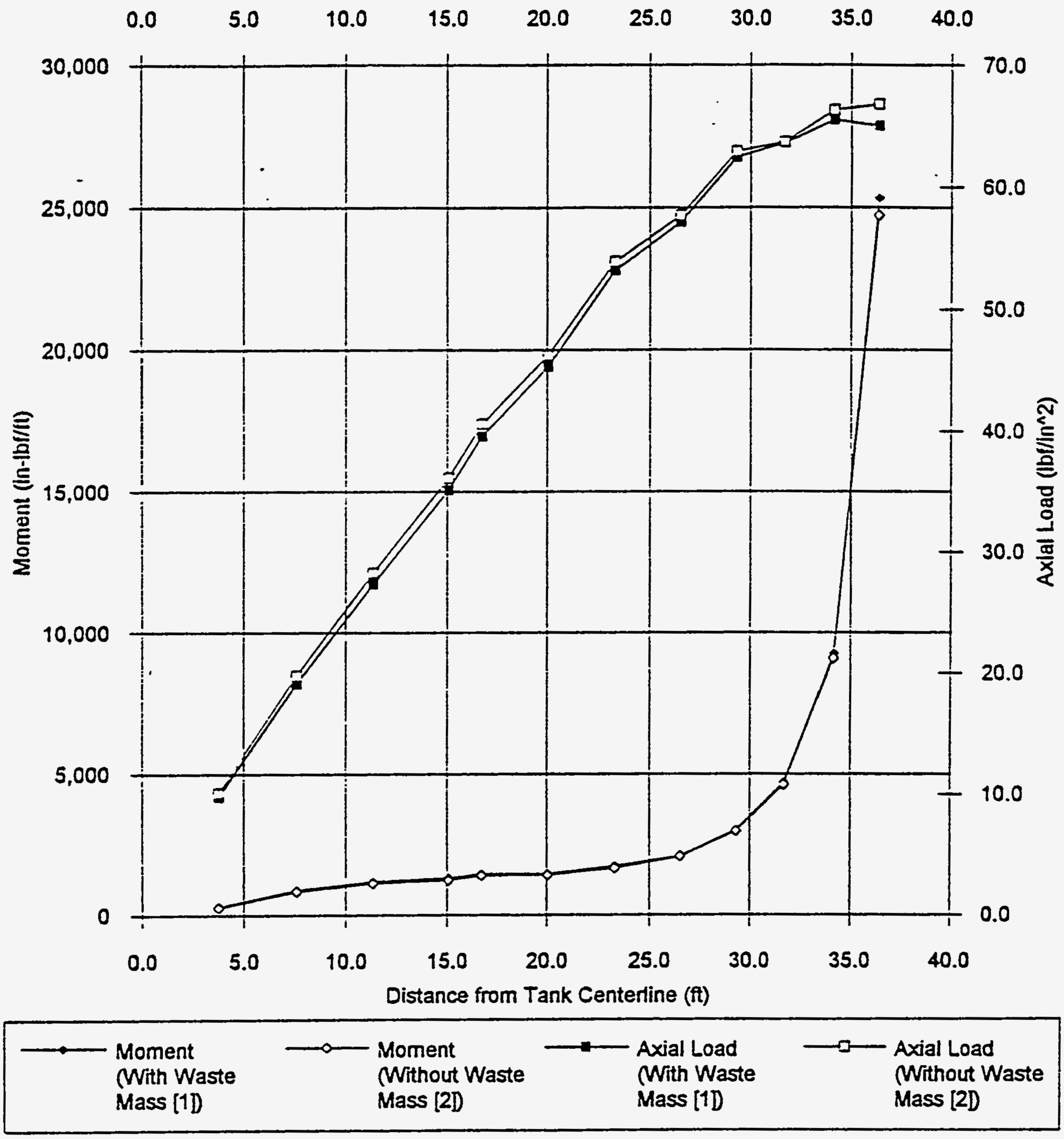
Figure A.3.3-5. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Effect of Waste Mass



Note: [1] = Run ID "Q5", [2] = Run ID "Q3".

q5\CDOMEI.XLC

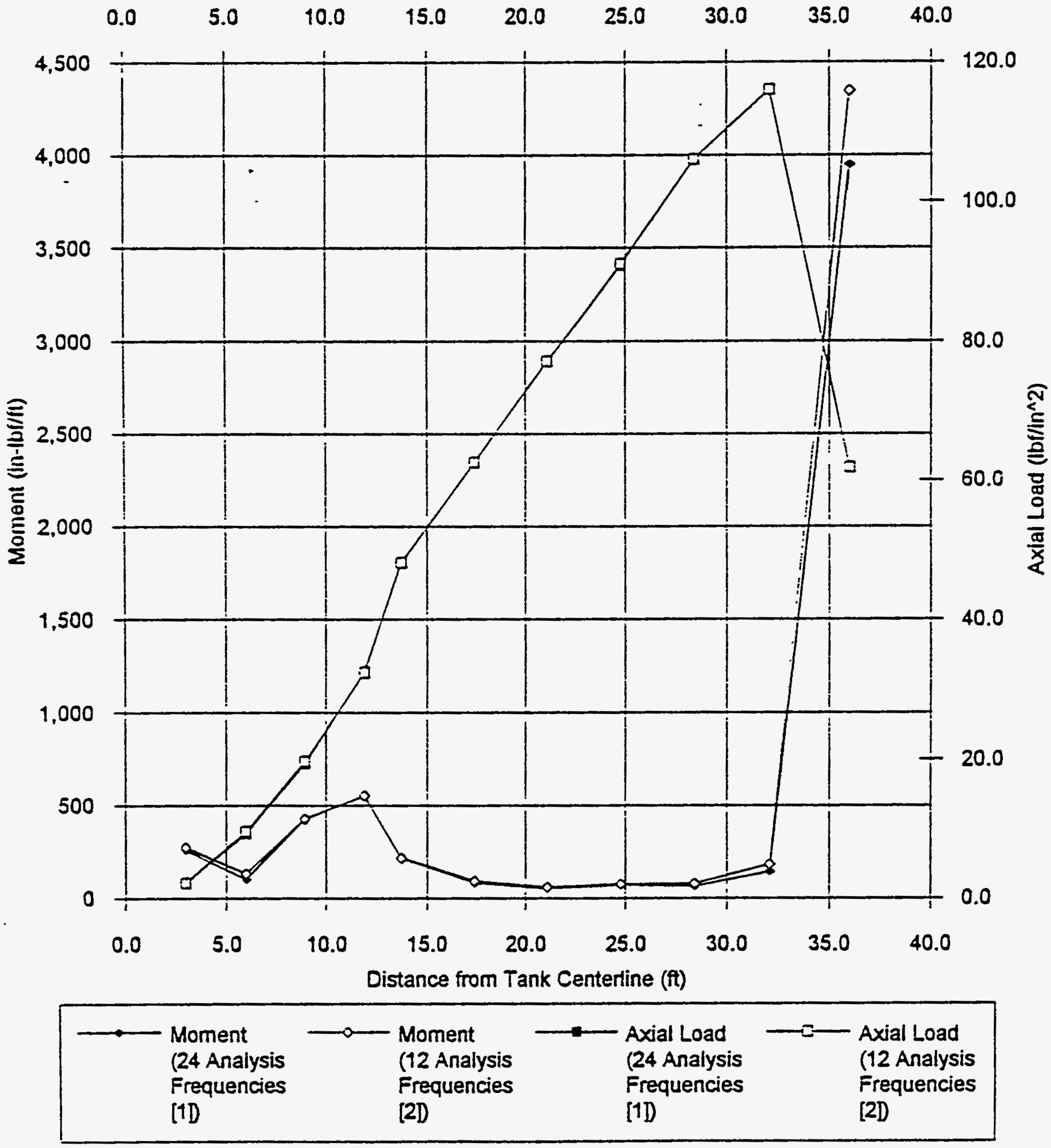
Figure A.3.3-6. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Effect of Waste Mass



Note: [1] = Run ID "Q5", [2] = Run ID "Q3".

q5\CDOMEO.XLC

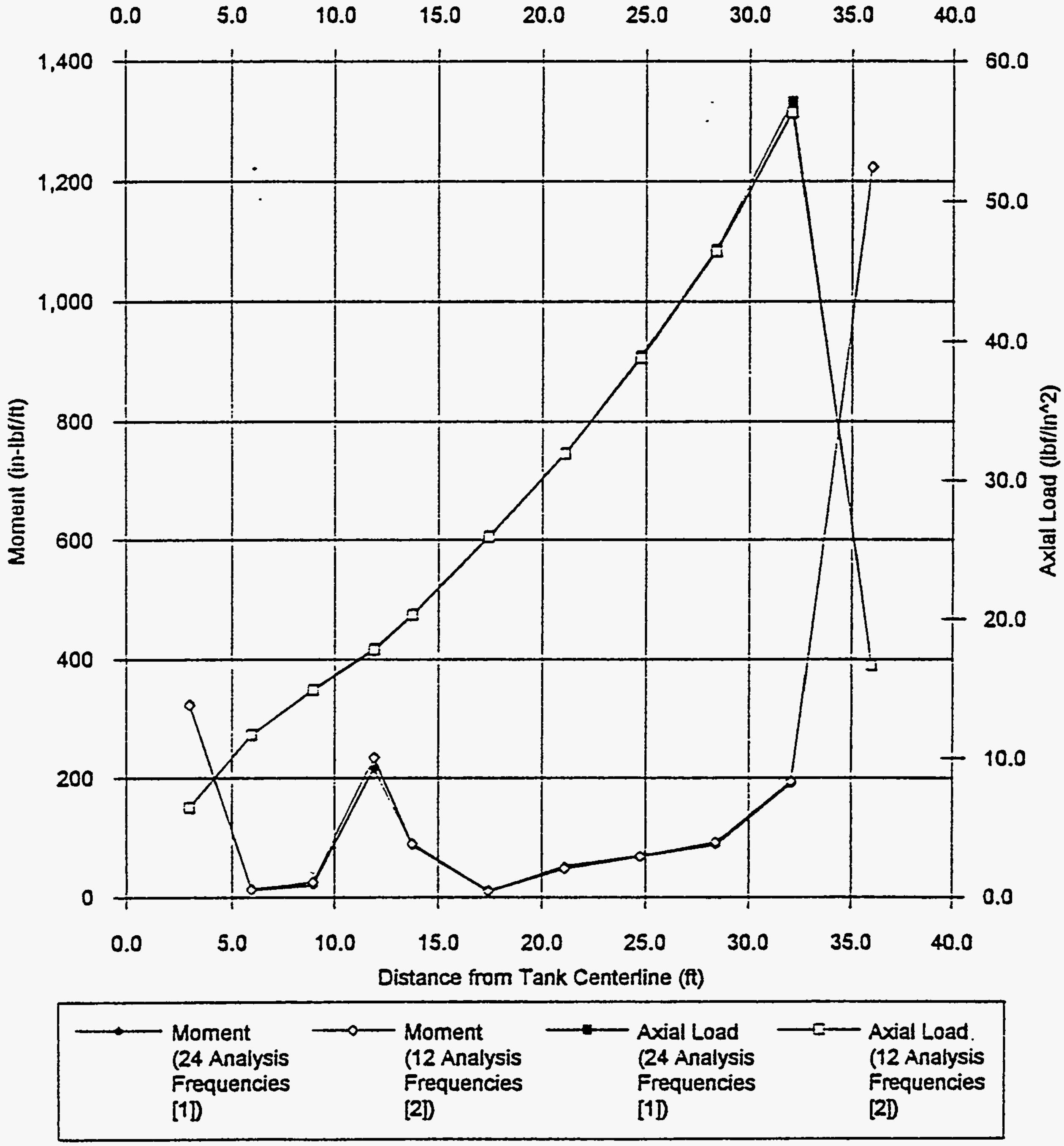
Figure A.4.1-1. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Number of Analysis Frequencies



Note: [1] = Run ID "Q4", [2] = Run ID "Q3".

q4\CBASEI.XLC

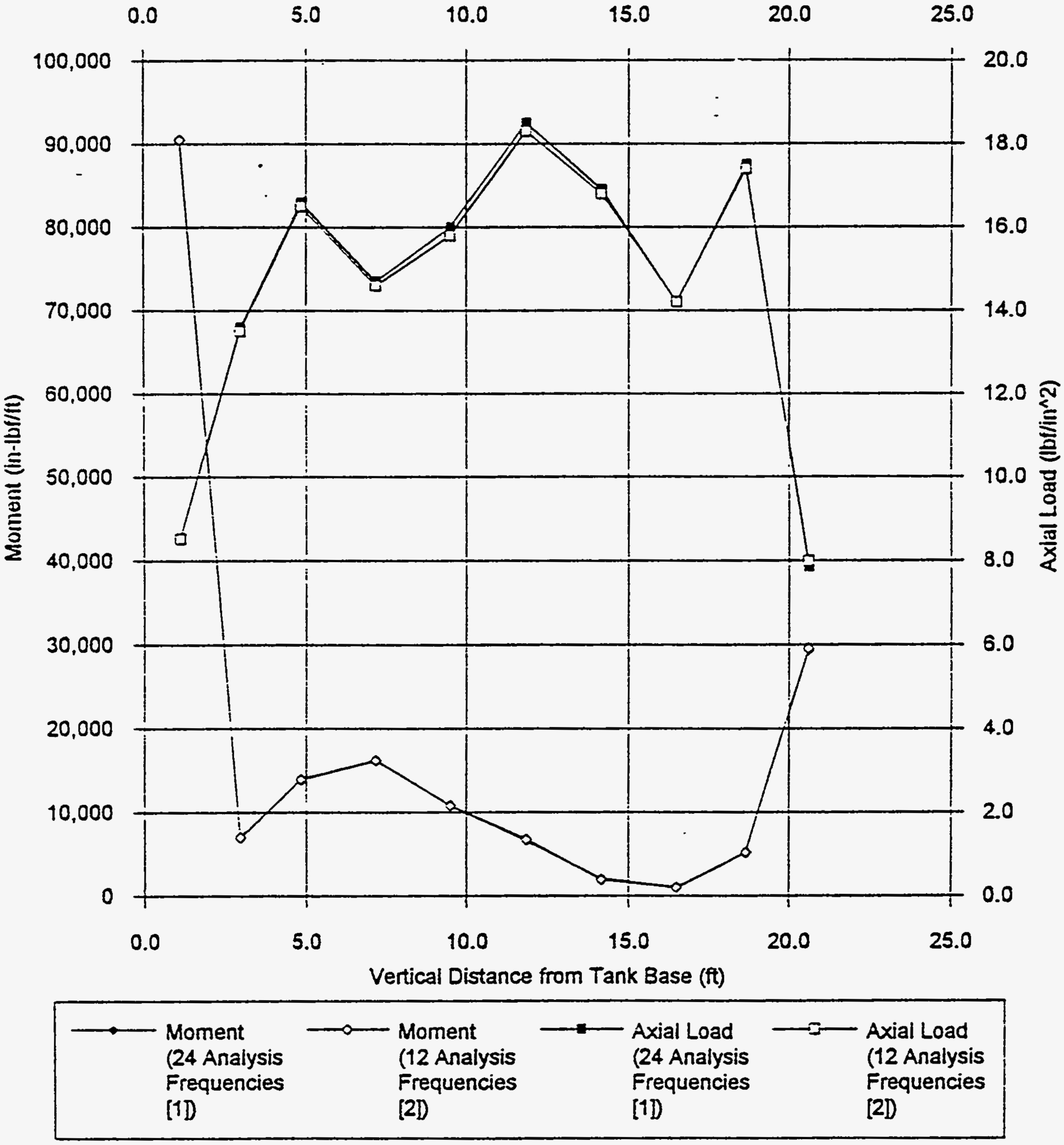
Figure A.4.1-2. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Number of Analysis Frequencies



Note: [1] = Run ID "Q4", [2] = Run ID "Q3".

q4\CBASEO.XLC

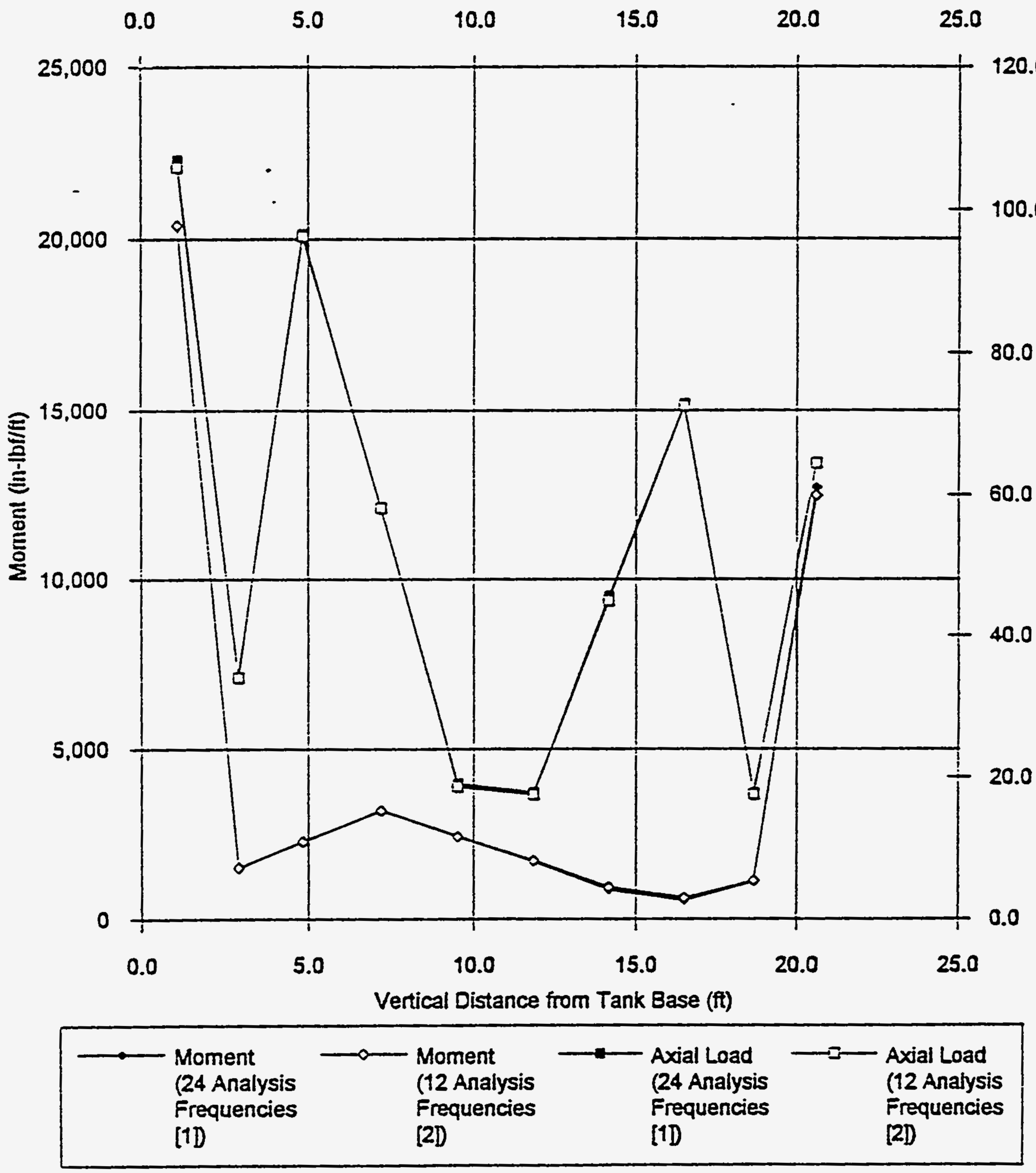
Figure A.4.1-3. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Number of Analysis Frequencies



Note: [1] = Run ID "Q4", [2] = Run ID "Q3".

q4\CWALLI.XLC

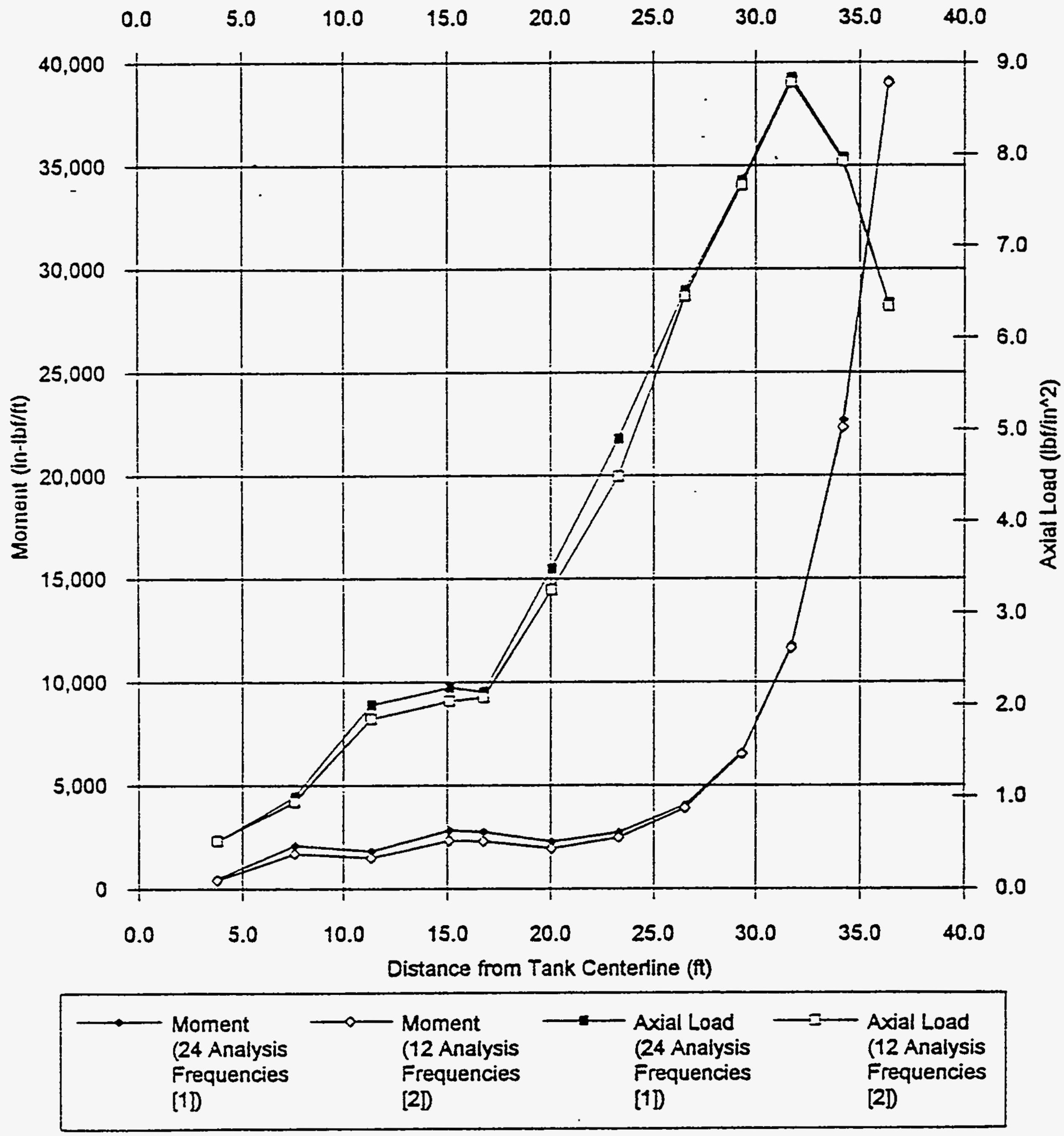
Figure A.4.1-4. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Number of Analysis Frequencies



Note: [1] = Run ID "Q4", [2] = Run ID "Q3".

q4\CWALLO.XLC

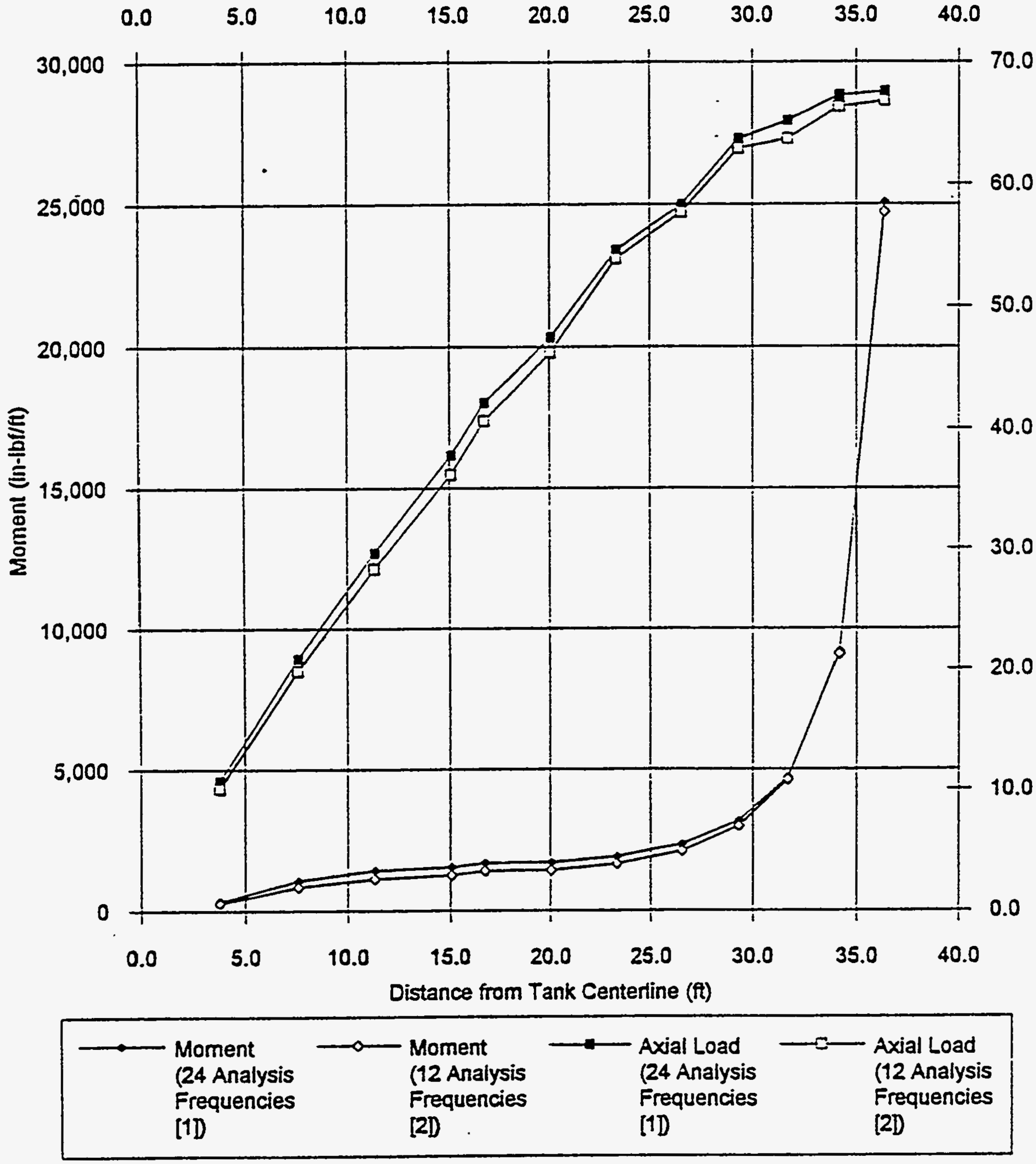
Figure A.4.1-5. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Number of Analysis Frequencies



Note: [1] = Run ID "Q4", [2] = Run ID "Q3".

q4\CDOMEI.XLC

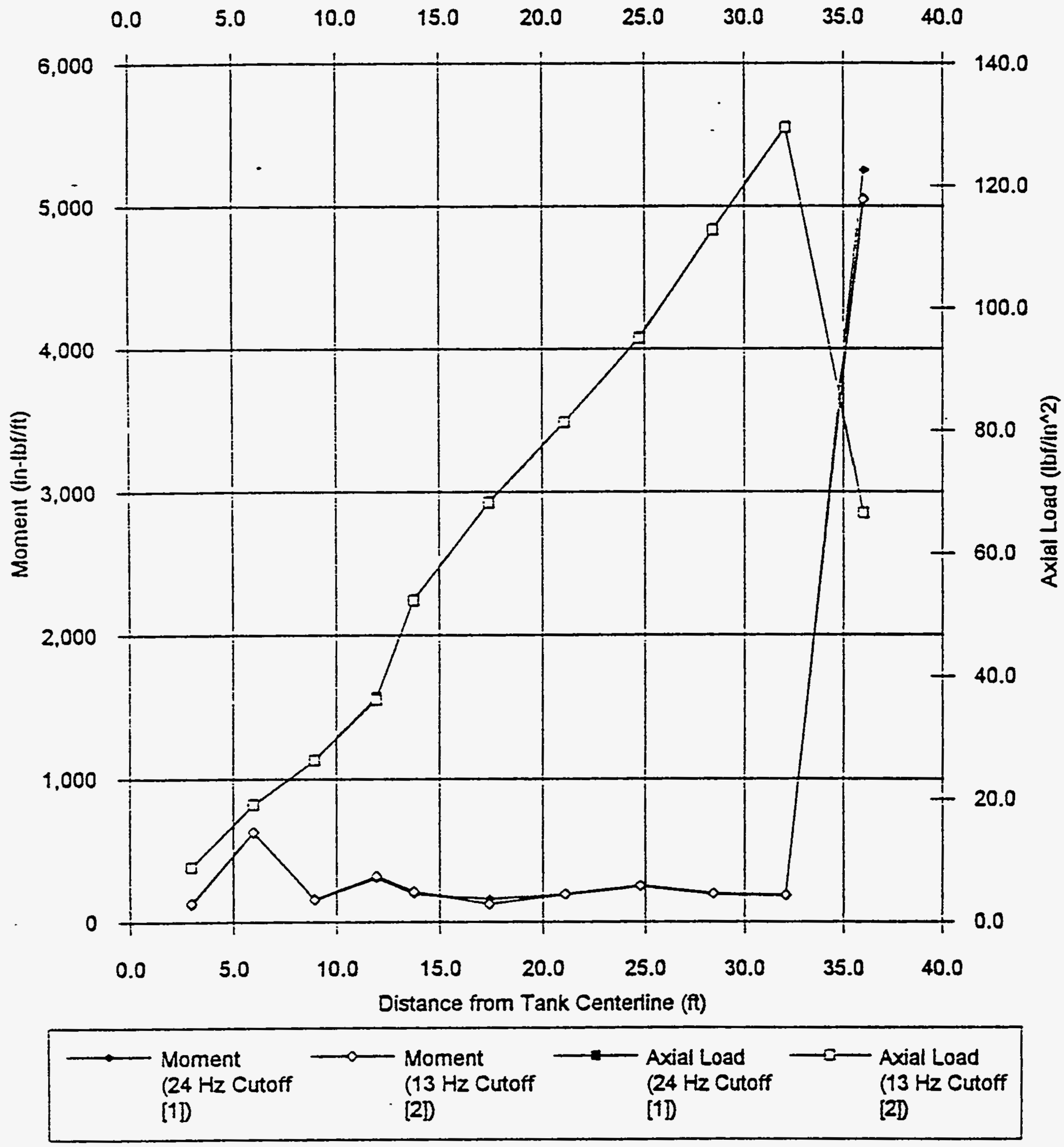
Figure A.4.1-6. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Number of Analysis Frequencies



Note: [1] = Run ID "Q4", [2] = Run ID "Q3".

q4\CDOMEO.XLC

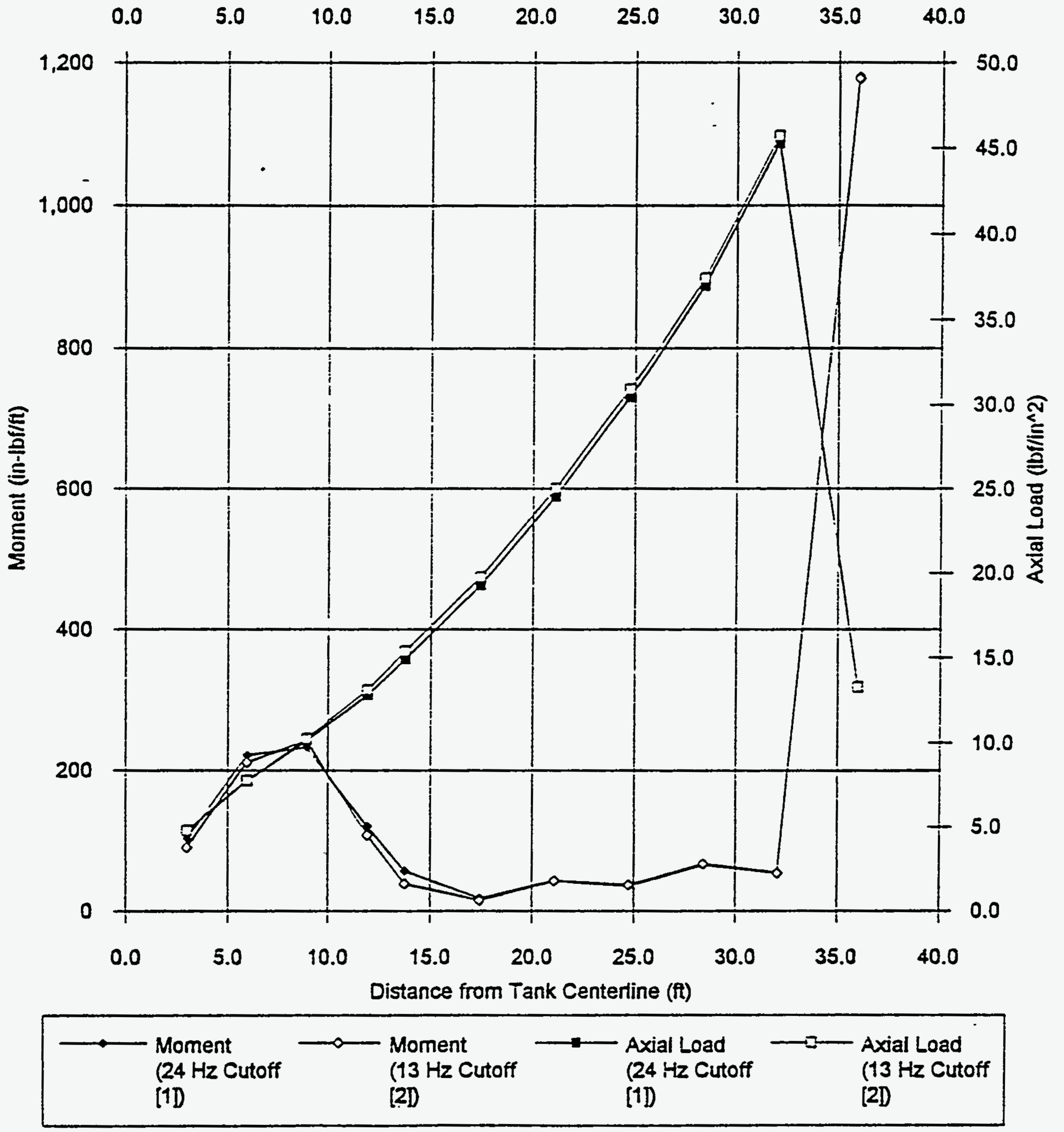
Figure A.4.2-1. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Analysis Cutoff Frequency



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = same as [1] but with 13 hz cutoff frequency.

qlow\anl\cmot50\7freq\CBASEI.XLC

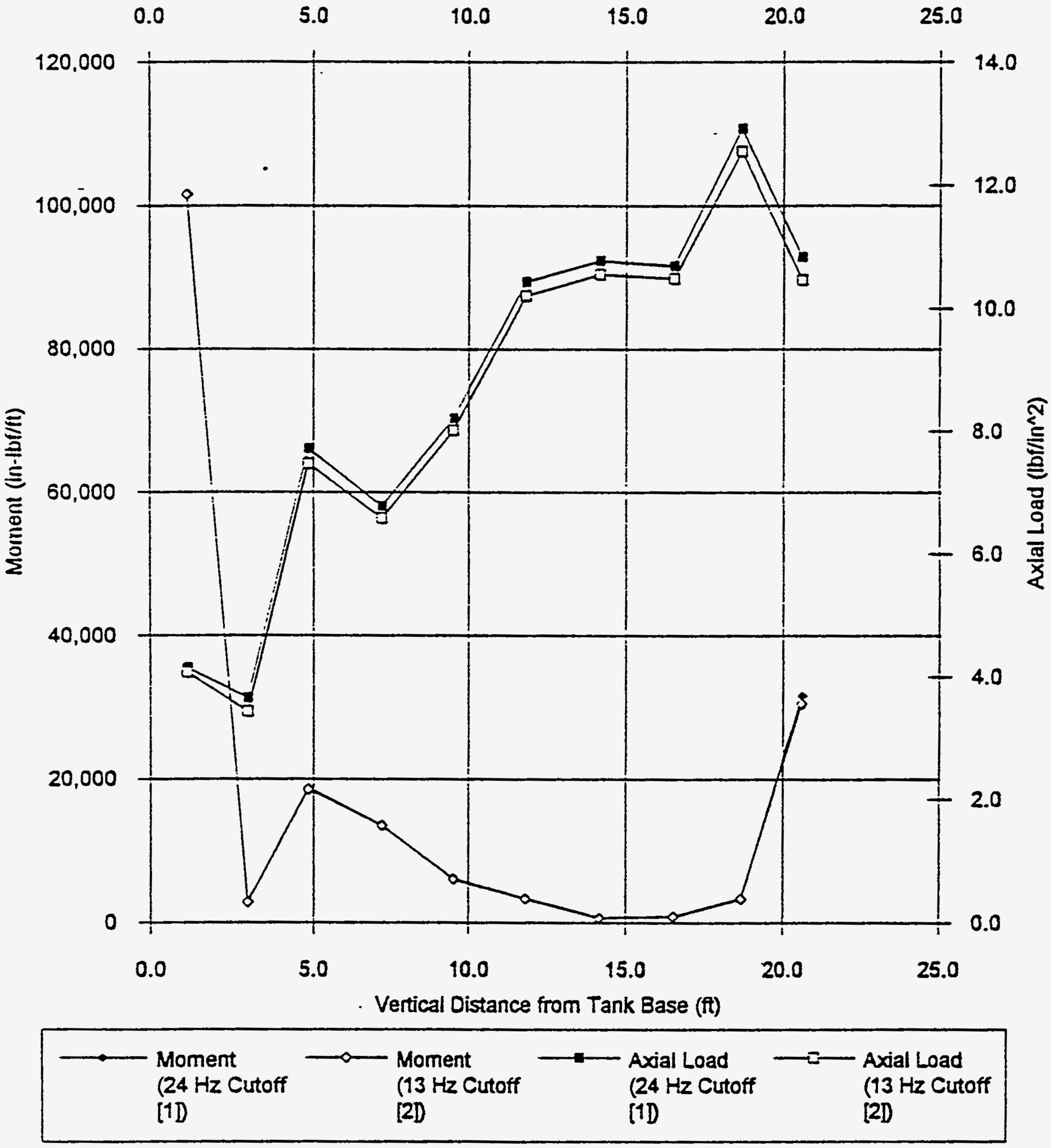
Figure A.4.2-2. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Analysis Cutoff Frequency



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = same as [1] but with 13 hz cutoff frequency.

qlow\anl\cmot50\7freq\CBASEO.XLC

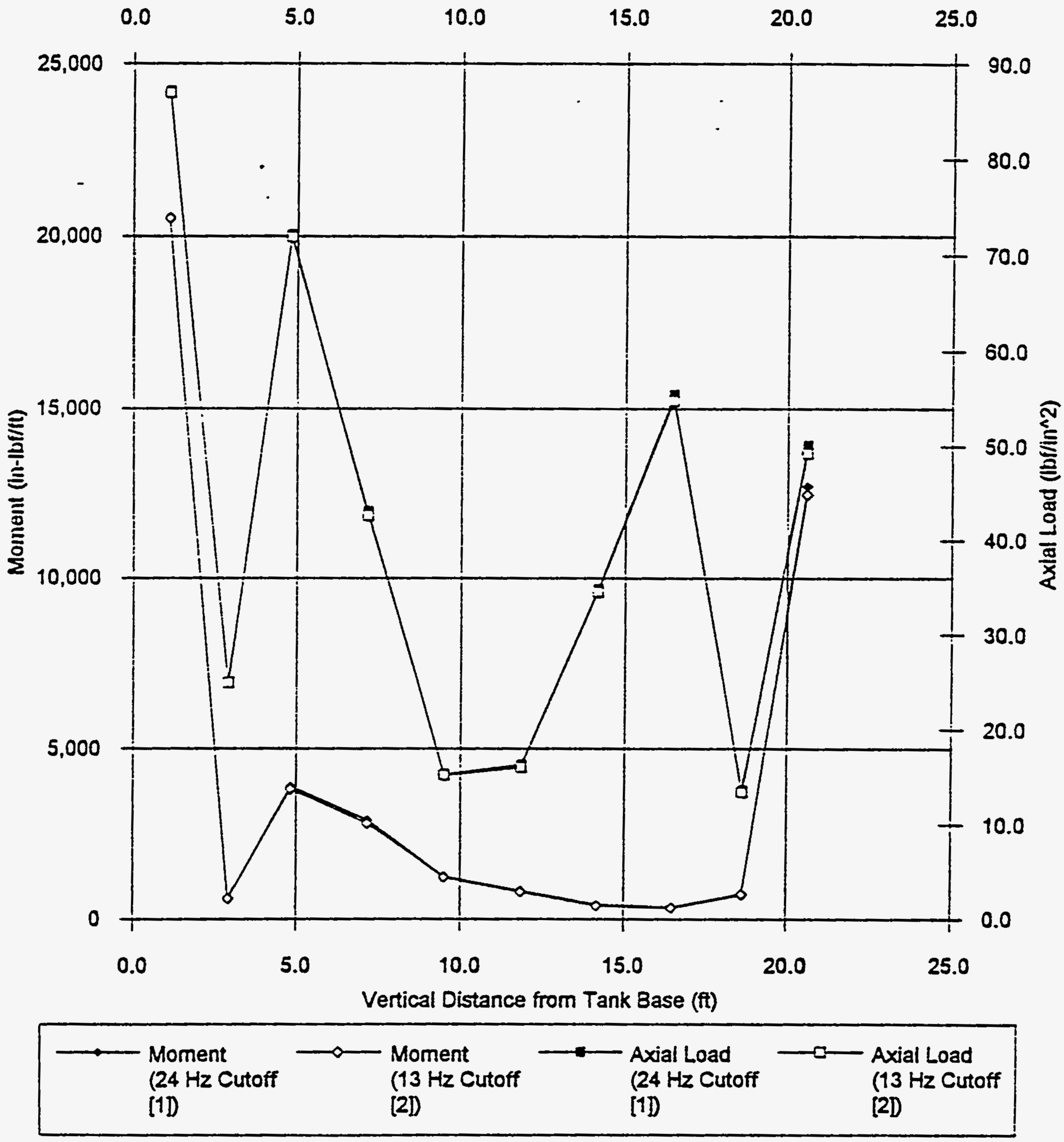
Figure A.4.2-3. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Analysis Cutoff Frequency



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = same as [1] but with 13 hz cutoff frequency.

qlow\lanl\cmot50\7freq\CWALLI.XLC

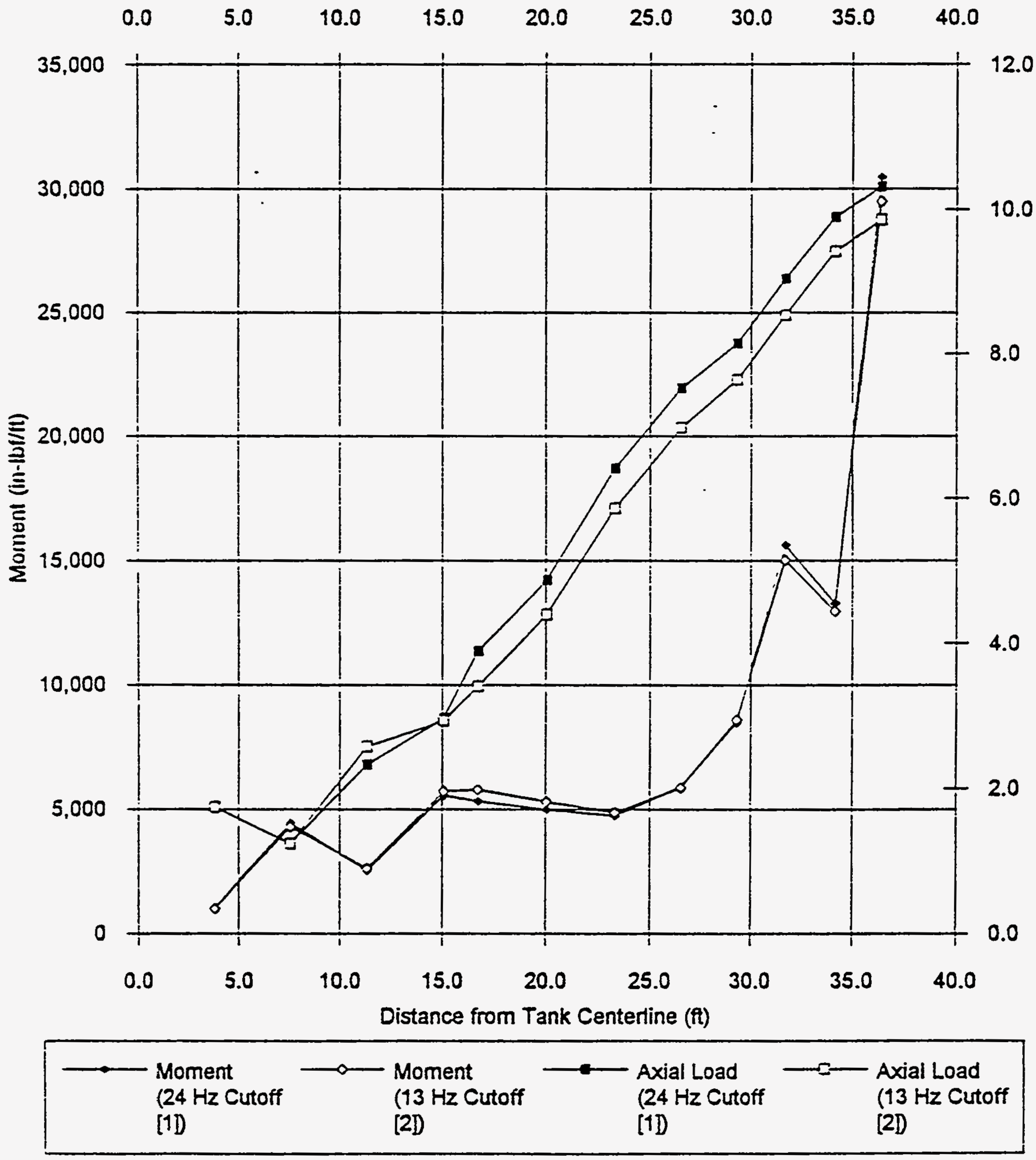
Figure A.4.2-4. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Analysis Cutoff Frequency



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = same as [1] but with 13 hz cutoff frequency.

qlow\anl\cmot50\7freq\CWALLO.XLC

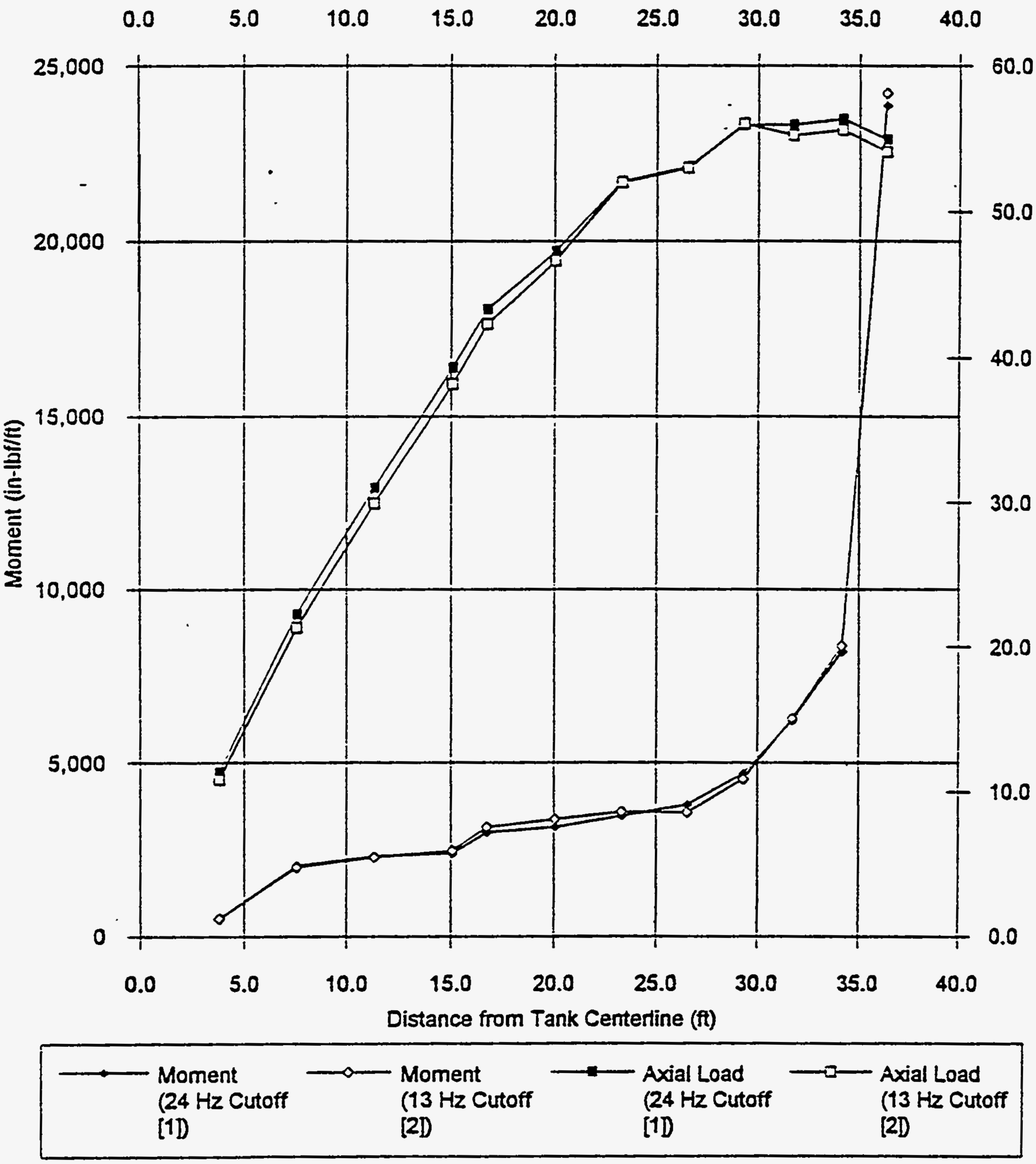
Figure A.4.2-5. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Analysis Cutoff Frequency



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = same as [1] but with 13 hz cutoff frequency.

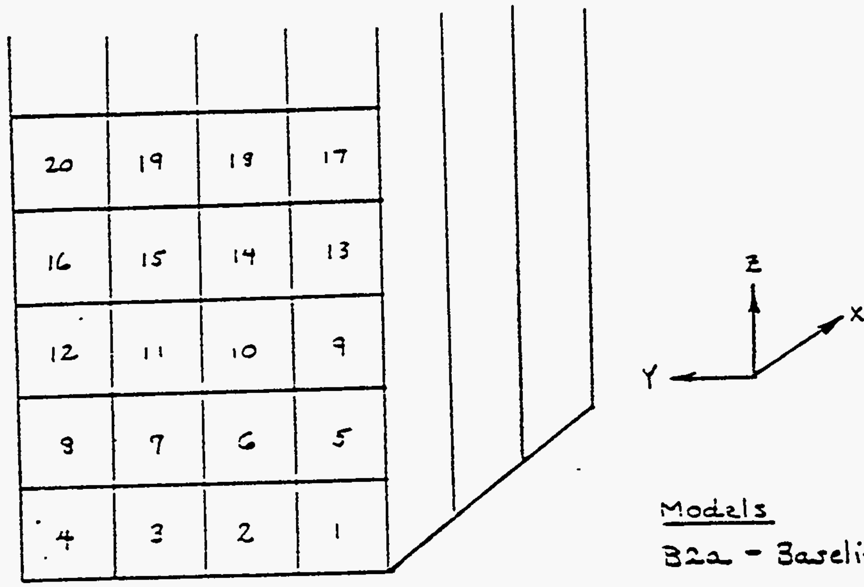
qlow\lanl\cmot50\7freq\CDOMEI.XLC

Figure A.4.2-6. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Analysis Cutoff Frequency



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = same as [1] but with 13 hz cutoff frequency.

qlow\lanl\cmot50\7freq\CDOMEO.XLC



Peak Accel.
32a: 0.6070
@ t=1.2050
DK: 0.6022
@ t=1.4000
CM: 0.6058
@ t=1.4000

Models
32a - Baseline
DK - nodes skipped
CM - mesh dens. change

Location 1

Model	Sxx	Syy	Sxy	Mxx	Myy	Mxy
32a	-52.96	-474.3	-30.67	-755.1	-4763	-437.5
DK	-52.30	-449.3	-26.35	718.4	4591	348.3
CM	-50.98	-447.6	-23.68	-762.9	-4937	-527.0
Location 10						
32a	-.948	-363.6	2.205	37.74	-2201	-8.73
DK	3.921	-339.1	-22.35	-103.9	1803	-107.1
CM	-4.596	-354.0	2.125	-73.11	-2181	-6.921
Location 18						
32a	0.875	-243.6	0.9459	74.51	-1325	24.76
DK	7.092	-219.4	-24.36	-76.33	1335	-28.16
CM	1.533	-235.3	0.9351	54.0	-1265	-12.43

Table A.2.1-1
Cantilever Test Model Results

Table A.2.2-1. Soil Layer Thicknesses Through Depth of Embedment.

	Coarse SASSI Model		Baseline SASSI Model	
Shear Wave Speed* (in/s)/(ft/s)	Soil Layer No.	Thickness (in)	Soil Layer No.	Thickness (in)
11,702 / 975	1	155	1	77.5
			2	77.5
18,454 / 1538	2	127	3	71
			4	56
18,071 / 1506	3	112	5	56
			6	56
17,790 / 1483	4	92	7	29
			8	63

* Best-estimate grout vault soil data (Dames and Moore 1988)

Table A.3.1-1
Comparison of Soil Profiles: Tank 241-C-106 vs. Tank 241-SY-101

Soil Layer	Thickness (in)	Unit Weight (lbf/ft^3)		Shear Wave Speed (ft/s)		Compression Wave Speed (ft/s)		% Damping	
		241-C-106	241-SY-101	241-C-106	241-SY-101	241-C-106	241-SY-101	241-C-106	241-SY-101
1	155	105	116	975	794	2979	1320	1.5	3.4
2	127	110	109	1538	826	4698	1577	1.5	5.8
3	112	110	109	1506	880	4601	1895	1.9	6.4
4	147	110	121	1483	868	4529	2015	2.2	7.4

Notes:
1. 241-C-106 data are based on Grout Vault soil data (Dames & Moore 1988).
2. 241-SY-101 data are from analysis by Giller & Weiner (1991).

SOILCOMP.XLS

Table A.4.1. Analysis Frequencies Chosen in Frequency Sensitivity Investigation.

Frequency (Hz)	Run Q3	Run Q4
0.29		X
0.59	X	X
0.78		X
0.98	X	X
1.22		X
1.51	X	X
1.76		X
2.00	X	X
2.29		X
2.59	X	X
2.98		X
3.42	X	X
3.91		X
4.39	X	X
4.98		X
5.52	X	X
6.15		X
6.79	X	X
7.37		X
8.01	X	X
8.98		X
10.0	X	X
11.5		X
13.0	X	X

Note: Analysis frequencies selected in the analysis are indicated by an "X".

Table A.4.2-1

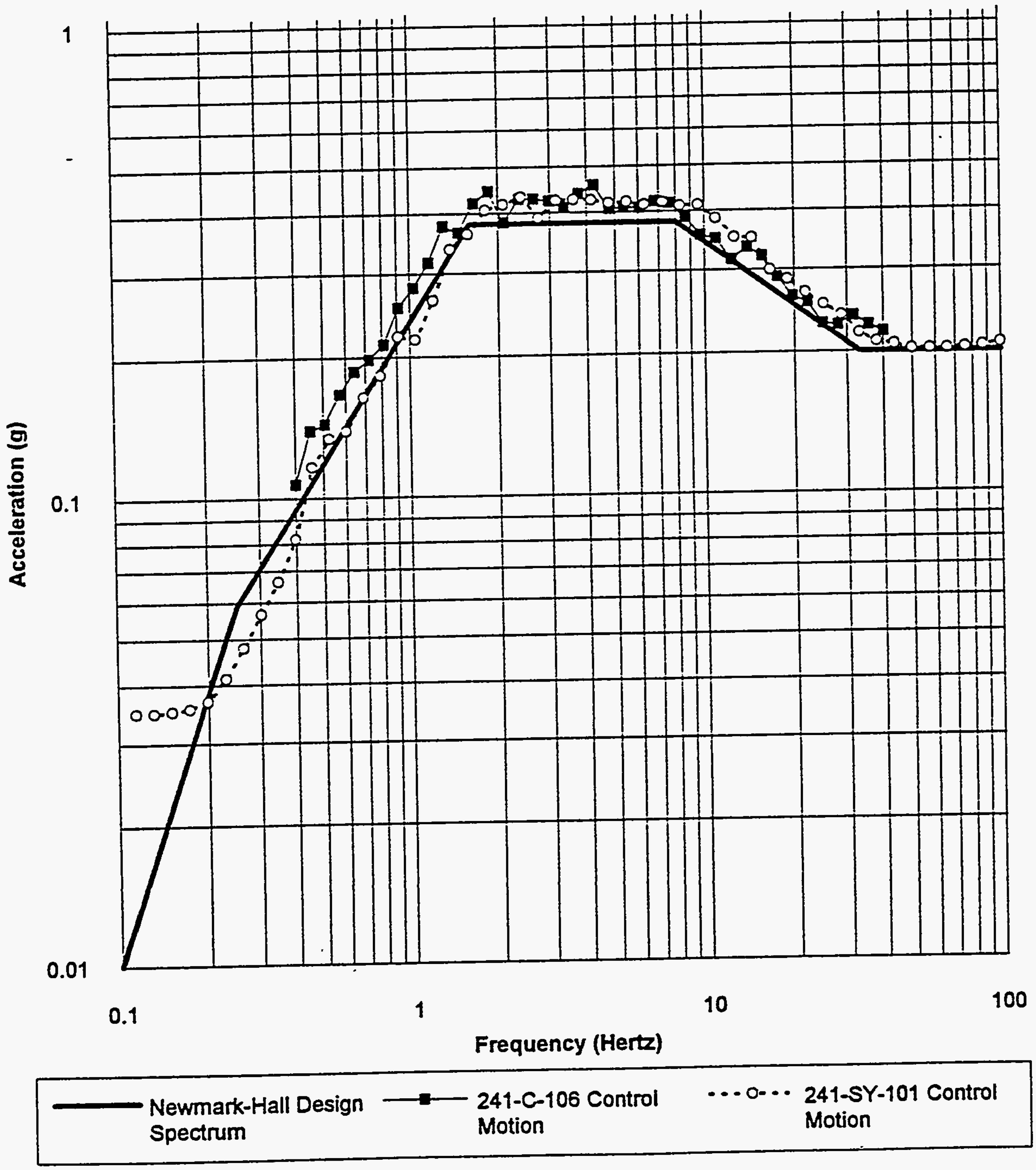
Sensitivity to Range and Number of Analysis Frequencies Using Lower-Bound Soil Properties

		Bending Moments (kip-ft/ft)		
Location	Direction	7 Frequencies 13 Hz Cutoff	18 Frequencies 24 Hz Cutoff	Ratio
Base	Merid.	0.420	0.438	0.96
Base	Circumf.	0.098	0.098	1.00
Wall	Merid.	8.465	8.478	1.00
Wall	Circumf.	1.711	1.711	1.00
Dome	Merid.	2.456	2.539	0.97
Dome	Circumf.	2.018	1.988	1.02

Notes:
1. Response is from the horizontal excitation.
2. Tabulated bending moments are the peak values within the region specified at the 180 deg. meridian.

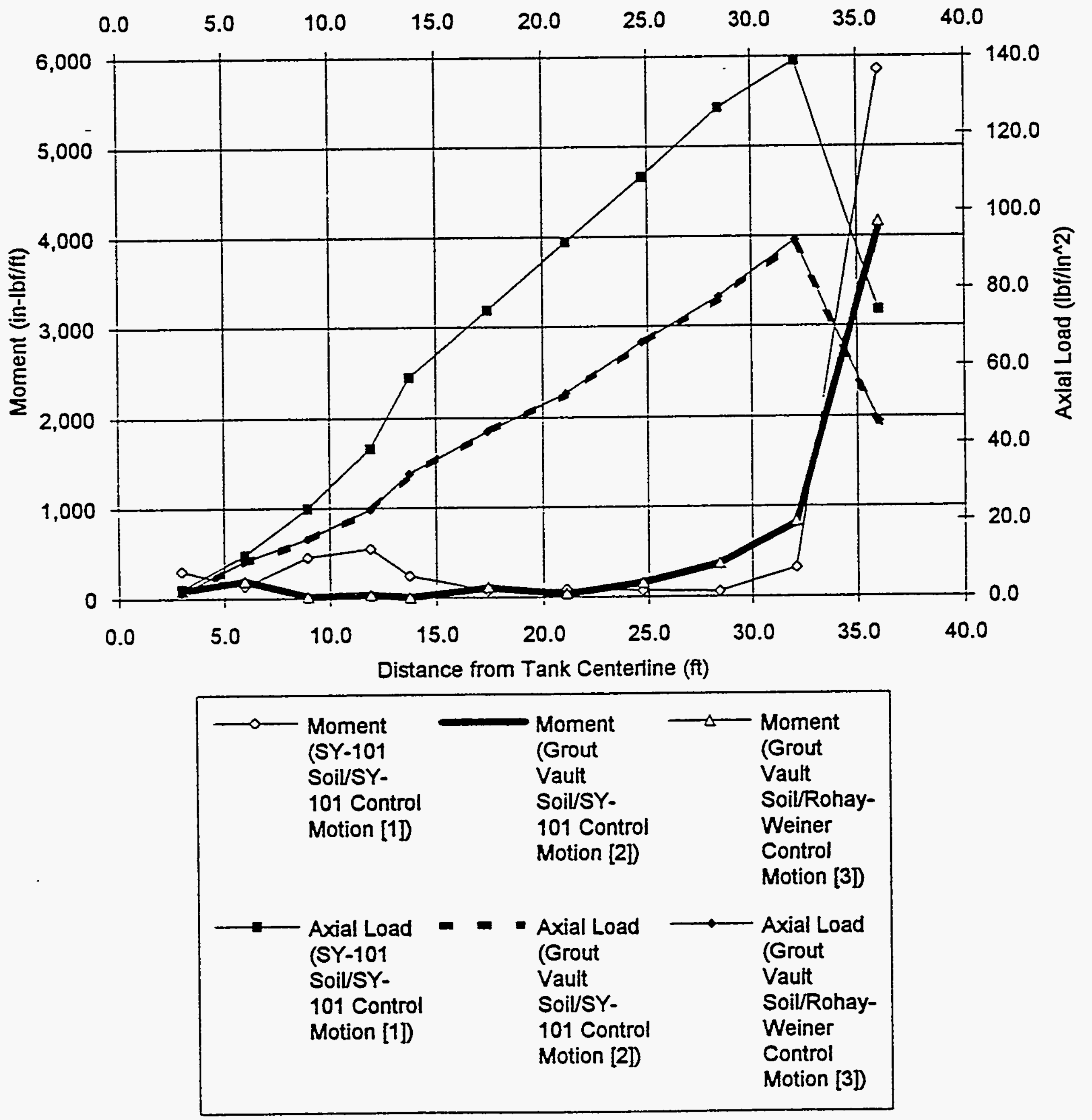
sassi\COMPTAB4.XLS

Figure A.3.1-1
Comparison of Horizontal Response Spectra (0.2 g Earthquake/7% Damping)



q7v\lanl\RESSY101.XLC

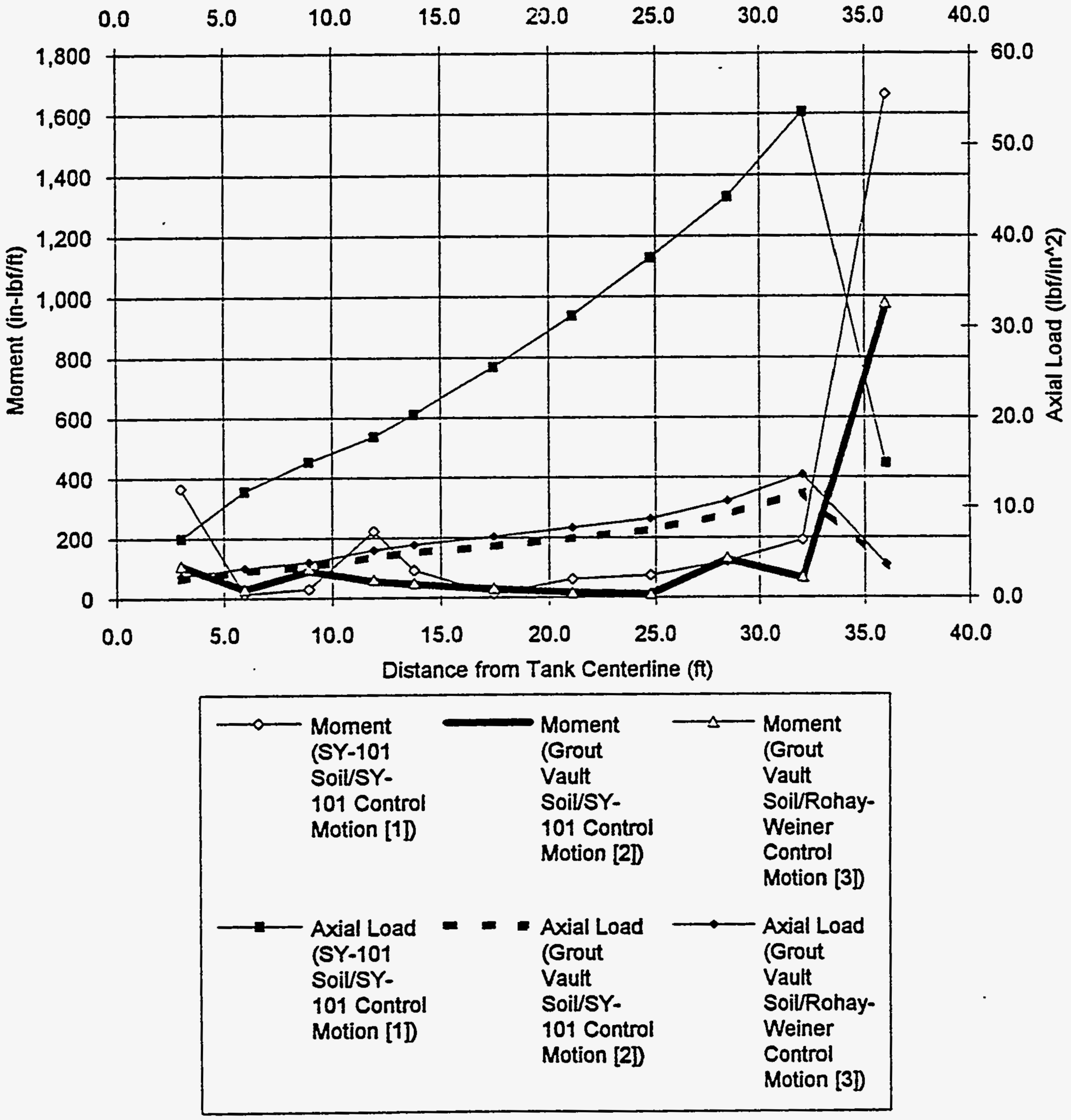
Figure A.3.1-2. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Change in Control Motion and Site Soil Profile



Note: [1] = Run ID "Q5", [2] = Run ID "Q5.5",[3] = Run ID "Q6".

q6\CBASEI.XLC

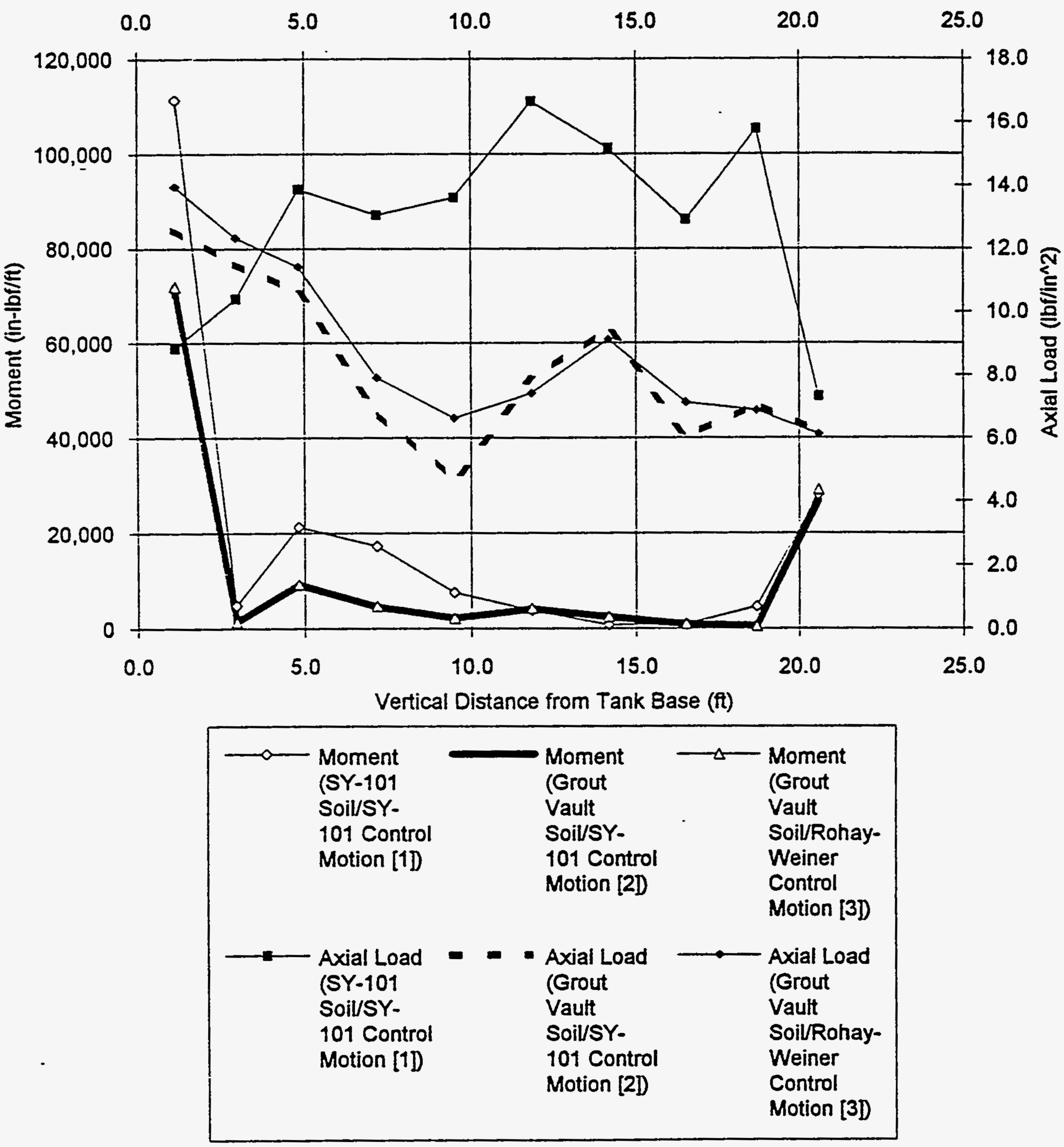
Figure A.3.1-3. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Change in Control Motion and Site Soil Profile



Note: [1] = Run ID "Q5", [2] = Run ID "Q5.5",[3] = Run ID "Q6".

q6\CBASEO.XLC

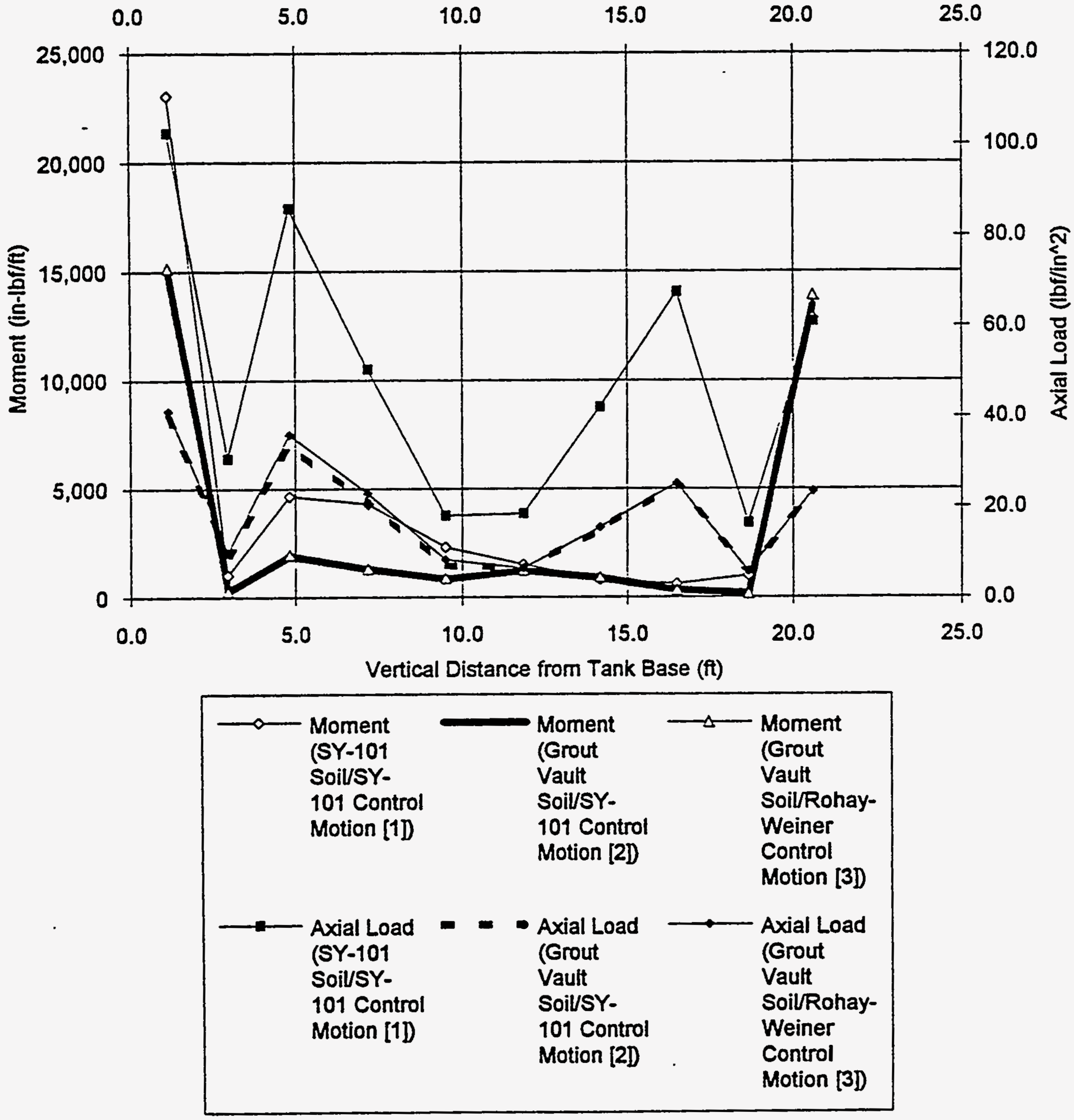
Figure A.3.1-4. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Change in Control Motion and Site Soil Profile



Note: [1] = Run ID "Q5", [2] = Run ID "Q5.5", [3] = Run ID "Q6".

q6\CWALLI.XLC

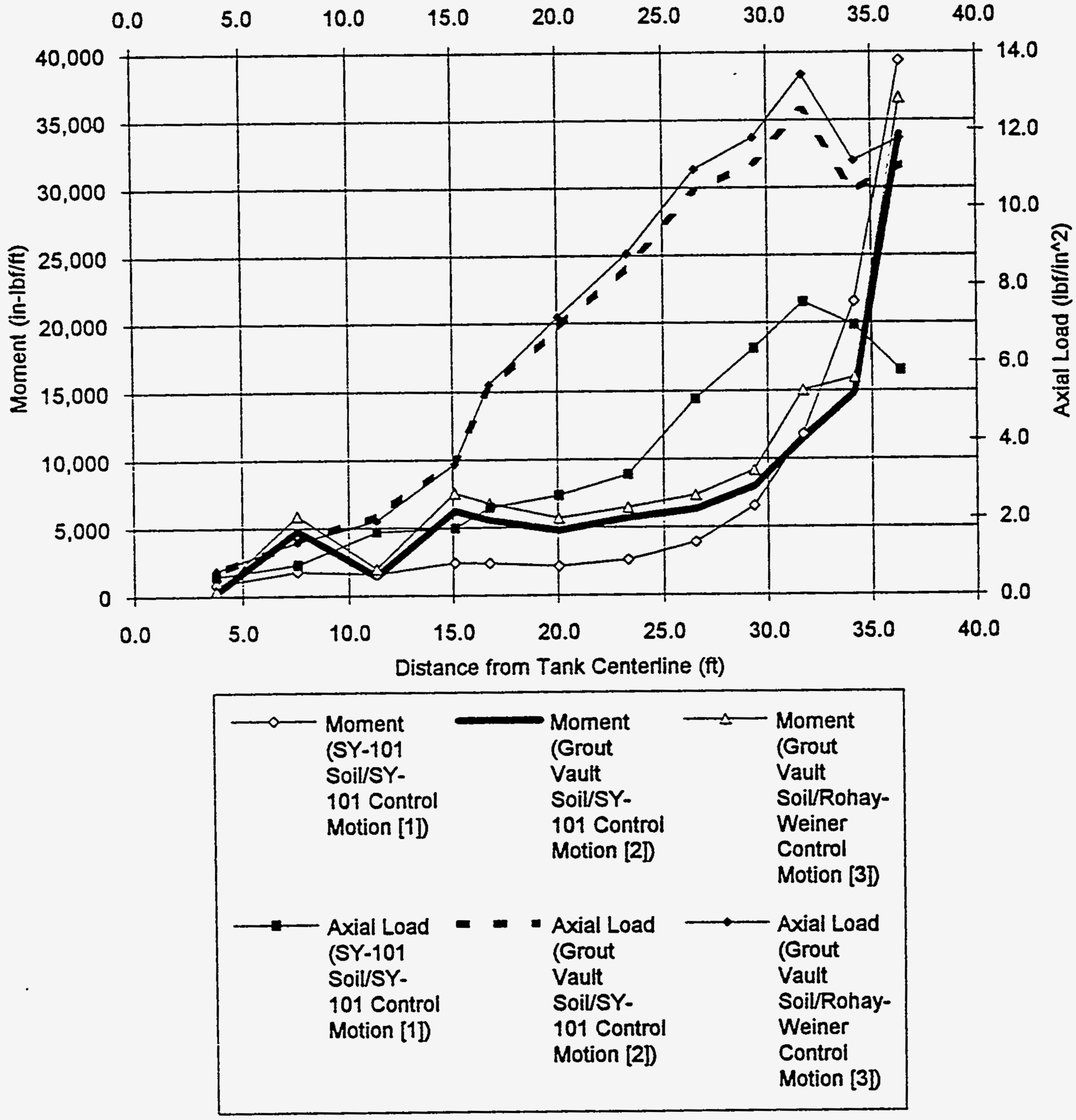
Figure A.3.1-5. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Change in Control Motion and Site Soil Profile



Note: [1] = Run ID "Q5", [2] = Run ID "Q5.5", [3] = Run ID "Q6".

q6\CWALLO.XLC

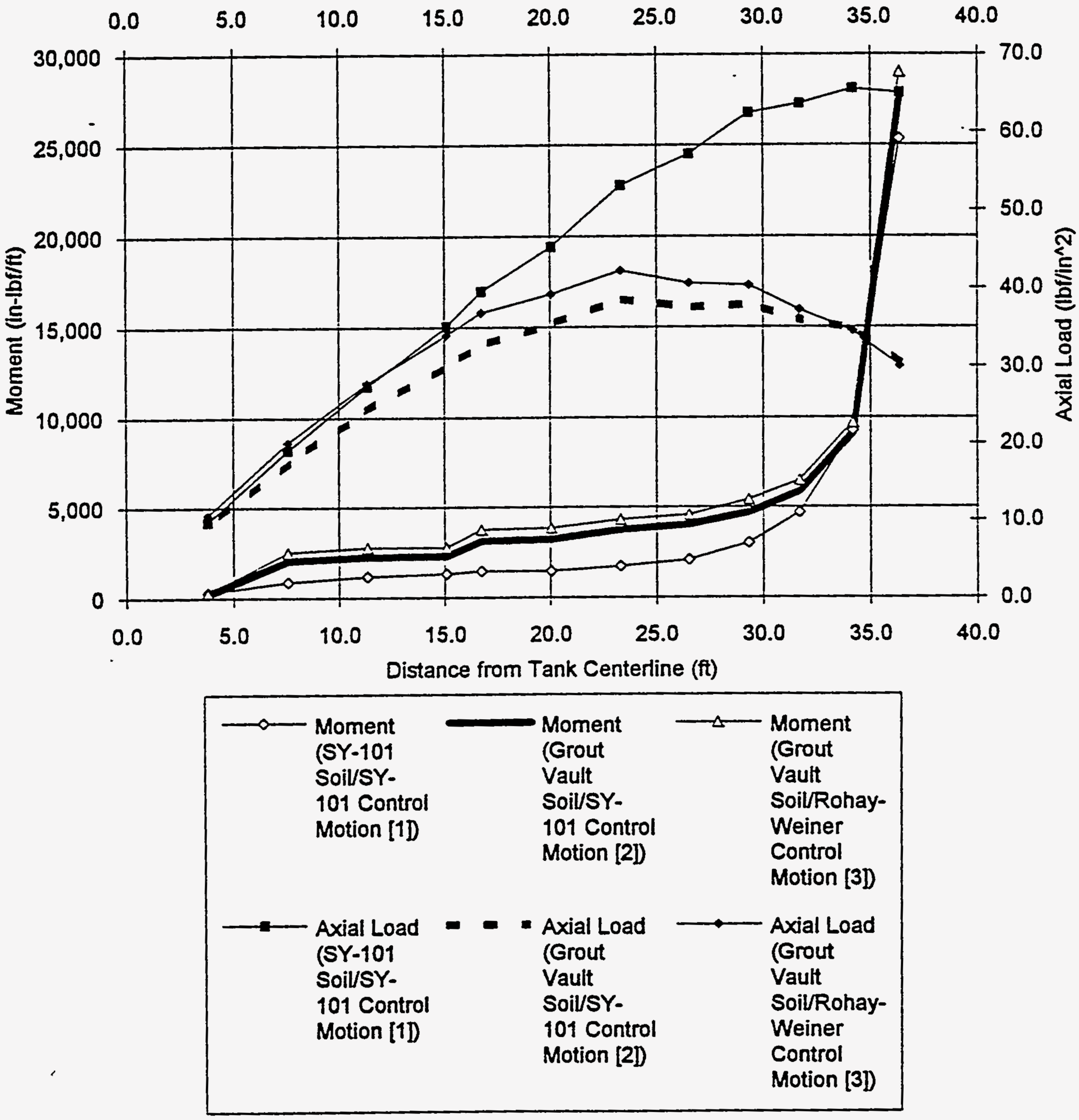
Figure A.3.1-6. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Change in Control Motion and Site Soil Profile



Note: [1] = Run ID "Q5", [2] = Run ID "Q5.5", [3] = Run ID "Q6".

q6\CDOMEI.XLC

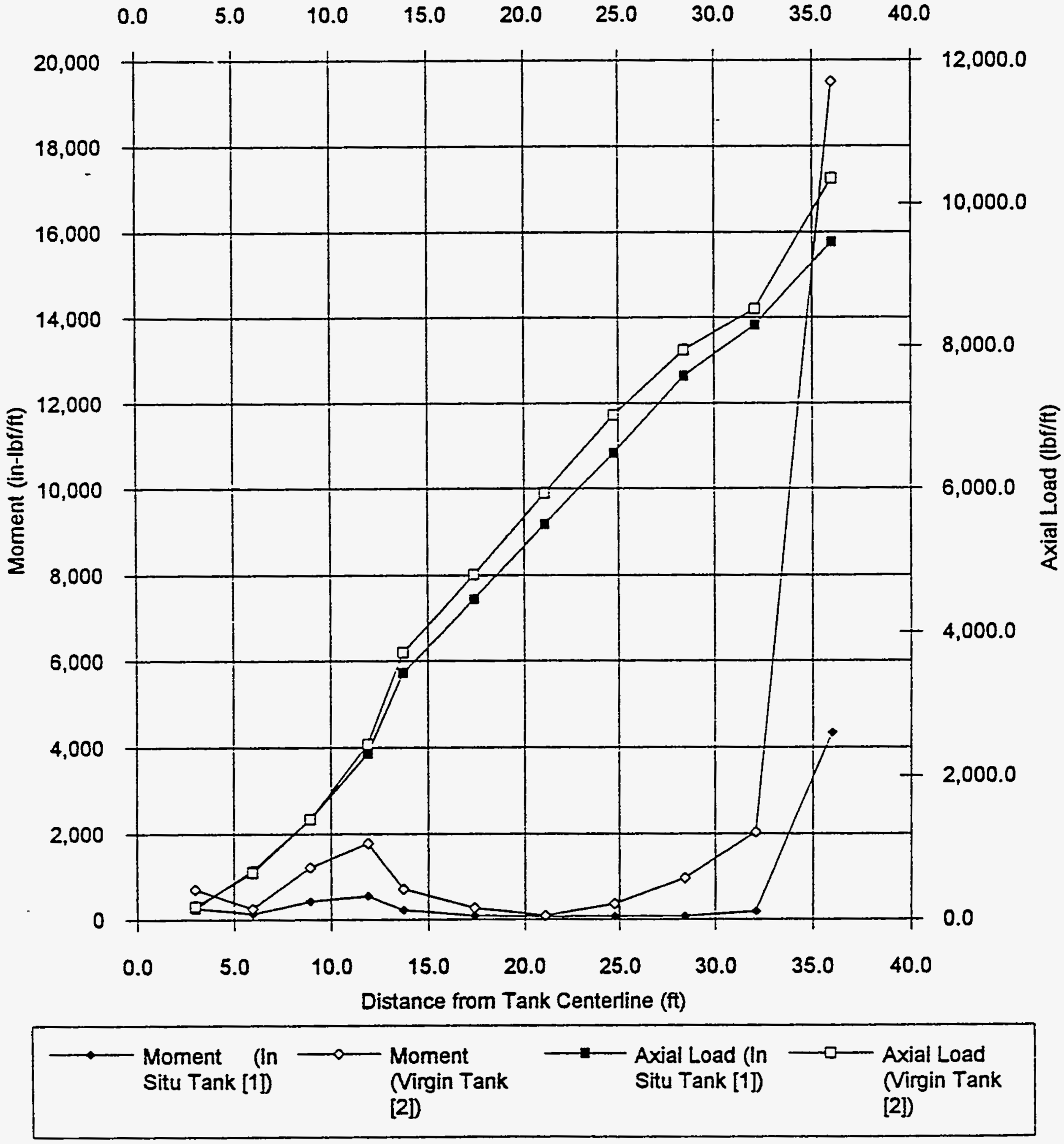
Figure A.3.1-7. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Change in Control Motion and Site Soil Profile



Note: [1] = Run ID "Q5", [2] = Run ID "Q5.5", [3] = Run ID "Q6".

q6\CDOMEO.XLC

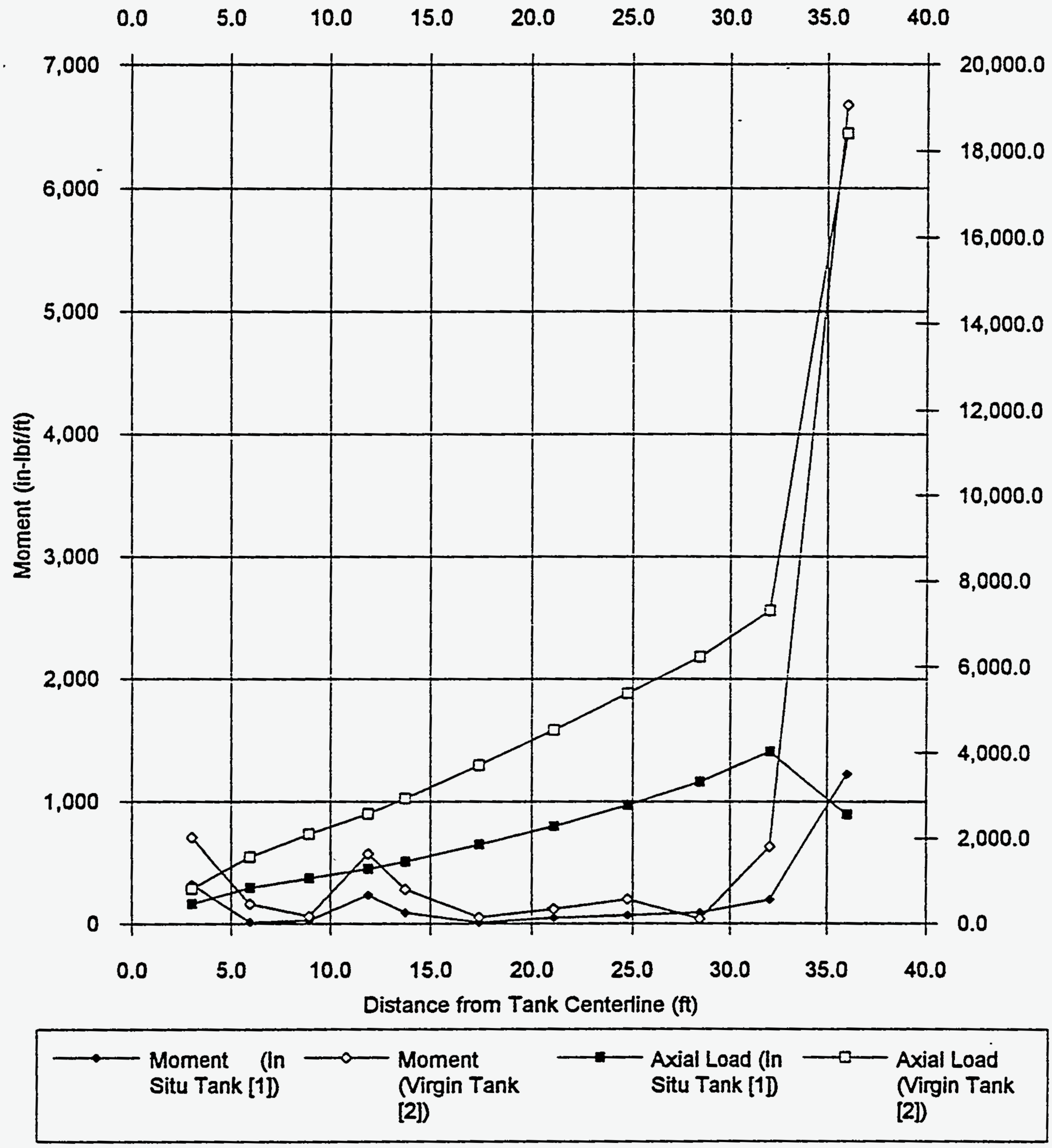
Figure A.3.2-1. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: In Situ Tank vs. Virgin Tank



Note: [1] = Run ID "Q3", [2] = Run ID "Q2".

q3\anl\CBASEI.XLC

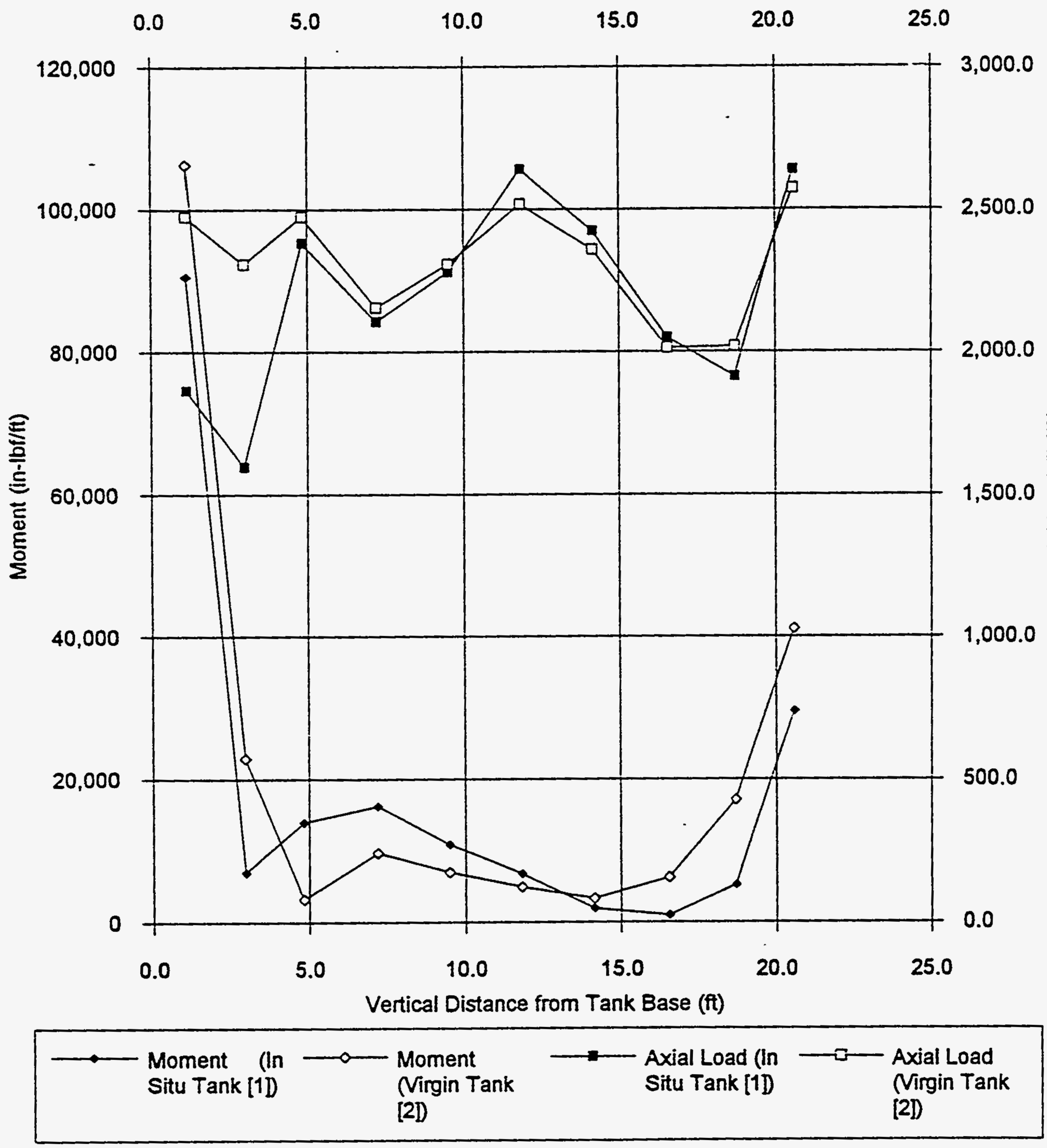
Figure A.3.2-2. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: In Situ Tank vs. Virgin Tank



Note: [1] = Run ID "Q3", [2] = Run ID "Q2".

q3\lanl\CBASEO.XLC

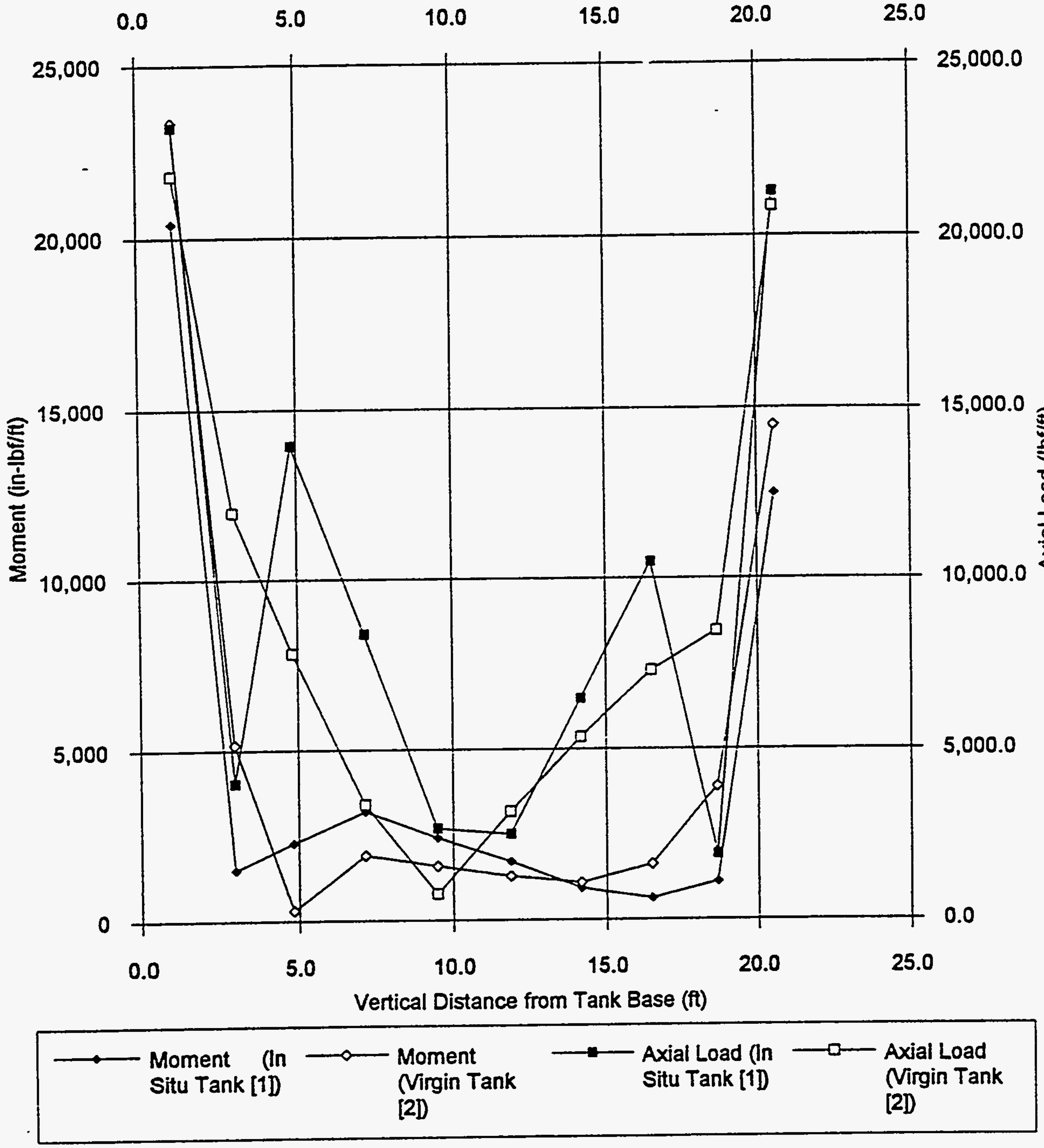
Figure A.3.2-3. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: In Situ Tank vs. Virgin Tank



Note: [1] = Run ID "Q3", [2] = Run ID "Q2".

q3\anl\CWALLI.XLC

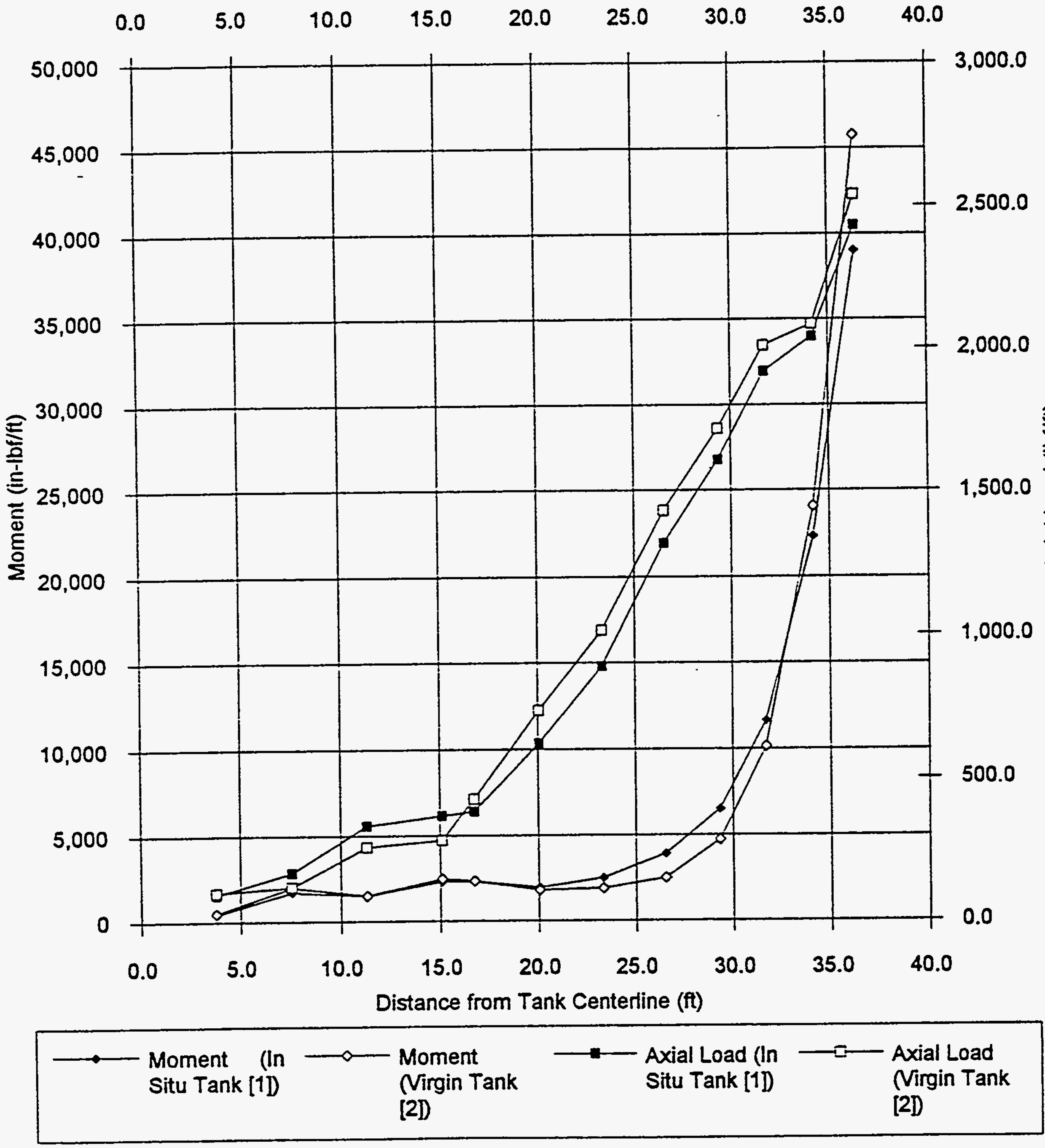
Figure A.3.2-4. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: In Situ Tank vs. Virgin Tank



Note: [1] = Run ID "Q3", [2] = Run ID "Q2".

q3\anl\CWALLO.XLC

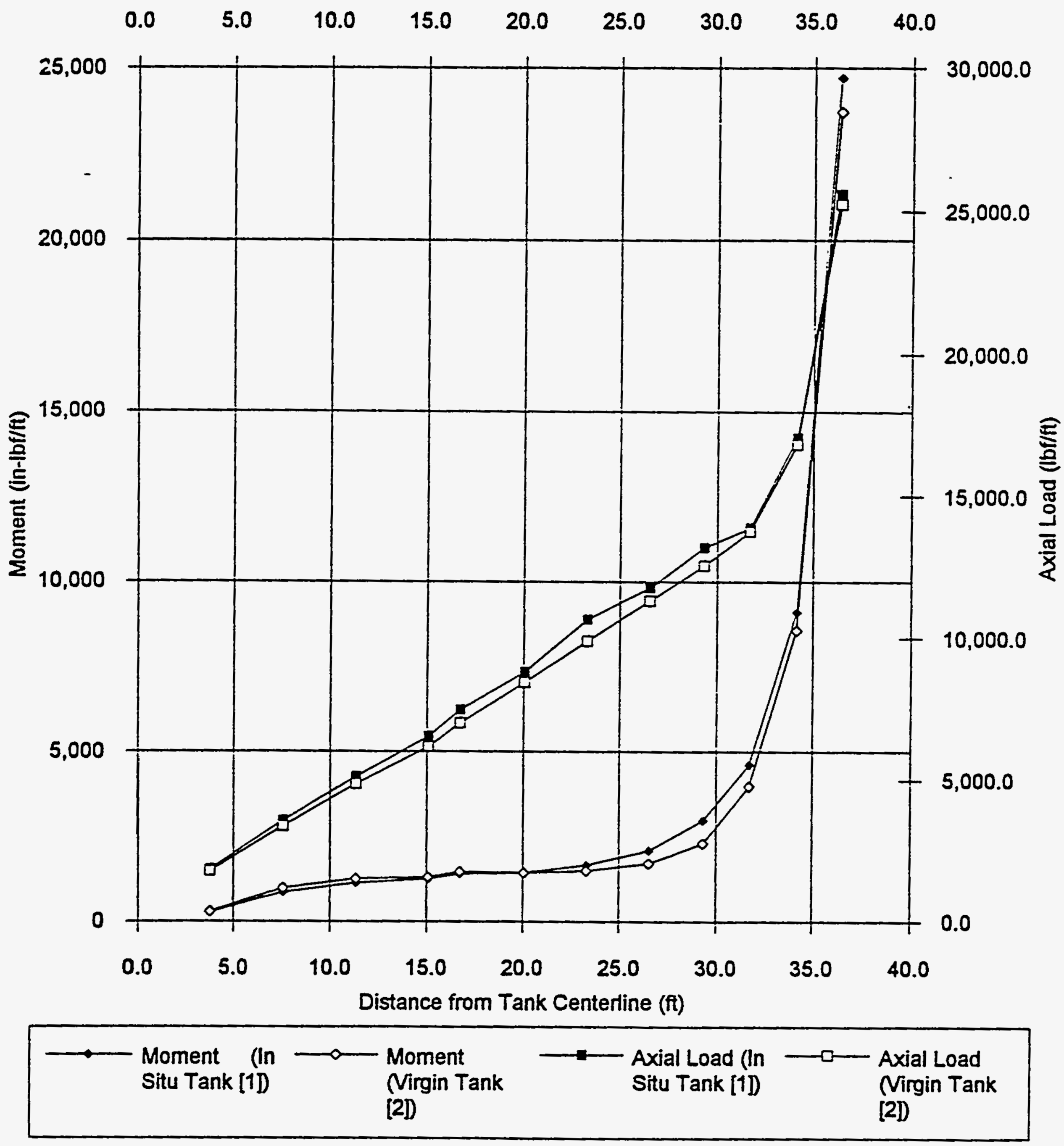
Figure A.3.2-5. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: In Situ Tank vs. Virgin Tank



Note: [1] = Run ID "Q3", [2] = Run ID "Q2".

q3\anl\CDOMEI.XLC

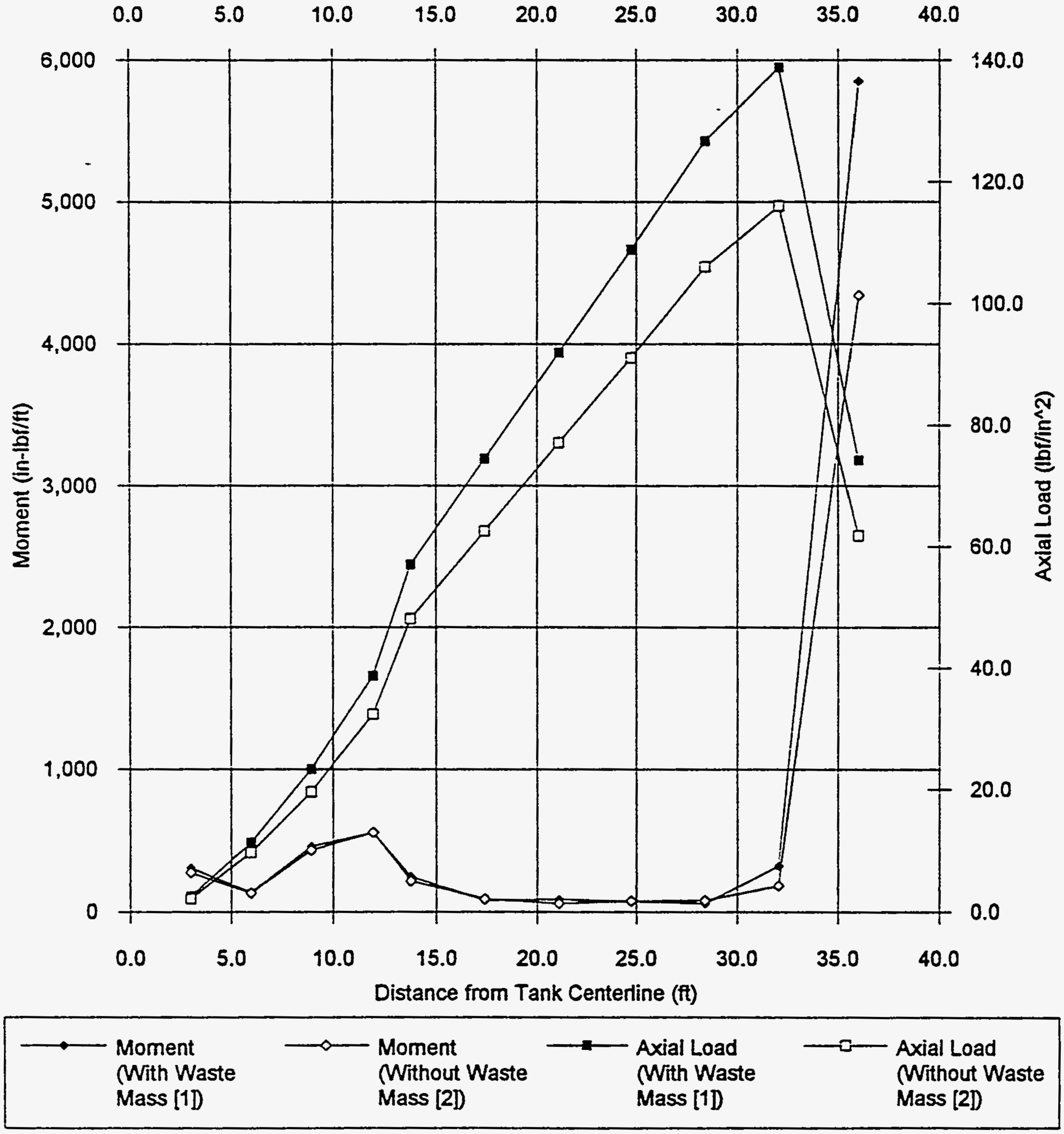
Figure A.3.2-6. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: In Situ Tank vs. Virgin Tank



Note: [1] = Run ID "Q3", [2] = Run ID "Q2".

q3\anl\CDOMEO.XLC

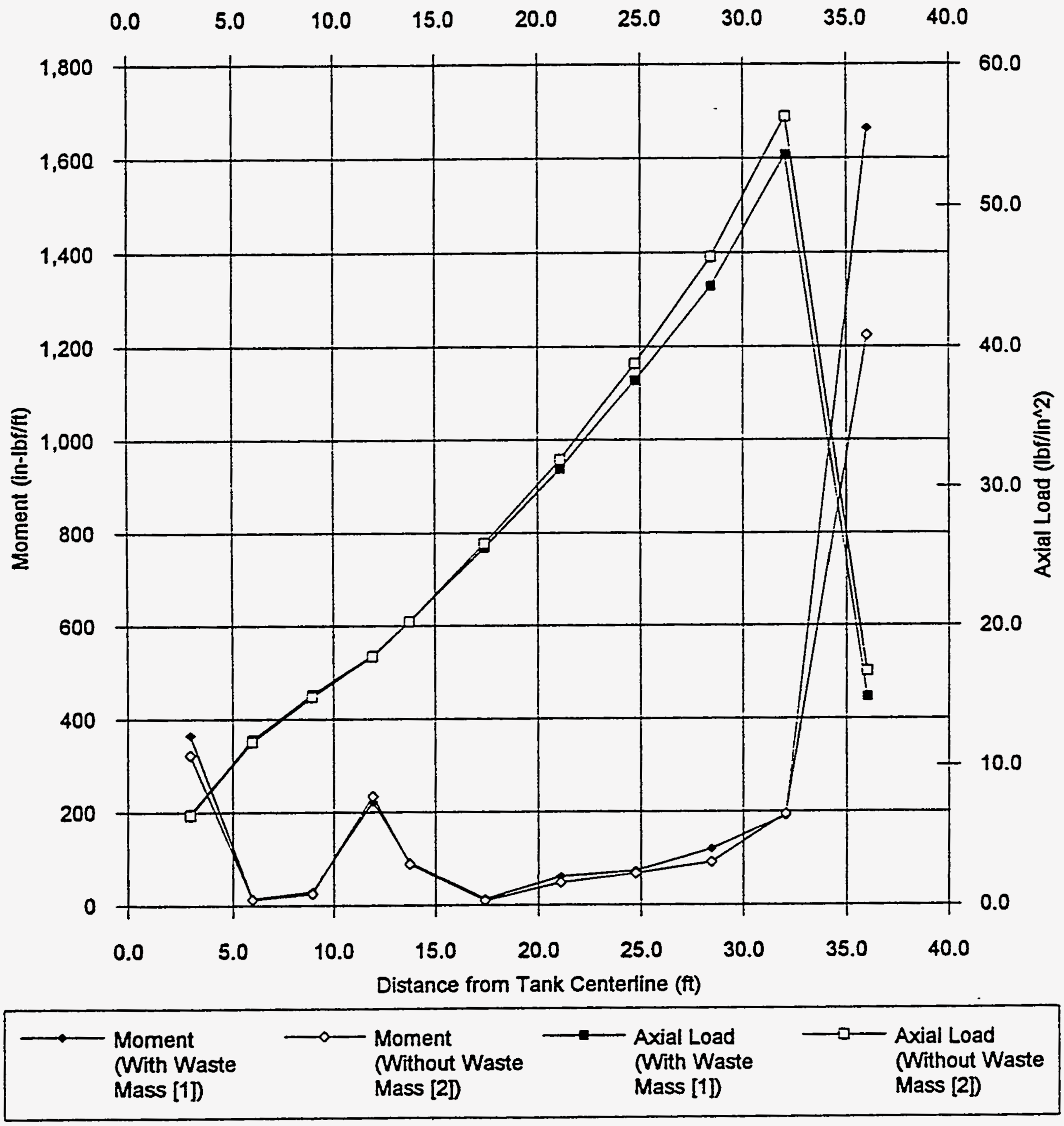
Figure A.3.3-1. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Effect of Waste Mass



Note: [1] = Run ID "Q5", [2] = Run ID "Q3".

q5\CBASEI.XLC

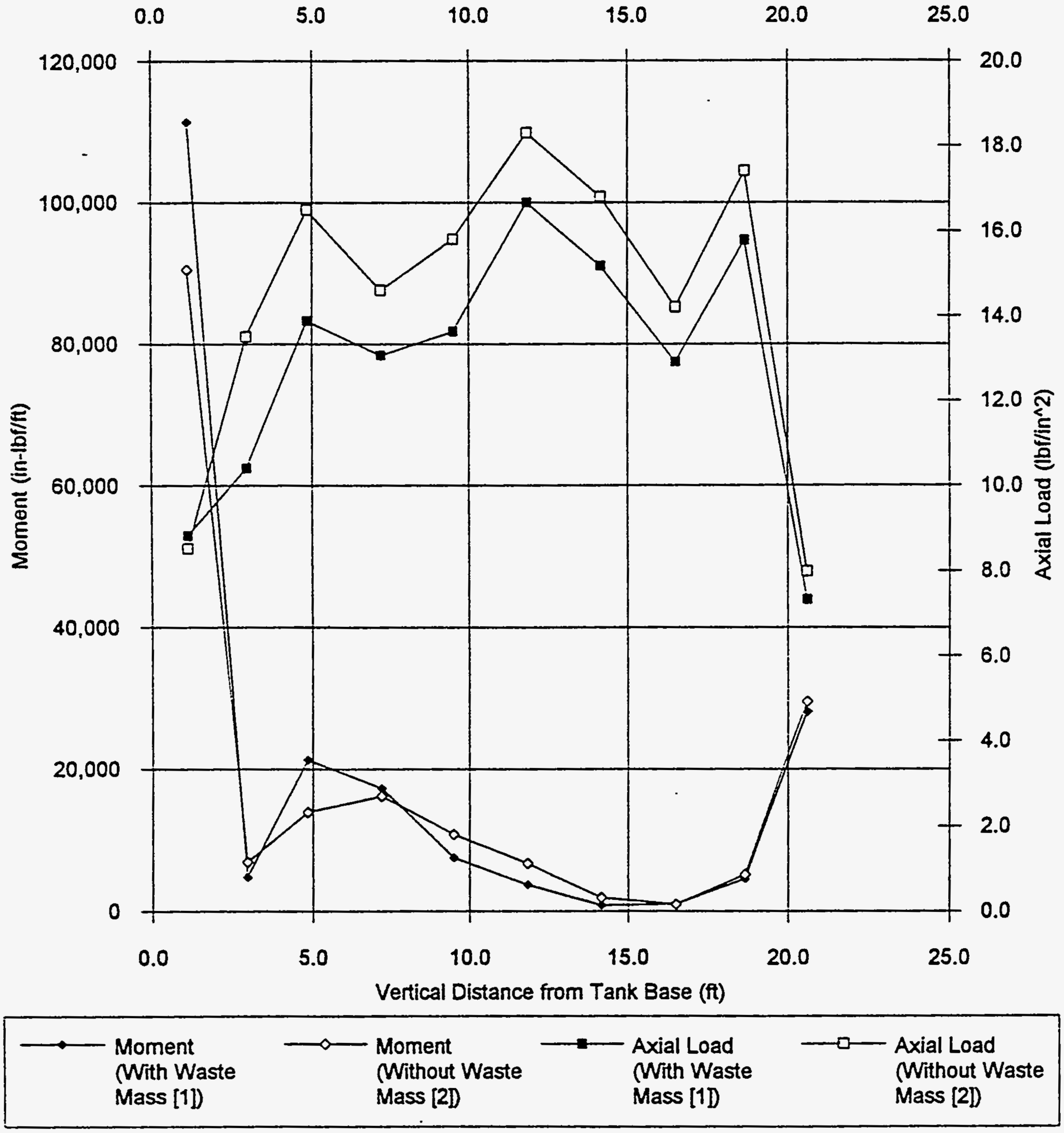
Figure A.3.3-2. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Effect of Waste Mass



Note: [1] = Run ID "Q5", [2] = Run ID "Q3".

q5\CBASEO.XLC

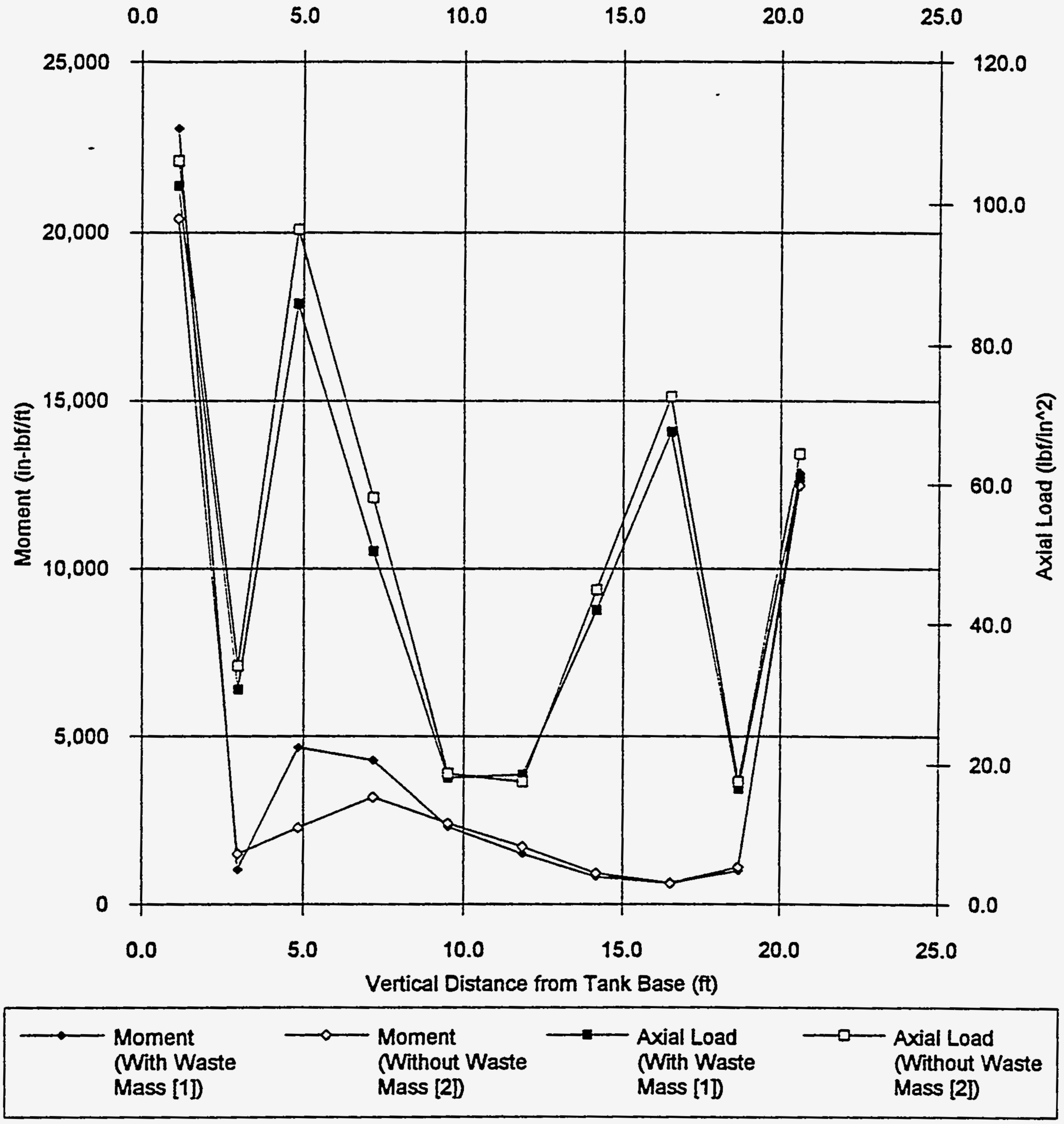
Figure A.3.3-3. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Effect of Waste Mass



Note: [1] = Run ID "Q5", [2] = Run ID "Q3".

q5\CWALLI.XLC

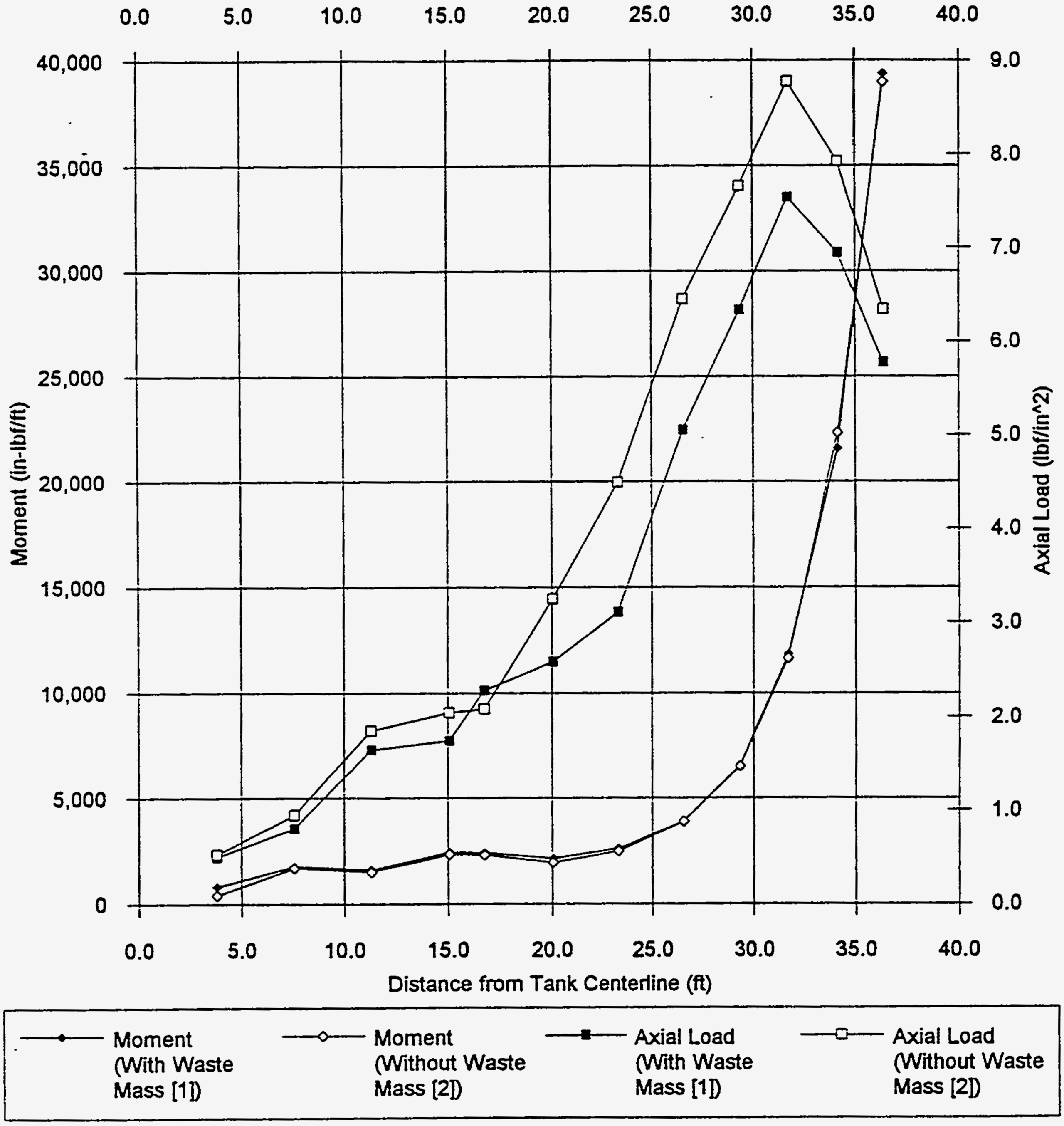
Figure A.3.3-4. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Effect of Waste Mass



Note: [1] = Run ID "Q5", [2] = Run ID "Q3".

q5\CWALLO.XLC

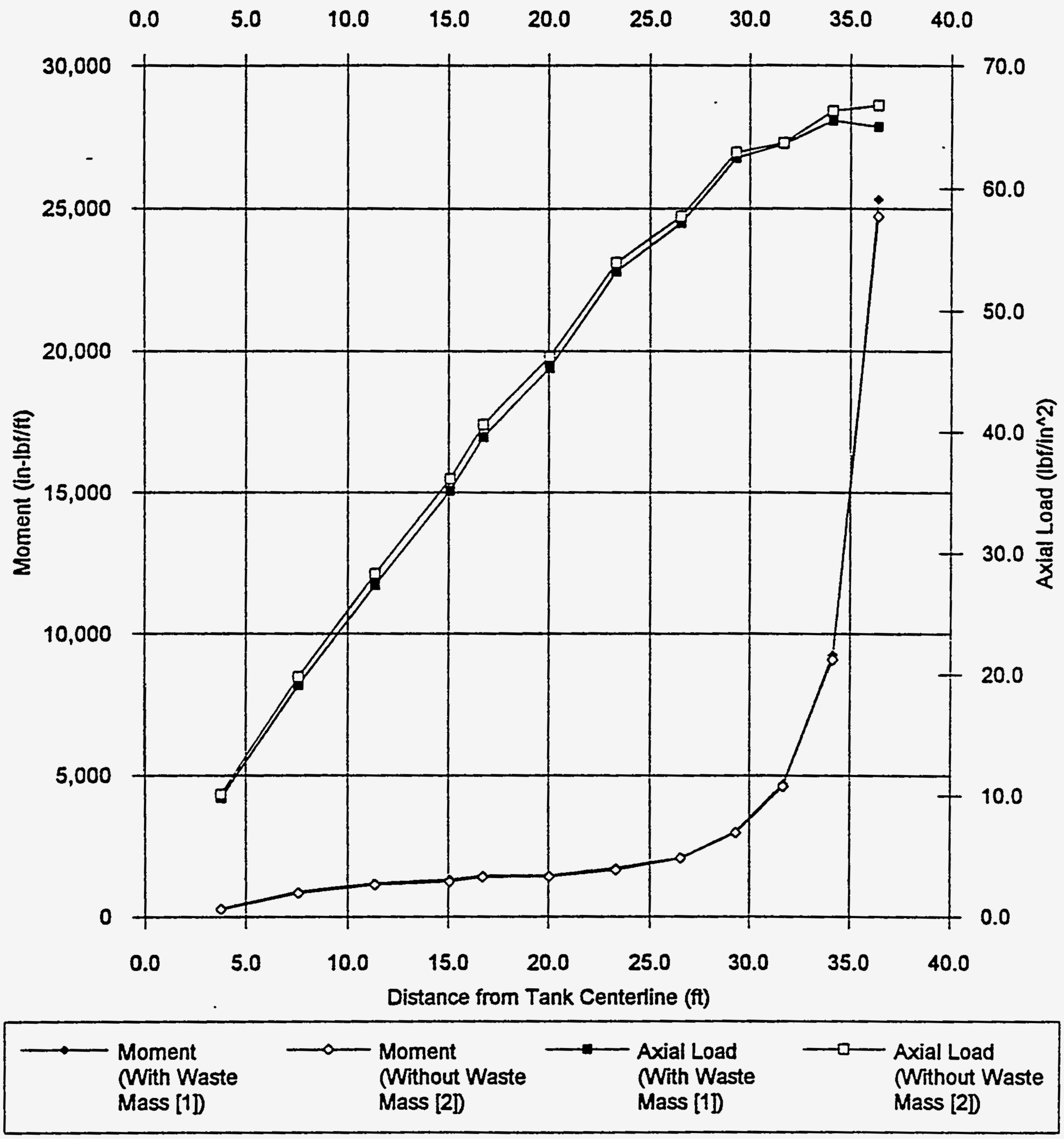
Figure A.3.3-5. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Effect of Waste Mass



Note: [1] = Run ID "Q5", [2] = Run ID "Q3".

q5\CDOMEI.XLC

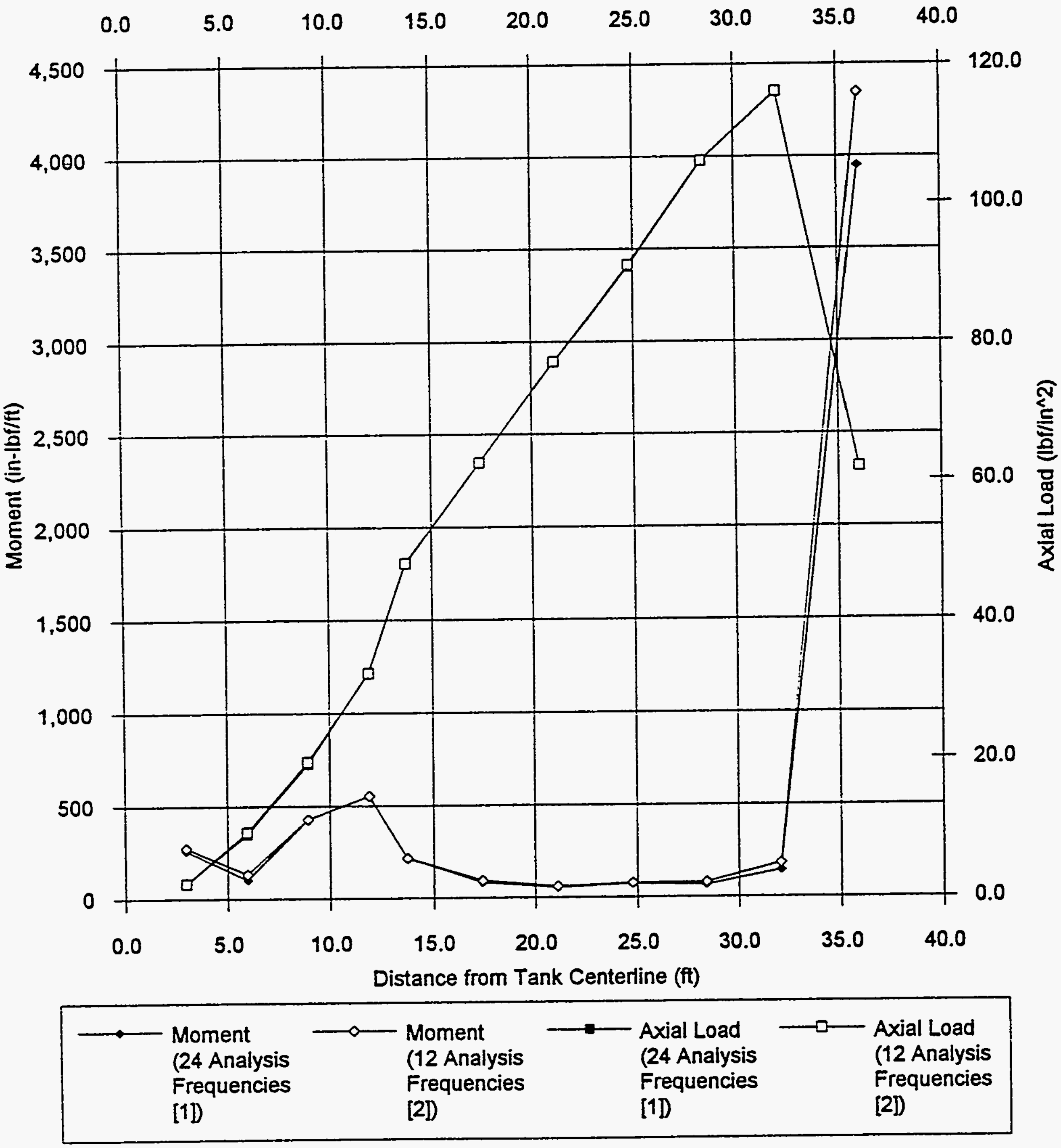
Figure A.3.3-6. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Effect of Waste Mass



Note: [1] = Run ID "Q5", [2] = Run ID "Q3".

q5\CDOMEO.XLC

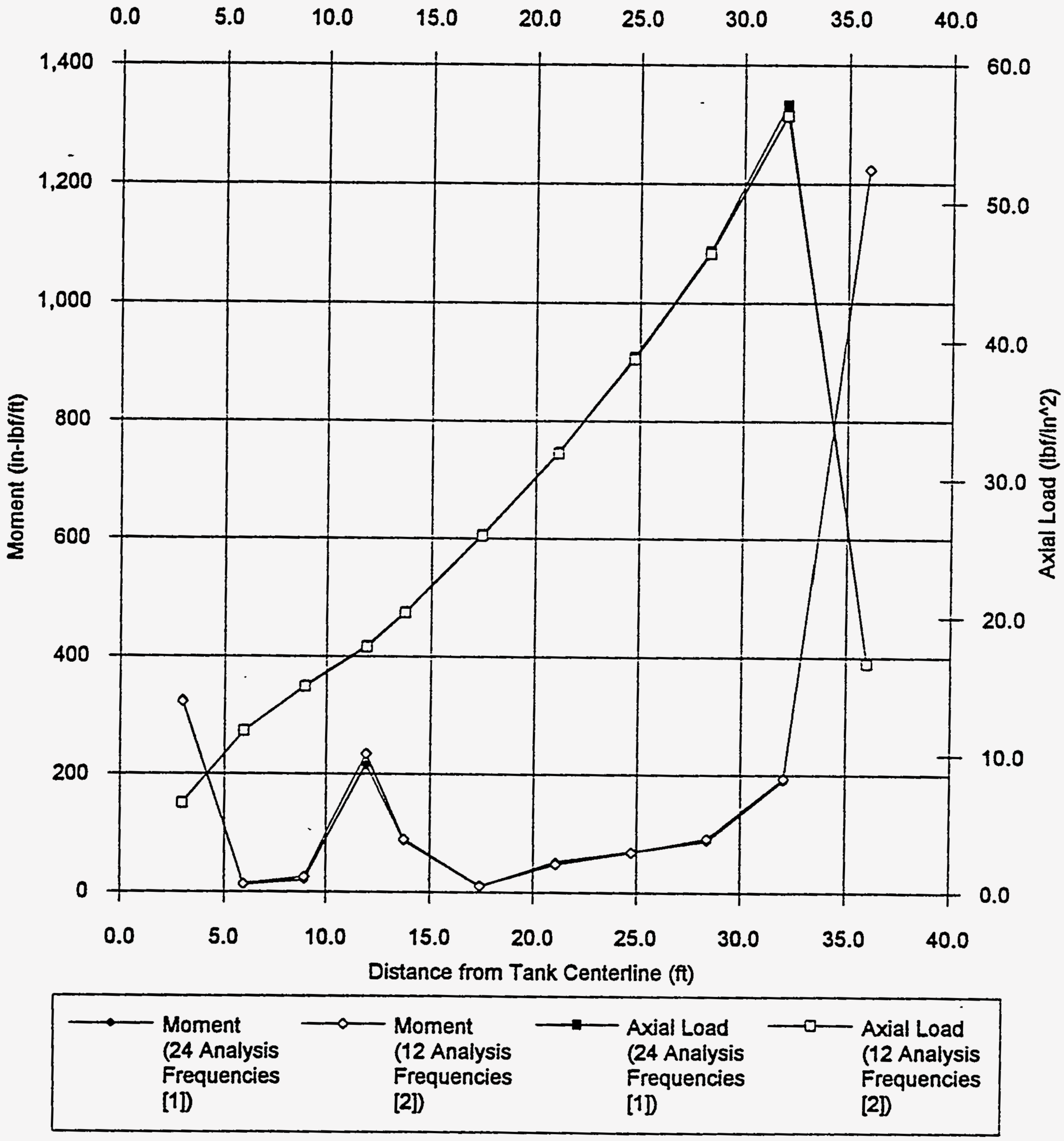
Figure A.4.1-1. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Number of Analysis Frequencies



Note: [1] = Run ID "Q4", [2] = Run ID "Q3".

q4\CBASEI.XLC

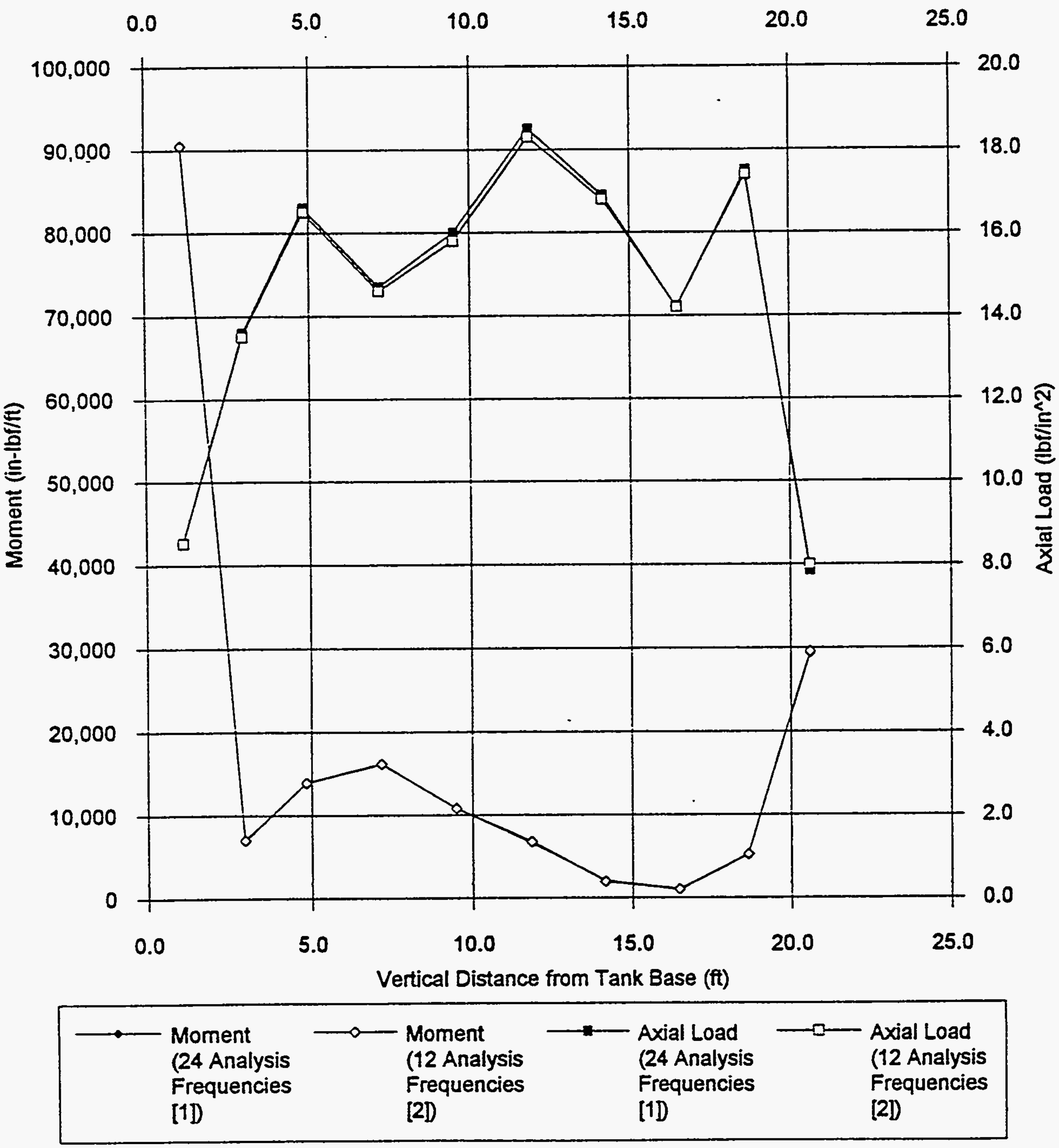
Figure A.4.1-2. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Number of Analysis Frequencies



Note: [1] = Run ID "Q4", [2] = Run ID "Q3".

q4\CBASEO.XLC

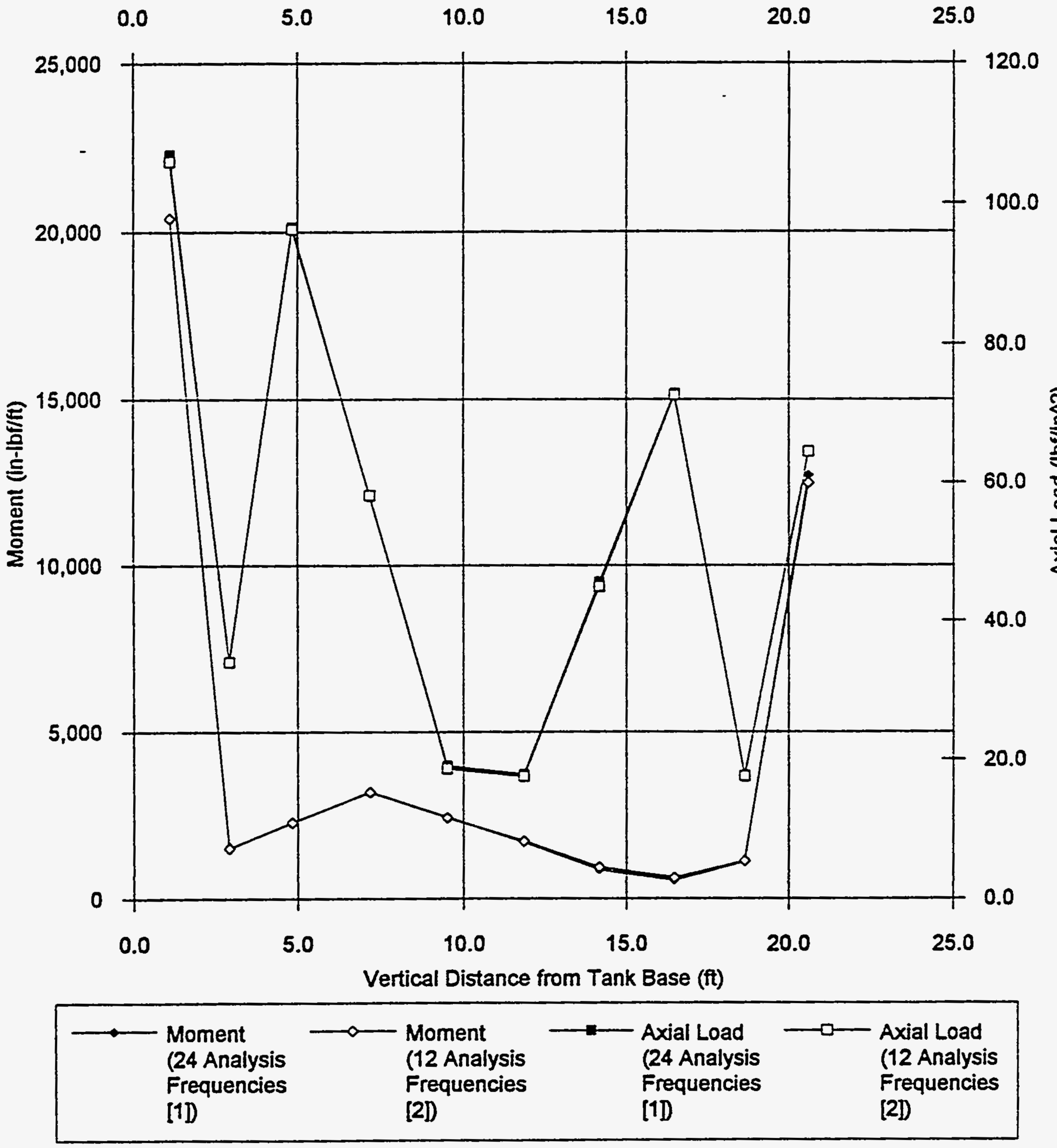
Figure A.4.1-3. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Number of Analysis Frequencies



Note: [1] = Run ID "Q4", [2] = Run ID "Q3".

q4\CWALLI.XLC

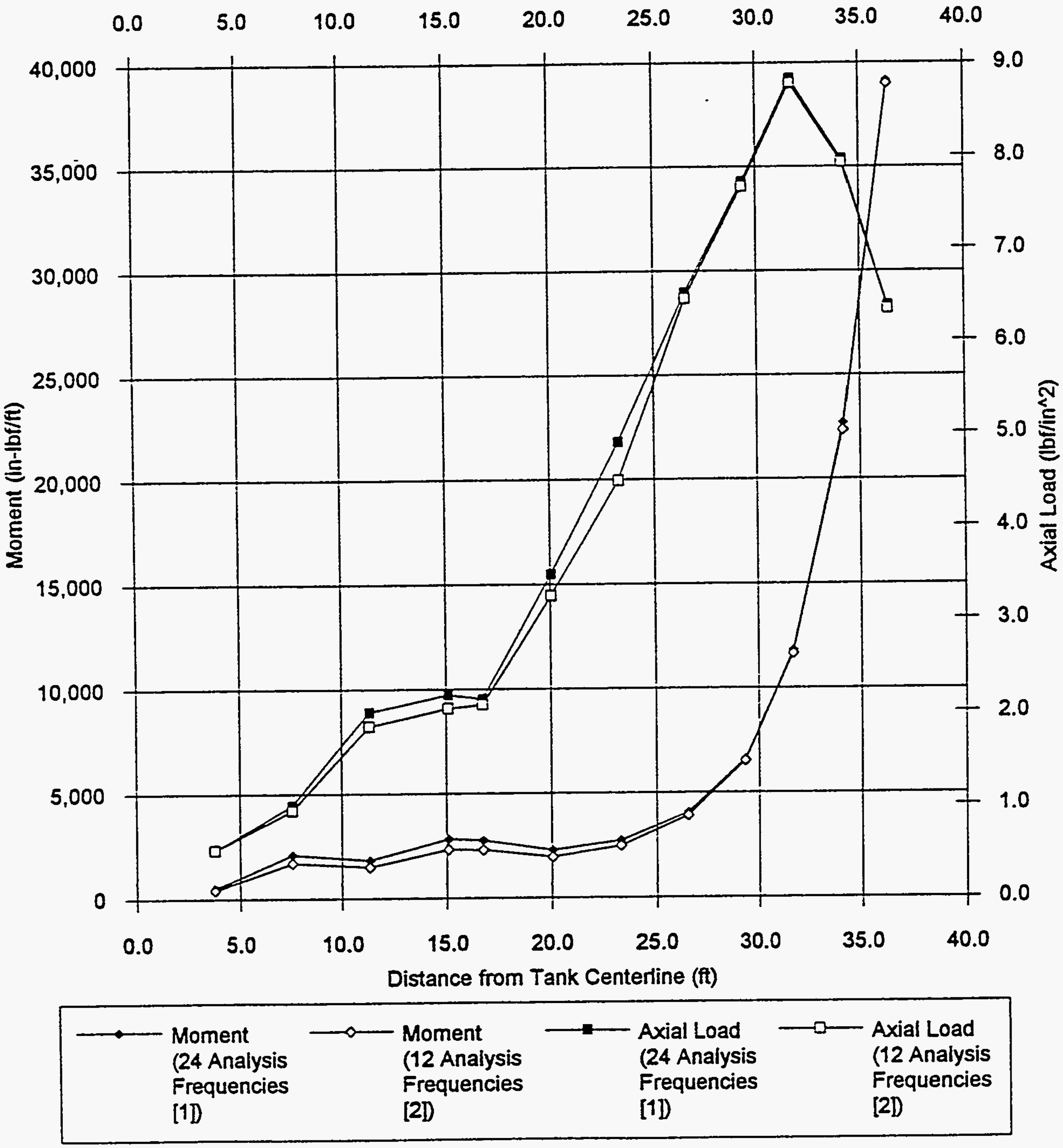
Figure A.4.1-4. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Number of Analysis Frequencies



Note: [1] = Run ID "Q4", [2] = Run ID "Q3".

q4\CWALLO.XLC

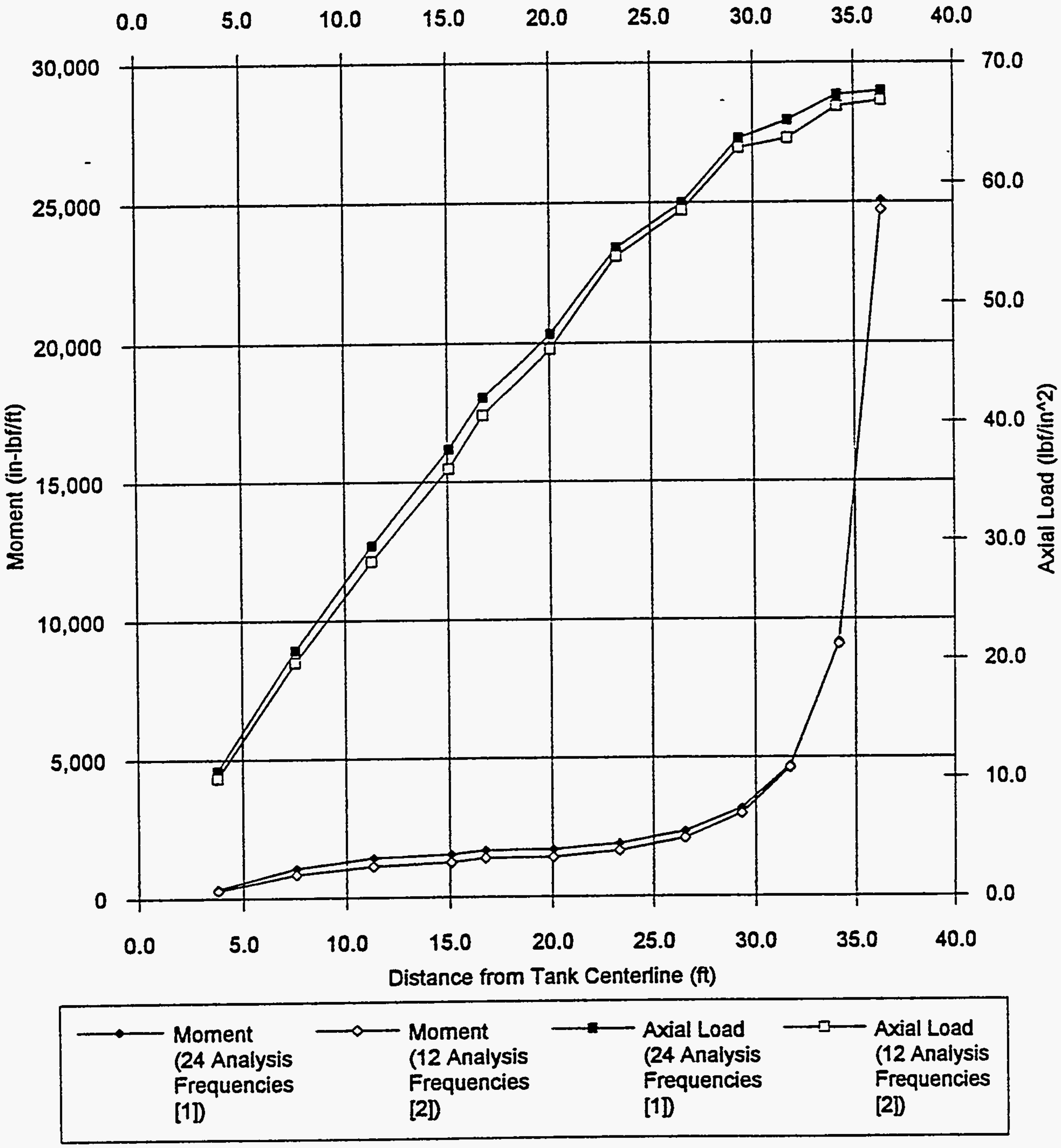
Figure A.4.1-5. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Number of Analysis Frequencies



Note: [1] = Run ID "Q4", [2] = Run ID "Q3".

q4\CDOMEI.XLC

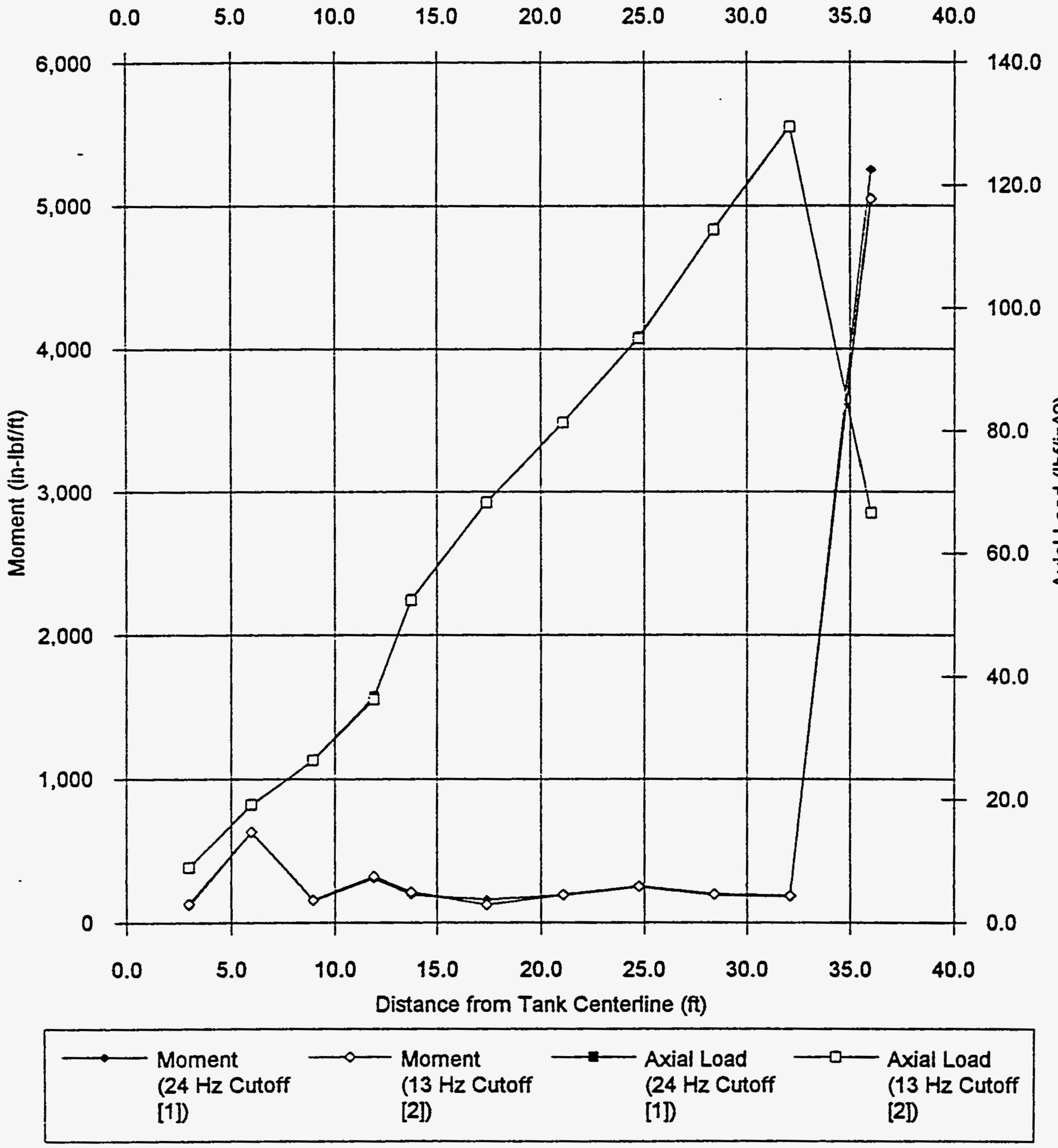
Figure A.4.1-6. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Number of Analysis Frequencies



Note: [1] = Run ID "Q4", [2] = Run ID "Q3".

q4\CDOMEO.XLC

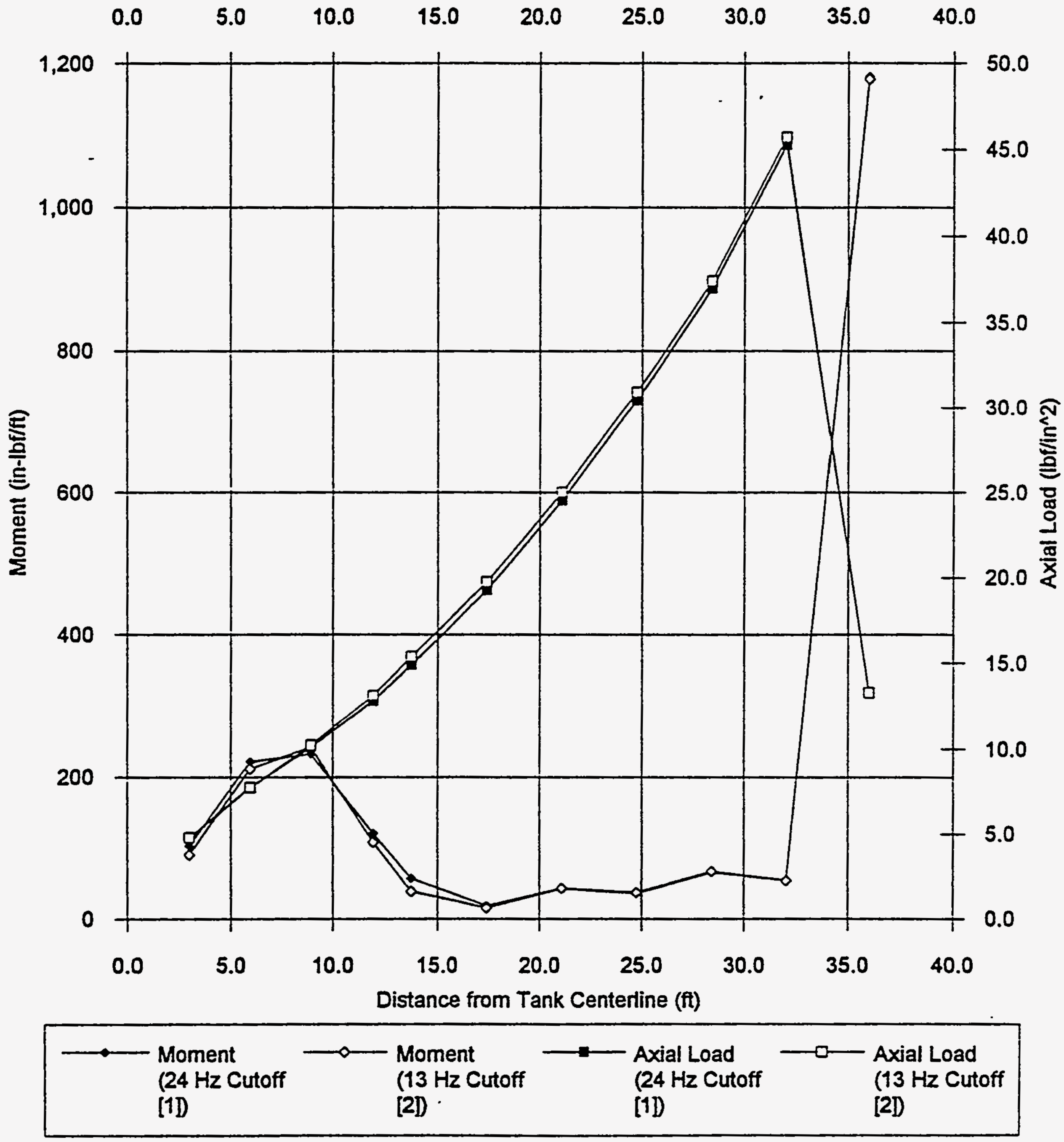
Figure A.4.2-1. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Analysis Cutoff Frequency



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = same as [1] but with 13 hz cutoff frequency.

qlow\lanl\cmot50\7freq\CBASEI.XLC

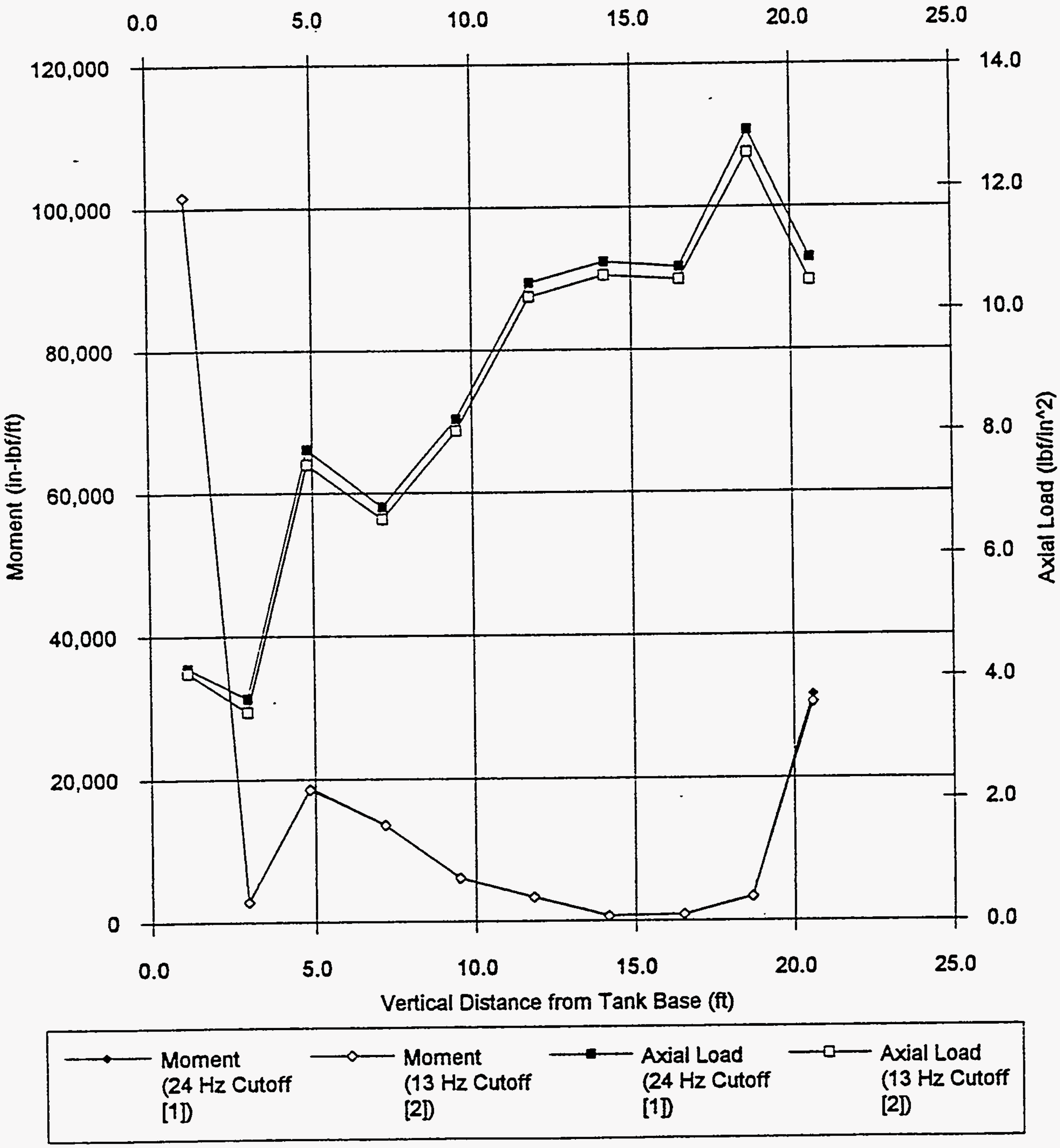
Figure A.4.2-2. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Analysis Cutoff Frequency



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = same as [1] but with 13 hz cutoff frequency.

qlow\lanl\cmot50\7freq\CBASEO.XLC

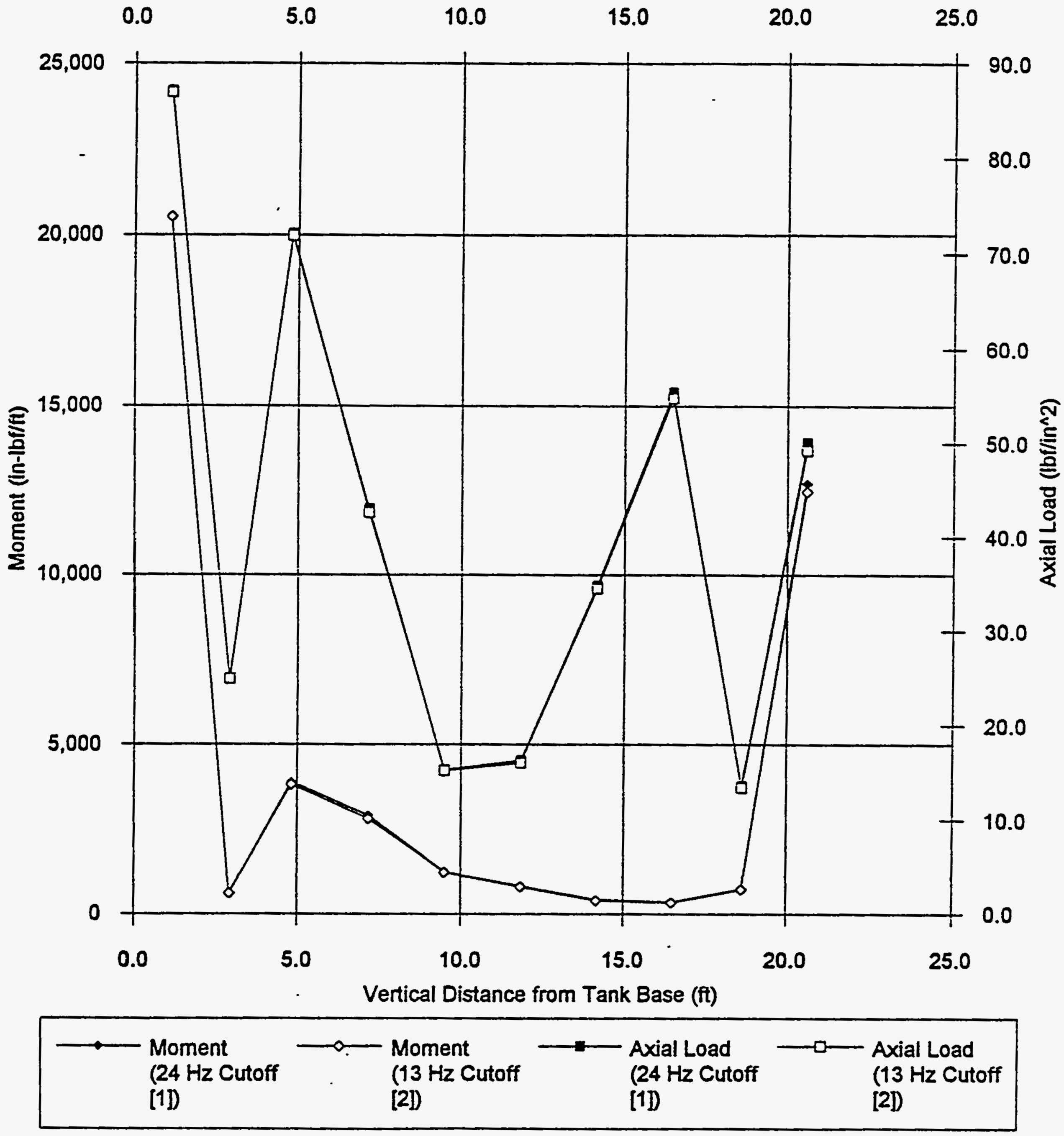
Figure A.4.2-3. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Analysis Cutoff Frequency



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = same as [1] but with 13 hz cutoff frequency.

qlow\lanl\cmot50\7freq\CWALLI.XLC

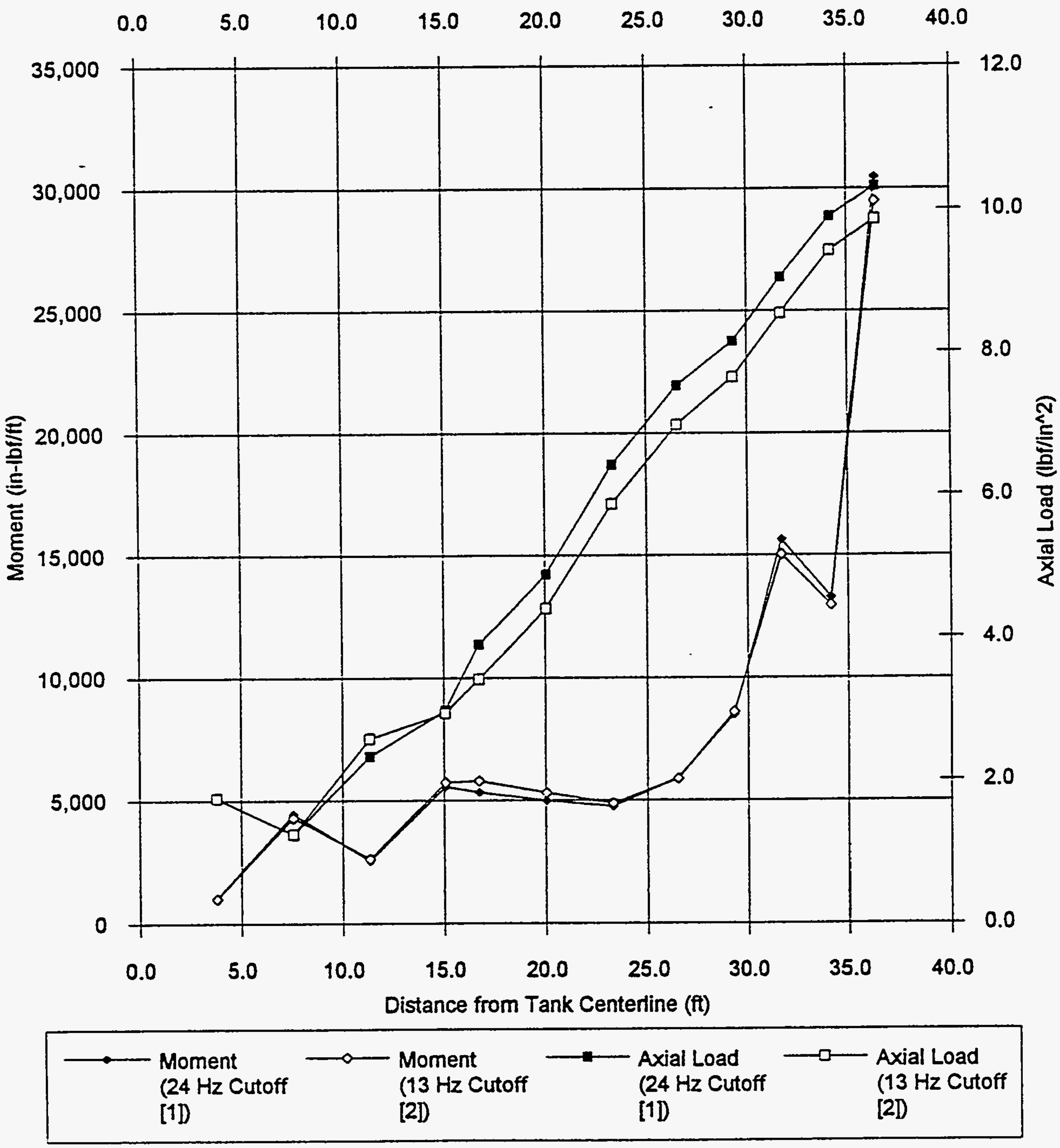
Figure A.4.2-4. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Analysis Cutoff Frequency



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = same as [1] but with 13 hz cutoff frequency.

qlow\anl\cmot50\7freq\CWALLO.XLC

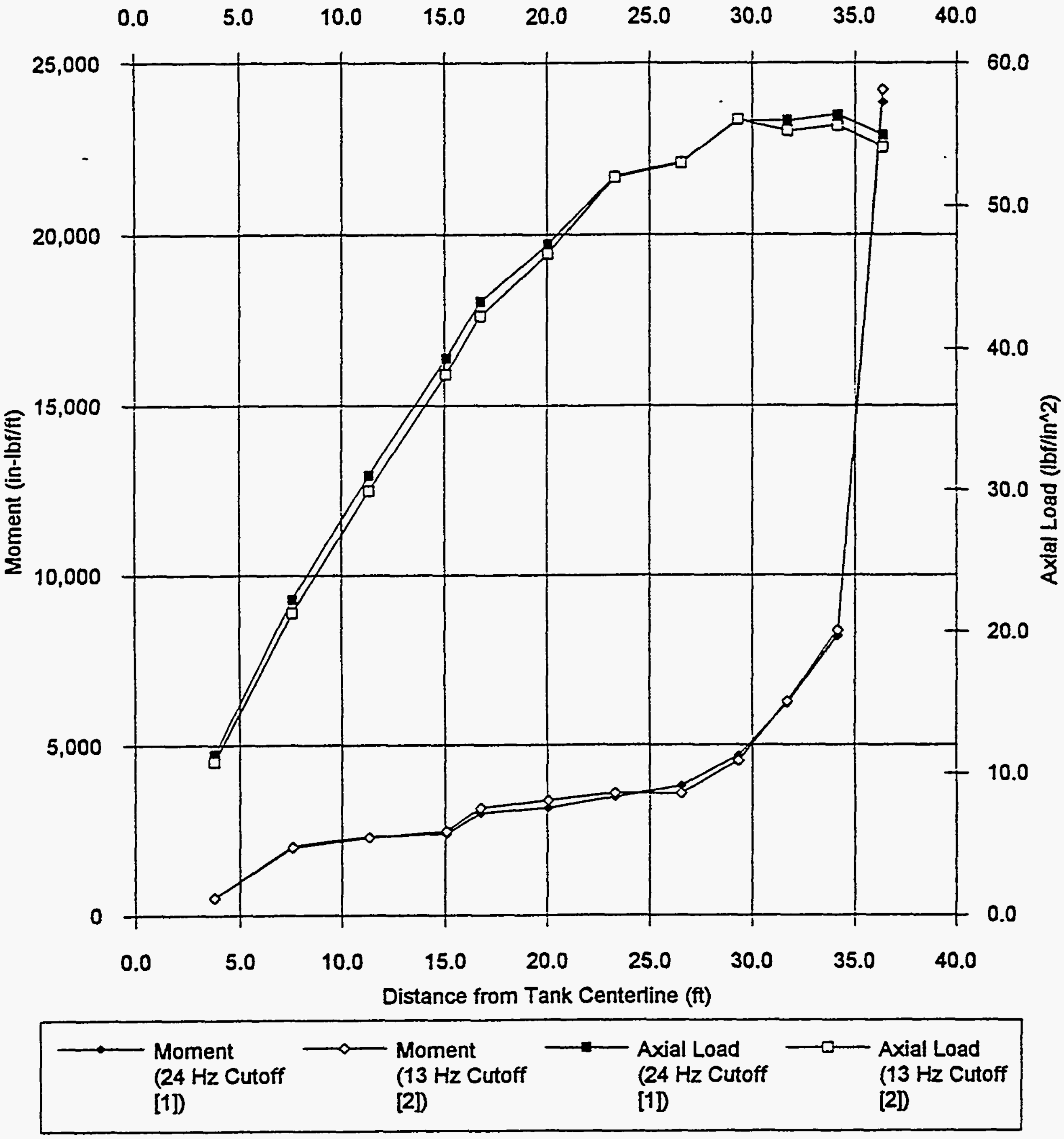
Figure A.4.2-5. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Analysis Cutoff Frequency



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = same as [1] but with 13 hz cutoff frequency.

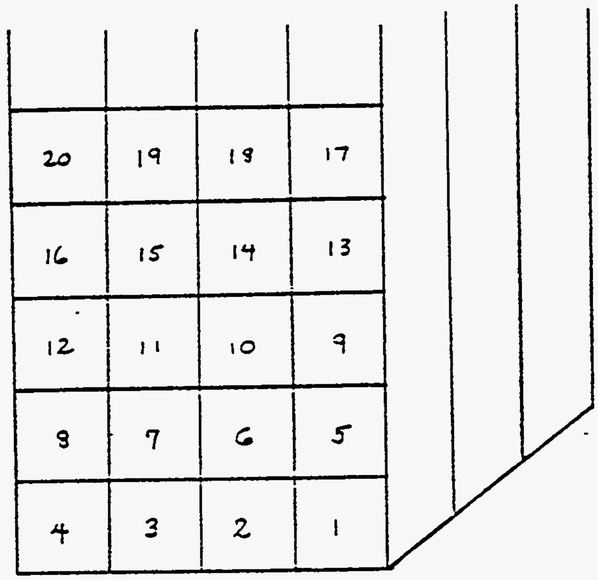
qlow\lanl\cmot50\7freq\CDOMEI.XLC

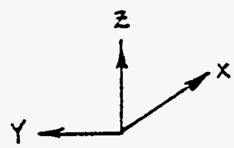
Figure A.4.2-6. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Analysis Cutoff Frequency



Note: [1] = Run ID "cmot50 QLOWpnt4", [2] = same as [1] but with 13 hz cutoff frequency.

qlow\lanl\cmot50\7freq\CDOMEO.XLC





Peak Accel.
B2a: 0.6070
@ t=1.2050
DK: 0.6022
@ t=1.4000
CM: 0.6058
@ t=1.4000

Models
B2a - Baseline
DK - nodes skipped
CM - mesh dens. change

Location 1

Model	Sxx	Syy	Sxy	Mxx	Myy	Mxy
B2a	-52.96	-474.8	-30.67	-755.1	-4763	-437.5
DK	-52.30	-449.3	-26.35	718.4	4591	348.3
CM	-50.98	-447.6	-23.68	-762.9	-4937	-527.0

Location 10

Model	Sxx	Syy	Sxy	Mxx	Myy	Mxy
B2a	-.948	-363.6	2.205	37.74	-2301	-8.73
DK	3.921	-339.1	-22.35	-103.9	1803	-107.1
CM	-4.596	-354.0	2.125	-73.11	-2181	-6.921

Location 18

Model	Sxx	Syy	Sxy	Mxx	Myy	Mxy
B2a	0.875	-243.6	0.9459	74.51	-1325	24.76
DK	7.092	-219.4	-24.36	-76.33	1335	-28.16
CM	1.533	-235.3	0.9351	54.0	-1265	-12.43

Table A.2.1-1
Cantilever Test Model Results

Table A.2.2-1. Soil Layer Thicknesses Through Depth of Embedment.

	Coarse SASSI Model		Baseline SASSI Model	
Shear Wave Speed* (in/s)/(ft/s)	Soil Layer No.	Thickness (in)	Soil Layer No.	Thickness (in)
11,702 / 975	1	155	1	77.5
			2	77.5
18,454 / 1538	2	127	3	71
			4	56
18,071 / 1506	3	112	5	56
			6	56
17,790 / 1483	4	92	7	29
			8	63

* Best-estimate grout vault soil data (Dames and Moore 1988)

Table A.3.1-1
Comparison of Soil Profiles: Tank 241-C-106 vs. Tank 241-SY-101

Soil Layer	Thickness (in)	Unit Weight (lbf/ft^3)		Shear Wave Speed (ft/s)		Compression Wave Speed (ft/s)		% Damping	
		241-C-106	241-SY-101	241-C-106	241-SY-101	241-C-106	241-SY-101	241-C-106	241-SY-101
1	155	105	116	975	794	2979	1320	1.5	3.4
2	127	110	109	1538	826	4698	1577	1.5	5.8
3	112	110	109	1506	880	4601	1895	1.9	6.4
4	147	110	121	1483	868	4529	2015	2.2	7.4

Notes:
1. 241-C-106 data are based on Grout Vault soil data (Dames & Moore 1988).
2. 241-SY-101 data are from analysis by Giller & Weiner (1991).

SOILCOMP.XLS

Table A.4.1. Analysis Frequencies Chosen in Frequency Sensitivity Investigation.

Frequency (Hz)	Run Q3	Run Q4
0.29		X
0.59	X	X
0.78		X
0.98	X	X
1.22		X
1.51	X	X
1.76		X
2.00	X	X
2.29		X
2.59	X	X
2:98		X
3.42	X	X
3.91		X
4.39	X	X
4.98		X
5.52	X	X
6.15		X
6.79	X	X
7.37		X
8.01	X	X
8.98		X
10.0	X	X
11.5		X
13.0	X	X

Note: Analysis frequencies selected in the analysis are indicated by an "X".

Table A.4.2-1

Sensitivity to Range and Number of Analysis Frequencies Using Lower-Bound Soil Properties

Location	Direction	Bending Moments (kip-ft/ft) 7 Frequencies 13 Hz Cutoff	Bending Moments (kip-ft/ft) 18 Frequencies 24 Hz Cutoff	Ratio
Base	Merid.	0.420	0.438	0.96
Base	Circumf.	0.098	0.098	1.00
Wall	Merid.	8.465	8.478	1.00
Wall	Circumf.	1.711	1.711	1.00
Dome	Merid.	2.456	2.539	0.97
Dome	Circumf.	2.018	1.988	1.02

Notes:
1. Response is from the horizontal excitation.
2. Tabulated bending moments are the peak values within the region specified at the 180 deg. meridian.

sassi\COMPTAB4.XLS

APPENDIX B

MATHCAD VERIFICATION OF OPERATIONS IN SASSI'S MOTION MODULE

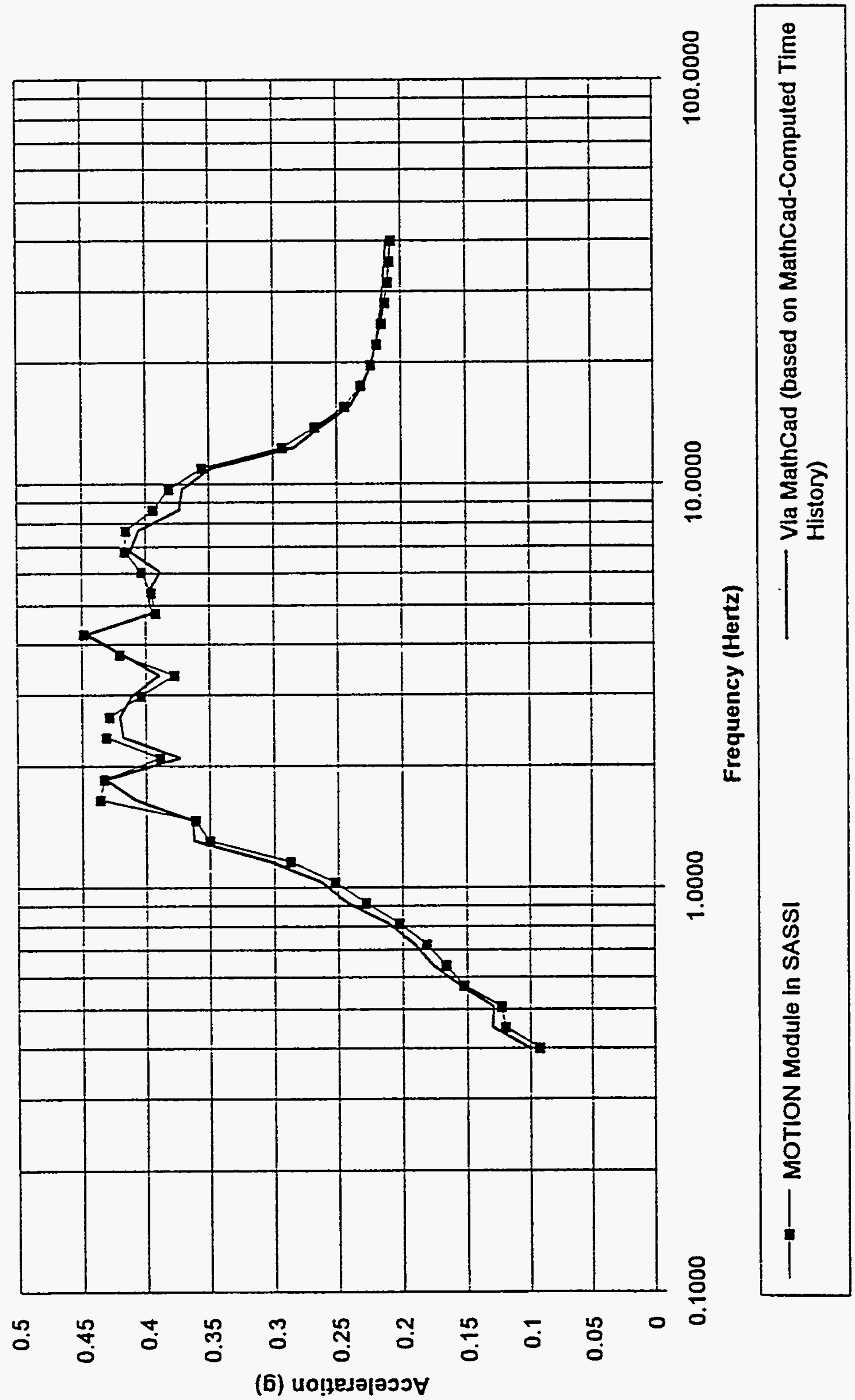
The following operations are performed by SASSI's MOTION module for selected nodes. These operations are duplicated in this appendix using MathCad to clearly demonstrate details of the numerical operations in MOTION and to assist in providing a general illustration of some of the theoretical aspects of the analyses.

MOTION Operations

- Transform the control motion from the time domain to the frequency domain via a Fast-Fourier-Transform (FFT).
- Read the uninterpolated transfer function as computed by SASSI's ANALYS module.
- Interpolate the transfer function to each control motion frequency.
- Multiply the control motion by the interpolated amplification (transfer function value) at each frequency to obtain the nodal acceleration in the frequency domain.
- Perform an inverse-FFT to transform the nodal acceleration from the frequency domain to the time domain.
- For the computed nodal acceleration time history, calculate the corresponding response spectrum for a given value of damping. In the MathCad calculation, the response spectrum is computed using an approach presented by Gupta (Gupta, A. K., 1990, *Response Spectrum Method in Seismic Analysis and Design of Structures*, CRC Press, Inc., Boca Raton, Florida.)

Figure B-1 compares the response spectrum at the dome apex as computed by MOTION with the response spectrum calculated via MathCad. The two curves are nearly identical. The nodal acceleration time history upon which the MathCad response spectrum is based is also calculated via MathCad. The MathCad files are provided in this appendix.

Figure B-1
Horizontal Response Spectrum (7% Damping) at Dome Apex (Coarse Model)



q8\FIGB-1.XLC

Computation of Nodal Acceleration Time History Given the SASSI Transfer Function and the Control Motion

Horizontal Direction Response at Dome Apex due to Horizontal Excitation

PRNPRECISION := 6 PRNCOLWIDTH := 12

M := READPRN(cmotion) Read the horizontal control motion

$accel := M^{<0>}$ The vector accel is defined as the first column of matrix M

$last(accel) = 2.303 \cdot 10^3$ Total number of data points

npts := 4096 No. of points in SASSI control motion

$i3 := 2304..4096$ $accel_{i3} := 0.0$ Pad with zeros

$i := 0..npts - 1$ $time_i := i \cdot .01$

$paccel_i := accel_i$

$npts \cdot .01 = 40.96$ Duration of strain record in seconds

c := fft(paccel) The complex vector, c, is the FFT of the control motion

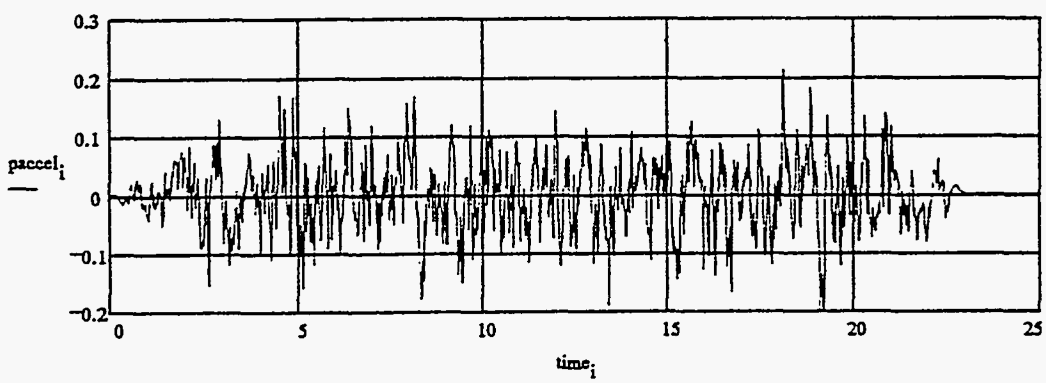
N := last(c) $N = 2.048 \cdot 10^3$ $j := 0..N$

$mag_j := |c_j|$ SRSS real and imag components of c $real_j := Re(c_j)$ real component of c

$sampf := \frac{1}{.01}$ Sampling frequency

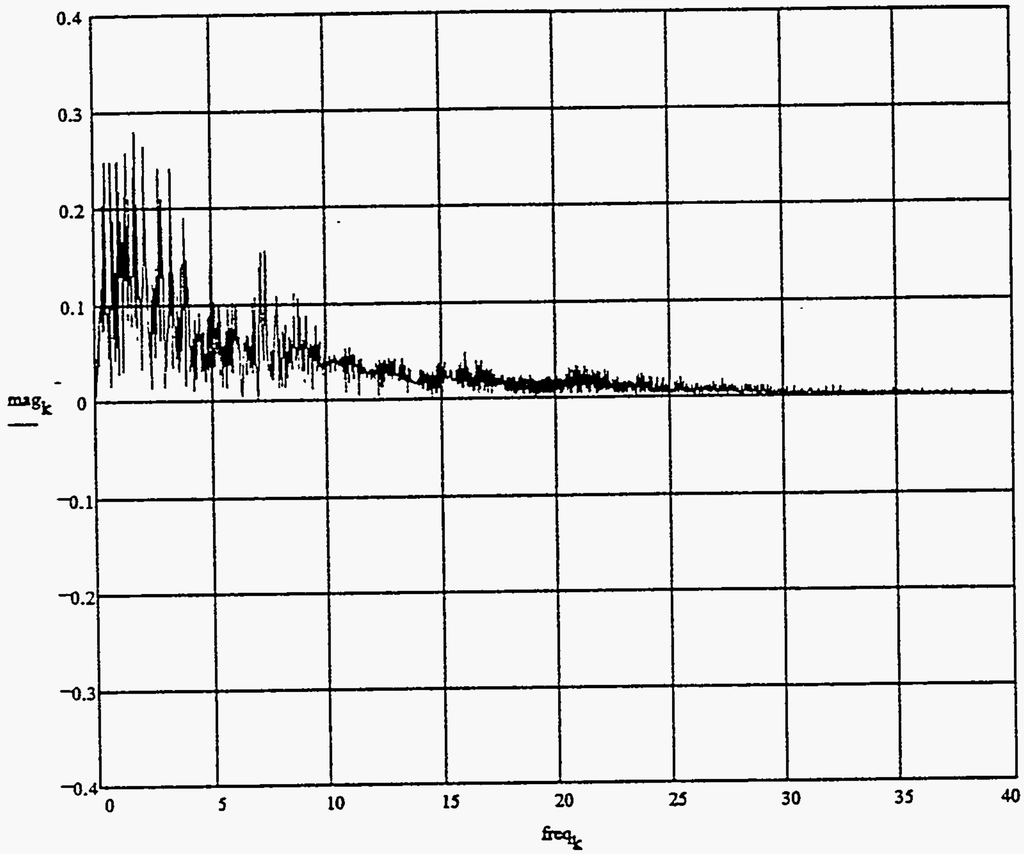
$freq_j := j \cdot \frac{sampf}{npts}$ $k := 0..N$

Control motion (Acceleration (G's) vs. Time (seconds))



min(paccel) = −0.216 max(paccel) = 0.21286

FFT of Control Motion (Acceleration (G's) vs. Frequency (Hz))



max(mag) = 0.28072

xfr := READPRN(xfr245) Read transfer function calculated by SASSI

$f := xfr^{<0>}$ $amp := xfr^{<1>}$

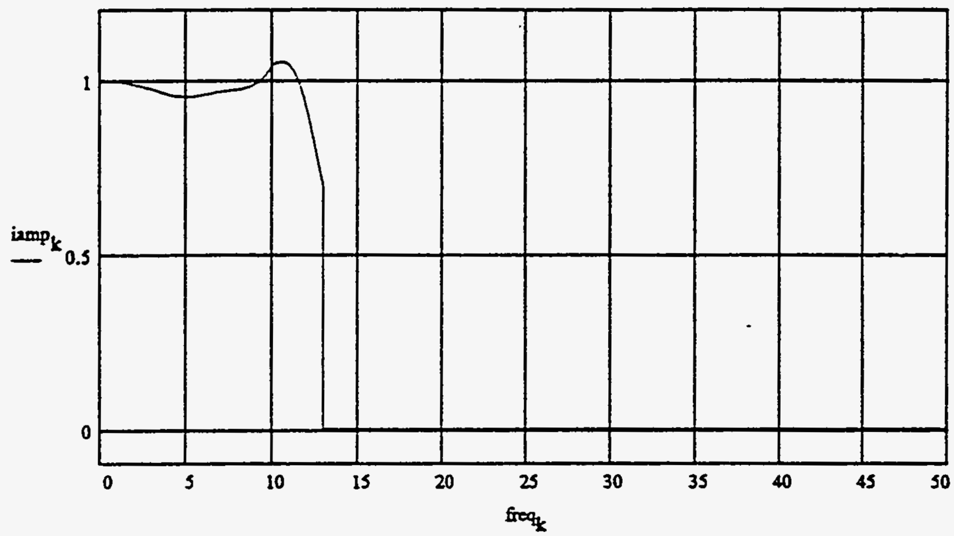
$iamp_k := linterp(f, amp, freq_k)$ Interpolate transfer function values to control motion frequencies

$freq_{532} = 12.98828$ $iamp_{532} = 0.69884$ Identify point corresponding to 13 hz (freq cutoff in SASSI analysis)

$kk := 0..532$ $jj := 532..2048$ $last(iamp) = 2.048 \cdot 10^3$

$iamp_{jj} := 0$ Set amplification to zero for frequencies greater than 13 hz

Interpolated Transfer Function (Amplification vs. Frequency)

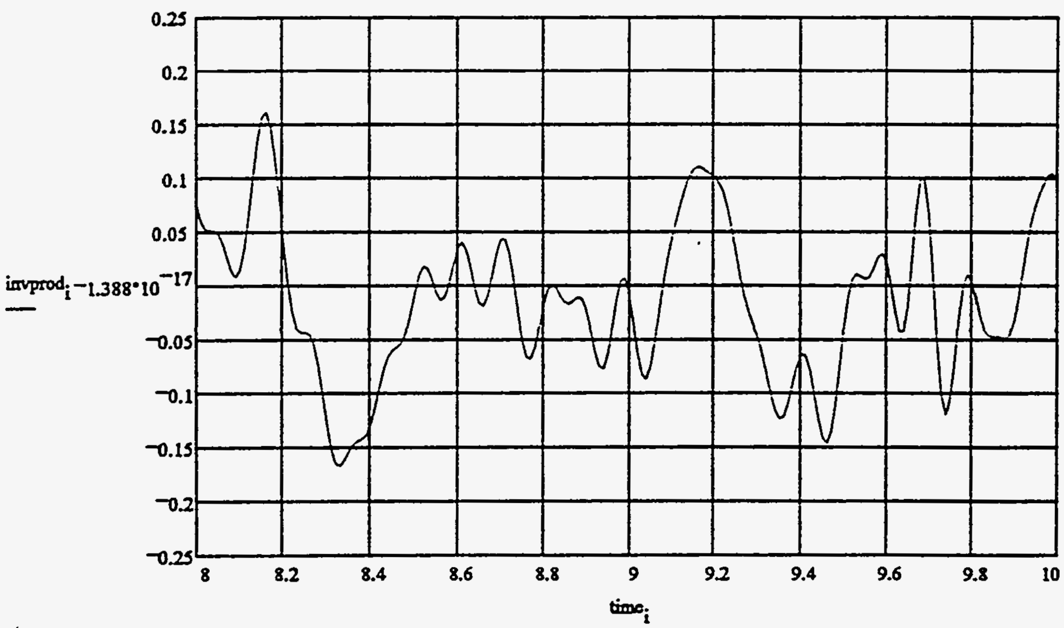


$prod_k := c_k \cdot iamp_k$ Multiply control motion by amplification (freq-by-freq basis)

$invprod := ifft(prod)$ Take inverse FFT of product to obtain nodal acceleration time history

WRITEPRN(mc245) := invprod Write to file

Acceleration of Dome at Apex (G's vs. seconds)



min(invprod) = −0.20828

max(invprod) = 0.20507

q8\pres2.mcd

Computation of Response Spectrum from Acceleration Time History

Ref: "Response Spectrum Method in Seismic Analysis and Design of Structures", A. K. Gupta, CRC Press, 1990.

Input Acceleration History = horizontal acceleration at Dome Apex calculated by MathCad in pres2.mcd.

PRNPRECISION := 6 PRNCOLWIDTH := 12

M := READPRN(mc245) — Read in the acceleration time history computed by MathCad at node 245.

$dt := .01$ — Time increment

$accel := M^{<0>}$ — The vector accel is defined as the first column of matrix M

$last(accel) = 4.095 \cdot 10^{3}$ — Total number of data points

$npts := 2400$ — No. of points for input time history

$npts \cdot .01 = 24$ — Duration of history in seconds

$j := 0 .. npts - 1$ $time_j := j \cdot .01$

$paccel_j := accel_j \cdot 1.0$ — Apply scaling factor to the input acceleration history

$\zeta := .07$ — Damping ratio

$n := 39$ $k := 0 .. n$ — n+1 is the no. of frequencies to define the response spectrum

$f_0 := .4$ $f_n := 40$ $x := \left(\frac{f_n}{f_0}\right)^{\frac{1}{n}}$ $x = 1.12534$ $f_{k+1} := f_k \cdot x$

$\omega_k := 2 \cdot \pi \cdot f_k$ Circular frequencies

$$\omega D_k := \frac{\omega_k}{\sqrt{1 - \zeta^2}} \qquad exp_k := e^{-\zeta \cdot \omega_k \cdot dt}$$

$$a11_k := exp_k \cdot \left(\cos(\omega D_k \cdot dt) + \frac{\zeta}{\sqrt{1 - \zeta^2}} \cdot \sin(\omega D_k \cdot dt)\right) \qquad a12_k := \frac{exp_k}{\omega D_k} \cdot \sin(\omega D_k \cdot dt)$$

$$a22_k := exp_k \cdot \left(\cos(\omega D_k \cdot dt) - \frac{\zeta}{\sqrt{1 - \zeta^2}} \cdot \sin(\omega D_k \cdot dt)\right) \qquad a21_k := -\frac{\omega_k}{\sqrt{1 - \zeta^2}} \cdot exp_k \cdot \sin(\omega D_k \cdot dt)$$

$$b11_k := exp_k \cdot \left[\left[\frac{2\cdot\zeta^2 - 1}{(\omega_k)^2 \cdot dt} + \frac{\zeta}{\omega_k} \right] \cdot \frac{\sin(\omega D_k \cdot dt)}{\omega D_k} + \left[\frac{2\cdot\zeta}{(\omega_k)^3 \cdot dt} + \frac{1}{(\omega_k)^2} \right] \cdot \cos(\omega D_k \cdot dt) \right] - \frac{2\cdot\zeta}{(\omega_k)^3 \cdot dt}$$

$$b12_k := (-exp)_k \cdot \left[\left[\frac{2\cdot\zeta^2 - 1}{(\omega_k)^2 \cdot dt} \right] \cdot \frac{\sin(\omega D_k \cdot dt)}{\omega D_k} + \left[\frac{2\cdot\zeta}{(\omega_k)^3 \cdot dt} \right] \cdot \cos(\omega D_k \cdot dt) \right] + \frac{2\cdot\zeta}{(\omega_k)^3 \cdot dt} - \frac{1}{(\omega_k)^2}$$

$$b21_k := \frac{1 - a11_k}{(\omega_k)^2 \cdot dt} - a12_k \qquad b22_k := -b21_k - a12_k$$

Step through time:

d = relative displacement of SDOF system subject to input motion at base

v = relative velocity of SDOF system subject to input motion at base

a = relative acceleration of SDOF system subject to input motion at base

$i := 0 .. npts - 2$

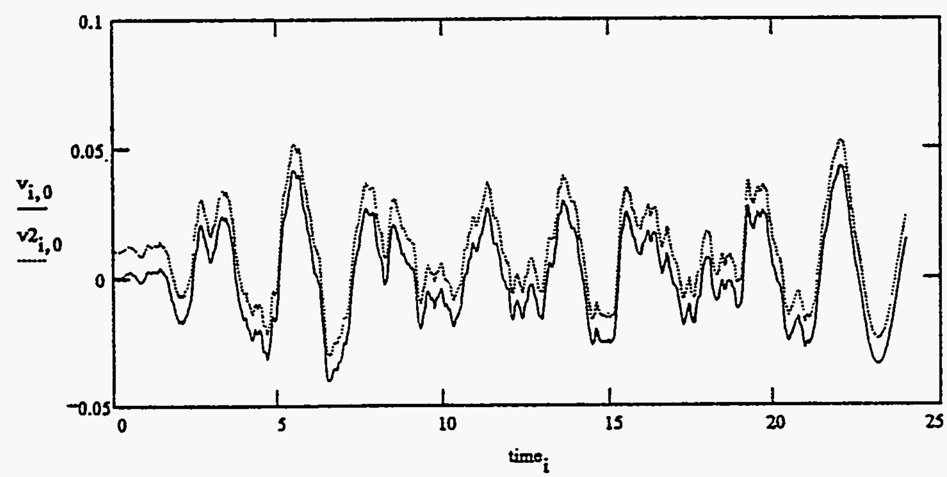
$d_{0,k} := 0$ $\quad v_{0,k} := 0$ $\quad$ Initial conditions

$$\begin{pmatrix} d_{i+1,k} \\ v_{i+1,k} \end{pmatrix} := \begin{pmatrix} a11_k \cdot d_{i,k} + a12_k \cdot v_{i,k} + b11_k \cdot paccel_i + b12_k \cdot paccel_{i+1} \\ a21_k \cdot d_{i,k} + a22_k \cdot v_{i,k} + b21_k \cdot paccel_i + b22_k \cdot paccel_{i+1} \end{pmatrix}$$

$v2_{0,k} := 0$ $\quad$ Initial Condition

$v2_{i+1,k} := \frac{d_{i+1,k} - d_{i,k}}{dt} + .01$ $\quad$ Check on velocity calculation (offset by .01 for clarity).

Relative Velocity of SDOF system with frequency f_0



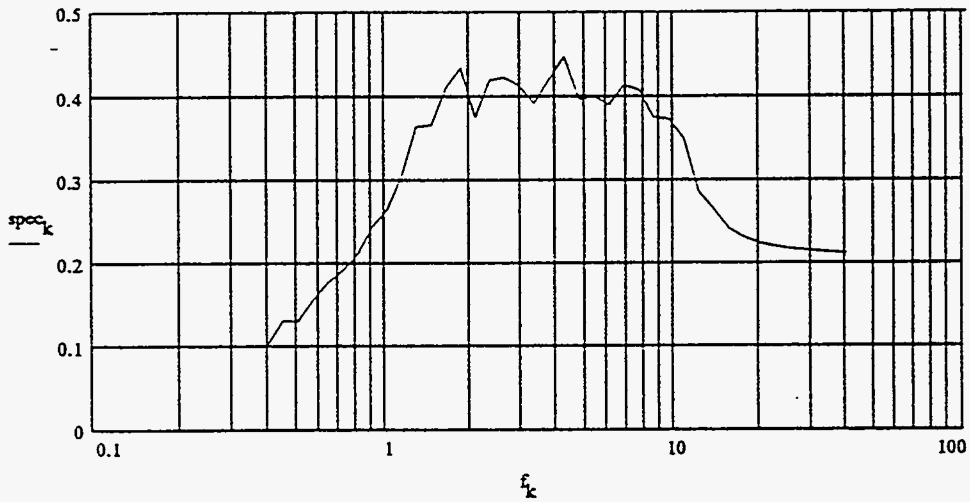
$a_{0,k} := paccel_0$ $\qquad$ $a_{i+1,k} := \frac{v_{i+1,k} - v_{i,k}}{dt} + paccel_{i+1}$

Obtain maximum absolute acceleration for each frequency:

$maxa_k := max\left(a^{<k>}\right)$

$mina_k := max\left[(-a)^{<k>}\right]$ $\qquad$ $spec_k := if\left(maxa_k > mina_k, maxa_k, mina_k\right)$

Horizontal Acceleration Response Spectrum (G's) at Dome Apex



WRITEPRN(freq) := f

WRITEPRN(spec) := spec

g8\figb-1.mcd

APPENDIX C

TRANSFER FUNCTIONS FOR HORIZONTAL AND VERTICAL SEISMIC EXCITATIONS

SASSI transfer functions are plotted for the model locations shown in Figure C-1. Using lower-bound soil properties, the calculated set of transfer functions corresponding to the horizontal excitation without tank-to-tank interaction, the horizontal excitation with tank-to-tank interaction, and the vertical excitation are shown in Figures C-2, C-3, and C-4, respectively. The number of analysis frequencies used in the three analyses are 19, 15, and 19, respectively. For the vertical excitation case, extremely large amplifications (approaching 50) occur over the center of the dome at a frequency of approximately 17.3 Hz. The spike in amplification cannot be attributed to interpolation since an analysis frequency equal to 17.27 Hz is included. Figure C-5 reproduces the data of Figure C-4 but with a different vertical scale to better examine vertical amplifications at locations other than over the center of the dome. The effect of live load is not considered in the data shown. Best-estimate tank stiffness is used.

Using best-estimate soil properties, the set of transfer functions corresponding to the horizontal excitation with tank-to-tank interaction and the vertical excitation are shown in Figures C-6 and C-7, respectively. The effect of live load is not considered in the data shown. Best-estimate tank stiffness is used. The number of analysis frequencies used in the two analyses are 11 and 19, respectively.

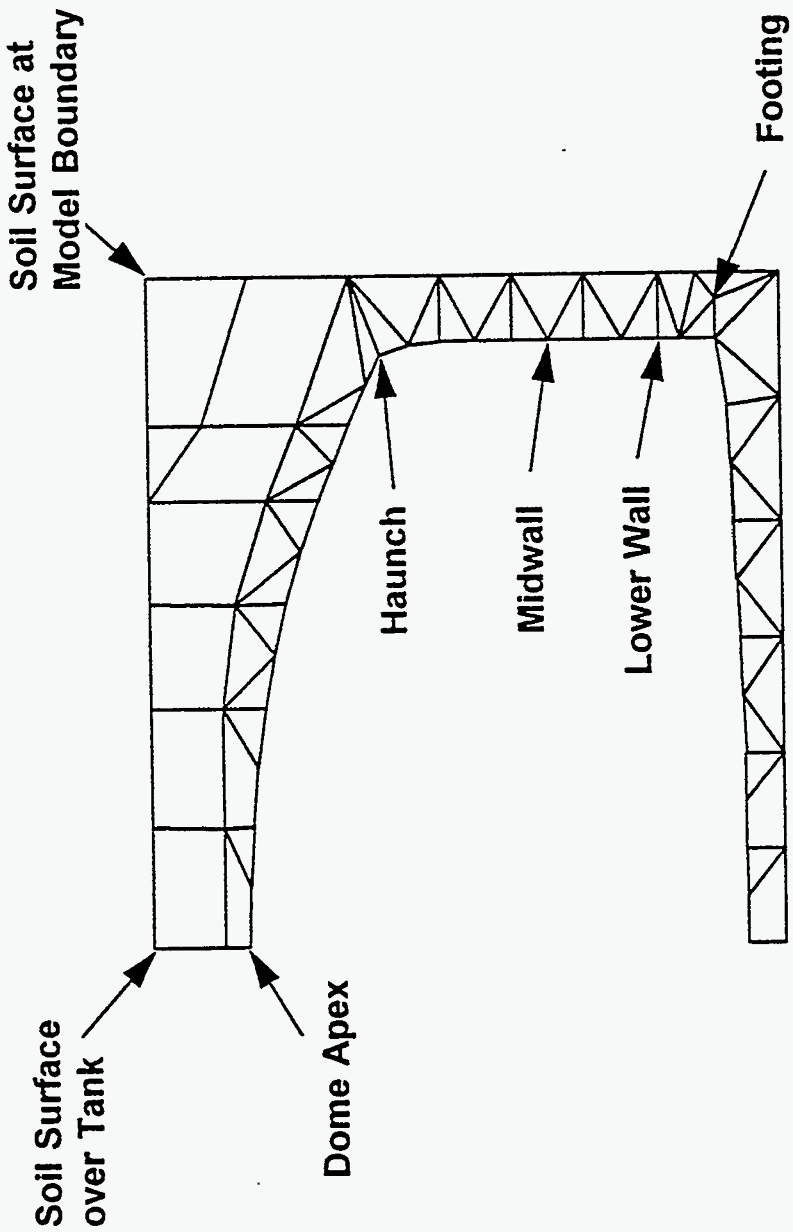


Figure C-1
Locations for Plotting of Transfer Functions

Figure C-2
X-Direction Transfer Functions (Lower-Bound Soil Properties / No TTI)

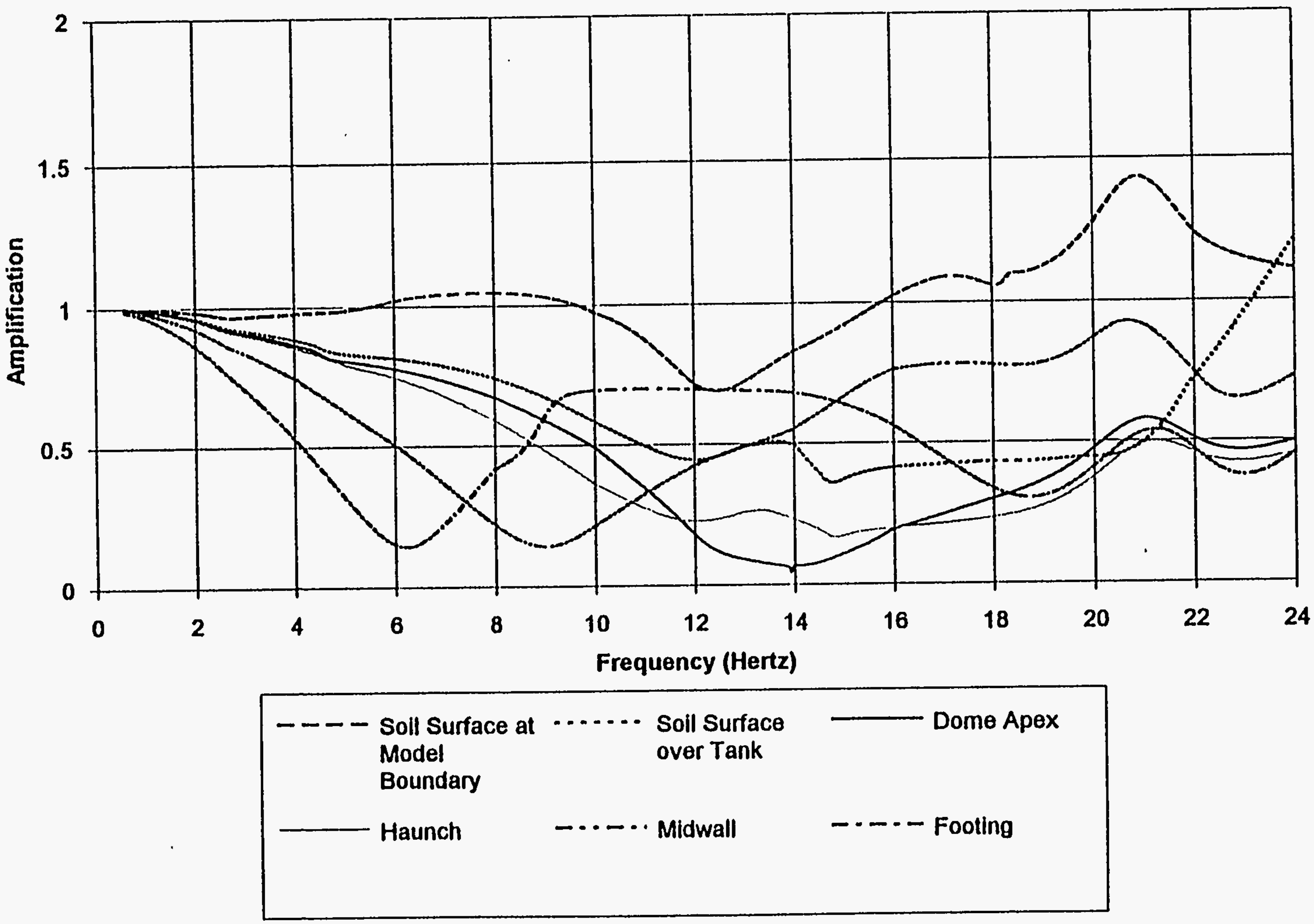


Figure C-3
X-Direction Transfer Functions (Lower-Bound Soil Properties / With TTI)

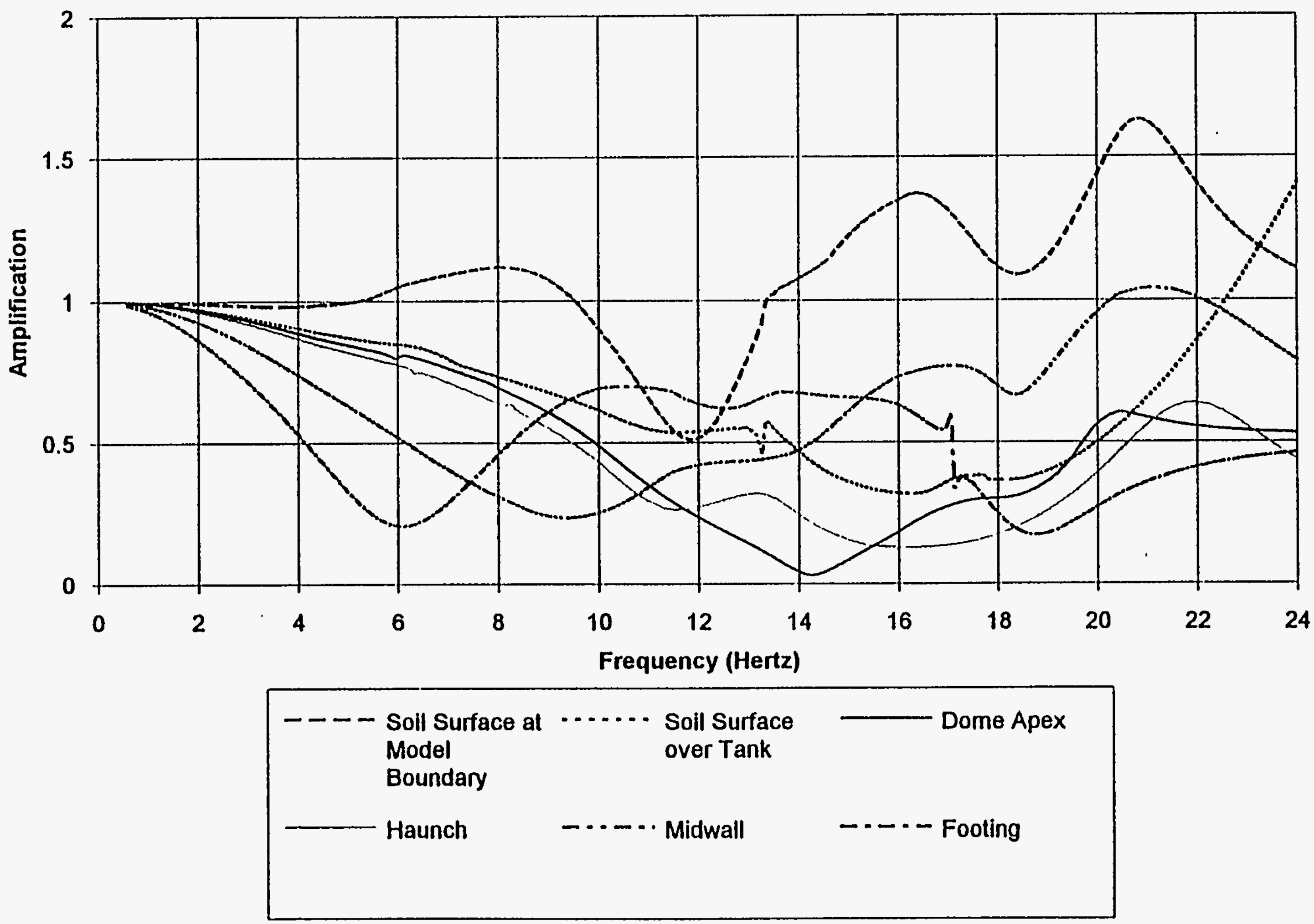


Figure C-4
Z-Direction Transfer Functions (Lower Bound Soil Properties / Vertical Excitation)

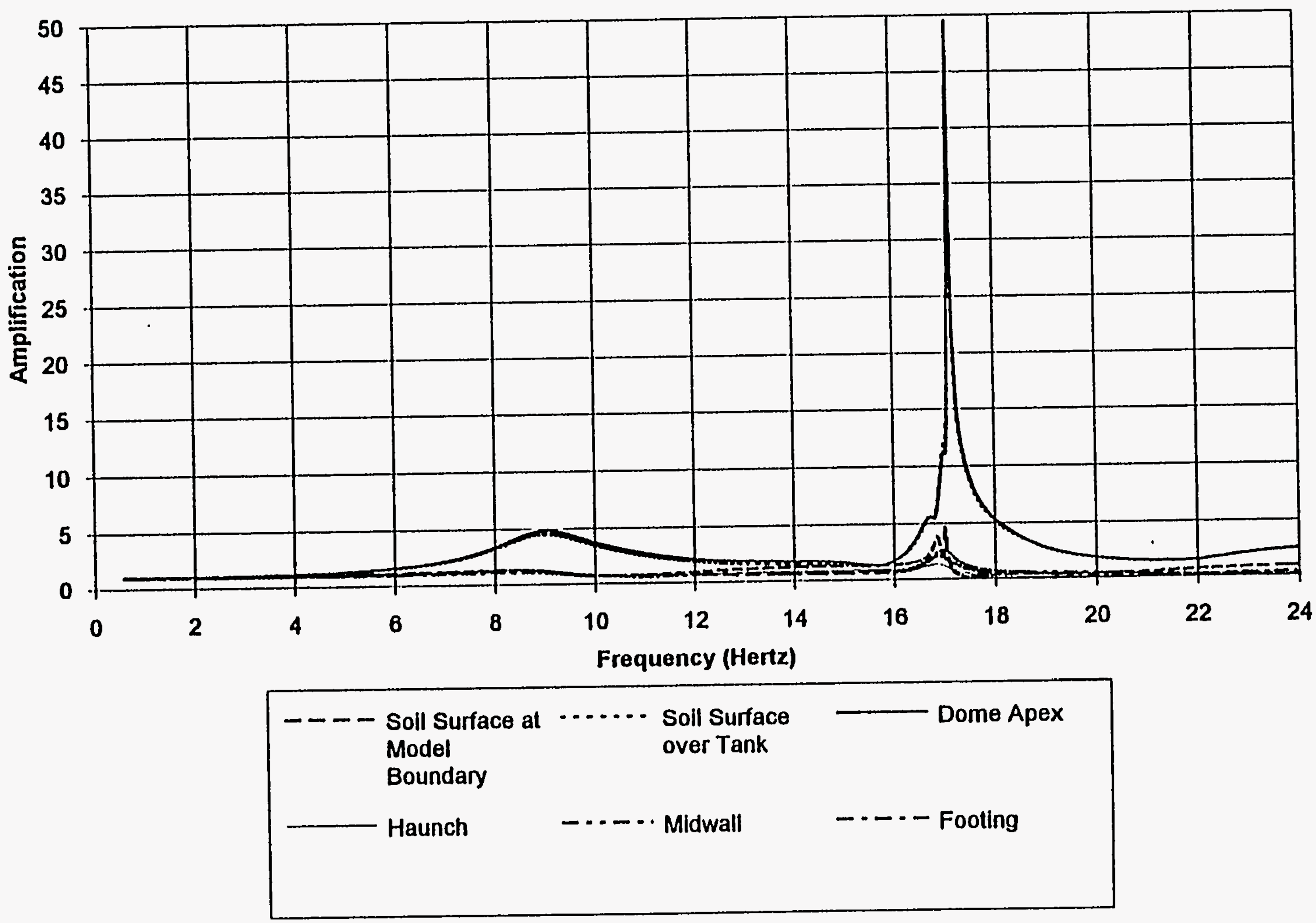


Figure C-5
Z-Direction Transfer Functions (Lower Bound Soil Properties / Vertical Excitation)

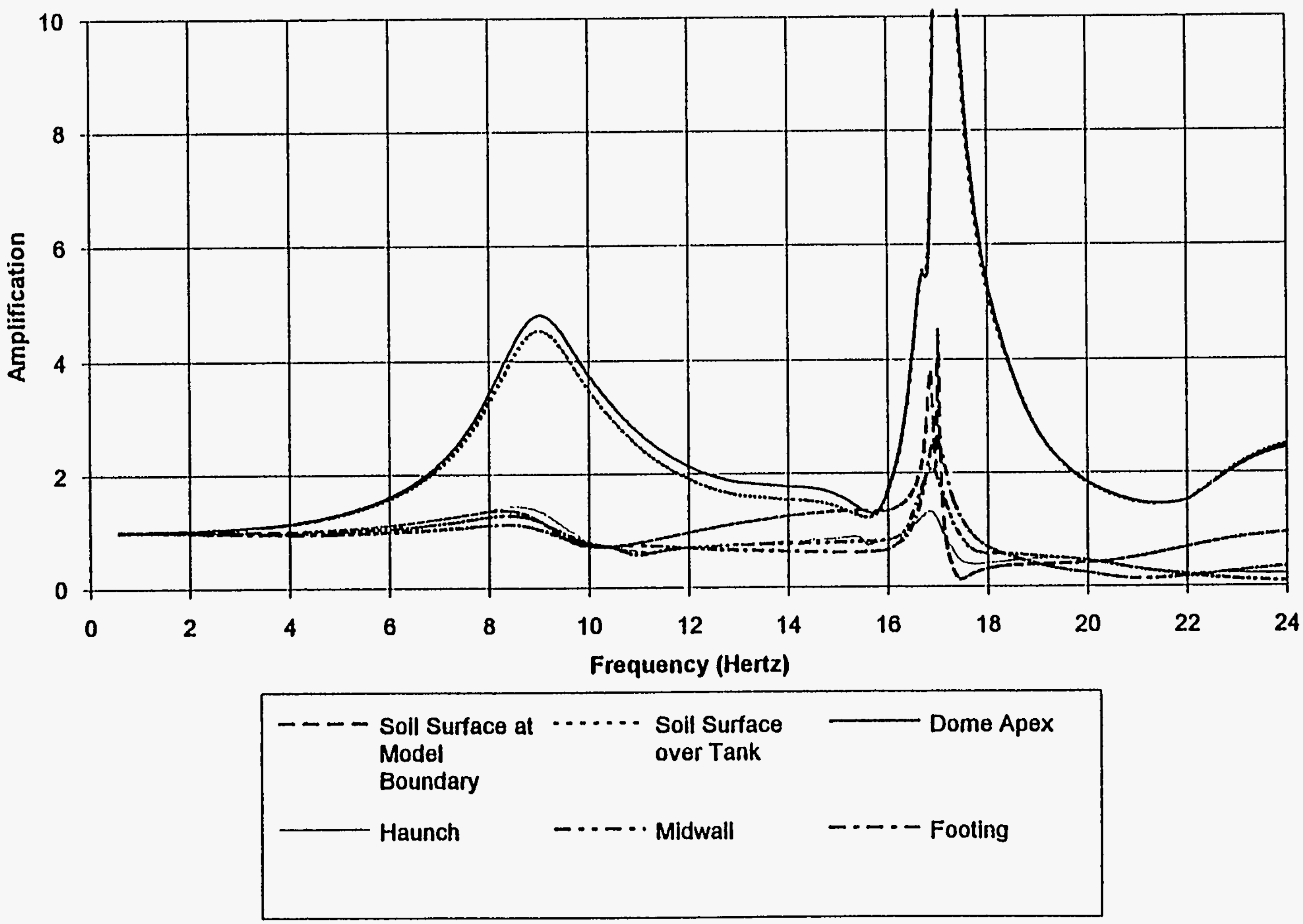


Figure C-6
X-Direction Transfer Functions (Best-Est. Soil Properties / With TTI)

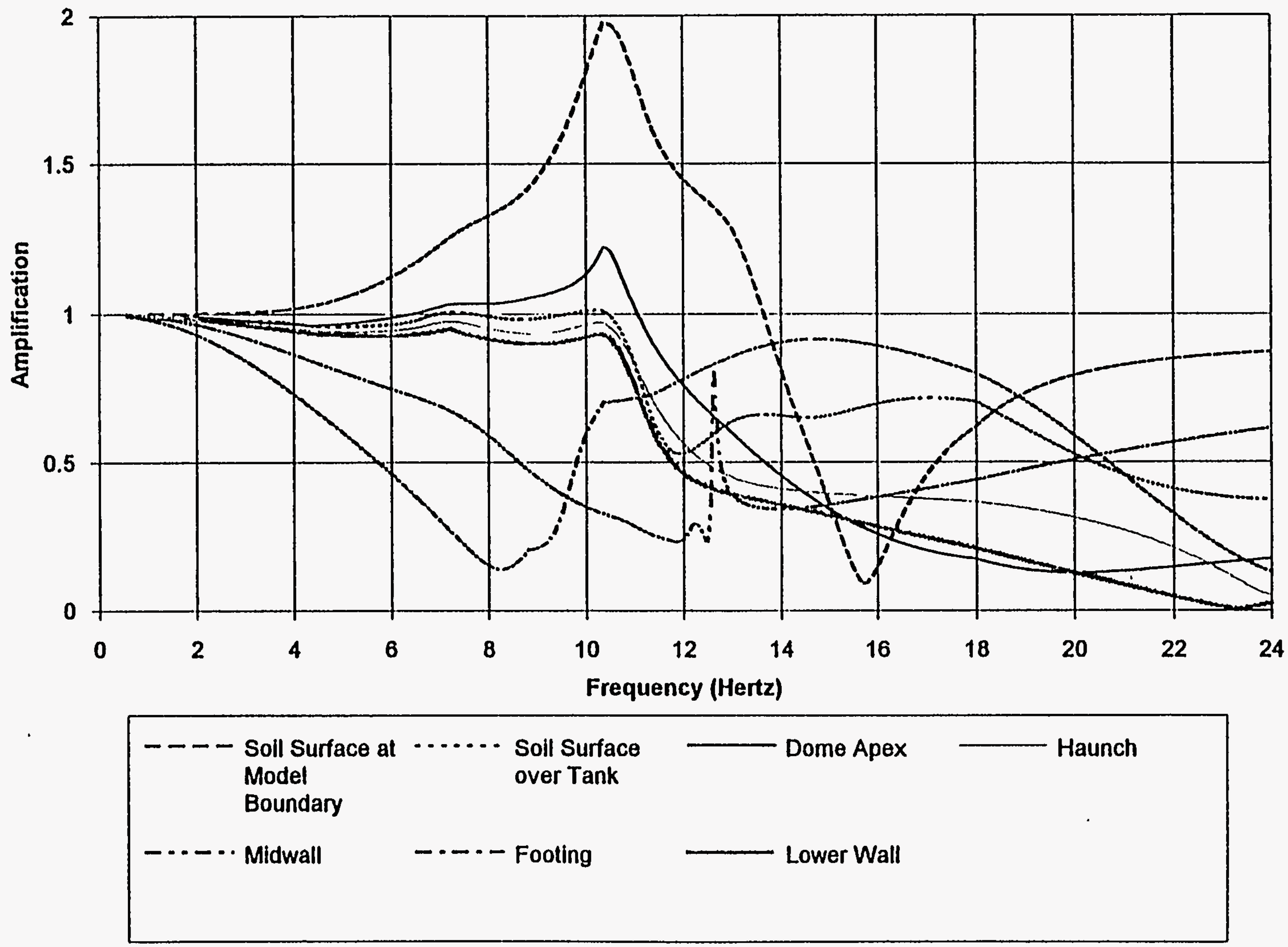
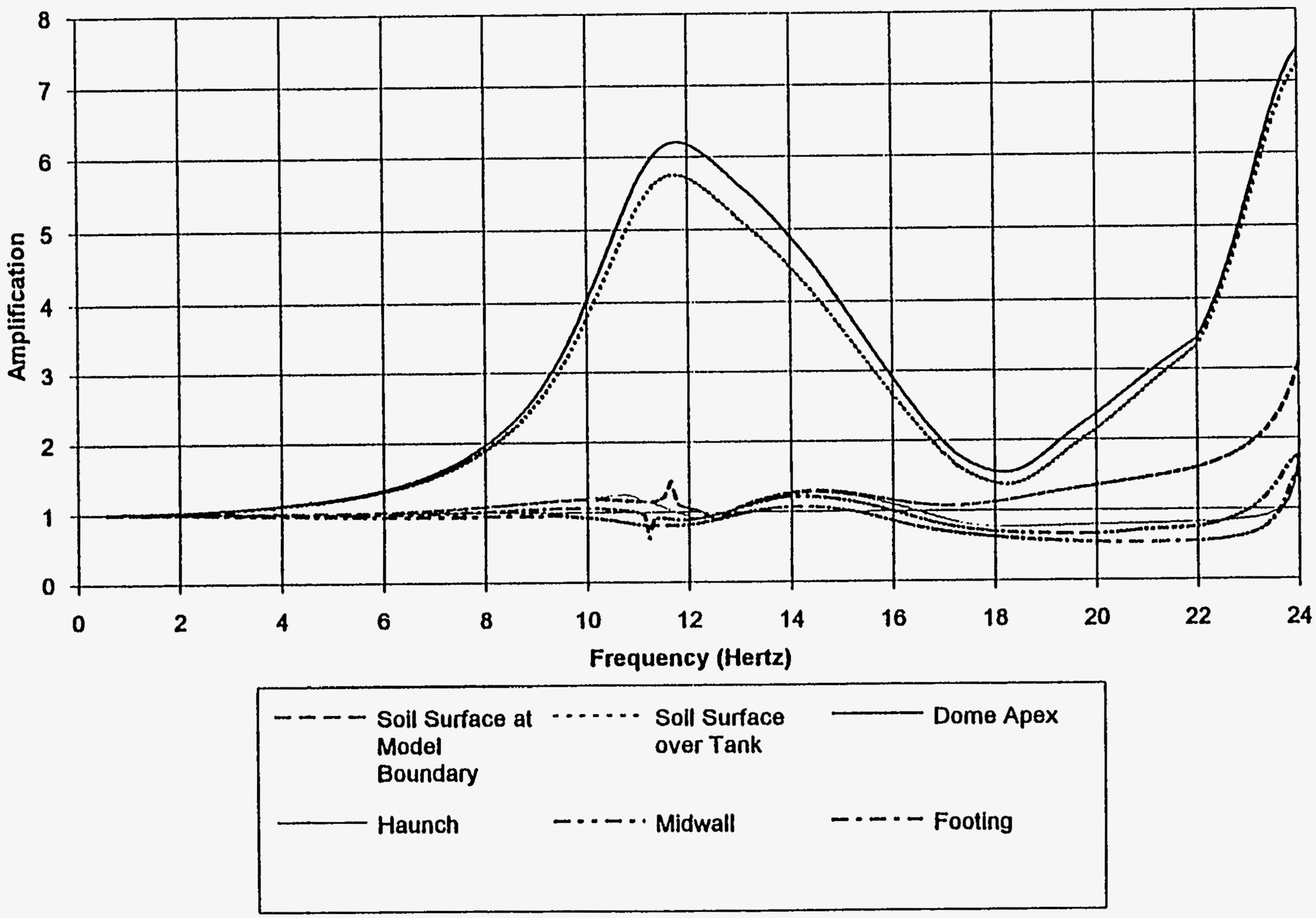


Figure C-7
Z-Direction Transfer Functions (Best-Estimate Soil Properties / Vertical Excitation)



q7v/TRANSFER.XLC

APPENDIX D

EXCEL SPREADSHEETS FOR COMBINING HORIZONTAL AND VERTICAL COMPONENTS OF SEISMIC RESPONSE

Spreadsheet *combin.xls* is used to combine the computed demands from the three seismic excitations and obtain total elastic seismic demand for the lower-bound soil condition. *Combin.xls* is linked to two additional spreadsheets, *stress-h.xls* which contains computed demands from the horizontal seismic excitation and *stress-v.xls* which contains computed demands from the vertical seismic excitation. These speadsheets are on the following pages.

	L	M	N	O	P	Q	R	S
1						0 degrees (tttlow - 15 freqs)		
2	distance	rad dist	rad dist	shell	demand		merid. (abs)	
3	to node	from CL	from CL	thickness	section	element	bending	axial
4	36	3.0	36	5.95		289	19	7
5	72	6.0	72	5.95		291	73	13
6	107	8.9	107	5.95	a	295	19	20
7	143	11.9	143	5.95		301	36	28
8	187	13.8	165	5.95	b	1,257	24	45
9	231	17.4	209	5.95		1,261	13	66
10	275	21.1	253	5.95	c,d	1,265	23	79
11	319	24.8	297	5.95		1,269	28	90
12	363	28.4	341	5.96	e	1,273	11	108
13	407	32.1	385	5.96	f,g,h,i	1,277	21	126
14	457	36.0	432	12.75		1,281	397	66
15			vert dist from base					
16	24	1.1	13	18.24		1,285	8,501	5
17	51	3.0	35	9.85		1,289	237	4
18	68	4.8	58	12.03	k	1,293	1,447	8
19	96	7.2	86	12.02	l	1,297	1,055	7
20	124	9.5	114	12.02	m	1,301	430	9
21	152	11.8	142	12.02	n	1,305	218	12
22	180	14.2	170	12.02		1,309	112	13
23	208	16.5	198	12.02	o,p,q	1,313	218	13
24	236	18.7	224	9.16	q	1,317	342	15
25	260	20.6	247	27.51	r	1,321	3,112	12
26	283	0.0						
27		#VALUE!	rad dist from CL					
28	448	36.4	436	31.93		1,325	3,061	13
29	425	34.2	410	21.46	s,t	1,329	1,262	13
30	395	31.7	381	18.18	u	1,333	1,289	13
31	366	29.3	352	17.48		1,337	769	12
32	338	26.5	318	17.01		1,341	568	12
33	299	23.3	280	16.48		1,345	479	10
34	260	20.1	241	15.90		1,349	502	9
35	221	16.7	201	15.33	x	1,353	514	7
36	181	15.1	181	15.06	y	308	527	6
37	136	11.3	136	15.05	z	314	219	5
38	91	7.6	91	14.97	aa	318	361	5
39	45	3.8	45	14.98	bb	320	84	6
40								
41		footing		24.13	j	1,357	7,341	16

	T	U	V	W	X	Y	Z	AA
1							Transverse shears ref. App. G	
2	circumf. (abs)		merid.	merid.	circumf.	circumf.	transverse	transverse
3	bending	axial	bending	axial	bending	axial	shear (merid)	shear (circum)
4	7	4	-19	-7	-7	4	1	0
5	31	6	73	-13	-31	6	1	2
6	22	8	19	20	-22	8	1	1
7	5	11	-36	28	-5	11	1	0
8	5	13	-24	45	5	13	1	1
9	4	17	13	66	-4	17	1	1
10	5	21	23	79	-5	21	1	1
11	4	28	-28	90	4	28	3	1
12	5	36	11	108	5	36	2	1
13	5	45	21	126	5	45	2	1
14	94	14	397	66	94	14	13	3
15								
16	1,816	86	-8,501	5	-1,816	86	362	3
17	56	24	-237	4	-56	24	109	3
18	244	72	1,447	-8	244	72	13	7
19	159	45	1,055	-7	159	45	30	4
20	53	21	430	-9	53	-21	3	3
21	40	24	218	-12	-40	24	8	3
22	90	36	112	-13	90	36	8	3
23	58	57	-218	-13	58	57	6	7
24	71	14	342	-15	71	14	27	2
25	978	51	3,112	-12	-978	51	133	36
26								
27								
28	2,009	56	3,061	-13	-2,009	56	125	35
29	709	57	1,262	-13	-709	57	25	14
30	507	57	-1,289	-13	-507	-57	25	3
31	398	58	-769	-12	-398	-58	5	4
32	341	55	-568	-12	-341	-55	9	2
33	315	55	-479	-10	-315	-55	3	2
34	290	49	-502	-9	-290	-49	4	1
35	268	46	-514	-7	-268	-46	3	1
36	267	41	-527	6	-267	-41	3	4
37	169	31	219	5	-169	-31	3	3
38	154	21	-361	5	-154	-21	3	2
39	65	13	-84	-6	-65	-13	2	2
40								
41	499	112	-7,341	16	-499	112	324	53

	AB	AC	AD	AE	AF	AG	AH	AI
1			90 degrees (tttlow - 15 freqs)					
2	in-plane	twisting		merid. (abs)		circumf. (abs)		merid.
3	shear	moment	element	bending	axial	bending	axial	bending
4	-2	-1	161	7	4	7	8	-7
5	-2	7	164	3	5	20	9	-3
6	-3	1	169	11	7	19	12	11
7	-5	-6	176	7	11	14	12	7
8	1	1	844	5	5	21	9	5
9	1	1	848	5	10	14	9	5
10	-1	-1	852	2	7	6	9	2
11	-2	1	856	4	6	4	10	-4
12	-2	-4	860	2	9	3	8	2
13	-2	-12	864	4	12	2	7	4
14	-2	-3	868	34	7	9	2	34
15								
16	-6	-316	872	378	1	92	8	-378
17	-6	-6	876	10	2	4	2	10
18	-6	45	880	47	2	17	8	-47
19	-5	-26	884	49	3	17	6	-49
20	-5	11	888	51	3	18	6	51
21	-5	32	892	67	3	25	5	-67
22	-5	40	896	62	3	27	5	62
23	-4	99	900	69	3	24	5	69
24	4	-8	904	31	3	5	1	-31
25	1	-359	908	288	1	61	5	-288
26								
27								
28	1	-377	912	322	1	268	4	-322
29	2	-138	916	118	2	62	4	-118
30	2	-32	920	61	4	59	3	-61
31	2	20	924	50	4	68	3	-50
32	2	10	928	46	4	67	4	-46
33	2	10	932	34	5	64	4	-34
34	1	7	936	27	5	62	4	-27
35	1	4	940	25	5	66	5	-25
36	-6	22	183	51	7	76	6	-51
37	-4	26	188	36	6	111	5	-36
38	-3	10	191	63	6	74	5	-63
39	2	9	192	23	6	93	5	-23
40								
41	-1	296	944	350	1	69	10	-350

	AJ	AK	AL	AM	AN	AO	AP	AQ
1				Transverse shears are bounding values from URS/Blume letter (7/22/				180 degrees (t
2		circumf.		transverse	transverse	in-plane	twisting	
3	axial	bending	axial	shear (merid)	shear (circum)	shear	moment	element
4	-4	7	-8	0	2	-3	-2	1
5	-5	20	9	0	2	-8	8	4
6	7	19	12	0	2	-12	13	9
7	11	14	-12	0	2	20	3	16
8	-5	21	-9	1	3	32	3	324
9	-10	14	-9	1	3	41	7	328
10	7	-6	-9	1	3	-56	-3	332
11	6	4	-10	1	3	-64	-1	336
12	9	3	8	1	3	-79	-3	340
13	12	2	7	1	3	-93	-1	344
14	7	-9	2	1	3	-50	11	348
15								
16	-1	-92	8	17	13	-79	388	352
17	-2	4	2	17	13	-132	-15	356
18	-2	17	8	17	13	-126	192	360
19	-3	17	-6	17	13	-130	166	364
20	3	18	-6	17	13	-129	135	368
21	-3	25	-5	17	13	-124	118	372
22	3	27	-5	17	13	-117	109	376
23	3	-24	-5	17	13	106	-108	380
24	3	-5	-1	17	13	112	69	384
25	1	-61	-5	17	13	40	-530	388
26								
27								
28	-1	268	-4	9	5	29	-1,011	392
29	2	-62	-4	9	5	36	-341	396
30	4	-59	-3	9	5	39	-188	400
31	4	-68	3	9	5	38	159	404
32	4	-67	4	9	5	35	-142	408
33	5	-64	4	9	5	31	-150	412
34	5	-62	4	9	5	26	-138	416
35	-5	-66	5	9	5	22	-127	420
36	7	-76	-6	1	5	-13	114	23
37	6	111	5	1	5	10	92	28
38	6	-74	5	1	5	6	80	31
39	-6	-93	5	1	5	3	20	32
40								
41	-1	69	10	18	113	16	459	424

	AR	AS	AT	AU	AV	AW	AX	AY
1	low - 15 freqs)							
2	merid. (abs)		circumf. (abs)		merid.		circumf.	
3	bending	axial	bending	axial	bending	axial	bending	axial
4	12	18	9	8	-12	-18	-9	8
5	63	37	18	10	-63	-37	-18	10
6	15	33	36	11	-15	-33	36	11
7	43	42	18	15	43	-42	18	15
8	26	59	6	17	26	-59	-6	17
9	13	83	3	21	-13	-83	3	21
10	23	95	6	27	-23	-95	6	27
11	28	104	3	32	28	-104	-3	32
12	29	121	5	38	29	-121	-5	-38
13	17	138	5	46	-17	-138	-5	-46
14	421	71	120	14	-421	-71	120	-14
15								
16	8,760	4	1,800	93	8,760	-4	1,800	93
17	229	4	50	25	-229	-4	-50	25
18	1,570	7	297	73	-1,570	7	-297	-73
19	1,239	6	214	43	-1,239	6	-214	-43
20	542	8	97	16	-542	8	-97	16
21	365	10	63	16	-365	10	-63	-16
22	88	11	31	35	88	11	31	-35
23	107	11	27	56	107	11	27	-56
24	300	13	65	14	-300	13	-65	-14
25	2,428	11	893	50	2,428	11	-893	-50
26								
27								
28	2,264	9	1,889	56	2,264	-9	1,889	-56
29	1,069	8	772	59	-1,069	-8	772	-59
30	1,328	8	534	61	-1,328	-8	534	-61
31	738	8	404	81	738	-8	404	-81
32	534	8	330	49	534	-8	330	49
33	417	7	298	51	417	-7	298	51
34	434	7	290	47	434	7	290	47
35	489	7	282	43	489	7	282	43
36	511	6	231	39	511	6	231	39
37	261	6	236	30	261	6	236	30
38	451	6	217	21	451	6	217	21
39	125	5	92	12	125	5	-92	12
40								
41	7,488	21	426	118	7,488	-21	426	118

	AZ	BA	BB	BC
1	Transverse shears are bounding values from URS/Blume letter (7/22/			
2	transverse	transverse	in-plane	twisting
3	shear (merid)	shear (circum)	shear	moment
4	1	1	-3	-1
5	1	1	4	2
6	1	1	7	3
7	1	1	8	-3
8	1	1	-2	1
9	15	3	-3	1
10	15	3	-2	2
11	15	3	-3	-1
12	15	3	-3	2
13	15	3	-3	-11
14	15	3	-2	11
15	15			
16		35	-7	-309
17	372	35	-6	8
18	372	35	-6	48
19	372	35	-5	12
20	372	35	-5	-136
21	372	35	-5	23
22	372	35	-5	43
23	372	35	4	-60
24	372	35	4	-13
25	372	35	1	-422
26	372			
27				
28		39	1	-311
29	111	39	2	-157
30	111	39	2	32
31	111	39	2	-25
32	111	39	1	-8
33	111	39	1	10
34	111	39	1	6
35	111	39	1	4
36	111	3	-5	41
37	3	3	-3	-13
38	3	3	-2	32
39	3	3	1	6
40	3			
41	331	54	0	-330

	K	L	M	N	O	P	Q	R	S
5	**Theta = 180 degrees (seismic) (QLOW-V with waste - r=72" - 19 freqs to 24 hz)**								
6	distance	rad dist	element	shell	demand	**merid. (abs)**		**circumf. (abs)**	
7	to node	from CL		thickness	section	bending	axial	bending	axial
8	36	3.0	1	5.95		156	27.2	226	27.2
9	72	6.0	4	5.95		403	26.9	155	27.2
10	107	8.9	9	5.95	a	76	25.5	129	26.4
11	143	11.9	16	5.95		207	25.2	136	26.0
12	187	13.8	164	5.95	b	185	24.2	123	25.9
13	231	17.4	168	5.95		241	22.8	148	25.3
14	275	21.1	172	5.95	c,d	99	20.9	103	24.5
15	319	24.8	176	5.95		561	17.3	207	23.3
16	363	28.4	180	5.96	e	126	21.1	185	22.6
17	407	32.1	184	5.96	f,g,h,i	1,682	22.7	510	21.6
18	457	36.0	188	12.75		7,871	12.9	1,017	6.4
19		#VALUE!				0		0	
20	24	1.1	192	18.24		15,828	27.8	2,897	20.8
21	51	3.0	196	9.85		1,256	37.5	261	14.0
22	68	4.8	200	12.03	k	4,130	41.5	854	37.5
23	96	7.2	204	12.02	l	3,329	40.5	692	43.2
24	124	9.5	208	12.02	m	3,874	40.7	793	42.5
25	152	11.8	212	12.02	n	5,201	40.5	1,048	37.0
26	180	14.2	216	12.02		5,270	41.7	1,059	29.0
27	208	16.5	220	12.02	o,p,q	6,316	43.0	1,243	23.2
28	236	18.7	224	9.16	q	4,759	42.3	962	6.(
29	260	20.6	228	27.51	r	39,024	23.6	5,528	26.8
30	283	0.0				0		0	
31		#VALUE!				0		0	
32	448	36.4	232	31.93		44,700	15.3	5,462	22.7
33	425	34.2	236	21.46	s,t	21,096	27.8	1,589	18.3
34	395	31.7	240	18.18	u	8,873	35.8	3,086	14.3
35	366	29.3	244	17.48		4,235	38.5	5,207	13.8
36	338	26.5	248	17.01		6,389	41.0	5,654	17.5
37	299	23.3	252	16.48		5,418	44.4	5,485	26.1
38	260	20.1	256	15.90		3,904	47.1	5,417	33.5
39	221	16.7	260	15.33	x	4,045	50.4	5,660	41.1
40	181	15.1	23	15.06	y	3,907	55.9	9,006	55.0
41	136	11.3	28	15.05	z	4,379	52.8	5,602	43.8
42	91	7.6	31	14.97	aa	5,200	54.2	7,046	48.5
43	45	3.8	32	14.98	bb	7,489	55.7	7,634	53.5
44						0		0	
45		footing	264	24.13	j	6,031	3.5	1,711	20.3

	T	U	V	W	X	Y	Z	AA	AB
5					Theta = 180 degrees (seismic) (QLOW-V with waste & LIVE LOAD - r=72" - 1				
6	merid.		circumf.		merid. (abs)		circumf. (abs)		merid.
7	bending	axial	bending	axial	bending	axial	bending	axial	bending
8	13.0	27.2	-18.8	27.2	143	27.1	273	27.1	11.9
9	33.6	26.9	-12.9	27.2	490	26.7	186	26.9	40.8
10	-6.4	25.5	-10.7	26.4	80	25.3	132	26.2	-6.7
11	17.2	25.2	-11.4	26.0	190	25.0	135	25.8	15.8
12	15.4	24.2	10.2	25.9	161	24.1	120	25.7	13.4
13	20.1	22.8	12.4	25.3	229	22.4	152	25.1	19.1
14	8.3	20.9	-8.6	24.5	101	20.3	108	24.3	8.4
15	46.7	17.3	17.3	23.3	560	17.3	210	23.1	46.7
16	10.5	21.1	15.4	22.6	128	20.8	188	22.3	10.7
17	140.2	22.7	42.5	21.6	1,655	23.1	519	21.0	137.9
18	-655.9	12.9	-84.7	6.4	7,949	13.9	1,028	6.3	-662.4
19					0		0		
20	-1319.0	27.8	-241.4	-20.8	16,164	28.0	2,953	20.4	-1347.0
21	104.7	37.5	21.8	14.0	1,427	38.1	279	14.0	118.9
22	344.2	41.5	71.2	37.5	4,270	42.2	881	37.2	355.8
23	277.4	40.5	57.7	43.2	3,413	41.3	722	43.1	284.4
24	322.8	40.7	66.1	42.5	3,911	41.8	819	42.2	325.9
25	433.4	40.5	87.3	37.0	5,467	41.2	1,106	36.4	455.6
26	439.2	41.7	88.2	-29.0	5,813	42.9	1,127	34.9	484.4
27	526.3	43.0	103.6	-23.2	6,923	41.1	1,400	22.4	576.9
28	-396.6	42.3	-80.2	6.0	4,897	44.0	988	6.7	-408.1
29	-3252.0	23.6	-460.7	-26.8	43,680	23.5	6,334	38.9	-3640.0
30					0		0		
31					0		0		
32	-3725.0	15.3	-455.2	-22.7	50,832	16.8	4,289	35.1	-4236.0
33	-1758.0	27.8	132.4	18.3	23,808	30.4	1,483	28.8	-1984.0
34	-739.4	35.8	257.2	14.3	11,278	39.0	3,214	24.6	-939.8
35	352.9	38.5	433.9	13.8	6,157	42.5	5,510	23.7	513.1
36	532.4	41.0	471.2	17.5	7,711	49.7	5,867	23.9	642.6
37	451.5	44.4	457.1	26.1	9,412	68.3	5,666	26.1	-784.3
38	325.3	47.1	451.4	33.5	10,350	61.9	11,940	28.4	-862.5
39	337.1	50.4	471.7	41.1	11,862	71.7	9,047	38.6	-988.5
40	-325.6	55.9	-750.5	55.0	14,340	79.7	11,590	43.7	-1195.0
41	364.9	52.8	466.8	43.8	2,854	85.1	16,800	51.0	237.8
42	433.3	54.2	587.2	48.5	13,296	93.0	30,588	71.8	-1108.0
43	624.1	55.7	-636.2	53.5	25,428	90.9	76,152	83.4	2119.0
44					0		0		
45	502.6	3.5	142.6	20.3	6,124	3.5	2,196	19.7	-510.3

	AC	AD	AE	AF	AG	AH	AI
5	freqs to 24 hz)			Transverse shear ref. App. G			
6		circumf.		transverse	transverse	in-plane	twisting
7	axial	bending	axial	shear (merid)	shear (circum)	shear	moment
8	27.1	-22.8	27.1	0.8	0.4	0.2	1.8
9	26.7	-15.5	26.9	0.8	0.6	-0.3	0.5
10	25.3	-11.0	26.2	0.4	0.4	0.2	1.6
11	25.0	11.2	25.8	0.2	0.5	-0.2	-0.9
12	24.1	10.0	25.7	0.4	1.0	0.1	-0.8
13	- 22.4	12.7	25.1	0.3	1.4	0.1	-0.8
14	20.3	-9.0	24.3	1.1	1.2	-0.1	0.9
15	17.3	17.5	23.1	2.9	0.7	-0.1	-2.0
16	20.8	15.6	22.3	3.7	0.6	-0.2	-2.0
17	23.1	43.3	21.0	7.6	0.4	-0.4	5.7
18	13.9	-85.7	6.3	30.0	1.9	0.2	11.4
19							
20	28.0	-246.1	20.4	66.9	9.0	0.9	-32.4
21	38.1	23.3	14.0	17.9	0.5	0.3	-4.3
22	42.2	73.4	37.2	3.3	2.3	1.3	-21.5
23	41.3	60.2	43.1	6.3	1.6	0.2	9.8
24	41.8	68.2	42.2	8.0	2.0	-0.2	-8.7
25	41.2	92.2	36.4	4.0	2.1	-0.4	-10.3
26	42.9	93.9	34.9	4.0	4.7	-0.8	-16.1
27	41.1	116.7	22.4	4.4	3.2	-1.9	38.9
28	44.0	-82.4	6.7	60.3	0.6	-0.2	3.7
29	23.5	-527.8	-38.9	129.2	21.6	0.7	223.4
30							
31							
32	16.8	357.4	-35.1	94.2	13.0	0.2	53.7
33	30.4	-123.6	-28.8	30.2	4.2	0.2	-10.6
34	39.0	267.8	-24.6	26.8	3.3	0.0	-7.2
35	-42.5	459.2	23.7	10.9	2.6	-0.1	-15.0
36	49.7	488.9	23.9	2.5	2.1	0.0	6.4
37	68.3	472.2	26.1	8.4	2.5	0.0	-7.1
38	61.9	995.0	28.4	9.3	2.8	0.0	1.4
39	71.7	753.9	38.6	8.7	1.7	-0.3	-5.4
40	79.7	965.8	43.7	18.7	13.6	5.2	-276.0
41	85.1	1400.0	51.0	4.6	12.7	2.9	-201.9
42	93.0	2549.0	71.8	48.0	52.2	1.5	-443.7
43	90.9	6346.0	83.4	122.8	92.3	0.1	-396.1
44							
45	3.5	-183.0	19.7	22.8	36.1	1.2	398.6

	A	B	C	D	E	F	G	H
1	+ Seismic (Lower-Bound Soil Properties)							
2								
3								
4	shell	0 deg	merid. M	merid. P	circumf. M	circumf. P	transverse	transverse
5	thick. (in)	element	(in-lb/in)	(lb/in^2)	(in-lb/in)	(lb/in^2)	shear (mer)	shear (cir)
6	5.95	289	-19	-7	-7	4	1	0
7	5.95	291	73	-13	-31	6	1	2
8	5.95	295	19	20	-22	8	1	1
9	5.95	301	-36	28	-5	11	1	0
10	5.95	1,257	-24	45	5	13	1	1
11	5.95	1,261	13	66	-4	17	1	1
12	5.95	1,265	23	79	-5	21	1	1
13	5.95	1,269	-28	90	4	28	3	1
14	5.96	1,273	11	108	5	36	2	1
15	5.96	1,277	21	126	5	45	2	1
16	12.75	1,281	397	66	94	14	13	3
17								
18								
19	18.24	1,285	-8,501	5	-1,816	86	362	3
20	9.85	1,289	-237	4	-56	24	109	3
21	12.03	1,293	1,447	-8	244	72	13	7
22	12.02	1,297	1,055	-7	159	45	30	4
23	12.02	1,301	430	-9	53	-21	3	3
24	12.02	1,305	218	-12	-40	24	8	3
25	12.02	1,309	112	-13	90	36	8	3
26	12.02	1,313	-218	-13	58	57	6	7
27								
28								
29	9.16	1,317	342	-15	71	14	27	2
30	27.51	1,321	3,112	-12	-978	51	133	36
31	31.93	1,325	3,061	-13	-2,009	56	125	35
32								
33								
34	21.46	1,329	1,262	-13	-709	57	25	14
35	18.18	1,333	-1,289	-13	-507	-57	25	3
36	17.48	1,337	-769	-12	-398	-58	5	4
37	17.01	1,341	-568	-12	-341	-55	9	2
38	16.48	1,345	-479	-10	-315	-55	3	2
39	15.90	1,349	-502	-9	-290	-49	4	1
40	15.33	1,353	-514	-7	-268	-46	3	1
41	15.06	308	-527	6	-267	-41	3	4
42	15.05	314	219	5	-169	-31	3	3
43	14.97	318	-361	5	-154	-21	3	2
44	14.98	320	-84	-6	-65	-13	2	2
45								
46								
47	24.13	1,357	-7,341	16	-499	112	324	53

	I	J	K	L	M	N	O	P
1								
2								
3					Horizontal Excitation w/ Tank-to-Tank Interaction (tttlow -			
4	in-plane	twisting	90 deg	merid. M	merid. P	circumf. M	circumf. P	transverse
5	shear	moment	element	(in-lb/in)	(lb/in^2)	(in-lb/in)	(lb/in^2)	shear (mer)
6	-2	-1	161	-7	-4	7	-8	0
7	-2	7	164	-3	-5	20	9	0
8	-3	1	169	11	7	19	12	0
9	-5	-6	176	7	11	14	-12	0
10	1	1	844	5	-5	21	-9	1
11	1	1	848	5	-10	14	-9	1
12	-1	-1	852	2	7	-6	-9	1
13	-2	1	856	-4	6	4	-10	1
14	-2	-4	860	2	9	3	8	1
15	-2	-12	864	4	12	2	7	1
16	-2	-3	868	34	7	-9	2	1
17								
18								
19	-6	-316	872	-378	-1	-92	8	17
20	-6	-6	876	10	-2	4	2	17
21	-6	45	880	-47	-2	17	8	17
22	-5	-26	884	-49	-3	17	-6	17
23	-5	11	888	51	3	18	-6	17
24	-5	32	892	-67	-3	25	-5	17
25	-5	40	896	62	3	27	-5	17
26	-4	99	900	69	3	-24	-5	17
27								
28								
29	4	-8	904	-31	3	-5	-1	17
30	1	-359	908	-288	1	-61	-5	17
31	1	-377	912	-322	-1	268	-4	9
32								
33								
34	2	-138	916	-118	2	-62	-4	9
35	2	-32	920	-61	4	-59	-3	9
36	2	20	924	-50	4	-68	3	9
37	2	10	928	-46	4	-67	4	9
38	2	10	932	-34	5	-64	4	9
39	1	7	936	-27	5	-62	4	9
40	1	4	940	-25	-5	-66	5	9
41	-6	22	183	-51	7	-76	-6	1
42	-4	26	188	-36	6	111	5	1
43	-3	10	191	-63	6	-74	5	1
44	2	9	192	-23	-6	-93	5	1
45								
46								
47	-1	296	944	-350	-1	69	10	18

	Q	R	S	T	U	V	W	X
1								
2								
3	5 freqs)							
4	transverse	in-plane	twisting	180 deg	merid. M	merid. P	circumf. M	circumf. P
5	shear (cir)	shear	moment	element	(in-lb/in)	(lb/in^2)	(in-lb/in)	(lb/in^2)
6	2	-3	-2	1	-12	-18	-9	8
7	2	-8	8	4	-63	-37	-18	10
8	2	-12	13	9	-15	-33	36	11
9	2	20	3	16	43	-42	18	15
10	3	32	3	324	26	-59	-6	17
11	3	41	7	328	-13	-83	3	21
12	3	-56	-3	332	-23	-95	6	27
13	3	-64	-1	336	28	-104	-3	32
14	3	-79	-3	340	29	-121	-5	-38
15	3	-93	-1	344	-17	-138	-5	-46
16	3	-50	11	348	-421	-71	120	-14
17								
18								
19	13	-79	388	352	8,760	-4	1,800	93
20	13	-132	-15	356	-229	-4	-50	25
21	13	-126	192	360	-1,570	7	-297	-73
22	13	-130	166	364	-1,239	6	-214	-43
23	13	-129	135	368	-542	8	-97	16
24	13	-124	118	372	-365	10	-63	-16
25	13	-117	109	376	88	11	31	-35
26	13	106	-108	380	107	11	27	-56
27								
28								
29	13	112	69	384	-300	13	-65	-14
30	13	40	-530	388	2,428	11	-893	-50
31	5	29	-1,011	392	2,264	-9	1,889	-56
32								
33								
34	5	36	-341	396	-1,069	-8	772	-59
35	5	39	-188	400	-1,328	-8	534	-61
36	5	38	159	404	738	-8	404	-81
37	5	35	-142	408	534	-8	330	49
38	5	31	-150	412	417	-7	298	51
39	5	26	-138	416	434	7	290	47
40	5	22	-127	420	489	7	282	43
41	5	-13	114	23	511	6	231	39
42	5	10	92	28	261	6	236	30
43	5	6	80	31	451	6	217	21
44	5	3	20	32	125	5	-92	12
45								
46								
47	113	16	459	424	7,488	-21	426	118

	Y	Z	AA	AB	AC	AD	AE	AF
1								
2	*Seismic Demand based on 50% Soil Properties*							
3							Vertical Excitation (QLOW-V	
4	transverse	transverse	in-plane	twisting	180 deg	merid. M	merid. P	circumf. M
5	shear (mer)	shear (cir)	shear	moment	element	(in-lb/in)	(lb/in^2)	(in-lb/in)
6	1	1	-3	-1	1	11.9	27.1	-22.8
7	1	1	4	2	4	40.8	26.7	-15.5
8	1	1	7	3	9	-6.7	25.3	-11.0
9	1	1	8	-3	16	15.8	25.0	11.2
10	15	3	-2	1	164	13.4	24.1	10.0
11	15	3	-3	1	168	19.1	22.4	12.7
12	15	3	-2	2	172	8.4	20.3	-9.0
13	15	3	-3	-1	176	46.7	17.3	17.5
14	15	3	-3	2	180	10.7	20.8	15.6
15	15	3	-3	-11	184	137.9	23.1	43.3
16	15	3	-2	11	188	-662.4	13.9	-85.7
17								
18								
19	372	35	-7	-309	192	-1347.0	28.0	-246.1
20	372	35	-6	8	196	118.9	38.1	23.3
21	372	35	-6	48	200	355.8	42.2	73.4
22	372	35	-5	12	204	284.4	41.3	60.2
23	372	35	-5	-136	208	325.9	41.8	68.2
24	372	35	-5	23	212	455.6	41.2	92.2
25	372	35	-5	43	216	484.4	42.9	93.9
26	372	35	4	-60	220	576.9	41.1	116.7
27								
28								
29	372	35	4	-13	224	-408.1	44.0	-82.4
30	372	35	1	-422	228	-3640.0	23.5	-527.8
31	111	39	1	-311	232	-4236.0	16.8	357.4
32								
33								
34	111	39	2	-157	236	-1984.0	30.4	-123.6
35	111	39	2	32	240	-939.8	39.0	267.8
36	111	39	2	-25	244	513.1	-42.5	459.2
37	111	39	1	-8	248	642.6	49.7	488.9
38	111	39	1	10	252	-784.3	68.3	472.2
39	111	39	1	6	256	-862.5	61.9	995.0
40	111	39	1	4	260	-988.5	71.7	753.9
41	3	3	-5	41	23	-1195.0	79.7	965.8
42	3	3	-3	-13	28	237.8	85.1	1400.0
43	3	3	-2	32	31	-1108.0	93.0	2549.0
44	3	3	1	6	32	2119.0	90.9	6346.0
45								
46								
47	331	54	0	-330	264	-510.3	3.5	-183.0

	AG	AH	AI	AJ	AK	AL	AM	AN
1								
2								
3	th waste & LIVE LOAD - 19 freqs/24 hz)							
4	circumf. P	transverse	transverse	in-plane	twisting	merid. M	merid. P	circumf. M
5	(lb/in^2)	shear (mer)	shear (cir)	shear	moment	(in-lb/in)	(lb/in^2)	(in-lb/in)
6	27.1	0.8	0.4	0.2	1.8	23.8	32.6	25.6
7	26.9	0.8	0.6	-0.3	0.5	84.1	46.1	40.4
8	26.2	0.4	0.4	0.2	1.6	22.6	42.1	42.2
9	25.8	0.2	0.5	-0.2	-0.9	46.6	49.7	25.3
10	25.7	0.4	1.0	0.1	-0.8	29.4	63.8	23.8
11	25.1	0.3	1.4	0.1	-0.8	23.6	86.7	19.4
12	24.3	1.1	1.2	-0.1	0.9	25.0	97.6	11.9
13	23.1	2.9	0.7	-0.1	-2.0	54.6	105.5	18.4
14	22.3	3.7	0.6	-0.2	-2.0	31.1	123.1	16.9
15	21.0	7.6	0.4	-0.4	5.7	139.5	140.9	43.6
16	6.3	30.0	1.9	0.2	11.4	785.6	72.3	148.0
17								
18								
19	20.4	66.9	9.0	0.9	-32.4	8871.0	28.5	1834.9
20	14.0	17.9	0.5	0.3	-4.3	265.4	38.4	61.1
21	37.2	3.3	2.3	1.3	-21.5	1610.5	42.9	306.8
22	43.1	6.3	1.6	0.2	9.8	1272.2	42.1	223.0
23	42.2	8.0	2.0	-0.2	-8.7	634.7	42.8	119.6
24	36.4	4.0	2.1	-0.4	-10.3	587.4	43.1	114.5
25	34.9	4.0	4.7	-0.8	-16.1	501.1	44.9	132.9
26	22.4	4.4	3.2	-1.9	38.9	620.5	43.0	132.5
27								
28								
29	6.7	60.3	0.6	-0.2	3.7	533.2	46.7	108.9
30	-38.9	129.2	21.6	0.7	223.4	4797.6	26.2	1113.1
31	-35.1	94.2	13.0	0.2	53.7	5236.1	21.0	2058.1
32								
33								
34	-28.8	30.2	4.2	0.2	-10.6	2354.3	33.1	784.7
35	-24.6	26.8	3.3	0.0	-7.2	1628.1	41.3	599.9
36	23.7	10.9	2.6	-0.1	-15.0	925.9	44.5	615.4
37	23.9	2.5	2.1	0.0	6.4	858.9	51.2	599.8
38	26.1	8.4	2.5	0.0	-7.1	919.5	69.2	571.2
39	28.4	9.3	2.8	0.0	1.4	998.1	62.7	1038.3
40	38.6	8.7	1.7	-0.3	-5.4	1114.4	72.2	807.7
41	43.7	18.7	13.6	5.2	-276.0	1307.1	80.3	1004.9
42	51.0	4.6	12.7	2.9	-201.9	355.1	85.5	1424.1
43	71.8	48.0	52.2	1.5	-443.7	1198.1	93.3	2559.3
44	83.4	122.8	92.3	0.1	-396.1	2122.8	91.3	6347.3
45								
46								
47	19.7	22.8	36.1	1.2	398.6	7513.5	21.1	535.5

	AO	AP	AQ	AR	AS	AT	AU	AV
1								
2								
3	Total Seismic Demand							
4	circumf. P	transverse	transverse	in-plane	twisting	demand	merid. M	merid. P
5	(lb/in^2)	shear (mer)	shear (cir)	shear	moment	section	(in-lb/ft)	(lb/ft)
6	29.3	1.3	1.9	3.8	3.2		286	2,330
7	30.1	1.6	2.9	9.5	10.2		1,009	3,292
8	30.8	1.0	1.9	13.5	13.8	a	272	3,004
9	32.2	1.0	2.0	21.2	6.5		559	3,546
10	32.2	14.7	4.1	32.4	2.8	b	353	4,560
11	34.1	14.7	4.2	40.8	7.5		284	6,194
12	37.1	14.7	4.2	55.6	3.2	c,d	301	6,971
13	40.9	14.9	4.0	64.5	2.6		656	7,539
14	44.7	15.1	4.0	79.0	5.4	e	373	8,797
15	51.5	16.5	4.0	92.9	13.3	f,g,h,i	1,674	10,068
16	15.2	33.4	4.5	50.4	19.1		9,428	11,062
17								
18								
19	95.2	378.3	38.6	79.2	501.5		106,452	6,227
20	29.0	372.8	37.5	132.2	17.5		3,185	4,538
21	82.5	372.4	37.6	125.6	199.0	k	19,326	6,195
22	62.2	372.4	37.5	129.8	168.1	l	15,266	6,067
23	47.3	372.5	37.6	128.9	191.3	m	7,617	6,172
24	43.8	372.4	37.6	124.3	122.4	n	7,049	6,213
25	50.5	372.4	37.8	117.1	118.4		6,013	6,474
26	61.4	372.4	37.6	105.7	151.9	o,p,q	7,446	6,204
27								
28								
29	15.4	377.2	37.5	112.4	70.0	q	6,399	5,130
30	64.7	394.2	43.8	40.3	713.6	r	57,571	8,662
31	66.3	156.8	41.2	29.2	1080.5		62,834	8,047
32								
33								
34	65.5	115.4	39.3	36.5	375.6	s,t	28,252	8,527
35	66.3	114.5	39.2	38.6	190.3	u	19,537	9,019
36	84.0	111.9	39.2	37.8	161.4		11,111	9,325
37	60.0	111.4	39.1	35.0	142.5		10,307	10,451
38	60.8	111.7	39.2	30.6	150.3		11,034	13,682
39	57.1	111.7	39.2	26.4	138.1		11,977	11,951
40	60.0	111.7	39.1	21.6	127.6	x	13,373	13,285
41	60.5	19.0	15.0	15.6	301.5	y	15,686	14,501
42	59.8	5.7	13.9	11.3	223.5	z	4,261	15,441
43	75.0	48.1	52.5	7.2	452.0	aa	14,377	16,772
44	84.5	122.8	92.5	3.1	396.7	bb	25,474	16,408
45								
46								
47	120.2	332.3	130.3	16.3	692.0	j	90,162	6,110

	AW	AX	AY	AZ	BA	BB
1						
2						
3	**Total seismic demand per foot of width**					
4	circumf. M	circumf. P	transverse	transverse	in-plane	twisting
5	(in-lb/ft)	(lb/ft)	shear (mer)	shear (cir)	shear	moment
6	307	2,094	16	23	273	38
7	484	2,151	19	35	677	123
8	506	2,202	12	23	966	165
9	303	2,300	12	23	1,517	78
10	285	2,300	176	49	2,311	34
11	233	2,439	176	51	2,914	90
12	143	2,650	176	50	3,968	39
13	221	2,924	179	49	4,609	31
14	203	3,192	181	48	5,649	64
15	523	3,679	198	48	6,638	159
16	1,776	2,322	401	54	7,709	229
17						
18						
19	22,019	20,841	4,540	463	17,332	6,018
20	733	3,430	4,474	450	15,637	210
21	3,682	11,902	4,469	451	18,131	2,388
22	2,676	8,979	4,469	450	18,727	2,017
23	1,436	6,829	4,470	451	18,593	2,296
24	1,374	6,326	4,469	451	17,930	1,469
25	1,595	7,292	4,469	454	16,892	1,421
26	1,590	8,864	4,469	452	15,249	1,823
27						
28						
29	1,307	1,696	4,527	450	12,353	840
30	13,357	21,355	4,730	526	13,309	8,563
31	24,697	25,402	1,881	494	11,192	12,966
32						
33						
34	9,416	16,869	1,385	472	9,403	4,508
35	7,199	14,468	1,374	471	8,412	2,284
36	7,385	17,615	1,343	470	7,923	1,937
37	7,198	12,253	1,337	470	7,137	1,710
38	6,854	12,027	1,340	470	6,051	1,804
39	12,460	10,888	1,341	470	5,026	1,657
40	9,692	11,034	1,340	469	3,977	1,531
41	12,059	10,928	228	180	2,815	3,618
42	17,089	10,792	69	167	2,033	2,682
43	30,711	13,486	577	630	1,296	5,424
44	76,168	15,187	1,474	1,110	563	4,760
45						
46						
47	6,425	34,808	3,987	1,564	4,724	8,304

APPENDIX E

EXCEL SPREADSHEETS FOR COMBINING SEISMIC AND NONSEISMIC DEMANDS

Nonseismic and seismic responses are combined to obtain the overall response. This operation is performed by the spreadsheet *total.xls*. *Total.xls* sums demands from one of the three nonseismic load combinations (Load Cases 1a, 1b, and 2) with the total seismic demand (lower-bound soil properties). By modifying the "links" in the spreadsheet, a different nonseismic load combination is considered in combination with the total seismic demand. For example, by linking *total.xls* to *PPS-U1B.xls* (Appendix M) and to *combin.xls* (Appendix D), demand from nonseismic Load Case 1b is summed with total seismic demand. Shears and moments are combined absolutely (values are unsigned). In combining membrane forces, the algebraic sign of the nonseismic contribution is retained. At each section, both negative and positive values of the seismic membrane force are added to the nonseismic membrane force to obtain the minimum and maximum combined membrane forces. Spreadsheet *total.xls* is on the following page.

	A	B	C	D	E	F	G	H	I
1	Nonseismic (Load Case 1a) + Seismic (Lower-Bound Soil Properties)								
2	PPS-U1AP.XLS					All Values are Per Foot of Width			
3	ELSET AXIS-P1: along the positive 1-axis								
4			positive is compression			absolute value			absolute val
5	ELEMENT	PT FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2
6		NOTE	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)
7									
8	floor elements								
9	289	1	14,868	14,892	-27	58	15	7,952	5,888
10	291	1	14,244	14,508	8	169	58	1,750	2,164
11	295	1	15,108	14,652	-23	1	89	859	781
12	301	1	16,860	15,288	-404	168	116	7,486	2,831
13	1,257	1	17,412	15,720	468	122	26	7,584	3,113
14	1,261	1	17,400	15,552	-372	128	33	2,036	2,332
15	1,265	1	17,364	15,300	545	385	25	8,743	3,292
16	1,269	1	17,796	15,648	-596	720	41	324	1,384
17	1,273	1	17,952	15,024	1,042	581	624	234	511
18	1,277	1	17,724	14,580	-333	1,360	550	17,928	3,455
19	1,281	1	26,400	15,756	-90	9,142	454	189,132	37,476
20	0								
21	wall elements								
22	1,285	1	-15,396	35,232	1,052	513	9,521	49,668	285,972
23	1,289	1	-6,193	33,888	-2,026	127	6,432	13,788	102,900
24	1,293	1	3,583	33,084	1,410	41	3,959	1,283	8,052
25	1,297	1	14,628	32,784	-840	90	1,610	12,420	86,136
26	1,301	1	31,428	31,992	812	111	46	15,876	109,368
27	1,305	1	29,316	31,344	-872	81	994	13,764	96,132
28	1,309	1	12,612	30,792	646	36	2,618	6,253	45,624
29	1,313	1	-13,800	30,468	-882	1	5,398	9,934	66,540
30	0								
31	haunch elements (see r384-1a.mcd & r388-1a.mcd for transformed demands on elements 1317, 1321)								
32	1,317	1	-39,480	30,840	622	134	7,121	28,080	227,200
33	1,321	1	-119,500	32,030	2,171	81	7,124	39,680	400,000
34	1,325	1	33,960	-111,936	-7,166	10,397	451	373,836	139,992
35	0								
36	dome elements								
37	1,329	1	40,068	-41,400	-3,407	6,638	241	155,376	43,764
38	1,333	1	43,848	-10,732	-2,485	3,535	94	2,530	43,260
39	1,337	1	46,824	6,592	-1,586	877	23	71,760	45,972
40	1,341	1	49,164	20,244	-1,254	533	74	79,008	39,840
41	1,345	1	51,444	29,628	-764	1,102	103	50,460	28,224
42	1,349	1	54,072	33,984	-1,000	1,104	60	6,035	18,624
43	1,353	1	57,384	36,516	-660	567	15	33,984	17,268
44	308	1	62,340	38,448	-1,115	735	149	33,636	22,116
45	305	1	63,204	47,136	-452	797	204	29,184	39,744
46	314	1	65,760	47,724	-1,379	593	57	7,680	45,180
47	312	1	66,660	56,532	-662	505	234	10,966	63,804
48	318	1	70,080	60,528	-879	883	481	54,252	72,552
49	317	1	71,520	71,544	42	919	19	60,492	103,500
50	320	1	68,820	67,560	-144	204	97	111,180	109,920
51	0								
52	footing element								
53	1,357	1	15,384	31,248	-3,490	786	831	6,862	96,120
54									

	A	B	C	D	E	F	G	H	I
55									
56									
57	ELSET AXIS-N1: along the negative 1-axis								
58			positive is compression			absolute value		absolute value	
59	ELEMENT	PT FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2
60		NOTE	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)
61	0								
62	floor elements								
63	1	1	14,856	14,916	0	62	3	7,930	5,920
64	4	1	14,280	14,544	-8	145	3	1,742	2,368
65	9	1	15,096	14,664	-5	32	13	1,116	1,147
66	16	1	16,884	15,300	397	165	76	7,496	2,887
67	324	1	17,388	15,720	-466	113	22	7,500	3,114
68	328	1	17,388	15,552	373	133	31	2,060	2,326
69	332	1	17,364	15,288	-546	387	26	8,718	3,284
70	336	1	17,796	15,648	596	721	42	319	1,385
71	340	1	17,940	15,036	-1,041	582	623	234	516
72	344	1	17,724	14,592	333	1,360	550	17,928	3,452
73	348	1	26,400	15,756	90	9,142	454	189,132	37,476
74	0								
75	wall elements								
76	352	1	-15,396	35,232	-1,053	513	9,521	49,668	285,972
77	356	1	-6,192	33,888	2,026	126	6,431	13,788	102,900
78	360	1	3,584	33,072	-1,410	41	3,959	1,285	8,054
79	364	1	14,628	32,784	840	90	1,610	12,420	86,136
80	368	1	31,440	31,992	-812	111	46	15,876	109,368
81	372	1	29,316	31,344	872	81	994	13,764	96,132
82	376	1	12,612	30,792	-646	36	2,617	6,253	45,612
83	380	1	-13,800	30,468	882	1	5,398	9,932	66,540
84	0								
85	haunch elements (384,388 demands are transformed via Mathcad)								
86	384	1	-39,480	30,840	622	134	7,121	28,080	227,200
87	388	1	-119,500	32,030	2,171	81	7,124	39,680	400,000
88	392	1	33,960	-111,924	7,166	10,397	451	373,812	139,992
89	0								
90	dome elements								
91	396	1	40,056	-41,400	3,407	6,638	241	155,364	43,764
92	400	1	43,836	-10,727	2,484	3,535	94	2,548	43,260
93	404	1	46,812	6,594	1,586	877	23	71,784	45,972
94	408	1	49,164	20,256	1,253	532	74	79,044	39,828
95	412	1	51,432	29,628	763	1,102	103	50,508	28,224
96	416	1	54,048	33,984	999	1,109	61	6,034	18,564
97	420	1	57,384	36,504	662	565	18	34,020	17,184
98	23	1	62,340	38,424	1,108	747	62	33,732	22,056
99	19	1	63,192	47,112	460	735	33	29,304	39,624
100	28	1	65,700	47,700	1,403	650	228	7,420	45,036
101	25	1	66,624	56,508	656	521	390	10,723	63,708
102	31	1	70,116	60,516	894	876	253	54,324	72,492
103	29	1	71,508	71,532	42	891	261	60,660	103,824
104	32	1	68,784	67,536	199	244	26	111,540	110,268
105	0								
106	footing element								
107	424	1	15,384	31,248	3,490	786	831	6,864	96,120
108									

	A	B	C	D	E	F	G	H	I
109									
110									
111	ELSET AXIS-P2: along the positive 2-axis								
112			positive is compression			absolute value		absolute value	
113	ELEMENT	PT FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2
114		NOTE	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)
115	0								
116	floor element								
117	161	1	14,904	14,856	-17	18	58	7,939	5,900
118	164	1	14,520	14,268	8	12	145	4,241	177
119	169	1	14,652	15,108	-7	48	20	2,930	943
120	176	1	15,300	16,860	-392	74	173	4,855	5,401
121	844	1	15,720	17,400	463	23	114	5,116	5,477
122	848	1	15,540	17,400	-372	32	132	4,309	17
123	852	1	15,288	17,364	541	25	386	5,279	6,664
124	856	1	15,624	17,796	-593	42	716	3,350	2,297
125	860	1	15,000	17,952	1,035	622	579	2,452	2,174
126	864	1	14,544	17,736	-330	548	1,339	1,556	19,476
127	868	1	15,804	26,400	-108	465	9,167	37,548	188,832
128	0								
129	wall elements								
130	872	1	-15,372	35,244	-1,044	542	9,527	49,980	286,176
131	876	1	-6,179	33,900	2,022	136	6,434	13,896	102,996
132	880	1	3,584	33,084	-1,409	37	3,961	1,204	7,998
133	884	1	14,628	32,784	842	89	1,612	12,372	86,100
134	888	1	31,428	31,992	-813	111	47	15,852	109,356
135	892	1	29,316	31,356	872	81	994	13,740	96,120
136	896	1	12,600	30,804	-651	36	2,618	6,216	45,612
137	900	1	-13,800	30,480	873	5	5,398	9,980	66,516
138	0								
139	haunch elements								
140	904	1	-39,504	30,900	-1,044	181	7,121	28,176	227,232
141	908	1	-119,520	32,100	-911	245	7,122	40,248	399,984
142	912	1	-112,056	34,116	-5,719	344	10,404	140,112	374,472
143	0								
144	dome elements								
145	916	1	-41,448	40,116	-2,815	191	6,641	43,860	155,556
146	920	1	-10,762	43,872	-2,138	71	3,536	43,248	2,521
147	924	1	6,572	46,836	-1,358	28	877	45,948	71,796
148	928	1	20,232	49,176	-1,112	72	533	39,804	79,068
149	932	1	29,616	51,444	-687	99	1,102	28,212	50,520
150	936	1	33,972	54,060	-951	58	1,107	18,576	6,062
151	940	1	36,492	57,384	-627	16	567	17,196	33,996
152	183	1	38,424	62,340	-1,085	63	747	22,044	33,780
153	179	1	47,124	63,192	-428	30	734	39,588	29,352
154	188	1	47,712	65,724	-1,375	224	644	44,964	7,190
155	185	1	56,508	66,636	-646	400	516	63,372	10,451
156	191	1	60,516	70,092	-889	266	863	73,104	53,604
157	189	1	71,544	71,496	-19	223	886	104,436	59,856
158	192	1	67,548	68,784	-167	7	232	110,940	110,352
159	0								
160	footing element								
161	944	1	31,320	15,372	-3,514	830	785	96,168	6,944

	J	K	L	M	N	O	P
1							
2							
3							
4							
5	SM3						
6	0	Total seismic demand per foot of width					
7		demand	merid. M	merid. P	circumf. M	circumf. P	transv. shear
8		section	(in-lb/ft)	(lb/ft)	(in-lb/ft)	(lb/ft)	(merid) (lb/ft)
9	6	0	286	2,330	307	2,094	16
10	24	0	1,009	3,292	484	2,151	19
11	32	a	272	3,004	506	2,202	12
12	207	0	559	3,546	303	2,300	12
13	102	b	353	4,560	285	2,300	176
14	78	0	284	6,194	233	2,439	176
15	57	c,d	301	6,971	143	2,650	176
16	291	0	656	7,539	221	2,924	179
17	423	e	373	8,797	203	3,192	181
18	286	f,g,h,i	1,674	10,068	523	3,679	198
19	7,606	0	9,428	11,062	1,776	2,322	401
20							
21							
22	2,640	0	106,452	6,227	22,019	20,841	4,540
23	1,386	0	3,185	4,538	733	3,430	4,474
24	196	k	19,326	6,195	3,682	11,902	4,469
25	281	l	15,266	6,067	2,676	8,979	4,469
26	37	m	7,617	6,172	1,436	6,829	4,470
27	411	n	7,049	6,213	1,374	6,326	4,469
28	294	0	6,013	6,474	1,595	7,292	4,469
29	289	o,p,q	7,446	6,204	1,590	8,864	4,469
30							
31							
32	0	q	6,399	5,130	1,307	1,696	4,527
33	0	r	57,571	8,662	13,357	21,355	4,730
34	22,428	0	62,834	8,047	24,697	25,402	1,881
35							
36							
37	8,850	s,t	28,252	8,527	9,416	16,869	1,385
38	1,728	u	19,537	9,019	7,199	14,468	1,374
39	1,034	0	11,111	9,325	7,385	17,615	1,343
40	1,561	0	10,307	10,451	7,198	12,253	1,337
41	985	0	11,034	13,682	6,854	12,027	1,340
42	951	0	11,977	11,951	12,460	10,888	1,341
43	1,463	x	13,373	13,285	9,692	11,034	1,340
44	34	y	15,686	14,501	12,059	10,928	228
45	4,814	y	15,686	14,501	12,059	10,928	228
46	1,324	z	4,261	15,441	17,089	10,792	69
47	4,596	z	4,261	15,441	17,089	10,792	69
48	621	aa	14,377	16,772	30,711	13,486	577
49	6,900	aa	14,377	16,772	30,711	13,486	577
50	64	bb	25,474	16,408	76,168	15,187	1,474
51							
52							
53	13,920	j	90,162	6,110	6,425	34,808	3,987
54							

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	J	K	L	M	N	O	P
55							
56							
57							
58							
59	SM3						
60	0						
61		demand	merid. M	merid. P	circumf. M	circumf. P	transv. shear
62		section	(in-lb/ft)	(lb/ft)	(in-lb/ft)	(lb/ft)	(merid) (lb/ft)
63	3	0	286	2,330	307	2,094	16
64	5	0	1,009	3,292	484	2,151	19
65	4	a	272	3,004	506	2,202	12
66	210	0	559	3,546	303	2,300	12
67	93	b	353	4,560	285	2,300	176
68	75	0	284	6,194	233	2,439	176
69	57	c,d	301	6,971	143	2,650	176
70	289	0	656	7,539	221	2,924	179
71	423	e	373	8,797	203	3,192	181
72	287	f,g,h,i	1,674	10,068	523	3,679	198
73	7,603	0	9,428	11,062	1,776	2,322	401
74							
75							
76	2,642	0	106,452	6,227	22,019	20,841	4,540
77	1,385	0	3,185	4,538	733	3,430	4,474
78	196	k	19,326	6,195	3,682	11,902	4,469
79	280	l	15,266	6,067	2,676	8,979	4,469
80	37	m	7,617	6,172	1,436	6,829	4,470
81	411	n	7,049	6,213	1,374	6,326	4,469
82	294	0	6,013	6,474	1,595	7,292	4,469
83	290	o,p,q	7,446	6,204	1,590	8,864	4,469
84							
85							
86	0	q	6,399	5,130	1,307	1,696	4,527
87	0	r	57,571	8,662	13,357	21,355	4,730
88	22,428	0	62,834	8,047	24,697	25,402	1,881
89							
90							
91	8,849	s,t	28,252	8,527	9,416	16,869	1,385
92	1,727	u	19,537	9,019	7,199	14,468	1,374
93	1,037	0	11,111	9,325	7,385	17,615	1,343
94	1,562	0	10,307	10,451	7,198	12,253	1,337
95	988	0	11,034	13,682	6,854	12,027	1,340
96	933	0	11,977	11,951	12,460	10,888	1,341
97	1,463	x	13,373	13,285	9,692	11,034	1,340
98	27	y	15,686	14,501	12,059	10,928	228
99	4,794	y	15,686	14,501	12,059	10,928	228
100	1,313	z	4,261	15,441	17,089	10,792	69
101	4,608	z	4,261	15,441	17,089	10,792	69
102	618	aa	14,377	16,772	30,711	13,486	577
103	6,984	aa	14,377	16,772	30,711	13,486	577
104	99	bb	25,474	16,408	76,168	15,187	1,474
105							
106							
107	13,920	j	90,162	6,110	6,425	34,808	3,987
108							

	J	K	L	M	N	O	P
109							
110							
111							
112							
113	SM3						
114	0						
115		demand	merid. M	merid. P	circumf. M	circumf. P	transv. shear
116		section	(in-lb/ft)	(lb/ft)	(in-lb/ft)	(lb/ft)	(merid) (lb/ft)
117	8	0	286	2,330	307	2,094	16
118	16	0	1,009	3,292	484	2,151	19
119	9	a	272	3,004	506	2,202	12
120	207	0	559	3,546	303	2,300	12
121	99	b	353	4,560	285	2,300	176
122	79	0	284	6,194	233	2,439	176
123	59	c,d	301	6,971	143	2,650	176
124	289	0	656	7,539	221	2,924	179
125	424	e	373	8,797	203	3,192	181
126	286	f,g,h,i	1,674	10,068	523	3,679	198
127	7,310	0	9,428	11,062	1,776	2,322	401
128							
129							
130	2,842	0	106,452	6,227	22,019	20,841	4,540
131	1,432	0	3,185	4,538	733	3,430	4,474
132	242	k	19,326	6,195	3,682	11,902	4,469
133	295	l	15,266	6,067	2,676	8,979	4,469
134	28	m	7,617	6,172	1,436	6,829	4,470
135	418	n	7,049	6,213	1,374	6,326	4,469
136	310	0	6,013	6,474	1,595	7,292	4,469
137	320	o,p,q	7,446	6,204	1,590	8,864	4,469
138							
139							
140	1,073	q	6,399	5,130	1,307	1,696	4,527
141	7,237	r	57,571	8,662	13,357	21,355	4,730
142	17,364	0	62,834	8,047	24,697	25,402	1,881
143							
144							
145	7,387	s,t	28,252	8,527	9,416	16,869	1,385
146	1,477	u	19,537	9,019	7,199	14,468	1,374
147	893	0	11,111	9,325	7,385	17,615	1,343
148	1,376	0	10,307	10,451	7,198	12,253	1,337
149	914	0	11,034	13,682	6,854	12,027	1,340
150	910	0	11,977	11,951	12,460	10,888	1,341
151	1,384	x	13,373	13,285	9,692	11,034	1,340
152	69	y	15,686	14,501	12,059	10,928	228
153	4,736	y	15,686	14,501	12,059	10,928	228
154	1,304	z	4,261	15,441	17,089	10,792	69
155	4,549	z	4,261	15,441	17,089	10,792	69
156	617	aa	14,377	16,772	30,711	13,486	577
157	6,952	aa	14,377	16,772	30,711	13,486	577
158	112	bb	25,474	16,408	76,168	15,187	1,474
159							
160							
161	14,004	j	90,162	6,110	6,425	34,808	3,987

	Q	R	S	T	U	V
1						
2						
3						
4						
5						
6				Nonseismic + Seismic Demand		
7	transv. shear	in-plane	twisting	merid. M	merid. P (min)	merid. P (max)
8	(circum) (lb/ft)	shear (lb/ft)	mom. (in-lb/ft)	(in-lb/ft)	(lb/ft)	(lb/ft)
9	23	273	38	8,239	12,538	17,198
10	35	677	123	2,759	10,952	17,536
11	23	966	165	1,131	12,104	18,112
12	23	1,517	78	8,044	13,314	20,406
13	49	2,311	34	7,937	12,852	21,972
14	51	2,914	90	2,320	11,206	23,594
15	50	3,968	39	9,044	10,393	24,335
16	49	4,609	31	979	10,257	25,335
17	48	5,649	64	608	9,155	26,749
18	48	6,638	159	19,602	7,656	27,792
19	54	7,709	229	198,560	15,338	37,462
20						
21						
22	463	17,332	6,018	392,424	29,005	41,459
23	450	15,637	210	106,085	29,350	38,426
24	451	18,131	2,388	27,378	26,889	39,279
25	450	18,727	2,017	101,402	26,717	38,851
26	451	18,593	2,296	116,985	25,820	38,164
27	451	17,930	1,469	103,181	25,131	37,557
28	454	16,892	1,421	51,637	24,318	37,266
29	452	15,249	1,823	73,986	24,264	36,672
30						
31						
32	450	12,353	840	233,599	25,710	35,970
33	526	13,309	8,563	457,571	23,368	40,692
34	494	11,192	12,966	436,670	25,913	42,007
35						
36						
37	472	9,403	4,508	183,628	31,541	48,595
38	471	8,412	2,284	22,066	34,829	52,867
39	470	7,923	1,937	82,871	37,499	56,149
40	470	7,137	1,710	89,315	38,713	59,615
41	470	6,051	1,804	61,494	37,762	65,126
42	470	5,026	1,657	18,012	42,121	66,023
43	469	3,977	1,531	47,357	44,099	70,669
44	180	2,815	3,618	49,322	47,839	76,841
45	180	2,815	3,618	44,870	48,703	77,705
46	167	2,033	2,682	11,941	50,319	81,201
47	167	2,033	2,682	15,226	51,219	82,101
48	630	1,296	5,424	68,629	53,308	86,852
49	630	1,296	5,424	74,869	54,748	88,292
50	1,110	563	4,760	136,654	52,412	85,228
51						
52						
53	1,564	4,724	8,304	97,024	9,274	21,494
54						

	Q	R	S	T	U	V
55						
56						
57						
58						
59						
60				**Nonseismic + Seismic Demand**		
61	transv. shear	in-plane	twisting	merid. M	merid. P (min)	merid. P (max)
62	(circum) (lb/ft)	shear (lb/ft)	mom. (in-lb/ft)	(in-lb/ft)	(lb/ft)	(lb/ft)
63	23	273	38	8,216	12,526	17,186
64	35	677	123	2,752	10,988	17,572
65	23	966	165	1,388	12,092	18,100
66	23	1,517	78	8,055	13,338	20,430
67	49	2,311	34	7,853	12,828	21,948
68	51	2,914	90	2,344	11,194	23,582
69	50	3,968	39	9,019	10,393	24,335
70	49	4,609	31	975	10,257	25,335
71	48	5,649	64	607	9,143	26,737
72	48	6,638	159	19,602	7,656	27,792
73	54	7,709	229	198,560	15,338	37,462
74						
75						
76	463	17,332	6,018	392,424	29,005	41,459
77	450	15,637	210	106,085	29,350	38,426
78	451	18,131	2,388	27,380	26,877	39,267
79	450	18,727	2,017	101,402	26,717	38,851
80	451	18,593	2,296	116,985	25,820	38,164
81	451	17,930	1,469	103,181	25,131	37,557
82	454	16,892	1,421	51,625	24,318	37,266
83	452	15,249	1,823	73,986	24,264	36,672
84						
85						
86	450	12,353	840	233,599	25,710	35,970
87	526	13,309	8,563	457,571	23,368	40,692
88	494	11,192	12,966	436,646	25,913	42,007
89						
90						
91	472	9,403	4,508	183,616	31,529	48,583
92	471	8,412	2,284	22,084	34,817	52,855
93	470	7,923	1,937	82,895	37,487	56,137
94	470	7,137	1,710	89,351	38,713	59,615
95	470	6,051	1,804	61,542	37,750	65,114
96	470	5,026	1,657	18,010	42,097	65,999
97	469	3,977	1,531	47,393	44,099	70,669
98	180	2,815	3,618	49,418	47,839	76,841
99	180	2,815	3,618	44,990	48,691	77,693
100	167	2,033	2,682	11,680	50,259	81,141
101	167	2,033	2,682	14,984	51,183	82,065
102	630	1,296	5,424	68,701	53,344	86,888
103	630	1,296	5,424	75,037	54,736	88,280
104	1,110	563	4,760	137,014	52,376	85,192
105						
106						
107	1,564	4,724	8,304	97,026	9,274	21,494
108						

	Q	R	S	T	U	V
109						
110						
111						
112						
113				Nonseismic + Seismic Demand		
114				merid. M	merid. P (min)	merid. P (max)
115	transv. shear	in-plane	twisting	(in-lb/ft)	(lb/ft)	(lb/ft)
116	(circum) (lb/ft)	shear (lb/ft)	mom. (in-lb/ft)	6,187	12,526	17,186
117	23	273	38	1,186	10,976	17,560
118	35	677	123	1,214	12,104	18,112
119	23	966	165	5,960	13,314	20,406
120	23	1,517	78	5,830	12,840	21,960
121	49	2,311	34	301	11,206	23,594
122	51	2,914	90	6,964	10,393	24,335
123	50	3,968	39	2,953	10,257	25,335
124	49	4,609	31	2,548	9,155	26,749
125	48	5,649	64	21,150	7,668	27,804
126	48	6,638	159	198,260	15,338	37,462
127	54	7,709	229			
128						
129			6,018	392,628	29,017	41,471
130	463	17,332	210	106,181	29,362	38,438
131	450	15,637	2,388	27,324	26,889	39,279
132	451	18,131	2,017	101,366	26,717	38,851
133	450	18,727	2,296	116,973	25,820	38,164
134	451	18,593	1,469	103,169	25,143	37,569
135	451	17,930	1,421	51,625	24,330	37,278
136	454	16,892	1,823	73,962	24,276	36,684
137	452	15,249				
138						
139			840	233,631	25,770	36,030
140	450	12,353	8,563	457,555	23,438	40,762
141	526	13,309	12,966	437,306	26,069	42,163
142	494	11,192				
143						
144			4,508	183,808	31,589	48,643
145	472	9,403	2,284	22,058	34,853	52,891
146	471	8,412	1,937	82,907	37,511	56,161
147	470	7,923	1,710	89,375	38,725	59,627
148	470	7,137	1,804	61,554	37,762	65,126
149	470	6,051	1,657	18,039	42,109	66,011
150	470	5,026	1,531	47,369	44,099	70,669
151	469	3,977	3,618	49,466	47,839	76,841
152	180	2,815	3,618	45,038	48,691	77,693
153	180	2,815	2,682	11,451	50,283	81,165
154	167	2,033	2,682	14,712	51,195	82,077
155	167	2,033	5,424	67,981	53,320	86,864
156	630	1,296	5,424	74,233	54,724	88,268
157	630	1,296	4,760	135,826	52,376	85,192
158	1,110	563				
159						
160			8,304	97,107	9,262	21,482
161	1,564	4,724				

	W	X	Y	Z	AA	AB
1						
2						
3						
4						
5						
6						
7	circumf. M	circumf. P (min)	circumf. P (max)	transv. shear	transv. shear	in-plane
8	(in-lb/ft)	(lb/ft)	(lb/ft)	(merid) (lb/ft)	(circum) (lb/ft)	shear (lb/ft)
9	6,195	12,798	16,986	74	38	300
10	2,648	12,357	16,659	187	94	685
11	1,287	12,450	16,854	13	112	988
12	3,134	12,988	17,588	180	140	1,920
13	3,398	13,420	18,020	298	75	2,779
14	2,564	13,113	17,991	304	83	3,286
15	3,434	12,650	17,950	562	75	4,513
16	1,605	12,724	18,572	900	90	5,205
17	713	11,832	18,216	763	672	6,691
18	3,978	10,901	18,259	1,558	598	6,971
19	39,252	13,434	18,078	9,542	508	7,799
20						
21						
22	71,687	-36,237	5,445	14,061	975	18,385
23	14,521	-9,624	-2,763	10,906	577	17,663
24	4,965	-8,319	15,486	8,428	492	19,541
25	15,096	5,649	23,607	6,080	540	19,566
26	17,312	24,599	38,257	4,516	562	19,406
27	15,138	22,990	35,642	5,462	532	18,802
28	7,848	5,320	19,904	7,087	490	17,538
29	11,524	-22,664	-4,936	9,866	453	16,131
30						
31						
32	29,387	-41,176	-37,784	11,648	584	12,975
33	53,037	-140,855	-98,145	11,854	607	15,480
34	164,689	-137,338	-86,534	12,278	945	18,359
35						
36						
37	53,180	-58,269	-24,531	8,023	713	12,810
38	50,459	-25,200	3,737	4,910	564	10,897
39	53,357	-11,023	24,206	2,220	492	9,509
40	47,038	7,991	32,497	1,869	544	8,391
41	35,078	17,601	41,655	2,442	573	6,815
42	31,084	23,096	44,872	2,445	530	6,027
43	26,960	25,482	47,550	1,908	484	4,637
44	34,175	27,520	49,376	964	329	3,930
45	51,803	36,208	58,064	1,025	384	3,268
46	62,269	36,932	58,516	662	224	3,412
47	80,893	45,740	67,324	573	401	2,696
48	103,263	47,042	74,014	1,460	1,111	2,175
49	134,211	58,058	85,030	1,496	648	1,338
50	186,088	52,373	82,747	1,678	1,207	708
51						
52						
53	102,545	-3,560	66,056	4,773	2,395	8,213
54						

	W	X	Y	Z	AA	AB
55						
56						
57						
58						
59						
60						
61	circumf. M	circumf. P (min)	circumf. P (max)	transv. shear	transv. shear	in-plane
62	(in-lb/ft)	(lb/ft)	(lb/ft)	(merid) (lb/ft)	(circum) (lb/ft)	shear (lb/ft)
63	6,226	12,822	17,010	78	26	273
64	2,852	12,393	16,695	164	38	685
65	1,653	12,462	16,866	44	37	970
66	3,190	13,000	17,600	177	100	1,913
67	3,399	13,420	18,020	289	72	2,777
68	2,558	13,113	17,991	309	81	3,287
69	3,427	12,638	17,938	563	76	4,514
70	1,606	12,724	18,572	900	90	5,205
71	719	11,844	18,228	763	671	6,690
72	3,976	10,913	18,271	1,558	598	6,971
73	39,252	13,434	18,078	9,542	508	7,799
74						
75						
76	71,687	-36,237	5,445	14,061	975	18,385
77	14,521	-9,622	-2,762	10,905	577	17,663
78	4,967	-8,318	15,487	8,428	492	19,541
79	15,096	5,649	23,607	6,080	540	19,566
80	17,312	24,611	38,269	4,516	562	19,406
81	15,138	22,990	35,642	5,463	532	18,802
82	7,848	5,320	19,904	7,086	490	17,538
83	11,522	-22,664	-4,936	9,866	453	16,131
84						
85						
86	29,387	-41,176	-37,784	11,648	584	12,975
87	53,037	-140,855	-98,145	11,854	607	15,480
88	164,689	-137,326	-86,522	12,278	945	18,359
89						
90						
91	53,180	-58,269	-24,531	8,023	713	12,810
92	50,459	-25,195	3,741	4,910	564	10,896
93	53,357	-11,021	24,209	2,220	493	9,509
94	47,026	8,003	32,509	1,869	544	8,390
95	35,078	17,601	41,655	2,442	572	6,814
96	31,024	23,096	44,872	2,450	531	6,025
97	26,876	25,470	47,538	1,905	487	4,639
98	34,115	27,496	49,352	975	242	3,923
99	51,683	36,184	58,040	963	213	3,276
100	62,125	36,908	58,492	718	394	3,436
101	80,797	45,716	67,300	589	557	2,690
102	103,203	47,030	74,002	1,453	883	2,190
103	134,535	58,046	85,018	1,468	890	1,339
104	186,436	52,349	82,723	1,718	1,135	762
105						
106						
107	102,545	-3,560	66,056	4,773	2,395	8,213
108						

	W	X	Y	Z	AA	AB
109						
110						
111						
112						
113						
114						
115	circumf. M	circumf. P (min)	circumf. P (max)	transv. shear	transv. shear	in-plane
116	(in-lb/ft)	(lb/ft)	(lb/ft)	(merid) (lb/ft)	(circum) (lb/ft)	shear (lb/ft)
117	8,246	12,810	16,998	74	42	290
118	4,725	12,369	16,671	164	47	684
119	3,436	12,450	16,854	32	71	972
120	5,158	13,000	17,600	184	97	1,909
121	5,401	13,420	18,020	290	73	2,774
122	4,542	13,101	17,979	308	82	3,286
123	5,422	12,638	17,938	562	75	4,509
124	3,572	12,700	18,548	895	90	5,202
125	2,654	11,808	18,192	760	671	6,684
126	2,080	10,865	18,223	1,537	596	6,968
127	39,324	13,482	18,126	9,567	519	7,817
128						
129						
130	71,999	-36,213	5,469	14,067	1,005	18,376
131	14,629	-9,609	-2,748	10,908	586	17,659
132	4,885	-8,318	15,487	8,430	488	19,539
133	15,048	5,649	23,607	6,081	539	19,569
134	17,288	24,599	38,257	4,516	562	19,406
135	15,114	22,990	35,642	5,462	532	18,802
136	7,811	5,308	19,892	7,087	489	17,543
137	11,570	-22,664	-4,936	9,866	457	16,122
138						
139						
140	29,483	-41,200	-37,808	11,648	631	13,397
141	53,605	-140,875	-98,165	11,852	771	14,220
142	164,809	-137,458	-86,654	12,285	838	16,911
143						
144						
145	53,276	-58,317	-24,579	8,025	663	12,218
146	50,447	-25,230	3,707	4,911	541	10,551
147	53,333	-11,042	24,187	2,220	498	9,281
148	47,002	7,979	32,485	1,869	541	8,250
149	35,066	17,589	41,643	2,443	569	6,738
150	31,036	23,084	44,860	2,448	528	5,978
151	26,888	25,458	47,526	1,907	486	4,604
152	34,103	27,496	49,352	975	242	3,900
153	51,647	36,196	58,052	962	210	3,243
154	62,053	36,920	58,504	713	391	3,408
155	80,461	45,716	67,300	584	566	2,680
156	103,815	47,030	74,002	1,440	896	2,185
157	135,147	58,058	85,030	1,463	853	1,316
158	187,108	52,361	82,735	1,706	1,117	731
159						
160						
161	102,593	-3,488	66,128	4,772	2,394	8,237

	AC
1	
2	
3	
4	
5	
6	
7	twisting
8	mom. (in-lb/ft)
9	45
10	146
11	197
12	285
13	136
14	167
15	96
16	322
17	487
18	445
19	7,835
20	
21	
22	8,658
23	1,596
24	2,584
25	2,297
26	2,333
27	1,880
28	1,716
29	2,112
30	
31	
32	840
33	8,563
34	35,394
35	
36	
37	13,358
38	4,012
39	2,971
40	3,271
41	2,789
42	2,608
43	2,994
44	3,652
45	8,432
46	4,006
47	7,278
48	6,045
49	12,324
50	4,824
51	
52	
53	22,224
54	

	AC
55	
56	
57	
58	
59	
60	
61	twisting
62	mom. (in-lb/ft)
63	42
64	128
65	169
66	289
67	127
68	165
69	96
70	320
71	488
72	447
73	7,832
74	
75	
76	8,660
77	1,595
78	2,584
79	2,297
80	2,333
81	1,880
82	1,716
83	2,113
84	
85	
86	840
87	8,563
88	35,394
89	
90	
91	13,356
92	4,011
93	2,974
94	3,272
95	2,792
96	2,590
97	2,994
98	3,644
99	8,412
100	3,995
101	7,290
102	6,042
103	12,408
104	4,859
105	
106	
107	22,224
108	

	AC
109	
110	
111	
112	
113	
114	
115	twisting
116	mom. (in-lb/ft)
117	47
118	139
119	175
120	286
121	133
122	168
123	98
124	320
125	489
126	445
127	7,539
128	
129	
130	8,860
131	1,641
132	2,630
133	2,311
134	2,324
135	1,887
136	1,732
137	2,143
138	
139	
140	1,913
141	15,800
142	30,330
143	
144	
145	11,895
146	3,761
147	2,830
148	3,086
149	2,718
150	2,567
151	2,915
152	3,687
153	8,354
154	3,986
155	7,231
156	6,041
157	12,376
158	4,873
159	
160	
161	22,308

	A	B	C	D	E	F	G	H	I
1	Nonseismic (Load Case 1b) + Seismic (Lower-Bound Soil Properties)								
2	PPS-U1BP.XLS					All Values are Per Foot of Width			
3	ELSET AXIS-P1: along the positive 1-axis								
4			positive is compression			absolute value			absolute val
5	ELEMENT	PT FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2
6		NOTE	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)
7									
8	floor elements								
9	289	1	15,108	14,664	-22	60	13	7,945	5,856
10	291	1	14,520	14,244	9	166	56	1,772	2,152
11	295	1	15,396	14,364	-25	2	83	929	775
12	301	1	17,172	14,964	-415	163	114	7,428	2,766
13	1,257	1	17,772	15,348	477	116	23	7,576	3,060
14	1,261	1	17,856	15,144	-386	133	31	2,040	2,288
15	1,265	1	17,904	14,832	555	390	25	8,760	3,260
16	1,269	1	18,456	15,108	-623	723	39	289	1,378
17	1,273	1	18,708	14,436	1,052	580	625	268	506
18	1,277	1	18,564	13,848	-361	1,358	545	17,940	3,492
19	1,281	1	27,420	12,816	-55	9,328	459	194,808	35,724
20	0								
21	wall elements								
22	1,285	1	-18,444	36,096	1,387	520	9,850	49,836	292,080
23	1,289	1	-7,871	35,076	-1,778	124	6,564	13,596	103,320
24	1,293	1	2,302	34,632	1,776	36	3,990	1,576	9,233
25	1,297	1	13,812	34,944	-512	72	1,555	12,480	87,060
26	1,301	1	31,140	34,656	1,217	70	97	15,780	110,220
27	1,305	1	29,520	34,584	-479	37	1,059	13,704	96,636
28	1,309	1	13,212	34,620	1,202	12	2,464	6,822	47,280
29	1,313	1	-13,032	34,440	-544	14	5,749	9,221	67,764
30	0								
31	haunch elements (1317,1321 demands are transformed via Mathcad)								
32	1,317	1	-36,640	30,020	666	139	6,972	26,650	224,100
33	1,321	1	-111,100	31,090	2,062	86	6,875	30,810	392,200
34	1,325	1	36,336	-97,632	-6,754	11,603	576	375,456	204,960
35	0								
36	dome elements								
37	1,329	1	42,348	-31,560	-3,293	6,679	350	144,564	60,984
38	1,333	1	45,060	-1,835	-2,012	3,418	220	10,064	54,060
39	1,337	1	46,584	16,392	-1,324	2,010	212	92,748	60,276
40	1,341	1	48,468	31,188	-669	397	88	120,696	59,532
41	1,345	1	50,124	39,036	-53	2,176	86	78,540	39,492
42	1,349	1	49,416	41,136	25	888	103	22,920	16,512
43	1,353	1	48,396	42,024	24	153	77	4,856	8,033
44	308	1	48,624	42,372	-183	43	65	3,191	6,696
45	305	1	48,756	43,920	-97	27	8	3,160	4,147
46	314	1	49,020	44,052	-80	185	28	1,784	3,301
47	312	1	48,888	43,512	-218	234	152	2,585	2,317
48	318	1	50,148	46,812	-55	243	211	5,584	2,136
49	317	1	50,628	50,640	240	252	15	4,222	6,268
50	320	1	48,024	47,148	78	168	54	9,702	9,582
51	0								
52	footing element								
53	1,357	1	15,732	25,380	-3,275	772	862	6,889	89,532
54									

	A	B	C	D	E	F	G	H	I
55									
56									
57	ELSET AXIS-N1: along the negative 1-axis								
58			positive is compression			absolute value		absolute value	
59	ELEMENT	PT FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2
60		NOTE	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)
61	0								
62	floor elements								
63	1	1	15,072	14,736	0	62	2	7,970	5,916
64	4	1	14,472	14,388	-6	146	4	1,759	2,360
65	9	1	15,264	14,532	-3	32	13	1,115	1,137
66	16	1	17,028	15,192	391	166	76	7,524	2,887
67	324	1	17,520	15,612	-459	114	23	7,514	3,113
68	328	1	17,496	15,468	368	131	30	2,080	2,324
69	332	1	17,436	15,228	-536	385	27	8,722	3,277
70	336	1	17,844	15,600	589	718	43	297	1,382
71	340	1	17,976	15,012	-1,028	576	617	306	510
72	344	1	17,772	14,604	330	1,333	543	17,520	3,366
73	348	1	26,364	16,032	106	9,017	448	186,900	37,332
74	0								
75	wall elements								
76	352	1	-15,084	34,464	-1,054	506	9,523	49,644	286,968
77	356	1	-6,134	33,132	1,981	123	6,440	13,824	103,788
78	360	1	3,545	32,328	-1,408	44	3,964	1,313	7,319
79	364	1	14,544	32,016	825	95	1,606	12,468	85,428
80	368	1	31,428	31,212	-805	114	34	15,864	108,456
81	372	1	29,520	30,564	873	81	1,006	13,620	94,908
82	376	1	13,224	29,976	-638	33	2,606	6,028	44,424
83	380	1	-12,516	29,640	871	7	5,312	9,986	66,372
84	0								
85	haunch elements (384,388 demands are transformed via Mathcad)								
86	384	1	-36,640	30,020	666	139	6,972	26,650	224,100
87	388	1	-111,100	31,090	2,062	86	6,875	30,810	392,200
88	392	1	32,568	-100,944	6,593	10,160	438	366,000	153,036
89	0								
90	dome elements								
91	396	1	38,076	-35,652	3,103	6,517	236	152,628	43,824
92	400	1	41,292	-5,911	2,142	3,546	95	3,457	43,128
93	404	1	43,584	11,552	1,247	966	17	74,316	45,996
94	408	1	44,964	25,800	836	429	62	85,476	39,948
95	412	1	45,996	35,892	351	905	77	64,260	28,164
96	416	1	46,512	40,980	277	647	59	36,540	17,112
97	420	1	46,728	42,924	23	443	67	16,548	9,517
98	23	1	47,532	43,224	308	15	65	7,204	6,346
99	19	1	47,652	44,676	222	8	23	7,104	4,506
100	28	1	48,252	44,844	190	179	33	455	3,432
101	25	1	48,120	44,088	319	195	148	169	3,233
102	31	1	49,848	47,460	83	190	196	3,844	2,982
103	29	1	50,268	50,916	-174	227	51	2,689	6,631
104	32	1	47,904	47,424	-35	206	5	10,205	9,799
105	0								
106	footing element								
107	424	1	15,468	32,328	3,515	987	806	9,854	97,740
108									

	A	B	C	D	E	F	G	H	I
109									
110									
111	ELSET AXIS-P2: along the positive 2-axis								
112			positive is compression			absolute value		absolute value	
113	ELEMENT	PT FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2
114		NOTE	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)
115	0								
116	floor element								
117	161	1	15,132	14,652	-24	22	58	7,952	5,885
118	164	1	14,748	14,064	2	13	145	4,260	181
119	169	1	14,880	14,904	-16	48	20	2,946	947
120	176	1	15,504	16,668	-399	75	173	4,865	5,388
121	844	1	15,948	17,196	461	24	113	5,135	5,461
122	848	1	15,756	17,196	-363	32	132	4,324	14
123	852	1	15,516	17,160	557	25	385	5,304	6,648
124	856	1	15,852	17,592	-556	41	715	3,377	2,296
125	860	1	15,240	17,748	1,079	622	579	2,473	2,154
126	864	1	14,796	17,532	-267	553	1,342	1,547	19,500
127	868	1	16,680	26,196	-31	454	9,134	38,124	187,788
128	0								
129	wall elements								
130	872	1	-14,532	35,136	-660	537	9,464	50,004	285,312
131	876	1	-5,734	33,636	2,382	143	6,402	14,016	103,272
132	880	1	3,917	32,832	-1,054	28	3,943	990	7,212
133	884	1	14,820	32,424	1,159	77	1,607	12,156	84,924
134	888	1	31,596	31,620	-544	102	47	15,780	108,072
135	892	1	29,616	30,912	1,125	80	979	13,920	94,944
136	896	1	13,284	30,360	-426	46	2,586	6,637	45,036
137	900	1	-12,528	30,012	1,144	14	5,341	9,386	65,868
138	0								
139	haunch elements								
140	904	1	-36,708	30,324	-746	160	7,007	26,460	224,424
141	908	1	-111,828	31,440	-465	237	6,914	31,728	393,288
142	912	1	-102,120	32,856	-4,922	349	10,192	149,364	367,836
143	0								
144	dome elements								
145	916	1	-36,120	38,244	-2,183	189	6,532	43,416	153,096
146	920	1	-6,098	41,364	-1,460	66	3,552	42,768	3,628
147	924	1	11,482	43,608	-669	28	974	45,744	74,820
148	928	1	25,872	44,928	-327	63	428	39,744	86,124
149	932	1	36,084	45,888	106	75	908	28,008	64,884
150	936	1	41,292	46,296	165	56	645	16,944	37,140
151	940	1	43,332	46,392	382	63	446	9,412	17,160
152	183	1	43,704	47,040	60	59	12	6,172	7,667
153	179	1	45,252	47,160	134	41	11	4,302	7,576
154	188	1	45,420	47,652	134	51	187	3,188	676
155	185	1	44,736	47,484	-58	163	200	2,980	60
156	191	1	48,132	49,044	125	214	182	2,726	4,021
157	189	1	51,720	49,440	293	107	216	6,554	2,882
158	192	1	48,204	47,028	121	28	204	9,713	9,616
159	0								
160	footing element								
161	944	1	33,048	15,324	-3,786	833	798	97,956	7,234

	J	K	L	M	N	O	P
1							
2							
3							
4							
5	SM3						
6	0	Total seismic demand per foot of width					
7		demand	merid. M	merid. P	circumf. M	circumf. P	transv. shear
8		section	(in-lb/ft)	(lb/ft)	(in-lb/ft)	(lb/ft)	(merid) (lb/ft)
9	5	0	286	2,330	307	2,094	16
10	23	0	1,009	3,292	484	2,151	19
11	26	a	272	3,004	506	2,202	12
12	209	0	559	3,546	303	2,300	12
13	106	b	353	4,560	285	2,300	176
14	78	0	284	6,194	233	2,439	176
15	62	c,d	301	6,971	143	2,650	176
16	284	0	656	7,539	221	2,924	179
17	425	e	373	8,797	203	3,192	181
18	297	f,g,h,i	1,674	10,068	523	3,679	198
19	7,118	0	9,428	11,062	1,776	2,322	401
20							
21							
22	2,737	0	106,452	6,227	22,019	20,841	4,540
23	1,367	0	3,185	4,538	733	3,430	4,474
24	64	k	19,326	6,195	3,682	11,902	4,469
25	153	l	15,266	6,067	2,676	8,979	4,469
26	171	m	7,617	6,172	1,436	6,829	4,470
27	184	n	7,049	6,213	1,374	6,326	4,469
28	1	0	6,013	6,474	1,595	7,292	4,469
29	150	o,p,q	7,446	6,204	1,590	8,864	4,469
30							
31							
32	5	q	6,399	5,130	1,307	1,696	4,527
33	48	r	57,571	8,662	13,357	21,355	4,730
34	27,264	0	62,834	8,047	24,697	25,402	1,881
35							
36							
37	9,776	s,t	28,252	8,527	9,416	16,869	1,385
38	2,983	u	19,537	9,019	7,199	14,468	1,374
39	160	0	11,111	9,325	7,385	17,615	1,343
40	2,138	0	10,307	10,451	7,198	12,253	1,337
41	3,480	0	11,034	13,682	6,854	12,027	1,340
42	1,428	0	11,977	11,951	12,460	10,888	1,341
43	392	x	13,373	13,285	9,692	11,034	1,340
44	211	y	15,686	14,501	12,059	10,928	228
45	280	y	15,686	14,501	12,059	10,928	228
46	656	z	4,261	15,441	17,089	10,792	69
47	334	z	4,261	15,441	17,089	10,792	69
48	20	aa	14,377	16,772	30,711	13,486	577
49	1,723	aa	14,377	16,772	30,711	13,486	577
50	80	bb	25,474	16,408	76,168	15,187	1,474
51							
52							
53	13,908	j	90,162	6,110	6,425	34,808	3,987
54							

	J	K	L	M	N	O	P
55							
56							
57							
58							
59	SM3						
60	0						
61		demand	merid. M	merid. P	circumf. M	circumf. P	transv. shear
62		section	(in-lb/ft)	(lb/ft)	(in-lb/ft)	(lb/ft)	(merid) (lb/ft)
63	4	0	286	2,330	307	2,094	16
64	6	0	1,009	3,292	484	2,151	19
65	3	a	272	3,004	506	2,202	12
66	208	0	559	3,546	303	2,300	12
67	92	b	353	4,560	285	2,300	176
68	75	0	284	6,194	233	2,439	176
69	56	c,d	301	6,971	143	2,650	176
70	287	0	656	7,539	221	2,924	179
71	417	e	373	8,797	203	3,192	181
72	279	f,g,h,i	1,674	10,068	523	3,679	198
73	7,499	0	9,428	11,062	1,776	2,322	401
74							
75							
76	2,621	0	106,452	6,227	22,019	20,841	4,540
77	1,386	0	3,185	4,538	733	3,430	4,474
78	220	k	19,326	6,195	3,682	11,902	4,469
79	265	l	15,266	6,067	2,676	8,979	4,469
80	79	m	7,617	6,172	1,436	6,829	4,470
81	468	n	7,049	6,213	1,374	6,326	4,469
82	338	0	6,013	6,474	1,595	7,292	4,469
83	282	o,p,q	7,446	6,204	1,590	8,864	4,469
84							
85							
86	5	q	6,399	5,130	1,307	1,696	4,527
87	48	r	57,571	8,662	13,357	21,355	4,730
88	22,728	0	62,834	8,047	24,697	25,402	1,881
89							
90							
91	8,761	s,t	28,252	8,527	9,416	16,869	1,385
92	1,687	u	19,537	9,019	7,199	14,468	1,374
93	1,143	0	11,111	9,325	7,385	17,615	1,343
94	1,807	0	10,307	10,451	7,198	12,253	1,337
95	1,544	0	11,034	13,682	6,854	12,027	1,340
96	666	0	11,977	11,951	12,460	10,888	1,341
97	504	x	13,373	13,285	9,692	11,034	1,340
98	319	y	15,686	14,501	12,059	10,928	228
99	264	y	15,686	14,501	12,059	10,928	228
100	604	z	4,261	15,441	17,089	10,792	69
101	192	z	4,261	15,441	17,089	10,792	69
102	95	aa	14,377	16,772	30,711	13,486	577
103	1,518	aa	14,377	16,772	30,711	13,486	577
104	3	bb	25,474	16,408	76,168	15,187	1,474
105							
106							
107	13,788	j	90,162	6,110	6,425	34,808	3,987
108							

	J	K	L	M	N	O	P
109							
110							
111							
112							
113	SM3						
114	0						
115		demand	merid. M	merid. P	circumf. M	circumf. P	transv. shear
116		section	(in-lb/ft)	(lb/ft)	(in-lb/ft)	(lb/ft)	(merid) (lb/ft)
117	18	0	286	2,330	307	2,094	16
118	22	0	1,009	3,292	484	2,151	19
119	10	a	272	3,004	506	2,202	12
120	211	0	559	3,546	303	2,300	12
121	97	b	353	4,560	285	2,300	176
122	82	0	284	6,194	233	2,439	176
123	58	c,d	301	6,971	143	2,650	176
124	292	0	656	7,539	221	2,924	179
125	426	e	373	8,797	203	3,192	181
126	296	f,g,h,i	1,674	10,068	523	3,679	198
127	7,711	0	9,428	11,062	1,776	2,322	401
128							
129							
130	2,599	0	106,452	6,227	22,019	20,841	4,540
131	1,277	0	3,185	4,538	733	3,430	4,474
132	141	k	19,326	6,195	3,682	11,902	4,469
133	299	l	15,266	6,067	2,676	8,979	4,469
134	76	m	7,617	6,172	1,436	6,829	4,470
135	247	n	7,049	6,213	1,374	6,326	4,469
136	201	0	6,013	6,474	1,595	7,292	4,469
137	384	o,p,q	7,446	6,204	1,590	8,864	4,469
138							
139							
140	712	q	6,399	5,130	1,307	1,696	4,527
141	6,859	r	57,571	8,662	13,357	21,355	4,730
142	17,352	0	62,834	8,047	24,697	25,402	1,881
143							
144							
145	6,928	s,t	28,252	8,527	9,416	16,869	1,385
146	1,220	u	19,537	9,019	7,199	14,468	1,374
147	1,168	0	11,111	9,325	7,385	17,615	1,343
148	1,721	0	10,307	10,451	7,198	12,253	1,337
149	1,540	0	11,034	13,682	6,854	12,027	1,340
150	675	0	11,977	11,951	12,460	10,888	1,341
151	508	x	13,373	13,285	9,692	11,034	1,340
152	370	y	15,686	14,501	12,059	10,928	228
153	331	y	15,686	14,501	12,059	10,928	228
154	712	z	4,261	15,441	17,089	10,792	69
155	79	z	4,261	15,441	17,089	10,792	69
156	260	aa	14,377	16,772	30,711	13,486	577
157	1,655	aa	14,377	16,772	30,711	13,486	577
158	158	bb	25,474	16,408	76,168	15,187	1,474
159							
160							
161	13,536	j	90,162	6,110	6,425	34,808	3,987

	Q	R	S	T	U	V
1						
2						
3						
4						
5						
6				Nonseismic + Seismic Demand		
7	transv. shear	in-plane	twisting	merid. M	merid. P (min)	merid. P (max)
8	(circum) (lb/ft)	shear (lb/ft)	mom. (in-lb/ft)	(in-lb/ft)	(lb/ft)	(lb/ft)
9	23	273	38	8,231	12,778	17,438
10	35	677	123	2,782	11,228	17,812
11	23	966	165	1,201	12,392	18,400
12	23	1,517	78	7,987	13,626	20,718
13	49	2,311	34	7,928	13,212	22,332
14	51	2,914	90	2,324	11,662	24,050
15	50	3,968	39	9,061	10,933	24,875
16	49	4,609	31	944	10,917	25,995
17	48	5,649	64	641	9,911	27,505
18	48	6,638	159	19,614	8,496	28,632
19	54	7,709	229	204,236	16,358	38,482
20						
21						
22	463	17,332	6,018	398,532	29,869	42,323
23	450	15,637	210	106,505	30,538	39,614
24	451	18,131	2,388	28,559	28,437	40,827
25	450	18,727	2,017	102,326	28,877	41,011
26	451	18,593	2,296	117,837	28,484	40,828
27	451	17,930	1,469	103,685	28,371	40,797
28	454	16,892	1,421	53,293	28,146	41,094
29	452	15,249	1,823	75,210	28,236	40,644
30						
31						
32	450	12,353	840	230,499	24,890	35,150
33	526	13,309	8,563	449,771	22,428	39,752
34	494	11,192	12,966	438,290	28,289	44,383
35						
36						
37	472	9,403	4,508	172,816	33,821	50,875
38	471	8,412	2,284	29,601	36,041	54,079
39	470	7,923	1,937	103,859	37,259	55,909
40	470	7,137	1,710	131,003	38,017	58,919
41	470	6,051	1,804	89,574	36,442	63,806
42	470	5,026	1,657	34,897	37,465	61,367
43	469	3,977	1,531	18,229	35,111	61,681
44	180	2,815	3,618	18,877	34,123	63,125
45	180	2,815	3,618	18,845	34,255	63,257
46	167	2,033	2,682	6,045	33,579	64,461
47	167	2,033	2,682	6,846	33,447	64,329
48	630	1,296	5,424	19,961	33,376	66,920
49	630	1,296	5,424	18,599	33,856	67,400
50	1,110	563	4,760	35,176	31,616	64,432
51						
52						
53	1,564	4,724	8,304	97,051	9,622	21,842
54						

	Q	R	S	T	U	V
55						
56						
57						
58						
59						
60				Nonseismic + Seismic Demand		
61	transv. shear	in-plane	twisting	merid. M	merid. P (min)	merid. P (max)
62	(circum) (lb/ft)	shear (lb/ft)	mom. (in-lb/ft)	(in-lb/ft)	(lb/ft)	(lb/ft)
63	23	273	38	8,257	12,742	17,402
64	35	677	123	2,769	11,180	17,764
65	23	966	165	1,387	12,260	18,268
66	23	1,517	78	8,083	13,482	20,574
67	49	2,311	34	7,867	12,960	22,080
68	51	2,914	90	2,363	11,302	23,690
69	50	3,968	39	9,022	10,465	24,407
70	49	4,609	31	953	10,305	25,383
71	48	5,649	64	679	9,179	26,773
72	48	6,638	159	19,194	7,704	27,840
73	54	7,709	229	196,328	15,302	37,426
74						
75						
76	463	17,332	6,018	393,420	28,237	40,691
77	450	15,637	210	106,973	28,594	37,670
78	451	18,131	2,388	26,645	26,133	38,523
79	450	18,727	2,017	100,694	25,949	38,083
80	451	18,593	2,296	116,073	25,040	37,384
81	451	17,930	1,469	101,957	24,351	36,777
82	454	16,892	1,421	50,437	23,502	36,450
83	452	15,249	1,823	73,818	23,436	35,844
84						
85						
86	450	12,353	840	230,499	24,890	35,150
87	526	13,309	8,563	449,771	22,428	39,752
88	494	11,192	12,966	428,834	24,521	40,615
89						
90						
91	472	9,403	4,508	180,880	29,549	46,603
92	471	8,412	2,284	22,994	32,273	50,311
93	470	7,923	1,937	85,427	34,259	52,909
94	470	7,137	1,710	95,783	34,513	55,415
95	470	6,051	1,804	75,294	32,314	59,678
96	470	5,026	1,657	48,517	34,561	58,463
97	469	3,977	1,531	29,921	33,443	60,013
98	180	2,815	3,618	22,889	33,031	62,033
99	180	2,815	3,618	22,790	33,151	62,153
100	167	2,033	2,682	4,716	32,811	63,693
101	167	2,033	2,682	4,430	32,679	63,561
102	630	1,296	5,424	18,221	33,076	66,620
103	630	1,296	5,424	17,066	33,496	67,040
104	1,110	563	4,760	35,678	31,496	64,312
105						
106						
107	1,564	4,724	8,304	100,017	9,358	21,578
108						

	Q	R	S	T	U	V
109						
110						
111						
112						
113						
114				Nonseismic + Seismic Demand		
115	transv. shear	in-plane	twisting	merid. M	merid. P (min)	merid. P (max)
116	(circum) (lb/ft)	shear (lb/ft)	mom. (in-lb/ft)	(in-lb/ft)	(lb/ft)	(lb/ft)
117	23	273	38	6,171	12,322	16,982
118	35	677	123	1,191	10,772	17,356
119	23	966	165	1,219	11,900	17,908
120	23	1,517	78	5,947	13,122	20,214
121	49	2,311	34	5,814	12,636	21,756
122	51	2,914	90	298	11,002	23,390
123	50	3,968	39	6,949	10,189	24,131
124	49	4,609	31	2,951	10,053	25,131
125	48	5,649	64	2,527	8,951	26,545
126	48	6,638	159	21,174	7,464	27,600
127	54	7,709	229	197,216	15,134	37,258
128						
129						
130	463	17,332	6,018	391,764	28,909	41,363
131	450	15,637	210	106,457	29,098	38,174
132	451	18,131	2,388	26,538	26,637	39,027
133	450	18,727	2,017	100,190	26,357	38,491
134	451	18,593	2,296	115,689	25,448	37,792
135	451	17,930	1,469	101,993	24,699	37,125
136	454	16,892	1,421	51,049	23,886	36,834
137	452	15,249	1,823	73,314	23,808	36,216
138						
139						
140	450	12,353	840	230,823	25,194	35,454
141	526	13,309	8,563	450,859	22,778	40,102
142	494	11,192	12,966	430,670	24,809	40,903
143						
144						
145	472	9,403	4,508	181,348	29,717	46,771
146	471	8,412	2,284	23,164	32,345	50,383
147	470	7,923	1,937	85,931	34,283	52,933
148	470	7,137	1,710	96,431	34,477	55,379
149	470	6,051	1,804	75,918	32,206	59,570
150	470	5,026	1,657	49,117	34,345	58,247
151	469	3,977	1,531	30,533	33,107	59,677
152	180	2,815	3,618	23,353	32,539	61,541
153	180	2,815	3,618	23,261	32,659	61,661
154	167	2,033	2,682	4,937	32,211	63,093
155	167	2,033	2,682	4,321	32,043	62,925
156	630	1,296	5,424	18,398	32,272	65,816
157	630	1,296	5,424	17,259	32,668	66,212
158	1,110	563	4,760	35,089	30,620	63,436
159						
160						
161	1,564	4,724	8,304	97,396	9,214	21,434

	W	X	Y	Z	AA	AB
1						
2						
3						
4						
5						
6						
7	circumf. M	circumf. P (min)	circumf. P (max)	transv. shear	transv. shear	in-plane
8	(in-lb/ft)	(lb/ft)	(lb/ft)	(merid) (lb/ft)	(circum) (lb/ft)	shear (lb/ft)
9	6,163	12,570	16,758	76	36	295
10	2,636	12,093	16,395	185	91	686
11	1,281	12,162	16,566	14	106	991
12	3,069	12,664	17,264	175	138	1,932
13	3,345	13,048	17,648	292	72	2,788
14	2,521	12,705	17,583	309	81	3,300
15	3,403	12,182	17,482	566	75	4,524
16	1,599	12,184	18,032	902	87	5,232
17	709	11,244	17,628	762	673	6,701
18	4,015	10,169	17,527	1,557	593	6,999
19	37,500	10,494	15,138	9,728	512	7,764
20						
21						
22	71,855	-39,285	2,397	14,390	983	18,719
23	14,329	-11,301	-4,440	11,038	574	17,416
24	5,257	-9,601	14,204	8,459	487	19,907
25	15,156	4,833	22,791	6,024	522	19,239
26	17,216	24,311	37,969	4,567	520	19,810
27	15,078	23,194	35,846	5,528	488	18,409
28	8,417	5,920	20,504	6,932	465	18,094
29	10,811	-21,896	-4,168	10,218	466	15,793
30						
31						
32	27,957	-38,336	-34,944	11,499	589	13,019
33	44,167	-132,455	-89,745	11,605	612	15,371
34	229,657	-123,034	-72,230	13,484	1,071	17,946
35						
36						
37	70,400	-48,429	-14,691	8,064	822	12,696
38	61,259	-16,303	12,633	4,792	691	10,425
39	67,661	-1,223	34,007	3,353	682	9,246
40	66,730	18,935	43,441	1,733	557	7,806
41	46,346	27,009	51,063	3,516	555	6,104
42	28,972	30,248	52,024	2,229	573	5,052
43	17,725	30,990	53,058	1,494	547	4,002
44	18,755	31,444	53,300	271	245	2,998
45	16,207	32,992	54,848	255	188	2,913
46	20,391	33,260	54,844	254	195	2,113
47	19,407	32,720	54,304	303	319	2,252
48	32,847	33,326	60,298	821	841	1,352
49	36,979	37,154	64,126	830	645	1,536
50	85,750	31,961	62,335	1,643	1,164	642
51						
52						
53	95,957	-9,428	60,188	4,759	2,425	7,999
54						

	W	X	Y	Z	AA	AB
55						
56						
57						
58						
59						
60						
61	circumf. M	circumf. P (min)	circumf. P (max)	transv. shear	transv. shear	in-plane
62	(in-lb/ft)	(lb/ft)	(lb/ft)	(merid) (lb/ft)	(circum) (lb/ft)	shear (lb/ft)
63	6,223	12,642	16,830	78	25	273
64	2,845	12,237	16,539	165	39	683
65	1,643	12,330	16,734	44	36	969
66	3,190	12,892	17,492	177	100	1,907
67	3,398	13,312	17,912	290	72	2,771
68	2,557	13,029	17,907	307	81	3,282
69	3,420	12,578	17,878	561	77	4,505
70	1,604	12,676	18,524	898	91	5,198
71	713	11,820	18,204	757	666	6,677
72	3,889	10,925	18,283	1,531	591	6,968
73	39,108	13,710	18,354	9,417	501	7,815
74						
75						
76	71,663	-35,925	5,757	14,063	968	18,386
77	14,557	-9,565	-2,704	10,914	573	17,618
78	4,995	-8,358	15,447	8,432	495	19,538
79	15,144	5,565	23,523	6,075	545	19,552
80	17,300	24,599	38,257	4,503	564	19,398
81	14,994	23,194	35,846	5,475	532	18,803
82	7,623	5,932	20,516	7,075	486	17,530
83	11,576	-21,380	-3,652	9,781	459	16,120
84						
85						
86	27,957	-38,336	-34,944	11,499	589	13,019
87	44,167	-132,455	-89,745	11,605	612	15,371
88	177,733	-126,346	-75,542	12,042	932	17,785
89						
90						
91	53,240	-52,521	-18,783	7,902	708	12,506
92	50,327	-20,379	8,557	4,920	566	10,554
93	53,381	-6,062	29,167	2,308	487	9,169
94	47,146	13,547	38,053	1,766	532	7,973
95	35,018	23,865	47,919	2,245	547	6,402
96	29,572	30,092	51,868	1,988	529	5,303
97	19,210	31,890	53,958	1,783	536	4,001
98	18,405	32,296	54,152	243	245	3,123
99	16,565	33,748	55,604	236	203	3,037
100	20,521	34,052	55,636	248	200	2,223
101	20,322	33,296	54,880	264	315	2,352
102	33,693	33,974	60,946	768	826	1,380
103	37,342	37,430	64,402	804	681	1,470
104	85,967	32,237	62,611	1,681	1,114	598
105						
106						
107	104,165	-2,480	67,136	4,974	2,369	8,239
108						

	W	X	Y	Z	AA	AB
109						
110						
111						
112						
113						
114						
115	circumf. M	circumf. P (min)	circumf. P (max)	transv. shear	transv. shear	in-plane
116	(in-lb/ft)	(lb/ft)	(lb/ft)	(merid) (lb/ft)	(circum) (lb/ft)	shear (lb/ft)
117	8,259	13,038	17,226	74	45	297
118	4,744	12,597	16,899	164	48	679
119	3,452	12,678	17,082	32	72	982
120	5,168	13,204	17,804	185	98	1,916
121	5,420	13,648	18,248	289	73	2,772
122	4,556	13,317	18,195	308	83	3,277
123	5,447	12,866	18,166	562	75	4,525
124	3,598	12,928	18,776	894	90	5,165
125	2,676	12,048	18,432	760	670	6,728
126	2,070	11,117	18,475	1,540	601	6,904
127	39,900	14,358	19,002	9,535	508	7,740
128						
129						
130	72,023	-35,373	6,309	14,004	1,000	17,992
131	14,749	-9,164	-2,303	10,876	593	18,019
132	4,671	-7,986	15,819	8,412	479	19,185
133	14,832	5,841	23,799	6,076	527	19,886
134	17,216	24,767	38,425	4,517	552	19,137
135	15,294	23,290	35,942	5,448	531	19,055
136	8,232	5,992	20,576	7,055	499	17,318
137	10,976	-21,392	-3,664	9,810	466	16,393
138						
139						
140	27,767	-38,404	-35,012	11,534	610	13,099
141	45,085	-133,183	-90,473	11,644	763	13,774
142	174,061	-127,522	-76,718	12,073	843	16,115
143						
144						
145	52,832	-52,989	-19,251	7,916	661	11,586
146	49,967	-20,567	8,370	4,926	536	9,873
147	53,129	-6,133	29,096	2,317	498	8,592
148	46,942	13,619	38,125	1,765	532	7,464
149	34,862	24,057	48,111	2,248	545	6,157
150	29,404	30,404	52,180	1,986	527	5,191
151	19,104	32,298	54,366	1,786	532	4,360
152	18,231	32,776	54,632	240	239	2,875
153	16,361	34,324	56,180	239	220	2,950
154	20,278	34,628	56,212	256	217	2,167
155	20,069	33,944	55,528	268	329	2,091
156	33,438	34,646	61,618	759	843	1,421
157	37,266	38,234	65,206	794	737	1,589
158	85,881	33,017	63,391	1,678	1,137	685
159						
160						
161	104,381	-1,760	67,856	4,786	2,397	8,510

	AC
1	
2	
3	
4	
5	
6	
7	twisting
8	mom. (in-lb/ft)
9	44
10	145
11	191
12	288
13	140
14	167
15	101
16	315
17	490
18	457
19	7,347
20	
21	
22	8,755
23	1,577
24	2,452
25	2,169
26	2,467
27	1,653
28	1,423
29	1,973
30	
31	
32	845
33	8,611
34	40,230
35	
36	
37	14,284
38	5,267
39	2,098
40	3,848
41	5,284
42	3,085
43	1,923
44	3,829
45	3,898
46	3,338
47	3,016
48	5,444
49	7,147
50	4,840
51	
52	
53	22,212
54	

	AC
55	
56	
57	
58	
59	
60	
61	twisting
62	mom. (in-lb/ft)
63	42
64	128
65	169
66	287
67	126
68	165
69	95
70	318
71	482
72	439
73	7,728
74	
75	
76	8,639
77	1,596
78	2,608
79	2,281
80	2,375
81	1,937
82	1,759
83	2,105
84	
85	
86	845
87	8,611
88	35,694
89	
90	
91	13,269
92	3,971
93	3,080
94	3,517
95	3,348
96	2,323
97	2,035
98	3,936
99	3,881
100	3,286
101	2,874
102	5,519
103	6,942
104	4,764
105	
106	
107	22,092
108	

	AC
109	
110	
111	
112	
113	
114	
115	twisting
116	mom. (in-lb/ft)
117	56
118	145
119	175
120	290
121	131
122	172
123	97
124	323
125	490
126	456
127	7,940
128	
129	
130	8,617
131	1,487
132	2,529
133	2,315
134	2,372
135	1,716
136	1,623
137	2,207
138	
139	
140	1,552
141	15,422
142	30,318
143	
144	
145	11,435
146	3,504
147	3,105
148	3,431
149	3,343
150	2,332
151	2,039
152	3,988
153	3,948
154	3,394
155	2,761
156	5,684
157	7,079
158	4,919
159	
160	
161	21,840

	A	B	C	D	E	F	G	H	I
1	Nonseismic (Load Case 2) + Seismic (Lower-Bound Soil Properties)								
2	PPS-U2P.XLS					All Values are Per Foot of Width			
3	ELSET AXIS-P1: along the positive 1-axis								
4			positive is compression			absolute value			absolute val
5	ELEMENT	PT FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2
6		NOTE	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)
7									
8	floor elements								
9	289	1	15,048	14,568	-19	60	10	7,928	5,838
10	291	1	14,484	14,136	8	163	53	1,828	2,192
11	295	1	15,360	14,244	-29	4	72	1,016	810
12	301	1	17,088	14,832	-404	157	105	7,385	2,729
13	1,257	1	17,688	15,216	462	111	20	7,529	3,036
14	1,261	1	17,784	15,000	-374	132	28	2,098	2,298
15	1,265	1	17,844	14,712	537	384	23	8,682	3,275
16	1,269	1	18,420	15,000	-609	705	32	102	1,495
17	1,273	1	18,660	14,340	1,017	558	600	272	613
18	1,277	1	18,612	13,776	-377	1,291	525	16,884	3,228
19	1,281	1	27,300	13,188	-75	8,950	432	187,632	35,184
20	0								
21	wall elements								
22	1,285	1	-17,844	33,924	1,253	497	9,770	49,764	290,700
23	1,289	1	-7,975	32,784	-1,696	110	6,466	13,776	103,608
24	1,293	1	1,675	32,268	1,643	41	3,818	587	5,819
25	1,297	1	12,852	32,652	-445	58	1,475	10,535	80,220
26	1,301	1	30,888	32,280	1,048	33	141	13,584	102,828
27	1,305	1	31,116	32,148	-362	3	891	12,156	91,956
28	1,309	1	17,748	32,040	973	14	1,921	7,306	52,236
29	1,313	1	-5,711	30,984	-709	30	5,243	5,977	48,348
30	0								
31	haunch elements 1317,1321 demands are transformed via Mathcad)								
32	1,317	1	-34,820	28,980	650	135	6,798	25,410	218,200
33	1,321	1	-106,600	30,040	1,974	81	6,652	26,770	381,500
34	1,325	1	33,372	-90,576	-5,741	9,850	412	359,016	128,184
35	0								
36	dome elements								
37	1,329	1	38,676	-34,152	-2,417	5,392	2	163,632	29,052
38	1,333	1	40,668	-7,507	-1,810	3,325	105	27,108	26,964
39	1,337	1	41,748	9,392	-1,218	1,740	63	51,996	33,264
40	1,341	1	43,032	23,916	-864	142	53	79,548	33,492
41	1,345	1	44,160	33,996	-315	916	76	62,580	24,420
42	1,349	1	44,604	39,012	-276	598	64	34,752	14,172
43	1,353	1	44,700	41,100	-8	386	61	16,248	8,002
44	308	1	45,420	41,520	-306	2	58	7,577	5,482
45	305	1	45,588	42,996	-161	19	37	7,435	3,713
46	314	1	46,176	43,152	-126	177	1	511	2,602
47	312	1	46,020	42,456	-284	229	173	149	2,273
48	318	1	47,580	45,780	-77	207	231	4,319	1,913
49	317	1	48,036	49,284	220	217	25	3,214	5,378
50	320	1	45,660	45,840	63	176	51	8,837	8,450
51	0								
52	footing element								
53	1,357	1	15,960	27,972	-3,413	1,220	800	13,488	93,204
54									

	A	B	C	D	E	F	G	H	I
55									
56									
57	ELSET AXIS-N1: along the negative 1-axis								
58			positive is compression			absolute value		absolute value	
59	ELEMENT	PT FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2
60		NOTE	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)
61	0								
62	floor elements								
63	1	1	15,012	14,640	-2	62	1	7,954	5,894
64	4	1	14,424	14,304	-6	144	4	1,811	2,381
65	9	1	15,204	14,448	-3	31	12	1,163	1,169
66	16	1	16,932	15,096	382	164	73	7,516	2,905
67	324	1	17,412	15,516	-450	114	22	7,505	3,126
68	328	1	17,376	15,372	360	130	29	2,110	2,339
69	332	1	17,304	15,132	-524	382	27	8,706	3,282
70	336	1	17,688	15,504	578	712	43	242	1,404
71	340	1	17,784	14,940	-1,013	570	608	289	545
72	344	1	17,616	14,532	328	1,309	533	17,112	3,244
73	348	1	26,088	16,092	107	8,821	440	182,784	36,924
74	0								
75	wall elements								
76	352	1	-14,832	33,444	-1,047	496	9,452	49,308	284,952
77	356	1	-6,144	32,136	1,931	117	6,397	13,692	103,092
78	360	1	3,335	31,332	-1,381	52	3,925	1,358	7,098
79	364	1	14,124	31,044	806	102	1,594	12,432	84,492
80	368	1	30,960	30,216	-763	119	17	15,708	107,136
81	372	1	29,244	29,556	867	83	997	13,356	93,516
82	376	1	13,380	28,944	-591	32	2,569	5,766	43,692
83	380	1	-11,738	28,608	854	8	5,170	9,906	64,560
84	0								
85	haunch elements (384,388 demands are transformed via Mathcad)								
86	384	1	-34,820	28,980	650	135	6,798	25,410	218,200
87	388	1	-106,600	30,040	1,974	81	6,652	26,770	381,500
88	392	1	31,536	-96,324	6,359	9,875	430	355,860	153,288
89	0								
90	dome elements								
91	396	1	36,804	-34,176	2,964	6,354	231	148,392	42,168
92	400	1	39,876	-5,465	2,083	3,455	93	3,706	41,784
93	404	1	42,072	11,414	1,167	934	18	72,648	44,616
94	408	1	43,368	25,224	807	416	62	83,484	38,676
95	412	1	44,292	35,004	303	883	77	62,916	27,156
96	416	1	44,736	39,876	265	634	59	35,892	16,320
97	420	1	44,880	41,676	-8	443	66	16,212	8,825
98	23	1	45,576	41,916	295	10	63	6,757	5,652
99	19	1	45,696	43,236	205	12	22	6,635	3,779
100	28	1	46,200	43,380	165	175	33	1	2,706
101	25	1	46,068	42,600	294	190	140	613	2,438
102	31	1	47,628	45,924	64	178	187	4,427	2,140
103	29	1	48,048	49,320	-186	214	42	3,348	5,476
104	32	1	45,636	45,864	-39	184	8	8,840	8,560
105	0								
106	footing element								
107	424	1	15,324	33,120	3,512	1,167	778	12,576	98,412
108									

	A	B	C	D	E	F	G	H	I
109									
110									
111	ELSET AXIS-P2: along the positive 2-axis								
112			positive is compression			absolute value		absolute value	
113	ELEMENT	PT FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2
114		NOTE	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)
115	0								
116	floor element								
117	161	1	15,084	14,556	-29	23	57	7,940	5,863
118	164	1	14,700	13,968	-7	13	144	4,284	130
119	169	1	14,820	14,796	-27	49	19	2,976	900
120	176	1	15,444	16,536	-403	72	171	4,883	5,383
121	844	1	15,876	17,052	433	24	113	5,150	5,453
122	848	1	15,684	17,052	-370	32	130	4,350	54
123	852	1	15,420	17,004	522	23	381	5,322	6,625
124	856	1	15,756	17,424	-559	40	706	3,431	2,197
125	860	1	15,108	17,580	1,031	611	568	2,507	2,140
126	864	1	14,664	17,400	-296	544	1,309	1,428	18,996
127	868	1	16,764	25,908	-49	442	8,904	37,848	183,024
128	0								
129	wall elements								
130	872	1	-14,436	33,936	-631	526	9,392	49,812	283,560
131	876	1	-5,922	32,484	2,274	141	6,350	14,016	102,936
132	880	1	3,504	31,644	-1,053	25	3,904	867	6,511
133	884	1	14,196	31,248	1,050	71	1,603	12,024	83,544
134	888	1	30,948	30,492	-607	99	44	15,816	106,464
135	892	1	29,256	29,832	982	87	943	14,268	93,708
136	896	1	13,416	29,388	-520	66	2,526	7,363	45,096
137	900	1	-11,635	29,100	1,049	43	5,218	8,311	63,204
138	0								
139	haunch elements								
140	904	1	-34,572	29,448	-762	122	6,853	24,468	218,172
141	908	1	-106,500	30,492	-398	210	6,700	25,284	382,560
142	912	1	-96,636	31,800	-4,732	350	9,890	150,696	357,672
143	0								
144	dome elements								
145	916	1	-34,200	36,816	-2,119	191	6,352	42,084	148,956
146	920	1	-5,311	39,768	-1,594	66	3,452	41,412	3,692
147	924	1	11,585	41,916	-829	27	945	44,256	72,972
148	928	1	25,464	43,200	-629	61	414	38,460	84,024
149	932	1	35,208	44,148	-228	75	887	27,072	63,360
150	936	1	40,080	44,592	-253	57	632	16,296	36,204
151	940	1	41,820	44,748	-7	64	443	8,927	16,488
152	183	1	42,060	45,444	-323	61	10	5,750	6,937
153	179	1	43,332	45,552	-241	30	13	3,935	6,814
154	188	1	43,488	46,128	-167	40	180	2,843	27
155	185	1	42,648	45,972	-338	140	193	2,555	607
156	191	1	45,972	47,556	-79	186	177	2,305	4,598
157	189	1	49,368	47,976	166	50	212	5,707	3,538
158	192	1	45,900	45,600	50	2	187	8,785	8,532
159	0								
160	footing element								
161	944	1	33,660	15,156	-3,752	790	1,035	99,216	10,682

	J	K	L	M	N	O	P
1							
2							
3							
4							
5	SM3						
6	0	Total seismic demand per foot of width					
7		demand	merid. M	merid. P	circumf. M	circumf. P	transv. shear
8		section	(in-lb/ft)	(lb/ft)	(in-lb/ft)	(lb/ft)	(merid) (lb/ft)
9	3	0	286	2,330	307	2,094	16
10	22	0	1,009	3,292	484	2,151	19
11	19	a	272	3,004	506	2,202	12
12	193	0	559	3,546	303	2,300	12
13	105	b	353	4,560	285	2,300	176
14	72	0	284	6,194	233	2,439	176
15	68	c,d	301	6,971	143	2,650	176
16	263	0	656	7,539	221	2,924	179
17	428	e	373	8,797	203	3,192	181
18	295	f,g,h,i	1,674	10,068	523	3,679	198
19	6,786	0	9,428	11,062	1,776	2,322	401
20							
21							
22	2,564	0	106,452	6,227	22,019	20,841	4,540
23	1,151	0	3,185	4,538	733	3,430	4,474
24	157	k	19,326	6,195	3,682	11,902	4,469
25	64	l	15,266	6,067	2,676	8,979	4,469
26	215	m	7,617	6,172	1,436	6,829	4,470
27	126	n	7,049	6,213	1,374	6,326	4,469
28	404	0	6,013	6,474	1,595	7,292	4,469
29	678	o,p,q	7,446	6,204	1,590	8,864	4,469
30							
31							
32	90	q	6,399	5,130	1,307	1,696	4,527
33	7	r	57,571	8,662	13,357	21,355	4,730
34	18,264	0	62,834	8,047	24,697	25,402	1,881
35							
36							
37	5,472	s,t	28,252	8,527	9,416	16,869	1,385
38	1,760	u	19,537	9,019	7,199	14,468	1,374
39	115	0	11,111	9,325	7,385	17,615	1,343
40	953	0	10,307	10,451	7,198	12,253	1,337
41	1,410	0	11,034	13,682	6,854	12,027	1,340
42	489	0	11,977	11,951	12,460	10,888	1,341
43	369	x	13,373	13,285	9,692	11,034	1,340
44	373	y	15,686	14,501	12,059	10,928	228
45	262	y	15,686	14,501	12,059	10,928	228
46	602	z	4,261	15,441	17,089	10,792	69
47	237	z	4,261	15,441	17,089	10,792	69
48	82	aa	14,377	16,772	30,711	13,486	577
49	1,450	aa	14,377	16,772	30,711	13,486	577
50	15	bb	25,474	16,408	76,168	15,187	1,474
51							
52							
53	13,152	j	90,162	6,110	6,425	34,808	3,987
54							

	J	K	L	M	N	O	P
55							
56							
57							
58							
59	SM3						
60	0						
61		demand	merid. M	merid. P	circumf. M	circumf. P	transv. shear
62		section	(in-lb/ft)	(lb/ft)	(in-lb/ft)	(lb/ft)	(merid) (lb/ft)
63	4	0	286	2,330	307	2,094	16
64	6	0	1,009	3,292	484	2,151	19
65	2	a	272	3,004	506	2,202	12
66	199	0	559	3,546	303	2,300	12
67	87	b	353	4,560	285	2,300	176
68	73	0	284	6,194	233	2,439	176
69	52	c,d	301	6,971	143	2,650	176
70	282	0	656	7,539	221	2,924	179
71	408	e	373	8,797	203	3,192	181
72	271	f,g,h,i	1,674	10,068	523	3,679	198
73	7,325	0	9,428	11,062	1,776	2,322	401
74							
75							
76	2,605	0	106,452	6,227	22,019	20,841	4,540
77	1,392	0	3,185	4,538	733	3,430	4,474
78	249	k	19,326	6,195	3,682	11,902	4,469
79	231	l	15,266	6,067	2,676	8,979	4,469
80	119	m	7,617	6,172	1,436	6,829	4,470
81	538	n	7,049	6,213	1,374	6,326	4,469
82	362	0	6,013	6,474	1,595	7,292	4,469
83	277	o,p,q	7,446	6,204	1,590	8,864	4,469
84							
85							
86	90	q	6,399	5,130	1,307	1,696	4,527
87	7	r	57,571	8,662	13,357	21,355	4,730
88	22,224	0	62,834	8,047	24,697	25,402	1,881
89							
90							
91	8,569	s,t	28,252	8,527	9,416	16,869	1,385
92	1,624	u	19,537	9,019	7,199	14,468	1,374
93	1,120	0	11,111	9,325	7,385	17,615	1,343
94	1,790	0	10,307	10,451	7,198	12,253	1,337
95	1,517	0	11,034	13,682	6,854	12,027	1,340
96	677	0	11,977	11,951	12,460	10,888	1,341
97	500	x	13,373	13,285	9,692	11,034	1,340
98	314	y	15,686	14,501	12,059	10,928	228
99	233	y	15,686	14,501	12,059	10,928	228
100	578	z	4,261	15,441	17,089	10,792	69
101	198	z	4,261	15,441	17,089	10,792	69
102	101	aa	14,377	16,772	30,711	13,486	577
103	1,440	aa	14,377	16,772	30,711	13,486	577
104	6	bb	25,474	16,408	76,168	15,187	1,474
105							
106							
107	13,548	j	90,162	6,110	6,425	34,808	3,987
108							

	J	K	L	M	N	O	P
109							
110							
111							
112							
113	SM3						
114	0						
115		demand	merid. M	merid. P	circumf. M	circumf. P	transv. shear
116		section	(in-lb/ft)	(lb/ft)	(in-lb/ft)	(lb/ft)	(merid) (lb/ft)
117	19	0	286	2,330	307	2,094	16
118	25	0	1,009	3,292	484	2,151	19
119	10	a	272	3,004	506	2,202	12
120	202	0	559	3,546	303	2,300	12
121	95	b	353	4,560	285	2,300	176
122	78	0	284	6,194	233	2,439	176
123	60	c,d	301	6,971	143	2,650	176
124	284	0	656	7,539	221	2,924	179
125	426	e	373	8,797	203	3,192	181
126	280	f,g,h,i	1,674	10,068	523	3,679	198
127	7,506	0	9,428	11,062	1,776	2,322	401
128							
129							
130	2,509	0	106,452	6,227	22,019	20,841	4,540
131	1,204	0	3,185	4,538	733	3,430	4,474
132	126	k	19,326	6,195	3,682	11,902	4,469
133	332	l	15,266	6,067	2,676	8,979	4,469
134	249	m	7,617	6,172	1,436	6,829	4,470
135	52	n	7,049	6,213	1,374	6,326	4,469
136	28	0	6,013	6,474	1,595	7,292	4,469
137	455	o,p,q	7,446	6,204	1,590	8,864	4,469
138							
139							
140	482	q	6,399	5,130	1,307	1,696	4,527
141	6,264	r	57,571	8,662	13,357	21,355	4,730
142	16,884	0	62,834	8,047	24,697	25,402	1,881
143							
144							
145	6,562	s,t	28,252	8,527	9,416	16,869	1,385
146	1,156	u	19,537	9,019	7,199	14,468	1,374
147	1,065	0	11,111	9,325	7,385	17,615	1,343
148	1,547	0	10,307	10,451	7,198	12,253	1,337
149	1,318	0	11,034	13,682	6,854	12,027	1,340
150	511	0	11,977	11,951	12,460	10,888	1,341
151	382	x	13,373	13,285	9,692	11,034	1,340
152	432	y	15,686	14,501	12,059	10,928	228
153	350	y	15,686	14,501	12,059	10,928	228
154	675	z	4,261	15,441	17,089	10,792	69
155	132	z	4,261	15,441	17,089	10,792	69
156	155	aa	14,377	16,772	30,711	13,486	577
157	1,477	aa	14,377	16,772	30,711	13,486	577
158	29	bb	25,474	16,408	76,168	15,187	1,474
159							
160							
161	13,428	j	90,162	6,110	6,425	34,808	3,987

	Q	R	S	T	U	V
1						
2						
3						
4						
5						
6				Nonseismic + Seismic Demand		
7	transv. shear	in-plane	twisting	merid. M	merid. P (min)	merid. P (max)
8	(circum) (lb/ft)	shear (lb/ft)	mom. (in-lb/ft)	(in-lb/ft)	(lb/ft)	(lb/ft)
9	23	273	38	8,215	12,718	17,378
10	35	677	123	2,837	11,192	17,776
11	23	966	165	1,288	12,356	18,364
12	23	1,517	78	7,943	13,542	20,634
13	49	2,311	34	7,882	13,128	22,248
14	51	2,914	90	2,381	11,590	23,978
15	50	3,968	39	8,983	10,873	24,815
16	49	4,609	31	758	10,881	25,959
17	48	5,649	64	645	9,863	27,457
18	48	6,638	159	18,558	8,544	28,680
19	54	7,709	229	197,060	16,238	38,362
20						
21						
22	463	17,332	6,018	397,152	27,697	40,151
23	450	15,637	210	106,793	28,246	37,322
24	451	18,131	2,388	25,145	26,073	38,463
25	450	18,727	2,017	95,486	26,585	38,719
26	451	18,593	2,296	110,445	26,108	38,452
27	451	17,930	1,469	99,005	25,935	38,361
28	454	16,892	1,421	58,249	25,566	38,514
29	452	15,249	1,823	55,794	24,780	37,188
30						
31						
32	450	12,353	840	224,599	23,850	34,110
33	526	13,309	8,563	439,071	21,378	38,702
34	494	11,192	12,966	421,850	25,325	41,419
35						
36						
37	472	9,403	4,508	191,884	30,149	47,203
38	471	8,412	2,284	46,645	31,649	49,687
39	470	7,923	1,937	63,107	32,423	51,073
40	470	7,137	1,710	89,855	32,581	53,483
41	470	6,051	1,804	73,614	30,478	57,842
42	470	5,026	1,657	46,729	32,653	56,555
43	469	3,977	1,531	29,621	31,415	57,985
44	180	2,815	3,618	23,263	30,919	59,921
45	180	2,815	3,618	23,121	31,087	60,089
46	167	2,033	2,682	4,772	30,735	61,617
47	167	2,033	2,682	4,410	30,579	61,461
48	630	1,296	5,424	18,696	30,808	64,352
49	630	1,296	5,424	17,591	31,264	64,808
50	1,110	563	4,760	34,310	29,252	62,068
51						
52						
53	1,564	4,724	8,304	103,650	9,850	22,070
54						

	Q	R	S	T	U	V
55						
56						
57						
58						
59						
60				Nonseismic + Seismic Demand		
61	transv. shear	in-plane	twisting	merid. M	merid. P (min)	merid. P (max)
62	(circum) (lb/ft)	shear (lb/ft)	mom. (in-lb/ft)	(in-lb/ft)	(lb/ft)	(lb/ft)
63	23	273	38	8,240	12,682	17,342
64	35	677	123	2,820	11,132	17,716
65	23	966	165	1,434	12,200	18,208
66	23	1,517	78	8,074	13,386	20,478
67	49	2,311	34	7,858	12,852	21,972
68	51	2,914	90	2,393	11,182	23,570
69	- 50	3,968	39	9,007	10,333	24,275
70	49	4,609	31	897	10,149	25,227
71	48	5,649	64	662	8,987	26,581
72	48	6,638	159	18,786	7,548	27,684
73	54	7,709	229	192,212	15,026	37,150
74						
75						
76	463	17,332	6,018	391,404	27,217	39,671
77	450	15,637	210	106,277	27,598	36,674
78	451	18,131	2,388	26,424	25,137	37,527
79	450	18,727	2,017	99,758	24,977	37,111
80	451	18,593	2,296	114,753	24,044	36,388
81	451	17,930	1,469	100,565	23,343	35,769
82	454	16,892	1,421	49,705	22,470	35,418
83	452	15,249	1,823	72,006	22,404	34,812
84						
85						
86	450	12,353	840	224,599	23,850	34,110
87	526	13,309	8,563	439,071	21,378	38,702
88	494	11,192	12,966	418,694	23,489	39,583
89						
90						
91	472	9,403	4,508	176,644	28,277	45,331
92	471	8,412	2,284	23,242	30,857	48,895
93	470	7,923	1,937	83,759	32,747	51,397
94	470	7,137	1,710	93,791	32,917	53,819
95	470	6,051	1,804	73,950	30,610	57,974
96	470	5,026	1,657	47,869	32,785	56,687
97	469	3,977	1,531	29,585	31,595	58,165
98	180	2,815	3,618	22,443	31,075	60,077
99	180	2,815	3,618	22,321	31,195	60,197
100	167	2,033	2,682	4,262	30,759	61,641
101	167	2,033	2,682	4,873	30,627	61,509
102	630	1,296	5,424	18,804	30,856	64,400
103	630	1,296	5,424	17,725	31,276	64,820
104	1,110	563	4,760	34,314	29,228	62,044
105						
106						
107	1,564	4,724	8,304	102,738	9,214	21,434
108						

	Q	R	S	T	U	V
109						
110						
111						
112						
113						
114				Nonseismic + Seismic Demand		
115	transv. shear	in-plane	twisting	merid. M	merid. P (min)	merid. P (max)
116	(circum) (lb/ft)	shear (lb/ft)	mom. (in-lb/ft)	(in-lb/ft)	(lb/ft)	(lb/ft)
117	23	273	38	6,149	12,226	16,886
118	35	677	123	1,139	10,676	17,260
119	23	966	165	1,172	11,792	17,800
120	23	1,517	78	5,942	12,990	20,082
121	49	2,311	34	5,806	12,492	21,612
122	51	2,914	90	338	10,858	23,246
123	50	3,968	39	6,926	10,033	23,975
124	49	4,609	31	2,853	9,885	24,963
125	48	5,649	64	2,513	8,783	26,377
126	48	6,638	159	20,670	7,332	27,468
127	54	7,709	229	192,452	14,846	36,970
128						
129						
130	463	17,332	6,018	390,012	27,709	40,163
131	450	15,637	210	106,121	27,946	37,022
132	451	18,131	2,388	25,837	25,449	37,839
133	450	18,727	2,017	98,810	25,181	37,315
134	451	18,593	2,296	114,081	24,320	36,664
135	451	17,930	1,469	100,757	23,619	36,045
136	454	16,892	1,421	51,109	22,914	35,862
137	452	15,249	1,823	70,650	22,896	35,304
138						
139						
140	450	12,353	840	224,571	24,318	34,578
141	526	13,309	8,563	440,131	21,830	39,154
142	494	11,192	12,966	420,506	23,753	39,847
143						
144						
145	472	9,403	4,508	177,208	28,289	45,343
146	471	8,412	2,284	23,229	30,749	48,787
147	470	7,923	1,937	84,083	32,591	51,241
148	470	7,137	1,710	94,331	32,749	53,651
149	470	6,051	1,804	74,394	30,466	57,830
150	470	5,026	1,657	48,181	32,641	56,543
151	469	3,977	1,531	29,861	31,463	58,033
152	180	2,815	3,618	22,623	30,943	59,945
153	180	2,815	3,618	22,499	31,051	60,053
154	167	2,033	2,682	4,287	30,687	61,569
155	167	2,033	2,682	4,868	30,531	61,413
156	630	1,296	5,424	18,975	30,784	64,328
157	630	1,296	5,424	17,915	31,204	64,748
158	1,110	563	4,760	34,006	29,192	62,008
159						
160						
161	1,564	4,724	8,304	100,845	9,046	21,266

	W	X	Y	Z	AA	AB
1						
2						
3						
4						
5						
6						
7	circumf. M	circumf. P (min)	circumf. P (max)	transv. shear	transv. shear	in-plane
8	(in-lb/ft)	(lb/ft)	(lb/ft)	(merid) (lb/ft)	(circum) (lb/ft)	shear (lb/ft)
9	6,145	12,474	16,662	76	33	292
10	2,677	11,985	16,287	182	89	685
11	1,316	12,042	16,446	17	96	994
12	3,032	12,532	17,132	168	129	1,920
13	3,321	12,916	17,516	287	69	2,774
14	2,531	12,561	17,439	307	78	3,288
15	3,418	12,062	17,362	560	73	4,505
16	1,716	12,076	17,924	885	81	5,218
17	816	11,148	17,532	740	648	6,666
18	3,751	10,097	17,455	1,489	573	7,014
19	36,960	10,866	15,510	9,350	486	7,784
20						
21						
22	71,783	-38,685	2,997	14,310	960	18,585
23	14,509	-11,406	-4,545	10,939	560	17,333
24	4,269	-10,227	13,578	8,287	492	19,773
25	13,210	3,873	21,831	5,944	509	19,172
26	15,020	24,059	37,717	4,610	484	19,641
27	13,530	24,790	37,442	5,360	454	18,292
28	8,901	10,456	25,040	6,390	467	17,865
29	7,567	-14,575	3,153	9,712	482	15,958
30						
31						
32	26,717	-36,516	-33,124	11,325	585	13,003
33	40,127	-127,955	-85,245	11,382	607	15,283
34	152,881	-115,978	-65,174	11,731	906	16,933
35						
36						
37	38,468	-51,021	-17,283	6,776	474	11,820
38	34,163	-21,975	6,961	4,700	575	10,222
39	40,649	-8,222	27,007	3,083	533	9,141
40	40,690	11,663	36,169	1,479	523	8,002
41	31,274	21,969	46,023	2,256	546	6,366
42	26,632	28,124	49,900	1,939	534	5,302
43	17,694	30,066	52,134	1,726	531	3,985
44	17,541	30,592	52,448	230	237	3,122
45	15,772	32,068	53,924	247	217	2,977
46	19,691	32,360	53,944	246	167	2,160
47	19,362	31,664	53,248	298	339	2,317
48	32,624	32,294	59,266	785	861	1,373
49	36,090	35,798	62,770	794	655	1,516
50	84,618	30,653	61,027	1,650	1,160	626
51						
52						
53	99,629	-6,836	62,780	5,207	2,364	8,137
54						

	W	X	Y	Z	AA	AB
55						
56						
57						
58						
59						
60						
61	circumf. M	circumf. P (min)	circumf. P (max)	transv. shear	transv. shear	in-plane
62	(in-lb/ft)	(lb/ft)	(lb/ft)	(merid) (lb/ft)	(circum) (lb/ft)	shear (lb/ft)
63	6,201	12,546	16,734	78	24	275
64	2,865	12,153	16,455	163	39	683
65	1,675	12,246	16,650	43	35	969
66	3,208	12,796	17,396	175	97	1,898
67	3,411	13,216	17,816	290	72	2,762
68	2,572	12,933	17,811	306	80	3,274
69	3,425	12,482	17,782	558	77	4,493
70	1,625	12,580	18,428	892	92	5,187
71	748	11,748	18,132	751	656	6,662
72	3,767	10,853	18,211	1,507	581	6,966
73	38,700	13,770	18,414	9,222	494	7,816
74						
75						
76	71,327	-35,673	6,009	13,992	959	18,380
77	14,425	-9,574	-2,714	10,871	567	17,568
78	5,040	-8,568	15,237	8,394	503	19,512
79	15,108	5,145	23,103	6,063	553	19,533
80	17,144	24,131	37,789	4,486	570	19,356
81	14,730	22,918	35,570	5,466	534	18,797
82	7,361	6,088	20,672	7,038	486	17,482
83	11,496	-20,603	-2,874	9,638	460	16,103
84						
85						
86	26,717	-36,516	-33,124	11,325	585	13,003
87	40,127	-127,955	-85,245	11,382	607	15,283
88	177,985	-121,726	-70,922	11,756	924	17,551
89						
90						
91	51,584	-51,045	-17,307	7,739	703	12,367
92	48,983	-19,933	9,003	4,829	563	10,495
93	52,001	-6,200	29,029	2,277	488	9,089
94	45,874	12,971	37,477	1,753	532	7,944
95	34,010	22,977	47,031	2,223	547	6,354
96	28,780	28,988	50,764	1,975	529	5,292
97	18,517	30,642	52,710	1,783	536	3,985
98	17,711	30,988	52,844	238	242	3,110
99	15,838	32,308	54,164	240	202	3,020
100	19,795	32,588	54,172	244	199	2,198
101	19,528	31,808	53,392	259	307	2,327
102	32,851	32,438	59,410	756	817	1,360
103	36,187	35,834	62,806	792	672	1,483
104	84,728	30,677	61,051	1,658	1,117	602
105						
106						
107	104,837	-1,688	67,928	5,155	2,342	8,236
108						

	W	X	Y	Z	AA	AB
109						
110						
111						
112						
113						
114						
115	circumf. M	circumf. P (min)	circumf. P (max)	transv. shear	transv. shear	in-plane
116	(in-lb/ft)	(lb/ft)	(lb/ft)	(merid) (lb/ft)	(circum) (lb/ft)	shear (lb/ft)
117	8,247	12,990	17,178	73	47	302
118	4,768	12,549	16,851	162	49	684
119	3,482	12,618	17,022	31	72	992
120	5,186	13,144	17,744	182	95	1,920
121	5,436	13,576	18,176	289	73	2,744
122	4,583	13,245	18,123	306	83	3,284
123	5,465	12,770	18,070	558	73	4,490
124	3,652	12,832	18,680	886	88	5,168
125	2,709	11,916	18,300	749	659	6,680
126	1,951	10,985	18,343	1,507	592	6,934
127	39,624	14,442	19,086	9,305	496	7,758
128						
129						
130	71,831	-35,277	6,405	13,932	989	17,964
131	14,749	-9,352	-2,492	10,824	592	17,911
132	4,549	-8,398	15,406	8,372	476	19,184
133	14,700	5,217	23,175	6,072	521	19,777
134	17,252	24,119	37,777	4,514	549	19,201
135	15,642	22,930	35,582	5,412	538	18,912
136	8,958	6,124	20,708	6,995	520	17,411
137	9,901	-20,499	-2,771	9,686	495	16,298
138						
139						
140	25,775	-36,268	-32,876	11,380	572	13,116
141	38,641	-127,855	-85,145	11,429	737	13,706
142	175,393	-122,038	-71,234	11,772	844	15,924
143						
144						
145	51,500	-51,069	-17,331	7,736	662	11,522
146	48,611	-19,779	9,157	4,827	536	10,006
147	51,641	-6,030	29,200	2,288	497	8,752
148	45,658	13,211	37,717	1,750	531	7,766
149	33,926	23,181	47,235	2,227	544	6,280
150	28,756	29,192	50,968	1,973	527	5,279
151	18,619	30,786	52,854	1,784	534	3,984
152	17,810	31,132	52,988	238	240	3,138
153	15,994	32,404	54,260	241	210	3,056
154	19,932	32,696	54,280	249	207	2,200
155	19,644	31,856	53,440	261	306	2,371
156	33,016	32,486	59,458	755	816	1,376
157	36,418	35,882	62,854	790	680	1,463
158	84,953	30,713	61,087	1,661	1,112	613
159						
160						
161	105,641	-1,148	68,468	5,022	2,354	8,476

	AC
1	
2	
3	
4	
5	
6	
7	twisting
8	mom. (in-lb/ft)
9	42
10	144
11	184
12	272
13	139
14	162
15	107
16	294
17	492
18	454
19	7,015
20	
21	
22	8,582
23	1,360
24	2,545
25	2,081
26	2,511
27	1,595
28	1,825
29	2,501
30	
31	
32	930
33	8,570
34	31,230
35	
36	
37	9,980
38	4,044
39	2,052
40	2,663
41	3,214
42	2,146
43	1,899
44	3,990
45	3,879
46	3,284
47	2,919
48	5,506
49	6,874
50	4,775
51	
52	
53	21,456
54	

	AC
55	
56	
57	
58	
59	
60	
61	twisting
62	mom. (in-lb/ft)
63	42
64	128
65	168
66	277
67	121
68	163
69	91
70	313
71	473
72	431
73	7,554
74	
75	
76	8,623
77	1,602
78	2,637
79	2,248
80	2,415
81	2,008
82	1,783
83	2,100
84	
85	
86	930
87	8,570
88	35,190
89	
90	
91	13,077
92	3,907
93	3,057
94	3,500
95	3,321
96	2,334
97	2,031
98	3,932
99	3,851
100	3,260
101	2,879
102	5,525
103	6,864
104	4,767
105	
106	
107	21,852
108	

	AC
109	
110	
111	
112	
113	
114	
115	twisting
116	mom. (in-lb/ft)
117	57
118	147
119	175
120	280
121	129
122	168
123	99
124	315
125	490
126	439
127	7,735
128	
129	
130	8,527
131	1,413
132	2,513
133	2,349
134	2,545
135	1,522
136	1,449
137	2,278
138	
139	
140	1,322
141	14,827
142	29,850
143	
144	
145	11,069
146	3,440
147	3,002
148	3,257
149	3,121
150	2,168
151	1,913
152	4,049
153	3,967
154	3,357
155	2,814
156	5,579
157	6,901
158	4,789
159	
160	
161	21,732

APPENDIX F

EXCEL SPREADSHEETS FOR COMPUTING SECTION M-P INTERATION DIAGRAMS

This appendix contains a listing of the spreadsheets for calculating combined moment-axial-load (M-P) capacity envelopes for the tank sections shown in Figure 9.2.1-4.

File Name	Description
LBCAP_IP.xls	Calculates three key capacity points for meridional M-P interaction diagrams at each capacity section.
LBINT_IP.xls	Summarizes and groups LBCAP_IP.xls M-P capacity data for plotting.
LBCAP_OP.xls	Calculates three key capacity points for circumferential M-P interaction diagrams at each capacity section.
LBINT_OP.xls	Summarizes and groups LBCAP_OP.xls M-P capacity data for plotting.
SEC2ABOT.xls	Calculates refined meridional capacity curve at capacity section 2a, with bottom steel in tension.
SECT3BOT.xls	Calculates refined meridional capacity curve at capacity section 3, with bottom steel in tension.
SEC4AOUT.xls	Calculates refined meridional capacity curve at capacity section 4a, with outer steel in tension.
SEC4A-2.xls	Calculates refined meridional capacity curve at capacity section 4a, with outer steel in tension (total steel considered).
SECT6.xls	Calculates refined meridional capacity curve at capacity section 6.
SEC6AOUT.xls	Calculates refined meridional capacity curve at capacity section 6a, with outer steel in tension.
SEC7TOP.xls	Calculates refined meridional capacity curve at capacity section 7, with top steel in tension.
SEC2TOP.xls	Calculates refined circumferential capacity curve at capacity section 2, with top steel in tension.
SEC7CBOT.xls	Calculates refined circumferential capacity curve at capacity section 7c, with bottom steel in tension.
SECT6CIR.xls	Calculates refined circumferential capacity curve at "weakest" haunch element (capacity section 6a).

Section	h	As per ft	d'	As' per ft	d"	d	b	Temp(55)	fc(55,95/95)	Beta 1
	[in]	[in^2]	[in]	[in^2]	[in]	[in]	[in]	[deg F]	[psi]	
1 (top)	6.00	0.20	1.750	0.00	0.000	4.250	12.0	148.60	3451	0.8500
2 (top)	6.00	0.02	1.750	0.00	0.000	4.250	12.0	135.80	3625	0.8500
3 (bot)	24.00	0.66	3.130	0.00	6.250	20.870	12.0	121.70	4049	0.8476
3 (top)	24.00	0.10	6.250	0.66	3.130	17.750	12.0	121.70	4049	0.8476
4	12.00	0.26	2.375	0.26	2.375	9.625	12.0	110.80	3899	0.8500
5	12.00	0.26	2.375	0.26	2.375	9.625	12.0	92.71	4399	0.8301
6	12.00	0.26	2.375	0.26	2.375	9.625	12.0	91.69	4418	0.8291
7 (in)	15.00	0.44	1.625	0.44	4.375	13.375	12.0	90.90	4431	0.8285
7 (out)	15.00	0.44	4.375	0.44	1.625	10.625	12.0	90.90	4431	0.8285
8 (in)	15.00	0.40	1.625	0.40	4.375	13.375	12.0	90.78	4428	0.8286
8 (out)	15.00	0.40	4.375	0.40	1.625	10.625	12.0	90.78	4428	0.8286
9 (in)	15.00	0.40	1.625	0.40	4.375	13.375	12.0	90.60	4429	0.8286
9 (out)	15.00	0.40	4.375	0.40	1.625	10.625	12.0	90.60	4429	0.8286
1 (bot)	6.00	0.20	4.250	0.00	0.000	1.750	12.0	148.60	3451	0.8500
2 (bot)	6.00	0.02	4.250	0.00	0.000	1.750	12.0	135.80	3625	0.8500
2a (bot)	16.49	0.66	3.130	0.00	6.250	13.360	12.0	135.80	3625	0.8500
4a (out)	18.30	0.17	2.375	0.17	8.675	15.925	12.0	110.80	3899	0.8500
6a (in)	15.00	0.62	1.625	0.62	2.000	13.375	12.0	91.69	4418	0.8291
6a (out)	15.00	0.62	2.000	0.62	1.625	13.000	12.0	91.69	4418	0.8291
6b (in)	27.29	0.85	1.625	0.84	2.000	25.665	12.0	91.69	4418	0.8291
6b (out)	27.29	0.85	2.000	0.84	1.625	25.290	12.0	91.69	4418	0.8291
6c (in)	31.62	0.88	1.625	0.84	4.375	29.995	12.0	91.69	4418	0.8291
6c (out)	31.62	0.88	4.375	0.84	1.625	27.245	12.0	91.69	4418	0.8291

Section	fy (rebar)	E (rebar)	yield strain	cb	0.85fc'b	xp	fs'	Cc	Cs	T
	[psi]	[psi]	=fy/E	[in]		[in] (1)	[psi]	[lbs]	[lbs]	[lbs]
1 (top)	36338	27,876,769	.0013035	2.963	35200	1.250	36338	88,644	0	7268
2 (top)	36776	27,945,692	.0013160	2.954	36975	1.250	36776	92,845	0	736
3 (bot)	37258	28,021,615	.0013296	14.461	41300	8.870	37258	506,184	0	24590
3 (top)	37258	28,021,615	.0013296	12.299	41300	5.750	37258	430,511	22319	3726
4	37631	28,080,308	.0013401	6.653	39770	3.625	37631	224,902	8922	9784
5	38000	28,177,715	.0013486	6.640	44870	3.625	38000	247,305	8908	9880
6	38000	28,183,208	.0013483	6.640	45064	3.625	38000	248,104	8904	9880
7 (in)	38000	28,187,462	.0013481	9.228	45196	5.875	38000	345,527	15063	16720
7 (out)	38000	28,187,462	.0013481	7.331	45196	3.125	38000	274,484	15063	16720
8 (in)	38000	28,188,108	.0013481	9.228	45166	5.875	38000	345,358	13694	15200
8 (out)	38000	28,188,108	.0013481	7.331	45166	3.125	38000	274,350	13694	15200
9 (in)	38000	28,189,077	.0013480	9.228	45176	5.875	38000	345,419	13694	15200
9 (out)	38000	28,189,077	.0013480	7.331	45176	3.125	38000	274,398	13694	15200
1 (bot)	36338	27,876,769	.0013035	1.220	35200	-1.250	36338	36,501	0	7268
2 (bot)	36776	27,945,692	.0013160	1.216	36975	-1.250	36776	38,230	0	736
2a (bot)	36776	27,945,692	.0013160	9.286	36975	5.115	27413	291,861	0	24272
4a (out)	37631	28,080,308	.0013401	11.008	39770	6.775	17852	372,111	2406	6228
6a (in)	38000	28,183,208	.0013483	9.228	45064	5.875	38000	344,767	21060	23370
6a (out)	38000	28,183,208	.0013483	8.969	45064	5.500	38000	335,101	21060	23370
6b (in)	38000	28,183,208	.0013483	17.707	45064	12.020	38000	661,567	28766	32300
6b (out)	38000	28,183,208	.0013483	17.448	45064	11.645	38000	651,901	28766	32300
6c (in)	38000	28,183,208	.0013483	20.694	45064	14.185	38000	773,181	28766	33440
6c (out)	38000	28,183,208	.0013483	18.797	45064	11.435	38000	702,295	28766	33440

Section	Pb	Mb	0.7Pb	0.7Mb	0.7Po	0.56Po	0.9Asfy
	[lbs]	[lb-in]	[lbs]	[lb-in]	[lbs]	[lbs]	[lbs]
1 (top)	81,377	163,401	56,964	114,381	152,517	122,014	6541
2 (top)	92,110	162,887	64,477	114,021	155,767	124,613	662
3 (bot)	481,593	3,190,344	337,115	2,233,241	709,460	567,568	22131
3 (top)	449,104	3,141,689	314,373	2,199,182	711,827	569,461	25484
4	224,041	781,301	156,828	546,911	346,558	277,246	17611
5	246,333	870,411	172,433	609,288	389,377	311,502	17784
6	247,127	873,729	172,989	611,610	390,999	312,799	17784
7 (in)	343,870	1,415,969	240,709	991,178	495,648	396,518	30096
7 (out)	272,827	1,365,881	190,979	956,117	495,648	396,518	30096
8 (in)	343,853	1,401,893	240,697	981,325	493,411	394,729	27360
8 (out)	272,844	1,352,336	190,991	946,635	493,411	394,729	27360
9 (in)	343,913	1,402,181	240,739	981,527	493,518	394,814	27360
9 (out)	272,892	1,352,591	191,025	946,814	493,518	394,814	27360
1 (bot)	29,233	81,493	20,463	57,045	152,517	122,014	6541
2 (bot)	37,495	94,007	26,246	65,805	155,767	124,613	662
2a (bot)	267,589	1,378,647	187,313	965,053	442,369	353,895	21845
4a (out)	368,289	1,707,301	257,802	1,195,111	517,402	413,922	11210
6a (in)	342,458	1,520,034	239,721	1,064,024	502,652	402,122	42066
6a (out)	332,792	1,519,587	232,954	1,063,711	502,652	402,122	42066
6b (in)	658,032	4,894,156	460,623	3,425,909	901,361	721,089	57798
6b (out)	648,366	4,901,806	453,856	3,431,264	901,361	721,089	57798
6c (in)	768,507	6,394,326	537,955	4,476,028	1,038,668	830,935	58824
6c (out)	697,620	6,421,241	488,334	4,494,869	1,038,668	830,935	58824

SECT 1		2		3 in		3 out		4
M	P	M	P	M	P	M	P	M
0	-6,541	0	-662	0	-22,131	0	-25,484	0
114,381	56,964	114,021	64,477	2,233,241	337,115	2,199,182	314,373	546,911
0	152,517	0	155,767	0	709,460	0	711,827	0
M-P values copied from file LBCAP_IP.xls:								
	-0.9Asfy	0.7Mb	0.7Pb	0.7Po		0.9Asfy		
1	-6,541	114,381	56,964	152,517		6,541		
2	-662	114,021	64,477	155,767		662		
3 (bot)	-22,131	2,233,241	337,115	709,460		22,131		
3 (top)	-25,484	2,199,182	314,373	711,827		25,484		
4	-17,611	546,911	156,828	346,558		17,611		
5	-17,784	609,288	172,433	389,377		17,784		
6	-17,784	611,610	172,989	390,999		17,784		
7 (in)	-30,096	991,178	240,709	495,648		30,096		
7 (out)	-30,096	956,117	190,979	495,648		30,096		
8 (in)	-27,360	981,325	240,697	493,411		27,360		
8 (out)	-27,360	946,635	190,991	493,411		27,360		
9 (in)	-27,360	981,527	240,739	493,518		27,360		
9 (out)	-27,360	946,814	191,025	493,518		27,360		
2a (bot)	-21,845	965,053	187,313	442,369		21,845		
4a (out)	-11,210	1,195,111	257,802	517,402		11,210		
1 (bot)	-6,541	57,045	20,463	152,517		6,541		
2 (bot)	-662	65,805	26,246	155,767		662		
6a (in)	-42,066	1,064,024	239,721	502,652		42,066		
6a (out)	-42,066	1,063,711	232,954	502,652		42,066		
6b (in)	-57,798	3,425,909	460,623	901,361		57,798		
6b (out)	-57,798	3,431,264	453,856	901,361		57,798		
6c (in)	-58,824	4,476,028	537,955	1,038,668		58,824		
6c (out)	-58,824	4,494,869	488,334	1,038,668		58,824		

	5		6		7 in		7 out	
P	M	P	M	P	M	P	M	P
-17,611	0	-17,784	0	-17,784	0	-30,096	0	-30,096
156,828	609,288	172,433	611,610	172,989	991,178	240,709	956,117	190,979
346,558	0	389,377	0	390,999	0	495,648	0	495,648

8 in		8 out		9 in		9 out		
M	P	M	P	M	P	M	P	
0	-27,360	0	-27,360	0	-27,360	0	-27,360	
981,325	240,697	946,635	190,991	981,527	240,739	946,814	191,025	
0	493,411	0	493,411	0	493,518	0	493,518	

2a (bot)		4a (out)			1 (bot)		2 (bot)	
M	P	M	P		M	P	M	P
0	-21,845	0	-11,210		0	-6,541	0	-662
965,053	187,313	1,195,111	257,802		57,045	20,463	65,805	26,246
0	442,369	0	517,402		0	152,517	0	155,767

	6a (in)		6a (out)		6b (in)		6b (out)	
	M	P	M	P	M	P	M	P
	0	-42,066	0	-42,066	0	-57,798	0	-57,798
	1,064,024	239,721	1,063,711	232,954	3,425,909	460,623	3,431,264	453,856
	0	502,652	0	502,652	0	901,361	0	901,361

6c (in)		6c (out)	
M	P	M	P
0	-58,824	0	-58,824
4,476,028	537,955	4,494,869	488,334
0	1,038,668	0	1,038,668

	Determination of 3 Key Circumferential Moment/Axial Capacity Points									
Section	h [in]	As per ft [in^2]	d' [in]	As' per ft [in^2]	d" [in]	d [in]	b [in]	Temp(55) [deg F]	'fc(55,95/95) [psi]	Beta 1
1 (top)	6.00	0.20	2.250	0.00	0.000	3.750	12.0	148.60	3451	0.8500
2 (top)	6.00	0.02	2.250	0.00	0.000	3.750	12.0	135.80	3625	0.8500
3 (bot)	24.00	1.50	4.000	1.50	7.000	20.000	12.0	121.70	4049	0.8476
3 (top)	24.00	1.50	7.000	1.50	4.000	17.000	12.0	121.70	4049	0.8476
4	12.00	1.02	3.188	1.02	3.188	8.813	12.0	110.80	3899	0.8500
5	12.00	0.72	3.188	0.72	3.188	8.813	12.0	92.71	4399	0.8301
6	12.00	0.54	3.188	0.54	3.188	8.813	12.0	91.69	4418	0.8291
7 (in)	15.00	0.44	2.375	0.44	3.625	12.625	12.0	90.90	4431	0.8285
7 (out)	15.00	0.44	3.625	0.44	2.375	11.375	12.0	90.90	4431	0.8285
8 (in)	15.00	0.44	2.375	0.44	3.625	12.625	12.0	90.78	4428	0.8286
8 (out)	15.00	0.44	3.625	0.44	2.375	11.375	12.0	90.78	4428	0.8286
9 (in)	15.00	0.44	2.375	0.44	3.625	12.625	12.0	90.60	4429	0.8286
9 (out)	15.00	0.44	3.625	0.44	2.375	11.375	12.0	90.60	4429	0.8286
1 (bot)	6.00	0.20	3.750	0.00	0.000	2.250	12.0	148.60	3451	0.8500
2 (bot)	6.00	0.02	3.750	0.00	0.000	2.250	12.0	135.80	3625	0.8500
2a(bot)	16.49	0.48	4.000	0.48	0.000	12.490	12.0	135.80	3625	0.8500
2a(top)	16.49	0.48	0.000	0.48	4.000	16.490	12.0	135.80	3625	0.8500
7a (in)	21.31	2.41	2.625	2.41	3.500	18.685	12.0	90.90	4431	0.8285
7a (out)	21.31	2.41	3.500	2.41	2.625	17.810	12.0	90.90	4431	0.8285
7b (in)	18.08	1.16	2.500	1.16	3.500	15.580	12.0	90.90	4431	0.8285
7b (out)	18.08	1.16	3.500	1.16	2.500	14.580	12.0	90.90	4431	0.8285
7c (in)	17.38	0.56	2.500	0.56	3.625	14.880	12.0	90.90	4431	0.8285
7c (out)	17.38	0.56	3.625	0.56	2.500	13.755	12.0	90.90	4431	0.8285

	Determination of 3 Key Circumferential Moment/Axial Capacity Points							
Section	fy (rebar) [psi]	E (rebar) [psi]	yield strain =fy/E	cb [in]	0.85fc*b	xp [in] (1)	fs' [psi]	Cc [lbs]
1 (top)	36338	27,876,769	.0013035	2.614	35200	0.750	36338	78,216
2 (top)	36776	27,945,692	.0013160	2.607	36975	0.750	36776	81,922
3 (bot)	37258	28,021,615	.0013296	13.858	41300	8.000	37258	485,082
3 (top)	37258	28,021,615	.0013296	11.779	41300	5.000	37258	412,320
4	37631	28,080,308	.0013401	6.091	39770	2.813	37631	205,917
5	38000	28,177,715	.0013486	6.080	44870	2.813	38000	226,428
6	38000	28,183,208	.0013483	6.080	45064	2.813	38000	227,160
7 (in)	38000	28,187,462	.0013481	8.711	45196	5.125	38000	326,152
7 (out)	38000	28,187,462	.0013481	7.848	45196	3.875	38000	293,859
8 (in)	38000	28,188,108	.0013481	8.711	45166	5.125	38000	325,992
8 (out)	38000	28,188,108	.0013481	7.848	45166	3.875	38000	293,716
9 (in)	38000	28,189,077	.0013480	8.711	45176	5.125	38000	326,050
9 (out)	38000	28,189,077	.0013480	7.848	45176	3.875	38000	293,767
1 (bot)	36338	27,876,769	.0013035	1.568	35200	-0.750	36338	46,929
2 (bot)	36776	27,945,692	.0013160	1.564	36975	-0.750	36776	49,153
2a(bot)	36776	27,945,692	.0013160	8.682	36975	4.245	36776	272,855
2a(top)	36776	27,945,692	.0013160	11.462	36975	8.245	36776	360,239
7a (in)	38000	28,187,462	.0013481	12.892	45196	8.030	38000	482,704
7a (out)	38000	28,187,462	.0013481	12.288	45196	7.155	38000	460,100
7b (in)	38000	28,187,462	.0013481	10.749	45196	6.540	38000	402,491
7b (out)	38000	28,187,462	.0013481	10.060	45196	5.540	38000	376,657
7c (in)	38000	28,187,462	.0013481	10.267	45196	6.190	38000	384,407
7c (out)	38000	28,187,462	.0013481	9.490	45196	5.065	38000	355,344

		Determination of 3 Key Circumferential Moment/Axial Capacity Points							
Section	Cs	T	Pb	Mb	0.7Pb	0.7Mb	0.7Po	0.56Po	0.9Asfy
	[lbs]	[lbs]	[lbs]	[lb-in]	[lbs]	[lb-in]	[lbs]	[lbs]	[lbs]
1 (top)	0	7268	70,948	153,199	49,664	107,239	152,517	122,014	6541
2 (top)	0	736	81,187	155,564	56,831	108,895	155,767	124,613	662
3 (bot)	50724	55887	479,920	3,672,963	335,944	2,571,074	764,851	611,881	100596
3 (top)	50724	55887	407,158	3,574,853	285,010	2,502,397	764,851	611,881	100596
4	35003	38383	202,537	908,810	141,776	636,167	383,070	306,456	69090
5	24668	27360	223,736	933,581	156,615	653,507	411,441	329,153	49248
6	18492	20520	225,132	900,139	157,592	630,097	404,423	323,539	36936
7 (in)	15063	16720	324,494	1,413,383	227,146	989,368	495,648	396,518	30096
7 (out)	15063	16720	292,202	1,390,616	204,542	973,431	495,648	396,518	30096
8 (in)	15064	16720	324,336	1,412,546	227,035	988,782	495,328	396,263	30096
8 (out)	15064	16720	292,060	1,389,831	204,442	972,882	495,328	396,263	30096
9 (in)	15064	16720	324,393	1,412,826	227,075	988,978	495,435	396,348	30096
9 (out)	15064	16720	292,111	1,390,097	204,478	973,068	495,435	396,348	30096
1 (bot)	0	7268	39,662	104,054	27,763	72,838	152,517	122,014	6541
2 (bot)	0	736	48,418	114,237	33,892	79,966	155,767	124,613	662
2a(bot)	16173	17652	271,376	1,451,213	189,963	1,015,849	449,445	359,556	31774
2a(top)	16173	17652	358,760	1,429,506	251,132	1,000,654	449,445	359,556	31774
7a (in)	82503	91580	473,628	3,891,223	331,539	2,723,856	789,696	631,757	164844
7a (out)	82503	91580	451,023	3,878,198	315,716	2,714,738	789,696	631,757	164844
7b (in)	39711	44080	398,122	2,354,626	278,685	1,648,238	627,599	502,079	79344
7b (out)	39711	44080	372,288	2,339,397	260,601	1,637,578	627,599	502,079	79344
7c (in)	19171	21280	382,298	1,934,573	267,608	1,354,201	576,696	461,357	38304
7c (out)	19171	21280	353,235	1,917,488	247,264	1,342,241	576,696	461,357	38304

SECT 1		2		3 in		3 out		4
M	P	M	P	M	P	M	P	M
0	-6,541	0	-662	0	-100,596	0	-100,596	0
107,239	49,664	108,895	56,831	2,571,074	335,944	2,502,397	285,010	636,167
0	152,517	0	155,767	0	764,851	0	764,851	0
RESULTS FOR LOWER BOUND, 55 YEAR CONCRETE COMPRESSIVE STRENGTH								
M-P values from LBCAP_OP.xls:								
	-0.9Asfy	0.7Mb	0.7Pb	0.7Po		0.9Asfy		
1 (top)	-6,541	107,239	49,664	152,517		6541		
2 (top)	-662	108,895	56,831	155,767		662		
3 (bot)	-100,596	2,571,074	335,944	764,851		100596		
3 (top)	-100,596	2,502,397	285,010	764,851		100596		
4	-69,090	636,167	141,776	383,070		69090		
5	-49,248	653,507	156,615	411,441		49248		
6	-36,936	630,097	157,592	404,423		36936		
7 (in)	-30,096	989,368	227,146	495,648		30096		
7 (out)	-30,096	973,431	204,542	495,648		30096		
8 (in)	-30,096	988,782	227,035	495,328		30096		
8 (out)	-30,096	972,882	204,442	495,328		30096		
9 (in)	-30,096	988,978	227,075	495,435		30096		
9 (out)	-30,096	973,068	204,478	495,435		30096		
2a(bot)	-31,774	1,015,849	189,963	449,445		31774		
2a(top)	-31,774	1,000,654	251,132	449,445		31774		
7a (in)	-164,844	2,723,856	331,539	789,696		164844		
7a (out)	-164,844	2,714,738	315,716	789,696		164844		
7b (in)	-79,344	1,648,238	278,685	627,599		79344		
7b (out)	-79,344	1,637,578	260,601	627,599		79344		
7c (in)	-38,304	1,354,201	267,608	576,696		38304		
7c (out)	-38,304	1,342,241	247,264	576,696		38304		
1 (bot)	-6,541	72,838	27,763	152,517		6541		
2 (bot)	-662	79,966	33,892	155,767		662		

	5		6		7 in		7 out	
P	M	P	M	P	M	P	M	P
-69,090	0	-49,248	0	-36,936	0	-30,096	0	-30,096
141,776	653,507	156,615	630,097	157,592	989,368	227,146	973,431	204,542
383,070	0	411,441	0	404,423	0	495,648	0	495,648

8 in		8 out		9 in		9 out	
M	P	M	P	M	P	M	P
0	-30,096	0	-30,096	0	-30,096	0	-30,096
988,782	227,035	972,882	204,442	988,978	227,075	973,068	204,478
0	495,328	0	495,328	0	495,435	0	495,435

2a bot		2a top		7a bot		7a top		7b bot
M	P	M	P	M	P	M	P	M
0	-31,774	0	-31,774	0	-164,844	0	-164,844	0
1,015,849	189,963	1,000,654	251,132	2,723,856	331,539	2,714,738	315,716	1,648,238
0	449,445	0	449,445	0	789,696	0	789,696	0

	7b top		7c bot		7c top			1 bot
P	M	P	M	P	M	P		M
-79,344	0	-79,344	0	-38,304	0	-38,304		0
278,685	1,637,578	260,601	1,354,201	267,608	1,342,241	247,264		72,838
627,599	0	627,599	0	576,696	0	576,696		0

	2 bot	
P	M	P
-6,541	0	-662
27,763	79,966	33,892
152,517	0	155,767

Section	h	As per ft	d'	As' per ft	d"	d	b	Temp(55,95/95)	fc	Beta 1	fy (rebar)
	[in]	[in^2]	[in]	[in^2]	[in]	[in]	[in]	[deg F]	[psi]		[psi]
2a (bot)	16.49	0.66	3.13	0	6.25	13.36	12.0	135.8	3625	0.85	36776

E (rebar)	yield strain=fy/E	Trial c	0.85fc*b	xp	eps	fs	eps'	fs'
[psi]		[in]		[in]		[psi]		[psi]
27,945,692	.0013160	0.500	36975	5.115	7.716E-02	36776	-3.450E-02	-36776
		1.250			2.906E-02	36776	-1.200E-02	-36776
		2.000			1.704E-02	36776	-6.375E-03	-36776
		2.750			1.157E-02	36776	-3.818E-03	-36776
		3.500			8.451E-03	36776	-2.357E-03	-36776
		4.250			6.431E-03	36776	-1.412E-03	-36776
		5.000			5.016E-03	36776	-7.500E-04	-20959
		5.750			3.970E-03	36776	-2.609E-04	-7290
		6.500			3.166E-03	36776	1.154E-04	3225
		7.250			2.528E-03	36776	4.138E-04	11564
		8.000			2.010E-03	36776	6.563E-04	18339
		8.750			1.581E-03	36776	8.571E-04	23953
		9.500			1.219E-03	34064	1.026E-03	28681
		10.250			9.102E-04	25437	1.171E-03	32717
		11.000			6.436E-04	17987	1.295E-03	36202
		11.750			4.111E-04	11487	1.404E-03	36776
		12.500			2.064E-04	5768	1.500E-03	36776
		13.250			2.491E-05	696	1.585E-03	36776
		14.000			-1.371E-04	-3833	1.661E-03	36776
		14.750			-2.827E-04	-7901	1.729E-03	36776

Cc	Cs	T	P	M	0.1fcAg/0.7	phi	phi x P	phi x M
[lbs]	[lbs]	[lbs]	[lbs]	[lb-in]			[lbs]	[lb-in]
15,714	0	24272	-8,558	250,377	102,474	0.900	-7,702	225,339
39,286	0	24272	15,014	427,193	102,474	0.871	13,073	371,955
62,858	0	24272	38,586	588,982	102,474	0.825	31,821	485,729
86,429	0	24272	62,157	735,745	102,474	0.779	48,401	572,914
110,001	0	24272	85,729	867,480	102,474	0.733	62,812	635,586
133,572	0	24272	109,300	984,189	102,474	0.700	76,510	688,932
157,144	0	24272	132,872	1,085,871	102,474	0.700	93,010	760,109
180,715	0	24272	156,443	1,172,526	102,474	0.700	109,510	820,768
204,287	0	24272	180,015	1,244,154	102,474	0.700	126,010	870,908
227,858	0	24272	203,587	1,300,755	102,474	0.700	142,511	910,528
251,430	0	24272	227,158	1,342,329	102,474	0.700	159,011	939,630
275,002	0	24272	250,730	1,368,877	102,474	0.700	175,511	958,214
298,573	0	22482	276,091	1,371,244	102,474	0.700	193,263	959,871
322,145	0	16789	305,356	1,338,614	102,474	0.700	213,749	937,030
345,716	0	11871	333,845	1,294,929	102,474	0.700	233,691	906,450
369,288	0	7582	361,706	1,239,428	102,474	0.700	253,194	867,599
392,859	0	3807	389,053	1,171,532	102,474	0.700	272,337	820,073
416,431	0	459	415,972	1,090,796	102,474	0.700	291,180	763,557
440,003	0	-2529	442,532	996,867	102,474	0.700	309,772	697,807
463,574	0	-5214	468,788	889,467	102,474	0.700	328,152	622,627

Section	h	As per ft	d'	As' per ft	d"	d	b	Temp(55,95/95)	fc	Beta 1	fy (rebar)
	[in]	[in^2]	[in]	[in^2]	[in]	[in]	[in]	[deg F]	[psi]		[psi]
3 (bot)	24	0.66	3.13	0	6.25	20.87	12	121.7	4049	0.84755	37258

E (rebar)	yield strain=fy/E	Trial c	0.85fc*b	xp	eps	fs	eps'	fs'
[psi]		[in]		[in]		[psi]		[psi]
28,021,615	.0013296	0.705	41300	8.870	8.581E-02	37258	-2.360E-02	-37258
		1.705			3.372E-02	37258	-7.997E-03	-37258
		2.705			2.015E-02	37258	-3.932E-03	-37258
		3.705			1.390E-02	37258	-2.061E-03	-37258
		4.705			1.031E-02	37258	-9.851E-04	-27605
		5.705			7.975E-03	37258	-2.866E-04	-8031
		6.705			6.338E-03	37258	2.036E-04	5705
		7.705			5.126E-03	37258	5.665E-04	15875
		8.705			4.192E-03	37258	8.461E-04	23708
		9.705			3.451E-03	37258	1.068E-03	29927
		10.705			2.849E-03	37258	1.248E-03	34984
		11.705			2.349E-03	37258	1.398E-03	37258
		12.705			1.928E-03	37258	1.524E-03	37258
		13.705			1.568E-03	37258	1.632E-03	37258
		14.705			1.258E-03	35244	1.725E-03	37258
		15.705			9.866E-04	27647	1.806E-03	37258
		16.705			7.480E-04	20960	1.878E-03	37258
		17.705			5.363E-04	15028	1.941E-03	37258
		18.705			3.472E-04	9730	1.998E-03	37258
		19.705			1.774E-04	4970	2.048E-03	37258

Cc	Cs	T	P	M	0.1fcAg/0.7	phi	phi x P	phi x M
[lbs]	[lbs]	[lbs]	[lbs]	[lb-in]			[lbs]	[lb-in]
24,678	0	24590	87	506,873	166,587	0.900	79	456,133
59,681	0	24590	35,091	891,168	166,587	0.858	30,104	764,507
94,685	0	24590	70,095	1,245,795	166,587	0.816	57,186	1,016,377
129,689	0	24590	105,098	1,570,755	166,587	0.774	81,327	1,215,485
164,692	0	24590	140,102	1,866,047	166,587	0.732	102,526	1,365,569
199,696	0	24590	175,106	2,131,673	166,587	0.700	122,574	1,492,171
234,699	0	24590	210,109	2,367,631	166,587	0.700	147,076	1,657,341
269,703	0	24590	245,113	2,573,921	166,587	0.700	171,579	1,801,745
304,707	0	24590	280,117	2,750,544	166,587	0.700	196,082	1,925,381
339,710	0	24590	315,120	2,897,500	166,587	0.700	220,584	2,028,250
374,714	0	24590	350,124	3,014,789	166,587	0.700	245,087	2,110,352
409,718	0	24590	385,127	3,102,410	166,587	0.700	269,589	2,171,687
444,721	0	24590	420,131	3,160,364	166,587	0.700	294,092	2,212,255
479,725	0	24590	455,135	3,188,650	166,587	0.700	318,594	2,232,055
514,729	0	23261	491,468	3,175,479	166,587	0.700	344,027	2,222,835
549,732	0	18247	531,485	3,099,957	166,587	0.700	372,040	2,169,970
584,736	0	13833	570,903	3,000,093	166,587	0.700	399,632	2,100,065
619,740	0	9918	609,821	2,874,983	166,587	0.700	426,875	2,012,488
654,743	0	6422	648,321	2,723,920	166,587	0.700	453,825	1,906,744
689,747	0	3280	686,467	2,546,336	166,587	0.700	480,527	1,782,435

Section	h	As per ft	d'	As' per ft	d"	d	b	Temp(55,95/95)	fc	Beta 1	fy (rebar)
	[in]	[in^2]	[in]	[in^2]	[in]	[in]	[in]	[deg F]	[psi]		[psi]
4a (out)	18.3	0.1655	2.375	0.1655	8.675	15.925	12.0	110.8	3899	0.85	37631

E (rebar)	yield strain=fy/E	Trial c	0.85fc*b	xp	eps	fs	eps'	fs'
[psi]		[in]		[in]		[psi]		[psi]
28,080,308	.0013401	1.000	39770	6.775	4.478E-02	37631	-2.303E-02	-37631
		1.750			2.430E-02	37631	-1.187E-02	-37631
		2.500			1.611E-02	37631	-7.410E-03	-37631
		3.250			1.170E-02	37631	-5.008E-03	-37631
		4.000			8.944E-03	37631	-3.506E-03	-37631
		4.750			7.058E-03	37631	-2.479E-03	-37631
		5.500			5.686E-03	37631	-1.732E-03	-37631
		6.250			4.644E-03	37631	-1.164E-03	-32685
		7.000			3.825E-03	37631	-7.179E-04	-20158
		7.750			3.165E-03	37631	-3.581E-04	-10055
		8.500			2.621E-03	37631	-6.176E-05	-1734
		9.250			2.165E-03	37631	1.865E-04	5237
		10.000			1.778E-03	37631	3.975E-04	11162
		10.750			1.444E-03	37631	5.791E-04	16260
		11.500			1.154E-03	32414	7.370E-04	20694
		12.250			9.000E-04	25272	8.755E-04	24585
		13.000			6.750E-04	18954	9.981E-04	28026
		13.750			4.745E-04	13325	1.107E-03	31093
		14.500			2.948E-04	8279	1.205E-03	33842
		15.250			1.328E-04	3729	1.293E-03	36320

Cc	Cs	T	P	M	0.1fcAg/0.7	phi	phi x P	phi x M
[lbs]	[lbs]	[lbs]	[lbs]	[lb-in]			[lbs]	[lb-in]
33,804	-6228	6228	21,349	334,178	122,317	0.865	18,469	289,095
59,158	-6228	6228	46,702	536,529	122,317	0.824	38,465	441,906
84,511	-6228	6228	72,055	722,717	122,317	0.782	56,360	565,297
109,864	-6228	6228	97,408	892,742	122,317	0.741	72,153	661,279
135,217	-6228	6228	122,762	1,046,605	122,317	0.700	85,933	732,623
160,571	-6228	6228	148,115	1,184,304	122,317	0.700	103,680	829,013
185,924	-6228	6228	173,468	1,305,842	122,317	0.700	121,428	914,089
211,277	-5409	6228	199,640	1,411,605	122,317	0.700	139,748	988,123
236,630	-3336	6228	227,066	1,501,801	122,317	0.700	158,946	1,051,261
261,984	-1664	6228	254,092	1,575,645	122,317	0.700	177,864	1,102,951
287,337	-287	6228	280,822	1,633,185	122,317	0.700	196,575	1,143,230
312,690	867	6228	307,329	1,674,457	122,317	0.700	215,130	1,172,120
338,043	1847	6228	333,663	1,699,483	122,317	0.700	233,564	1,189,638
363,397	2143	6228	359,311	1,708,022	122,317	0.700	251,518	1,195,615
388,750	2876	5365	386,262	1,694,757	122,317	0.700	270,383	1,186,330
414,103	3520	4183	413,441	1,663,128	122,317	0.700	289,409	1,164,189
439,456	4090	3137	440,409	1,616,224	122,317	0.700	308,286	1,131,357
464,810	4597	2205	467,202	1,553,902	122,317	0.700	327,041	1,087,731
490,163	5052	1370	493,845	1,476,044	122,317	0.700	345,691	1,033,231
515,516	5463	617	520,361	1,382,559	122,317	0.700	364,253	967,791

Section	h	As per ft	d'	As' per ft	d"	d	b	Temp(55,95/95)	fc	Beta 1	fy (rebar)
	[in]	[in^2]	[in]	[in^2]	[in]	[in]	[in]	[deg F]	[psi]		[psi]
4a (out)	18.3	0.44	2.375	0.44	8.675	15.925	12.0	110.8	3899	0.85	37631

E (rebar)	yield strain=fy/E	Trial c	0.85fc*b	xp	eps	fs	eps'	fs'
[psi]		[in]		[in]		[psi]		[psi]
28,080,308	.0013401	1.000	39770	6.775	4.478E-02	37631	-2.303E-02	-37631
		1.750			2.430E-02	37631	-1.187E-02	-37631
		2.500			1.611E-02	37631	-7.410E-03	-37631
		3.250			1.170E-02	37631	-5.008E-03	-37631
		4.000			8.944E-03	37631	-3.506E-03	-37631
		4.750			7.058E-03	37631	-2.479E-03	-37631
		5.500			5.686E-03	37631	-1.732E-03	-37631
		6.250			4.644E-03	37631	-1.164E-03	-32685
		7.000			3.825E-03	37631	-7.179E-04	-20158
		7.750			3.165E-03	37631	-3.581E-04	-10055
		8.500			2.621E-03	37631	-6.176E-05	-1734
		9.250			2.165E-03	37631	1.865E-04	5237
		10.000			1.778E-03	37631	3.975E-04	11162
		10.750			1.444E-03	37631	5.791E-04	16260
		11.500			1.154E-03	32414	7.370E-04	20694
		12.250			9.000E-04	25272	8.755E-04	24585
		13.000			6.750E-04	18954	9.981E-04	28026
		13.750			4.745E-04	13325	1.107E-03	31093
		14.500			2.948E-04	8279	1.205E-03	33842
		15.250			1.328E-04	3729	1.293E-03	36320

Cc	Cs	T	P	M	0.1fcAg/0.7	phi	phi x P	phi x M
[lbs]	[lbs]	[lbs]	[lbs]	[lb-in]			[lbs]	[lb-in]
33,804	-16557	16557	689	399,255	122,317	0.899	620	358,879
59,158	-16557	16557	26,043	601,606	122,317	0.857	22,329	515,827
84,511	-16557	16557	51,396	787,793	122,317	0.816	41,937	642,810
109,864	-16557	16557	76,749	957,819	122,317	0.775	59,443	741,838
135,217	-16557	16557	102,102	1,111,681	122,317	0.733	74,846	814,921
160,571	-16557	16557	127,456	1,249,381	122,317	0.700	89,219	874,567
185,924	-16557	16557	152,809	1,370,918	122,317	0.700	106,966	959,643
211,277	-14382	16557	180,338	1,477,326	122,317	0.700	126,237	1,034,128
236,630	-8869	16557	211,203	1,569,156	122,317	0.700	147,842	1,098,409
261,984	-4424	16557	241,002	1,644,317	122,317	0.700	168,701	1,151,022
287,337	-763	16557	270,016	1,702,942	122,317	0.700	189,011	1,192,059
312,690	2304	16557	298,437	1,745,123	122,317	0.700	208,906	1,221,586
338,043	4911	16557	326,397	1,770,922	122,317	0.700	228,478	1,239,645
363,397	5696	16557	352,535	1,779,693	122,317	0.700	246,775	1,245,785
388,750	7647	14262	382,135	1,757,306	122,317	0.700	267,494	1,230,114
414,103	9359	11120	412,342	1,712,901	122,317	0.700	288,640	1,199,031
439,456	10873	8340	441,990	1,654,696	122,317	0.700	309,393	1,158,287
464,810	12222	5863	471,169	1,582,305	122,317	0.700	329,818	1,107,614
490,163	13432	3643	499,952	1,495,421	122,317	0.700	349,967	1,046,795
515,516	14523	1641	528,398	1,393,797	122,317	0.700	369,879	975,658

Section	h	As per ft	d'	As' per ft	d"	d	b	Temp(55,95/95)	fc	Beta 1	fy (rebar)
	[in]	[in^2]	[in]	[in^2]	[in]	[in]	[in]	[deg F]	[psi]		[psi]
6	12	0.26	2.375	0.26	2.375	9.625	12.0	91.69	4418	0.8291	38000

E (rebar) [psi]	yield strain=fy/E	Trial c [in]	0.85fc*b	xp [in]	eps	fs [psi]	eps'	fs' [psi]
28,183,208	.0013483	0.200	45064	3.625	1.414E-01	38000	-3.263E-02	-38000
		0.600			4.513E-02	38000	-8.875E-03	-38000
		1.000			2.588E-02	38000	-4.125E-03	-38000
		1.400			1.763E-02	38000	-2.089E-03	-38000
		1.800			1.304E-02	38000	-9.583E-04	-27009
		2.200			1.013E-02	38000	-2.386E-04	-6726
		2.600			8.106E-03	38000	2.596E-04	7317
		3.000			6.625E-03	38000	6.250E-04	17615
		3.400			5.493E-03	38000	9.044E-04	25489
		3.800			4.599E-03	38000	1.125E-03	31706
		4.200			3.875E-03	38000	1.304E-03	36739
		4.600			3.277E-03	38000	1.451E-03	38000
		5.000			2.775E-03	38000	1.575E-03	38000
		5.400			2.347E-03	38000	1.681E-03	38000
		5.800			1.978E-03	38000	1.772E-03	38000
		6.200			1.657E-03	38000	1.851E-03	38000
		6.600			1.375E-03	38000	1.920E-03	38000
		7.000			1.125E-03	31706	1.982E-03	38000
		7.400			9.020E-04	25422	2.037E-03	38000
		7.800			7.019E-04	19782	2.087E-03	38000

Cc	Cs	T	P	M	0.1fcAg/0.7	phi	phi x P	phi x M
[lbs]	[lbs]	[lbs]	[lbs]	[lb-in]			[lbs]	[lb-in]
7,472	-9880	9880	-12,288	44,215	90,885	0.900	-11,059	39,794
22,417	-9880	9880	2,657	128,928	90,885	0.894	2,376	115,281
37,362	-9880	9880	17,602	208,685	90,885	0.861	15,160	179,733
52,307	-9880	9880	32,547	283,485	90,885	0.828	26,961	234,833
67,252	-7022	9880	50,350	363,688	90,885	0.789	39,736	287,023
82,197	-1749	9880	70,568	447,693	90,885	0.745	52,553	333,401
97,142	1902	9880	89,164	520,860	90,885	0.704	62,752	366,574
112,087	3603	9880	105,810	582,001	90,885	0.700	74,067	407,401
127,032	5651	9880	122,802	639,442	90,885	0.700	85,9[illegible]	447,609
141,976	7267	9880	139,364	690,363	90,885	0.700	97,555	483,254
156,921	8576	9880	155,617	735,213	90,885	0.700	108,932	514,649
171,866	8904	9880	170,890	771,551	90,885	0.700	119,623	540,086
186,811	8904	9880	185,835	801,745	90,885	0.700	130,084	561,221
201,756	8904	9880	200,780	826,982	90,885	0.700	140,546	578,887
216,701	8904	9880	215,725	847,263	90,885	0.700	151,007	593,084
231,646	8904	9880	230,669	862,587	90,885	0.700	161,469	603,811
246,591	8904	9880	245,614	872,955	90,885	0.700	171,930	611,069
261,536	8904	8244	262,196	872,435	90,885	0.700	183,537	610,705
276,481	8904	6610	278,774	866,968	90,885	0.700	195,142	606,878
291,425	8904	5143	295,186	857,152	90,885	0.700	206,630	600,006

Section	h	As per ft	d'	As' per ft	d"	d	b	Temp(55,95/95)	fc	Beta 1	fy (rebar)
	[in]	[in^2]	[in]	[in^2]	[in]	[in]	[in]	[deg F]	[psi]		[psi]
6a (out)	15	0.615	2	0.615	1.625	13	12.0	91.69	4418	0.8291	38000

E (rebar)	yield strain=fy/E	Trial c	0.85fc*b	xp	eps	fs	eps'	fs'
[psi]		[in]		[in]		[psi]		[psi]
28,183,208	.0013483	0.500	45064	5.500	7.500E-02	38000	-6.750E-03	-38000
		1.000			3.600E-02	38000	-1.875E-03	-38000
		1.500			2.300E-02	38000	-2.500E-04	-7046
		2.000			1.650E-02	38000	5.625E-04	15853
		2.500			1.260E-02	38000	1.050E-03	29592
		3.000			1.000E-02	38000	1.375E-03	38000
		3.500			8.143E-03	38000	1.607E-03	38000
		4.000			6.750E-03	38000	1.781E-03	38000
		4.500			5.667E-03	38000	1.917E-03	38000
		5.000			4.800E-03	38000	2.025E-03	38000
		5.500			4.091E-03	38000	2.114E-03	38000
		6.000			3.500E-03	38000	2.188E-03	38000
		6.500			3.000E-03	38000	2.250E-03	38000
		7.000			2.571E-03	38000	2.304E-03	38000
		7.500			2.200E-03	38000	2.350E-03	38000
		8.000			1.875E-03	38000	2.391E-03	38000
		8.500			1.588E-03	38000	2.426E-03	38000
		9.000			1.333E-03	37578	2.458E-03	38000
		9.500			1.105E-03	31150	2.487E-03	38000
		10.000			9.000E-04	25365	2.513E-03	38000

Cc	Cs	T	P	M	0.1fcAg/0.7	phi	phi x P	phi x M
[lbs]	[lbs]	[lbs]	[lbs]	[lb-in]			[lbs]	[lb-in]
18,681	-23370	23370	-28,059	127,472	113,606	0.900	-25,253	114,725
37,362	-23370	23370	-9,378	255,964	113,606	0.900	-8,440	230,368
56,043	-4333	23370	28,340	488,554	113,606	0.850	24,092	415,323
74,724	7440	23370	58,795	670,725	113,606	0.796	46,830	534,228
93,406	15890	23370	85,925	825,626	113,606	0.749	64,335	618,172
112,087	21060	23370	109,777	953,519	113,606	0.707	77,584	673,890
130,768	21060	23370	128,458	1,043,290	113,606	0.700	89,921	730,303
149,449	21060	23370	147,139	1,125,316	113,606	0.700	102,998	787,721
168,130	21060	23370	165,821	1,199,598	113,606	0.700	116,074	839,719
186,811	21060	23370	184,502	1,266,136	113,606	0.700	129,151	886,295
205,492	21060	23370	203,183	1,324,930	113,606	0.700	142,228	927,451
224,173	21060	23370	221,864	1,375,979	113,606	0.700	155,305	963,186
242,854	21060	23370	240,545	1,419,284	113,606	0.700	168,381	993,499
261,536	21060	23370	259,226	1,454,845	113,606	0.700	181,458	1,018,392
280,217	21060	23370	277,907	1,482,662	113,606	0.700	194,535	1,037,863
298,898	21060	23370	296,588	1,502,734	113,606	0.700	207,612	1,051,914
317,579	21060	23370	315,269	1,515,063	113,606	0.700	220,689	1,060,544
336,260	21060	23110	334,210	1,518,218	113,606	0.700	233,947	1,062,752
354,941	21060	19157	356,845	1,493,315	113,606	0.700	249,791	1,045,321
373,622	21060	15599	379,083	1,462,843	113,606	0.700	265,358	1,023,990

SEC6AOUT.XLS

Section	h	As per ft	d'	As' per ft	d"	d	b	Temp(55,95/95)	fc	Beta 1	fy (rebar)
	[in]	[in^2]	[in]	[in^2]	[in]	[in]	[in]	[deg F]	[psi]		[psi]
7 (out)	15	0.44	4.375	0.44	1.625	10.625	12.0	90.9	4431	0.82845	38000

E (rebar) [psi]	yield strain=fy/E	Trial c [in]	0.85fc*b	xp [in]	eps	fs [psi]	eps'	fs' [psi]
28,187,462	.0013481	1.000	45196	3.125	2.888E-02	38000	-1.875E-03	-38000
		1.500			1.825E-02	38000	-2.500E-04	-7047
		2.000			1.294E-02	38000	5.625E-04	15855
		2.500			9.750E-03	38000	1.050E-03	29597
		3.000			7.625E-03	38000	1.375E-03	38000
		3.500			6.107E-03	38000	1.607E-03	38000
		4.300			4.413E-03	38000	1.866E-03	38000
		5.100			3.250E-03	38000	2.044E-03	38000
		5.900			2.403E-03	38000	2.174E-03	38000
		6.700			1.757E-03	38000	2.272E-03	38000
		7.500			1.250E-03	35234	2.350E-03	38000
		8.300			8.404E-04	23688	2.413E-03	38000
		9.100			5.027E-04	14171	2.464E-03	38000
		9.900			2.197E-04	6193	2.508E-03	38000
		10.700			-2.103E-05	-593	2.544E-03	38000
		11.500			-2.283E-04	-6434	2.576E-03	38000
		12.300			-4.085E-04	-11516	2.604E-03	38000
		13.100			-5.668E-04	-15976	2.628E-03	38000
		13.900			-7.068E-04	-19924	2.649E-03	38000
		14.700			-8.316E-04	-23442	2.668E-03	38000

Cc	Cs	T	P	M	0.1fcAg/0.7	phi	phi x P	phi x M
[lbs]	[lbs]	[lbs]	[lbs]	[lb-in]			[lbs]	[lb-in]
37,443	-16720	16720	4,003	219,331	113,940	0.893	3,574	195,857
56,164	-3101	16720	36,344	420,368	113,940	0.836	30,391	351,514
74,886	5319	16720	63,485	583,103	113,940	0.789	50,062	459,815
93,607	11365	16720	88,252	724,138	113,940	0.745	65,756	539,548
112,328	15063	16720	110,671	843,619	113,940	0.706	78,105	595,374
131,050	15063	16720	129,393	933,623	113,940	0.700	90,575	653,536
161,004	15063	16720	159,347	1,061,499	113,940	0.700	111,543	743,049
190,958	15063	16720	189,301	1,169,522	113,940	0.700	132,511	818,666
220,912	15063	16720	219,255	1,257,693	113,940	0.700	153,479	880,385
250,867	15063	16720	249,210	1,326,012	113,940	0.700	174,447	928,208
280,821	15063	15503	280,381	1,370,675	113,940	0.700	196,266	959,473
310,775	15063	10423	315,415	1,383,412	113,940	0.700	220,791	968,389
340,729	15063	6235	349,557	1,379,088	113,940	0.700	244,690	965,362
370,684	15063	2725	383,022	1,357,027	113,940	0.700	268,115	949,919
400,638	15063	-261	415,961	1,316,753	113,940	0.700	291,173	921,727
430,592	15063	-2831	448,486	1,257,925	113,940	0.700	313,940	880,547
460,546	15063	-5067	480,676	1,180,289	113,940	0.700	336,473	826,202
490,501	15063	-5372	510,936	1,088,833	113,940	0.700	357,655	762,183
520,455	15063	-7109	542,627	973,051	113,940	0.700	379,839	681,136
550,409	15063	-8657	574,129	838,008	113,940	0.700	401,890	586,606

Section	h	As per ft	d'	As' per ft	d"	d	b	Temp(55,95/95)	fc	Beta 1	fy (rebar)
	[in]	[in^2]	[in]	[in^2]	[in]	[in]	[in]	[deg F]	[psi]		[psi]
2 top	6	0.02	2.25	0	0	3.75	12.0	135.8	3625	0.85	36776

E (rebar)	yield strain=fy/E	Trial c	0.85fc*b	xp	eps	fs	eps'	fs'
[psi]		[in]		[in]		[psi]		[psi]
27,945,692	.0013160	0.020	36975	0.750	5.595E-01	36776	3.000E-03	36776
		0.170			6.318E-02	36776	3.000E-03	36776
		0.320			3.216E-02	36776	3.000E-03	36776
		0.470			2.094E-02	36776	3.000E-03	36776
		0.620			1.515E-02	36776	3.000E-03	36776
		0.770			1.161E-02	36776	3.000E-03	36776
		0.920			9.228E-03	36776	3.000E-03	36776
		1.070			7.514E-03	36776	3.000E-03	36776
		1.220			6.221E-03	36776	3.000E-03	36776
		1.370			5.212E-03	36776	3.000E-03	36776
		1.520			4.401E-03	36776	3.000E-03	36776
		1.670			3.737E-03	36776	3.000E-03	36776
		1.820			3.181E-03	36776	3.000E-03	36776
		1.970			2.711E-03	36776	3.000E-03	36776
		2.120			2.307E-03	36776	3.000E-03	36776
		2.270			1.956E-03	36776	3.000E-03	36776
		2.420			1.649E-03	36776	3.000E-03	36776
		2.570			1.377E-03	36776	3.000E-03	36776
		2.720			1.136E-03	31747	3.000E-03	36776
		2.870			9.199E-04	25706	3.000E-03	36776

Cc	Cs	T	P	M	0.1fcAg/0.7	phi	phi x P	phi x M
[lbs]	[lbs]	[lbs]	[lbs]	[lb-in]			[lbs]	[lb-in]
629	0	736	-107	2,432	37,286	0.900	-96	2,189
5,343	0	736	4,607	16,194	37,286	0.875	4,033	14,175
10,057	0	736	9,322	29,355	37,286	0.850	7,923	24,952
14,772	0	736	14,036	41,916	37,286	0.825	11,576	34,568
19,486	0	736	18,750	53,875	37,286	0.799	14,989	43,069
24,200	0	736	23,465	65,233	37,286	0.774	18,165	50,499
28,914	0	736	28,179	75,989	37,286	0.749	21,102	56,905
33,629	0	736	32,893	86,145	37,286	0.724	23,800	62,331
38,343	0	736	37,608	95,700	37,286	0.700	26,325	66,990
43,057	0	736	42,322	104,654	37,286	0.700	29,625	73,258
47,772	0	736	47,036	113,006	37,286	0.700	32,925	79,104
52,486	0	736	51,750	120,758	37,286	0.700	36,225	84,530
57,200	0	736	56,465	127,908	37,286	0.700	39,525	89,536
61,915	0	736	61,179	134,458	37,286	0.700	42,825	94,120
66,629	0	736	65,893	140,406	37,286	0.700	46,125	98,284
71,343	0	736	70,608	145,753	37,286	0.700	49,425	102,027
76,058	0	736	75,322	150,499	37,286	0.700	52,725	105,349
80,772	0	736	80,036	154,644	37,286	0.700	56,025	108,251
85,486	0	635	84,851	158,113	37,286	0.700	59,396	110,679
90,201	0	514	89,686	160,965	37,286	0.700	62,780	112,676

Section	h	As per ft	d'	As' per ft	d"	d	b	Temp(55,95/95)	fc	Beta 1	fy (rebar)
	[in]	[in^2]	[in]	[in^2]	[in]	[in]	[in]	[deg F]	[psi]		[psi]
7c (bot)	17.38	0.56	2.5	0.56	3.625	14.88	12.0	90.9	4431	0.82845	38000

E (rebar)	yield strain=fy/E	Trial c	0.85fc*b	xp	eps	fs	eps'	fs'
[psi]		[in]		[in]		[psi]		[psi]
28,187,462	.0013481	0.020	45196	6.190	2.229E+00	38000	-5.408E-01	-38000
		0.520			8.285E-02	38000	-1.791E-02	-38000
		1.020			4.076E-02	38000	-7.662E-03	-38000
		1.520			2.637E-02	38000	-4.155E-03	-38000
		2.020			1.910E-02	38000	-2.384E-03	-38000
		2.520			1.471E-02	38000	-1.315E-03	-37080
		3.020			1.178E-02	38000	-6.010E-04	-16940
		3.520			9.682E-03	38000	-8.949E-05	-2522
		4.020			8.104E-03	38000	2.948E-04	8309
		4.520			6.876E-03	38000	5.940E-04	16744
		5.020			5.892E-03	38000	8.337E-04	23499
		5.520			5.087E-03	38000	1.030E-03	29030
		6.020			4.415E-03	38000	1.194E-03	33642
		6.520			3.847E-03	38000	1.332E-03	37547
		7.020			3.359E-03	38000	1.451E-03	38000
		7.520			2.936E-03	38000	1.554E-03	38000
		8.020			2.566E-03	38000	1.644E-03	38000
		8.520			2.239E-03	38000	1.724E-03	38000
		9.020			1.949E-03	38000	1.794E-03	38000
		9.520			1.689E-03	38000	1.858E-03	38000

Cc [lbs]	Cs [lbs]	T [lbs]	P [lbs]	M [lb-in]	0.1fcAg/0.7	phi	phi x P [lbs]	phi x M [lb-in]
749	-21280	21280	-41,811	30,441	132,018	0.900	-37,630	27,397
19,470	-21280	21280	-23,090	188,943	132,018	0.900	-20,781	170,048
38,192	-21280	21280	-4,368	339,689	132,018	0.900	-3,932	305,720
56,913	-21280	21280	14,353	482,681	132,018	0.878	12,606	423,917
75,634	-21280	21280	33,074	617,917	132,018	0.850	28,110	525,164
94,356	-20765	21280	52,311	748,009	132,018	0.821	42,934	613,930
113,077	-9487	21280	82,311	924,859	132,018	0.775	63,816	717,048
131,799	-1413	21280	109,106	1,077,727	132,018	0.735	80,161	791,818
150,520	4653	21280	133,893	1,212,666	132,018	0.700	93,725	848,866
169,241	7268	21280	155,229	1,322,371	132,018	0.700	108,660	925,660
187,963	11050	21280	177,733	1,430,238	132,018	0.700	124,413	1,001,166
206,684	14148	21280	199,552	1,526,879	132,018	0.700	139,686	1,068,815
225,406	16731	21280	220,856	1,613,159	132,018	0.700	154,599	1,129,211
244,127	18917	21280	241,764	1,689,678	132,018	0.700	169,235	1,182,774
262,848	19171	21280	260,739	1,748,650	132,018	0.700	182,517	1,224,055
281,570	19171	21280	279,461	1,798,583	132,018	0.700	195,622	1,259,008
300,291	19171	21280	298,182	1,840,761	132,018	0.700	208,727	1,288,533
319,013	19171	21280	316,903	1,875,185	132,018	0.700	221,832	1,312,629
337,734	19171	21280	335,625	1,901,853	132,018	0.700	234,937	1,331,297
356,455	19171	21280	354,346	1,920,767	132,018	0.700	248,042	1,344,537

Section	h	As per ft	d'	As' per ft	d"	d	b	Temp(55,95/95)	fc	Beta 1	fy (rebar)
	[in]	[in^2]	[in]	[in^2]	[in]	[in]	[in]	[deg F]	[psi]		[psi]
6	12	3.94	3.375	3.94	3.375	8.8125	12.0	91.69	4418	0.8291	38000
(first element w/ haunch steel)											

E (rebar) [psi]	yield strain=fy/E	Trial c [in]	0.85fc*b	xp [in]	eps	fs [psi]	eps'	fs' [psi]
28,183,208	.0013483	0.200	45064	2.625	1.292E-01	38000	-4.763E-02	-38000
		0.600			4.106E-02	38000	-1.388E-02	-38000
		1.000			2.344E-02	38000	-7.125E-03	-38000
		1.400			1.588E-02	38000	-4.232E-03	-38000
		1.800			1.169E-02	38000	-2.625E-03	-38000
		2.200			9.017E-03	38000	-1.602E-03	-38000
		2.600			7.168E-03	38000	-8.942E-04	-25202
		3.000			5.813E-03	38000	-3.750E-04	-10569
		3.400			4.776E-03	38000	2.206E-05	622
		3.800			3.957E-03	38000	3.355E-04	9456
		4.200			3.295E-03	38000	5.893E-04	16608
		4.600			2.747E-03	38000	7.989E-04	22516
		5.000			2.288E-03	38000	9.750E-04	27479
		5.400			1.896E-03	38000	1.125E-03	31706
		5.800			1.558E-03	38000	1.254E-03	35350
		6.200			1.264E-03	35627	1.367E-03	38000
		6.600			1.006E-03	28343	1.466E-03	38000
		7.000			7.768E-04	21892	1.554E-03	38000
		7.400			5.726E-04	16139	1.632E-03	38000
		7.800			3.894E-04	10975	1.702E-03	38000

Cc	Cs	T	P	M	0.1fcAg/0.7	phi	phi x P	phi x M
[lbs]	[lbs]	[lbs]	[lbs]	[lb-in]			[lbs]	[lb-in]
7,472	-149720	149720	-291,968	17,544	90,885	0.900	-262,771	15,789
22,417	-149720	149720	-277,023	105,059	90,885	0.900	-249,320	94,553
37,362	-149720	149720	-262,078	187,618	90,885	0.900	-235,870	168,856
52,307	-149720	149720	-247,133	265,220	90,885	0.900	-222,420	238,698
67,252	-149720	149720	-232,188	337,867	90,885	0.900	-208,969	304,080
82,197	-149720	149720	-217,243	405,556	90,885	0.900	-195,519	365,001
97,142	-99297	149720	-151,875	610,105	90,885	0.900	-136,688	549,094
112,087	-41641	149720	-79,274	830,040	90,885	0.900	-71,347	747,036
127,032	2449	149720	-20,239	1,006,865	90,885	0.900	-18,215	906,178
141,976	37257	149720	29,514	1,152,627	90,885	0.835	24,646	962,503
156,921	50639	149720	57,841	1,233,172	90,885	0.773	44,695	952,892
171,866	73917	149720	96,063	1,336,592	90,885	0.700	67,244	935,614
186,811	93470	149720	130,561	1,424,580	90,885	0.700	91,393	997,206
201,756	110126	149720	162,162	1,499,465	90,885	0.700	113,514	1,049,626
216,701	124485	149720	191,466	1,562,933	90,885	0.700	134,026	1,094,053
231,646	134924	140369	226,201	1,585,874	90,885	0.700	158,340	1,110,112
246,591	134924	111673	269,842	1,523,716	90,885	0.700	188,889	1,066,601
261,536	134924	86256	310,204	1,465,210	90,885	0.700	217,143	1,025,647
276,481	134924	63586	347,818	1,408,961	90,885	0.700	243,473	986,273
291,425	134924	43242	383,107	1,353,859	90,885	0.700	268,175	947,701

APPENDIX G

CALCULATION OF SECTION TRANSVERSE SHEARS (SEISMIC ANALYSES)

The version of SASSI used in the seismic analyses does not report transverse shear for shell elements. URS Consultants, Inc., John A. Blume and Associates, Engineers, hereinafter referred to as Blume, was contracted to manipulate the binary output from the seismic analyses and obtain the values of transverse shear demand required for the ACI code-based transverse shear evaluation. Documentation of Blume's approach for computing the transverse shear demands and their results is provided in this appendix. The "1/4 tank" and "1/2 tank" models that Blume refers to correspond to the vertical excitation analysis (run QLOWVLILV) and horizotal excitation with tank-to-tank interaction analysis (run TTTLOW), respectively. Both analyses use lower-bound soil properties.

Following the Blume documentation in this appendix is an independent verification of their results.

URS CONSULTANTS, INC.
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July 22, 1994

Mr. David Wallace
Westinghouse Hanford Company
P.O. Box 1970
Richland, WA 99352

Subject: Extract Transverse Shear Forces from WHC/SASSI results

Project: P.O. #MJB-SMV-384095, Task 003

Reference: URS/Blume progress report Fax from B.Mosaddad to D. Wallace

Dear Mr. Wallace:

We have completed our work. The transfer shears are computed for selected elements of both 1/4 tank and 1/2 tank models. Please refer to the attached calculations for a detail description of the methodology, assumptions and computational equations involved in generation of these results.

The difference between computed moments and membrane forces at centroid of elements by MTR/SASSI and those provided by WHC/SASSI are within few percentage points. These small differences which are due to differences in the formulations of shell finite elements in these versions of SASSI, indicate that the computed results, if not exact, are quite adequate for use in design.

It should be mentioned that the procedure adopted by us to compute the transverse shears, although adequate, is an approximate and can be applied to similar results from any other finite element analysis computer program. A more rigorous approach would be one that utilizes the stiffness and transformation matrices of the shell finite element currently available in WHC/SASSI code. However the results from our analyses, reported in the attached calculations, show that the accuracy of the methodology adopted in our computations is quite adequate.

Please call us if you have any questions or comments

Very Truly,

Bahram Mosaddad

Bahram Mosaddad, Ph.D., P.E.

cc:RMC, File 66481-03

URS CORPORATION -
URS/John A. Blume & Associates, Engineers

Sheet No. 1/14	Calc. No. 66481-01-CA-1	Rev. No.
Job No. 66481-03	Job Compute Transfer Shear from SASSI Tape 8	By MTR Date 7/21/94
Client WHC	Subject	Chk'd BM Date 7/22/94

Computation of Transverse Shear from the Results of SSI Analyses on two SASSI tape 8's furnished by WHC

The results of SASSI analyses of a single tank (1/4 model incorporating 1/4 of the tank) and a double tank (1/4 model incorporating 1/2 of one tank) were furnished on two Tape 8 format's. Tape 8 contains complex transfer function of displacement and rotational response at all nodes of the model. Additionally the data file for the HOUSE program which was used to generate the stiffness and mass matrices for the SSI models were provided. The purpose of our study was to use the above data (Tape 8 and HOUSE model) to compute the transverse shear for the selected plate elements used to model the tank structure.

$\frac{1}{2}$?

We understand that the plate element used in WHC's version of SASSI, which generated the above data, is based on Kirchhoff plate theory which does not incorporate transverse shear deformation in the element stiffness formulation. This element is basically applicable to thin plates where transverse shear deformation does not govern the plate bending behavior. MTR/SASSI uses a mindlin type plate element formulation which accounts for shear deformation in the stiffness formulation. Therefore, the transverse shear

URS CORPORATION
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Sheet No. 2/14
Calc. No. 66481-01-CA-1
Rev. No.

Job No. 66481-03 Job Compute Transfer Shear from SASSI Tape 8 By MTR Date 7/21/94
Client WHC Subject Chk'd BM Date 7/22/94

can be computed and output directly by the program.

Assuming that the bending moments (M1, M2 & M12) computed by WHC/SASSI represent the actual behavior of the tank structure, a simple procedure can be used to compute the transverse shear forces in equilibrium with the moments at element nodes. This can be simply achieved by setting the transverse shear equal to derivative of the plate bending moments. Alternatively, the element stiffness matrix can be multiplied by the displacement and rotational response of the element nodes to obtain the element transverse nodal forces from which the transverse shear can be computed from equilibrium of forces. For this study, the former approach was adopted.

The procedure consisted of input of the above 'Tape 8's developed by WHC into program module STRESS of MTR/SASSI together with a new tape 4 generated by HOUSE module of MTR/SASSI using the data file furnished by WHC. This analyses resulted in membrane forces and bending moments which were verified against those furnished by WHC from WHC's stress runs. Although some discrepancies in the the sign of few M12 terms are observed, the absolute values seem to agree within a few percent.

URS CORPORATION -
URS/John A. Blume & Associates, Engineers

Sheet No. 3/14
Calc. No. 66481-01-CA-1
Rev. No.

Job No. 66481-03 Job Subject Compute Transfer Shear from SASSI Tape8 By MTR Date 7/21/94
Client WHC Chk'd BM Date 7/22/94

In conjunction with this, the program module STRESS was modified to incorporate the transverse shear calculation based on the computed moments at the element nodes. The theoretical derivation of this methodology is provided on page 4 and 5.

The results of transverse shear computation for the elements requested by WHC are attached.

In using these results, it should be noted that N1, N2 and N12 are membrane forces (not stresses) per unit length; M1, M2 and M12 are plate bending moments per unit length, and S1 and S2 are transverse shear forces (not stresses) per unit length. For quadrilateral plate elements, the forces and moments are all output at the center of the element. For triangular elements the membrane forces and bending moments are output at Node K (to be consistent with WHC's results) while transverse shear forces are provided at the center of the element. All forces and moments conform to the sign convention of MTR/SASSI attached hereto.

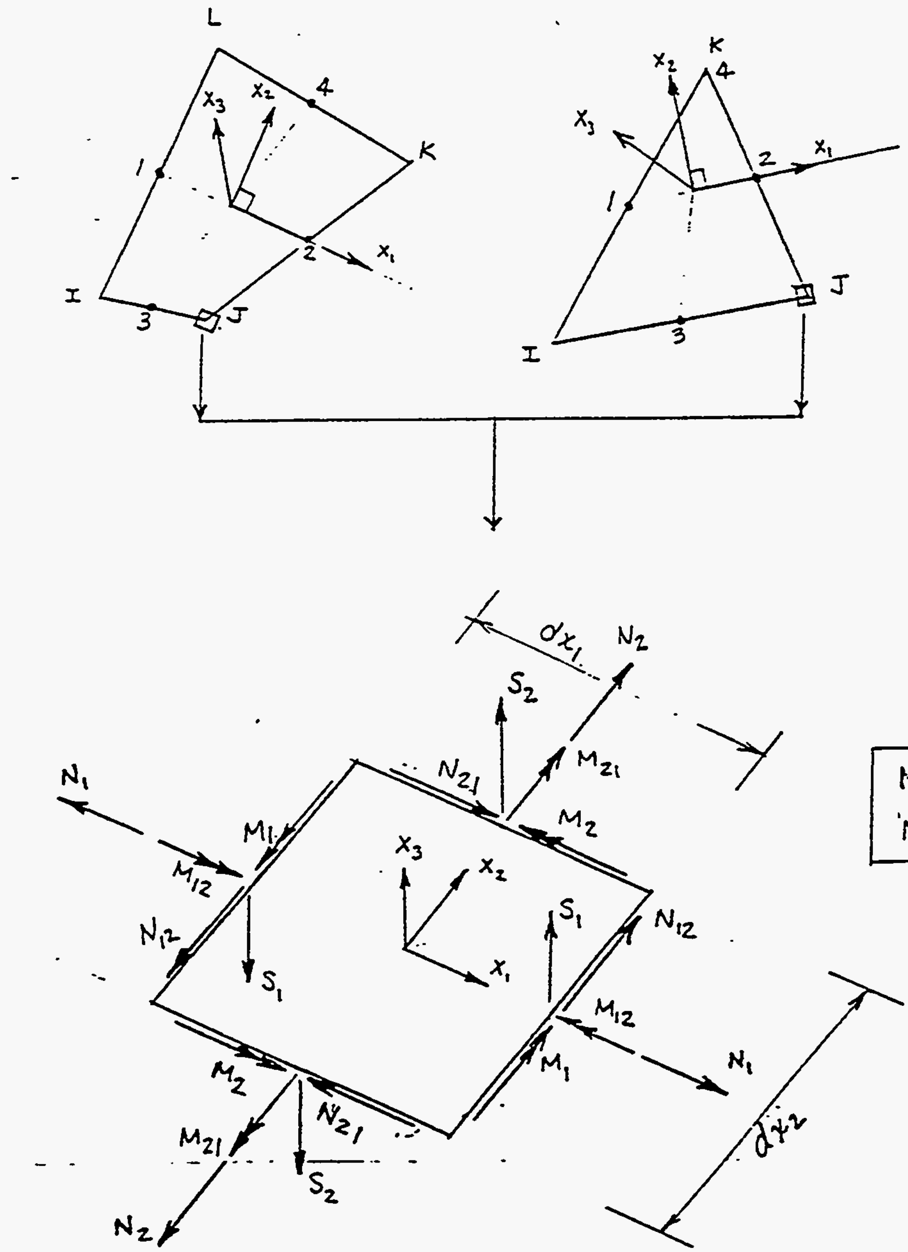
Sheet No. 4/14

URS CORPORATION -
URS/John A. Blume & Associates, Engineers

Calc. No. 66481-01-CA-1
Rev. No.

Job No. 66481-03	Job Compute Transfer Shear from SASSI Tape 8	By MTR	Date 7/21/94
Client WHC	Subject	Chk'd BM	Date 7/22/94

The following sign convention has been adopted for plate elements.



$M_{21} = M_{12}$
$N_{21} = N_{12}$

Note: N_1, N_2 & N_{12} are membrane forces per unit length
M_1, M_2 & M_{12} are plate bending moments per unit length
S_1 & S_2 are transverse shear forces per unit length

URS CORPORATION -
URS/John A. Blume & Associates, Engineers

Calc. No. 66481-01-CA-
Rev. No.

Job No. 66481-03 Job Compute Transfer Shear from SASSI Tape8 By MTR Date 7/21/94
Client WHC Subject Chk'd BM Date 7/22/94

For the infinitesimal element shown above, we can write:

$$S_1 = \frac{\partial M_1}{\partial x_1} + \frac{\partial M_{21}}{\partial x_2} \qquad (1)$$

$$S_2 = \frac{\partial M_{12}}{\partial x_1} + \frac{\partial M_2}{\partial x_2}$$

Because the bending moment along each element side has a linear variation, the plate bending moments M1, M2 and M12 (or M_{21}) in the middle of each element side (midside points 1, 2, 3 or 4) may be calculated as average of the moments at either end of the respective element side, e.g:

$$(M_1)_1 = \frac{1}{2}\left[(M_1)_I + (M_1)_L\right]$$

$$(M_2)_1 = \frac{1}{2}\left[(M_2)_I + (M_2)_L\right] \qquad (2)$$

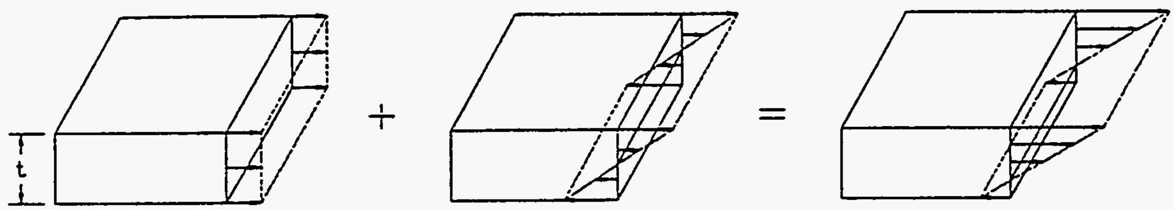
$$(M_{12})_1 = \frac{1}{2}\left[(M_{12})_I + (M_{12})_L\right] \qquad \text{etc.}$$

Finally assuming that bending moments vary linearly along lines 1-2 and 3-4 and that these two lines are approximately perpendicular, we can use Eqn(1) to evaluate the transverse shear force in the middle of the elements.

$$S_1 = \frac{(M_1)_2 - (M_1)_1}{(X_1)_2 - (X_1)_1} + \frac{(M_{21})_4 - (M_{21})_3}{(X_2)_4 - (X_2)_3}$$

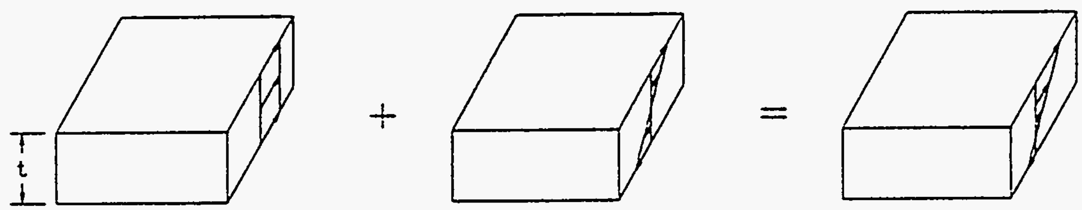
$$S_2 = \frac{(M_{12})_2 - (M_{12})_1}{(X_1)_2 - (X_1)_1} + \frac{(M_2)_4 - (M_2)_3}{(X_2)_4 - (X_2)_3}$$

NORMAL STRESSES

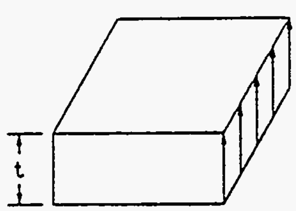


$\frac{N_i}{t}$ $\quad$ $\frac{6M_i}{t^2}$ $\quad$ Total

SHEAR STRESSES

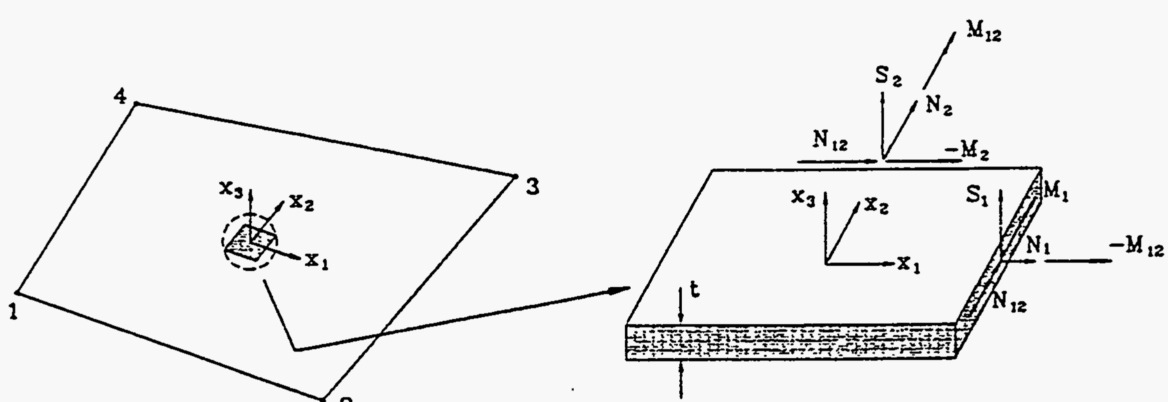


$\frac{N_{ij}}{t}$ $\quad$ $\frac{6M_{ij}}{t^2}$ $\quad$ Total direct shear



$\frac{S_i}{t}$

transverse shear stresses



Forces and moments are per unit length

Calc No. 66481-01-CA-1
Client: WHC

BM 7/22/94

STRESS MTR/ S A S S I 22 JUL 1994

C-106 Quarter Model with updated soil - stress

COMPUTED STRESSES / FORCES / MOMENTS

3-D FLAT PLATE/SHELL ELEMENTS (ORDER = 1)

TITLE :

ELEM	N1 S1	N12 S2	N2	M1	M12	M2
1	.1591E+03 .8348E+00	.1343E+01 .3670E+00	.1593E+03	-.1224E+02	-.1877E+01	.2264E+02
4	.1560E+03 .7675E+00	-.1620E+01 .6361E+00	.1577E+03	-.4157E+02	.5047E+00	.1533E+02
9	.1488E+03 -.4412E+00	.1076E+01 -.4472E+00	.1537E+03	.6666E+01	-.1671E+01	.1080E+02
16	.1475E+03 .2402E+00	-.1474E+01 .4973E+00	.1516E+03	-.1577E+02	.8952E+00	-.1104E+02
23	.1181E+04 -.1866E+02	.7901E+02 -.1356E+02	.6609E+03	.1213E+04	.2767E+03	-.9563E+03
28	.1254E+04 .4627E+01	.4345E+02 -.1269E+02	.7773E+03	-.2418E+03	.2015E+03	-.1394E+04
31	.1362E+04 -.4803E+02	.2232E+02 -.5220E+02	.1060E+04	.1074E+04	.4409E+03	-.2541E+04
32	.1332E+04 -.1228E+03	.9833E+00 -.9225E+02	.1229E+04	-.2096E+04	.3956E+03	-.6317E+04
164	.1512E+03 .9777E+00	.4323E+00 -.3568E+00	.1436E+03	-.9764E+01	.7960E+00	-.1362E+02
168	.1478E+03 -.1381E+01	.4592E+00 -.3083E+00	.1340E+03	-.1280E+02	.8603E+00	-.1897E+02
172	.1433E+03 -.1162E+01	-.6734E+00 -.1127E+01	.1215E+03	.8767E+01	.9026E+00	-.8203E+01
176	.1360E+03 .7130E+00	-.4504E+00 .2917E+01	.1026E+03	-.1765E+02	.2084E+01	-.4829E+02
180	.1322E+03 .5594E+00	-.1345E+01 -.3704E+01	.1260E+03	-.1572E+02	.1992E+01	-.1098E+02
184	.1254E+03 .3847E+00	-.2210E+01 .7623E+01	.1411E+03	-.4318E+02	-.5817E+01	-.1416E+03
188	.8008E+02 -.1855E+01	.2040E+01 -.3004E+02	.1821E+03	.8640E+02	-.1181E+02	.6609E+03
192	.3761E+03 .9044E+01	.1740E+02 .6693E+02	.5129E+03	.2549E+03	-.3348E+02	.1395E+04
196	.1395E+03 .5113E+00	.3141E+01 .1786E+02	.3763E+03	-.2404E+02	.4471E+01	-.1231E+03
200	.4487E+03 .2303E+01	.1594E+02 .3336E+01	.5108E+03	-.7495E+02	.2153E+02	-.3631E+03

204	.5180E+03	.2022E+01	.4995E+03	-.6126E+02	-.1005E+02	-.2916E+03
	.1603E+01	-.6315E+01				
208	.5075E+03	-.2127E+01	.5050E+03	-.7016E+02	.8435E+01	-.3359E+03
	.2034E+01	.7984E+01				
212	.4405E+03	-.4512E+01	.4979E+03	-.9479E+02	.1057E+02	-.4665E+03
	.2067E+01	.4025E+01				
216	.4302E+03	-.9032E+01	.5190E+03	-.9510E+02	.1603E+02	-.4946E+03
	.4726E+01	.3988E+01				
220	.2780E+03	-.2349E+02	.4946E+03	-.1200E+03	-.3924E+02	-.5904E+03
	.3189E+01	-.4364E+01				
224	.6272E+02	-.1910E+01	.4035E+03	.8176E+02	-.3773E+01	.4052E+03
	-.5858E+00	-.6029E+02				
228	-.1048E+04	.2056E+02	.6468E+03	.5298E+03	-.2168E+03	.3639E+04
	-.2158E+02	-.1292E+03				
232	-.1109E+04	.6276E+01	.5366E+03	-.3703E+03	-.5484E+02	.4245E+04
	-.1301E+02	.9419E+02				
236	-.6211E+03	.5350E+01	.6568E+03	.1218E+03	.1062E+02	.2006E+04
	-.4152E+01	.3020E+02				
240	-.4441E+03	-.5750E+00	.7181E+03	-.2701E+03	.6867E+01	.9381E+03
	-.3288E+01	.2680E+02				
244	-.4147E+03	-.1810E+01	.7458E+03	-.4601E+03	.1505E+02	.5108E+03
	-.2585E+01	.1091E+02				
248	.4114E+03	-.6119E+00	.8414E+03	-.4958E+03	-.6249E+01	-.6458E+03
	-.2140E+01	-.2486E+01				
252	.4351E+03	-.5045E+00	.1124E+04	-.4836E+03	.6966E+01	.8138E+03
	-.2526E+01	-.8402E+01				
256	.4581E+03	-.2804E+00	.9917E+03	-.1016E+04	-.1420E+01	.8807E+03
	-.2751E+01	-.9300E+01				
260	.5919E+03	-.4036E+01	.1091E+04	-.7409E+03	.5517E+01	.1007E+04
	-.1746E+01	-.8739E+01				
264	.8567E+02	.2858E+02	.4677E+03	.5242E+03	-.3998E+03	.1837E+03
	.2279E+02	.3605E+02				

NOTE: "-0.9999E+99" INDICATES THAT CORRESPONDING COMPONENT NOT REQUESTED.

Calc. No. 66481-01-01-1
Client: WHC

STRESS MTR/ S A S S I 22 JUL 1994

WHCT3 - C-106 Half Model with updated soil - stress

C O M P U T E D   S T R E S S E S / F O R C E S / M O M E N T S

3-D FLAT PLATE/SHELL ELEMENTS (ORDER = 1)

TITLE :

ELEM	N1 S1	N12 S2	N2	M1	M12	M2
1	-.1009E+03 -.2086E+00	-.1527E+02 .3510E+00	.4797E+02	.1114E+02	.7594E+00	.9329E+01
4	-.2255E+03 --.9125E+00	.2671E+02 -.8614E+00	.5588E+02	.6316E+02	-.2077E+01	.1799E+02
9	-.1933E+03 .7319E+00	.3888E+02 -.7841E+00	.6394E+02	.1572E+02	-.2962E+01	-.3580E+02
16	-.2432E+03 .5660E+00	.4629E+02 .9675E+00	.8655E+02	-.4281E+02	.2844E+01	-.1698E+02
23	.9390E+02 .3243E+01	-.7660E+02 .1022E+01	.5783E+03	-.5000E+03	-.4025E+02	-.2252E+03
28	.9634E+02 -.3140E+01	-.4554E+02 -.1552E+01	.4513E+03	.2540E+03	.1338E+02	-.2300E+03
31	.8043E+02 .3126E+01	-.2533E+02 .2642E+01	.3147E+03	-.4403E+03	-.3115E+02	-.2103E+03
32	.7351E+02 -.1238E+01	.1777E+02 -.6961E+00	.1749E+03	-.1217E+03	.6431E+01	.9053E+02
324	.9970E+02 .6848E+00	-.1283E+02 -.1006E+01	-.3451E+03	.5958E+01	.7626E+00	-.2575E+02
328	.1223E+03 -.6616E+00	-.1513E+02 -.6964E+00	-.4873E+03	-.3028E+01	-.8813E+00	.1335E+02
332	-.1540E+03 -.6254E+00	-.1394E+02 -.5203E+00	-.5577E+03	-.5873E+01	-.1555E+01	.2313E+02
336	-.1916E+03 -.1627E+01	-.1724E+02 .2269E+01	-.6075E+03	.3334E+01	.7538E+00	-.2902E+02
340	-.2331E+03 .9426E+00	-.1906E+02 .2096E+01	-.7089E+03	.5356E+01	-.2206E+01	-.2965E+02
344	-.2850E+03 -.8727E+00	-.1728E+02 .1674E+01	-.8107E+03	.5083E+01	.1048E+02	.1700E+02
348	-.1772E+03 -.3096E+01	-.3032E+02 -.1457E+02	-.8836E+03	-.1194E+03	-.1079E+02	.4295E+03
352	-.1704E+04 -.8215E+01	-.1159E+03 -.3720E+03	-.7454E+02	-.1753E+04	.2957E+03	-.8597E+04
356	-.2556E+03 -.1993E+01	-.5679E+02 -.1159E+03	-.3856E+02	.5002E+02	-.7853E+01	.2317E+03
360	-.9026E+03 -.2510E+01	.6505E+02 -.1418E+02	.8370E+02	.2959E+03	-.4734E+02	.1549E+04

364	-.5300E+03	.6081E+02	.7302E+02	.2128E+03	-.1315E+02	.1204E+04
	-.1068E+01	.3076E+02				
368	-.1836E+03	-.5402E+02	.9438E+02	.9590E+02	.1379E+03	-.5291E+03
	-.3859E+01	-.3559E+01				
372	-.1810E+03	.5645E+02	.1216E+03	.6429E+02	-.2223E+02	.3489E+03
	.2959E+01	-.7881E+01				
376	-.4001E+03	.5593E+02	.1260E+03	-.3038E+02	.4372E+02	-.8768E+02
	-.6723E+01	-.7000E+01				
380	-.6484E+03	.4870E+02	.1297E+03	.2662E+02	.5942E+02	-.1114E+03
	-.1221E+02	.2913E+01				
384	-.1221E+03	.3815E+02	.1104E+03	.6323E+02	.1260E+02	-.2950E+03
	-.1920E+01	.2035E+02				
388	-.1342E+04	.1946E+02	.2931E+03	.8837E+03	.4206E+03	-.2521E+04
	.3509E+02	.1128E+03				
392	-.1714E+04	.3454E+02	-.2993E+03	-.1927E+04	.3103E+03	-.2351E+04
	-.3872E+02	-.1108E+03				
396	-.1208E+04	.3817E+02	-.1815E+03	-.7959E+03	.1500E+03	-.1050E+04
	.1315E+02	.3047E+02				
400	-.1080E+04	.3191E+02	-.1379E+03	-.5500E+03	.3239E+02	-.1314E+04
	.2715E+01	.2408E+02				
404	-.1372E+04	.2882E+02	-.1297E+03	-.4054E+03	.2451E+02	-.7629E+03
	.3761E+01	-.5054E+01				
408	.8346E+03	.2468E+02	-.1255E+03	-.3337E+03	.7387E+01	-.5349E+03
	.2323E+01	.9387E+01				
412	.8669E+03	.2135E+02	-.1159E+03	-.3032E+03	-.9371E+01	-.4229E+03
	.1990E+01	.3154E+01				
416	.7506E+03	.1753E+02	.1074E+03	-.2845E+03	-.6172E+01	-.4407E+03
	.9752E+00	.3900E+01				
420	.6536E+03	.1690E+02	.1024E+03	-.2759E+03	-.4047E+01	-.4784E+03
	.4171E+00	.4113E+01				
424	-.4850E+03	.4307E+01	-.2889E+04	-.7387E+04	.3311E+03	-.4168E+03
	-.3313E+03	-.5392E+02				

NOTE: "-0.9999E+99" INDICATES THAT CORRESPONDING COMPONENT NOT REQUESTED.

Job NO. 66481-00
Calc. NO. 66481-01-
Client: WHC

BM 7/22/94

STRESS MTR/ S A S S I 22 JUL 1994

WHCT2 - C-106 Half Model with updated soil - stress

C O M P U T E D S T R E S S E S / F O R C E S / M O M E N T S

3-D FLAT PLATE/SHELL ELEMENTS (ORDER = 1)

TITLE :

ELEM	N1 S1	N12 S2	N2	M1	M12	M2
161	-.2443E+02 -.4011E+00	-.1740E+02 -.6410E+00	-.4562E+02	.7150E+01	.2226E+01	-.6852E+01
164	-.3320E+02 -.1236E+00	-.5077E+02 -.1206E+01	.5690E+02	.3104E+01	-.8007E+01	-.2070E+02
169	.4041E+02 .3148E+00	-.7176E+02 .1594E+01	.7264E+02	-.1089E+02	-.1342E+02	-.1907E+02
176	.6509E+02 -.3393E+00	-.1188E+03 .8175E+00	.7281E+02	-.6901E+01	-.3252E+01	-.1421E+02
183	.1011E+03 .1077E+01	-.1987E+03 -.4199E+01	.8387E+02	.4987E+02	-.1124E+03	.7285E+02
188	.8919E+02 -.2986E+00	.1438E+03 .3130E+01	.7603E+02	.3656E+02	-.9089E+02	.1109E+03
191	.8329E+02 .8321E+00	.9216E+02 -.4753E+01	.7191E+02	.6229E+02	-.7916E+02	.7579E+02
192	-.8586E+02 .1111E+01	.3915E+02 .1978E+01	.6956E+02	.2278E+02	-.1931E+02	.9298E+02
844	.5213E+02 -.2520E+01	.1972E+03 .8861E-01	-.2662E+02	-.2003E+02	-.2579E+01	-.5228E+01
848	.5084E+02 -.1286E+01	.2489E+03 -.5719E+00	-.5915E+02	-.1393E+02	-.7370E+01	-.4666E+01
852	-.4962E+02 -.6922E+00	.3214E+03 -.1030E+01	.4157E+02	.5536E+01	.2742E+01	-.2204E+01
856	-.5674E+02 .5181E+00	.3687E+03 -.1173E+00	.3819E+02	-.4357E+01	.1436E+01	.3616E+01
860	.4677E+02 .2325E+01	-.4491E+03 .1426E+00	.5414E+02	-.3253E+01	.3087E+01	-.1950E+01
864	.4312E+02 .4530E+00	-.5283E+03 .2657E+00	.7368E+02	-.1586E+01	.1051E+01	-.4381E+01
868	.2427E+02 .8417E+00	-.6152E+03 .1300E+01	.8907E+02	.8739E+01	-.1080E+02	-.3336E+02
872	.1523E+03 .6794E+01	-.1374E+04 .1678E+02	-.2664E+02	.9383E+02	.3799E+03	.3742E+03
876	.1963E+02 -.2061E+00	.1244E+04 .4544E+01	-.2017E+02	-.4078E+01	-.1471E+02	-.9706E+01
880	.1017E+03 .9387E+00	.1449E+04 -.8321E+00	-.2651E+02	-.1752E+02	.1938E+03	.4768E+02

Job No. [illegible]
Calc. No. 66481-01-CA-1
Client: WHC

BM 7/22/94

884	.7565E+02	.1506E+04	-.2981E+02	-.1698E+02	-.1620E+03	.4990E+02
	.2695E+01	-.8329E+00				
888	.6768E+02	.1515E+04	-.3047E+02	-.1682E+02	-.1333E+03	-.5220E+02
	.1323E+01	-.8886E+00				
892	-.6026E+02	.1481E+04	-.3017E+02	-.2335E+02	-.1145E+03	.6775E+02
	.1247E+01	.8254E+00				
896	-.5961E+02	.1414E+04	-.3180E+02	-.2600E+02	-.1044E+03	-.5982E+02
	-.7306E+00	.5403E+00				
900	-.5679E+02	.1300E+04	-.2984E+02	.2442E+02	.1106E+03	-.6666E+02
	-.9476E+00	.4708E+00				
904	-.8278E+01	.1049E+04	.2511E+02	.5008E+01	-.7084E+02	.3006E+02
	-.3304E+00	-.5569E+01				
908	.1231E+03	.1132E+04	.3949E+02	.5940E+02	.5301E+03	-.2897E+03
	.1324E+02	.9330E+01				
912	-.1205E+03	.9496E+03	-.4859E+02	-.2742E+03	.1015E+04	.3031E+03
	.3837E+01	.8948E+01				
916	-.7538E+02	.7961E+03	-.4959E+02	.6081E+02	.3435E+03	.1165E+03
	.5447E+01	-.3755E+01				
920	-.6110E+02	.7112E+03	.7744E+02	.5763E+02	.1910E+03	.6093E+02
	.3877E+01	.1727E+01				
924	.5599E+02	.6694E+03	.7255E+02	.6723E+02	-.1615E+03	.5023E+02
	.1420E+01	-.7927E+00				
928	.5847E+02	.6023E+03	.7314E+02	.6518E+02	-.1447E+03	.4679E+02
	.2205E+01	-.8472E+00				
932	.6453E+02	.5097E+03	.7380E+02	.6295E+02	.1477E+03	.3430E+02
	.1825E+01	-.4174E+00				
936	.6488E+02	.4234E+03	-.7645E+02	.6149E+02	.1358E+03	.2671E+02
	.2108E+01	-.4426E+00				
940	.6810E+02	.3354E+03	-.8084E+02	.6542E+02	.1254E+03	.2468E+02
	-.1170E+01	.2528E+00				
944	-.3108E+02	.3765E+03	.2401E+03	.3443E+03	-.4643E+03	-.7004E+02
	.1765E+02	-.1134E+03				

NOTE: "-0.9999E+99" INDICATES THAT CORRESPONDING COMPONENT NOT REQUESTED.

Job No ... Calc No ... Client: WHC

MTR 7/22/94 .3/12
EM 7/22/94

WHCT1 - C-106 Half Model with updated soil - stress

COMPUTED STRESSES / FORCES / MOMENTS

3-D FLAT PLATE/SHELL ELEMENTS (ORDER = 1)

TITLE :

ELEM	N1 S1	N12 S2	N2	M1	M12	M2
289	-.3988E+02 .9963E+00	-.1041E+02 .2967E+00	.2345E+02	-.1968E+02	.1246E+01	.7123E+01
291	-.8024E+02 -.1287E+01	-.1195E+02 -.2384E+01	.3610E+02	-.7456E+02	-.6579E+01	.3061E+02
295	.1168E+03 -.6564E+00	-.1916E+02 -.8884E+00	.4977E+02	-.1879E+02	-.1125E+01	.2122E+02
301	.1608E+03 -.6375E+00	-.2925E+02 -.2130E+00	.6631E+02	.3620E+02	.5654E+01	.4573E+01
308	.8621E+02 -.2949E+01	-.9664E+02 -.3967E+01	-.6196E+03	.5238E+03	-.2191E+02	.2668E+03
314	.7903E+02 .2741E+01	-.6703E+02 .2866E+01	-.4634E+03	-.2139E+03	-.2545E+02	.1670E+03
318	.7891E+02 -.2573E+01	-.4400E+02 .1815E+01	-.3280E+03	.3527E+03	-.1003E+02	.1508E+03
320	-.9224E+02 .1714E+01	-.2307E+02 .1783E+01	-.1882E+03	.8243E+02	-.9374E+01	.6317E+02
1257	.7830E+02 .5594E+00	.7257E+01 .8589E+00	.2639E+03	-.5493E+01	-.9362E+00	.2368E+02
1261	.1022E+03 -.8931E+00	.8579E+01 .7994E+00	.3827E+03	.3768E+01	-.1456E+01	-.1288E+02
1265	.1298E+03 .1062E+01	-.8124E+01 -.5531E+00	.4598E+03	.5511E+01	.9548E+00	-.2236E+02
1269	.1709E+03 -.1051E+01	-.1161E+02 .2778E+01	.5272E+03	-.3796E+01	-.5366E+00	.2875E+02
1273	.2155E+03 -.6346E+00	-.1429E+02 -.2226E+01	.6350E+03	-.5039E+01	.3849E+01	-.1098E+02
1277	.2718E+03 -.1187E+01	-.1372E+02 -.1764E+01	.7372E+03	-.5419E+01	.1155E+02	-.2115E+02
1281	.1781E+03 -.3165E+01	-.2370E+02 .1335E+02	.8229E+03	-.9541E+02	.2610E+01	-.4046E+03
1285	.1609E+04 -.3253E+01	-.1064E+03 .3621E+03	.8754E+02	.1762E+04	-.3066E+03	.8345E+04
1289	.2453E+03 -.2697E+01	-.5495E+02 .1091E+03	.4106E+02	-.5631E+02	.6326E+01	.2337E+03
1293	.8869E+03 -.7360E+01	-.6390E+02 -.1306E+02	-.8828E+02	-.2403E+03	-.4411E+02	-.1423E+04

Job NO. 66481-02
Calc NO 66481-01-...
Client: WHC

MTR 7/22/94
BM 7/22/94

1297	.5497E+03	-.5959E+02	-.8569E+02	-.1588E+03	.2686E+02	-.1022E+04
	-.3844E+01	-.2985E+02				
1301	-.2377E+03	-.5429E+02	-.1025E+03	.5435E+02	-.1142E+02	.4339E+03
	.3332E+01	.3435E+01				
1305	.2857E+03	-.5247E+02	-.1432E+03	.4073E+02	-.3106E+02	-.2099E+03
	.3277E+01	.8254E+01				
1309	.4168E+03	.5486E+02	-.1496E+03	-.9125E+02	-.4042E+02	-.1105E+03
	-.2663E+01	-.7502E+01				
1313	.6612E+03	.5294E+02	-.1467E+03	-.5887E+02	-.9559E+02	.2257E+03
	-.6868E+01	-.6018E+01				
1317	.1199E+03	.4023E+02	-.1346E+03	-.6773E+02	.7854E+01	-.3250E+03
	-.1852E+01	.2651E+02				
1321	.1357E+04	.2001E+02	-.3111E+03	.9950E+03	.3626E+03	-.3004E+04
	.3581E+02	.1330E+03				
1325	-.1727E+04	.3706E+02	-.3902E+03	.2074E+04	.3874E+03	-.2958E+04
	.3482E+02	-.1249E+03				
1329	-.1218E+04	.4267E+02	-.2686E+03	.7343E+03	.1319E+03	-.1203E+04
	.1366E+02	-.2514E+02				
1333	-.1054E+04	.3600E+02	-.2270E+03	.5230E+03	.3314E+02	.1352E+04
	.2918E+01	-.2474E+02				
1337	-.1039E+04	.3277E+02	-.2047E+03	.3967E+03	-.2046E+02	.7882E+03
	.3825E+01	.4672E+01				
1341	-.9596E+03	.2985E+02	-.1880E+03	.3453E+03	.9916E+01	.5695E+03
	.2360E+01	.9029E+01				
1345	-.9126E+03	.2734E+02	-.1625E+03	.3231E+03	-.1002E+02	.4898E+03
	.2038E+01	-.3428E+01				
1349	-.7796E+03	.2391E+02	-.1331E+03	.2985E+03	-.6487E+01	.5154E+03
	.9633E+00	.4070E+01				
1353	-.6967E+03	.2317E+02	-.1108E+03	.2701E+03	-.3671E+01	.5172E+03
	.4599E+00	-.3422E+01				
1357	.3697E+03	-.1652E+02	.2773E+04	.7215E+04	-.3022E+03	.4859E+03
	.3239E+03	.5339E+02				

NOTE: "-0.9999E+99" INDICATES THAT CORRESPONDING COMPONENT NOT REQUESTED.

DESIGN CALCULATION

WHC-SD-W320-ANAL-002
Rev. 0

(1) Drawing ______ (2) Doc. No. ______ (3) Page 1 of ____

(4) Building ______ (5) Rev. ______ (6) Job No. ______

(7) Subject Transfer Shear Calculation

(8) Originator RS Marlow Date 7/28/94

(9) Checker ______ Date ______

(10)

Meridional Transverse Shear Calculation in Lower Wall of Tank 241C106

R.S. Marlow
7/28/94

1.0 Introduction

This document describes a calculation of the meridional transverse shear in the lower wall of tank 241C106 for a seismic analysis of the 241C106 half-model. The purpose of the calculation is to verify results obtained from the engineering firm of URS Consultants, Incorporated.

2.0 Methodology

The shear is calculated using thin shell theory (Novozhilov 1964) and simple difference methods (Smith 1985). The formulas for the shears in the selected elements are given on page 2. The elements are shown in Figure 1 on page 3. Elements 1285 and 1286 are at the bottom of the tank wall. The X axis is in the hoop direction. The Y axis is in the meridional direction. The shear in element 1285 is calculated using a forward difference method because it is at the edge. The shears in elements 1289 and 1293 are calculated with a modified central difference method because the meridional spacing of elements 1285, 1289, and 1293 is not regular. The shears in elements 1297 and 1301 are calculated with a central difference method. Note that the in-plane twisting moments in the "ghost" elements on the other side of the symmetry boundary have opposite sign from the twisting moments on this side of the symmetry boundary.

3.0 Results

In Figure 2 on page 4, the shear calculated using the method described above is compared with the shear reported by URS. The correlation is apparent. The maximum shear in the wall as reported by URS is 362.1 lbf/in in element 1285. The maximum shear in the wall as calculated is 399.1 lbf/in, also in element 1285. These two quantities differ by less than 10%.

4.0 References

Novozhilov, V. V., 1964, Thin Shell Theory, P. Noordhoff Ltd., Groningen, The Netherlands.

Smith, G. D., 1985, Numerical Solution of Partial Differential Equations: Finite Difference Methods, Third Edition, Clarendon Press, Oxford, England.

BD-6400-060.1 (12/87)

DESIGN CALCULATION

(1) Drawing ______ (2) Doc. No. ______ (3) Page 3 of ______

(4) Building ______ (5) Rev. ______ (6) Job No. ______

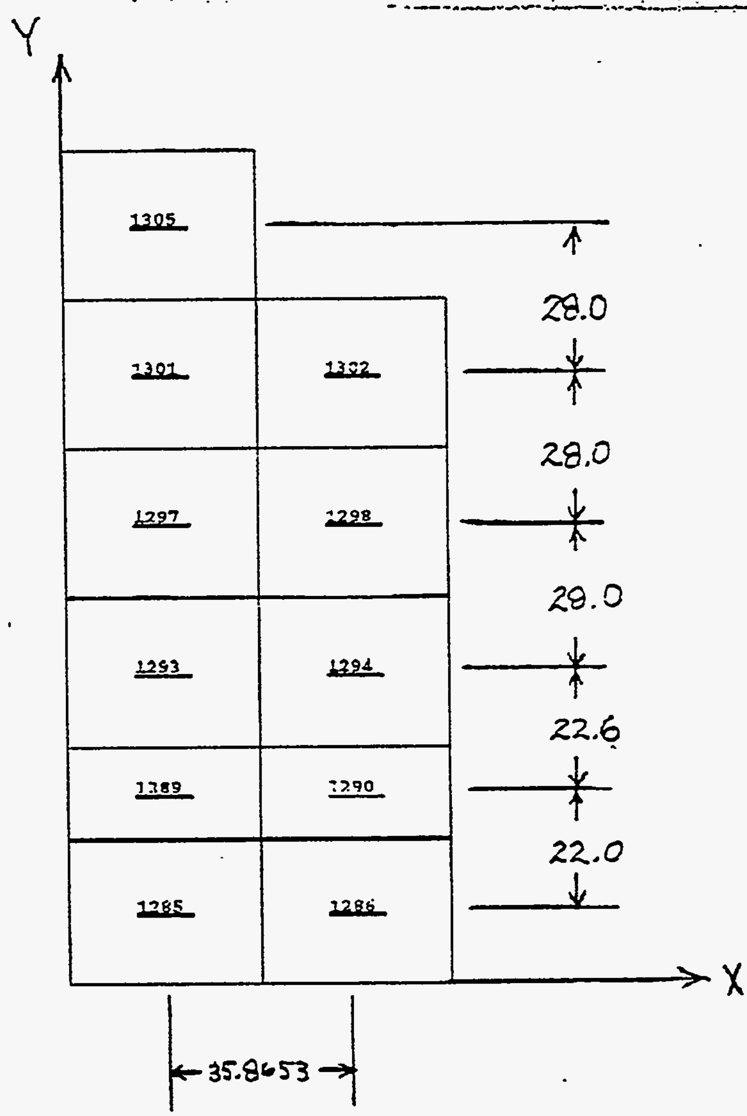
(7) Subject Transverse Shear Calculation

(8) Originator R.S. Marlow Date 7/28/94

(9) Checker ______ Date ______

(10)-

Figure 1. Elements



BD-6400-060.1 (12/87)

DESIGN CALCULATION

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(10)

Difference Formulas

Element 1285 (Numerical subscripts denote element numbers)

$$V_Y = \frac{(M_{XY})_{1286} - (M_{XY})_{1285}}{35.9653} + \frac{(M_{YY})_{1289} - (M_{YY})_{1285}}{22}$$

Element 1289

$$V_Y = \frac{(M_{XY})_{1290} + (M_{XY})_{1289}}{71.7306} + \frac{(M_{YY})_{1293} - (M_{YY})_{1285}}{44.6}$$

Element 1293

$$V_Y = \frac{(M_{XY})_{1294} + (M_{XY})_{1293}}{71.7306} + \frac{(M_{YY})_{1297} - (M_{YY})_{1289}}{50.6}$$

Element 1297

$$V_Y = \frac{(M_{XY})_{1298} + (M_{XY})_{1297}}{71.7306} + \frac{(M_{YY})_{1301} - (M_{YY})_{1293}}{56.0}$$

The expression for V_Y for element 1301 is similar to the one for V_Y for element 1297.

DESIGN CALCULATION

(1) Drawing ______ (2) Doc. No. ______ (3) Page 4 of ______

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(10)

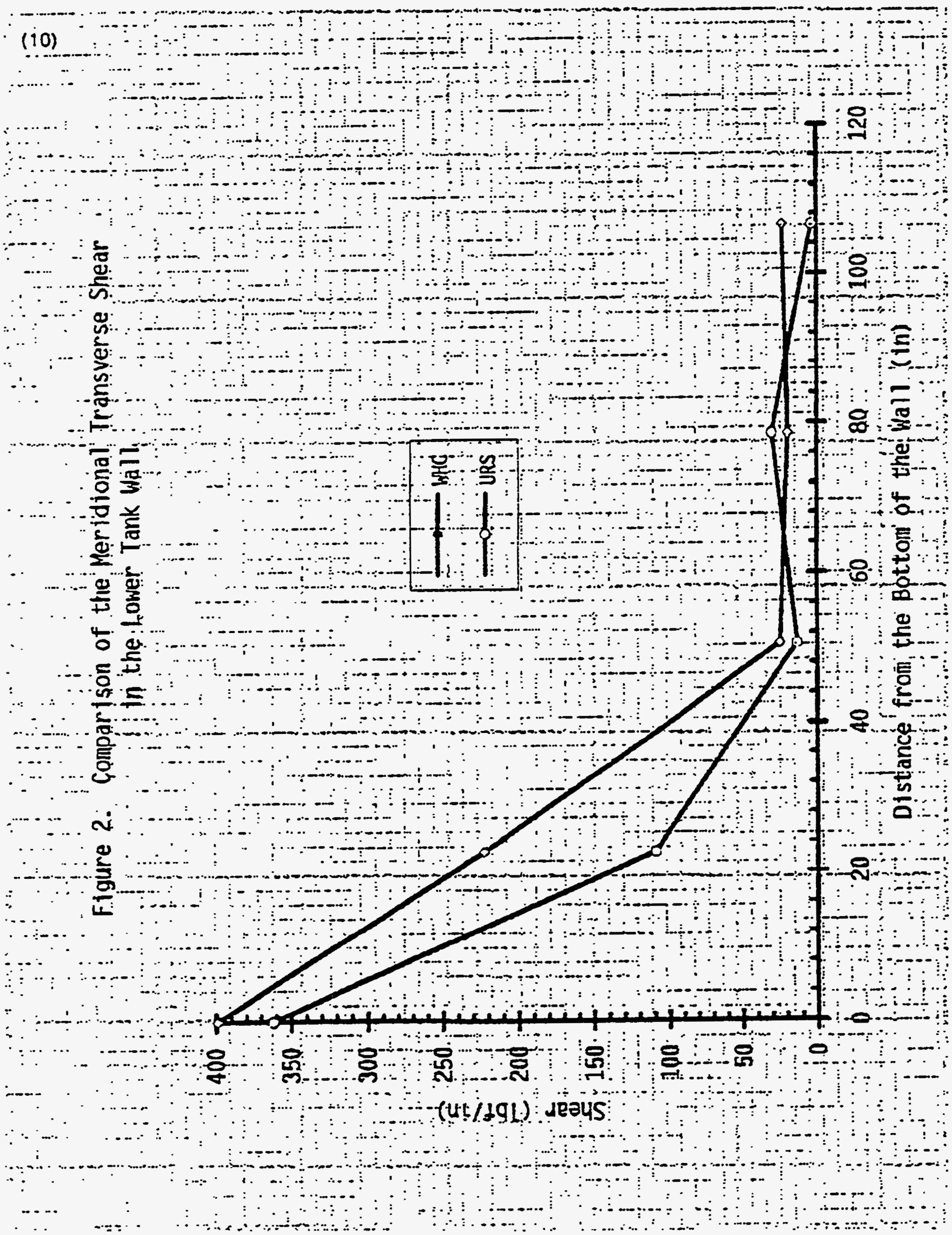

Figure 2. Comparison of the Meridional Transverse Shear in the Lower Tank Wall

APPENDIX H

SHAKE INPUT FILES AND EXCERPTS FROM OUTPUT FILES

The SHAKE input files for the lower-bound soil properties case, best-estimate soil properties case, and upper-bound soil properties case are provided in this appendix. Excerpts from the corresponding output files are also given.

```
TITLE    : SHAKE input and excerpts from output

************** SHAKE input for lower-bound soil properties ************
Filename:  shx5rev.i2

 4096
    8
    4    1   10     1.
   11  1.  SHEAR MODULUS CLAY
  .0001    .000316    .001     .00316      .01      .0316       .1       .316
     1.       3.16     10.
     1.         1.     .99        .95      .85        .62       .36       .16
   .08        .08     .08
   11  1.  DAMPING CLAY
  .0001    .000316    .001     .00316      .01      .0316       .1       .316
     1.       3.16     10.
     .1         .5     1.0        1.5      2.5        5.5      10.       16.0
   21.0        24.     24.
   11  1.  SHEAR MODULUS SAND :  IDRISS 1990
  .0001    .000316    .001     .00316      .01      .0316       .1       .316
     1.       3.16     10.
     1.         1.     .99        .95      .85        .62      .36        .16
   .08        .08     .08
   11 .038 DAMPING SAND :  IDRISS 1990
  .0001    .000316    .001     .00316      .01      .0316       .1       .316
     1.       3.16     10.
     .1         .5     1.0        1.5      2.5        5.5      10.       16.0
   21.0        24.     24.
   2   1.  SHEAR MODULUS ROCK :  NOT USED
  .0001    10.
      1      1
    2  1.  DAMPING ROCK   : NOT USED
  .0001    10.
      1      1
   10 1.   SHEAR MODULUS GRAVEL  :  HWVP 11/89  PLATE 11
  .0001     .0003     .001      .003      .01       .03        .1       .3
      1       10.
     1.       .96      .85       .73      .54       .36        .2       .1
    .05       .05
   10 .038 DAMPING GRAVEL  :  HWVP 11/89  PLATE 11
  .0001     .0003     .001      .003      .01       .03        .1       .3
     1.       10.
     .5        1.      1.7        3.      5.4       10.      15.5      21.
    25.       26.
     1
 2300 4096        .01      WHC-SD-GN-DA-30018   TH1.HST
                 .216        15
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  0.00180  0.00223  0.00268  0.00263  0.00105 -0.00027  0.00050  0.00187   2
  0.00204  0.00125  0.00070  0.00110  0.00141  0.00083 -0.00029 -0.00126   3
 -0.00097 -0.00165 -0.00471 -0.00771 -0.00965 -0.01001 -0.00946 -0.00872   4
 -0.00844 -0.01017 -0.01258 -0.01490 -0.01507 -0.01281 -0.01268 -0.01205   5
 -0.00973 -0.00879 -0.00587 -0.00180 -0.00171 -0.00506 -0.00774 -0.00799   6
 -0.00705 -0.00728 -0.00938 -0.01207 -0.01301 -0.00636  0.00556  0.01345   7
  0.01387  0.01396  0.01754  0.01687  0.01087  0.00660  0.00706  0.00546   8
 -0.00186 -0.00701 -0.00500 -0.00184  0.00178  0.01037  0.02048  0.02676   9
  0.02610  0.02011  0.01487  0.01256  0.01002  0.00724  0.01155  0.01893  10
  0.01957  0.01782  0.01660  0.01379  0.00527 -0.00952 -0.01908 -0.01671  11
 -0.01184 -0.01511 -0.02109 -0.01952 -0.01893 -0.02160 -0.01861 -0.01362  12
 -0.01477 -0.02539 -0.03350 -0.03288 -0.03059 -0.03097 -0.03582 -0.03987  13
 -0.03593 -0.02353 -0.01111 -0.00214  0.00961  0.01467  0.00796  0.01087  14
  0.02281  0.01869 -0.00275 -0.01672 -0.01209 -0.00048  0.00150 -0.01025  15
 -0.02064 -0.01762 -0.01121 -0.01443 -0.01745 -0.01326 -0.00222  0.00556  16
 -0.00432 -0.01137 -0.00195  0.00630  0.00684  0.00484  0.00352  0.00286  17
 -0.00286 -0.02101 -0.04126 -0.04843 -0.04523 -0.04063 -0.04058 -0.03053  18
 -0.00354  0.02449  0.03787  0.02587  0.00150 -0.00394  0.00743  0.00696  19
 -0.00217 -0.00160  0.00882  0.01287  0.00946  0.01069  0.01130  0.00226  20
 -0.00792 -0.00708  0.00060  0.01391  0.02989  0.03860  0.03514  0.03128  21
  0.04193  0.05309  0.05697  0.05965  0.05751  0.05423  0.05136  0.05000  22
  0.05283  0.05406  0.04734  0.02808  0.01074  0.01138  0.02086  0.03544  23
  0.05332  0.05950  0.05808  0.06037  0.06407  0.06855  0.06927  0.05480  24
  0.02913  0.01339  0.01865  0.03384  0.04442  0.05288  0.06123  0.05739  25
```

0.04715	0.04547	0.04081	0.01547	-0.01549	-0.02342	-0.01709	-0.01276	26
0.01233	0.05624	0.07748	0.07315	0.05364	0.02852	0.01320	-0.00730	27
-0.03215	-0.03363	-0.00794	0.01567	0.01774	0.01923	0.03877	0.05156	28
0.02733	-0.00956	-0.01880	-0.01469	-0.01968	-0.01482	-0.00239	0.00963	29
0.02685	0.02719	0.01123	0.00297	-0.00535	-0.03263	-0.06205	-0.07828	30
-0.08510	-0.08266	-0.08296	-0.08215	-0.07587	-0.07209	-0.06879	-0.06851	31
-0.07494	-0.07786	-0.06029	-0.03512	-0.02455	-0.01372	0.01004	0.02779	32
0.02951	0.01064	-0.03078	-0.07822	-0.11984	-0.14281	-0.13064	-0.08465	33
-0.02719	0.00576	0.00727	0.00537	0.01198	0.02475	0.04570	0.07319	34
0.07938	0.05384	0.04667	0.06784	0.08151	0.08382	0.07163	0.04668	35
0.02590	0.02498	0.05496	0.08416	0.07512	0.05428	0.04138	0.03046	36
0.04389	0.08585	0.11999	0.10886	0.06818	0.05043	0.05362	0.03992	37
0.01456	0.00073	-0.01156	-0.03307	-0.06004	-0.07566	-0.05438	-0.02834	38
-0.03802	-0.05441	-0.04845	-0.02472	-0.00705	-0.01983	-0.04567	-0.05696	39
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0.05824	0.06707	0.06487	0.05790	0.05942	0.05844	0.03843	0.02088	47
0.01455	0.00922	0.01516	0.02825	0.03126	0.01655	0.00168	0.00089	48
0.00425	-0.00063	-0.01869	-0.03017	-0.01565	0.00201	0.01103	0.01920	49
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0.03420	0.02485	0.02567	0.04525	0.04953	0.02528	-0.00235	-0.02570	53
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0.06174	0.07295	0.10367	0.14132	0.15731	0.15379	0.13311	0.10246	57
0.08015	0.05374	0.03407	0.02048	0.00372	0.01904	0.06200	0.10034	58
0.12799	0.13603	0.10974	0.06854	0.03716	0.01078	-0.01119	-0.02591	59
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0.01413	0.03655	0.08622	0.10696	0.08510	0.07067	0.07177	0.05520	72
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0.01173	0.02478	0.03622	0.03910	0.03474	0.01099	-0.01704	-0.02291	76
-0.01376	-0.00192	0.00177	-0.01699	-0.04384	-0.06674	-0.08531	-0.09014	77
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0.07338	0.05925	0.03090	0.03327	0.09071	0.13753	0.13521	0.11800	80
0.10833	0.11321	0.11848	0.10540	0.09378	0.08433	0.06063	0.03467	81
0.02118	0.01379	-0.00078	-0.01721	-0.02465	-0.03243	-0.04090	-0.03437	82
-0.02611	-0.03212	-0.03670	-0.02848	-0.03114	-0.05515	-0.06491	-0.05851	83
-0.06180	-0.05840	-0.03899	-0.02308	-0.01802	-0.01237	0.00394	0.02066	84
0.02607	0.03937	0.05282	0.04047	0.02448	0.00603	-0.02779	-0.06435	85
-0.07395	-0.03618	0.02134	0.06464	0.08044	0.06753	0.04167	0.01539	86
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-0.03306	-0.01337	0.01867	0.07637	0.10995	0.10811	0.09426	0.05826	88
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 0.02340  0.02195  0.01833  0.01118  0.00422 -0.01040 -0.03481 -0.05658 266
-0.06442 -0.06328 -0.06315 -0.05607 -0.03116 -0.00300  0.00467 -0.01590 267
-0.03414 -0.02546 -0.01519 -0.00927 -0.00785 -0.02015 -0.03655 -0.04928 268
-0.04753 -0.03607 -0.02557 -0.01855 -0.02376 -0.04230 -0.05944 -0.05615 269
-0.03722 -0.01489  0.00661  0.01665  0.01820  0.02410  0.03552  0.03743 270
 0.02524  0.01588  0.00984 -0.00337 -0.02609 -0.03577 -0.02342 -0.02651 271
-0.04141 -0.03900 -0.03996 -0.05987 -0.07288 -0.06972 -0.05630 -0.03898 272
-0.03238 -0.03061 -0.02836 -0.02761 -0.02560 -0.02267 -0.02237 -0.02819 273
-0.02926 -0.02017 -0.01678 -0.02066 -0.01874 -0.01229 -0.01250 -0.02941 274
-0.05520 -0.06286 -0.05180 -0.05143 -0.06669 -0.07635 -0.07409 -0.06564 275
-0.05432 -0.04222 -0.02764 -0.02106 -0.02980 -0.03730 -0.02935 -0.01766 276
-0.01587 -0.01467 -0.01077 -0.00717  0.00136  0.01851  0.03460  0.03787 277
 0.03396  0.03195  0.03413  0.03584  0.03718  0.03524  0.02465  0.01546 278
 0.01459  0.02073  0.03535  0.05370  0.05595  0.03385  0.00942  0.00554 279
 0.01195  0.01092  0.00929  0.01135  0.01239  0.01567  0.02118  0.01909 280
 0.01418  0.01688  0.01917  0.01486  0.00712 -0.00490 -0.02066 -0.03406 281
-0.03927 -0.03514 -0.02892 -0.02451 -0.02076 -0.02331 -0.02971 -0.02735 282
-0.02038 -0.01797 -0.01574 -0.00862  0.00126  0.00480  0.00055 -0.00321 283
-0.00232  0.00268  0.00693  0.00917  0.01203  0.01197  0.00972  0.01100 284
 0.01228  0.01155  0.01210  0.01240  0.01244  0.01362  0.01399  0.01315 285
 0.01086  0.00836  0.00741  0.00742  0.00771  0.00741  0.00663  0.00518 286
 0.00362  0.00287  0.00283  0.00297  0.00307  0.00314  0.00299  0.00260 287
 0.00197  0.00137  0.00112  0.00119                                     288
   2
   1   17   17     GROUT VAULT SITE
   1    1    1  12.92       1630.5      0.05    0.1050           1630.5  1.
   2    1    1  10.58       4258.5      0.05    0.1100           4258.5  1.
   3    1    1   9.33       4258.5      0.05    0.1100           4258.5  1.
   4    1    1  12.25       4258.5      0.05    0.1100           4258.5  1.
   5    1    1   6.92       4258.5      0.05    0.1100           4258.5  1.
   6    1    1  13.00        6629.      0.05    0.1100            6629.  1.
   7    1    1  15.00        6629.      0.05    0.1100            6629.  1.
   8    1    1  20.00        6629.      0.05    0.1100            6629.  1.
   9    1    1  20.00        6629.      0.05    0.1100            6629.  1.
  10    1    1  25.00       12131.      0.05    0.1250           12131.  1.
  11    1    1  25.00       12131.      0.05    0.1250           12131.  1.
  12    1    1  30.00       12131.      0.05    0.1250           12131.  1.
  13    1    1  30.00       12131.      0.05    0.1250           12131.  1.
  14    1    1  30.00       12131.      0.05    0.1250           12131.  1.
  15    1    1  35.00       12131.      0.05    0.1250           12131.  1.
```

FILENAME : print.fil DATE : 08-08-94 TIME : 2:32p PAGE 6
TITLE : SHAKE input and excerpts from output

```
  16    1    1   35.00     12131.      0.05    0.1250          12131.  1.
  17    1                  98100.              0.1500
   3
   2    0
   4
   0    5   5.      0.65
   5
   1    2   18
   1    1    1
   1    1    1
   0
```

*********** Excerpt from SHAKE output for lower-bound soil properties ***********
Filename: shx5rev.out

```
*********************************************
*********************************************
**                                         **
** SHAKE -- A COMPUTER PROGRAM FOR         **
**         EARTHQUAKE RESPONSE ANALYSIS    **
**         OF HORIZONTALLY LAYERED SITES   **
**                                         **
** MS-DOS VERSION - CONVERTED TO IBM-PC BY **
**         Shyh-Shiun Lai                  **
**         UNIVERSITY OF CALIFORNIA        **
**                 and                     **
**         WOODWARD-CLYDE CONSULTANTS      **
**         January 1985                    **
** cft77 4/26/91; WHC                      **
*********************************************
*********************************************
```

MAX. NUMBER OF TERMS IN FOURIER TRANSFORM = 4096
NECESSARY LENGTH OF BLANK COMMON X = 25619
EARTH PRESSURE AT REST FOR SAND = 0.450

[portion of output omitted here]

EARTHQUAKE - WHC-SD-GN-DA-30018 TH1.
SOIL PROFILE - GROUT VAULT SITE

ITERATION NUMBER 3
THE CALCULATION HAS BEEN CARRIED OUT IN THE TIME DOMAIN WITH EFF. STRAIN = .65* MAX. STRAIN

LAYER	TYPE	DEPTH	EFF. STRAIN	NEW DAMP.	DAMP USED	ERROR	NEW G	G USED	ERROR
			%	ratio					
1	1	6.5	0.00752	0.023	0.022	0.7	1426.23	1428.72	-0.2
2	1	18.2	0.00699	0.022	0.022	0.4	3752.09	3755.41	-0.1
3	1	28.2	0.01039	0.026	0.026	1.4	3587.52	3599.69	-0.3
4	1	39.0	0.01465	0.035	0.034	3.3	3294.84	3332.79	-1.2
5	1	48.5	0.01942	0.042	0.041	4.0	3054.92	3110.05	-1.8
6	1	58.5	0.01375	0.033	0.032	3.4	5212.57	5269.84	-1.1
7	1	72.5	0.01787	0.040	0.039	3.6	4865.43	4938.47	-1.5
8	1	90.0	0.02189	0.045	0.044	3.4	4596.49	4674.02	-1.7
9	1	110.0	0.02466	0.049	0.047	2.8	4438.68	4507.71	-1.6
10	1	132.5	0.01165	0.029	0.029	-0.3	9941.74	9933.42	0.1
11	1	157.5	0.01222	0.030	0.031	-1.0	9824.24	9796.51	0.3
12	1	185.0	0.01391	0.034	0.033	2.7	9511.51	9595.57	-0.9
13	1	215.0	0.01571	0.037	0.036	2.6	9216.25	9303.79	-0.9
14	1	245.0	0.01632	0.038	0.037	1.6	9123.16	9180.61	-0.6
15	1	277.5	0.01755	0.040	0.039	2.1	8947.32	9026.43	-0.9
16	1	312.5	0.02009	0.043	0.042	3.7	8619.10	8767.56	-1.7

VALUES IN TIME DOMAIN

LAYER	TYPE	THICKNESS FT	DEPTH FT	MAX STRAIN PRCNT	MAX STRESS PSF	TIME SEC
1	1	12.9	6.5	0.01157	165.04	18.12
2	1	10.6	18.2	0.01075	403.51	18.12
3	1	9.3	28.2	0.01598	573.21	19.19
4	1	12.3	39.0	0.02253	742.45	19.18
5	1	6.9	48.5	0.02987	912.50	19.16

6	1	13.0	58.5	0.02116	1102.73	19.16
7	1	15.0	72.5	0.02749	1337.54	19.15
8	1	20.0	90.0	0.03368	1547.94	19.14
9	1	20.0	110.0	0.03794	1683.85	19.14
10	1	25.0	132.5	0.01792	1781.33	19.12
11	1	25.0	157.5	0.01881	1847.66	19.11
12	1	30.0	185.0	0.02140	2035.08	8.06
13	1	30.0	215.0	0.02417	2227.22	8.05
14	1	30.0	245.0	0.02511	2291.01	8.03
15	1	35.0	277.5	0.02700	2415.82	8.00
16	1	35.0	312.5	0.03091	2664.50	7.98

PERIOD = 0.96 FROM AVERAGE SHEARVEL. = 1370.

MAXIMUM AMPLIFICATION = 17.92
FOR FREQUENCY = 1.17 C/SEC.
PERIOD = 0.85 SEC.

FILENAME : print.fil DATE : 08-08-94 TIME : 2:32p PAGE 9
TITLE : SHAKE input and excerpts from output

****** OPTION 5 *** COMPUTE MOTION IN NEW SUBLAYERS

EARTHQUAKE - WHC-SD-GN-DA-30018 TH1.
SOIL DEPOSIT - GROUT VAULT SITE

LAYER	DEPTH FT	MAX. ACC. G	TIME SEC	MEAN SQ. FR. C/SEC	ACC. RATIO QUIET ZONE	PUNCHED CARDS ACC. RECORD
WITHIN	0.0	0.25131	18.12	4.43	0.003	1
WITHIN	12.9	0.18422	19.18	2.78	0.001	1
WITHIN	0.0	0.00009	40.95	0.00	1.000	1

```
 ************** SHAKE input for best-estimate soil properties ************
Filename:  shxxc106.i2

 4096
    8
    4    1   10     1.
   11  1.  SHEAR MODULUS CLAY
  .0001    .000316    .001     .00316      .01      .0316       .1       .316
     1.       3.16     10.
     1.         1.     .99        .95      .85        .62      .36        .16
    .08        .08     .08
   11 .038 DAMPING CLAY
  .0001    .000316    .001     .00316      .01      .0316       .1       .316
     1.       3.16     10.
     .1         .5     1.0        1.5      2.5        5.5      10.       16.0
   21.0        24.     24.
   11  1.  SHEAR MODULUS SAND :  IDRISS 1990
  .0001    .000316    .001     .00316      .01      .0316       .1       .316
     1.       3.16     10.
     1.         1.     .99        .95      .85        .62      .36        .16
    .08        .08     .08
   11 .038 DAMPING SAND :  IDRISS 1990
  .0001    .000316    .001     .00316      .01      .0316       .1       .316
     1.       3.16     10.
     .1         .5     1.0        1.5      2.5        5.5      10.       16.0
   21.0        24.     24.
   2   1.  SHEAR MODULUS ROCK :  NOT USED
  .0001     10.
     1       1
    2  1.  DAMPING ROCK  : NOT USED
  .0001     10.
     1       1
   10 1.   SHEAR MODULUS GRAVEL  :  HWVP 11/89  PLATE 11
  .0001      .0003     .001      .003      .01       .03       .1       .3
     1        10.
     1.        .96     .85       .73      .54       .36       .2       .1
    .05        .05
   10 .038 DAMPING GRAVEL  :  HWVP 11/89  PLATE 11
  .0001      .0003     .001      .003      .01       .03       .1       .3
     1.        10.
     .5         1.     1.7        3.      5.4       10.     15.5       21.
    25.        26.
    1
 2300 4096       .01      WHC-SD-GN-DA-30018   TH1.HST
                .216        15
 -0.00030 -0.00070 -0.00075 -0.00096 -0.00109 -0.00058  0.00023  0.00107   1
  0.00180  0.00223  0.00268  0.00263  0.00105 -0.00027  0.00050  0.00187   2
  0.00204  0.00125  0.00070  0.00110  0.00141  0.00083 -0.00029 -0.00126   3
 -0.00097 -0.00165 -0.00471 -0.00771 -0.00965 -0.01001 -0.00946 -0.00872   4
 -0.00844 -0.01017 -0.01258 -0.01490 -0.01507 -0.01281 -0.01268 -0.01205   5
 -0.00973 -0.00879 -0.00587 -0.00180 -0.00171 -0.00506 -0.00774 -0.00799   6
 -0.00705 -0.00728 -0.00938 -0.01207 -0.01301 -0.00636  0.00556  0.01345   7
  0.01387  0.01396  0.01754  0.01687  0.01087  0.00660  0.00706  0.00546   8
 -0.00186 -0.00701 -0.00500 -0.00184  0.00178  0.01037  0.02048  0.02676   9
  0.02610  0.02011  0.01487  0.01256  0.01002  0.00724  0.01155  0.01893  10
  0.01957  0.01782  0.01660  0.01379  0.00527 -0.00952 -0.01908 -0.01671  11
 -0.01184 -0.01511 -0.02109 -0.01952 -0.01893 -0.02160 -0.01861 -0.01362  12
 -0.01477 -0.02539 -0.03350 -0.03288 -0.03059 -0.03097 -0.03582 -0.03987  13
 -0.03593 -0.02353 -0.01111 -0.00214  0.00961  0.01467  0.00796  0.01087  14
  0.02281  0.01869 -0.00275 -0.01672 -0.01209 -0.00048  0.00150 -0.01025  15
 -0.02064 -0.01762 -0.01121 -0.01443 -0.01745 -0.01326 -0.00222  0.00556  16
 -0.00432 -0.01137 -0.00195  0.00630  0.00684  0.00484  0.00352  0.00286  17
 -0.00286 -0.02101 -0.04126 -0.04843 -0.04523 -0.04063 -0.04058 -0.03053  18
 -0.00354  0.02449  0.03787  0.02587  0.00150 -0.00394  0.00743  0.00696  19
 -0.00217 -0.00160  0.00882  0.01287  0.00946  0.01069  0.01130  0.00226  20
 -0.00792 -0.00708  0.00060  0.01391  0.02989  0.03860  0.03514  0.03128  21
  0.04193  0.05309  0.05697  0.05965  0.05751  0.05423  0.05136  0.05000  22
  0.05283  0.05406  0.04734  0.02808  0.01074  0.01138  0.02086  0.03544  23
  0.05332  0.05950  0.05808  0.06037  0.06407  0.06855  0.06927  0.05480  24
  0.02913  0.01339  0.01865  0.03384  0.04442  0.05288  0.06123  0.05739  25
```

0.04715	0.04547	0.04081	0.01547	-0.01549	-0.02342	-0.01709	-0.01276	26
0.01233	0.05624	0.07748	0.07315	0.05364	0.02852	0.01320	-0.00730	27
-0.03215	-0.03363	-0.00794	0.01567	0.01774	0.01923	0.03877	0.05156	28
0.02733	-0.00956	-0.01880	-0.01469	-0.01968	-0.01482	-0.00239	0.00963	29
0.02685	0.02719	0.01123	0.00297	-0.00535	-0.03263	-0.06205	-0.07828	30
-0.08510	-0.08266	-0.08296	-0.08215	-0.07587	-0.07209	-0.06879	-0.06851	31
-0.07494	-0.07786	-0.06029	-0.03512	-0.02455	-0.01372	0.01004	0.02779	32
0.02951	0.01064	-0.03078	-0.07822	-0.11984	-0.14281	-0.13064	-0.08465	33
-0.02719	0.00576	0.00727	0.00537	0.01198	0.02475	0.04570	0.07319	34
0.07938	0.05384	0.04667	0.06784	0.08151	0.08382	0.07163	0.04668	35
0.02590	0.02498	0.05496	0.08416	0.07512	0.05428	0.04138	0.03046	36
0.04389	0.08585	0.11999	0.10886	0.06818	0.05043	0.05362	0.03992	37
0.01456	0.00073	-0.01156	-0.03307	-0.06004	-0.07566	-0.05438	-0.02834	38
-0.03802	-0.05441	-0.04845	-0.02472	-0.00705	-0.01983	-0.04567	-0.05696	39
-0.06206	-0.07345	-0.09217	-0.11137	-0.10549	-0.07271	-0.04850	-0.06030	40
-0.08346	-0.08768	-0.08781	-0.08570	-0.07623	-0.06471	-0.06151	-0.06958	41
-0.07685	-0.07582	-0.05525	-0.02639	-0.02069	-0.03682	-0.03996	-0.02660	42
-0.01082	0.00809	0.00764	-0.02534	-0.06101	-0.07600	-0.08522	-0.08566	43
-0.05007	-0.00774	-0.00244	-0.01202	-0.01687	-0.02777	-0.03662	-0.04074	44
-0.03598	-0.01717	-0.00106	0.00641	0.00057	-0.00645	-0.00391	0.00385	45
0.02746	0.03295	0.00747	0.00634	0.03121	0.04435	0.04406	0.04726	46
0.05824	0.06707	0.06487	0.05790	0.05942	0.05844	0.03843	0.02088	47
0.01455	0.00922	0.01516	0.02825	0.03126	0.01655	0.00168	0.00089	48
0.00425	-0.00063	-0.01869	-0.03017	-0.01565	0.00201	0.01103	0.01920	49
0.01365	-0.00405	-0.01756	-0.01531	-0.00550	-0.01965	-0.05926	-0.08895	50
-0.09568	-0.07650	-0.03345	0.01254	0.03638	0.02590	0.01413	0.02239	51
0.02155	0.00522	-0.01151	-0.02708	-0.02232	-0.00829	-0.00226	0.01969	52
0.03420	0.02485	0.02567	0.04525	0.04953	0.02528	-0.00235	-0.02570	53
-0.03869	-0.04674	-0.06604	-0.09174	-0.10398	-0.08481	-0.05592	-0.03509	54
-0.00213	0.02969	0.04934	0.05556	0.03596	0.01932	0.01525	0.00852	55
-0.01028	-0.03738	-0.05189	-0.04329	-0.01894	0.00003	0.01634	0.04336	56
0.06174	0.07295	0.10367	0.14132	0.15731	0.15379	0.13311	0.10246	57
0.08015	0.05374	0.03407	0.02048	0.00372	0.01904	0.06200	0.10034	58
0.12799	0.13603	0.10974	0.06854	0.03716	0.01078	-0.01119	-0.02591	59
-0.03047	-0.02798	-0.03213	-0.02495	-0.01369	-0.03741	-0.07620	-0.09048	60
-0.08669	-0.08197	-0.05798	-0.01545	0.02493	0.05800	0.09311	0.13804	61
0.15486	0.12096	0.08044	0.06783	0.06100	0.05035	0.04602	0.03578	62
0.00911	-0.02880	-0.06109	-0.08499	-0.10525	-0.11476	-0.11637	-0.10774	63
-0.09083	-0.08671	-0.09354	-0.08026	-0.05457	-0.04652	-0.05865	-0.09261	64
-0.13144	-0.14645	-0.13056	-0.09411	-0.04754	0.00608	0.04883	0.05165	65
0.04120	0.04749	0.02610	-0.03020	-0.05722	-0.03649	0.00073	0.02695	66
0.02737	0.01272	-0.01081	-0.04421	-0.06884	-0.07394	-0.06791	-0.04488	67
-0.01288	-0.01209	-0.04942	-0.07592	-0.06365	-0.04400	-0.05263	-0.09404	68
-0.10993	-0.06058	-0.00526	0.00976	0.01110	0.02323	0.02556	0.00352	69
-0.01256	-0.00076	0.01861	0.03795	0.04775	0.03565	0.01584	-0.00761	70
-0.03787	-0.06255	-0.07107	-0.06749	-0.06000	-0.04400	-0.00973	0.01321	71
0.01413	0.03655	0.08622	0.10696	0.08510	0.07067	0.07177	0.05520	72
0.02296	0.00756	0.01296	0.01058	-0.01807	-0.06018	-0.08614	-0.07500	73
-0.02046	0.03415	0.05012	0.05703	0.06493	0.05222	0.00804	-0.04113	74
-0.07040	-0.06877	-0.02579	0.01439	0.00092	-0.03043	-0.01631	0.00725	75
0.01173	0.02478	0.03622	0.03910	0.03474	0.01099	-0.01704	-0.02291	76
-0.01376	-0.00192	0.00177	-0.01699	-0.04384	-0.06674	-0.08531	-0.09014	77
-0.07555	-0.05184	-0.04033	-0.03949	-0.03527	-0.03314	-0.03337	-0.03026	78
-0.02284	0.00858	0.06070	0.09097	0.08702	0.08164	0.08500	0.08067	79
0.07338	0.05925	0.03090	0.03327	0.09071	0.13753	0.13521	0.11800	80
0.10833	0.11321	0.11848	0.10540	0.09378	0.08433	0.06063	0.03467	81
0.02118	0.01379	-0.00078	-0.01721	-0.02465	-0.03243	-0.04090	-0.03437	82
-0.02611	-0.03212	-0.03670	-0.02848	-0.03114	-0.05515	-0.06491	-0.05851	83
-0.06180	-0.05840	-0.03899	-0.02308	-0.01802	-0.01237	0.00394	0.02066	84
0.02607	0.03937	0.05282	0.04047	0.02448	0.00603	-0.02779	-0.06435	85
-0.07395	-0.03618	0.02134	0.06464	0.08044	0.06753	0.04167	0.01539	86
-0.00492	-0.00820	-0.00576	0.00244	0.00797	-0.01458	-0.04125	-0.04751	87
-0.03306	-0.01337	0.01867	0.07637	0.10995	0.10811	0.09426	0.05826	88
0.01899	-0.00151	-0.00320	0.01072	0.01679	0.00989	0.00793	0.01426	89
0.01090	-0.01005	-0.03169	-0.05552	-0.07953	-0.08716	-0.07372	-0.04090	90
-0.01167	-0.02135	-0.05763	-0.07263	-0.05598	-0.02673	-0.00836	-0.02004	91
-0.03176	-0.01093	0.01905	0.02754	0.01162	-0.00670	0.00026	0.02556	92
0.03593	0.02642	0.01026	-0.00046	0.00614	0.02816	0.05289	0.06426	93
0.04856	0.01683	-0.00741	-0.02696	-0.04102	-0.03561	-0.02215	-0.02304	94
-0.02376	0.00346	0.03232	0.02390	0.00022	-0.00971	-0.01831	-0.03736	95

-0.04866	-0.03226	-0.00693	0.01767	0.02650	0.01823	0.02271	0.02878	96
0.04089	0.06415	0.08149	0.08966	0.08727	0.07036	0.04630	0.03242	97
0.03656	0.04980	0.04174	0.01642	0.00055	-0.00213	0.01200	0.01207	98
-0.02634	-0.04521	-0.01082	0.03892	0.07370	0.08613	0.09033	0.08888	99
0.08471	0.09903	0.12820	0.14622	0.14445	0.13027	0.10118	0.07420	100
0.06538	0.06348	0.05489	0.05320	0.06155	0.04130	0.00793	0.00824	101
0.02453	0.01883	0.01006	0.03373	0.06556	0.09100	0.12019	0.14148	102
0.15574	0.14676	0.11676	0.08752	0.04074	-0.01171	-0.03264	-0.03565	103
-0.03371	-0.02400	-0.03575	-0.06636	-0.08261	-0.09543	-0.11865	-0.13410	104
-0.14222	-0.14961	-0.15963	-0.16601	-0.15269	-0.12331	-0.10516	-0.11748	105
-0.13627	-0.13073	-0.09538	-0.05376	-0.04147	-0.05823	-0.06425	-0.05262	106
-0.04105	-0.02196	0.00194	0.01133	0.01159	0.01309	0.00845	-0.00129	107
-0.01916	-0.02184	0.01590	0.04284	0.02894	0.00821	0.01568	0.03920	108
0.02426	-0.02608	-0.04336	-0.00474	0.02838	0.03099	0.03263	0.03394	109
0.02831	0.01289	-0.02070	-0.06083	-0.06576	-0.04522	-0.04521	-0.05536	110
-0.03400	0.00830	0.01729	-0.00310	-0.01921	-0.01962	-0.00815	-0.00394	111
-0.01042	-0.01654	-0.02137	-0.03278	-0.05763	-0.07758	-0.07002	-0.04878	112
-0.03595	-0.02482	0.00030	0.02058	0.00217	-0.04780	-0.07914	-0.06603	113
-0.05233	-0.07171	-0.07801	-0.03552	0.01235	0.02335	0.03181	0.06791	114
0.08148	0.06881	0.08131	0.10504	0.11127	0.11054	0.10921	0.09909	115
0.08336	0.07642	0.07963	0.07522	0.06419	0.04232	-0.00153	-0.03320	116
-0.03401	-0.02935	-0.02784	-0.04446	-0.08214	-0.11265	-0.12629	-0.11726	117
-0.09272	-0.07333	-0.08410	-0.10557	-0.08172	-0.03642	-0.04328	-0.09869	118
-0.13492	-0.13923	-0.13118	-0.11981	-0.10307	-0.06589	-0.03613	-0.02204	119
-0.00364	0.01879	0.02720	0.00795	-0.00081	0.01857	0.02862	0.01986	120
0.01157	0.00416	-0.00539	-0.02808	-0.05516	-0.03964	0.02603	0.08985	121
0.11012	0.08393	0.04025	0.00284	-0.04354	-0.09079	-0.10188	-0.08724	122
-0.07508	-0.04795	-0.01099	0.01113	0.01779	0.00235	-0.02465	-0.04704	123
-0.06223	-0.05884	-0.03220	-0.02042	-0.03821	-0.05464	-0.05274	-0.02193	124
0.02113	0.04842	0.05646	0.06347	0.09027	0.10568	0.08846	0.07965	125
0.07947	0.07228	0.06030	0.01660	-0.04628	-0.05915	-0.01902	0.00998	126
0.02500	0.05818	0.09276	0.08905	0.04493	-0.00026	-0.01700	-0.01014	127
0.01698	0.06422	0.09920	0.10232	0.09359	0.08651	0.08227	0.07471	128
0.07247	0.08740	0.09148	0.07006	0.03405	-0.01352	-0.05104	-0.05854	129
-0.03167	0.01653	0.04130	0.03264	0.01351	0.00147	-0.00064	0.00415	130
0.01686	0.01250	0.00287	0.00804	0.01002	0.02412	0.06193	0.07139	131
0.01033	-0.06937	-0.09333	-0.06034	-0.04165	-0.06060	-0.05646	-0.03424	132
-0.04716	-0.06844	-0.05680	-0.03096	-0.01251	-0.00659	-0.00021	0.02566	133
0.05996	0.06786	0.04430	0.02220	0.00548	-0.01257	-0.03103	-0.05002	134
-0.06031	-0.05019	-0.01557	0.01462	0.02196	0.02352	0.03334	0.03491	135
-0.00207	-0.05497	-0.08447	-0.07773	-0.04010	-0.01254	0.00309	0.03725	136
0.06808	0.08144	0.08211	0.07611	0.08608	0.08663	0.06018	0.03322	137
0.01863	0.03518	0.04983	0.01231	-0.04886	-0.07370	-0.04851	-0.02368	138
-0.02517	-0.02690	-0.01833	-0.01831	-0.02992	-0.02789	-0.00921	0.00858	139
0.00506	-0.02438	-0.05211	-0.06493	-0.05906	-0.03585	-0.02130	-0.02900	140
-0.04016	-0.04593	-0.06057	-0.08479	-0.10786	-0.09923	-0.06337	-0.05165	141
-0.05668	-0.04499	-0.01923	0.00660	0.03374	0.04649	0.03192	0.01272	142
0.01313	0.04368	0.07275	0.06866	0.05452	0.04848	0.05627	0.08501	143
0.09473	0.07096	0.04726	0.04118	0.04330	0.03218	0.00803	-0.01773	144
-0.03863	-0.05987	-0.07577	-0.06347	-0.02820	-0.01031	-0.02272	-0.01489	145
0.02229	0.04179	0.03679	0.02611	0.02274	0.02218	0.01162	0.00654	146
0.02764	0.05844	0.07383	0.07760	0.07398	0.05352	0.02360	0.00095	147
-0.01271	-0.02789	-0.03683	-0.03485	-0.02829	-0.01179	0.00584	0.01521	148
0.02007	0.02348	0.01837	-0.00088	-0.02633	-0.04622	-0.06483	-0.07090	149
-0.03900	0.01680	0.06877	0.10686	0.13165	0.13210	0.10594	0.09623	150
0.10159	0.06912	0.01980	-0.00275	-0.01230	-0.03217	-0.05360	-0.07482	151
-0.09557	-0.10694	-0.11353	-0.11021	-0.08879	-0.07531	-0.07955	-0.06654	152
-0.04687	-0.03530	-0.01561	0.00437	0.01049	0.01174	0.03231	0.05573	153
0.04538	0.01903	0.01005	0.02476	0.04590	0.05660	0.05745	0.05892	154
0.06087	0.04906	0.02444	-0.01098	-0.04900	-0.06880	-0.07652	-0.08195	155
-0.06943	-0.05024	-0.05299	-0.06869	-0.06348	-0.02548	0.01763	0.03014	156
0.00081	-0.03719	-0.05999	-0.07427	-0.07917	-0.08680	-0.09082	-0.05607	157
-0.00409	0.01175	-0.00584	-0.01876	-0.01765	-0.01572	-0.00578	0.01671	158
0.03489	0.03841	0.03829	0.03903	0.04938	0.07747	0.09289	0.07770	159
0.05557	0.04476	0.05047	0.07243	0.08193	0.07260	0.07710	0.09937	160
0.10543	0.08121	0.06808	0.08699	0.09917	0.08372	0.05642	0.04012	161
0.03188	0.02196	0.03755	0.06112	0.05786	0.04093	0.01506	-0.01098	162
-0.03121	-0.04491	-0.05521	-0.08237	-0.10884	-0.10509	-0.09482	-0.08134	163
-0.04754	-0.03192	-0.03216	-0.02006	-0.01431	-0.02607	-0.05562	-0.08412	164
-0.09125	-0.08495	-0.06975	-0.04343	-0.01037	0.02066	0.04067	0.05002	165

0.05271	0.06203	0.07981	0.07010	0.04670	0.04089	0.02220	-0.00491	166
-0.01077	-0.00936	-0.01971	-0.03657	-0.05015	-0.06323	-0.07312	-0.06781	167
-0.05573	-0.05123	-0.05603	-0.06890	-0.08156	-0.10271	-0.14473	-0.17596	168
-0.16003	-0.10101	-0.03923	-0.01039	0.00156	0.01276	0.01133	-0.01064	169
-0.04239	-0.05461	-0.05902	-0.07983	-0.09891	-0.09593	-0.06606	-0.03045	170
-0.00281	0.03051	0.04509	0.02557	0.00347	-0.00676	-0.00163	-0.00099	171
-0.01780	-0.02487	-0.01532	0.00237	0.02356	0.04551	0.06831	0.07436	172
0.05423	0.02453	-0.00187	-0.01546	-0.01187	-0.00435	-0.00180	-0.00175	173
-0.01180	-0.01935	-0.00747	-0.01263	-0.04402	-0.06661	-0.06392	-0.05541	174
-0.06590	-0.06058	-0.02872	-0.01585	-0.01581	0.00611	0.02393	0.00550	175
-0.02531	-0.02974	-0.00201	0.02692	0.05660	0.09502	0.10061	0.06303	176
0.02467	-0.00507	-0.02179	-0.00840	0.00904	0.00643	-0.00030	0.01629	177
0.02794	0.01151	0.00519	0.01127	0.01158	0.01249	0.01905	0.03165	178
0.04766	0.05094	0.03824	0.03831	0.05461	0.05780	0.06513	0.07328	179
0.06339	0.05993	0.05749	0.05194	0.05526	0.05309	0.03700	0.01981	180
0.01531	0.02907	0.04731	0.04796	0.03216	0.01801	-0.00853	-0.04205	181
-0.05136	-0.05626	-0.06433	-0.06062	-0.05413	-0.05440	-0.06554	-0.07664	182
-0.08264	-0.09643	-0.10485	-0.07220	-0.01175	0.03204	0.05139	0.05637	183
0.05827	0.05111	0.03578	0.03004	0.03515	0.05287	0.05647	0.02749	184
0.00477	0.00648	0.02631	0.04637	0.03394	-0.00312	-0.02330	-0.01666	185
0.00077	0.02427	0.04166	0.04080	0.02795	0.02351	0.03866	0.06047	186
0.06361	0.03712	0.00629	-0.00449	-0.00010	0.01204	0.03005	0.03495	187
0.03679	0.06177	0.09366	0.10770	0.09238	0.05533	0.02261	0.01722	188
0.03225	0.04043	0.04507	0.06939	0.08312	0.06266	0.04813	0.03994	189
0.01225	-0.01460	-0.03275	-0.06644	-0.09567	-0.08762	-0.06829	-0.07416	190
-0.09328	-0.09443	-0.08400	-0.08660	-0.09879	-0.11637	-0.13440	-0.12161	191
-0.09196	-0.08705	-0.10209	-0.11574	-0.12076	-0.12412	-0.11566	-0.06809	192
-0.00503	0.02186	0.02000	0.00961	0.00030	0.01415	0.03074	0.00485	193
-0.04829	-0.06297	-0.02947	-0.00371	-0.01248	-0.01886	0.00146	0.03183	194
0.06788	0.09337	0.09201	0.08673	0.07384	0.04038	0.01973	0.03130	195
0.06457	0.10104	0.10630	0.08463	0.07986	0.09754	0.11620	0.11015	196
0.08325	0.06630	0.06056	0.03778	0.01211	0.02613	0.05528	0.07597	197
0.08667	0.07956	0.06562	0.06029	0.05748	0.05150	0.05978	0.06565	198
0.04489	0.02428	0.02123	0.01962	0.02047	0.02775	0.02361	0.00886	199
0.01102	0.02098	0.00476	-0.03553	-0.08392	-0.11909	-0.10646	-0.05313	200
-0.00241	0.01148	-0.00496	-0.01652	-0.01820	-0.01928	-0.01558	-0.01114	201
-0.02060	-0.04669	-0.07105	-0.08660	-0.09806	-0.08416	-0.05085	-0.01807	202
0.01778	0.03330	0.03448	0.05308	0.07056	0.06639	0.04311	0.01495	203
-0.00386	-0.02957	-0.05790	-0.07686	-0.10711	-0.12870	-0.10383	-0.04818	204
-0.01057	-0.01218	-0.02837	-0.02868	-0.02525	-0.02773	-0.00600	0.02306	205
0.03428	0.05643	0.08232	0.07635	0.04654	0.03070	0.03344	0.04644	206
0.06895	0.06650	0.03732	0.01450	0.01151	0.02889	0.04621	0.04165	207
0.02967	0.00746	-0.04470	-0.09588	-0.11545	-0.10147	-0.07874	-0.07078	208
-0.07469	-0.08530	-0.08455	-0.06721	-0.05313	-0.07341	-0.12722	-0.15539	209
-0.12874	-0.07290	-0.01194	0.02911	0.03432	0.02903	0.04066	0.05397	210
0.03595	0.00370	-0.00060	0.01126	0.01286	0.00588	0.01188	0.04110	211
0.05001	0.02121	0.00035	-0.00698	-0.01981	-0.03729	-0.04284	-0.02390	212
-0.01368	-0.02282	-0.03141	-0.03934	-0.03897	-0.02152	0.00374	0.02098	213
0.02180	0.01696	0.02583	0.03281	0.02474	0.02749	0.04025	0.04055	214
0.03829	0.03070	0.02333	0.04855	0.07877	0.07467	0.05283	0.04030	215
0.03304	0.01537	-0.00462	-0.02229	-0.04849	-0.06472	-0.06359	-0.06883	216
-0.06954	-0.05206	-0.03434	-0.03052	-0.04477	-0.05850	-0.06104	-0.07162	217
-0.08456	-0.08803	-0.08035	-0.05423	-0.02938	-0.00743	0.03265	0.07709	218
0.10280	0.10519	0.09417	0.07451	0.06109	0.05360	0.03257	0.02132	219
0.03378	0.03989	0.02674	0.00842	0.00026	-0.01499	-0.06016	-0.09640	220
-0.09138	-0.07948	-0.08989	-0.09656	-0.07420	-0.04972	-0.04121	-0.03128	221
-0.00987	0.01627	0.02783	0.01553	0.00014	0.00247	-0.00740	-0.05231	222
-0.09316	-0.10007	-0.08761	-0.08798	-0.11110	-0.11115	-0.06248	-0.03251	223
-0.05874	-0.07222	-0.02441	0.01644	0.00113	-0.02652	-0.04518	-0.05668	224
-0.04320	-0.00455	0.01957	0.01512	0.00156	-0.01304	-0.00494	0.02806	225
0.04532	0.03002	0.00111	-0.01899	-0.02028	0.01273	0.05653	0.08888	226
0.13688	0.18099	0.19709	0.19005	0.15801	0.11756	0.09890	0.09158	227
0.06359	0.04058	0.04579	0.06622	0.07197	0.04894	0.03376	0.04067	228
0.05934	0.05890	0.02349	-0.00227	0.00169	0.01512	0.01476	-0.00780	229
-0.03186	-0.04329	-0.04830	-0.05762	-0.07226	-0.07050	-0.05087	-0.04595	230
-0.05297	-0.04081	-0.00417	0.03405	0.05580	0.07875	0.10127	0.10230	231
0.09981	0.09453	0.07500	0.05096	0.01184	-0.02801	-0.03838	-0.04254	232
-0.05310	-0.04850	-0.01059	0.03964	0.04512	0.00921	-0.01114	0.01365	233
0.04265	0.03890	0.02741	0.03350	0.03848	0.03283	0.04944	0.07925	234
0.07677	0.05519	0.06227	0.07141	0.05153	0.03074	0.02946	0.04423	235

0.06321	0.08555	0.11924	0.15520	0.16827	0.15487	0.12804	0.09644	236
0.06582	0.03601	0.00511	-0.00432	0.01580	0.03269	0.04392	0.05138	237
0.03466	0.01529	0.02062	0.03417	0.02543	-0.00883	-0.03991	-0.05789	238
-0.06822	-0.07200	-0.08964	-0.14155	-0.18495	-0.17386	-0.14917	-0.13785	239
-0.12684	-0.12806	-0.14191	-0.16011	-0.17285	-0.17524	-0.18293	-0.20000	240
-0.17174	-0.08058	-0.01462	0.01375	0.04897	0.08296	0.10632	0.11875	241
0.12429	0.12242	0.11049	0.08016	0.03963	0.03067	0.05372	0.06024	242
0.03849	0.02434	0.02814	0.03978	0.02975	-0.01141	-0.04252	-0.05679	243
-0.07032	-0.07627	-0.06810	-0.04756	-0.03020	-0.04820	-0.07629	-0.07822	244
-0.06162	-0.03560	-0.01878	-0.01222	0.00603	0.03286	0.04486	0.02793	245
0.00156	-0.01007	-0.03236	-0.07023	-0.09136	-0.10389	-0.11323	-0.09173	246
-0.05164	-0.02905	-0.02441	-0.00636	0.02544	0.02167	-0.02454	-0.05281	247
-0.04775	-0.04076	-0.03999	-0.03079	-0.00658	0.01391	0.03952	0.07208	248
0.08982	0.08711	0.07503	0.06900	0.05448	0.02222	-0.01250	-0.03463	249
-0.01772	0.02764	0.04890	0.03812	0.02594	0.03019	0.03433	0.01308	250
-0.02126	-0.05249	-0.06259	-0.03145	-0.00180	-0.01627	-0.04375	-0.03223	251
0.00303	0.01357	0.00558	-0.00576	-0.00733	0.00010	-0.01640	-0.05694	252
-0.07464	-0.05419	-0.04472	-0.06319	-0.06147	-0.01288	0.03617	0.04770	253
0.03169	0.01545	0.02486	0.04264	0.04961	0.05414	0.06913	0.10024	254
0.12385	0.10537	0.06572	0.05891	0.05672	0.01106	-0.03358	-0.03181	255
0.00688	0.04876	0.05388	0.03304	0.00696	-0.02793	-0.04886	-0.04399	256
-0.03863	-0.04592	-0.05553	-0.06629	-0.06965	-0.05100	-0.02734	-0.02235	257
-0.03616	-0.04933	-0.04714	-0.04392	-0.04894	-0.05466	-0.05980	-0.05307	258
-0.03783	-0.03451	-0.03798	-0.03497	-0.02792	-0.02659	-0.02296	-0.01531	259
-0.02011	-0.03250	-0.02319	0.00894	0.02677	0.04679	0.08566	0.10568	260
0.10012	0.06194	0.00219	-0.02136	0.00617	0.05828	0.10343	0.12543	261
0.12827	0.12508	0.12369	0.11958	0.11592	0.10808	0.08350	0.03817	262
-0.00725	-0.02812	-0.03448	-0.03430	-0.01181	0.01915	0.04757	0.08776	263
0.10702	0.08153	0.05081	0.04456	0.04757	0.03963	0.02836	0.02343	264
0.02105	0.02411	0.03383	0.03660	0.03267	0.03267	0.03124	0.02708	265
0.02340	0.02195	0.01833	0.01118	0.00422	-0.01040	-0.03481	-0.05658	266
-0.06442	-0.06328	-0.06315	-0.05607	-0.03116	-0.00300	0.00467	-0.01590	267
-0.03414	-0.02546	-0.01519	-0.00927	-0.00785	-0.02015	-0.03655	-0.04928	268
-0.04753	-0.03607	-0.02557	-0.01855	-0.02376	-0.04230	-0.05944	-0.05615	269
-0.03722	-0.01489	0.00661	0.01665	0.01820	0.02410	0.03552	0.03743	270
0.02524	0.01588	0.00984	-0.00337	-0.02609	-0.03577	-0.02342	-0.02651	271
-0.04141	-0.03900	-0.03996	-0.05987	-0.07288	-0.06972	-0.05630	-0.03898	272
-0.03238	-0.03061	-0.02836	-0.02761	-0.02560	-0.02267	-0.02237	-0.02819	273
-0.02926	-0.02017	-0.01678	-0.02066	-0.01874	-0.01229	-0.01250	-0.02941	274
-0.05520	-0.06286	-0.05180	-0.05143	-0.06669	-0.07635	-0.07409	-0.06564	275
-0.05432	-0.04222	-0.02764	-0.02106	-0.02980	-0.03730	-0.02935	-0.01766	276
-0.01587	-0.01467	-0.01077	-0.00717	0.00136	0.01851	0.03460	0.03787	277
0.03396	0.03195	0.03413	0.03584	0.03718	0.03524	0.02465	0.01546	278
0.01459	0.02073	0.03535	0.05370	0.05595	0.03385	0.00942	0.00554	279
0.01195	0.01092	0.00929	0.01135	0.01239	0.01567	0.02118	0.01909	280
0.01418	0.01688	0.01917	0.01486	0.00712	-0.00490	-0.02066	-0.03406	281
-0.03927	-0.03514	-0.02892	-0.02451	-0.02076	-0.02331	-0.02971	-0.02735	282
-0.02038	-0.01797	-0.01574	-0.00862	0.00126	0.00480	0.00055	-0.00321	283
-0.00232	0.00268	0.00693	0.00917	0.01203	0.01197	0.00972	0.01100	284
0.01228	0.01155	0.01210	0.01240	0.01244	0.01362	0.01399	0.01315	285
0.01086	0.00836	0.00741	0.00742	0.00771	0.00741	0.00663	0.00518	286
0.00362	0.00287	0.00283	0.00297	0.00307	0.00314	0.00299	0.00260	287
0.00197	0.00137	0.00112	0.00119					288

2

1 17 17 GROUT VAULT SITE

1	1	1	12.92	3261.	0.05	0.1050	3261.	1.
2	1	1	10.58	8517.	0.05	0.1100	8517.	1.
3	1	1	9.33	8517.	0.05	0.1100	8517.	1.
4	1	1	12.25	8517.	0.05	0.1100	8517.	1.
5	1	1	6.92	8517.	0.05	0.1100	8517.	1.
6	1	1	13.00	13258.	0.05	0.1100	13258.	1.
7	1	1	15.00	13258.	0.05	0.1100	13258.	1.
8	1	1	20.00	13258.	0.05	0.1100	13258.	1.
9	1	1	20.00	13258.	0.05	0.1100	13258.	1.
10	1	1	25.00	24262.	0.05	0.1250	24262.	1.
11	1	1	25.00	24262.	0.05	0.1250	24262.	1.
12	1	1	30.00	24262.	0.05	0.1250	24262.	1.
13	1	1	30.00	24262.	0.05	0.1250	24262.	1.
14	1	1	30.00	24262.	0.05	0.1250	24262.	1.
15	1	1	35.00	24262.	0.05	0.1250	24262.	1.

```
  16    1    1   35.00     24262.      0.05    0.1250            24262.  1.
  17    1                  98100.              0.1500
   3
   1    0
   4
   0    5   5.       0.65
   5
   1    2    3    4    5    6    7    8    9   10   11   12   13   14   18
   1    1    1    1    1    1    1    1    1    1    1    1    1    1    1
   1    1    1    1    1    1    1    1                                 1
   9
   1    1
   3    0    1    1    4
0.05     0.07      0.10
   9
   2    1
   3    0    1    1    4
0.05     0.07      0.10
   9
   6    1
   3    0    1    1    4
0.05     0.07      0.10
   9
   8    1
   3    0    1    1    4
0.05     0.07      0.10
   0
```

*********** Excerpt from SHAKE output for best-estimate soil properties ***********
Filename: shakexx.out

```
*********************************************
*********************************************
**                                         **
** SHAKE -- A COMPUTER PROGRAM FOR         **
**          EARTHQUAKE RESPONSE ANALYSIS   **
**          OF HORIZONTALLY LAYERED SITES  **
**                                         **
** MS-DOS VERSION - CONVERTED TO IBM-PC BY **
**          Shyh-Shiun Lai                 **
**          UNIVERSITY OF CALIFORNIA       **
**                 and                     **
**          WOODWARD-CLYDE CONSULTANTS     **
**          January 1985                   **
** cft77 4/26/91; WHC                      **
*********************************************
*********************************************

MAX. NUMBER OF TERMS IN FOURIER TRANSFORM =     4096
NECESSARY LENGTH OF BLANK COMMON X        =    25619
EARTH PRESSURE AT REST FOR SAND           =    0.450
```

[omitted portion of output here]

```
EARTHQUAKE  -     WHC-SD-GN-DA-30018   TH1.
SOIL PROFILE -    GROUT VAULT SITE

ITERATION NUMBER  3
THE CALCULATION HAS BEEN CARRIED OUT IN THE TIME DOMAIN WITH EFF. STRAIN = .65* MAX. STRAIN
```

LAYER	TYPE	DEPTH	EFF. STRAIN	NEW DAMP.	DAMP USED	ERROR	NEW G	G USED	ERROR
1	1	6.5	0.00308	0.015	0.015	0.0	3101.03	3101.15	0.0
2	1	18.2	0.00321	0.015	0.015	0.1	8078.80	8080.07	0.0
3	1	28.2	0.00504	0.019	0.019	0.3	7746.50	7750.73	-0.1

4	1	39.0	0.00695	0.022	0.022	0.4	7508.46	7515.29	-0.1
5	1	48.5	0.00851	0.024	0.024	0.4	7358.50	7366.35	-0.1
6	1	58.5	0.00615	0.021	0.021	0.3	11829.07	11837.53	-0.1
7	1	72.5	0.00769	0.023	0.023	0.4	11572.23	11584.85	-0.1
8	1	90.0	0.00977	0.025	0.025	0.5	11295.58	11311.65	-0.1
9	1	110.0	0.01222	0.030	0.029	3.1	10737.51	10831.77	-0.9
10	1	132.5	0.00721	0.022	0.022	0.3	21311.57	21326.57	-0.1
11	1	157.5	0.00830	0.023	0.023	0.2	21015.33	21026.43	-0.1
12	1	185.0	0.00927	0.024	0.024	0.2	20781.51	20791.95	-0.1
13	1	215.0	0.00993	0.025	0.025	0.1	20637.87	20642.65	0.0
14	1	245.0	0.01024	0.026	0.026	0.3	20508.00	20522.20	-0.1
15	1	277.5	0.01027	0.026	0.026	0.1	20492.65	20498.63	0.0
16	1	312.5	0.01045	0.026	0.026	1.2	20410.64	20471.10	-0.3

VALUES IN TIME DOMAIN

LAYER	TYPE	THICKNESS FT	DEPTH FT	MAX STRAIN PRCNT	MAX STRESS PSF	TIME SEC
1	1	12.9	6.5	0.00473	146.71	19.18
2	1	10.6	18.2	0.00494	399.37	19.18
3	1	9.3	28.2	0.00775	600.26	19.17
4	1	12.3	39.0	0.01069	802.81	19.17
5	1	6.9	48.5	0.01310	963.70	19.17
6	1	13.0	58.5	0.00946	1118.92	19.16
7	1	15.0	72.5	0.01182	1368.33	19.15
8	1	20.0	90.0	0.01504	1698.55	19.14
9	1	20.0	110.0	0.01880	2018.99	19.14
10	1	25.0	132.5	0.01109	2364.01	19.13
11	1	25.0	157.5	0.01277	2683.23	19.13
12	1	30.0	185.0	0.01427	2964.93	19.12
13	1	30.0	215.0	0.01527	3152.27	19.12
14	1	30.0	245.0	0.01575	3230.58	19.11
15	1	35.0	277.5	0.01580	3238.40	19.10
16	1	35.0	312.5	0.01607	3280.44	8.04

PERIOD = 0.64 FROM AVERAGE SHEARVEL. = 2060.

MAXIMUM AMPLIFICATION = 27.59
FOR FREQUENCY = 1.76 C/SEC.
PERIOD = 0.57 SEC.

[omitted portion of output here]

```
 ************** SHAKE input for upper-bound soil properties ************
Filename:  shx2c106.i2

 4096
    8
    4    1   10      1.
   11  1.   SHEAR MODULUS CLAY
  .0001    .000316    .001     .00316      .01       .0316       .1        .316
     1.       3.16     10.
     1.         1.     .99        .95      .85         .62      .36         .16
   .08         .08     .08
   11  1.   DAMPING CLAY
  .0001    .000316    .001     .00316      .01       .0316       .1        .316
     1.       3.16     10.
     .1         .5     1.0        1.5      2.5         5.5      10.        16.0
  21.0         24.     24.
   11  1.  _SHEAR MODULUS SAND :  IDRISS 1990
  .0001    .000316    .001     .00316      .01       .0316       .1        .316
     1.       3.16     10.
     1.         1.     .99        .95      .85         .62      .36         .16
   .08         .08     .08
   11 .038 DAMPING SAND :  IDRISS 1990
  .0001    .000316    .001     .00316      .01       .0316       .1        .316
     1.       3.16     10.
     .1         .5     1.0        1.5      2.5         5.5      10.        16.0
  21.0         24.     24.
   2    1.   SHEAR MODULUS ROCK :  NOT USED
  .0001     10.
      1      1
    2  1.   DAMPING ROCK   : NOT USED
  .0001     10.
      1      1
   10 1.    SHEAR MODULUS GRAVEL   :  HWVP 11/89   PLATE 11
  .0001     .0003      .001       .003      .01        .03        .1        .3
      1      10.
     1.       .96      .85        .73      .54        .36        .2        .1
   .05        .05
   10 .038 DAMPING GRAVEL   :  HWVP 11/89   PLATE 11
  .0001     .0003      .001       .003      .01        .03        .1        .3
     1.       10.
     .5        1.      1.7         3.      5.4        10.      15.5       21.
   25.        26.
    1
 2300 4096        .01       WHC-SD-GN-DA-30018    TH1.HST
                .216        15
 -0.00030 -0.00070 -0.00075 -0.00096 -0.00109 -0.00058  0.00023  0.00107   1
  0.00180  0.00223  0.00268  0.00263  0.00105 -0.00027  0.00050  0.00187   2
  0.00204  0.00125  0.00070  0.00110  0.00141  0.00083 -0.00029 -0.00126   3
 -0.00097 -0.00165 -0.00471 -0.00771 -0.00965 -0.01001 -0.00946 -0.00872   4
 -0.00844 -0.01017 -0.01258 -0.01490 -0.01507 -0.01281 -0.01268 -0.01205   5
 -0.00973 -0.00879 -0.00587 -0.00180 -0.00171 -0.00506 -0.00774 -0.00799   6
 -0.00705 -0.00728 -0.00938 -0.01207 -0.01301 -0.00636  0.00556  0.01345   7
  0.01387  0.01396  0.01754  0.01687  0.01087  0.00660  0.00706  0.00546   8
 -0.00186 -0.00701 -0.00500 -0.00184  0.00178  0.01037  0.02048  0.02676   9
  0.02610  0.02011  0.01487  0.01256  0.01002  0.00724  0.01155  0.01893  10
  0.01957  0.01782  0.01660  0.01379  0.00527 -0.00952 -0.01908 -0.01671  11
 -0.01184 -0.01511 -0.02109 -0.01952 -0.01893 -0.02160 -0.01861 -0.01362  12
 -0.01477 -0.02539 -0.03350 -0.03288 -0.03059 -0.03097 -0.03582 -0.03987  13
 -0.03593 -0.02353 -0.01111 -0.00214  0.00961  0.01467  0.00796  0.01087  14
  0.02281  0.01869 -0.00275 -0.01672 -0.01209 -0.00048  0.00150 -0.01025  15
 -0.02064 -0.01762 -0.01121 -0.01443 -0.01745 -0.01326 -0.00222  0.00556  16
 -0.00432 -0.01137 -0.00195  0.00630  0.00684  0.00484  0.00352  0.00286  17
 -0.00286 -0.02101 -0.04126 -0.04843 -0.04523 -0.04063 -0.04058 -0.03053  18
 -0.00354  0.02449  0.03787  0.02587  0.00150 -0.00394  0.00743  0.00696  19
 -0.00217 -0.00160  0.00882  0.01287  0.00946  0.01069  0.01130  0.00226  20
 -0.00792 -0.00708  0.00060  0.01391  0.02989  0.03860  0.03514  0.03128  21
  0.04193  0.05309  0.05697  0.05965  0.05751  0.05423  0.05136  0.05000  22
  0.05283  0.05406  0.04734  0.02808  0.01074  0.01138  0.02086  0.03544  23
  0.05332  0.05950  0.05808  0.06037  0.06407  0.06855  0.06927  0.05480  24
  0.02913  0.01339  0.01865  0.03384  0.04442  0.05288  0.06123  0.05739  25
```

0.04715	0.04547	0.04081	0.01547	-0.01549	-0.02342	-0.01709	-0.01276	26
0.01233	0.05624	0.07748	0.07315	0.05364	0.02852	0.01320	-0.00730	27
-0.03215	-0.03363	-0.00794	0.01567	0.01774	0.01923	0.03877	0.05156	28
0.02733	-0.00956	-0.01880	-0.01469	-0.01968	-0.01482	-0.00239	0.00963	29
0.02685	0.02719	0.01123	0.00297	-0.00535	-0.03263	-0.06205	-0.07828	30
-0.08510	-0.08266	-0.08296	-0.08215	-0.07587	-0.07209	-0.06879	-0.06851	31
-0.07494	-0.07786	-0.06029	-0.03512	-0.02455	-0.01372	0.01004	0.02779	32
0.02951	0.01064	-0.03078	-0.07822	-0.11984	-0.14281	-0.13064	-0.08465	33
-0.02719	0.00576	0.00727	0.00537	0.01198	0.02475	0.04570	0.07319	34
0.07938	0.05384	0.04667	0.06784	0.08151	0.08382	0.07163	0.04668	35
0.02590	0.02498	0.05496	0.08416	0.07512	0.05428	0.04138	0.03046	36
0.04389	0.08585	0.11999	0.10886	0.06818	0.05043	0.05362	0.03992	37
0.01456	0.00073	-0.01156	-0.03307	-0.06004	-0.07566	-0.05438	-0.02834	38
-0.03802	-0.05441	-0.04845	-0.02472	-0.00705	-0.01983	-0.04567	-0.05696	39
-0.06206	-0.07345	-0.09217	-0.11137	-0.10549	-0.07271	-0.04850	-0.06030	40
-0.08346	-0.08768	-0.08781	-0.08570	-0.07623	-0.06471	-0.06151	-0.06958	41
-0.07685	-0.07582	-0.05525	-0.02639	-0.02069	-0.03682	-0.03996	-0.02660	42
-0.01082	0.00809	0.00764	-0.02534	-0.06101	-0.07600	-0.08522	-0.08566	43
-0.05007	-0.00774	-0.00244	-0.01202	-0.01687	-0.02777	-0.03662	-0.04074	44
-0.03598	-0.01717	-0.00106	0.00641	0.00057	-0.00645	-0.00391	0.00385	45
0.02746	0.03295	0.00747	0.00634	0.03121	0.04435	0.04406	0.04726	46
0.05824	0.06707	0.06487	0.05790	0.05942	0.05844	0.03843	0.02088	47
0.01455	0.00922	0.01516	0.02825	0.03126	0.01655	0.00168	0.00089	48
0.00425	-0.00063	-0.01869	-0.03017	-0.01565	0.00201	0.01103	0.01920	49
0.01365	-0.00405	-0.01756	-0.01531	-0.00550	-0.01965	-0.05926	-0.08895	50
-0.09568	-0.07650	-0.03345	0.01254	0.03638	0.02590	0.01413	0.02239	51
0.02155	0.00522	-0.01151	-0.02708	-0.02232	-0.00829	-0.00226	0.01969	52
0.03420	0.02485	0.02567	0.04525	0.04953	0.02528	-0.00235	-0.02570	53
-0.03869	-0.04674	-0.06604	-0.09174	-0.10398	-0.08481	-0.05592	-0.03509	54
-0.00213	0.02969	0.04934	0.05556	0.03596	0.01932	0.01525	0.00852	55
-0.01028	-0.03738	-0.05189	-0.04329	-0.01894	0.00003	0.01634	0.04336	56
0.06174	0.07295	0.10367	0.14132	0.15731	0.15379	0.13311	0.10246	57
0.08015	0.05374	0.03407	0.02048	0.00372	0.01904	0.06200	0.10034	58
0.12799	0.13603	0.10974	0.06854	0.03716	0.01078	-0.01119	-0.02591	59
-0.03047	-0.02798	-0.03213	-0.02495	-0.01369	-0.03741	-0.07620	-0.09048	60
-0.08669	-0.08197	-0.05798	-0.01545	0.02493	0.05800	0.09311	0.13804	61
0.15486	0.12096	0.08044	0.06783	0.06100	0.05035	0.04602	0.03578	62
0.00911	-0.02880	-0.06109	-0.08499	-0.10525	-0.11476	-0.11637	-0.10774	63
-0.09083	-0.08671	-0.09354	-0.08026	-0.05457	-0.04652	-0.05865	-0.09261	64
-0.13144	-0.14645	-0.13056	-0.09411	-0.04754	0.00608	0.04883	0.05165	65
0.04120	0.04749	0.02610	-0.03020	-0.05722	-0.03649	0.00073	0.02695	66
0.02737	0.01272	-0.01081	-0.04421	-0.06884	-0.07394	-0.06791	-0.04488	67
-0.01288	-0.01209	-0.04942	-0.07592	-0.06365	-0.04400	-0.05263	-0.09404	68
-0.10993	-0.06058	-0.00526	0.00976	0.01110	0.02323	0.02556	0.00352	69
-0.01256	-0.00076	0.01861	0.03795	0.04775	0.03565	0.01584	-0.00761	70
-0.03787	-0.06255	-0.07107	-0.06749	-0.06000	-0.04400	-0.00973	0.01321	71
0.01413	0.03655	0.08622	0.10696	0.08510	0.07067	0.07177	0.05520	72
0.02296	0.00756	0.01296	0.01058	-0.01807	-0.06018	-0.08614	-0.07500	73
-0.02046	0.03415	0.05012	0.05703	0.06493	0.05222	0.00804	-0.04113	74
-0.07040	-0.06877	-0.02579	0.01439	0.00092	-0.03043	-0.01631	0.00725	75
0.01173	0.02478	0.03622	0.03910	0.03474	0.01099	-0.01704	-0.02291	76
-0.01376	-0.00192	0.00177	-0.01699	-0.04384	-0.06674	-0.08531	-0.09014	77
-0.07555	-0.05184	-0.04033	-0.03949	-0.03527	-0.03314	-0.03337	-0.03026	78
-0.02284	0.00858	0.06070	0.09097	0.08702	0.08164	0.08500	0.08067	79
0.07338	0.05925	0.03090	0.03327	0.09071	0.13753	0.13521	0.11800	80
0.10833	0.11321	0.11848	0.10540	0.09378	0.08433	0.06063	0.03467	81
0.02118	0.01379	-0.00078	-0.01721	-0.02465	-0.03243	-0.04090	-0.03437	82
-0.02611	-0.03212	-0.03670	-0.02848	-0.03114	-0.05515	-0.06491	-0.05851	83
-0.06180	-0.05840	-0.03899	-0.02308	-0.01802	-0.01237	0.00394	0.02066	84
0.02607	0.03937	0.05282	0.04047	0.02448	0.00603	-0.02779	-0.06435	85
-0.07395	-0.03618	0.02134	0.06464	0.08044	0.06753	0.04167	0.01539	86
-0.00492	-0.00820	-0.00576	0.00244	0.00797	-0.01458	-0.04125	-0.04751	87
-0.03306	-0.01337	0.01867	0.07637	0.10995	0.10811	0.09426	0.05826	88
0.01899	-0.00151	-0.00320	0.01072	0.01679	0.00989	0.00793	0.01426	89
0.01090	-0.01005	-0.03169	-0.05552	-0.07953	-0.08716	-0.07372	-0.04090	90
-0.01167	-0.02135	-0.05763	-0.07263	-0.05598	-0.02673	-0.00836	-0.02004	91
-0.03176	-0.01093	0.01905	0.02754	0.01162	-0.00670	0.00026	0.02556	92
0.03593	0.02642	0.01026	-0.00046	0.00614	0.02816	0.05289	0.06426	93
0.04856	0.01683	-0.00741	-0.02696	-0.04102	-0.03561	-0.02215	-0.02304	94
-0.02376	0.00346	0.03232	0.02390	0.00022	-0.00971	-0.01831	-0.03736	95

-0.04866	-0.03226	-0.00693	0.01767	0.02650	0.01823	0.02271	0.02878	96
0.04089	0.06415	0.08149	0.08966	0.08727	0.07036	0.04630	0.03242	97
0.03656	0.04980	0.04174	0.01642	0.00055	-0.00213	0.01200	0.01207	98
-0.02634	-0.04521	-0.01082	0.03892	0.07370	0.08613	0.09033	0.08888	99
0.08471	0.09903	0.12820	0.14622	0.14445	0.13027	0.10118	0.07420	100
0.06538	0.06348	0.05489	0.05320	0.06155	0.04130	0.00793	0.00824	101
0.02453	0.01883	0.01006	0.03373	0.06556	0.09100	0.12019	0.14148	102
0.15574	0.14676	0.11676	0.08752	0.04074	-0.01171	-0.03264	-0.03565	103
-0.03371	-0.02400	-0.03575	-0.06636	-0.08261	-0.09543	-0.11865	-0.13410	104
-0.14222	-0.14961	-0.15963	-0.16601	-0.15269	-0.12331	-0.10516	-0.11748	105
-0.13627	-0.13073	-0.09538	-0.05376	-0.04147	-0.05823	-0.06425	-0.05262	106
-0.04105	-0.02196	0.00194	0.01133	0.01159	0.01309	0.00845	-0.00129	107
-0.01916	-0.02184	0.01590	0.04284	0.02894	0.00821	0.01568	0.03920	108
0.02426	-0.02608	-0.04336	-0.00474	0.02838	0.03099	0.03263	0.03394	109
0.02831	0.01289	-0.02070	-0.06083	-0.06576	-0.04522	-0.04521	-0.05536	110
-0.03400	0.00830	0.01729	-0.00310	-0.01921	-0.01962	-0.00815	-0.00394	111
-0.01042	-0.01654	-0.02137	-0.03278	-0.05763	-0.07758	-0.07002	-0.04878	112
-0.03595	-0.02482	0.00030	0.02058	0.00217	-0.04780	-0.07914	-0.06603	113
-0.05233	-0.07171	-0.07801	-0.03552	0.01235	0.02335	0.03181	0.06791	114
0.08148	0.06881	0.08131	0.10504	0.11127	0.11054	0.10921	0.09909	115
0.08336	0.07642	0.07963	0.07522	0.06419	0.04232	-0.00153	-0.03320	116
-0.03401	-0.02935	-0.02784	-0.04446	-0.08214	-0.11265	-0.12629	-0.11726	117
-0.09272	-0.07333	-0.08410	-0.10557	-0.08172	-0.03642	-0.04328	-0.09869	118
-0.13492	-0.13923	-0.13118	-0.11981	-0.10307	-0.06589	-0.03613	-0.02204	119
-0.00364	0.01879	0.02720	0.00795	-0.00081	0.01857	0.02862	0.01986	120
0.01157	0.00416	-0.00539	-0.02808	-0.05516	-0.03964	0.02603	0.08985	121
0.11012	0.08393	0.04025	0.00284	-0.04354	-0.09079	-0.10188	-0.08724	122
-0.07508	-0.04795	-0.01099	0.01113	0.01779	0.00235	-0.02465	-0.04704	123
-0.06223	-0.05884	-0.03220	-0.02042	-0.03821	-0.05464	-0.05274	-0.02193	124
0.02113	0.04842	0.05646	0.06347	0.09027	0.10568	0.08846	0.07965	125
0.07947	0.07228	0.06030	0.01660	-0.04628	-0.05915	-0.01902	0.00998	126
0.02500	0.05818	0.09276	0.08905	0.04493	-0.00026	-0.01700	-0.01014	127
0.01698	0.06422	0.09920	0.10232	0.09359	0.08651	0.08227	0.07471	128
0.07247	0.08740	0.09148	0.07006	0.03405	-0.01352	-0.05104	-0.05854	129
-0.03167	0.01653	0.04130	0.03264	0.01351	0.00147	-0.00064	0.00415	130
0.01686	0.01250	0.00287	0.00804	0.01002	0.02412	0.06193	0.07139	131
0.01033	-0.06937	-0.09333	-0.06034	-0.04165	-0.06060	-0.05646	-0.03424	132
-0.04716	-0.06844	-0.05680	-0.03096	-0.01251	-0.00659	-0.00021	0.02566	133
0.05996	0.06786	0.04430	0.02220	0.00548	-0.01257	-0.03103	-0.05002	134
-0.06031	-0.05019	-0.01557	0.01462	0.02196	0.02352	0.03334	0.03491	135
-0.00207	-0.05497	-0.08447	-0.07773	-0.04010	-0.01254	0.00309	0.03725	136
0.06808	0.08144	0.08211	0.07611	0.08608	0.08663	0.06018	0.03322	137
0.01863	0.03518	0.04983	0.01231	-0.04886	-0.07370	-0.04851	-0.02368	138
-0.02517	-0.02690	-0.01833	-0.01831	-0.02992	-0.02789	-0.00921	0.00858	139
0.00506	-0.02438	-0.05211	-0.06493	-0.05906	-0.03585	-0.02130	-0.02900	140
-0.04016	-0.04593	-0.06057	-0.08479	-0.10786	-0.09923	-0.06337	-0.05165	141
-0.05668	-0.04499	-0.01923	0.00660	0.03374	0.04649	0.03192	0.01272	142
0.01313	0.04368	0.07275	0.06866	0.05452	0.04848	0.05627	0.08501	143
0.09473	0.07096	0.04726	0.04118	0.04330	0.03218	0.00803	-0.01773	144
-0.03863	-0.05987	-0.07577	-0.06347	-0.02820	-0.01031	-0.02272	-0.01489	145
0.02229	0.04179	0.03679	0.02611	0.02274	0.02218	0.01162	0.00654	146
0.02764	0.05844	0.07383	0.07760	0.07398	0.05352	0.02360	0.00095	147
-0.01271	-0.02789	-0.03683	-0.03485	-0.02829	-0.01179	0.00584	0.01521	148
0.02007	0.02348	0.01837	-0.00088	-0.02633	-0.04622	-0.06483	-0.07090	149
-0.03900	0.01680	0.06877	0.10686	0.13165	0.13210	0.10594	0.09623	150
0.10159	0.06912	0.01980	-0.00275	-0.01230	-0.03217	-0.05360	-0.07482	151
-0.09557	-0.10694	-0.11353	-0.11021	-0.08879	-0.07531	-0.07955	-0.06654	152
-0.04687	-0.03530	-0.01561	0.00437	0.01049	0.01174	0.03231	0.05573	153
0.04538	0.01903	0.01005	0.02476	0.04590	0.05660	0.05745	0.05892	154
0.06087	0.04906	0.02444	-0.01098	-0.04900	-0.06880	-0.07652	-0.08195	155
-0.06943	-0.05024	-0.05299	-0.06869	-0.06348	-0.02548	0.01763	0.03014	156
0.00081	-0.03719	-0.05999	-0.07427	-0.07917	-0.08680	-0.09082	-0.05607	157
-0.00409	0.01175	-0.00584	-0.01876	-0.01765	-0.01572	-0.00578	0.01671	158
0.03489	0.03841	0.03829	0.03903	0.04938	0.07747	0.09289	0.07770	159
0.05557	0.04476	0.05047	0.07243	0.08193	0.07260	0.07710	0.09937	160
0.10543	0.08121	0.06808	0.08699	0.09917	0.08372	0.05642	0.04012	161
0.03188	0.02196	0.03755	0.06112	0.05786	0.04093	0.01506	-0.01098	162
-0.03121	-0.04491	-0.05521	-0.08237	-0.10884	-0.10509	-0.09482	-0.08134	163
-0.04754	-0.03192	-0.03216	-0.02006	-0.01431	-0.02607	-0.05562	-0.08412	164
-0.09125	-0.08495	-0.06975	-0.04343	-0.01037	0.02066	0.04067	0.05002	165

0.05271	0.06203	0.07981	0.07010	0.04670	0.04089	0.02220	-0.00491	166
-0.01077	-0.00936	-0.01971	-0.03657	-0.05015	-0.06323	-0.07312	-0.06781	167
-0.05573	-0.05123	-0.05603	-0.06890	-0.08156	-0.10271	-0.14473	-0.17596	168
-0.16003	-0.10101	-0.03923	-0.01039	0.00156	0.01276	0.01133	-0.01064	169
-0.04239	-0.05461	-0.05902	-0.07983	-0.09891	-0.09593	-0.06606	-0.03045	170
-0.00281	0.03051	0.04509	0.02557	0.00347	-0.00676	-0.00163	-0.00099	171
-0.01780	-0.02487	-0.01532	0.00237	0.02356	0.04551	0.06831	0.07436	172
0.05423	0.02453	-0.00187	-0.01546	-0.01187	-0.00435	-0.00180	-0.00175	173
-0.01180	-0.01935	-0.00747	-0.01263	-0.04402	-0.06661	-0.06392	-0.05541	174
-0.06590	-0.06058	-0.02872	-0.01585	-0.01581	0.00611	0.02393	0.00550	175
-0.02531	-0.02974	-0.00201	0.02692	0.05660	0.09502	0.10061	0.06303	176
0.02467	-0.00507	-0.02179	-0.00840	0.00904	0.00643	-0.00030	0.01629	177
0.02794	0.01151	0.00519	0.01127	0.01158	0.01249	0.01905	0.03165	178
0.04766	0.05094	0.03824	0.03831	0.05461	0.05780	0.06513	0.07328	179
0.06339	0.05993	0.05749	0.05194	0.05526	0.05309	0.03700	0.01981	180
0.01531	0.02907	0.04731	0.04796	0.03216	0.01801	-0.00853	-0.04205	181
-0.05136	-0.05626	-0.06433	-0.06062	-0.05413	-0.05440	-0.06554	-0.07664	182
-0.08264	-0.09643	-0.10485	-0.07220	-0.01175	0.03204	0.05139	0.05637	183
0.05827	0.05111	0.03578	0.03004	0.03515	0.05287	0.05647	0.02749	184
0.00477	0.00648	0.02631	0.04637	0.03394	-0.00312	-0.02330	-0.01666	185
0.00077	0.02427	0.04166	0.04080	0.02795	0.02351	0.03866	0.06047	186
0.06361	0.03712	0.00629	-0.00449	-0.00010	0.01204	0.03005	0.03495	187
0.03679	0.06177	0.09366	0.10770	0.09238	0.05533	0.02261	0.01722	188
0.03225	0.04043	0.04507	0.06939	0.08312	0.06266	0.04813	0.03994	189
0.01225	-0.01460	-0.03275	-0.06644	-0.09567	-0.08762	-0.06829	-0.07416	190
-0.09328	-0.09443	-0.08400	-0.08660	-0.09879	-0.11637	-0.13440	-0.12161	191
-0.09196	-0.08705	-0.10209	-0.11574	-0.12076	-0.12412	-0.11566	-0.06809	192
-0.00503	0.02186	0.02000	0.00961	0.00030	0.01415	0.03074	0.00485	193
-0.04829	-0.06297	-0.02947	-0.00371	-0.01248	-0.01886	0.00146	0.03183	194
0.06788	0.09337	0.09201	0.08673	0.07384	0.04038	0.01973	0.03130	195
0.06457	0.10104	0.10630	0.08463	0.07986	0.09754	0.11620	0.11015	196
0.08325	0.06630	0.06056	0.03778	0.01211	0.02613	0.05528	0.07597	197
0.08667	0.07956	0.06562	0.06029	0.05748	0.05150	0.05978	0.06565	198
0.04489	0.02428	0.02123	0.01962	0.02047	0.02775	0.02361	0.00886	199
0.01102	0.02098	0.00476	-0.03553	-0.08392	-0.11909	-0.10646	-0.05313	200
-0.00241	0.01148	-0.00496	-0.01652	-0.01820	-0.01928	-0.01558	-0.01114	201
-0.02060	-0.04669	-0.07105	-0.08660	-0.09806	-0.08416	-0.05085	-0.01807	202
0.01778	0.03330	0.03448	0.05308	0.07056	0.06639	0.04311	0.01495	203
-0.00386	-0.02957	-0.05790	-0.07686	-0.10711	-0.12870	-0.10383	-0.04818	204
-0.01057	-0.01218	-0.02837	-0.02868	-0.02525	-0.02773	-0.00600	0.02306	205
0.03428	0.05643	0.08232	0.07635	0.04654	0.03070	0.03344	0.04644	206
0.06895	0.06650	0.03732	0.01450	0.01151	0.02889	0.04621	0.04165	207
0.02967	0.00746	-0.04470	-0.09588	-0.11545	-0.10147	-0.07874	-0.07078	208
-0.07469	-0.08530	-0.08455	-0.06721	-0.05313	-0.07341	-0.12722	-0.15539	209
-0.12874	-0.07290	-0.01194	0.02911	0.03432	0.02903	0.04066	0.05397	210
0.03595	0.00370	-0.00060	0.01126	0.01286	0.00588	0.01188	0.04110	211
0.05001	0.02121	0.00035	-0.00698	-0.01981	-0.03729	-0.04284	-0.02390	212
-0.01368	-0.02282	-0.03141	-0.03934	-0.03897	-0.02152	0.00374	0.02098	213
0.02180	0.01696	0.02583	0.03281	0.02474	0.02749	0.04025	0.04055	214
0.03829	0.03070	0.02333	0.04855	0.07877	0.07467	0.05283	0.04030	215
0.03304	0.01537	-0.00462	-0.02229	-0.04849	-0.06472	-0.06359	-0.06883	216
-0.06954	-0.05206	-0.03434	-0.03052	-0.04477	-0.05850	-0.06104	-0.07162	217
-0.08456	-0.08803	-0.08035	-0.05423	-0.02938	-0.00743	0.03265	0.07709	218
0.10280	0.10519	0.09417	0.07451	0.06109	0.05360	0.03257	0.02132	219
0.03378	0.03989	0.02674	0.00842	0.00026	-0.01499	-0.06016	-0.09640	220
-0.09138	-0.07948	-0.08989	-0.09656	-0.07420	-0.04972	-0.04121	-0.03128	221
-0.00987	0.01627	0.02783	0.01553	0.00014	0.00247	-0.00740	-0.05231	222
-0.09316	-0.10007	-0.08761	-0.08798	-0.11110	-0.11115	-0.06248	-0.03251	223
-0.05874	-0.07222	-0.02441	0.01644	0.00113	-0.02652	-0.04518	-0.05668	224
-0.04320	-0.00455	0.01957	0.01512	0.00156	-0.01304	-0.00494	0.02806	225
0.04532	0.03002	0.00111	-0.01899	-0.02028	0.01273	0.05653	0.08888	226
0.13688	0.18099	0.19709	0.19005	0.15801	0.11756	0.09890	0.09158	227
0.06359	0.04058	0.04579	0.06622	0.07197	0.04894	0.03376	0.04067	228
0.05934	0.05890	0.02349	-0.00227	0.00169	0.01512	0.01476	-0.00780	229
-0.03186	-0.04329	-0.04830	-0.05762	-0.07226	-0.07050	-0.05087	-0.04595	230
-0.05297	-0.04081	-0.00417	0.03405	0.05580	0.07875	0.10127	0.10230	231
0.09981	0.09453	0.07500	0.05096	0.01184	-0.02801	-0.03838	-0.04254	232
-0.05310	-0.04850	-0.01059	0.03964	0.04512	0.00921	-0.01114	0.01365	233
0.04265	0.03890	0.02741	0.03350	0.03848	0.03283	0.04944	0.07925	234
0.07677	0.05519	0.06227	0.07141	0.05153	0.03074	0.02946	0.04423	235

0.06321	0.08555	0.11924	0.15520	0.16827	0.15487	0.12804	0.09644	236
0.06582	0.03601	0.00511	-0.00432	0.01580	0.03269	0.04392	0.05138	237
0.03466	0.01529	0.02062	0.03417	0.02543	-0.00883	-0.03991	-0.05789	238
-0.06822	-0.07200	-0.08964	-0.14155	-0.18495	-0.17386	-0.14917	-0.13785	239
-0.12684	-0.12806	-0.14191	-0.16011	-0.17285	-0.17524	-0.18293	-0.20000	240
-0.17174	-0.08058	-0.01462	0.01375	0.04897	0.08296	0.10632	0.11875	241
0.12429	0.12242	0.11049	0.08016	0.03963	0.03067	0.05372	0.06024	242
0.03849	0.02434	0.02814	0.03978	0.02975	-0.01141	-0.04252	-0.05679	243
-0.07032	-0.07627	-0.06810	-0.04756	-0.03020	-0.04820	-0.07629	-0.07822	244
-0.06162	-0.03560	-0.01878	-0.01222	0.00603	0.03286	0.04486	0.02793	245
0.00156	-0.01007	-0.03236	-0.07023	-0.09136	-0.10389	-0.11323	-0.09173	246
-0.05164	-0.02909	-0.02441	-0.00636	0.02544	0.02167	-0.02454	-0.05281	247
-0.04775	-0.04076	-0.03999	-0.03079	-0.00658	0.01391	0.03952	0.07208	248
0.08982	0.08711	0.07503	0.06900	0.05448	0.02222	-0.01250	-0.03463	249
-0.01772	0.02764	0.04890	0.03812	0.02594	0.03019	0.03433	0.01308	250
-0.02126	-0.05249	-0.06259	-0.03145	-0.00180	-0.01627	-0.04375	-0.03223	251
0.00303	0.01357	0.00558	-0.00576	-0.00733	0.00010	-0.01640	-0.05694	252
-0.07464	-0.05419	-0.04472	-0.06319	-0.06147	-0.01288	0.03617	0.04770	253
0.03169	0.01545	0.02486	0.04264	0.04961	0.05414	0.06913	0.10024	254
0.12385	0.10537	0.06572	0.05891	0.05672	0.01106	-0.03358	-0.03181	255
0.00688	0.04876	0.05388	0.03304	0.00696	-0.02793	-0.04886	-0.04399	256
-0.03863	-0.04592	-0.05553	-0.06629	-0.06965	-0.05100	-0.02734	-0.02235	257
-0.03616	-0.04933	-0.04714	-0.04392	-0.04894	-0.05466	-0.05980	-0.05307	258
-0.03783	-0.03451	-0.03798	-0.03497	-0.02792	-0.02659	-0.02296	-0.01531	259
-0.02011	-0.03250	-0.02319	0.00894	0.02677	0.04679	0.08566	0.10568	260
0.10012	0.06194	0.00219	-0.02136	0.00617	0.05828	0.10343	0.12543	261
0.12827	0.12508	0.12369	0.11958	0.11592	0.10808	0.08350	0.03817	262
-0.00725	-0.02812	-0.03448	-0.03430	-0.01181	0.01915	0.04757	0.08776	263
0.10702	0.08153	0.05081	0.04456	0.04757	0.03963	0.02836	0.02343	264
0.02105	0.02411	0.03383	0.03660	0.03267	0.03267	0.03124	0.02708	265
0.02340	0.02195	0.01833	0.01118	0.00422	-0.01040	-0.03481	-0.05658	266
-0.06442	-0.06328	-0.06315	-0.05607	-0.03116	-0.00300	0.00467	-0.01590	267
-0.03414	-0.02546	-0.01519	-0.00927	-0.00785	-0.02015	-0.03655	-0.04928	268
-0.04753	-0.03607	-0.02557	-0.01855	-0.02376	-0.04230	-0.05944	-0.05615	269
-0.03722	-0.01489	0.00661	0.01665	0.01820	0.02410	0.03552	0.03743	270
0.02524	0.01588	0.00984	-0.00337	-0.02609	-0.03577	-0.02342	-0.02651	271
-0.04141	-0.03900	-0.03996	-0.05987	-0.07288	-0.06972	-0.05630	-0.03898	272
-0.03238	-0.03061	-0.02836	-0.02761	-0.02560	-0.02267	-0.02237	-0.02819	273
-0.02926	-0.02017	-0.01678	-0.02066	-0.01874	-0.01229	-0.01250	-0.02941	274
-0.05520	-0.06286	-0.05180	-0.05143	-0.06669	-0.07635	-0.07409	-0.06564	275
-0.05432	-0.04222	-0.02764	-0.02106	-0.02980	-0.03730	-0.02935	-0.01766	276
-0.01587	-0.01467	-0.01077	-0.00717	0.00136	0.01851	0.03460	0.03787	277
0.03396	0.03195	0.03413	0.03584	0.03718	0.03524	0.02465	0.01546	278
0.01459	0.02073	0.03535	0.05370	0.05595	0.03385	0.00942	0.00554	279
0.01195	0.01092	0.00929	0.01135	0.01239	0.01567	0.02118	0.01909	280
0.01418	0.01688	0.01917	0.01486	0.00712	-0.00490	-0.02066	-0.03406	281
-0.03927	-0.03514	-0.02892	-0.02451	-0.02076	-0.02331	-0.02971	-0.02735	282
-0.02038	-0.01797	-0.01574	-0.00862	0.00126	0.00480	0.00055	-0.00321	283
-0.00232	0.00268	0.00693	0.00917	0.01203	0.01197	0.00972	0.01100	284
0.01228	0.01155	0.01210	0.01240	0.01244	0.01362	0.01399	0.01315	285
0.01086	0.00836	0.00741	0.00742	0.00771	0.00741	0.00663	0.00518	286
0.00362	0.00287	0.00283	0.00297	0.00307	0.00314	0.00299	0.00260	287
0.00197	0.00137	0.00112	0.00119					288

2

1	17	18	GROUT VAULT SITE					
1	1	1	12.92	6522.	0.05	0.1050	6522.	1.
2	1	1	10.58	17034.	0.05	0.1100	17034.	1.
3	1	1	9.33	17034.	0.05	0.1100	17034.	1.
4	1	1	12.25	17034.	0.05	0.1100	17034.	1.
5	1	1	6.92	17034.	0.05	0.1100	17034.	1.
6	1	1	13.00	26516.	0.05	0.1100	26516.	1.
7	1	1	15.00	26516.	0.05	0.1100	26516.	1.
8	1	1	20.00	26516.	0.05	0.1100	26516.	1.
9	1	1	20.00	26516.	0.05	0.1100	26516.	1.
10	1	1	25.00	48524.	0.05	0.1250	48524.	1.
11	1	1	25.00	48524.	0.05	0.1250	48524.	1.
12	1	1	30.00	48524.	0.05	0.1250	48524.	1.
13	1	1	30.00	48524.	0.05	0.1250	48524.	1.
14	1	1	30.00	48524.	0.05	0.1250	48524.	1.
15	1	1	35.00	48524.	0.05	0.1250	48524.	1.

```
  16    1    1   35.00     48524.      0.05    0.1250             48524.  1.
  17    1                  98100.              0.1500
   3
   1    0
   4
   0    5   5.       0.65
   5
   1    2    3    4    5    6    7    8    9   10   11   12   13   14   18
   1    1    1    1    1    1    1    1    1    1    1    1    1    1    1
   1    1    1    1    1    1    1    1                                  1
   9
   1    1
   3    0    1    1    4
 0.05      0.07      0.10
   9
   2    1
   3    0    1    1    4
 0.05      0.07      0.10
   9
   6    1
   3    0    1    1    4
 0.05      0.07      0.10
   9
   8    1
   3    0    1    1    4
 0.05      0.07      0.10
   0
```

*********** Excerpt from SHAKE output for upper-bound soil properties ***********
Filename: shake2.out

[omitted portion of output here]

EARTHQUAKE - WHC-SD-GN-DA-30018 TH1.
SOIL PROFILE - GROUT VAULT SITE

ITERATION NUMBER 2
THE CALCULATION HAS BEEN CARRIED OUT IN THE TIME DOMAIN WITH EFF. STRAIN = .65* MAX. STRAIN

LAYER	TYPE	DEPTH	EFF. STRAIN	NEW DAMP.	DAMP USED	ERROR	NEW G	G USED	ERROR
1	1	6.5	0.00150	0.012	0.012	-0.1	6364.66	6364.28	0.0
2	1	18.2	0.00161	0.012	0.012	0.0	16582.47	16581.96	0.0
3	1	28.2	0.00250	0.014	0.014	0.4	16320.28	16328.75	-0.1
4	1	39.0	0.00344	0.016	0.015	1.5	16057.77	16098.26	-0.3
5	1	48.5	0.00426	0.018	0.017	2.3	15740.06	15809.65	-0.4
6	1	58.5	0.00314	0.015	0.015	0.8	25196.53	25220.78	-0.1
7	1	72.5	0.00382	0.017	0.016	1.9	24756.06	24840.64	-0.3
8	1	90.0	0.00462	0.018	0.018	2.4	24317.05	24431.96	-0.5
9	1	110.0	0.00563	0.020	0.019	3.3	23860.87	24037.07	-0.7
10	1	132.5	0.00361	0.016	0.016	2.6	45542.57	45743.09	-0.4
11	1	157.5	0.00444	0.018	0.017	3.3	44665.18	44953.45	-0.6
12	1	185.0	0.00528	0.019	0.019	3.5	43936.21	44262.97	-0.7
13	1	215.0	0.00610	0.021	0.020	3.8	43330.02	43710.27	-0.9
14	1	245.0	0.00676	0.022	0.021	3.8	42891.67	43288.68	-0.9
15	1	277.5	0.00729	0.022	0.021	3.6	42574.62	42961.26	-0.9
16	1	312.5	0.00771	0.023	0.022	3.6	42338.45	42731.54	-0.9

VALUES IN TIME DOMAIN

LAYER	TYPE	THICKNESS FT	DEPTH FT	MAX STRAIN PRCNT	MAX STRESS PSF	TIME SEC
1	1	12.9	6.5	0.00231	147.00	19.18
2	1	10.6	18.2	0.00247	410.16	19.18
3	1	9.3	28.2	0.00385	628.51	19.18

4	1	12.3	39.0	0.00529	849.25	19.18
5	1	6.9	48.5	0.00656	1031.99	19.17
6	1	13.0	58.5	0.00483	1216.55	19.17
7	1	15.0	72.5	0.00587	1453.35	19.17
8	1	20.0	90.0	0.00710	1727.56	19.16
9	1	20.0	110.0	0.00866	2066.72	19.15
10	1	25.0	132.5	0.00555	2526.03	19.14
11	1	25.0	157.5	0.00683	3051.09	19.14
12	1	30.0	185.0	0.00812	3568.37	19.14
13	1	30.0	215.0	0.00938	4063.86	19.13
14	1	30.0	245.0	0.01041	4463.95	19.13
15	1	35.0	277.5	0.01122	4777.35	19.13
16	1	35.0	312.5	0.01187	5024.83	19.12

PERIOD = 0.44 FROM AVERAGE SHEARVEL. = 2994.

MAXIMUM AMPLIFICATION = 33.44
FOR FREQUENCY = 2.56 C/SEC.
PERIOD = 0.39 SEC.

FILENAME : print.fil DATE : 10-07-94 TIME : 10:25a PAGE 24
TITLE : SHAKE input and excerpts from output

****** OPTION 5 *** COMPUTE MOTION IN NEW SUBLAYERS

EARTHQUAKE - WHC-SD-GN-DA-30018 TH1.
SOIL DEPOSIT - GROUT VAULT SITE

LAYER	DEPTH FT	MAX. ACC. G	TIME SEC	MEAN SQ. FR. C/SEC	ACC. RATIO QUIET ZONE	PUNCHED CARDS ACC. RECORD
WITHIN	0.0	0.21591	18.10	3.59	0.002	1
WITHIN	12.9	0.20534	19.18	3.26	0.001	1
WITHIN	23.5	0.19785	19.17	3.01	0.001	1
WITHIN	32.8	0.18917	19.17	2.73	0.000	1
WITHIN	45.1	0.17649	19.16	2.38	0.001	1
WITHIN	52.0	0.17628	19.15	2.25	0.001	1
WITHIN	65.0	0.18204	19.14	2.19	0.002	1
WITHIN	80.0	0.18723	19.14	2.20	0.002	1
WITHIN	100.0	0.18856	19.13	2.30	0.001	1
WITHIN	120.0	0.18504	19.13	2.41	0.000	1
WITHIN	145.0	0.17652	19.13	2.43	0.001	1
WITHIN	170.0	0.16129	19.13	2.35	0.001	1
WITHIN	200.0	0.14282	19.12	2.24	0.001	1
WITHIN	230.0	0.12756	19.10	2.21	0.000	1
WITHIN	0.0	0.10959	19.18	3.59	0.003	1

[omitted portion of output here]

I.2 TANK-TO-TANK INTERACTION HALF MODEL (LOWER-BOUND SOIL PROPERTIES)

The set of SASSI inputs provided in this section models the following set of conditions:

Run ID:	TTTLOW
Excitation direction:	Horizontal
Model type:	TTI half model with 1053 interaction nodes
Soil properties:	Lower-bound
Tank stiffness:	Best-estimate
Waste effects:	Impulsive (100% of mass)
Live load mass:	None

SASSI Input File	Description
tttlowa.jci to tttlowf.jci, combin.jci	Job control (also ANALYS & COMBIN input)
site.inp	SITE input
point.inp	POINT input
house.inp	HOUSE input
motion.inp	MOTION input
stress180.inp	STRESS input (elements along 180° meridian)

I.3 QUARTER MODEL FOR VERTICAL EXCITATION (LOWER-BOUND SOIL PROPERTIES)

The set of SASSI inputs provided in this section models the following set of conditions:

Run ID:	QLOWVLIV
Excitation direction:	Vertical
Model type:	Baseline quarter model with 558 interaction nodes
Soil properties:	Lower-bound
Tank stiffness:	Best-estimate
Waste effects:	Impulsive (100% of mass)
Live load mass:	100 tons concentrated over center of dome

SASSI Input File	Description
qlowliv.jci	Job control (also ANALYS & COMBIN input)
site19.inp	SITE input
point4.inp	POINT input
houseliv.inp	HOUSE input
motion.inp	MOTION input
stress180.inp	STRESS input (elements along 180° meridian)

I.4 COARSE QUARTER MODEL FOR HORIZONTAL EXCITATION (UPPER-BOUND SOIL PROPERTIES)

The set of SASSI inputs provided in this section models the following set of conditions:

Run ID: QHI
Excitation direction: Horizontal
Model type: Coarse quarter model with 95 interaction nodes
Soil properties: Upper-bound
Tank stiffness: Best-estimate
Waste effects: Impulsive (100% of mass)
Live load mass: None

SASSI Input File	Description
qhi.jci	Job control (also ANALYS & COMBIN input)
site.inp	SITE input
point.inp	POINT input
house.inp	HOUSE input
(not included)	MOTION input
(not included)	STRESS input (elements along 180° meridian)

I.5 COARSE QUARTER MODEL WITH LOWER-BOUND TANK STIFFNESS (BEST-ESTIMATE SOIL PROPERTIES)

The set of SASSI inputs provided in this section models the following set of conditions:

Run ID: Q9
Excitation direction: Horizontal
Model type: Coarse quarter model with 95 interaction nodes
Soil properties: Best-estimate
Tank stiffness: Lower-Bound
Waste effects: Impulsive (100% of mass)
Live load mass: None

SASSI Input File	Description
anal.nqs	Job control (also ANALYS & COMBIN input)
site	SITE input
point	POINT input
house	HOUSE input
(not included)	MOTION input
(not included)	STRESS input (elements along 180° meridian)

I.6 QUARTER MODEL WITH PITS AND RISERS FOR Y-DIRECTION HORIZONTAL EXCITATION (BEST-ESTIMATE SOIL PROPERTIES)

The set of SASSI inputs provided in this section models the following set of conditions:

Run ID:	Q7risers (y-dir)
Excitation direction:	Horizontal (Y-direction)
Model type:	Baseline quarter model with 558 interaction nodes
Soil properties:	Best-estimate
Tank stiffness:	Best-estimate (pits and risers included)
Waste effects:	Impulsive (100% of mass)
Live load mass:	None

SASSI Input File	Description
q7ris-y.jci	Job control (also ANALYS & COMBIN input)
sitey.inp	SITE input
point.inp	POINT input
housey.inp	HOUSE input
motiony.inp	MOTION input
stress180.inp	STRESS input (elements along 180° meridian)

APPENDIX J

COMPUTER PROGRAM FOR HOUSE-TO-ANSYS CONVERSION (CONV3)

This appendix contains a listing of a FORTRAN program (CONV3) that was developed to convert a HOUSE input file into an ANSYS PREP7 input file. Since SASSI has no preprocessing/plotting capability, all plots of the model were made via ANSYS PREP7. PREP7 files also were utilized in checking boundary conditions, material types, and section properties of the numerous HOUSE models.

```
      Program Conv3

c  This version produces ANSYS element numbers identical to the
c  SASSI element numbers and assigns proper material constants to
c  shell elements.

      Character Title*72
      Character D(6)*4

      Integer*2 NUMNP, NUMEG, NUML, NIMP

      Real      x(3)
      Real      rp(99)
      Integer*2 Nrp

      Integer*2 N1,N2,N3,N4,N5,N6,N7,N8,N(8),M(8)
      Integer*2 T8,T7,T6,T5,T4,TE
      Integer*2 NC,NL(8)

      Equivalence(N(1),N1)
      Equivalence(N(2),N2)
      Equivalence(N(3),N3)
      Equivalence(N(4),N4)
      Equivalence(N(5),N5)
      Equivalence(N(6),N6)
      Equivalence(N(7),N7)
      Equivalence(N(8),N8)

      Write(*,'(1x,6h/PREP7)')
      Read(*,'(8x,A72)') Title
      Write(*,'(1x,7h/TITLE,,A72)')Title
      write(*,999)
  999 format(' /out,junk,dat'/
     &          ' /vup,1,z'/
     &          ' /view,1,1,-1,1'/
     &          ' /show,,,2'/
     &          ' /type,1,2'/
     &          ' /num,2')

      Read(*,*)
      Read(*,'(I5,5x,2I5,10x,I5)') NUMNP, NUMEG, NUML, NIMP

      If(NIMP .ne. 1) Then
         Write(*,*) ' Only direct method is implemented !'
         Stop
      Endif

      Read(*,*)
      Read(*,*)

C Nodal Generation

      Write(*,'(1x, 7hC***   )')
      Write(*,'(1x,12hC***   Nodes)')
      Write(*,'(1x, 7hC***   )')

    1 Read(*,*)i, (N(j),j=1,6), x

         ND = 0
         Do j = 1, 6
            If(N(j) .eq. 1) Then
               ND = ND + 1
               If(    j .eq. 1) Then
                  D(ND) = '  UX'
               Elseif(j .eq. 2) Then
                  D(ND) = '  UY'
               Elseif(j .eq. 3) Then
                  D(ND) = '  UZ'
               Elseif(j .eq. 4) Then
                  D(ND) = 'ROTX'
```

```
            Elseif(j .eq. 5) Then
               D(ND) = "ROTY"
            Elseif(j .eq. 6) Then
               D(ND) = "ROTZ"
            Endif
         Endif
      Enddo

      If(ND .eq. 0) Then
         Write(*,101)i,x
 101     Format(1x,2hN,i5,3(1h,F9.3))
      Else
         Write(*,102)i,x,i,(D(j),j=1,ND)
 102    Format(1x,2hN,i5,3(1h,F9.3),3x,3h$D,i5,1h,a4,4h,,,,,5(1h,a4))
      Endif

   If(i .ne. NUMNP) Goto 1

   Read(*,*)i
   If(i .ne. 0) Then
      j = (i-1)/16 + 1
      Do k = 1, j
         Read(*,*)
      Enddo
   Endif

   Do k = 1, NUML
      Read(*,*)
   Enddo

   Do i = 1, NUMEG,1

      Read(*,*)K1,K2,K3

      If(K1 .eq. 1) Then

         Write(*,'(1x, 7hC***    )')
         Write(*,'(1x,20hC***    Element Group, I4)')i
         Write(*,'(1x,20hC***    3-D Solid         )')
         Write(*,'(1x, 7hC***    )')

         Write(*,'(1x, 3hET,i3,4h, 45 )')i

         Write(*,'(1x,31hR,1,1.00    * Soil        Element)')
         Write(*,'(1x,31hR,2,2.00    * Structural Element)')

         Do k = 1, K3
            Read(*,*)
            Write(*,'(1x,3hEX,,i4,5h,3.e7,3x,6h$DENS,,i4,5h,.003,)')
 +          i*100+k, i*100+k
         Enddo

         Write(*,'(1x, 5hTYPE,i3 )')i

         T8 = 0
         T7 = 0
         T6 = 0
         T5 = 0
         T4 = 0
         TB = 0

         NT = 0

  11     Read(*,*)NE,N,M1,M2,M3
         If(M2 .eq.  1) M2 = 2
         If(M2 .eq. -1) M2 = 1
         M3 = i*100+M3

         NT = NT + 1
         NC = 0
```

```
          Do ii = 1, 8
             Iflg = 0
             do j = 1, NC
                If(NL(j) .eq. N(ii)) Iflg = 1
             Enddo
             If(Iflg .eq. 0) Then
                NC = NC + 1
                NL(NC) = N(ii)
             Endif
          Enddo

          Iflg = 0

          If(NC .eq. 8) Then
             T8 = T8 + 1
             Iflg = 1
             write(*,201) M2, M3, NE, N
 201 Format(1x,5hReal,,I1,3x,5h$MAT,,I3,3x,4h$EN,,I5,8(1h,I5))
          Elseif(NC .eq. 7) Then
             T7 = T7 + 1
             If(N7 .eq. N8) Then
                Iflg = 1
             Endif
             write(*,901) M2, M3, NE, N, NC
 901 Format(1x,5hReal,,I1,3x,5h$MAT,,I3,3x,3hERR,I5,9(1h,I5))
          Elseif(NC .eq. 6) Then
             T6 = T6 + 1
             If(    N7 .eq. N8 .and. N5 .eq. N6) Then
                Iflg = 1
                M(1) = N(1)
                M(2) = N(2)
                M(3) = N(5)
                M(4) = N(6)
                M(5) = N(4)
                M(6) = N(3)
                M(7) = N(7)
                M(8) = N(8)
             Elseif(N3 .eq. N4 .and. N7 .eq. N8) Then
                Iflg = 2
                M(1) = N(1)
                M(2) = N(2)
                M(3) = N(3)
                M(4) = N(4)
                M(5) = N(5)
                M(6) = N(6)
                M(7) = N(7)
                M(8) = N(8)
             Elseif(N3 .eq. N7 .and. N4 .eq. N8) Then
                Iflg = 3
                M(1) = N(1)
                M(2) = N(4)
                M(3) = N(5)
                M(4) = N(5)
                M(5) = N(2)
                M(6) = N(3)
                M(7) = N(6)
                M(8) = N(6)
             Elseif(N1 .eq. N4 .and. N5 .eq. N8) Then
                Iflg = 4
                M(1) = N(1)
                M(2) = N(2)
                M(3) = N(3)
                M(4) = N(3)
                M(5) = N(5)
                M(6) = N(6)
                M(7) = N(7)
                M(8) = N(7)
             Else
                write(*,901) M2, M3, NE, N, NC
```

```
        Endif
        write(*,201) M2, M3, NE, M
      Elseif(NC .eq. 5) Then
        T5 = T5 + 1
        If(    N7 .eq. N8 .and. N5 .eq. N6 .and. N7 .eq. N5) Then
          Iflg = 1
          M(1) = N(1)
          M(2) = N(2)
          M(3) = N(3)
          M(4) = N(4)
          M(5) = N(5)
          M(6) = N(5)
          M(7) = N(5)
          M(8) = N(5)
          write(*,201) M2, M3, NE, M
        Elseif(N1 .eq. N4 .and. N5 .eq. N8 .and. N6 .eq. N7) Then
          Iflg = 2
          M(1) = N(1)
          M(2) = N(2)
          M(3) = N(6)
          M(4) = N(5)
          M(5) = N(3)
          M(6) = N(3)
          M(7) = N(3)
          M(8) = N(3)
          write(*,201) M2, M3, NE, M
        Else
          write(*,901) M2, M3, NE, N, NC
        Endif
      Elseif(NC .eq. 4) Then
        T4 = T4 + 1
        If(    N7 .eq. N8 .and. N3 .eq. N4 .and.
     +         N1 .eq. N5 .and. N2 .eq. N6      ) Then
          Iflg = 1
          M(1) = N(1)
          M(2) = N(2)
          M(3) = N(3)
          M(4) = N(3)
          M(5) = N(7)
          M(6) = N(7)
          M(7) = N(7)
          M(8) = N(7)
          write(*,201) M2, M3, NE, M
        Elseif(N5 .eq. N6 .and. N7 .eq. N8 .and.
     +         N5 .eq. N7 .and. N1 .eq. N4      ) Then
          Iflg = 2
          M(1) = N(1)
          M(2) = N(2)
          M(3) = N(3)
          M(4) = N(3)
          M(5) = N(7)
          M(6) = N(7)
          M(7) = N(7)
          M(8) = N(7)
          write(*,201) M2, M3, NE, M
        Elseif(N3 .eq. N4 .and. N7 .eq. N8 .and.
     +         N3 .eq. N7 .and. N2 .eq. N6      ) Then
          Iflg = 3
          M(1) = N(1)
          M(2) = N(2)
          M(3) = N(3)
          M(4) = N(3)
          M(5) = N(5)
          M(6) = N(5)
          M(7) = N(5)
          M(8) = N(5)
          write(*,201) M2, M3, NE, M
        Elseif(N3 .eq. N4 .and. N7 .eq. N8 .and.
     +         N3 .eq. N7 .and. N1 .eq. N5      ) Then
          Iflg = 4
```

```
                M(1) = N(1)
                M(2) = N(2)
                M(3) = N(3)
                M(4) = N(3)
                M(5) = N(6)
                M(6) = N(6)
                M(7) = N(6)
                M(8) = N(6)
                write(*,201) M2, M3, NE, M
             Elseif(N3 .eq. N4 .and. N5 .eq. N6 .and.
     +              N7 .eq. N8 .and. N5 .eq. N7       ) Then
                Iflg = 5
                M(1) = N(1)
                M(2) = N(2)
                M(3) = N(3)
                M(4) = N(3)
                M(5) = N(5)
                M(6) = N(5)
                M(7) = N(5)
                M(8) = N(5)
                write(*,201) M2, M3, NE, M
             Else
                write(*,901) M2, M3, NE, N, NC
             Endif
          Else
             TE = TE + 1
             write(*,'(1x,9I5,5x,4h*** ,I1,4h ERR)')NE,N,NC
          Endif

          If(NE .ne. K2)Goto 11

       Elseif(K1 .eq. 3) Then

          Write(*,'(1x, 7hC***    )')
          Write(*,'(1x,20hC***    Element Group, I4)')i
          Write(*,'(1x,20hC***    Plate/Shell      )')
          Write(*,'(1x, 7hC***    )')

          Write(*,'(1x, 3hET,i3,4h, 63 )')i

          Do k = 1, K3
             Read(*,*)mat,E,pr,den
             Write(*,'(1x,3hEX,,i4,1h,e10.4,3x,6h$DENS,,i4,1h,,f6.4,
     +       3x,6h$NUXY,,i4,1h,,f4.2)') k,E,k,den,k,pr
          Enddo

          Nrp = 0

          Open(11,File='tmp.tmp')

 31       Read(  *,'(5I5,5x,I5,5x,F10.3)')NE,N1,N2,N3,N4,M3,thick
          Write(11,'(5I5,5x,I5,5x,F10.3)')NE,N1,N2,N3,N4,M3,thick

          Iflg = 0
          Do j = 1, Nrp
             If(abs((rp(j)-thick)/thick) .lt. 0.00001) Iflg = 1
          Enddo

          If(Iflg .eq. 0) Then
             Nrp = Nrp + 1
             rp(Nrp) = thick
          Endif

          If(NE .ne. K2)Goto 31

          Rewind(11)
c  assign shell reals
          Do j = 1, Nrp
             Write(*,300)i*100+j,rp(j)
 300         Format(1x,2hR,,i4,1h,F9.4,3x,17h* Plate Thickness)
```

```
          Enddo

          Write(*,'(1x, 5hTYPE,i3 )')i

 32       Read(11,'(5I5,5x,I5,5x,F10.0)')NE,N1,N2,N3,N4,M3,thick

          M2 = 999

          Do j = 1, Nrp
             If(abs((rp(j)-thick)/thick) .lt. 0.001) M2 = i*100+j
          Enddo

c          M3 = i*100+M3

          If(N4 .eq. 0) N4 = N3

          write(*,301) M2, M3, NE, (N(j),j=1,4)

301 Format(1x,5hReal,,I4,3x,5h$MAT,,I3,3x,4h$EN,,I5,4(1h,I5))

          If(NE .ne. K2)Goto 32

          Close(11)

       Else

          Write(*,*) ' Such Element Group is not implemented !'
          Stop

       Endif

    Enddo

    End
```

APPENDIX K

MATHCAD FILES FOR ROTATING NONSEISMIC DEMANDS IN HAUNCH ELEMENTS INTO PRINCIPAL TANK DIRECTIONS

ABAQUS reports shell element forces and moments in the local element coordinate system. For the ACI code evaluation, section demands must be in the principal (circumferential and meridional) directions of the tank. The convention for the ABAQUS local coordinate system is such that the local element axes at the 0°, 90°, and 180° meridians of the model are generally well-aligned with the principal tank directions. The general correlation of local axes to global axes is indicated in Figure 7.2-1 where the +1, -1, and +2 global axes are equivalent to the 0°, 180°, and 90° meridians, respectively. Exceptions arise for two haunch elements on the 0° meridian (elements 1317 and 1321) and on the 180° meridian (elements 384 and 388) which have local coordinate systems that do not align with the tank principal directions. At these locations, a transformation is made via MathCad to convert the ABAQUS nonseismic response from the local element coordinate system to the principal directions of the tank. The methodology used in the transformation is identical to that used in Appendix B of WHC-SD-W340-ANAL-001 (Marlow 1994). This methodology makes use of the fact that the principal stress directions for axisymmetric loading on the axisymmetric structure are nearly aligned with the circumferential and meridional directions of the structure. The principal stress directions associated with the axisymmetric response of the tank to nonseismic Load Case 1a are taken as the principal directions for all nonseismic loading conditions.

The nonseismic demands for elements 384, 388, 1317, and 1321 as transformed by MathCad are included in the spreadsheets listed in Appendix M.

Compute Rotated Moments and Forces for Element 384 - Load Case 1a

(r384-1a.mcd)

$$M := \begin{pmatrix} 193716 & -74508 \\ -74508 & 61596 \end{pmatrix} \qquad F := \begin{pmatrix} -18540 & 26722 \\ 26722 & 27180 \end{pmatrix}$$

Define in-plane forces and moments for element 384. Units are lbf/ft and in-lbf/ft, respectively.

$$M_I := \begin{pmatrix} 193716 & -74508 \\ -74508 & 61596 \end{pmatrix}$$

Define moments for axisym. load case (1a).

$$c := \mathrm{eigenvals}(M_I) \qquad c = \begin{pmatrix} 2.272 \cdot 10^5 \\ 2.808 \cdot 10^4 \end{pmatrix}$$

$$u_c := \mathrm{eigenvec}(M_I, c_0) \qquad v_c := \mathrm{eigenvec}(M_I, c_1)$$

$$u_c = \begin{pmatrix} 0.912 \\ -0.41 \end{pmatrix} \qquad v_c = \begin{pmatrix} 0.41 \\ 0.912 \end{pmatrix}$$

$$R := \begin{bmatrix} (-u_c)_0 & (-u_c)_1 \\ v_{c_0} & v_{c_1} \end{bmatrix} \qquad R = \begin{pmatrix} -0.912 & 0.41 \\ 0.41 & 0.912 \end{pmatrix}$$

$$M_{code} := R \cdot M \cdot R^T \qquad M_{code} = \begin{pmatrix} 2.272 \cdot 10^5 & -2.91 \cdot 10^{-11} \\ -1.273 \cdot 10^{-11} & 2.808 \cdot 10^4 \end{pmatrix}$$

$$F_{code} := R \cdot F \cdot R^T \qquad F_{code} = \begin{pmatrix} -3.084 \cdot 10^4 & -622.665 \\ -622.665 & 3.948 \cdot 10^4 \end{pmatrix}$$

Use these values in the code check.

$$V := \begin{pmatrix} 6439 \\ -3043 \end{pmatrix}$$

Define tranverse shears for element 384 as reported by ABAQUS.

$$V_{code} := R \cdot V \qquad V_{code} = \begin{pmatrix} -7.121 \cdot 10^3 \\ -133.646 \end{pmatrix}$$

Use these values in the code check.

11 = merid
22 = circum
(+) = tension

Compute Rotated Moments and Forces for Element 388 - Load Case 1a

(r388-1a.mcd)

$M := \begin{pmatrix} 393576 & -47784 \\ -47784 & 46128 \end{pmatrix}$ $F := \begin{pmatrix} -29892 & 18000 \\ 18000 & 117360 \end{pmatrix}$

Define in-plane forces and moments for element 388.
Units are lbf/ft and in-lbf/ft, respectively.

$M_I := \begin{pmatrix} 393576 & -47784 \\ -47784 & 46128 \end{pmatrix}$

Define moments for axisym. load case (1a).

$c := \text{eigenvals}(M_I)$ $c = \begin{pmatrix} 4 \cdot 10^5 \\ 3.968 \cdot 10^4 \end{pmatrix}$

$u_c := \text{eigenvec}(M_I, c_0)$ $v_c := \text{eigenvec}(M_I, c_1)$

$u_c = \begin{pmatrix} -0.991 \\ 0.134 \end{pmatrix}$ $v_c = \begin{pmatrix} 0.134 \\ 0.991 \end{pmatrix}$

$R := \begin{bmatrix} (-u_c)_0 & (-u_c)_1 \\ v_{c_0} & v_{c_1} \end{bmatrix}$ $R = \begin{pmatrix} 0.991 & -0.134 \\ 0.134 & 0.991 \end{pmatrix}$

$M_{code} := R \cdot M \cdot R^T$ $M_{code} = \begin{pmatrix} 4 \cdot 10^5 & 0 \\ -6.366 \cdot 10^{-12} & 3.968 \cdot 10^4 \end{pmatrix}$

Use these values in the code check.

$F_{code} := R \cdot F \cdot R^T$ $F_{code} = \begin{pmatrix} -3.203 \cdot 10^4 & -2.171 \cdot 10^3 \\ -2.171 \cdot 10^3 & 1.195 \cdot 10^5 \end{pmatrix}$

$V := \begin{pmatrix} 7049 \\ -1034 \end{pmatrix}$

Define tranverse shears for element 388 as reported by ABAQUS.

$V_{code} := R \cdot V$ $V_{code} = \begin{pmatrix} 7.124 \cdot 10^3 \\ -81.496 \end{pmatrix}$

Use these values in the code check.

Compute Rotated Moments and Forces for Element 384 - Load Case 1b

(r384-1b.mcd)

$M := \begin{pmatrix} 190860 & -73872 \\ -73872 & 59880 \end{pmatrix}$ $\quad F := \begin{pmatrix} -18300 & 25380 \\ 25380 & 24924 \end{pmatrix}$

Define in-plane forces and moments for element 384. Units are lbf/ft and in-lbf/ft, respectively.

$M_I := \begin{pmatrix} 193716 & -74508 \\ -74508 & 61596 \end{pmatrix}$

Define moments for axisym. load case (1a).

$c := \text{eigenvals}(M_I)$ $\quad c = \begin{pmatrix} 2.272 \cdot 10^5 \\ 2.808 \cdot 10^4 \end{pmatrix}$

$u_c := \text{eigenvec}(M_I, c_0)$ $\quad v_c := \text{eigenvec}(M_I, c_1)$

$u_c = \begin{pmatrix} 0.912 \\ -0.41 \end{pmatrix}$ $\quad v_c = \begin{pmatrix} 0.41 \\ 0.912 \end{pmatrix}$

$R := \begin{bmatrix} (-u_c)_0 & (-u_c)_1 \\ v_{c_0} & v_{c_1} \end{bmatrix}$ $\quad R = \begin{pmatrix} -0.912 & 0.41 \\ 0.41 & 0.912 \end{pmatrix}$

$M_{code} := R \cdot M \cdot R^T$ $\quad M_{code} = \begin{pmatrix} 2.241 \cdot 10^5 & 4.573 \\ 4.573 & 2.665 \cdot 10^4 \end{pmatrix}$

Use these values in the code check.

$F_{code} := R \cdot F \cdot R^T$ $\quad F_{code} = \begin{pmatrix} -3.002 \cdot 10^4 & -666.184 \\ -666.184 & 3.664 \cdot 10^4 \end{pmatrix}$

$V := \begin{pmatrix} 6301 \\ -2987 \end{pmatrix}$

Define tranverse shears for element 384 as reported by ABAQUS.

$V_{code} := R \cdot V$ $\quad V_{code} = \begin{pmatrix} -6.972 \cdot 10^3 \\ -139.188 \end{pmatrix}$

Use these values in the code check.

Compute Rotated Moments and Forces for Element 388 - Load Case 1b

(r388-1b.mcd)

$M := \begin{pmatrix} 385692 & -47964 \\ -47964 & 37296 \end{pmatrix}$ $F := \begin{pmatrix} -29088 & 16872 \\ 16872 & 109140 \end{pmatrix}$ Define in-plane forces and moments for element 388. Units are lbf/ft and in-lbf/ft, respectively.

$M_I := \begin{pmatrix} 393576 & -47784 \\ -47784 & 46128 \end{pmatrix}$ Define moments for axisym. load case (1a).

$c := \text{eigenvals}(M_I)$ $c = \begin{pmatrix} 4 \cdot 10^5 \\ 3.968 \cdot 10^4 \end{pmatrix}$

$u_c := \text{eigenvec}(M_I, c_0)$ $v_c := \text{eigenvec}(M_I, c_1)$

$u_c = \begin{pmatrix} -0.991 \\ 0.134 \end{pmatrix}$ $v_c = \begin{pmatrix} 0.134 \\ 0.991 \end{pmatrix}$

$R := \begin{bmatrix} (-u_c)_0 & (-u_c)_1 \\ v_{c_0} & v_{c_1} \end{bmatrix}$ $R = \begin{pmatrix} 0.991 & -0.134 \\ 0.134 & 0.991 \end{pmatrix}$

$M_{code} := R \cdot M \cdot R^T$ $M_{code} = \begin{pmatrix} 3.922 \cdot 10^5 & -47.846 \\ -47.846 & 3.081 \cdot 10^4 \end{pmatrix}$

$F_{code} := R \cdot F \cdot R^T$ $F_{code} = \begin{pmatrix} -3.109 \cdot 10^4 & -2.062 \cdot 10^3 \\ -2.062 \cdot 10^3 & 1.111 \cdot 10^5 \end{pmatrix}$ Use these values in the code check.

$V := \begin{pmatrix} 6802 \\ -1005 \end{pmatrix}$ Define tranverse shears for element 388 as reported by ABAQUS.

$V_{code} := R \cdot V$ $V_{code} = \begin{pmatrix} 6.875 \cdot 10^3 \\ -85.807 \end{pmatrix}$ Use these values in the code check.

Compute Rotated Moments and Forces for Element 384 - Load Case 2 (r384-2.mcd)

$$M := \begin{pmatrix} 185676 & -72180 \\ -72180 & 57924 \end{pmatrix} \qquad F := \begin{pmatrix} -17760 & 24300 \\ 24300 & 23592 \end{pmatrix}$$

Define in-plane forces and moments for element 384. Units are lbf/ft and in-lbf/ft, respectively.

$$M_I := \begin{pmatrix} 193716 & -74508 \\ -74508 & 61596 \end{pmatrix}$$

Define moments for axisym. load case (1a).

$$c := \mathrm{eigenvals}(M_I) \qquad c = \begin{pmatrix} 2.272 \cdot 10^5 \\ 2.808 \cdot 10^4 \end{pmatrix}$$

$$u_c := \mathrm{eigenvec}(M_I, c_0) \qquad v_c := \mathrm{eigenvec}(M_I, c_1)$$

$$u_c = \begin{pmatrix} 0.912 \\ -0.41 \end{pmatrix} \qquad v_c = \begin{pmatrix} 0.41 \\ 0.912 \end{pmatrix}$$

$$R := \begin{bmatrix} (-u_c)_0 & (-u_c)_1 \\ {v_c}_0 & {v_c}_1 \end{bmatrix} \qquad R = \begin{pmatrix} -0.912 & 0.41 \\ 0.41 & 0.912 \end{pmatrix}$$

$$M_{code} := R \cdot M \cdot R^T \qquad M_{code} = \begin{pmatrix} 2.182 \cdot 10^5 & 89.759 \\ 89.759 & 2.541 \cdot 10^4 \end{pmatrix}$$

$$F_{code} := R \cdot F \cdot R^T \qquad F_{code} = \begin{pmatrix} -2.898 \cdot 10^4 & -650.063 \\ -650.063 & 3.482 \cdot 10^4 \end{pmatrix}$$

Use these values in the code check.

$$V := \begin{pmatrix} 6144 \\ -2912 \end{pmatrix}$$

Define tranverse shears for element 384 as reported by ABAQUS.

$$V_{code} := R \cdot V \qquad V_{code} = \begin{pmatrix} -6.798 \cdot 10^3 \\ -135.196 \end{pmatrix}$$

Use these values in the code check.

Compute Rotated Moments and Forces for Element 388 - Load Case 2 (r388-2.mcd)

$M := \begin{pmatrix} 375108 & -47040 \\ 47040 & 33120 \end{pmatrix}$ $F := \begin{pmatrix} -28116 & 16212 \\ 16212 & 104652 \end{pmatrix}$ Define in-plane forces and moments for element 388. Units are lbf/ft and in-lbf/ft, respectively.

$M_I := \begin{pmatrix} 393576 & -47784 \\ -47784 & 46128 \end{pmatrix}$ Define moments for axisym. load case (1a).

$c := \mathrm{eigenvals}(M_I)$ $c = \begin{pmatrix} 4 \cdot 10^5 \\ 3.968 \cdot 10^4 \end{pmatrix}$

$u_c := \mathrm{eigenvec}(M_I, c_0)$ $v_c := \mathrm{eigenvec}(M_I, c_1)$

$u_c = \begin{pmatrix} -0.991 \\ 0.134 \end{pmatrix}$ $v_c = \begin{pmatrix} 0.134 \\ 0.991 \end{pmatrix}$

$R := \begin{bmatrix} (-u_c)_0 & (-u_c)_1 \\ v_{c_0} & v_{c_1} \end{bmatrix}$ $R = \begin{pmatrix} 0.991 & -0.134 \\ 0.134 & 0.991 \end{pmatrix}$

$M_{code} := R \cdot M \cdot R^T$ $M_{code} = \begin{pmatrix} 3.815 \cdot 10^5 & -6.658 \\ -6.658 & 2.677 \cdot 10^4 \end{pmatrix}$

Use these values in the code check.

$F_{code} := R \cdot F \cdot R^T$ $F_{code} = \begin{pmatrix} -3.004 \cdot 10^4 & -1.974 \cdot 10^3 \\ -1.974 \cdot 10^3 & 1.066 \cdot 10^5 \end{pmatrix}$

$V := \begin{pmatrix} 6581 \\ -970 \end{pmatrix}$ Define tranverse shears for element 388 as reported by ABAQUS.

$V_{code} := R \cdot V$ $V_{code} = \begin{pmatrix} 6.652 \cdot 10^3 \\ -80.693 \end{pmatrix}$ Use these values in the code check.

APPENDIX L

TANK EVALUATION USING BEST-ESTIMATE SOIL PROPERTIES IN SSI ANALYSIS

Although seismic response of the tank computed using best-estimate soil properties is less than seismic response based on lower-bound soil properties, a code-based evaluation using results from the best-estimate soil analysis is provided in this appendix. The larger of the horizontal seismic demands from the lower-bound tank stiffness condition and the best-estimate tank stiffness condition are considered in calculating the total seismic response. Vertical seismic demands come solely from the best-estimate tank stiffness analysis. Spreadsheets used in the calculation of tank demands are included at the back of this appendix. Since the total demands are generally not very sensitive to the choice of nonseismic load case, only one of the nonseismic load cases (Load Case 2) is considered herein.

Figures L-1 to L-12 and Figures L-13 to L-22 provide M-P interaction diagrams for the meridional and circumferential directions, respectively. All sections meet ACI 349-90 criteria for combined moment and axial load; however, Figure L-17 warrants further discussion. In Figure L-17, it appears that a number of demands exceed capacities at circumferential capacity sections 4, 5, and/or 6. The demands labeled "bottom of wall" correspond to capacity section 4 and are thus acceptable. The demands labeled "haunch" correspond to capacity section 6 where the capacity shown considers only a portion of the actual circumferential reinforcement. The circumferential steel in the most lightly reinforced haunch element consists of 12 - 1¼ in. square bars. The area of circumferential reinforcement not considered in the capacity calculation is as follows:

$$(A_s)_{supp} = (A_s)_{haunch} - (A_s)_{capacity\ section\ 6}$$

$$= [12(1.25)^2 \times 12/23.8] - (0.72 + 0.72)$$

$$= 8.01\ in^2/ft$$

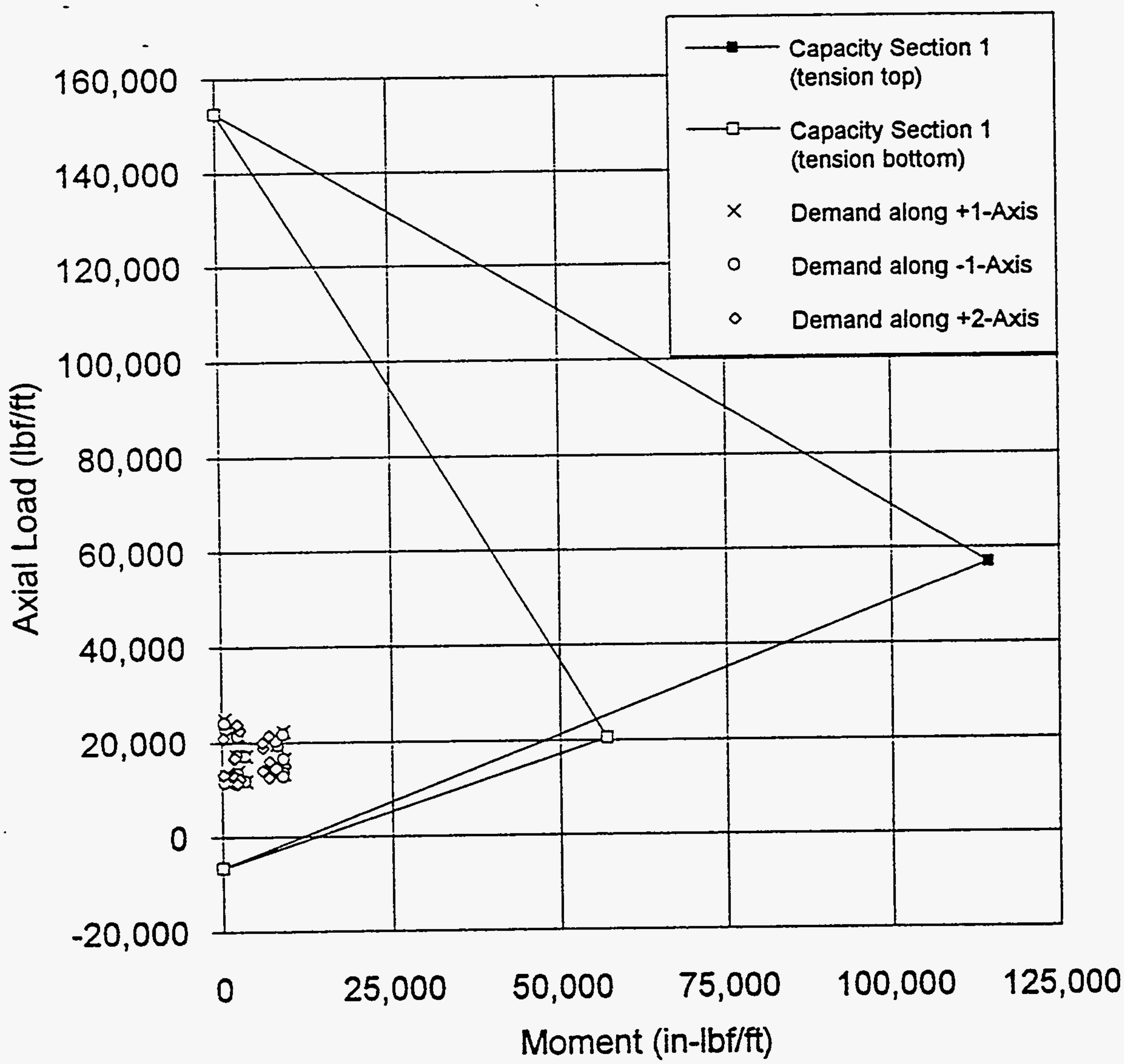
where the width of the haunch element is 23.8 in. The tensile capacity associated with the "supplemental" area of reinforcement is as follows:

$$T_{supp} = 0.9(A_s)_{supp}f_y = 0.9(8.01)38,000 = 273,900\ lbf/ft$$

This minimum additional tensile capacity in the haunch is clearly larger than the margin by which the haunch axial load demand exceeds the capacity section 6 capacity envelope. Therefore, the circumferential haunch demands shown in Figure L-17 are acceptable by this simple, rational approach.

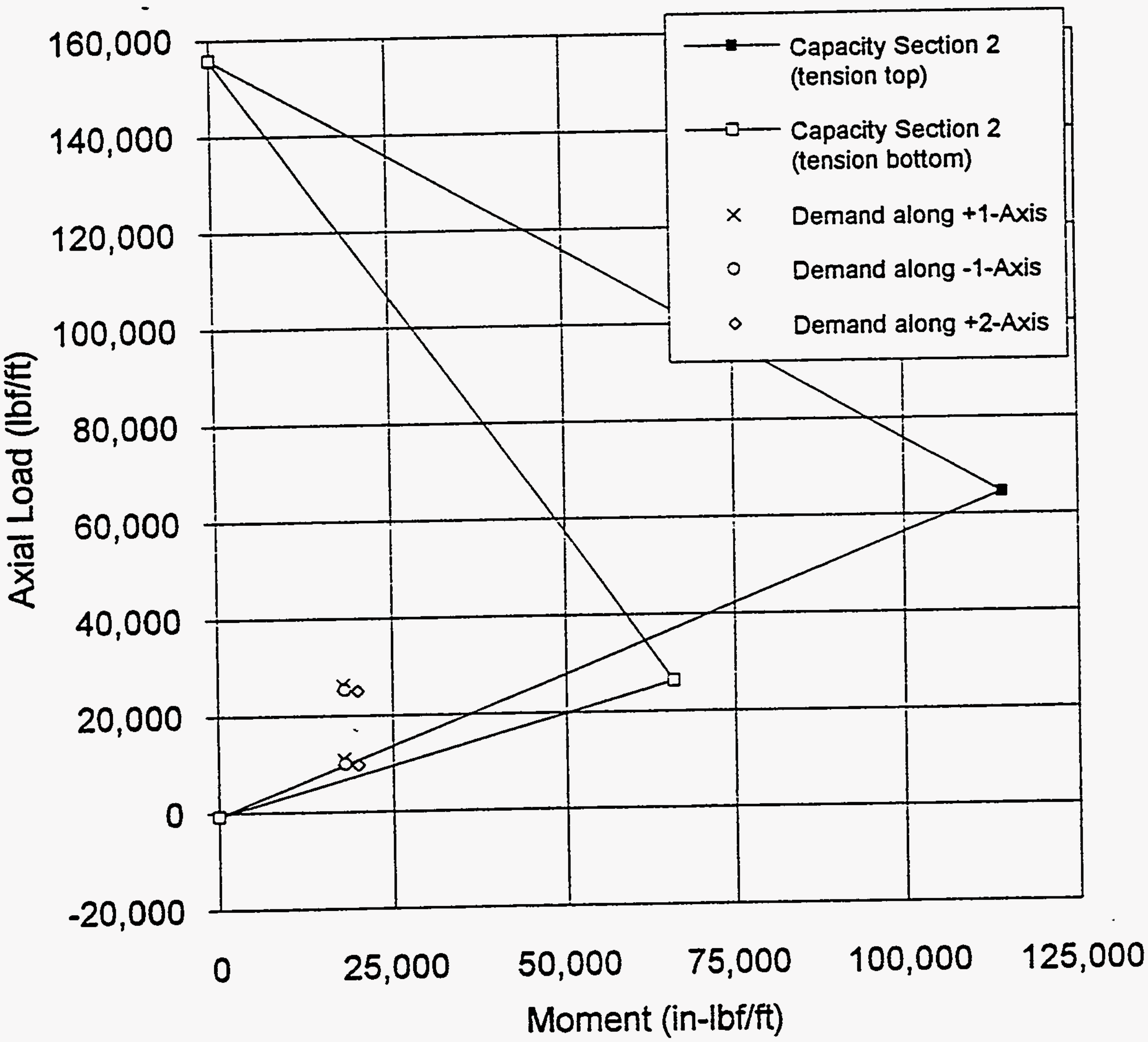
Table L-1 summarizes the code evaluation for in-plane shear and twisting moment. Transverse shear and construction joint shear friction are not checked since seismic transverse shear values were not computed for the best-estimate soil properties case (refer to Appendix G).

Figure L-1
Meridional M-P Interaction Diagram for Inner Base Sections: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



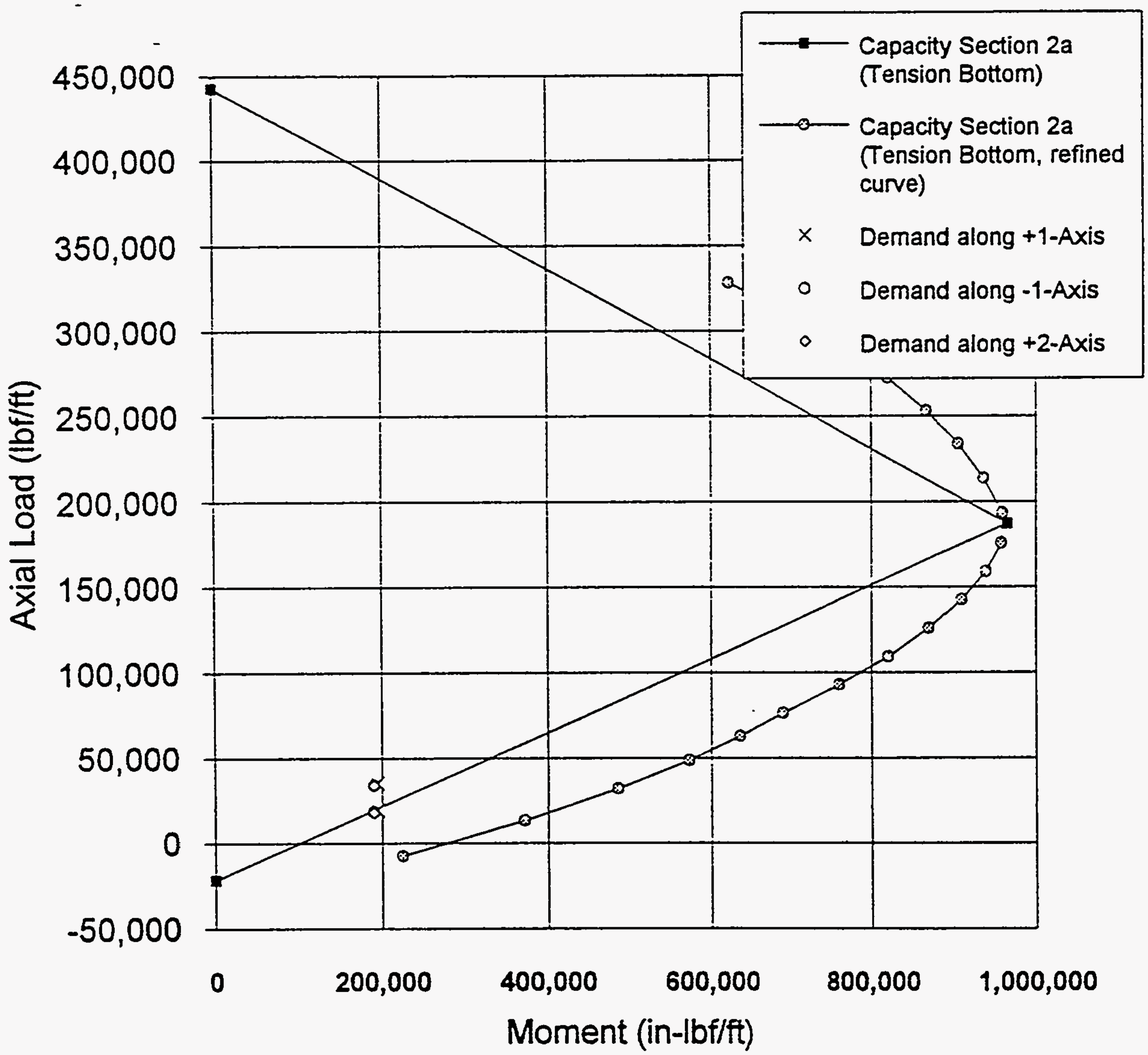
M1-1.XLC

Figure L-2
Meridional M-P Interaction Diagram for Outer Base Sections: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



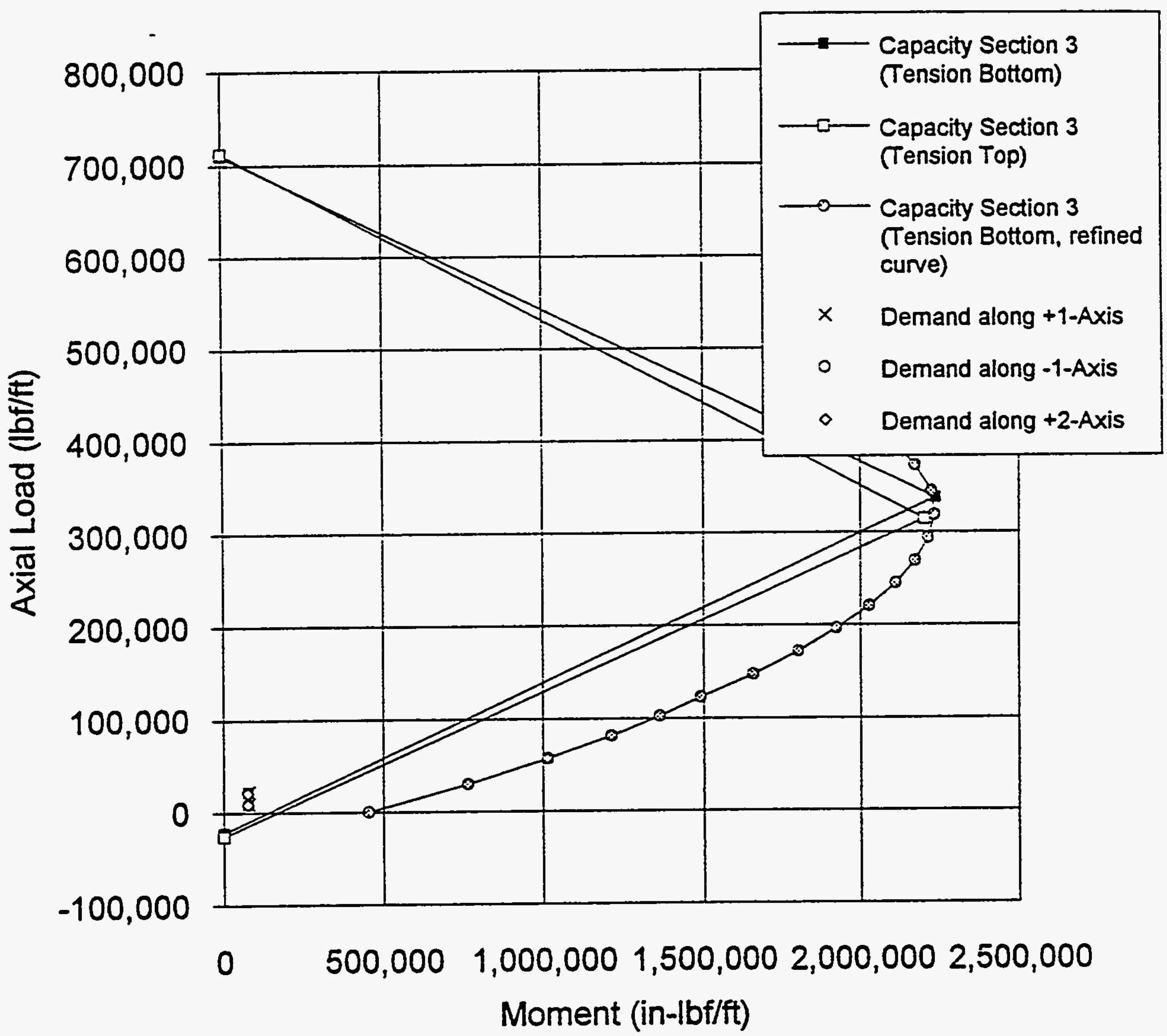
M1-2.XLC

Figure L-3
Meridional M-P Interaction Diagram for Base/Wall Interface
Section: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



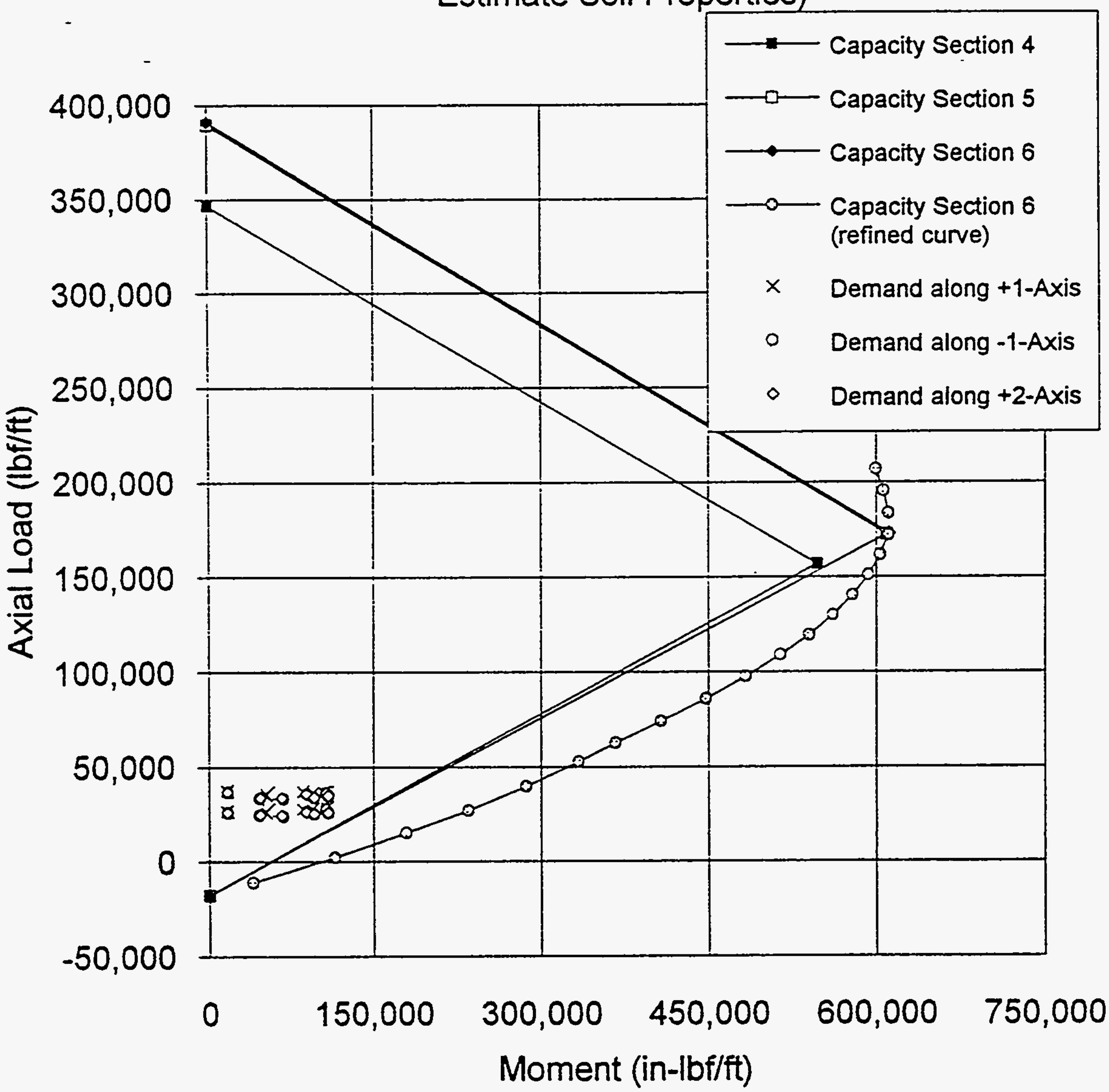
M1-2A.XLC

Figure L-4
Meridional M-P Interaction Diagram for Footing Section:
Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



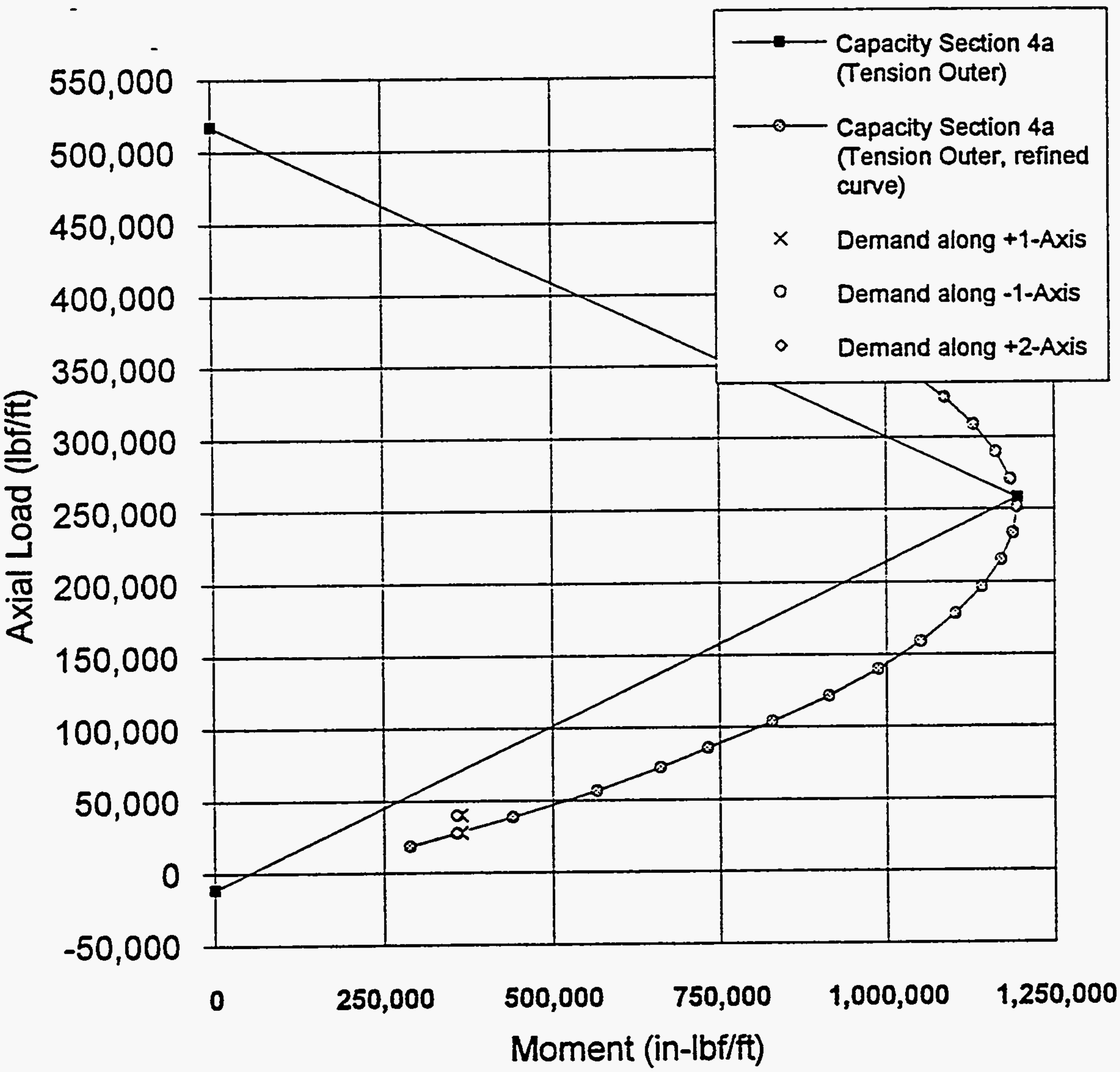
M1-3.XLC

Figure L-5
Meridional M-P Interaction Diagram for 12-In.-Thick Wall Sections: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



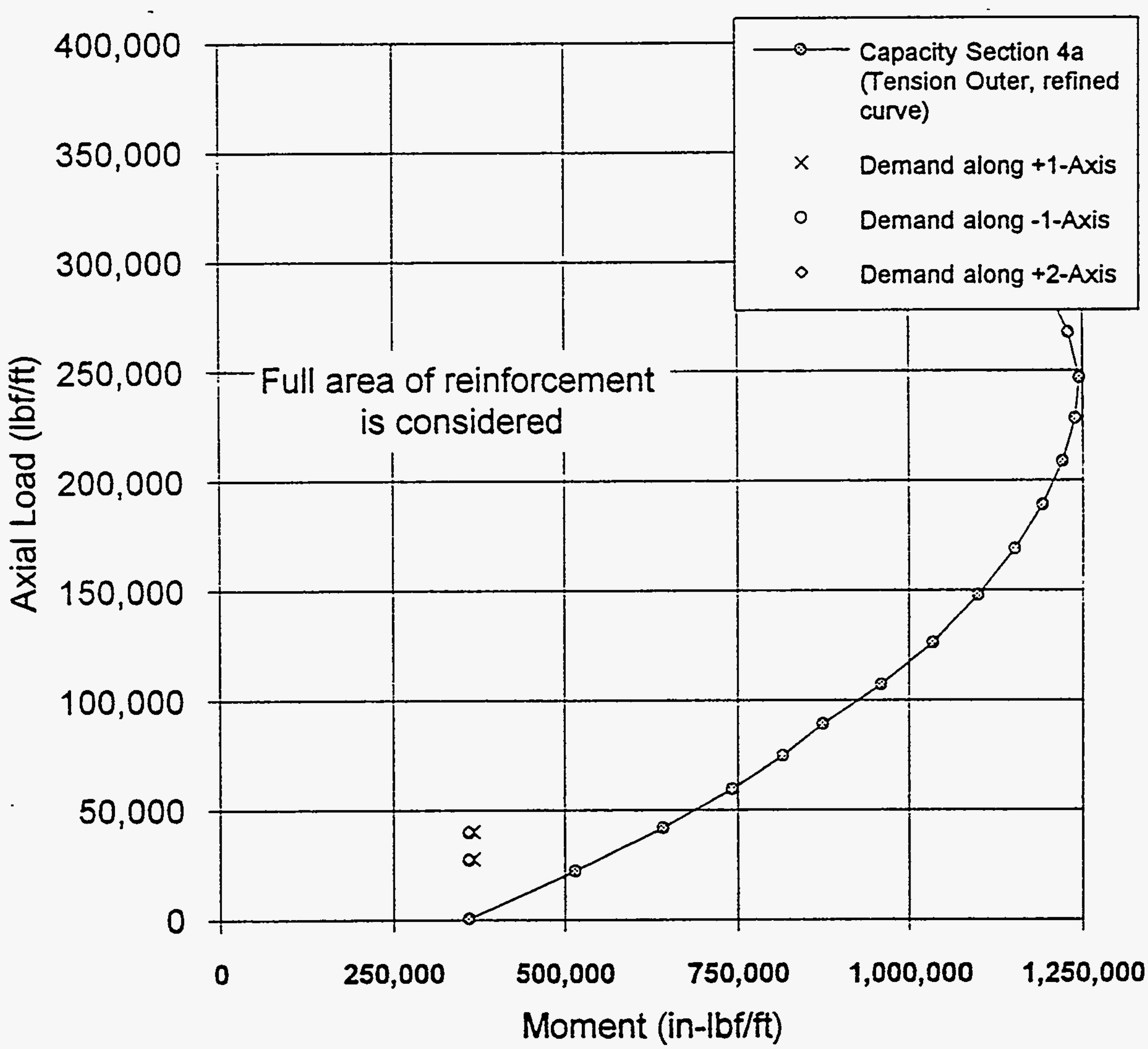
M1-456.XLC

Figure L-6
Meridional M-P Interaction Diagram for Lower Wall Section (Reduced Reinforcement): Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



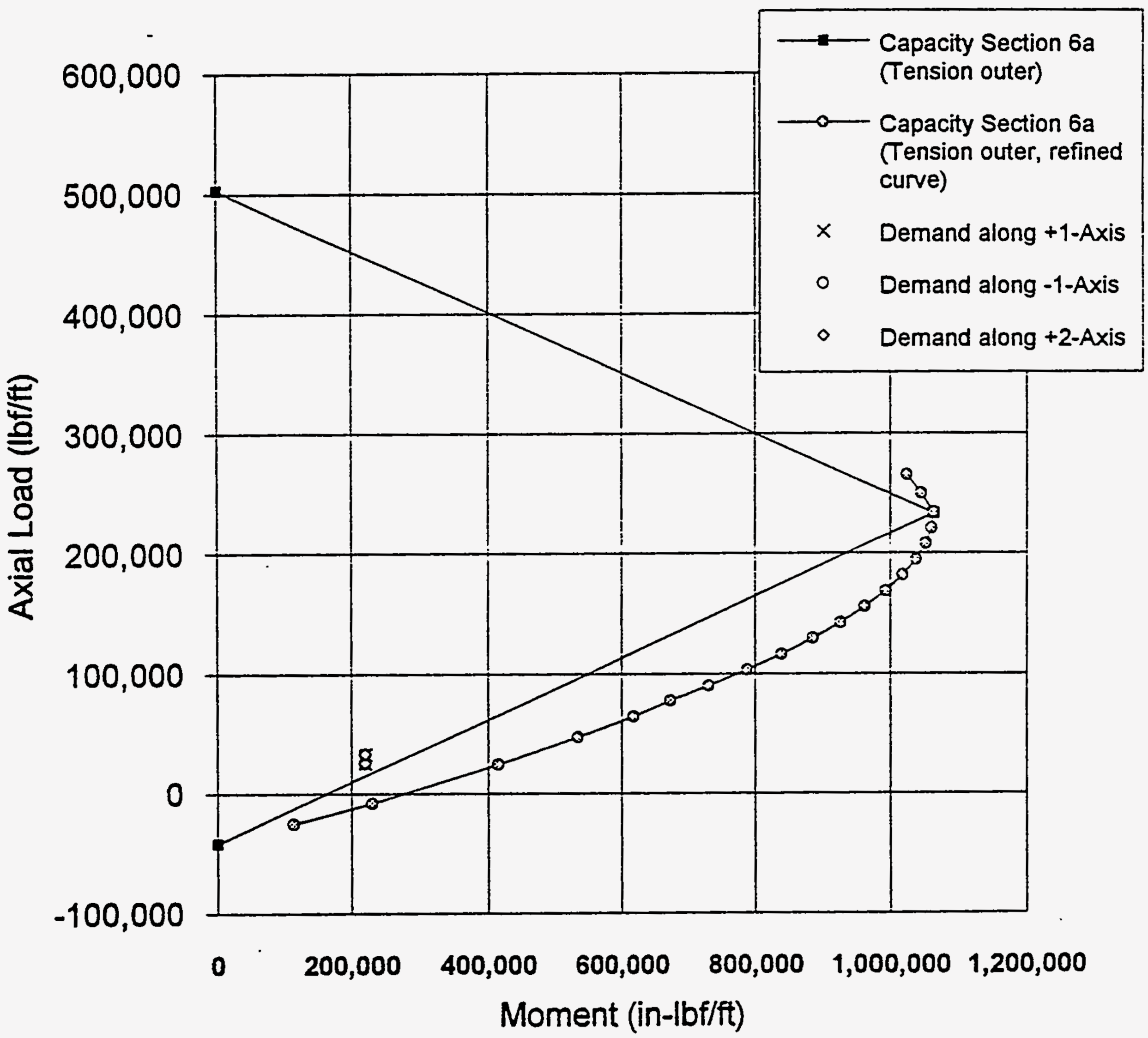
M1-4A.XLC

Figure L-7
Meridional M-P Interaction Diagram for Lower Wall Section: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



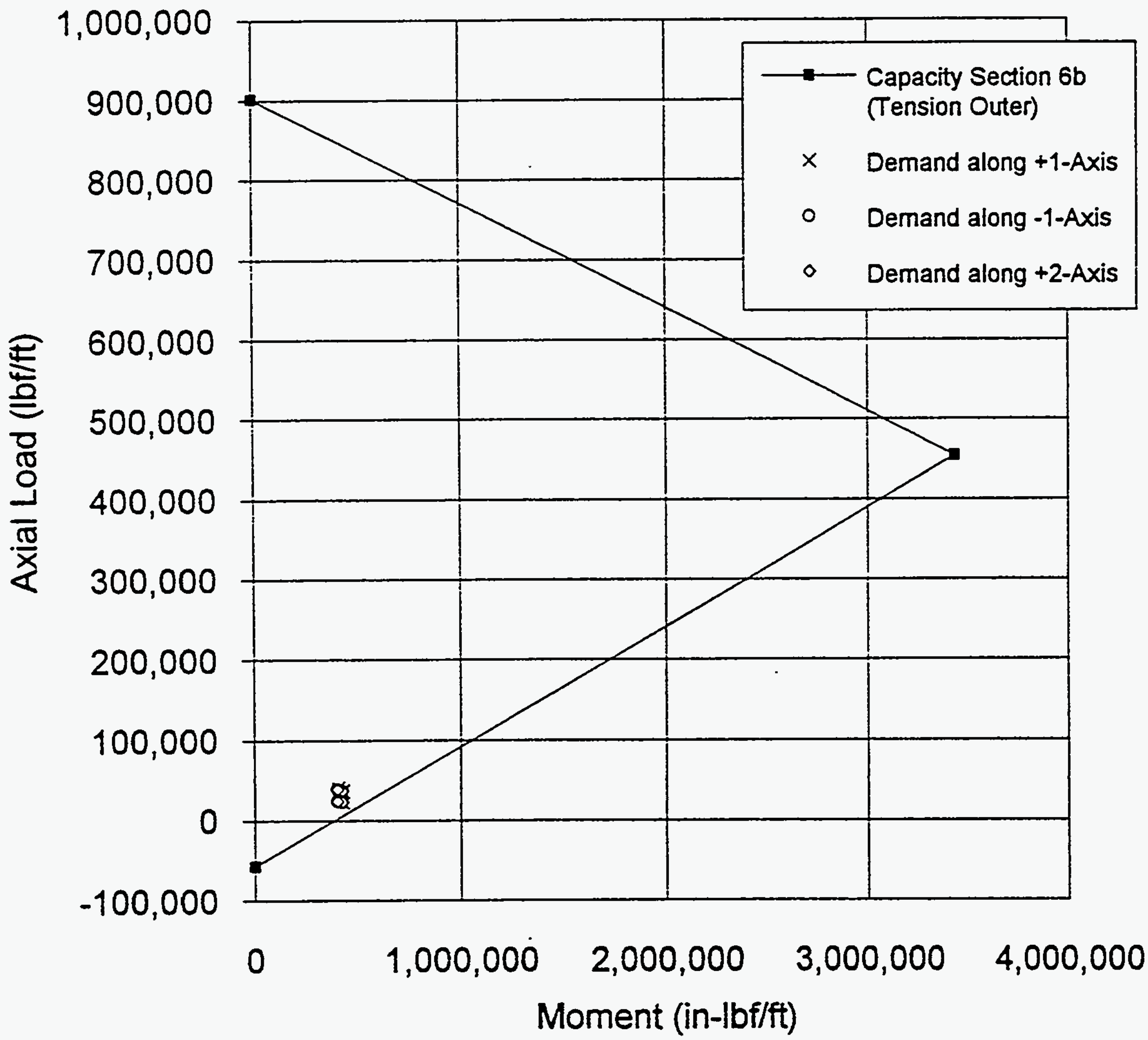
M1-4A-2.XLC

Figure L-8
Meridional M-P Interaction Diagram for Wall/Haunch Interface Section: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



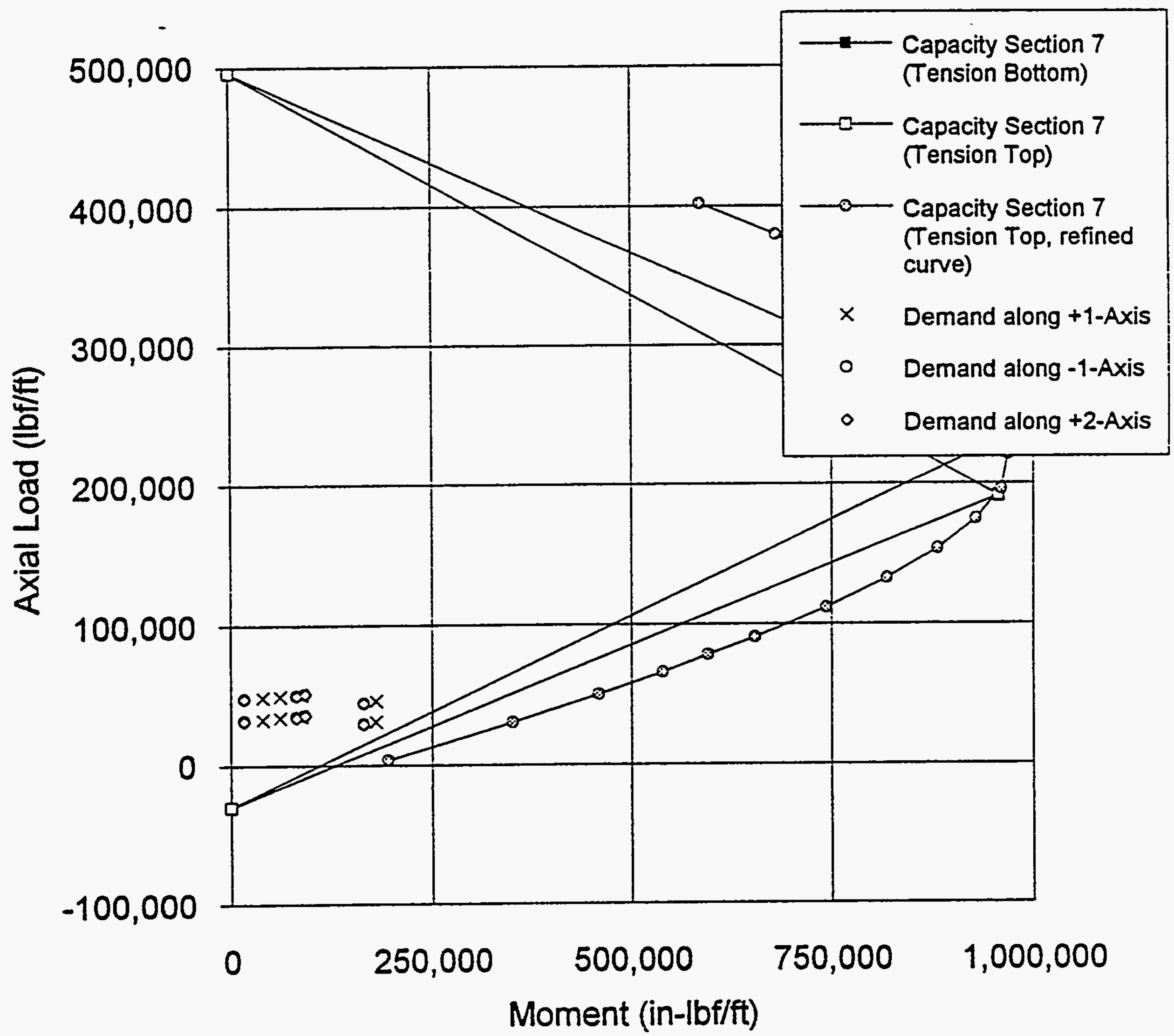
M1-6A.XLC

Figure L-9
Meridional M-P Interaction Diagram for Haunch Section:
Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



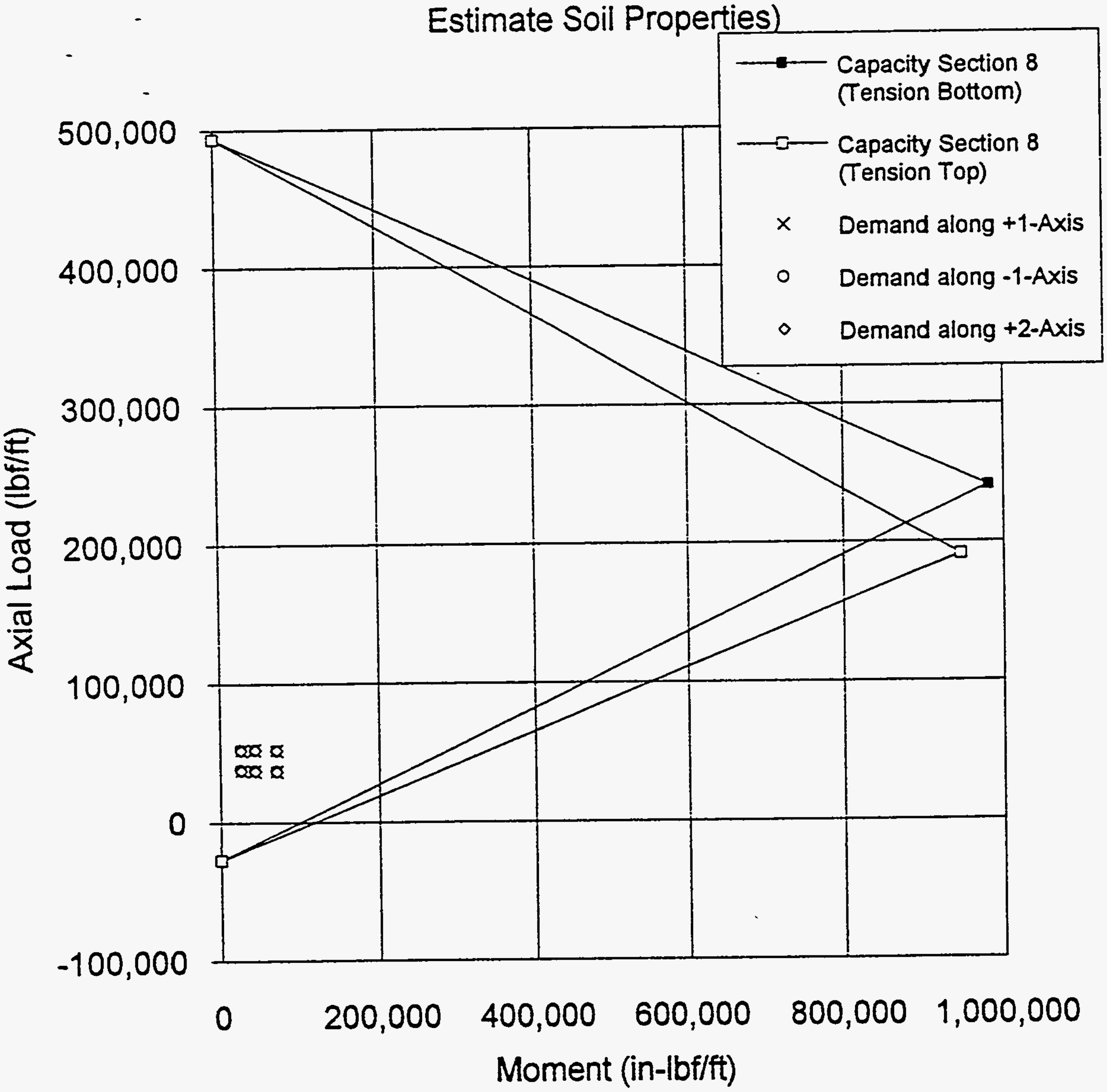
M1-6B.XLC

Figure L-10
Meridional M-P Interaction Diagram for Haunch/Dome
Interface Section: Nonseismic (Load Case 2) + Seismic
(Best-Estimate Soil Properties)



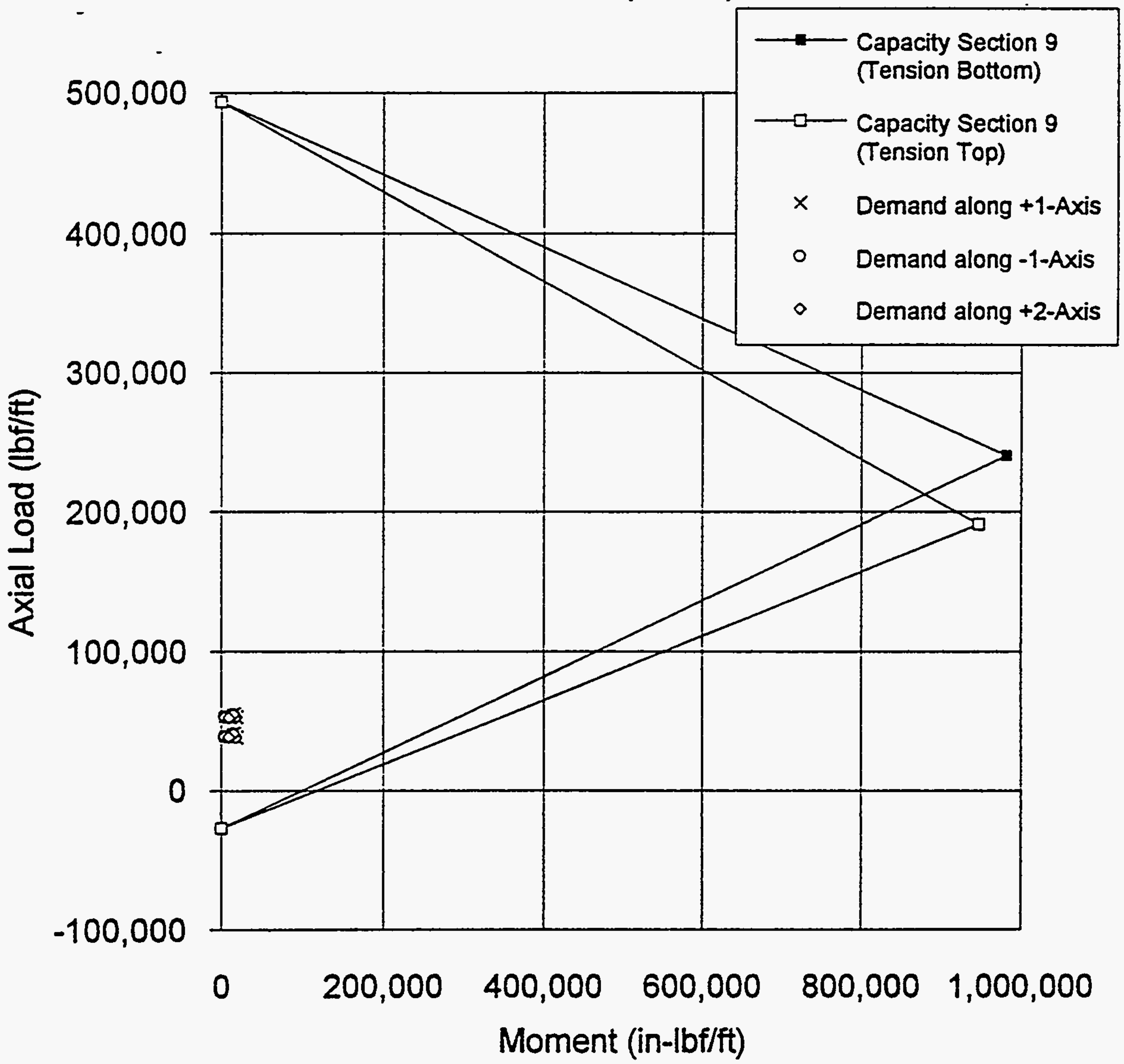
M1-7.XLC

Figure L-11
Meridional M-P Interaction Diagram for Intermediate Dome Sections: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



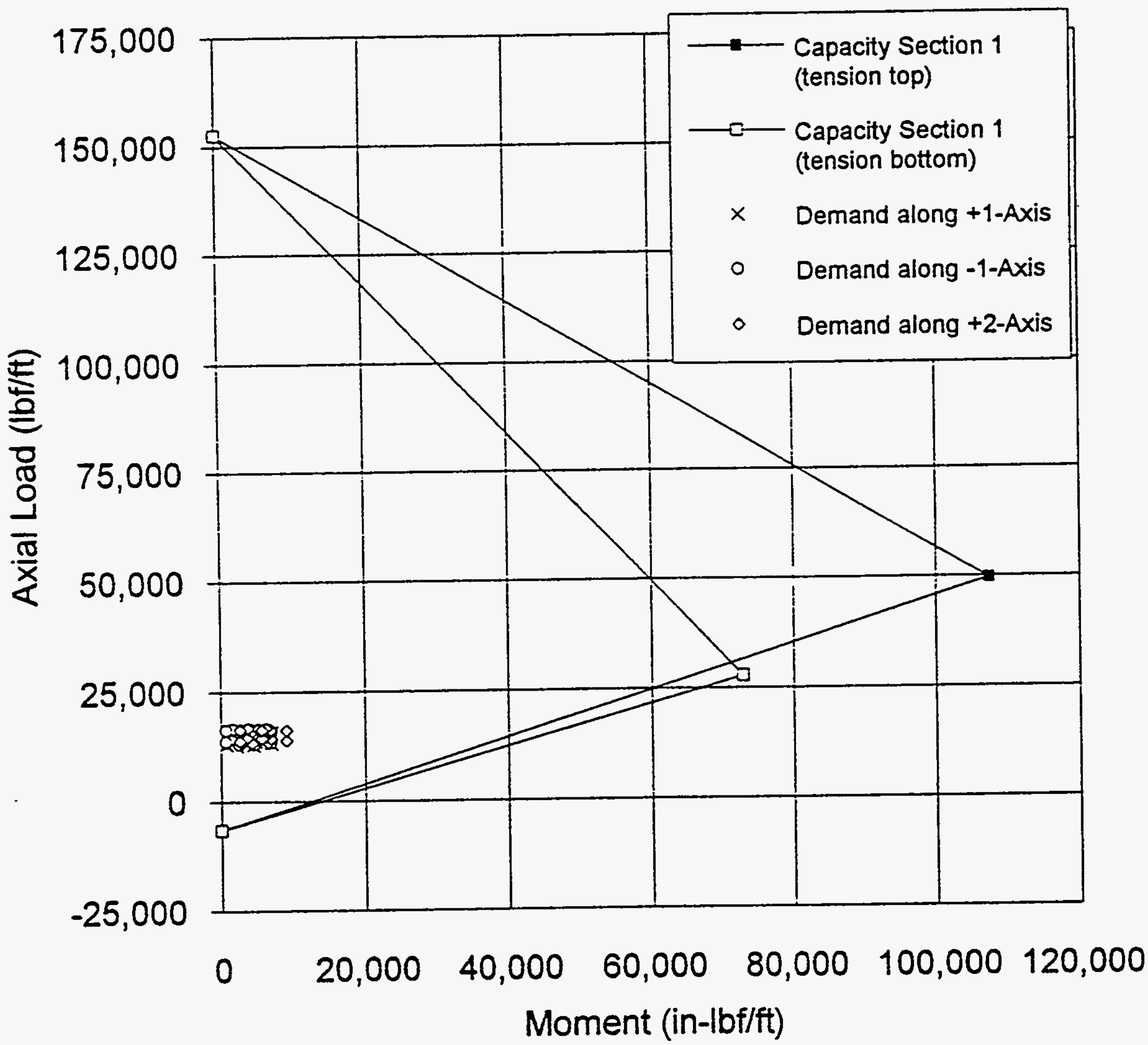
M1-8.XLC

Figure L-12
Meridional M-P Interaction Diagram for Dome Sections Near Apex: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



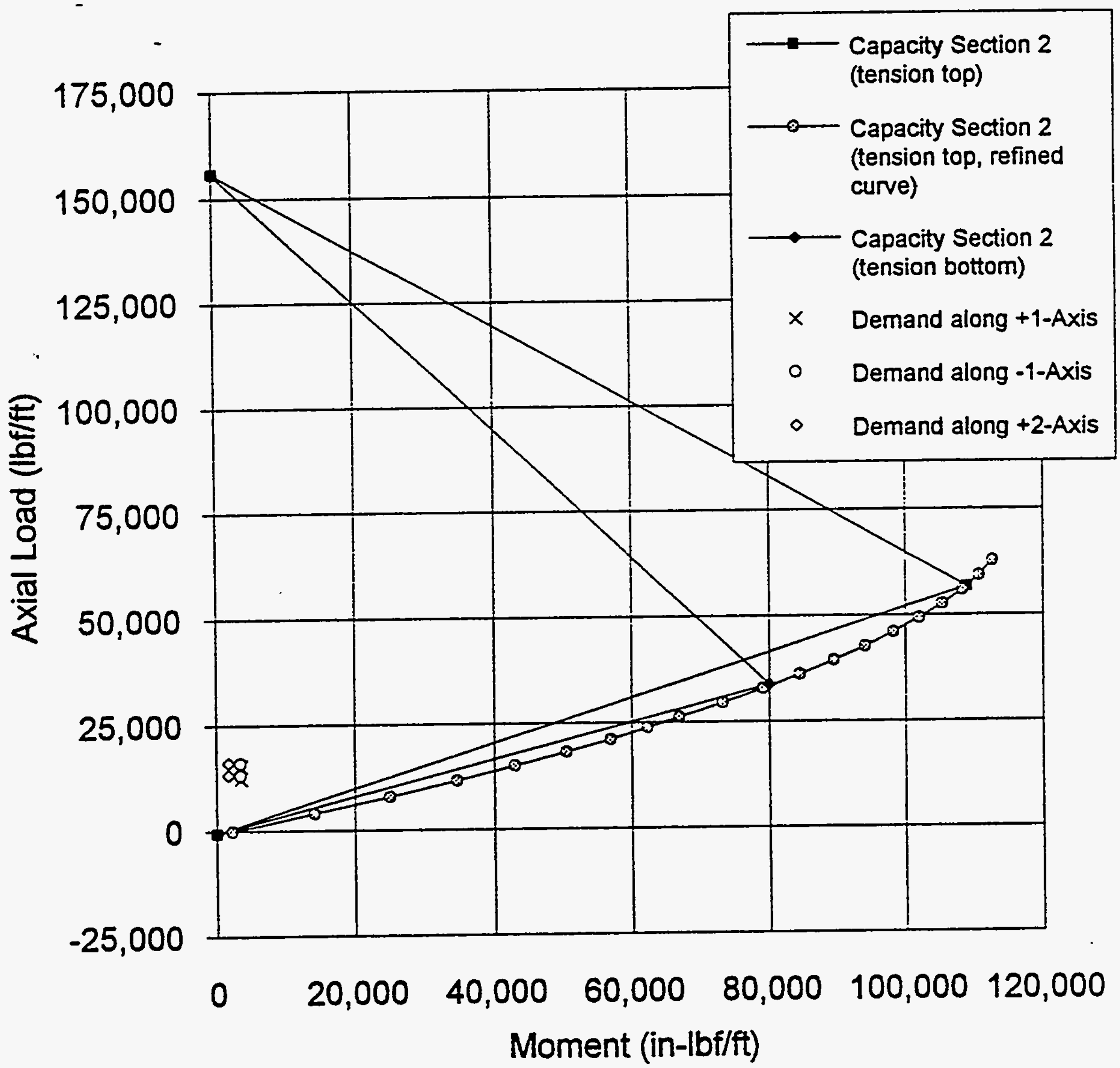
M1-9.XLC

Figure L-13
Circumferential M-P Interaction Diagram for Inner Base Sections: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



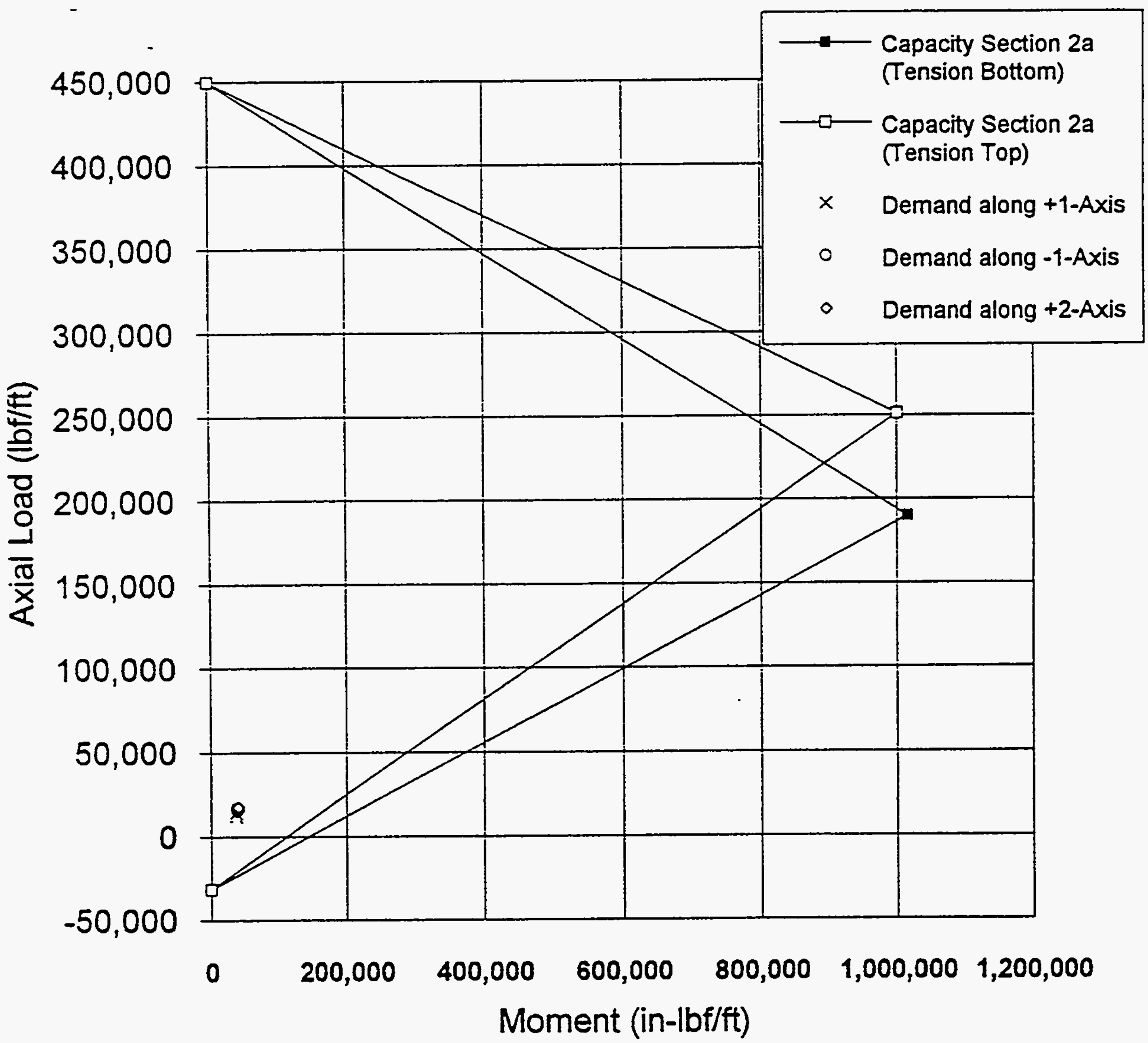
C1-1.XLC

Figure L-14
Circumferential M-P Interaction Diagram for Outer Base Sections: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



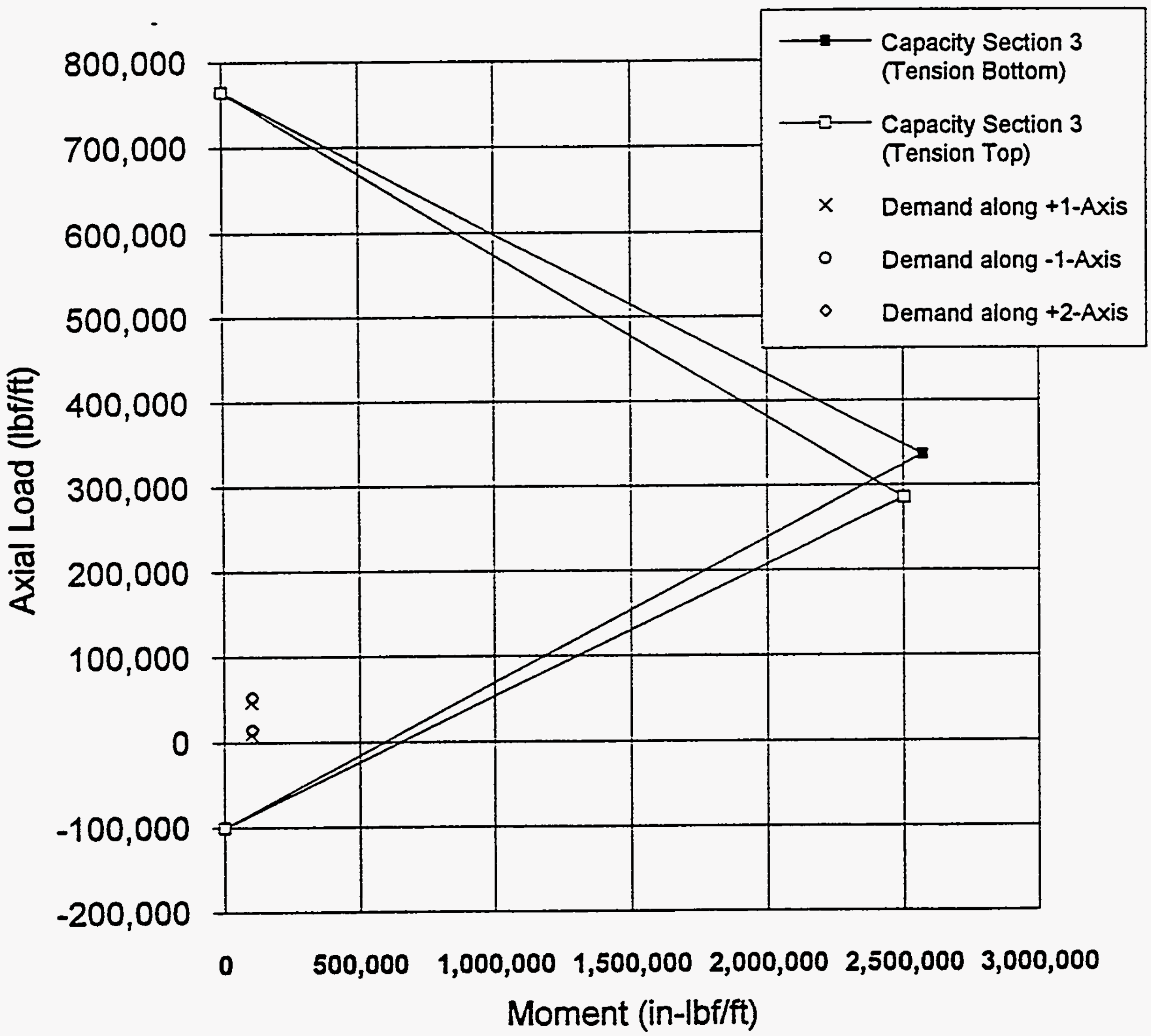
C1-2.XLC

Figure L-15
Circumferential M-P Interaction Diagram for Base/Wall Interface Section: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



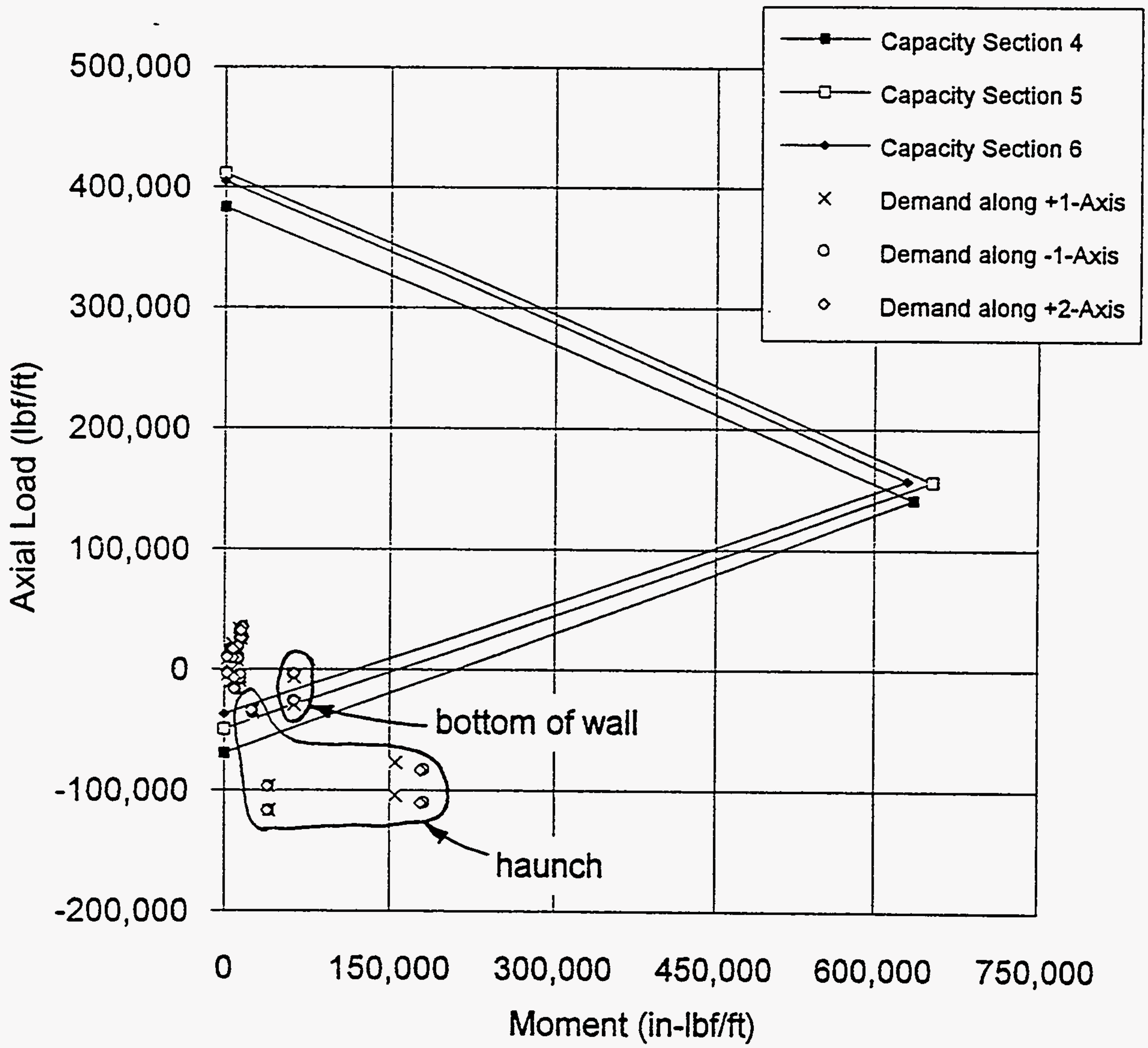
C1-2A.XLC

Figure L-16
Circumferential M-P Interaction Diagram for Footing Section: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



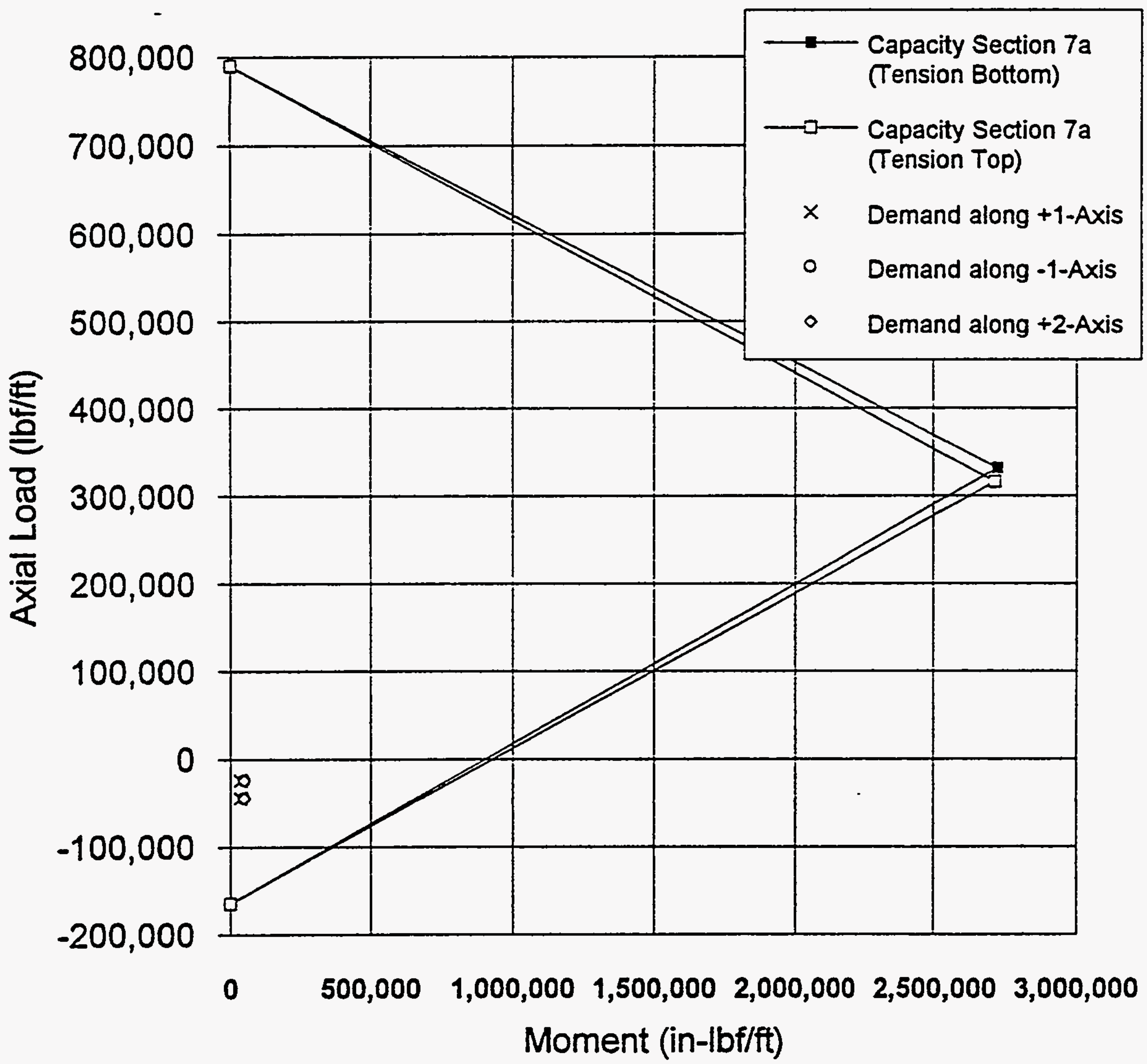
C1-3.XLC

Figure L-17
Circumferential M-P Interaction Diagram for 12-In.-Thick Wall Sections: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



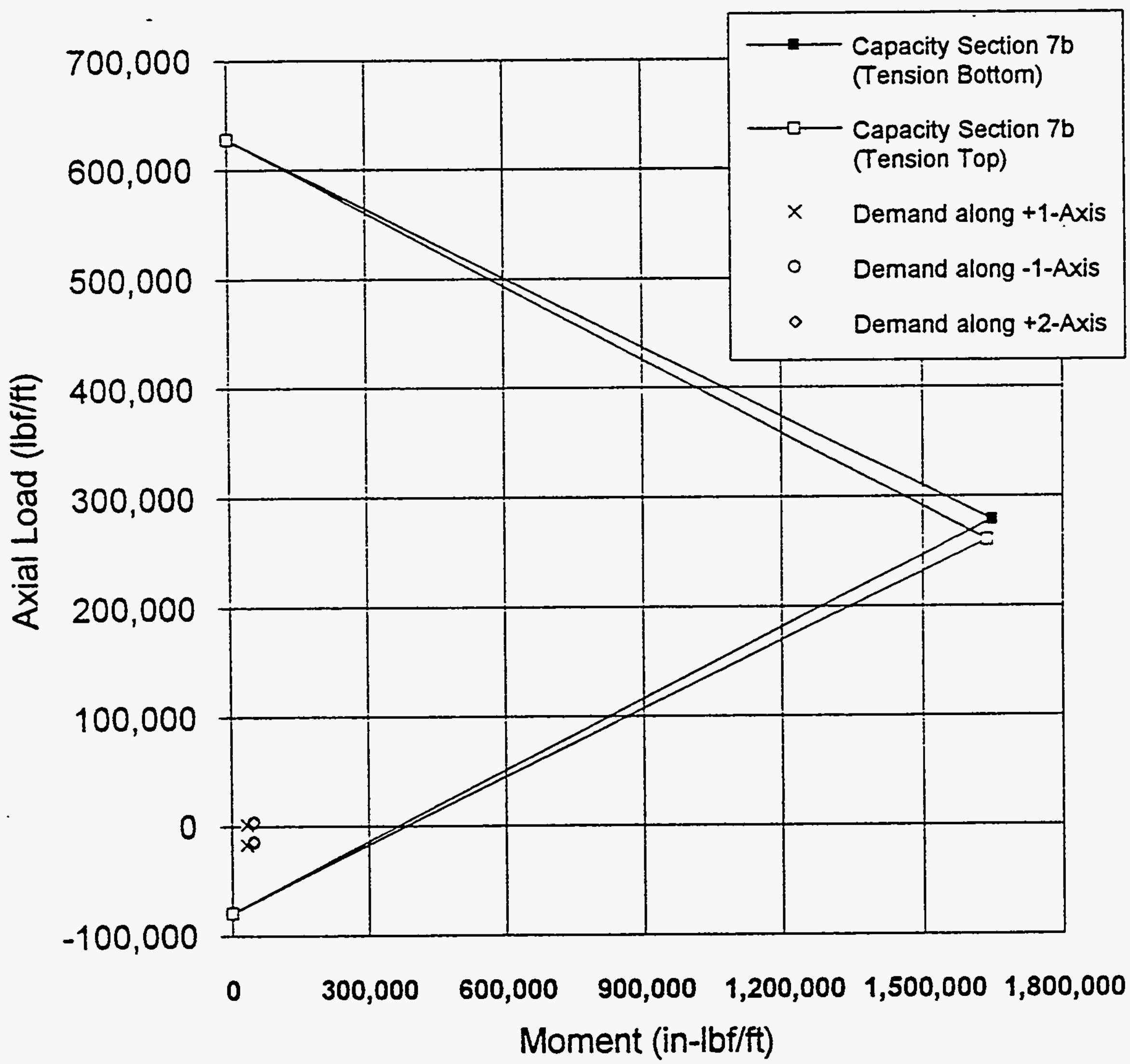
C1-456.XLC

Figure L-18
Circumferential M-P Interaction Diagram for Haunch Section: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



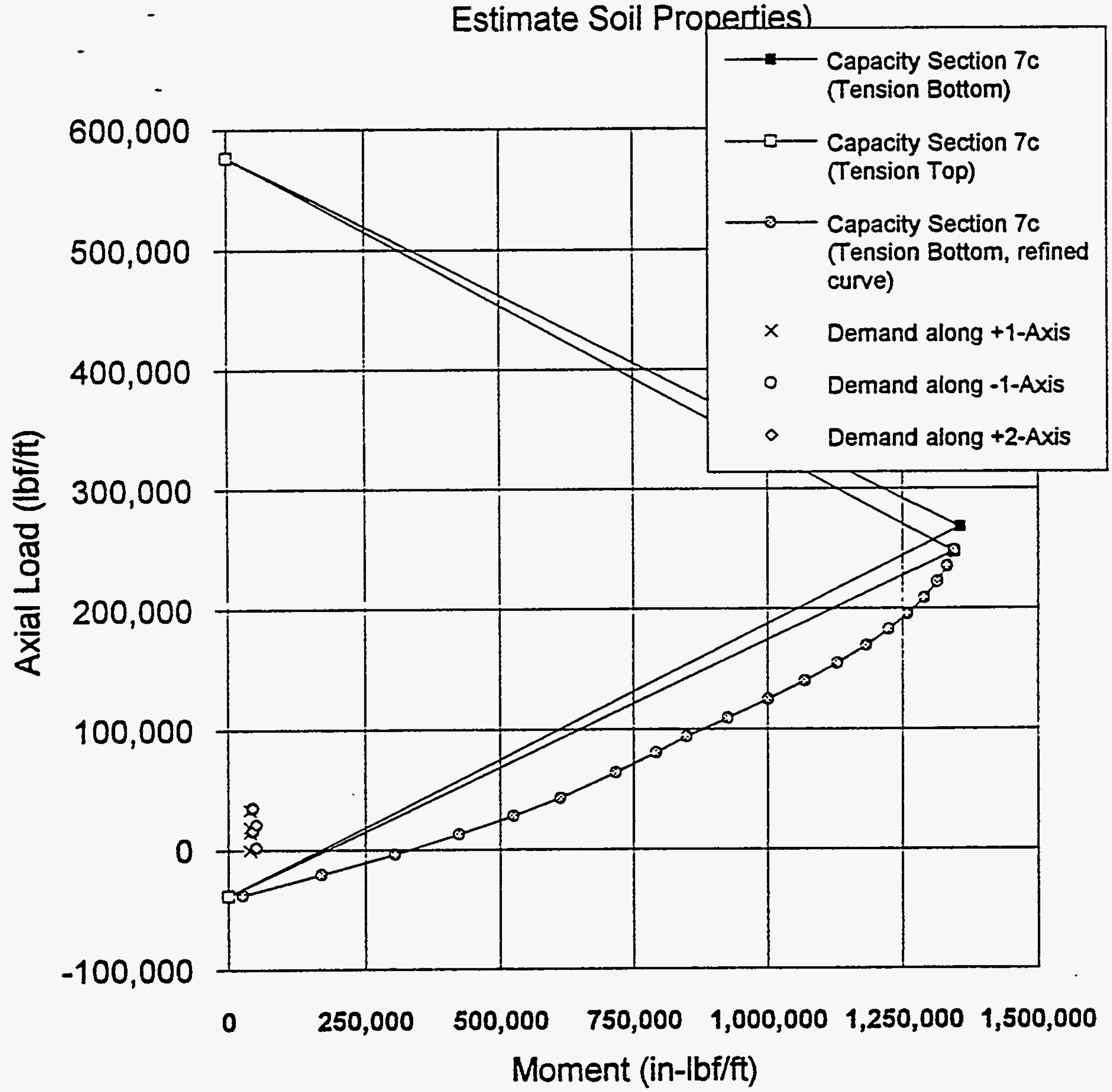
C1-7A.XLC

Figure L-19
Circumferential M-P Interaction Diagram for Haunch/Dome Interface Section: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



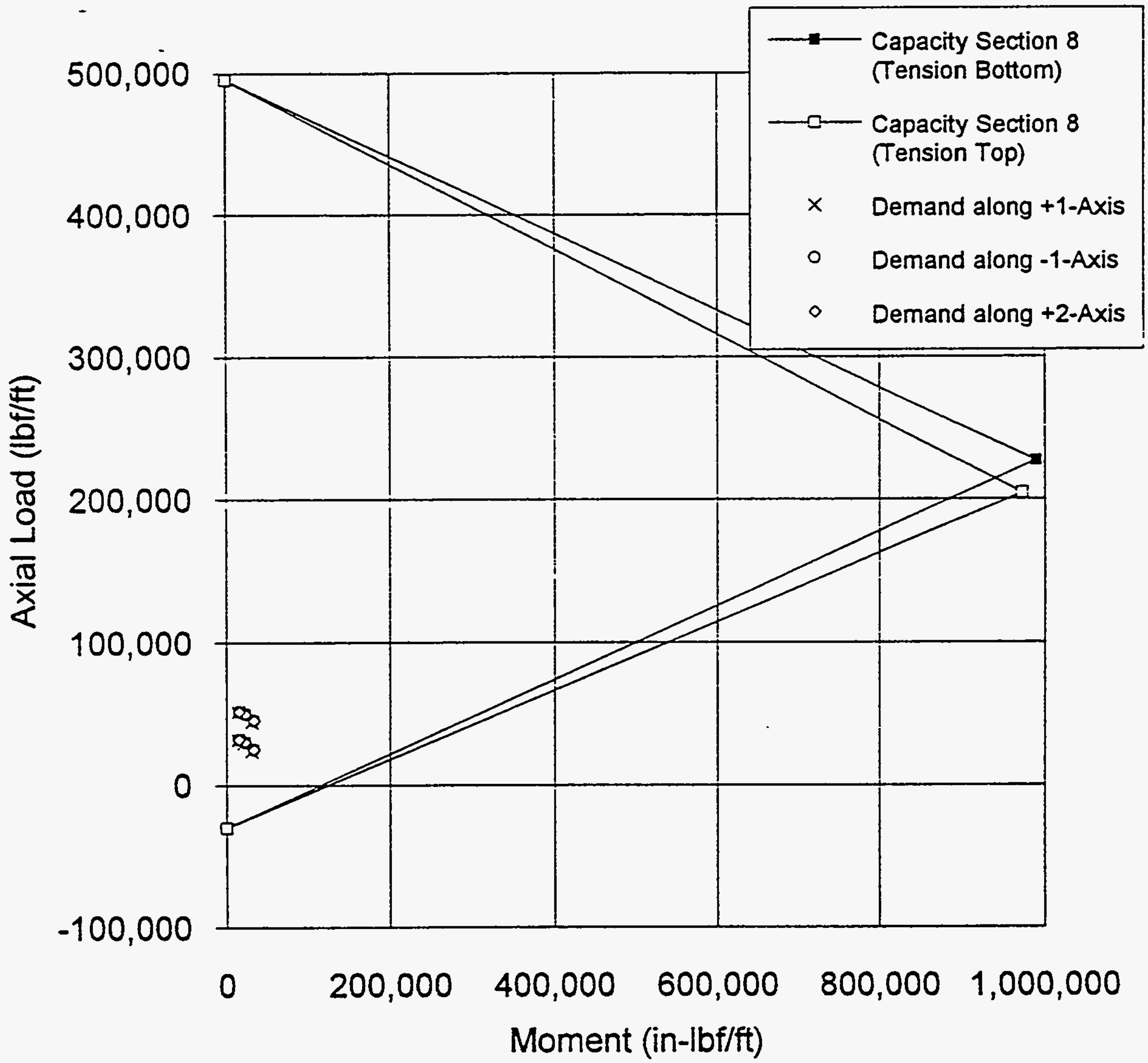
C1-7B.XLC

Figure L-20
Circumferential M-P Interaction Diagram for Outer Dome Section: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



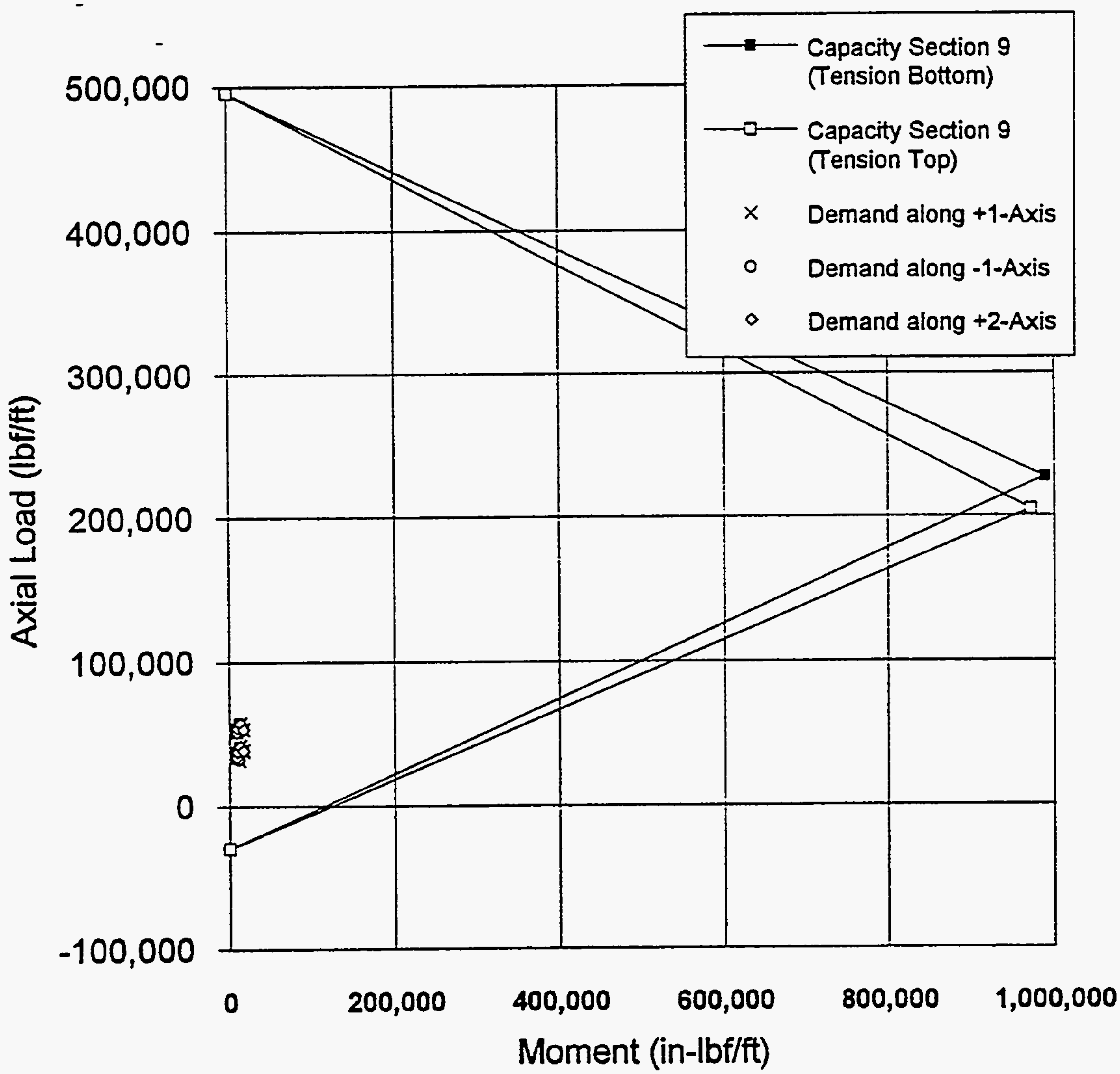
C1-7C.XLC

Figure L-21
Circumferential M-P Interaction Diagram for Intermediate Dome Sections: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



C1-8.XLC

Figure L-22
Circumferential M-P Interaction Diagram for Dome Sections Near Apex: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)



C1-9.XLC

Table L-1
Evaluation of In-Plane Shear and Twisting Moment: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)

Elements Along the Positive 1-Axis d=lw=12"

ELEMENT	fc [lbf/in^2]	Thickness [in]	Merid. P (min.) [lbf/ft]	Circum. P (min.) [lbf/ft]	min. Nu [lbf/ft]	phi*Vc Eqn 11-32 [lbf/ft]	phi*Vc/2 [lbf/ft]	In-plane shear [lbf/ft]	T threshold [in-lbf/ft]	Twist. moment [in-lbf/ft]
floor elements										
289	3317	6.00	13,541	13,429	13,429	14,485	7,242	359	10,574	155
291	3321	6.00	11,822	12,907	11,822	14,151	7,075	859	10,581	227
295	3330	6.00	13,357	12,871	12,871	14,389	7,194	527	10,594	230
301	3343	6.00	14,701	13,882	13,882	14,627	7,313	1,136	10,616	242
1257	3361	6.00	14,703	14,305	14,305	14,747	7,374	1,871	10,643	211
1261	3382	6.00	13,862	14,085	13,862	14,691	7,345	2,153	10,677	185
1265	3421	6.00	13,382	13,770	13,382	14,656	7,328	2,744	10,738	155
1269	3456	6.00	13,269	13,929	13,269	14,693	7,346	3,262	10,794	351
1273	3519	6.00	12,436	13,075	12,436	14,622	7,311	4,456	10,891	487
1277	3610	6.00	10,912	12,329	10,912	14,452	7,226	4,487	11,031	354
1281	3747	16.49	19,425	12,271	12,271	36,584	18,292	4,961	84,889	7,094
wall elements										
1285	3795	18.30	27,756	-28,989	-28,989	31,785	15,892	13,854	105,212	7,477
1289	3912	12.30	28,600	-9,657	-9,657	23,841	11,921	11,447	48,256	1,422
1293	4073	12.00	26,843	-5,017	-5,017	24,711	12,355	14,451	46,867	1,163
1297	4327	12.00	27,972	7,782	7,782	28,224	14,112	13,761	48,310	1,154
1301	4403	12.00	27,759	26,315	26,315	32,393	16,196	14,462	48,728	1,274
1305	4413	12.00	27,837	28,160	27,837	32,748	16,374	13,357	48,786	966
1309	4433	12.00	27,553	14,329	14,329	29,937	14,969	13,377	48,896	1,307
1313	4443	12.00	26,323	-10,434	-10,434	24,705	12,352	12,206	48,949	1,630
haunch elements										
1317	4480	15.00	25,088	-35,768	-35,768	26,194	13,097	8,965	76,805	645
1321	4526	27.29	23,080	-116,645	-116,645	37,009	18,505	13,226	255,519	8,433
1325	4533	31.62	25,977	-104,196	-104,196	49,513	24,757	15,600	343,291	30,975
dome elements										
1329	4506	21.31	31,228	-44,260	-44,260	38,744	19,372	10,814	155,465	9,535
1333	4492	18.08	32,674	-16,617	-16,617	37,257	18,628	9,526	111,734	4,230
1337	4492	17.38	34,003	-106	-106	39,185	19,593	8,665	103,247	2,512
1341	4492	16.91	35,370	14,436	14,436	41,215	20,608	7,812	97,738	3,250
1345	4499	16.38	36,665	23,868	23,868	42,052	21,026	6,501	91,777	3,736
1349	4502	15.83	37,139	29,218	29,218	41,960	20,980	5,674	85,748	2,575
1353	4504	15.28	37,438	31,414	31,414	41,193	20,596	4,450	79,913	2,895
308	4513	15.00	38,151	32,156	32,156	40,751	20,375	3,541	77,086	2,365
305	4513	15.00	38,319	33,632	33,632	41,064	20,532	3,396	77,086	2,254
314	4514	15.00	39,133	34,471	34,471	41,247	20,624	2,337	77,096	2,132
312	4514	15.00	38,977	33,775	33,775	41,100	20,550	2,495	77,096	1,768
318	4507	15.00	40,502	37,736	37,736	41,914	20,957	1,391	77,034	1,953
317	4507	15.00	40,958	41,240	40,958	42,599	21,299	1,534	77,034	3,321
320	4508	15.00	38,607	38,506	38,506	42,082	21,041	423	77,045	735
footing element										
1357	4136	24.00	9,601	9,014	9,014	53,871	26,935	6,407	188,928	19,693

Table L-1
Evaluation of In-Plane Shear and Twisting Moment:
Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)

Elements Along the Negative 1-Axis

ELEMENT	fc [lbf/in^2]	Thickness [in]	Merid. P (min.) [lbf/ft]	Circum. P (min.) [lbf/ft]	min. Nu [lbf/ft]	phi*Vc Eqn 11-32 [lbf/ft]	phi*Vc/2 [lbf/ft]	In-plane shear [lbf/ft]	T threshold [in-lbf/ft]	Twist. moment [in-lbf/ft]
floor elements										
1	3317	6.00	13,505	13,501	13,501	14,500	7,250	342	10,574	155
4	3321	6.00	11,762	13,075	11,762	14,138	7,069	858	10,581	211
9	3330	6.00	13,201	13,075	13,075	14,432	7,216	502	10,594	213
16	3343	6.00	14,545	14,146	14,146	14,683	7,342	1,115	10,616	248
324	3361	6.00	14,427	14,605	14,427	14,773	7,387	1,858	10,643	194
328	3382	6.00	13,454	14,457	13,454	14,604	7,302	2,139	10,677	185
332	3421	6.00	12,842	14,190	12,842	14,541	7,270	2,732	10,738	139
336	3456	6.00	12,537	14,433	12,537	14,537	7,269	3,231	10,794	371
340	3519	6.00	11,560	13,675	11,560	14,436	7,218	4,451	10,891	468
344	3610	6.00	9,916	13,085	9,916	14,241	7,120	4,438	11,031	331
348	3747	16.49	18,213	15,175	15,175	37,201	18,601	4,993	84,889	7,633
wall elements										
352	3795	18.30	27,276	-25,977	-25,977	32,425	16,213	13,649	105,212	7,518
356	3912	12.30	27,952	-7,826	-7,826	24,230	12,115	11,682	48,256	1,664
360	4073	12.00	25,907	-3,357	-3,357	25,063	12,532	14,189	46,867	1,254
364	4327	12.00	26,364	9,054	9,054	28,495	14,247	14,122	48,310	1,321
368	4403	12.00	25,695	26,387	25,695	32,261	16,130	14,177	48,728	1,178
372	4413	12.00	25,245	26,288	25,245	32,197	16,099	13,862	48,786	1,379
376	4433	12.00	24,457	9,961	9,961	29,009	14,505	12,995	48,896	1,265
380	4443	12.00	23,947	-16,461	-16,461	23,424	11,712	12,351	48,949	1,229
haunch elements										
384	4480	15.00	25,088	-35,768	-35,768	26,194	13,097	8,965	76,805	645
388	4526	27.29	23,080	-116,645	-116,645	37,009	18,505	13,226	255,519	8,433
392	4533	31.62	24,141	-109,944	-109,944	48,292	24,146	16.218	343,291	34,935
dome elements										
396	4506	21.31	29,356	-44,284	-44,284	38,739	19,370	11,361	155,465	12,633
400	4492	18.08	31,882	-14,575	-14,575	37,691	18,845	9,799	111,734	4,094
404	4492	17.38	34,327	1,916	1,916	39,615	19,807	8,613	103,247	3,517
408	4492	16.91	35,706	15,744	15,744	41,493	20,747	7,754	97,738	4,087
412	4499	16.38	36,797	24,876	24,876	42,266	21,133	6,489	91,777	3,843
416	4502	15.83	37,271	30,082	30,082	42,143	21,072	5,664	85,748	2,764
420	4504	15.28	37,618	31,990	31,990	41,315	20,658	4,450	79,913	3,027
23	4513	15.00	38,307	32,552	32,552	40,835	20,417	3,530	77,086	2,307
19	4513	15.00	38,427	33,872	33,872	41,115	20,558	3,440	77,086	2,226
28	4514	15.00	39,157	34,699	34,699	41,296	20,648	2,376	77,096	2,108
25	4514	15.00	39,025	33,919	33,919	41,130	20,565	2,505	77,096	1,728
31	4507	15.00	40,550	37,880	37,880	41,945	20,972	1,378	77,034	1,972
29	4507	15.00	40,970	41,276	40,970	42,601	21,301	1,501	77,034	3,312
32	4508	15.00	38,583	38,530	38,530	42,087	21,044	399	77,045	727
footing element										
424	4136	24.00	8,965	14,162	8,965	53,860	26,930	6,506	188,928	20,089

Table L-1
Evaluation of In-Plane Shear and Twisting Moment: Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)

Elements Along the Positive 2-Axis

ELEMENT	fc [lbf/in^2]	Thickness [in]	Merid. P (min.) [lbf/ft]	Circum. P (min.) [lbf/ft]	min. Nu [lbf/ft]	phi*Vc Eqn 11-32 [lbf/ft]	phi*Vc/2 [lbf/ft]	In-plane shear [lbf/ft]	T threshold [in-lbf/ft]	Twist. moment [in-lbf/ft]
floor elements										
161	3317	6.00	13,049	13,945	13,049	14,404	7,202	369	10,574	170
164	3321	6.00	11,306	13,471	11,306	14,041	7,021	858	10,581	230
169	3330	6.00	12,793	13,447	12,793	14,372	7,186	525	10,594	220
176	3343	6.00	14,149	14,494	14,149	14,684	7,342	1,136	10,616	251
844	3361	6.00	14,067	14,965	14,067	14,697	7,348	1,841	10,643	202
848	3382	6.00	13,130	14,769	13,130	14,535	7,268	2,149	10,677	191
852	3421	6.00	12,542	14,478	12,542	14,477	7,239	2,729	10,738	147
856	3456	6.00	12,273	14,685	12,273	14,481	7,241	3,212	10,794	372
860	3519	6.00	11,356	13,843	11,356	14,393	7,196	4,470	10,891	485
864	3610	6.00	9,700	13,217	9,700	14,195	7,097	4,406	11,031	340
868	3747	16.49	18,033	15,847	15,847	37,344	18,672	4,936	84,889	7,814
wall elements										
872	3795	18.30	27,768	-25,581	-25,581	32,509	16,255	13,233	105,212	7,422
876	3912	12.30	28,300	-7,604	-7,604	24,278	12,139	12,025	48,256	1,475
880	4073	12.00	26,219	-3,188	-3,188	25,099	12,550	13,861	46,867	1,131
884	4327	12.00	26,568	9,126	9,126	28,510	14,255	14,366	48,310	1,423
888	4403	12.00	25,971	26,375	25,971	32,320	16,160	14,022	48,728	1,309
892	4413	12.00	25,521	26,300	25,521	32,256	16,128	13,978	48,786	893
896	4433	12.00	24,901	9,997	9,997	29,017	14,508	12,924	48,896	932
900	4443	12.00	24,439	-16,358	-16,358	23,446	11,723	12,546	48,949	1,407
haunch elements										
904	4480	15.00	25,556	-35,520	-35,520	26,246	13,123	9,077	76,805	1,037
908	4526	27.29	23,532	-116,545	-116,545	37,031	18,515	11,650	255,519	14,690
912	4533	31.62	24,405	-110,256	-110,256	48,225	24,113	14,591	343,291	29,595
dome elements										
916	4506	21.31	29,368	-44,308	-44,308	38,734	19,367	10,516	155,465	10,625
920	4492	18.08	31,774	-14,421	-14,421	37,724	18,862	9,310	111,734	3,626
924	4492	17.38	34,171	2,086	2,086	39,651	19,826	8,276	103,247	3,462
928	4492	16.91	35,538	15,984	15,984	41,544	20,772	7,577	97,738	3,843
932	4499	16.38	36,653	25,080	25,080	42,309	21,155	6,414	91,777	3,643
936	4502	15.83	37,127	30,286	30,286	42,187	21,093	5,651	85,748	2,598
940	4504	15.28	37,486	32,134	32,134	41,346	20,673	4,449	79,913	2,908
183	4513	15.00	38,175	32,696	32,696	40,866	20,433	3,558	77,086	2,424
179	4513	15.00	38,283	33,968	33,968	41,136	20,568	3,476	77,086	2,342
188	4514	15.00	39,085	34,807	34,807	41,319	20,659	2,378	77,096	2,205
185	4514	15.00	38,929	33,967	33,967	41,140	20,570	2,548	77,096	1,662
191	4507	15.00	40,478	37,928	37,928	41,955	20,977	1,394	77,034	2,027
189	4507	15.00	40,898	41,324	40,898	42,586	21,293	1,481	77,034	3,349
192	4508	15.00	38,547	38,566	38,547	42,091	21,045	410	77,045	750
footing element										
944	4136	24.00	8,797	14,702	8,797	53,824	26,912	6,746	188,928	19,969

	L	M	N	O	P	Q	R	S	T
1						0 degrees (q7ttt - 11 freqs)			
2	distance	rad dist	rad dist	shell	demand		merid. (abs)		circumf. (abs)
3	to node	from CL	from CL	thickness	section	element	bending	axial	bending
4	36	3.0	36	5.95		289	64	9	40
5	72	6.0	72	5.95		291	86	20	31
6	107	8.9	107	5.95	a	295	27	15	77
7	143	11.9	143	5.95		301	31	20	21
8	187	13.8	165	5.95	b	1,257	24	30	11
9	231	17.4	209	5.95		1,261	4	43	7
10	275	21.1	253	5.95	c,d	1,265	18	51	5
11	319	24.8	297	5.95		1,269	24	60	5
12	363	28.4	341	5.96	e	1,273	6	74	2
13	407	32.1	385	5.96	f,g,h,i	1,277	55	93	13
14	457	36.0	432	12.75		1,281	391	46	77
15			vert dist from base						
16	24	1.1	13	18.24		1,285	5,735	15	1,201
17	51	3.0	35	9.85		1,289	145	14	28
18	68	4.8	58	12.03	k	1,293	733	14	130
19	96	7.2	86	12.02	l	1,297	364	9	67
20	124	9.5	114	12.02	m	1,301	153	8	65
21	152	11.8	142	12.02	n	1,305	166	7	46
22	180	14.2	170	12.02		1,309	37	8	30
23	208	16.5	198	12.02	o,p,q	1,313	79	9	27
24	236	18.7	224	9.16	q	1,317	148	11	29
25	260	20.6	247	27.51	r	1,321	2,367	10	931
26	283	0.0							
27		#VALUE!	rad dist from CL						
28	448	36.4	436	31.93		1,325	2,369	11	1,949
29	425	34.2	410	21.46	s,t	1,329	787	11	612
30	395	31.7	381	18.18	u	1,333	938	12	496
31	366	29.3	352	17.48		1,337	706	11	441
32	338	26.5	318	17.01		1,341	577	10	405
33	299	23.3	280	16.48		1,345	586	9	415
34	260	20.1	241	15.90		1,349	613	8	358
35	221	16.7	201	15.33	x	1,353	668	7	338
36	181	15.1	181	15.06	y	308	725	6	356
37	136	11.3	136	15.05	z	314	166	6	207
38	91	7.6	91	14.97	aa	318	587	5	208
39	45	3.8	45	14.98	bb	320	57	5	213
40									
41		footing		24.13	j	1,357	5,090	16	411

	U	V	W	X	Y	Z	AA	AB
1								
2		merid.	merid.	circumf.	circumf.	transverse	transverse	in-plane
3	axial	bending	axial	bending	axial	shear (merid)	shear (circum)	shear
4	7	-64	-9	40	7			1
5	7	86	-20	-31	7			-2
6	7	27	15	-77	7			2
7	4	-31	20	-21	4			3
8	4	-24	30	-11	-4			-1
9	4	-4	43	7	-4			-1
10	5	-18	51	5	5			-1
11	7	-24	60	5	7			-1
12	10	-6	74	-2	10			-1
13	13	-55	93	13	13			-1
14	4	-391	46	-77	4			-1
15								
16	40	-5,735	15	-1,201	-40			-5
17	9	145	-14	28	9			-4
18	33	733	14	130	33			-5
19	21	364	9	67	-21			-4
20	8	-153	8	65	8			-4
21	6	166	7	46	6			3
22	17	37	8	30	17			-3
23	30	79	-9	-27	30			-3
24	7	148	-11	29	-7			-3
25	27	2,367	-10	931	27			1
26								
27								
28	32	2,369	-11	1,949	32			1
29	35	787	-11	-612	35			1
30	39	938	-12	-496	-39			1
31	41	-706	-11	-441	-41			1
32	42	-577	-10	-405	-42			1
33	44	-586	-9	-415	-44			1
34	42	-613	8	-358	-42			1
35	40	-668	7	-338	-40			1
36	36	-725	6	-356	-36			-5
37	29	-166	-6	-207	-29			-3
38	21	-587	-5	-208	-21			-2
39	12	-57	-5	213	-12			1
40								
41	55	-5,090	16	-411	55			0

	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1		90 degrees (q7ttt - 11 freqs)							
2	twisting		merid. (abs)		circumf. (abs)		merid.		circumf.
3	moment	element	bending	axial	bending	axial	bending	axial	bending
4	4	161	61	4	67	7	61	-4	67
5	16	164	7	6	61	8	7	-6	-61
6	12	169	50	4	83	10	50	-4	83
7	3	176	39	5	138	7	39	5	138
8	6	844	19	4	89	6	19	-4	89
9	-3	848	12	3	63	5	12	-3	63
10	-3	852	6	3	25	5	6	-3	25
11	3	856	7	4	22	4	7	4	22
12	-3	860	3	4	11	4	3	-4	11
13	3	864	6	4	2	4	-6	-4	2
14	-16	868	27	2	5	1	27	-2	5
15									
16	-318	872	236	2	55	3	236	-2	55
17	10	876	18	2	7	1	-18	-2	-7
18	18	880	38	2	16	6	38	2	16
19	-25	884	32	3	43	3	-32	-3	43
20	-20	888	44	2	83	3	44	-2	83
21	-36	892	62	3	91	2	-62	3	91
22	23	896	21	3	63	2	-21	3	-63
23	35	900	42	3	39	3	42	3	39
24	-7	904	14	2	3	1	-14	2	3
25	-248	908	197	2	108	3	-197	-2	-108
26									
27									
28	361	912	226	1	252	2	-226	1	-252
29	-105	916	99	2	63	3	99	2	-63
30	18	920	63	2	49	3	-63	2	-49
31	21	924	51	3	54	3	-51	3	-54
32	-11	928	41	3	56	4	41	3	-56
33	9	932	41	4	58	5	41	4	-58
34	-10	936	38	4	59	5	38	4	59
35	-4	940	45	4	65	6	45	4	65
36	23	183	61	7	87	9	-61	7	87
37	40	188	39	6	130	8	-39	6	130
38	10	191	90	5	122	7	90	5	122
39	-13	192	10	5	110	6	-10	5	110
40									
41	-392	944	230	1	102	6	230	-1	-102

	AL	AM	AN	AO	AP	AQ	AR	AS
1						180 degrees (q7ttt - 11 freqs)		
2		transverse	transverse	in-plane	twisting		merid. (abs)	
3	axial	shear (merid)	shear (circum)	shear	moment	element	bending	axial
4	-7			-4	-8	1	59	18
5	8			-11	7	4	132	35
6	-10			-5	13	9	62	26
7	-7			-9	-3	16	33	32
8	6			20	-2	324	28	40
9	5			25	-9	328	9	54
10	5			-31	5	332	19	62
11	4			-37	-6	336	25	72
12	4			-48	4	340	8	86
13	4			-57	-4	344	62	107
14	1			-32	12	348	434	51
15								
16	3			-57	-258	352	6,122	16
17	1			-82	18	356	174	15
18	6			-89	-75	360	832	14
19	3			-92	83	364	458	11
20	3			-93	84	368	137	9
21	2			-90	53	372	142	9
22	2			-86	64	376	82	9
23	-3			-80	62	380	106	12
24	-1			-76	-45	384	135	10
25	3			-34	-618	388	2,825	9
26								
27								
28	-2			-26	-965	392	2,651	15
29	3			-33	-311	396	738	13
30	3			35	-205	400	863	14
31	3			35	-198	404	649	13
32	4			34	-191	408	689	13
33	5			31	-194	412	640	11
34	5			28	-174	416	692	10
35	6			24	-211	420	827	8
36	9			-17	143	23	909	8
37	8			-11	117	28	232	7
38	7			-7	143	31	795	8
39	6			-2	-12	32	81	9
40								
41	6			10	217	424	5,346	22

	AT	AU	AV	AW	AX	AY	AZ	BA
1								
2	*circumf. (abs)*		merid.		circumf.		transverse	transverse
3	bending	axial	bending	axial	bending	axial	shear (merid)	shear (circum)
4	64	10	-59	18	64	-10		
5	128	11	-132	35	-128	-11		
6	54	12	-62	26	54	-12		
7	93	5	33	32	93	5		
8	15	6	28	40	15	-6		
9	12	7	9	54	-12	-7		
10	10	8	-19	62	-10	-8		
11	5	12	25	72	5	-12		
12	2	15	-8	86	2	-15		
13	- 15	18	62	-107	15	-18		
14	81	5	-434	-51	-81	-5		
15								
16	1,191	50	6,122	16	1,191	-50		
17	37	12	-174	15	-37	-12		
18	170	41	832	14	-170	-41		
19	81	27	458	11	-81	-27		
20	26	23	137	9	26	-23		
21	22	7	-142	-9	-22	7		
22	28	17	82	-9	28	-17		
23	37	30	-106	-12	37	30		
24	30	7	135	-10	30	7		
25	1,126	28	-2,825	-9	-1,126	28		
26								
27								
28	2,250	34	-2,651	15	2,250	34		
29	694	38	738	13	694	38		
30	570	41	863	14	570	41		
31	494	44	649	13	494	44		
32	475	45	689	13	475	45		
33	502	48	640	11	502	48		
34	478	47	692	10	478	47		
35	463	45	827	8	463	45		
36	321	42	909	8	321	42		
37	353	35	-232	7	353	35		
38	344	26	795	8	344	26		
39	161	15	-81	9	161	15		
40								
41	489	65	5,346	22	489	-65		

	BB	BC
1		
2	in-plane	twisting
3	shear	moment
4	-2	10
5	-5	9
6	-4	12
7	-4	-3
8	1	9
9	1	-2
10	1	-5
11	2	-4
12	-2	3
13	1	-3
14	2	20
15		
16	-5	-297
17	4	13
18	5	31
19	4	-36
20	4	-25
21	4	46
22	4	36
23	-3	48
24	3	6
25	1	-299
26		
27		
28	1	-435
29	2	-134
30	2	-19
31	2	22
32	2	-11
33	2	11
34	1	-10
35	1	-4
36	-6	79
37	-4	-7
38	-3	63
39	1	8
40		
41	-1	424

	K	L	M	N	O	P	Q	R
1	Moment (Lower-Bound Tank Stiffness [1])			Moment (Lower-Bound Tank Stiffness [1])				
2	Moment (Best-Estimate Tank Stiffness [2])			Moment (Best-Estimate Tank Stiffness [2])				
3	Axial Load (Lower-Bound Tank Stiffness [1])			Axial Load (Lower-Bound Tank Stiffness [1])				
4	Axial Load (Best-Estimate Tank Stiffness [2])			Axial Load (Best-Estimate Tank Stiffness [2])				
5	Theta = 180 degrees (seismic) (Q9)							
6	distance	rad dist	element	shell	demand	in-plane (abs)		out-of-plane (a
7	to node	from CL		thickness	section	bending	axial	bending
8	36	3.0	1	4.86		1.3	0.4	1.1
9	72	6.0	4	4.86		3.3	5.5	1.0
10	107	8.9	9	4.86	a	1.3	6.7	3.2
11	143	11.9	16	4.85		2.4	8.7	2.1
12	187	13.8	164	4.85	b	0.9	11.2	2.0
13	231	17.4	168	4.84		2.3	15.7	0.8
14	275	21.1	172	4.83	c,d	1.1	18.9	0.3
15	319	24.8	176	4.82		3.7	26.1	0.3
16	363	28.4	180	4.80	e	7.2	31.5	1.9
17	407	32.1	184	4.78	f,g,h,i	18.2	37.0	2.8
18	457	36.0	188	13.00		569.9	39.6	120.8
19		#VALUE!						
20	24	1.1	192	15.43		1559.0	21.2	308.7
21	51	3.0	196	10.05		373.2	28.5	76.1
22	68	4.8	200	9.69	k	160.0	23.9	36.4
23	96	7.2	204	9.49	l	18.6	17.2	9.2
24	124	9.5	208	9.45	m	30.2	14.7	12.9
25	152	11.8	212	9.44	n	45.5	12.8	13.7
26	180	14.2	216	9.41		31.6	13.6	10.4
27	208	16.5	220	9.41	o,p,q	60.9	15.4	8.4
28	236	18.7	224	9.37	q	76.2	17.0	16.5
29	260	20.6	228	21.06	r	1004.0	12.0	291.8
30	283	0.0						
31		#VALUE!						
32	448	36.4	232	27.69		1125.0	14.4	647.0
33	425	34.2	236	17.93	s,t	319.3	19.3	187.4
34	395	31.7	240	13.73	u	137.7	24.0	122.9
35	366	29.3	244	12.93		132.2	22.7	113.0
36	338	26.5	248	12.82		120.3	22.0	122.9
37	299	23.3	252	12.54		229.2	19.5	155.8
38	260	20.1	256	13.37		207.1	19.9	181.3
39	221	16.7	260	12.74	x	399.9	16.8	202.2
40	181	15.1	23	13.09	y	550.3	15.7	120.9
41	136	11.3	28	12.76	z	38.1	10.4	183.3
42	91	7.6	31	11.33	aa	480.7	9.5	159.1
43	45	3.8	32	10.92	bb	83.8	1.8	48.0
44								
45		footing	264	21.06	j	1173.0	12.4	129.9

	S	T	U	V	W	X	Y	Z
1								
2								
3								
4								
5						**M/P per foot (Q9)**		
6	**s)**	**In-plane**		**out-of-plane**		demand	**In-plane**	
7	axial	bending	axial	bending	axial	section	moment	axial force
8	0.7	1.3	0.4	1.1	-0.7		15	24
9	0.4	-3.3	5.5	1.0	0.4		40	319
10	0.5	1.3	6.7	-3.2	-0.5	a	16	389
11	1.1	-2.4	-8.7	-2.1	-1.1		29	507
12	1.3	0.9	-11.2	2.0	-1.3	b	11	654
13	1.1	2.3	-15.7	0.8	-1.1		27	912
14	1.3	1.1	-18.9	0.3	-1.3	c,d	14	1,093
15	2.1	3.7	26.1	-0.3	-2.1		44	1,507
16	2.5	-7.2	-31.5	-1.9	-2.5	e	86	1,817
17	2.7	18.2	-37.0	2.8	2.7	f,g,h,i	218	2,120
18	4.6	-569.9	-39.6	-120.8	-4.6		6,839	6,179
19								
20	7.4	1559.0	21.2	308.7	-7.4		18,708	3,927
21	4.1	-373.2	28.5	-76.1	-4.1		4,478	3,438
22	2.9	-160.0	23.9	-36.4	-2.9	k	1,920	2,773
23	4.5	18.6	17.2	-9.2	4.5	l	223	1,963
24	1.5	30.2	14.7	12.9	-1.5	m	363	1,661
25	2.0	45.5	-12.8	13.7	2.0	n	546	1,444
26	3.3	-31.6	13.6	-10.4	3.3		379	1,539
27	5.2	-60.9	-15.4	-8.4	5.2	o,p,q	730	1,739
28	6.2	-76.2	17.0	-16.5	6.2	q	915	1,908
29	6.6	1004.0	12.0	-291.8	6.6	r	12,048	3,025
30								
31								
32	7.0	1125.0	14.4	647.0	7.0		13,500	4,788
33	9.4	-319.3	19.3	187.4	9.4	s,t	3,832	4,148
34	9.1	137.7	24.0	122.9	9.1	u	1,652	3,948
35	12.2	132.2	22.7	113.0	12.2		1,586	3,525
36	12.0	120.3	-22.0	122.9	12.0		1,444	3,386
37	14.6	229.2	-19.5	-155.8	14.6		2,750	2,937
38	14.1	207.1	-19.9	-181.3	14.1		2,485	3,188
39	14.7	-399.9	-16.8	-202.2	14.7	x	4,799	2,568
40	15.7	-550.3	-15.7	-120.9	15.7	y	6,604	2,458
41	13.5	38.1	-10.4	-183.3	13.5	z	458	1,592
42	11.1	-480.7	-9.5	-159.1	11.1	aa	5,768	1,293
43	6.9	83.8	-1.8	48.0	6.9	bb	1,006	230
44								
45	9.2	1173.0	-12.4	129.9	-9.2	j	14,076	3,141

	AA	AB
1		
2		
3		
4		
5		
6	out-of-plane	
7	moment	axial force
8	13	40
9	12	23
10	38	28
11	25	62
12	24	73
13	10	67
14	3	78
15	3	124
16	23	142
17	34	154
18	1,450	715
19		
20	3,704	1,378
21	913	490
22	436	332
23	111	515
24	155	174
25	165	231
26	124	374
27	101	583
28	198	702
29	3,502	1,679
30		
31		
32	7,764	2,338
33	2,249	2,021
34	1,475	1,493
35	1,356	1,890
36	1,475	1,846
37	1,870	2,192
38	2,176	2,259
39	2,426	2,243
40	1,451	2,466
41	2,200	2,066
42	1,909	1,508
43	576	908
44		
45	1,559	2,328

	K	L	M	N	O	P	Q	R
1						Theta = 180 degrees (seismic) (Q7V with wast		
2	distance	rad dist	element	shell	demand	merid. (abs)		circumf. (abs)
3	to node	from CL		thickness	section	bending	axial	bending
4	36	36	1	5.95		4.6	10.6	6.2
5	72	72	4	5.95		9.6	10.3	127.2
6	107	107	9	5.95	a	2.6	9.8	4.3
7	143	143	16	5.95		7.6	9.7	4.8
8	187	165	164	5.95	b	5.1	9.7	2.6
9	231	209	168	5.95		6.3	8.7	3.8
10	275	253	172	5.95	c,d	5.7	8.1	2.0
11	319	297	176	5.95		15.9	6.7	4.9
12	363	341	180	5.96	e	1.5	9.9	3.9
13	407	385	184	5.96	f,g,h,i	61.3	13.4	16.8
14	457	432	188	12.75		242.7	7.2	31.6
15		vert dist from base						
16	24	13	192	18.24		948.0	18.4	178.0
17	51	35	196	9.85		78.5	20.9	16.8
18	68	58	200	12.03	k	160.2	29.0	30.5
19	96	86	204	12.02	l	104.3	27.4	21.2
20	124	114	208	12.02	m	120.2	27.6	23.9
21	152	142	212	12.02	n	171.4	26.9	34.5
22	180	170	216	12.02		142.8	27.8	28.4
23	208	198	220	12.02	o,p,q	277.6	28.3	52.5
24	236	224	224	9.16	q	163.1	31.0	33.0
25	260	247	228	27.51	r	2380.0	17.3	394.4
26	283							
27		rad dist from CL						
28	448	436	232	31.93		2745.0	12.4	84.8
29	425	410	236	21.46	s,t	1162.0	21.5	37.3
30	395	381	240	18.18	u	564.5	27.6	113.6
31	366	352	244	17.48		289.9	29.0	233.9
32	338	318	248	17.01		230.3	30.3	264.7
33	299	280	252	16.48		196.3	32.3	276.3
34	260	241	256	15.90		164.8	33.5	291.6
35	221	201	260	15.33	x	210.8	35.5	334.5
36	181	181	23	15.06	y	241.2	36.5	328.7
37	136	136	28	15.05	z	258.2	37.2	477.4
38	91	91	31	14.97	aa	573.2	37.8	527.7
39	45	45	32	14.98	bb	75.4	37.9	660.4
40								
41		footing	264	24.13	j	633.4	1.3	62.8

	S	T	U	V	W	X	Y	Z
1	- r=72" - 19 freqs to 24 hz)							
2		merid.		circumf.		transverse	transverse	in-plane
3	axial	bending	axial	bending	axial	shear (merid)	shear (circum)	shear
4	10.5	4.6	-10.6	-6.2	-10.5			0.2
5	10.5	9.6	-10.3	-127.2	-10.5			0.2
6	10.2	2.6	9.8	4.3	10.2			-0.1
7	9.8	-7.6	9.7	-4.8	9.8			-0.2
8	9.8	-5.1	9.7	-2.6	9.8			0.0
9	9.4	6.3	-8.7	3.8	-9.4			0.0
10	9.1	5.7	-8.1	2.0	-9.1			0.0
11	8.6	15.9	6.7	4.9	-8.6			-0.1
12	8.8	1.5	9.9	3.9	-8.8			-0.1
13	9.0	61.3	13.4	16.8	-9.0			-0.3
14	3.1	-242.7	7.2	-31.6	3.1			-0.1
15								
16	11.2	-948.0	18.4	-178.0	11.2			0.6
17	7.6	-78.5	20.9	16.8	7.6			0.3
18	19.9	160.2	-29.0	30.5	19.9			1.2
19	22.1	-104.3	-27.4	-21.2	22.1			0.1
20	21.5	120.2	-27.6	-23.9	21.5			0.1
21	19.1	-171.4	-26.9	34.5	-19.1			0.3
22	16.5	142.8	-27.8	28.4	-16.5			-0.6
23	12.3	277.6	28.3	52.5	12.3			1.8
24	4.3	-163.1	-31.0	-33.0	-4.3			0.2
25	12.5	-2380.0	-17.3	-394.4	12.5			0.7
26								
27								
28	11.0	-2745.0	12.4	-84.8	11.0			0.2
29	9.3	-1162.0	21.5	-37.3	-9.3			-0.2
30	8.9	564.5	27.6	113.6	8.9			0.0
31	10.5	289.9	29.0	233.9	10.5			-0.1
32	12.2	230.3	30.3	264.7	-12.2			0.0
33	16.4	196.3	32.3	276.3	16.4			0.0
34	21.1	-164.8	33.5	-291.6	21.1			0.0
35	26.7	210.8	35.5	334.5	26.7			-0.1
36	29.2	241.2	36.5	328.7	29.2			1.2
37	32.5	258.2	37.2	477.4	32.5			0.5
38	36.1	573.2	37.8	527.7	36.1			-0.1
39	37.4	-75.4	37.9	660.4	37.4			-0.1
40								
41	7.9	-633.4	1.3	-62.8	-7.9			-0.8

	AA
1	
2	twisting
3	moment
4	0.9
5	-0.4
6	-0.4
7	-0.5
8	0.3
9	0.5
10	-0.7
11	-1.4
12	-0.7
13	1.1
14	-10.8
15	
16	12.1
17	5.5
18	-20.0
19	-3.7
20	-4.5
21	-3.2
22	-14.4
23	13.9
24	-7.4
25	-148.5
26	
27	
28	43.7
29	-15.4
30	-7.6
31	-14.8
32	4.4
33	-3.5
34	1.7
35	-2.1
36	-32.7
37	-29.3
38	-5.2
39	-57.5
40	
41	265.9

	A	B	C	D	E	F	G	H
1	+ Seismic (Best-Estimate Soil Properties)							
2								
3								
4	shell	0 deg	merid. M	merid. P	circumf. M	circumf. P	transverse	transverse
5	thick. (in)	element	(in-lb/in)	(lb/in^2)	(in-lb/in)	(lb/in^2)	shear (mer)	shear (cir)
6	5.95	289	-64	-9	40	7	0	0
7	5.95	291	86	-20	-31	7	0	0
8	5.95	295	27	15	-77	7	0	0
9	5.95	301	-31	20	-21	4	0	0
10	5.95	1,257	-24	30	-11	-4	0	0
11	5.95	1,261	-4	43	7	-4	0	0
12	5.95	1,265	-18	51	5	5	0	0
13	5.95	1,269	-24	60	5	7	0	0
14	5.96	1,273	-6	74	-2	10	0	0
15	5.96	1,277	-55	93	13	13	0	0
16	12.75	1,281	-391	46	-77	4	0	0
17								
18								
19	18.24	1,285	-5,735	15	-1,201	-40	0	0
20	9.85	1,289	145	-14	28	9	0	0
21	12.03	1,293	733	14	130	33	0	0
22	12.02	1,297	364	9	67	-21	0	0
23	12.02	1,301	-153	8	65	8	0	0
24	12.02	1,305	166	7	46	6	0	0
25	12.02	1,309	37	8	30	17	0	0
26	12.02	1,313	79	-9	-27	30	0	0
27								
28								
29	9.16	1,317	148	-11	29	-7	0	0
30	27.51	1,321	2,367	-10	931	27	0	0
31	31.93	1,325	2,369	-11	1,949	32	0	0
32								
33								
34	21.46	1,329	787	-11	-612	35	0	0
35	18.18	1,333	938	-12	-496	-39	0	0
36	17.48	1,337	-706	-11	-441	-41	0	0
37	17.01	1,341	-577	-10	-405	-42	0	0
38	16.48	1,345	-586	-9	-415	-44	0	0
39	15.90	1,349	-613	8	-358	-42	0	0
40	15.33	1,353	-668	7	-338	-40	0	0
41	15.06	308	-725	6	-356	-36	0	0
42	15.05	314	-166	-6	-207	-29	0	0
43	14.97	318	-587	-5	-208	-21	0	0
44	14.98	320	-57	-5	213	-12	0	0
45								
46								
47	24.13	1,357	-5,090	16	-411	55	0	0

	I	J	K	L	M	N	O	P
1								
2								
3	Horizontal Excitation w/ Tank-to-Tank Interaction (q7ttt - 11 freqs; also q9 for 180							
4	in-plane	twisting	90 deg	merid. M	merid. P	circumf. M	circumf. P	transverse
5	shear	moment	element	(in-lb/in)	(lb/in^2)	(in-lb/in)	(lb/in^2)	shear (mer)
6	1	4	161	61	-4	67	-7	0
7	-2	16	164	7	-6	-61	8	0
8	2	12	169	50	-4	83	-10	0
9	3	3	176	39	5	138	-7	0
10	-1	6	844	19	-4	89	6	0
11	-1	-3	848	12	-3	63	5	0
12	-1	-3	852	6	-3	25	5	0
13	-1	3	856	7	4	22	4	0
14	-1	-3	860	3	-4	11	4	0
15	-1	3	864	-6	-4	2	4	0
16	-1	-16	868	27	-2	5	1	0
17								
18								
19	-5	-318	872	236	-2	55	3	0
20	-4	10	876	-18	-2	-7	1	0
21	-5	18	880	38	2	16	6	0
22	-4	-25	884	-32	-3	43	3	0
23	-4	-20	888	44	-2	83	3	0
24	3	-36	892	-62	3	91	2	0
25	-3	23	896	-21	3	-63	2	0
26	-3	35	900	42	3	39	-3	0
27								
28								
29	-3	-7	904	-14	2	3	-1	0
30	1	-248	908	-197	-2	-108	3	0
31	1	361	912	-226	1	-252	-2	0
32								
33								
34	1	-105	916	99	2	-63	3	0
35	1	18	920	-63	2	-49	3	0
36	1	21	924	-51	3	-54	3	0
37	1	-11	928	41	3	-56	4	0
38	1	9	932	41	4	-58	5	0
39	1	-10	936	38	4	59	5	0
40	1	-4	940	45	4	65	6	0
41	-5	23	183	-61	7	87	9	0
42	-3	40	188	-39	6	130	8	0
43	-2	10	191	90	5	122	7	0
44	1	-13	192	-10	5	110	6	0
45								
46								
47	0	-392	944	230	-1	-102	6	0

	Q	R	S	T	U	V	W	X
1								
2								
3	g meridian/horizon. excit. only)							
4	transverse	in-plane	twisting	180 deg	merid. M	merid. P	circumf. M	circumf. P
5	shear (cir)	shear	moment	element	(in-lb/in)	(lb/in^2)	(in-lb/in)	(lb/in^2)
6	0	-4	-8	1	59	18	64	10
7	0	-11	7	4	132	35	128	11
8	0	-5	13	9	62	26	54	12
9	0	-9	-3	16	33	32	93	5
10	0	20	-2	324	28	40	15	6
11	0	25	-9	328	9	54	12	7
12	0	-31	5	332	19	62	10	8
13	0	-37	-6	336	25	72	5	12
14	0	-48	4	340	8	86	2	15
15	0	-57	-4	344	62	107	15	18
16	0	-32	12	348	570	51	121	5
17								
18								
19	0	-57	-258	352	6,122	21	1,191	50
20	0	-82	18	356	373	29	76	12
21	0	-89	-75	360	832	24	170	41
22	0	-92	83	364	458	17	81	27
23	0	-93	84	368	137	15	26	23
24	0	-90	53	372	142	13	22	7
25	0	-86	64	376	82	14	28	17
26	0	-80	62	380	106	15	37	30
27								
28								
29	0	-76	-45	384	135	17	30	7
30	0	-34	-618	388	2,825	12	1,126	28
31	0	-26	-965	392	2,651	15	2,250	34
32								
33								
34	0	-33	-311	396	738	19	694	38
35	0	35	-205	400	863	24	570	41
36	0	35	-198	404	649	23	494	44
37	0	34	-191	408	689	22	475	45
38	0	31	-194	412	640	20	502	48
39	0	28	-174	416	692	20	478	47
40	0	24	-211	420	827	17	463	45
41	0	-17	143	23	909	16	321	42
42	0	-11	117	28	232	10	353	35
43	0	-7	143	31	795	10	344	26
44	0	-2	-12	32	84	9	161	15
45								
46								
47	0	10	217	424	5,346	22	489	65

	Y	Z	AA	AB	AC	AD	AE	AF
1								
2	***Seismic Demand based on Best-Estimate Soil Properties***							
3								**Vertical Excitation (q7v with**
4	transverse	transverse	in-plane	twisting	180 deg	merid. M	merid. P	circumf. M
5	shear (mer)	shear (cir)	shear	moment	element	(in-lb/in)	(lb/in^2)	(in-lb/in)
6	0	0	-2	10	1	4.6	-10.6	-6.2
7	0	0	-5	9	4	9.6	-10.3	-127.2
8	0	0	-4	12	9	2.6	9.8	4.3
9	0	0	-4	-3	16	-7.6	9.7	-4.8
10	0	0	1	9	164	-5.1	9.7	-2.6
11	0	0	1	-2	168	6.3	-8.7	3.8
12	0	0	1	-5	172	5.7	-8.1	2.0
13	0	0	2	-4	176	15.9	6.7	4.9
14	0	0	-2	3	180	1.5	9.9	3.9
15	0	0	1	-3	184	61.3	13.4	16.8
16	0	0	2	20	188	-242.7	7.2	-31.6
17								
18								
19	0	0	-5	-297	192	-948.0	18.4	-178.0
20	0	0	4	13	196	-78.5	20.9	16.8
21	0	0	5	31	200	160.2	-29.0	30.5
22	0	0	4	-36	204	-104.3	-27.4	-21.2
23	0	0	4	-25	208	120.2	-27.6	-23.9
24	0	0	4	46	212	-171.4	-26.9	34.5
25	0	0	4	36	216	142.8	-27.8	28.4
26	0	0	-3	48	220	277.6	28.3	52.5
27								
28								
29	0	0	3	6	224	-163.1	-31.0	-33.0
30	0	0	1	-299	228	-2380.0	-17.3	-394.4
31	0	0	1	-435	232	-2745.0	12.4	-84.8
32								
33								
34	0	0	2	-134	236	-1162.0	21.5	-37.3
35	0	0	2	-19	240	564.5	27.6	113.6
36	0	0	2	22	244	289.9	29.0	233.9
37	0	0	2	-11	248	230.3	30.3	264.7
38	0	0	2	11	252	196.3	32.3	276.3
39	0	0	1	-10	256	-164.8	33.5	-291.6
40	0	0	1	-4	260	210.8	35.5	334.5
41	0	0	-6	79	23	241.2	36.5	328.7
42	0	0	-4	-7	28	258.2	37.2	477.4
43	0	0	-3	63	31	573.2	37.8	527.7
44	0	0	1	8	32	-75.4	37.9	660.4
45								
46								
47	0	0	-1	424	264	-633.4	1.3	-62.8

	AG	AH	AI	AJ	AK	AL	AM	AN
1								
2								
3	waste & no live load - 19 freqs/24 hz)							
4	circumf. P	transverse	transverse	in-plane	twisting	merid. M	merid. P	circumf. M
5	(lb/in^2)	shear (mer)	shear (cir)	shear	moment	(in-lb/in)	(lb/in^2)	(in-lb/in)
6	-10.5	0.0	0.0	0.2	0.9	88.1	21.1	92.8
7	-10.5	0.0	0.0	0.2	-0.4	132.7	37.3	190.1
8	10.2	0.0	0.0	-0.1	-0.4	80.1	28.0	113.3
9	9.8	0.0	0.0	-0.2	-0.5	52.0	33.4	166.8
10	9.8	0.0	0.0	0.0	0.3	34.1	41.8	89.9
11	-9.4	0.0	0.0	0.0	0.5	16.2	54.9	63.8
12	-9.1	0.0	0.0	0.0	-0.7	20.3	62.5	27.2
13	-8.6	0.0	0.0	-0.1	-1.4	30.0	72.1	22.7
14	-8.8	0.0	0.0	-0.1	-0.7	8.8	87.1	12.2
15	-9.0	0.0	0.0	-0.3	1.1	87.6	107.7	22.6
16	3.1	0.0	0.0	-0.1	-10.8	620.0	51.5	125.0
17								
18								
19	11.2	0.0	0.0	0.6	12.1	6199.5	28.2	1215.4
20	7.6	0.0	0.0	0.3	5.5	381.8	35.4	78.2
21	19.9	0.0	0.0	1.2	-20.0	848.0	37.6	173.6
22	22.1	0.0	0.0	0.1	-3.7	471.0	32.4	94.4
23	21.5	0.0	0.0	0.1	-4.5	199.4	31.3	108.4
24	-19.1	0.0	0.0	0.3	-3.2	246.3	29.9	107.8
25	-16.5	0.0	0.0	-0.6	-14.4	165.9	31.1	75.5
26	12.3	0.0	0.0	1.8	13.9	300.2	32.3	75.0
27								
28								
29	-4.3	0.0	0.0	0.2	-7.4	220.8	35.4	44.7
30	12.5	0.0	0.0	0.7	-148.5	3699.2	21.1	1197.9
31	11.0	0.0	0.0	0.2	43.7	3822.8	19.3	2265.6
32								
33								
34	-9.3	0.0	0.0	-0.2	-15.4	1406.8	28.9	698.1
35	8.9	0.0	0.0	0.0	-7.6	1096.2	36.6	583.2
36	10.5	0.0	0.0	-0.1	-14.8	765.1	36.9	549.3
37	-12.2	0.0	0.0	0.0	4.4	727.3	37.5	546.9
38	16.4	0.0	0.0	0.0	-3.5	670.8	37.9	575.5
39	21.1	0.0	0.0	0.0	1.7	712.7	39.1	563.1
40	26.7	0.0	0.0	-0.1	-2.1	854.3	39.5	575.1
41	29.2	0.0	0.0	1.2	-32.7	942.4	40.2	492.0
42	32.5	0.0	0.0	0.5	-29.3	349.4	39.0	607.7
43	36.1	0.0	0.0	-0.1	-5.2	983.9	39.4	641.6
44	37.4	0.0	0.0	-0.1	-57.5	113.2	39.2	702.4
45								
46								
47	-7.9	0.0	0.0	-0.8	265.9	5388.3	22.0	503.8

	AO	AP	AQ	AR	AS	AT	AU	AV
1								
2								
3	**Total Seismic Demand**							
4	circumf. P	transverse	transverse	in-plane	twisting	demand	merid. M	merid. P
5	(lb/in^2)	shear (mer)	shear (cir)	shear	moment	section	(in-lb/ft)	(lb/ft)
6	15.9	0.0	0.0	4.8	12.6		1,057	1,507
7	17.2	0.0	0.0	11.9	17.2		1,593	2,662
8	19.2	0.0	0.0	7.0	17.6	a	961	2,003
9	13.3	0.0	0.0	10.3	4.1		625	2,387
10	12.8	0.0	0.0	19.7	8.9	b	409	2,985
11	12.8	0.0	0.0	24.9	9.4		195	3,922
12	13.2	0.0	0.0	30.9	7.2	c,d	243	4,462
13	15.0	0.0	0.0	37.1	7.4		360	5,151
14	17.7	0.0	0.0	48.1	5.0	e	106	6,224
15	20.2	0.0	0.0	57.5	5.0	f,g,h,i	1,051	7,700
16	6.0	0.0	0.0	31.9	25.7		7,440	7,875
17								
18								
19	50.9	0.0	0.0	57.6	409.4		74,394	6,168
20	14.2	0.0	0.0	82.5	22.6		4,582	4,184
21	46.4	0.0	0.0	88.7	83.8	k	10,176	5,425
22	35.1	0.0	0.0	92.3	90.8	l	5,652	4,680
23	31.7	0.0	0.0	93.0	88.3	m	2,392	4,521
24	20.5	0.0	0.0	90.1	70.1	n	2,956	4,311
25	23.7	0.0	0.0	86.0	75.3		1,991	4,487
26	32.7	0.0	0.0	79.7	79.3	o,p,q	3,602	4,661
27								
28								
29	8.6	0.0	0.0	75.6	46.2	q	2,649	3,892
30	30.4	0.0	0.0	34.1	702.2	r	44,390	6,960
31	35.5	0.0	0.0	25.7	1059.2		45,874	7,395
32								
33								
34	39.3	0.0	0.0	32.6	338.6	s,t	16,881	7,448
35	41.8	0.0	0.0	35.4	205.8	u	13,155	7,994
36	45.3	0.0	0.0	35.5	199.8		9,181	7,745
37	46.4	0.0	0.0	34.0	191.4		8,727	7,662
38	51.2	0.0	0.0	31.3	193.8		8,049	7,495
39	51.3	0.0	0.0	28.3	173.9		8,552	7,465
40	52.7	0.0	0.0	24.1	210.6	x	10,251	7,262
41	51.8	0.0	0.0	17.9	166.0	y	11,309	7,269
42	48.1	0.0	0.0	12.2	127.5	z	4,192	7,043
43	44.8	0.0	0.0	7.3	156.0	aa	11,807	7,078
44	40.8	0.0	0.0	2.0	60.1	bb	1,359	7,053
45								
46								
47	65.5	0.0	0.0	10.3	545.1	j	64,660	6,359

	AW	AX	AY	AZ	BA	BB
1						
2						
3	Total seismic demand per foot of width					
4	circumf. M	circumf. P	transverse	transverse	in-plane	twisting
5	(in-lb/ft)	(lb/ft)	shear (mer)	shear (cir)	shear	moment
6	1,113	1,139	0	0	340	151
7	2,281	1,229	0	0	851	206
8	1,360	1,373	0	0	499	211
9	2,002	950	0	0	733	49
10	1,079	911	0	0	1,408	107
11	766	915	0	0	1,779	112
12	326	942	0	0	2,207	87
13	272	1,071	0	0	2,653	88
14	147	1,265	0	0	3,439	59
15	271	1,447	0	0	4,110	60
16	1,499	917	0	0	4,886	308
17						
18						
19	14,585	11,145	0	0	12,601	4,912
20	939	1,682	0	0	9,751	272
21	2,083	6,692	0	0	12,808	1,006
22	1,133	5,070	0	0	13,315	1,090
23	1,301	4,573	0	0	13,414	1,059
24	1,294	2,956	0	0	12,996	841
25	906	3,419	0	0	12,405	903
26	900	4,723	0	0	11,497	952
27						
28						
29	536	948	0	0	8,315	555
30	14,375	10,045	0	0	11,252	8,426
31	27,187	13,620	0	0	9,859	12,711
32						
33						
34	8,377	10,108	0	0	8,397	4,063
35	6,998	9,110	0	0	7,716	2,470
36	6,592	9,499	0	0	7,447	2,398
37	6,563	9,480	0	0	6,948	2,297
38	6,906	10,128	0	0	6,186	2,326
39	6,757	9,794	0	0	5,398	2,087
40	6,901	9,686	0	0	4,442	2,527
41	5,905	9,364	0	0	3,235	1,992
42	7,292	8,681	0	0	2,211	1,530
43	7,699	8,044	0	0	1,314	1,872
44	8,428	7,334	0	0	360	721
45						
46						
47	6,046	18,958	0	0	2,994	6,541

	A	B	C	D	E	F	G	H	I
1	Nonseismic (Load Case 2) + Seismic (Best-Estimate Soil Properties)								
2	PPS-U2P.XLS					All Values are Per Foot of Width			
3	ELSET AXIS-P1: along the positive 1-axis								
4			positive is compression			absolute value			absolute val
5	ELEMENT	PT FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2
6		NOTE	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)
7									
8	floor elements								
9	289	1	15,048	14,568	-19	60	10	7,928	5,838
10	291	1	14,484	14,136	8	163	53	1,828	2,192
11	295	1	15,360	14,244	-29	4	72	1,016	810
12	301	1	17,088	14,832	-404	157	105	7,385	2,729
13	1,257	1	17,688	15,216	462	111	20	7,529	3,036
14	1,261	1	17,784	15,000	-374	132	28	2,098	2,298
15	-1,265	1	17,844	14,712	537	384	23	8,682	3,275
16	1,269	1	18,420	15,000	-609	705	32	102	1,495
17	1,273	1	18,660	14,340	1,017	558	600	272	613
18	1,277	1	18,612	13,776	-377	1,291	525	16,884	3,228
19	1,281	1	27,300	13,188	-75	8,950	432	187,632	35,184
20	0								
21	wall elements								
22	1,285	1	-17,844	33,924	1,253	497	9,770	49,764	290,700
23	1,289	1	-7,975	32,784	-1,696	110	6,466	13,776	103,608
24	1,293	1	1,675	32,268	1,643	41	3,818	587	5,819
25	1,297	1	12,852	32,652	-445	58	1,475	10,535	80,220
26	1,301	1	30,888	32,280	1,048	33	141	13,584	102,828
27	1,305	1	31,116	32,148	-362	3	891	12,156	91,956
28	1,309	1	17,748	32,040	973	14	1,921	7,306	52,236
29	1,313	1	-5,711	30,984	-709	30	5,243	5,977	48,348
30	0								
31	haunch elements 1317,1321 demands are transformed via Mathcad)								
32	1,317	1	-34,820	28,980	650	135	6,798	25,410	218,200
33	1,321	1	-106,600	30,040	1,974	81	6,652	26,770	381,500
34	1,325	1	33,372	-90,576	-5,741	9,850	412	359,016	128,184
35	0								
36	dome elements								
37	1,329	1	38,676	-34,152	-2,417	5,392	2	163,632	29,052
38	1,333	1	40,668	-7,507	-1,810	3,325	105	27,108	26,964
39	1,337	1	41,748	9,392	-1,218	1,740	63	51,996	33,264
40	1,341	1	43,032	23,916	-864	142	53	79,548	33,492
41	1,345	1	44,160	33,996	-315	916	76	62,580	24,420
42	1,349	1	44,604	39,012	-276	598	64	34,752	14,172
43	1,353	1	44,700	41,100	-8	386	61	16,248	8,002
44	308	1	45,420	41,520	-306	2	58	7,577	5,482
45	305	1	45,588	42,996	-161	19	37	7,435	3,713
46	314	1	46,176	43,152	-126	177	1	511	2,602
47	312	1	46,020	42,456	-284	229	173	149	2,273
48	318	1	47,580	45,780	-77	207	231	4,319	1,913
49	317	1	48,036	49,284	220	217	25	3,214	5,378
50	320	1	45,660	45,840	63	176	51	8,837	8,450
51	0								
52	footing element								
53	1,357	1	15,960	27,972	-3,413	1,220	800	13,488	93,204
54									

	A	B	C	D	E	F	G	H	I
55									
56									
57	ELSET AXIS-N1: along the negative 1-axis								
58			positive is compression			absolute value		absolute value	
59	ELEMENT	PT FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2
60		NOTE	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)
61	0								
62	floor elements								
63	1	1	15,012	14,640	-2	62	1	7,954	5,894
64	4	1	14,424	14,304	-6	144	4	1,811	2,381
65	9	1	15,204	14,448	-3	31	12	1,163	1,169
66	16	1	16,932	15,096	382	164	73	7,516	2,905
67	324	1	17,412	15,516	-450	114	22	7,505	3,126
68	328	1	17,376	15,372	360	130	29	2,110	2,339
69	332	1	17,304	15,132	-524	382	27	8,706	3,282
70	336	1	17,688	15,504	578	712	43	242	1,404
71	340	1	17,784	14,940	-1,013	570	608	289	545
72	344	1	17,616	14,532	328	1,309	533	17,112	3,244
73	348	1	26,088	16,092	107	8,821	440	182,784	36,924
74	0								
75	wall elements								
76	352	1	-14,832	33,444	-1,047	496	9,452	49,308	284,952
77	356	1	-6,144	32,136	1,931	117	6,397	13,692	103,092
78	360	1	3,335	31,332	-1,381	52	3,925	1,358	7,098
79	364	1	14,124	31,044	806	102	1,594	12,432	84,492
80	368	1	30,960	30,216	-763	119	17	15,708	107,136
81	372	1	29,244	29,556	867	83	997	13,356	93,516
82	376	1	13,380	28,944	-591	32	2,569	5,766	43,692
83	380	1	-11,738	28,608	854	8	5,170	9,906	64,560
84	0								
85	haunch elements (384,388 demands are transformed via Mathcad)								
86	384	1	-34,820	28,980	650	135	6,798	25,410	218,200
87	388	1	-106,600	30,040	1,974	81	6,652	26,770	381,500
88	392	1	31,536	-96,324	6,359	9,875	430	355,860	153,288
89	0								
90	dome elements								
91	396	1	36,804	-34,176	2,964	6,354	231	148,392	42,168
92	400	1	39,876	-5,465	2,083	3,455	93	3,706	41,784
93	404	1	42,072	11,414	1,167	934	18	72,648	44,616
94	408	1	43,368	25,224	807	416	62	83,484	38,676
95	412	1	44,292	35,004	303	883	77	62,916	27,156
96	416	1	44,736	39,876	265	634	59	35,892	16,320
97	420	1	44,880	41,676	-8	443	66	16,212	8,825
98	23	1	45,576	41,916	295	10	63	6,757	5,652
99	19	1	45,696	43,236	205	12	22	6,635	3,779
100	28	1	46,200	43,380	165	175	33	1	2,706
101	25	1	46,068	42,600	294	190	140	613	2,438
102	31	1	47,628	45,924	64	178	187	4,427	2,140
103	29	1	48,048	49,320	-186	214	42	3,348	5,476
104	32	1	45,636	45,864	-39	184	8	8,840	8,560
105	0								
106	footing element								
107	424	1	15,324	33,120	3,512	1,167	778	12,576	98,412
108									

	A	B	C	D	E	F	G	H	I
109									
110									
111	ELSET AXIS-P2: along the positive 2-axis								
112			positive is compression			absolute value		absolute value	
113	ELEMENT	PT FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2
114		NOTE	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)
115	0								
116	floor element								
117	161	1	15,084	14,556	-29	23	57	7,940	5,863
118	164	1	14,700	13,968	-7	13	144	4,284	130
119	169	1	14,820	14,796	-27	49	19	2,976	900
120	176	1	15,444	16,536	-403	72	171	4,883	5,383
121	844	1	15,876	17,052	433	24	113	5,150	5,453
122	848	1	15,684	17,052	-370	32	130	4,350	54
123	852	1	15,420	17,004	522	23	381	5,322	6,625
124	856	1	15,756	17,424	-559	40	706	3,431	2,197
125	860	1	15,108	17,580	1,031	611	568	2,507	2,140
126	864	1	14,664	17,400	-296	544	1,309	1,428	18,996
127	868	1	16,764	25,908	-49	442	8,904	37,848	183,024
128	0								
129	wall elements								
130	872	1	-14,436	33,936	-631	526	9,392	49,812	283,560
131	876	1	-5,922	32,484	2,274	141	6,350	14,016	102,936
132	880	1	3,504	31,644	-1,053	25	3,904	867	6,511
133	884	1	14,196	31,248	1,050	71	1,603	12,024	83,544
134	888	1	30,948	30,492	-607	99	44	15,816	106,464
135	892	1	29,256	29,832	982	87	943	14,268	93,708
136	896	1	13,416	29,388	-520	66	2,526	7,363	45,096
137	900	1	-11,635	29,100	1,049	43	5,218	8,311	63,204
138	0								
139	haunch elements								
140	904	1	-34,572	29,448	-762	122	6,853	24,468	218,172
141	908	1	-106,500	30,492	-398	210	6,700	25,284	382,560
142	912	1	-96,636	31,800	-4,732	350	9,890	150,696	357,672
143	0								
144	dome elements								
145	916	1	-34,200	36,816	-2,119	191	6,352	42,084	148,956
146	920	1	-5,311	39,768	-1,594	66	3,452	41,412	3,692
147	924	1	11,585	41,916	-829	27	945	44,256	72,972
148	928	1	25,464	43,200	-629	61	414	38,460	84,024
149	932	1	35,208	44,148	-228	75	887	27,072	63,360
150	936	1	40,080	44,592	-253	57	632	16,296	36,204
151	940	1	41,820	44,748	-7	64	443	8,927	16,488
152	183	1	42,060	45,444	-323	61	10	5,750	6,937
153	179	1	43,332	45,552	-241	30	13	3,935	6,814
154	188	1	43,488	46,128	-167	40	180	2,843	27
155	185	1	42,648	45,972	-338	140	193	2,555	607
156	191	1	45,972	47,556	-79	186	177	2,305	4,598
157	189	1	49,368	47,976	166	50	212	5,707	3,538
158	192	1	45,900	45,600	50	2	187	8,785	8,532
159	0								
160	footing element								
161	944	1	33,660	15,156	-3,752	790	1,035	99,216	10,682

	J	K	L	M	N	O	P
1							
2							
3							
4							
5	SM3						
6	0	**Total seismic demand per foot of width**					
7		demand	merid. M	merid. P	circumf. M	circumf. P	transv. shear
8		section	(in-lb/ft)	(lb/ft)	(in-lb/ft)	(lb/ft)	(merid) (lb/ft)
9	3	0	1,057	1,507	1,113	1,139	0
10	22	0	1,593	2,662	2,281	1,229	0
11	19	a	961	2,003	1,360	1,373	0
12	193	0	625	2,387	2,002	950	0
13	105	b	409	2,985	1,079	911	0
14	72	0	195	3,922	766	915	0
15	68	c,d	243	4,462	326	942	0
16	263	0	360	5,151	272	1,071	0
17	428	e	106	6,224	147	1,265	0
18	295	f,g,h,i	1,051	7,700	271	1,447	0
19	6,786	0	7,440	7,875	1,499	917	0
20							
21							
22	2,564	0	74,394	6,168	14,585	11,145	0
23	1,151	0	4,582	4,184	939	1,682	0
24	157	k	10,176	5,425	2,083	6,692	0
25	64	l	5,652	4,680	1,133	5,070	0
26	215	m	2,392	4,521	1,301	4,573	0
27	126	n	2,956	4,311	1,294	2,956	0
28	404	0	1,991	4,487	906	3,419	0
29	678	o,p,q	3,602	4,661	900	4,723	0
30							
31							
32	90	q	2,649	3,892	536	948	0
33	7	r	44,390	6,960	14,375	10,045	0
34	18,264	0	45,874	7,395	27,187	13,620	0
35							
36							
37	5,472	s,t	16,881	7,448	8,377	10,108	0
38	1,760	u	13,155	7,994	6,998	9,110	0
39	115	0	9,181	7,745	6,592	9,499	0
40	953	0	8,727	7,662	6,563	9,480	0
41	1,410	0	8,049	7,495	6,906	10,128	0
42	489	0	8,552	7,465	6,757	9,794	0
43	369	x	10,251	7,262	6,901	9,686	0
44	373	y	11,309	7,269	5,905	9,364	0
45	262	y	11,309	7,269	5,905	9,364	0
46	602	z	4,192	7,043	7,292	8,681	0
47	237	z	4,192	7,043	7,292	8,681	0
48	82	aa	11,807	7,078	7,699	8,044	0
49	1,450	aa	11,807	7,078	7,699	8,044	0
50	15	bb	1,359	7,053	8,428	7,334	0
51							
52							
53	13,152	j	64,660	6,359	6,046	18,958	0
54							

	J	K	L	M	N	O	P
55							
56							
57							
58							
59	SM3						
60	0						
61		demand	merid. M	merid. P	circumf. M	circumf. P	transv. shear
62		section	(in-lb/ft)	(lb/ft)	(in-lb/ft)	(lb/ft)	(merid) (lb/ft)
63	4	0	1,057	1,507	1,113	1,139	0
64	6	0	1,593	2,662	2,281	1,229	0
65	2	a	961	2,003	1,360	1,373	0
66	199	0	625	2,387	2,002	950	0
67	87	b	409	2,985	1,079	911	0
68	73	0	195	3,922	766	915	0
69	52	c,d	243	4,462	326	942	0
70	282	0	360	5,151	272	1,071	0
71	408	e	106	6,224	147	1,265	0
72	271	f,g,h,i	1,051	7,700	271	1,447	0
73	7,325	0	7,440	7,875	1,499	917	0
74							
75							
76	2,605	0	74,394	6,168	14,585	11,145	0
77	1,392	0	4,582	4,184	939	1,682	0
78	249	k	10,176	5,425	2,083	6,692	0
79	231	l	5,652	4,680	1,133	5,070	0
80	119	m	2,392	4,521	1,301	4,573	0
81	538	n	2,956	4,311	1,294	2,956	0
82	362	0	1,991	4,487	906	3,419	0
83	277	o,p,q	3,602	4,661	900	4,723	0
84							
85							
86	90	q	2,649	3,892	536	948	0
87	7	r	44,390	6,960	14,375	10,045	0
88	22,224	0	45,874	7,395	27,187	13,620	0
89							
90							
91	8,569	s,t	16,881	7,448	8,377	10,108	0
92	1,624	u	13,155	7,994	6,998	9,110	0
93	1,120	0	9,181	7,745	6,592	9,499	0
94	1,790	0	8,727	7,662	6,563	9,480	0
95	1,517	0	8,049	7,495	6,906	10,128	0
96	677	0	8,552	7,465	6,757	9,794	0
97	500	x	10,251	7,262	6,901	9,686	0
98	314	y	11,309	7,269	5,905	9,364	0
99	233	y	11,309	7,269	5,905	9,364	0
100	578	z	4,192	7,043	7,292	8,681	0
101	198	z	4,192	7,043	7,292	8,681	0
102	101	aa	11,807	7,078	7,699	8,044	0
103	1,440	aa	11,807	7,078	7,699	8,044	0
104	6	bb	1,359	7,053	8,428	7,334	0
105							
106							
107	13,548	j	64,660	6,359	6,046	18,958	0
108							

	J	K	L	M	N	O	P
109							
110							
111							
112							
113	SM3						
114	0						
115		demand	merid. M	merid. P	circumf. M	circumf. P	transv. shear
116		section	(in-lb/ft)	(lb/ft)	(in-lb/ft)	(lb/ft)	(merid) (lb/ft)
117	19	0	1,057	1,507	1,113	1,139	0
118	25	0	1,593	2,662	2,281	1,229	0
119	10	a	961	2,003	1,360	1,373	0
120	202	0	625	2,387	2,002	950	0
121	95	b	409	2,985	1,079	911	0
122	78	0	195	3,922	766	915	0
123	60	c,d	243	4,462	326	942	0
124	284	0	360	5,151	272	1,071	0
125	426	e	106	6,224	147	1,265	0
126	280	f,g,h,i	1,051	7,700	271	1,447	0
127	7,506	0	7,440	7,875	1,499	917	0
128							
129							
130	2,509	0	74,394	6,168	14,585	11,145	0
131	1,204	0	4,582	4,184	939	1,682	0
132	126	k	10,176	5,425	2,083	6,692	0
133	332	l	5,652	4,680	1,133	5,070	0
134	249	m	2,392	4,521	1,301	4,573	0
135	52	n	2,956	4,311	1,294	2,956	0
136	28	0	1,991	4,487	906	3,419	0
137	455	o,p,q	3,602	4,661	900	4,723	0
138							
139							
140	482	q	2,649	3,892	536	948	0
141	6,264	r	44,390	6,960	14,375	10,045	0
142	16,884	0	45,874	7,395	27,187	13,620	0
143							
144							
145	6,562	s,t	16,881	7,448	8,377	10,108	0
146	1,156	u	13,155	7,994	6,998	9,110	0
147	1,065	0	9,181	7,745	6,592	9,499	0
148	1,547	0	8,727	7,662	6,563	9,480	0
149	1,318	0	8,049	7,495	6,906	10,128	0
150	511	0	8,552	7,465	6,757	9,794	0
151	382	x	10,251	7,262	6,901	9,686	0
152	432	y	11,309	7,269	5,905	9,364	0
153	350	y	11,309	7,269	5,905	9,364	0
154	675	z	4,192	7,043	7,292	8,681	0
155	132	z	4,192	7,043	7,292	8,681	0
156	155	aa	11,807	7,078	7,699	8,044	0
157	1,477	aa	11,807	7,078	7,699	8,044	0
158	29	bb	1,359	7,053	8,428	7,334	0
159							
160							
161	13,428	j	64,660	6,359	6,046	18,958	0

	Q	R	S	T	U	V
1						
2						
3						
4						
5						
6				**Nonseismic + Seismic Demand**		
7	transv. shear	in-plane	twisting	merid. M	merid. P (min)	merid. P (max)
8	(circum) (lb/ft)	shear (lb/ft)	mom. (in-lb/ft)	(in-lb/ft)	(lb/ft)	(lb/ft)
9	0	340	151	8986	13541	16555
10	0	851	206	3420	11822	17146
11	0	499	211	1977	13357	17363
12	0	733	49	8009	14701	19475
13	0	1,408	107	7938	14703	20673
14	0	1,779	112	2292	13862	21706
15	0	2,207	87	8925	13382	22306
16	0	2,653	88	462	13269	23571
17	0	3,439	59	378	12436	24884
18	0	4,110	60	17935	10912	26312
19	0	4,886	308	195072	19425	35175
20						
21						
22	0	12,601	4,912	365094	27756	40092
23	0	9,751	272	108190	28600	36968
24	0	12,808	1,006	15995	26843	37693
25	0	13,315	1,090	85872	27972	37332
26	0	13,414	1,059	105220	27759	36801
27	0	12,996	841	94912	27837	36459
28	0	12,405	903	54227	27553	36527
29	0	11,497	952	51950	26323	35645
30						
31						
32	0	8,315	555	220849	25088	32872
33	0	11,252	8,426	425890	23080	37000
34	0	9,859	12,711	404890	25977	40767
35						
36						
37	0	8,397	4,063	180513	31228	46124
38	0	7,716	2,470	40263	32674	48662
39	0	7,447	2,398	61177	34003	49493
40	0	6,948	2,297	88275	35370	50694
41	0	6,186	2,326	70629	36665	51655
42	0	5,398	2,087	43304	37139	52069
43	0	4,442	2,527	26499	37438	51962
44	0	3,235	1,992	18886	38151	52689
45	0	3,235	1,992	18744	38319	52857
46	0	2,211	1,530	4704	39133	53219
47	0	2,211	1,530	4342	38977	53063
48	0	1,314	1,872	16126	40502	54658
49	0	1,314	1,872	15021	40958	55114
50	0	360	721	10195	38607	52713
51						
52						
53	0	2,994	6,541	78148	9601	22319
54						

c106\nonseis3d\TOTAL.XLS

	Q	R	S	T	U	V
55						
56						
57						
58						
59						
60				Nonseismic + Seismic Demand		
61	transv. shear	in-plane	twisting	merid. M	merid. P (min)	merid. P (max)
62	(circum) (lb/ft)	shear (lb/ft)	mom. (in-lb/ft)	(in-lb/ft)	(lb/ft)	(lb/ft)
63	0	340	151	9011	13505	16519
64	0	851	206	3404	11762	17086
65	0	499	211	2123	13201	17207
66	0	733	49	8140	14545	19319
67	0	1,408	107	7914	14427	20397
68	0	1,779	112	2304	13454	21298
69	0	2,207	87	8949	12842	21766
70	0	2,653	88	602	12537	22839
71	0	3,439	59	395	11560	24008
72	0	4,110	60	18163	9916	25316
73	0	4,886	308	190224	18213	33963
74						
75						
76	0	12,601	4,912	359346	27276	39612
77	0	9,751	272	107674	27952	36320
78	0	12,808	1,006	17274	25907	36757
79	0	13,315	1,090	90144	26364	35724
80	0	13,414	1,059	109528	25695	34737
81	0	12,996	841	96472	25245	33867
82	0	12,405	903	45683	24457	33431
83	0	11,497	952	68162	23947	33269
84						
85						
86	0	8,315	555	220849	25088	32872
87	0	11,252	8,426	425890	23080	37000
88	0	9,859	12,711	401734	24141	38931
89						
90						
91	0	8,397	4,063	165273	29356	44252
92	0	7,716	2,470	16860	31882	47870
93	0	7,447	2,398	81829	34327	49817
94	0	6,948	2,297	92211	35706	51030
95	0	6,186	2,326	70965	36797	51787
96	0	5,398	2,087	44444	37271	52201
97	0	4,442	2,527	26463	37618	52142
98	0	3,235	1,992	18066	38307	52845
99	0	3,235	1,992	17944	38427	52965
100	0	2,211	1,530	4194	39157	53243
101	0	2,211	1,530	4805	39025	53111
102	0	1,314	1,872	16234	40550	54706
103	0	1,314	1,872	15155	40970	55126
104	0	360	721	10199	38583	52689
105						
106						
107	0	2,994	6,541	77236	8965	21683
108						

	Q	R	S	T	U	V
109						
110						
111						
112						
113						
114				Nonseismic + Seismic Demand		
115	transv. shear	in-plane	twisting	merid. M	merid. P (min)	merid. P (max)
116	(circum) (lb/ft)	shear (lb/ft)	mom. (in-lb/ft)	(in-lb/ft)	(lb/ft)	(lb/ft)
117	0	340	151	6920	13049	16063
118	0	851	206	1723	11306	16630
119	0	499	211	1861	12793	16799
120	0	733	49	6008	14149	18923
121	0	1,408	107	5862	14067	20037
122	0	1,779	112	249	13130	20974
123	0	2,207	87	6869	12542	21466
124	0	2,653	88	2557	12273	22575
125	0	3,439	59	2246	11356	23804
126	0	4,110	60	20047	9700	25100
127	0	4,886	308	190464	18033	33783
128						
129						
130	0	12,601	4,912	357954	27768	40104
131	0	9,751	272	107518	28300	36668
132	0	12,808	1,006	16688	26219	37069
133	0	13,315	1,090	89196	26568	35928
134	0	13,414	1,059	108856	25971	35013
135	0	12,996	841	96664	25521	34143
136	0	12,405	903	47087	24901	33875
137	0	11,497	952	66806	24439	33761
138						
139						
140	0	8,315	555	220821	25556	33340
141	0	11,252	8,426	426950	23532	37452
142	0	9,859	12,711	403546	24405	39195
143						
144						
145	0	8,397	4,063	165837	29368	44264
146	0	7,716	2,470	16847	31774	47762
147	0	7,447	2,398	82153	34171	49661
148	0	6,948	2,297	92751	35538	50862
149	0	6,186	2,326	71409	36653	51643
150	0	5,398	2,087	44756	37127	52057
151	0	4,442	2,527	26739	37486	52010
152	0	3,235	1,992	18246	38175	52713
153	0	3,235	1,992	18123	38283	52821
154	0	2,211	1,530	4219	39085	53171
155	0	2,211	1,530	4799	38929	53015
156	0	1,314	1,872	16405	40478	54634
157	0	1,314	1,872	15345	40898	55054
158	0	360	721	9891	38547	52653
159						
160						
161	0	2,994	6,541	75342	8797	21515

	W	X	Y	Z	AA	AB
1						
2						
3						
4						
5						
6						
7	circumf. M	circumf. P (min)	circumf. P (max)	transv. shear	transv. shear	in-plane
8	(in-lb/ft)	(lb/ft)	(lb/ft)	(merid) (lb/ft)	(circum) (lb/ft)	shear (lb/ft)
9	6951	13429	15707	60	10	359
10	4474	12907	15365	163	53	859
11	2170	12871	15617	4	72	527
12	4731	13882	15782	157	105	1,136
13	4115	14305	16127	111	20	1,871
14	3064	14085	15915	132	28	2,153
15	3601	13770	15654	384	23	2,744
16	1767	13929	16071	705	32	3,262
17	760	13075	15605	558	600	4,456
18	3499	12329	15223	1291	525	4,487
19	36683	12271	14105	8950	432	4,961
20						
21						
22	64349	-28989	-6699	9770	497	13,854
23	14715	-9657	-6293	6466	110	11,447
24	2670	-5017	8367	3818	41	14,451
25	11668	7782	17922	1475	58	13,761
26	14885	26315	35461	141	33	14,462
27	13450	28160	34072	891	3	13,357
28	8212	14329	21167	1921	14	13,377
29	6877	-10434	-988	5243	30	12,206
30						
31						
32	25946	-35768	-33872	6798	135	8,965
33	41145	-116645	-96555	6652	81	13,226
34	155371	-104196	-76956	9850	412	15,600
35						
36						
37	37429	-44260	-24044	5392	2	10,814
38	33962	-16617	1603	3325	105	9,526
39	39856	-106	18891	1740	63	8,665
40	40055	14436	33396	142	53	7,812
41	31326	23868	44124	916	76	6,501
42	20929	29218	48806	598	64	5,674
43	14903	31414	50786	386	61	4,450
44	11386	32156	50884	2	58	3,541
45	9617	33632	52360	19	37	3,396
46	9893	34471	51833	177	1	2,337
47	9565	33775	51137	229	173	2,495
48	9612	37736	53824	207	231	1,391
49	13077	41240	57328	217	25	1,534
50	16879	38506	53174	176	51	423
51						
52						
53	99250	9014	46930	1220	800	6,407
54						

	W	X	Y	Z	AA	AB
55						
56						
57						
58						
59						
60						
61	circumf. M	circumf. P (min)	circumf. P (max)	transv. shear	transv. shear	in-plane
62	(in-lb/ft)	(lb/ft)	(lb/ft)	(merid) (lb/ft)	(circum) (lb/ft)	shear (lb/ft)
63	7008	13501	15779	62	1	342
64	4662	13075	15533	144	4	858
65	2529	13075	15821	31	12	502
66	4907	14146	16046	164	73	1,115
67	4205	14605	16427	114	22	1,858
68	3105	14457	16287	130	29	2,139
69	3608	14190	16074	382	27	2,732
70	1676	14433	16575	712	43	3,231
71	692	13675	16205	570	608	4,451
72	3515	13085	15979	1309	533	4,438
73	38423	15175	17009	8821	440	4,993
74						
75						
76	63893	-25977	-3687	9452	496	13,649
77	14631	-7826	-4462	6397	117	11,682
78	3441	-3357	10027	3925	52	14,189
79	13565	9054	19194	1594	102	14,122
80	17009	26387	35533	17	119	14,177
81	14650	26288	32200	997	83	13,862
82	6672	9961	16799	2569	32	12,995
83	10806	-16461	-7015	5170	8	12,351
84						
85						
86	25946	-35768	-33872	6798	135	8,965
87	41145	-116645	-96555	6652	81	13,226
88	180475	-109944	-82704	9875	430	16,218
89						
90						
91	50545	-44284	-24068	6354	231	11,361
92	48782	-14575	3645	3455	93	9,799
93	51208	1916	20913	934	18	8,613
94	45239	15744	34704	416	62	7,754
95	34062	24876	45132	883	77	6,489
96	23077	30082	49670	634	59	5,664
97	15726	31990	51362	443	66	4,450
98	11557	32552	51280	10	63	3,530
99	9683	33872	52600	12	22	3,440
100	9998	34699	52061	175	33	2,376
101	9730	33919	51281	190	140	2,505
102	9839	37880	53968	178	187	1,378
103	13175	41276	57364	214	42	1,501
104	16988	38530	53198	184	8	399
105						
106						
107	104458	14162	52078	1167	778	6,506
108						

	W	X	Y	Z	AA	AB
109						
110						
111						
112						
113						
114						
115	circumf. M	circumf. P (min)	circumf. P (max)	transv. shear	transv. shear	in-plane
116	(in-lb/ft)	(lb/ft)	(lb/ft)	(merid) (lb/ft)	(circum) (lb/ft)	shear (lb/ft)
117	9054	13945	16223	57	23	369
118	6565	13471	15929	144	13	858
119	4336	13447	16193	19	49	525
120	6885	14494	16394	171	72	1,136
121	6229	14965	16787	113	24	1,841
122	5116	14769	16599	130	32	2,149
123	5648	14478	16362	381	23	2,729
124	3703	14685	16827	706	40	3,212
125	2654	13843	16373	568	611	4,470
126	1699	13217	16111	1309	544	4,406
127	39347	15847	17681	8904	442	4,936
128						
129						
130	64397	-25581	-3291	9392	526	13,233
131	14955	-7604	-4240	6350	141	12,025
132	2950	-3188	10196	3904	25	13,861
133	13157	9126	19266	1603	71	14,366
134	17117	26375	35521	44	99	14,022
135	15562	26300	32212	943	87	13,978
136	8269	9997	16835	2526	66	12,924
137	9211	-16358	-6912	5218	43	12,546
138						
139						
140	25004	-35520	-33624	6853	122	9,077
141	39659	-116545	-96455	6700	210	11,650
142	177883	-110256	-83016	9890	350	14,591
143						
144						
145	50461	-44308	-24092	6352	191	10,516
146	48410	-14421	3799	3452	66	9,310
147	50848	2086	21083	945	27	8,276
148	45023	15984	34944	414	61	7,577
149	33978	25080	45336	887	75	6,414
150	23053	30286	49874	632	57	5,651
151	15828	32134	51506	443	64	4,449
152	11655	32696	51424	10	61	3,558
153	9839	33968	52696	13	30	3,476
154	10135	34807	52169	180	40	2,378
155	9847	33967	51329	193	140	2,548
156	10004	37928	54016	177	186	1,394
157	13406	41324	57412	212	50	1,481
158	17214	38566	53234	187	2	410
159						
160						
161	105262	14702	52618	1035	790	6,746

	AC
1	
2	
3	
4	
5	
6	
7	twisting
8	mom. (in-lb/ft)
9	155
10	227
11	230
12	242
13	211
14	185
15	155
16	351
17	487
18	354
19	7094
20	
21	
22	7477
23	1422
24	1163
25	1154
26	1274
27	966
28	1307
29	1630
30	
31	
32	645
33	8433
34	30975
35	
36	
37	9535
38	4230
39	2512
40	3250
41	3736
42	2575
43	2895
44	2365
45	2254
46	2132
47	1768
48	1953
49	3321
50	735
51	
52	
53	19693
54	

	AC
55	
56	
57	
58	
59	
60	
61	twisting
62	mom. (in-lb/ft)
63	155
64	211
65	213
66	248
67	194
68	185
69	139
70	371
71	468
72	331
73	7633
74	
75	
76	7518
77	1664
78	1254
79	1321
80	1178
81	1379
82	1265
83	1229
84	
85	
86	645
87	8433
88	34935
89	
90	
91	12633
92	4094
93	3517
94	4087
95	3843
96	2764
97	3027
98	2307
99	2226
100	2108
101	1728
102	1972
103	3312
104	727
105	
106	
107	20089
108	

	AC
109	
110	
111	
112	
113	
114	
115	twisting
116	mom. (in-lb/ft)
117	170
118	230
119	220
120	251
121	202
122	191
123	147
124	372
125	485
126	340
127	7814
128	
129	
130	7422
131	1475
132	1131
133	1423
134	1309
135	893
136	932
137	1407
138	
139	
140	1037
141	14690
142	29595
143	
144	
145	10625
146	3626
147	3462
148	3843
149	3643
150	2598
151	2908
152	2424
153	2342
154	2205
155	1662
156	2027
157	3349
158	750
159	
160	
161	19969

APPENDIX M

ABAQUS INPUT/OUTPUT FILES AND EXCEL SPREADSHEETS FOR DETERMINING NONSEISMIC DEMAND

This appendix contains spreadsheets and ABAQUS input and output files used in calculating and compiling tank section demands from nonseismic loads.

File Name	Description
PPS-U1A.abdat	ABAQUS input file to add temperature, waste load, and Load Case 1a live loads (restarts from binary file LOAD1.res).
PPS-U1B.abdat	ABAQUS input file to add temperature, waste load, and Load Case 1b live loads (restarts from binary file LOAD1.res).
PPS-U2.abdat	ABAQUS input file to add temperature, waste load, and Load Case 1b live loads (restarts from binary file LOAD1.res).
PPS-U1AP.abdat	ABAQUS input file to extract Load Case 1a element demands (restarts from binary file PPS-U1A.res).
PPS-U1BP.abdat	ABAQUS input file to extract Load Case 1b element demands (restarts from binary file PPS-U1B.res).
PPS-U2P.abdat	ABAQUS input file to extract Load Case 2 element demands (restarts from binary file PPS-U2.res).
PPS-U1AP.about	ABAQUS output file containing nonseismic Load Case 1a element demands.
PPS-U1BP.about	ABAQUS output file containing nonseismic Load Case 1b element demands.
PPS-U2P.about	ABAQUS output file containing nonseismic Load Case 2 element demands.
PPS-U1AP.xls	Spreadsheet containing demands reported in PPS-U1AP.about.
PPS-U1BP.xls	Spreadsheet containing demands reported in PPS-U1BP.about.
PPS-U2P.xls	Spreadsheet containing demands reported in PPS-U2P.about.

```
*HEADING
PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS
40 PSF SNOW LOAD, 100 TON SOIL LOAD OVER DOME APEX, NO CRANE LOAD 20 FT. FROM EDGE
RESTART LOAD1NB.RES
****
*RESTART,READ,STEP=2,INC=10,WRITE,FREQ=100
****
**  step 3 applies live load, temperature, and hydro load
**  hydra contains lower three rows of tank wall elements onto which the
**  waste pressure is applied
*ELSET,ELSET=HYDRA,GENERATE
1285,1296
1181,1192
1077,1088
973,984
869,880
765,776
661,672
557,568
453,464
349,360
**  OVER contains elements above tank
**  (OVER also contains a thin layer of elements below the tank)
*ELSET,ELSET=OVER,GENERATE
2121,6000
**  SIDE contains all soil elements not in over
*ELSET,ELSET=SIDE,GENERATE
6001,10000
**  refined TOPELS contains top layer of soil elements above the tank
**
**  TOPELS2 is surface soil elements with face 2 up
*ELSET,ELSET=TOPELS2,GENERATE
2444, 5576, 348
2445, 5577, 348
2446, 5578, 348
2447, 5579, 348
2448, 5580, 348
2449, 5581, 348
2450, 5582, 348
2451, 5583, 348
2458, 5590, 348
2459, 5591, 348
8001, 8100, 11
7001, 7010, 1
7111, 7120, 1
**
**  TOPELS1 is surface soil elements with face 1 up
*ELSET,ELSET=TOPELS1, GENERATE
2454,5586,348
2455,5587,348
2466, 5598, 348
**
**  TOPELS5 is surface soil elements with face 5 up
*ELSET,ELSET=TOPELS5, GENERATE
2464, 5596, 348
2463, 5595, 348
**
*STEP,INC=9999,CYC=3
*STATIC,PTOL=100.,MTOL=1200.,DIRECT=NOSTOP
0.05,1.
**
**  apply distributed live load on soil surface (40psf)
*DLOAD
TOPELS1,P1,0.278
TOPELS2,P2,0.278
TOPELS5,P5,0.278
**
**  apply 100 ton concentrated load over dome apex (half-value due to symmetry)
*CLOAD
377,3,-100000
```

```
**
**  apply waste pressure
*DLOAD
HYDRA,P,3.18
**  apply temperature to temperature distribution in f
*TEMPERATURE
171,200
172,200
173,200
.
.
.
1852,90
1853,200
1854,200
1855,200
1856,200
*END STEP
****
****
**  no crane load (live load) for this load case
****
**
**END OF ANALYSIS
```

```
*HEADING
PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS
40 PSF SNOW LOAD, 100 TON SOIL LOAD OVER TANK EDGE, CRANE LOAD 19.5 FT. FROM EDGE
RESTART LOAD1NB.RES
****
*RESTART,READ,STEP=2,INC=10,WRITE,FREQ=100
****
**  step 3 applies live load, temperature, and hydro load
**  hydra contains lower three rows of tank wall elements onto which the
**  waste pressure is applied
****
*ELSET,ELSET=HYDRA,GENERATE
1285,1296
1181,1192
1077,1088
973,984
869,880
765,776
661,672
557,568
453,464
349,360
**  OVER contains elements above tank
**  (OVER also contains a thin layer of elements below the tank)
*ELSET,ELSET=OVER,GENERATE
2121,6000
**  SIDE contains all soil elements not in over
*ELSET,ELSET=SIDE,GENERATE
6001,10000
**  refined TOPELS contains top layer of soil elements above the tank
**
**  TOPELS2 is surface soil elements with face 2 up
*ELSET,ELSET=TOPELS2,GENERATE
2444, 5576, 348
2445, 5577, 348
2446, 5578, 348
2447, 5579, 348
2448, 5580, 348
2449, 5581, 348
2450, 5582, 348
2451, 5583, 348
2458, 5590, 348
2459, 5591, 348
8001, 8100, 11
7001, 7010, 1
7111, 7120, 1
**
**  TOPELS1 is surface soil elements with face 1 up
*ELSET,ELSET=TOPELS1, GENERATE
2454,5586,348
2455,5587,348
2466, 5598, 348
**
**  TOPELS5 is surface soil elements with face 5 up
*ELSET,ELSET=TOPELS5, GENERATE
2464, 5596, 348
2463, 5595, 348
**
*STEP,INC=9999,CYC=3
*STATIC,PTOL=100.,MTOL=1200.,DIRECT=NOSTOP
0.05,1.
**
**  apply distributed live load on soil surface (40psf)
*DLOAD
TOPELS1,P1,0.278
TOPELS2,P2,0.278
TOPELS5,P5,0.278
**
**  apply 100 ton concentrated load over tank wall (half value due to symmetry)
*CLOAD
```

```
1902,3,-100000
**
**  apply waste pressure
*DLOAD
HYDRA,P,3.18
**  apply temperature to temperature distribution in f
*TEMPERATURE
171,200
172,200
173,200
174,200
.
.
.
1851,90
1852,90
1853,200
1854,200
1855,200
1856,200
*END STEP
****
*STEP,INC=9999,CYC=3
*STATIC,PTOL=100.,MTOL=1200.,DIRECT=NOSTOP
0.1,1.
**  apply 85 ton concentrated crane load 19.5 ft. from tank edge (half value due to symmetry)
*CLOAD
6033,3,-85000
*END STEP
****
**
**END OF ANALYSIS
```

```
*HEADING
PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS
NO SNOW LOAD, 100 TON SOIL LOAD 20 FT. FROM EDGE, CRANE LOAD 20 FT. FROM EDGE
RESTART LOAD1NB.RES
****
*RESTART,READ,STEP=2,INC=10,WRITE,FREQ=100
****
**  step 3 applies temperature and hydro load
**  hydra contains lower three rows of tank wall elements onto which the
**  waste pressure is applied
*ELSET,ELSET=HYDRA,GENERATE
1285,1296
1181,1192
1077,1088
973,984
869,880
765,776
661,672
557,568
453,464
349,360
**  OVER contains elements above tank
**  (OVER also contains a thin layer of elements below the tank)
*ELSET,ELSET=OVER,GENERATE
2121,6000
**  SIDE contains all soil elements not in over
*ELSET,ELSET=SIDE,GENERATE
6001,10000
**  TOPELS contains top layer of soil elements above the tank
*ELSET,ELSET=TOPELS
2460
2463
2466
2467
2808
2812
2813
2814
8001
8012
2460
2464
2465
2466
8001
2808
2811
2814
2815
3156
3160
3161
3162
8012
8023
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3511
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2444
2792
3140
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4184
4532
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5228
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3150
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2800
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** TOPELS2 contains the balance of the soil surface elements
*ELSET,ELSET=TOPELS2, GENERATE
7001,7010,1
7111,7120,1
**
*STEP,INC=9999,CYC=3
*STATIC,PTOL=100.,MTOL=1200.,DIRECT=NOSTOP
0.05,1.
**
** no snow load for this load case
**
** apply 100 ton concentrated load 20 ft. from tank edge (half value due to symmetry)
*CLOAD
6033,3,-100000
**
** apply waste pressure
*DLOAD
HYDRA,P,3.18
** apply temperature to temperature distribution in f
*TEMPERATURE
171,200
172,200
173,200
174,200
175,200
176,200
.
.
.
1853,200
1854,200
1855,200
1856,200
*END STEP
****
*STEP,INC=9999,CYC=3
*STATIC,PTOL=100.,MTOL=1200.,DIRECT=NOSTOP
0.1,1.
** apply 85 ton concentrated crane load 20 ft. from tank edge (half value due to symmetry)
** (add to existing 100 ton live load at this node)
*CLOAD
6033,3,-185000
*END STEP
**
**END OF ANALYSIS
```

```
*** Restart pps-u1a.res to postprocess run of unfactored in situ loads
*** for local forces and moments
*POST OUTPUT, STEP=3
20
**
** elements along the positive 1-axis
*ELSET, ELSET=AXIS-P1
289, 290, 291, 293, 295, 298, 301
308, 305, 314, 312, 318, 317, 320
*ELSET, ELSET=AXIS-P1, GENERATE
1257, 1357, 4
**
** elements along the negative 1-axis
*ELSET, ELSET=AXIS-N1
 1,   2,   4,   6,   9,  12,  16
 23,  19,  28,  25,  31,  29,  32
*ELSET, ELSET=AXIS-N1, GENERATE
 324,  424, 4
**
** elements along the positive 2-axis
*ELSET, ELSET=AXIS-P2
161, 162, 164, 166, 169, 172, 176
183, 179, 188, 185, 191, 189, 192
*ELSET, ELSET=AXIS-P2, GENERATE
 844,  944, 4
**
*EL PRINT, ELSET=AXIS-P1, SUMMARY=NO
SF
*EL PRINT, ELSET=AXIS-N1, SUMMARY=NO
SF
*EL PRINT, ELSET=AXIS-P2, SUMMARY=NO
SF
```

```
*** Restart pps-u1b.res to postprocess run of unfactored in situ loads
*** for local forces and moments
*POST OUTPUT, STEP=4
10
**
** elements along the positive 1-axis
*ELSET, ELSET=AXIS-P1
289, 290, 291, 293, 295, 298, 301
308, 305, 314, 312, 318, 317, 320
*ELSET, ELSET=AXIS-P1, GENERATE
1257, 1357, 4
**
** elements along the negative 1-axis
*ELSET, ELSET=AXIS-N1
  1,   2,   4,   6,   9,  12,  16
 23,  19,  28,  25,  31,  29,  32
*ELSET, ELSET=AXIS-N1, GENERATE
 324,  424, 4
**
** elements along the positive 2-axis
*ELSET, ELSET=AXIS-P2
161, 162, 164, 166, 169, 172, 176
183, 179, 188, 185, 191, 189, 192
*ELSET, ELSET=AXIS-P2, GENERATE
 844,  944, 4
**
*EL PRINT, ELSET=AXIS-P1, SUMMARY=NO
SF
*EL PRINT, ELSET=AXIS-N1, SUMMARY=NO
SF
*EL PRINT, ELSET=AXIS-P2, SUMMARY=NO
SF
```

```
*** Restart pps-u2.res to postprocess run of unfactored in situ loads
*** for local forces and moments
*POST OUTPUT, STEP=4
10
**
** elements along the positive 1-axis
*ELSET, ELSET=AXIS-P1
289, 290, 291, 293, 295, 298, 301
308, 305, 314, 312, 318, 317, 320
*ELSET, ELSET=AXIS-P1, GENERATE
1257, 1357, 4
**
** elements along the negative 1-axis
*ELSET, ELSET=AXIS-N1
 1,   2,   4,   6,   9,  12,  16
 23,  19,  28,  25,  31,  29,  32
*ELSET, ELSET=AXIS-N1, GENERATE
 324,  424, 4
**
** elements along the positive 2-axis
*ELSET, ELSET=AXIS-P2
161, 162, 164, 166, 169, 172, 176
183, 179, 188, 185, 191, 189, 192
*ELSET, ELSET=AXIS-P2, GENERATE
 844,  944, 4
**
*EL PRINT, ELSET=AXIS-P1, SUMMARY=NO
SF
*EL PRINT, ELSET=AXIS-N1, SUMMARY=NO
SF
*EL PRINT, ELSET=AXIS-P2, SUMMARY=NO
SF
```

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 1
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 0 INCREMENT 0
TIME COMPLETED IN THIS STEP .000
E+00

STEP NUMBER 3 INCREMENT NUMBER 20

TIME COMPLETED DURING THIS STEP 1.00 FRACTION OF STEP IS 1.00
TOTAL ACCUMULATED TIME 3.00

E L E M E N T O U T P U T

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
289	1		-1239.	-1241.	-2.222	-4.843	1.214	662.7	490.7	.5336
290	1		-1195.	-1236.	-6.686	-23.18	4.115	201.8	413.2	60.70
291	1		-1187.	-1209.	.6442	-14.06	-4.852	145.8	180.3	1.975
293	1		-1254.	-1219.	4.235	6.058	-2.900	91.61	169.2	17.65
295	1		-1259.	-1221.	-1.914	4.6548E-02	-7.403	71.60	65.06	-2.672
298	1		-1372.	-1236.	4.713	20.23	-3.973	584.3	139.4	-25.66
301	1		-1405.	-1274.	-33.65	14.01	9.704	623.8	235.9	17.23

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
305	1		-5267.	-3928.	-37.69	66.44	-17.01	2432.	-3312.	401.2
308	1		-5195.	-3204.	-92.92	61.29	12.43	2803.	-1843.	-2.857

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 2
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
312	1		-5555.	-4711.	-55.20	42.06	19.54	-913.8	-5317.	383.0
314	1		-5480.	-3977.	-114.9	49.45	-4.781	-640.0	-3765.	110.3

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

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ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
317	1		-5960.	-5962.	3.502	76.58	1.554	-5041.	-8625.	575.0
318	1		-5840.	-5044.	-73.23	73.55	40.10	-4521.	-6046.	51.76

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
320	1		-5735.	-5630.	-12.01	-16.98	-8.119	-9265.	-9160.	5.315

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1257	1		-1451.	-1310.	38.99	-10.19	2.159	632.0	259.4	-8.510
1261	1		-1450.	-1296.	-30.98	-10.70	2.713	169.7	194.3	6.459
1265	1		-1447.	-1275.	45.40	32.10	-2.058	728.6	274.3	-4.768

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 3
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1269	1		-1483.	-1304.	-49.70	-60.03	-3.450	-26.98	115.3	24.26
1273	1		-1496.	-1252.	86.80	48.45	-51.97	-19.53	42.56	35.24

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1277	1		-1477.	-1215.	-27.74	-113.3	-45.86	-1494.	-287.9	23.82

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1281	1		-2200.	-1313.	-7.499	761.8	37.85	1.5761E+04	-3123.	-633.8

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THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1285	1		1283.	-2936.	87.69	42.72	793.4	4139.	2.3831E+04	-220.0

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 4
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1289	1		516.1	-2824.	-168.8	10.55	536.0	1149.	8575.	-115.5

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1293	1		-298.6	-2757.	117.5	-3.415	329.9	-106.9	-671.0	-16.30

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1297	1		-1219.	-2732.	-69.96	-7.503	134.2	-1035.	-7178.	-23.40

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1301	1		-2619.	-2666.	67.70	-9.258	3.832	-1323.	-9114.	3.066

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 5
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

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1305	1	-2443.	-2612.	-72.68	-6.770	-82.80	-1147.	-8011.	34.21

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1309	1	-1051.	-2566.	53.82	-3.041	-218.2	-521.1	-3802.	24.54

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1313	1	1150.	-2539.	-73.48	.1102	-449.8	827.8	5545.	24.12

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1317	1	-1545.	2265.	-2231.	-536.6	-253.6	1.6143E+04	5133.	6209.

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 6
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1321	1	-2491.	9781.	-1500.	-587.4	-86.18	3.2800E+04	3845.	3982.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1325	1	-2830.	9328.	-597.2	866.4	37.57	3.1153E+04	-1.1666E+04	1869.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1329	1	-3339.	3450.	-283.9	553.2	20.08	1.2948E+04	-3647.	737.5

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THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1333	1		-3654.	894.3	-207.1	294.6	7.806	-210.8	-3605.	144.0

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 7
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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1337	1		-3902.	-549.3	-132.2	73.09	-1.880	-5980.	-3831.	-86.20

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1341	1		-4097.	-1687.	-104.5	-44.40	-6.184	-6584.	-3320.	-130.1

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1345	1		-4287.	-2469.	-63.63	-91.85	-8.564	-4205.	-2352.	-82.08

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1349	1		-4506.	-2832.	-83.34	-92.03	-4.997	-502.9	-1552.	79.25

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 8
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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

1353	1	-4782.	-3043.	-54.98	-47.27	-1.218	2832.	-1439.	121.9

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1357	1		-1282.	-2604.	-290.8	65.46	69.27	-571.8	-8010.	1160.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1	1		-1238.	-1243.	3.6542E-02	5.197	.2289	660.8	493.3	.2809
2	1		-1195.	-1237.	4.205	22.71	3.075	200.3	416.5	-58.03
4	1		-1190.	-1212.	-.7050	12.12	-.2456	145.2	197.3	.4267
6	1		-1255.	-1222.	-4.068	-6.975	-1.881	107.0	188.8	-13.36
9	1		-1258.	-1222.	-.3753	-2.668	1.123	93.03	95.59	-.3305
12	1		-1373.	-1238.	-6.969	-18.29	-.2908	590.8	167.4	19.28
16	1		-1407.	-1275.	33.08	-13.78	6.367	624.7	240.6	-17.54

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
19	1		-5266.	-3926.	38.35	-61.22	-2.759	2442.	-3302.	-399.5

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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
23	1		-5195.	-3202.	92.30	-62.26	-5.177	2811.	-1838.	2.221

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
25	1		-5552.	-4709.	54.69	-43.39	32.51	-893.6	-5309.	-384.0
28	1		-5475.	-3975.	116.9	-54.15	-18.98	-618.3	-3753.	-109.4

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

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29	1	-5959.	-5961.	3.531	-74.23	21.72	-5055.	-8652.	-582.0
31	1	-5843.	-5043.	74.47	-72.97	21.08	-4527.	-6041.	-51.49

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
32	1		-5732.	-5628.	16.57	20.33	2.151	-9295.	-9189.	-8.235

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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
324	1		-1449.	-1310.	-38.83	9.386	1.859	625.0	259.5	7.771
328	1		-1449.	-1296.	31.06	11.06	2.549	171.7	193.8	-6.266
332	1		-1447.	-1274.	-45.50	-32.24	-2.183	726.5	273.7	4.760

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
336	1		-1483.	-1304.	49.66	60.05	-3.474	-26.59	115.4	-24.06
340	1		-1495.	-1253.	-86.75	-48.46	-51.93	-19.47	43.03	-35.27

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
344	1		-1477.	-1216.	27.78	113.3	-45.83	-1494.	-287.7	-23.93

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
348	1		-2200.	-1313.	7.532	-761.8	37.86	1.5761E+04	-3123.	633.6

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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 2
TIME COMPLETED IN THIS STEP

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
352	1		1283.	-2936.	-87.73	-42.72	793.4	4139.	2.3831E+04	220.2

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
356	1		516.0	-2824.	168.8	-10.54	535.9	1149.	8575.	115.4

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
360	1		-298.7	-2756.	-117.5	3.418	329.9	-107.1	-671.2	16.33

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
364	1		-1219.	-2732.	69.96	7.505	134.2	-1035.	-7178.	23.36

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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
368	1		-2620.	-2666.	-67.70	9.258	3.827	-1323.	-9114.	-3.069

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
372	1		-2443.	-2612.	72.68	6.771	-82.81	-1147.	-8011.	-34.24

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
376	1		-1051.	-2566.	-53.82	3.040	-218.1	-521.1	-3801.	-24.53

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
380	1		1150.	-2539.	73.48	-.1108	-449.8	827.7	5545.	-24.14

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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
384	1		-1545.	2265.	2231.	536.6	-253.6	1.6143E+04	5133.	-6208.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
388	1		-2491.	9780.	1500.	587.4	-86.17	3.2798E+04	3844.	-3982.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
392	1		-2830.	9327.	597.2	-866.4	37.57	3.1151E+04	-1.1666E+04	-1869.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
396	1		-3338.	3450.	283.9	-553.2	20.08	1.2947E+04	-3647.	-737.4

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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 2
TIME COMPLETED IN THIS STEP .

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THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
400	1		-3653.	893.9	207.0	-294.6	7.804	-212.3	-3605.	-143.9

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
404	1		-3901.	-549.5	132.2	-73.09	-1.883	-5982.	-3831.	86.38

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
408	1		-4097.	-1688.	104.4	44.36	-6.171	-6587.	-3319.	130.2

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
412	1		-4286.	-2469.	63.57	91.85	-8.543	-4209.	-2352.	82.32

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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
416	1		-4504.	-2832.	83.24	92.40	-5.090	-502.8	-1547.	-77.76

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
420	1		-4782.	-3042.	55.13	47.06	-1.493	2835.	-1432.	-121.9

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TITLE : Appendix M

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
424	1		-1282.	-2604.	290.8	-65.46	69.26	-572.0	-8010.	-1160.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
161	1		-1242.	-1238.	-1.420	-1.531	4.850	661.6	491.7	.7042
162	1		-1236.	-1195.	-5.436	-3.578	22.66	584.1	40.23	59.90
164	1		-1210.	-1189.	.6401	.9808	12.11	353.4	-14.74	1.330
166	1		-1220.	-1255.	4.029	2.381	-6.390	343.6	-61.62	15.81
169	1		-1221.	-1259.	-.5691	4.002	-1.644	244.2	-78.55	-.7772
172	1		-1237.	-1373.	6.475	2.278	-18.76	317.5	414.8	-22.20
176	1		-1275.	-1405.	-32.68	-6.137	-14.39	404.6	450.1	17.28

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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
179	1		-3927.	-5266.	-35.66	-2.517	61.18	-3299.	2446.	394.7
183	1		-3202.	-5195.	-90.38	-5.210	62.25	-1837.	2815.	-5.791

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
185	1		-4709.	-5553.	-53.86	33.30	42.99	-5281.	-870.9	379.1
188	1		-3976.	-5477.	-114.6	-18.68	53.70	-3747.	-599.2	108.7

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
189	1		-5962.	-5958.	-1.594	18.58	73.82	-8703.	-4988.	579.3
191	1		-5043.	-5841.	-74.06	22.18	71.88	-6092.	-4467.	51.43

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

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NOTE

192	1	-5629.	-5732.	-13.93	.5885	-19.31	-9245.	-9196.	9.344

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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
844	1		-1310.	-1450.	38.55	-1.945	9.477	426.3	456.4	-8.215
848	1		-1295.	-1450.	-30.98	-2.625	11.00	359.1	1.451	6.550
852	1		-1274.	-1447.	45.05	2.103	-32.14	439.9	555.3	-4.882

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
856	1		-1302.	-1483.	-49.44	3.482	59.67	279.2	-191.4	24.09
860	1		-1250.	-1496.	86.21	51.86	-48.24	204.3	-181.2	35.36

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
864	1		-1212.	-1478.	-27.51	45.64	111.6	-129.7	-1623.	23.80

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
868	1		-1317.	-2200.	-8.975	-38.74	-763.9	-3129.	1.5736E+04	-609.2

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 18
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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
872	1		1281.	-2937.	-86.97	-45.15	793.9	4165.	2.3848E+04	236.8

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
876	1		514.9	-2825.	168.5	-11.34	536.2	1158.	8583.	119.3

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
880	1		-298.7	-2757.	-117.4	3.123	330.1	-100.3	-666.5	20.15

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
884	1		-1219.	-2732.	70.17	7.412	134.3	-1031.	-7175.	24.57

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 19
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PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
888	1		-2619.	-2666.	-67.75	9.251	3.883	-1321.	-9113.	-2.343

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
892	1		-2443.	-2613.	72.67	6.757	-82.80	-1145.	-8010.	-34.82

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
896	1		-1050.	-2567.	-54.26	2.962	-218.2	-518.0	-3801.	-25.87

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THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
900	1		1150.	-2540.	72.73	-.4098	-449.8	831.7	5543.	-26.66

1

ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 20
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
904	1		3292.	-2575.	-86.98	-15.12	-593.4	2348.	1.8936E+04	89.43

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
908	1		9960.	-2675.	-75.91	-20.41	-593.5	3354.	3.3332E+04	603.1

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
912	1		9338.	-2843.	-476.6	28.68	867.0	-1.1676E+04	3.1206E+04	1447.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
916	1		3454.	-3343.	-234.6	15.91	553.4	-3655.	1.2963E+04	615.6

1

ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 21
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

920	1	896.8	-3656.	-178.2	5.900	294.7	-3604.	-210.1	123.1

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
924	1		-547.7	-3903.	-113.2	-2.305	73.10	-3829.	-5983.	-74.42

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
928	1		-1686.	-4098.	-92.70	-5.964	-44.39	-3317.	-6589.	-114.7

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
932	1		-2468.	-4287.	-57.21	-8.241	-91.87	-2351.	-4210.	-76.17

1

ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 10:37:12 PAGE 22
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1a.ABDAT (6/24/94), UNFACTORED LOAD CASE 1a WITH PPS SPECIFIC LIVE LOADS STEP 3 INCREMENT 20
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
936	1		-2831.	-4505.	-79.26	-4.825	-92.29	-1548.	-505.2	75.82

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
940	1		-3041.	-4782.	-52.23	-1.373	-47.25	-1433.	2833.	115.3

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
944	1		-2610.	-1281.	-292.8	-69.20	-65.39	-8014.	-578.7	1167.

THE ANALYSIS HAS BEEN COMPLETED

END OF RUN

RUN SUMMARY:

TOTAL OF	0	INCREMENTS
	0	CUTBACKS IN AUTOMATIC INCREMENTATION
	0	ITERATIONS
	0	PASSES THROUGH THE EQUATION SOLVER OF WHICH
	0	REPRESENT(S) DECOMPOSITION OF THE MASS MATRIX

1

ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 1
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 0 INCREMENT 0
TIME COMPLETED IN THIS STEP .000
E+00

STEP NUMBER 4 INCREMENT NUMBER 10

TIME COMPLETED DURING THIS STEP 1.00 FRACTION OF STEP IS 1.00
TOTAL ACCUMULATED TIME 4.00

E L E M E N T O U T P U T

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
289	1		-1259.	-1222.	-1.845	-4.988	1.050	662.1	488.0	.4455
290	1		-1218.	-1217.	-6.484	-22.97	4.024	203.4	410.8	60.28
291	1		-1210.	-1187.	.7836	-13.86	-4.636	147.7	179.3	1.910
293	1		-1279.	-1197.	4.086	6.107	-2.794	96.88	168.7	17.48
295	1		-1283.	-1197.	-2.086	.1735	-6.931	77.41	64.56	-2.170
298	1		-1398.	-1212.	4.167	19.47	-3.815	580.3	137.4	-24.52
301	1		-1431.	-1247.	-34.62	13.58	9.539	619.0	230.5	17.43

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
305	1		-4063.	-3660.	-8.105	2.273	.6831	-263.3	-345.6	23.37
308	1		-4052.	-3531.	-15.26	3.561	-5.426	-265.9	-558.0	17.58

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 2
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
312	1		-4074.	-3626.	-18.20	-19.53	12.68	215.4	-193.1	-27.81
314	1		-4085.	-3671.	-6.672	-15.44	-2.355	148.7	-275.1	54.67

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

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TITLE : Appendix M

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
317	1		-4219.	-4220.	19.96	21.03	1.240	351.8	-522.3	143.6
318	1		-4179.	-3901.	-4.608	20.27	17.56	465.3	-178.0	1.692

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
320	1		-4002.	-3929.	6.529	-14.04	-4.520	-808.5	-798.5	6.666

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1257	1		-1481.	-1279.	39.74	-9.635	1.920	631.3	255.0	-8.845
1261	1		-1488.	-1262.	-32.16	-11.07	2.542	170.0	190.7	6.463
1265	1		-1492.	-1236.	46.27	32.48	-2.101	730.0	271.7	-5.182

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 3
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1269	1		-1538.	-1259.	-51.88	-60.22	-3.228	-24.06	114.8	23.63
1273	1		-1559.	-1203.	87.70	48.37	-52.07	-22.32	42.17	35.44

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1277	1		-1547.	-1154.	-30.11	-113.2	-45.42	-1495.	-291.0	24.79

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1281	1		-2285.	-1068.	-4.610	777.3	38.21	1.6234E+04	-2977.	-593.2

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1285	1		1537.	-3008.	115.6	43.34	820.8	4153.	2.4340E+04	-228.1

1

ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 4
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1289	1		655.9	-2923.	-148.2	10.34	547.0	1133.	8610.	-113.9

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1293	1		-191.8	-2886.	148.0	-3.030	332.5	-131.3	-769.4	-5.310

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1297	1		-1151.	-2912.	-42.69	-5.977	129.6	-1040.	-7255.	-12.72

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1301	1		-2595.	-2888.	101.4	-5.816	8.109	-1315.	-9185.	14.29

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 5
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

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1305	1	-2460.	-2882.	-39.89	-3.079	-88.24	-1142.	-8053.	15.33

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1309	1	-1101.	-2885.	100.2	-.9763	-205.3	-568.5	-3940.	-.1176

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1313	1	1086.	-2870.	-45.34	-1.203	-479.1	768.4	5647.	-12.48

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1317	1	-1816.	2098.	-2362.	-556.2	-258.8	1.6795E+04	5236.	6510.

1

ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 6
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1321	1	-2818.	9293.	-1490.	-593.5	-82.86	3.3892E+04	2758.	4310.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1325	1	-3028.	8136.	-562.8	966.9	48.04	3.1288E+04	-1.7080E+04	2272.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1329	1	-3529.	2630.	-274.4	556.6	29.20	1.2047E+04	-5082.	814.7

FILENAME : print.fil DATE : 08-06-94 TIME : 8:53p PAGE 37
TITLE : Appendix M

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1333	1		-3755.	152.9	-167.7	284.8	18.36	-838.7	-4505.	248.6

1

ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 7
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1337	1		-3882.	-1366.	-110.3	167.5	17.65	-7729.	-5023.	-13.37

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1341	1		-4039.	-2599.	-55.75	-33.07	7.304	-1.0058E+04	-4961.	-178.2

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1345	1		-4177.	-3253.	-4.413	-181.3	-7.126	-6545.	-3291.	-290.0

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1349	1		-4118.	-3428.	2.118	-74.03	-8.546	-1910.	-1376.	-119.0

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 8
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PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

1353	1	-4033.	-3502.	2.026	-12.78	-6.431	-404.7	-669.4	-32.69

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1357	1		-1311.	-2115.	-272.9	64.36	71.81	-574.1	-7461.	1159.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1	1		-1256.	-1228.	2.2616E-02	5.166	.1411	664.2	493.0	.2946
2	1		-1211.	-1223.	4.089	22.83	3.063	201.8	416.0	-58.14
4	1		-1206.	-1199.	-.4904	12.19	-.3351	146.6	196.7	.4800
6	1		-1269.	-1209.	-4.030	-6.981	-1.916	107.0	188.0	-13.37
9	1		-1272.	-1211.	-.2620	-2.654	1.043	92.92	94.73	-.2818
12	1		-1386.	-1226.	-7.085	-18.45	-.3245	593.1	166.9	19.44
16	1		-1419.	-1266.	32.57	-13.82	6.347	627.0	240.6	-17.36

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
19	1		-3971.	-3723.	18.51	.6771	1.937	-592.0	-375.5	-21.99

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 9
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PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
23	1		-3961.	-3602.	25.66	-1.236	-5.413	-600.3	-528.8	-26.55

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
25	1		-4010.	-3674.	26.58	16.28	12.34	14.10	-269.4	15.99
28	1		-4021.	-3737.	15.83	14.94	2.774	-37.91	-286.0	-50.34

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

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29	1	-4189.	-4243.	-14.46	-18.92	4.235	224.1	-552.6	-126.5
31	1	-4154.	-3955.	6.940	-15.84	16.34	320.3	-248.5	-7.927

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
32	1		-3992.	-3952.	-2.876	17.20	-.4101	-850.4	-816.6	.2727

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 10
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1B.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
324	1		-1460.	-1301.	-38.29	9.504	1.883	626.2	259.4	7.646
328	1		-1458.	-1289.	30.67	10.95	2.511	173.3	193.7	-6.254
332	1		-1453.	-1269.	-44.70	-32.09	-2.236	726.8	273.1	4.633

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
336	1		-1487.	-1300.	49.08	59.85	-3.571	-24.76	115.2	-23.93
340	1		-1498.	-1251.	-85.63	-47.96	-51.45	-25.49	42.54	-34.77

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
344	1		-1481.	-1217.	27.50	111.1	-45.25	-1460.	-280.5	-23.28

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
348	1		-2197.	-1336.	8.841	-751.4	37.30	1.5575E+04	-3111.	624.9

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 11
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PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
352	1		1257.	-2872.	-87.81	-42.13	793.6	4137.	2.3914E+04	218.4

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
356	1		511.2	-2761.	165.1	-10.27	536.7	1152.	8649.	115.5

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
360	1		-295.4	-2694.	-117.3	3.705	330.3	-109.4	-609.9	18.35

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
364	1		-1212.	-2668.	68.78	7.875	133.8	-1039.	-7119.	22.06

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 12
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PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
368	1		-2619.	-2601.	-67.06	9.485	2.812	-1322.	-9038.	-6.583

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
372	1		-2460.	-2547.	72.78	6.747	-83.82	-1135.	-7909.	-38.97

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
376	1		-1102.	-2498.	-53.16	2.719	-217.2	-502.3	-3702.	-28.18

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
380	1	-	1043.	-2470.	72.58	-.5790	-442.7	832.2	5531.	-23.53

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 13
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
384	1		-1525.	2077.	2115.	525.1	-248.9	1.5905E+04	4990.	-6156.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
388	1		-2424.	9095.	1406.	566.8	-83.75	3.2141E+04	3108.	-3997.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
392	1		-2714.	8412.	549.4	-846.7	36.50	3.0500E+04	-1.2753E+04	-1894.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
396	1		-3173.	2971.	258.6	-543.1	19.69	1.2719E+04	-3652.	-730.1

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 14
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PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT •
TIME COMPLETED IN THIS STEP 0

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
400	1		-3441.	492.6	178.5	-295.5	7.924	-288.1	-3594.	-140.6

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
404	1		-3632.	-962.7	103.9	-80.48	-1.456	-6193.	-3833.	95.21

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
408	1		-3747.	-2150.	69.64	35.79	-5.171	-7123.	-3329.	150.6

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
412	1		-3833.	-2991.	29.21	75.43	-6.436	-5355.	-2347.	128.7

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 15
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
416	1		-3876.	-3415.	23.05	53.92	-4.942	-3045.	-1426.	55.52

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
420	1		-3894.	-3577.	1.939	36.88	-5.561	-1379.	-793.1	42.03

FILENAME : print.fil DATE : 08-06-94 TIME : 8:53p PAGE 43
TITLE : Appendix M

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
424	1		-1289.	-2694.	292.9	-82.24	67.13	-821.2	-8145.	-1149.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
161	1		-1261.	-1221.	-2.004	-1.833	4.817	662.7	490.4	1.498
162	1		-1256.	-1178.	-5.109	-3.687	22.58	585.4	39.87	60.52
164	1		-1229.	-1172.	.1488	1.060	12.11	355.0	-15.12	1.848
166	1		-1239.	-1238.	4.023	2.400	-6.358	345.3	-61.80	16.08
169	1		-1240.	-1242.	-1.343	4.040	-1.636	245.5	-78.94	-.7979
172	1		-1256.	-1356.	6.679	2.279	-18.68	318.7	413.6	-22.15
176	1		-1292.	-1389.	-33.27	-6.246	-14.41	405.4	449.0	17.59

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 16
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PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
179	1		-3771.	-3930.	11.20	3.388	-.9337	-358.5	-631.3	27.55
183	1		-3642.	-3920.	4.978	-4.958	1.000	-514.3	-638.9	30.86

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
185	1		-3728.	-3957.	-4.851	13.56	-16.64	-248.3	-5.023	-6.571
188	1		-3785.	-3971.	11.18	4.221	-15.62	-265.7	-56.34	59.34

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
189	1		-4310.	-4120.	24.39	8.899	18.01	-546.2	240.2	137.9
191	1		-4011.	-4087.	10.38	17.80	15.16	-227.2	335.1	21.67

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT PT FOOT- SF1 SF2 SF3 SF4 SF5 SM1 SM2 SM3

		NOTE								
192	1		-4017.	-3919.	10.12	2.303	-16.99	-809.4	-801.3	13.20

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 17
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PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
844	1		-1329.	-1433.	38.41	-1.968	9.456	427.9	455.1	-8.096
848	1		-1313.	-1433.	-30.21	-2.662	10.97	360.3	1.151	6.843
852	1		-1293.	-1430.	46.38	2.054	-32.10	442.0	554.0	-4.857

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
856	1		-1321.	-1466.	-46.35	3.442	59.58	281.4	-191.3	24.35
860	1		-1270.	-1479.	89.88	51.81	-48.21	206.1	-179.5	35.49

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
864	1		-1233.	-1461.	-22.23	46.07	111.8	-128.9	-1625.	24.70

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
868	1		-1390.	-2183.	-2.609	-37.87	-761.2	-3177.	1.5649E+04	-642.6

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 18
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PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
872	1		1211.	-2928.	-54.96	-44.77	788.7	4167.	2.3776E+04	216.6

FILENAME : print.fil DATE : 08-06-94 TIME : 8:53p PAGE 45
TITLE : Appendix M

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
876	1		477.8	-2803.	198.5	-11.92	533.5	1168.	8606.	106.4

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
880	1		-326.4	-2736.	-87.84	2.332	328.6	-82.48	-601.0	11.78

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
884	1		-1235.	-2702.	96.61	6.416	133.9	-1013.	-7077.	24.90

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 19
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PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
888	1		-2633.	-2635.	-45.36	8.472	3.933	-1315.	-9006.	6.360

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
892	1		-2468.	-2576.	93.76	6.678	-81.62	-1160.	-7912.	-20.55

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
896	1		-1107.	-2530.	-35.48	3.830	-215.5	-553.1	-3753.	-16.78

FILENAME : print.fil DATE : 08-06-94 TIME : 8:53p PAGE 46
TITLE : Appendix M

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
900	1		1044.	-2501.	95.30	1.170	-445.1	782.2	5489.	-31.98

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 20
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PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
904	1		3059.	-2527.	-62.16	-13.31	-583.9	2205.	1.8702E+04	59.32

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
908	1		9319.	-2620.	-38.74	-19.74	-576.2	2644.	3.2774E+04	571.6

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
912	1		8510.	-2738.	-410.2	29.11	849.3	-1.2447E+04	3.0653E+04	1446.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
916	1		3010.	-3187.	-181.9	15.77	544.3	-3618.	1.2758E+04	577.3

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 21
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PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.0

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

920	1	508.2	-3447.	-121.7	5.480	296.0	-3564.	-302.3	101.7

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
924	1		-956.8	-3634.	-55.78	-2.345	81.17	-3812.	-6235.	-97.32

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
928	1		-2156.	-3744.	-27.23	-5.229	-35.69	-3312.	-7177.	-143.4

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
932	1		-3007.	-3824.	8.843	-6.265	-75.67	-2334.	-5407.	-128.3

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 25-Jun-94 TIME 11:14:10 PAGE 22
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U1b.ABDAT (6/24/94), UNFACTORED LOAD CASE 1b WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
936	1		-3441.	-3858.	13.73	-4.706	-53.77	-1412.	-3095.	-56.29

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
940	1		-3611.	-3866.	31.86	-5.224	-37.16	-784.3	-1430.	-42.34

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
944	1		-2754.	-1277.	-315.5	-69.42	-66.54	-8163.	-602.8	1128.

THE ANALYSIS HAS BEEN COMPLETED

END OF RUN

RUN SUMMARY:

TOTAL OF	0	INCREMENTS
	0	CUTBACKS IN AUTOMATIC INCREMENTATION
	0	ITERATIONS
	0	PASSES THROUGH THE EQUATION SOLVER OF WHICH
	0	REPRESENT(S) DECOMPOSITION OF THE MASS MATRIX

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 21-Jun-94 TIME 10:29:33 PAGE 1
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 0 INCREMENT 0
TIME COMPLETED IN THIS STEP .000
E+00

STEP NUMBER 4 INCREMENT NUMBER 10

TIME COMPLETED DURING THIS STEP 1.00 FRACTION OF STEP IS 1.00
TOTAL ACCUMULATED TIME 4.00

E L E M E N T   O U T P U T

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
289	1		-1254.	-1214.	-1.572	-4.996	.8401	660.7	486.5	.2880
290	1		-1214.	-1209.	-6.264	-22.63	3.905	207.1	410.3	59.28
291	1		-1207.	-1178.	.6604	-13.60	-4.452	152.3	182.7	1.799
293	1		-1275.	-1188.	3.849	6.034	-2.686	103.6	172.3	17.40
295	1		-1280.	-1187.	-2.394	.3593	-6.036	84.65	67.53	-1.591
298	1		-1393.	-1202.	3.754	19.05	-3.496	579.1	139.1	-23.15
301	1		-1424.	-1236.	-33.64	13.06	8.763	615.4	227.4	16.11

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
305	1		-3799.	-3583.	-13.44	-1.583	3.096	-619.6	-309.4	21.81
308	1		-3785.	-3460.	-25.52	.1869	-4.804	-631.4	-456.8	31.07

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 21-Jun-94 TIME 10:29:33 PAGE 2
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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
312	1		-3835.	-3538.	-23.66	-19.10	14.38	12.45	-189.4	-19.79
314	1		-3848.	-3596.	-10.53	-14.77	6.7058E-02	-42.60	-216.8	50.19

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

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ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
317	1		-4003.	-4107.	18.34	18.05	2.067	267.8	-448.2	120.8
318	1		-3965.	-3815.	-6.390	17.28	19.27	359.9	-159.4	6.816

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
320	1		-3805.	-3820.	5.246	-14.67	-4.231	-736.4	-704.2	1.216

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1257	1		-1474.	-1268.	38.54	-9.271	1.671	627.4	253.0	-8.715
1261	1		-1482.	-1250.	-31.16	-10.96	2.320	174.8	191.5	6.039
1265	1		-1487.	-1226.	44.73	32.00	-1.932	723.5	272.9	-5.690

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 21-Jun-94 TIME 10:29:33 PAGE 3
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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1269	1		-1535.	-1250.	-50.72	-58.78	-2.704	-8.525	124.6	21.89
1273	1		-1555.	-1195.	84.77	46.53	-49.98	-22.69	51.09	35.64

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1277	1		-1551.	-1148.	-31.39	-107.6	-43.72	-1407.	-269.0	24.56

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1281	1		-2275.	-1099.	-6.228	745.8	36.01	1.5636E+04	-2932.	-565.5

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THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1285	1		1487.	-2827.	104.4	41.40	814.2	4147.	2.4225E+04	-213.7

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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1289	1		664.6	-2732.	-141.3	9.192	538.8	1148.	8634.	-95.88

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1293	1		-139.6	-2689.	136.9	-3.445	318.2	-48.90	-484.9	13.12

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1297	1		-1071.	-2721.	-37.09	-4.846	122.9	-877.9	-6685.	5.348

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1301	1		-2574.	-2690.	87.32	-2.763	11.72	-1132.	-8569.	17.90

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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

1305	1	-2593.	-2679.	-30.14	.2579	-74.29	-1013.	-7663.	-10.46

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1309	1		-1479.	-2670.	81.06	1.136	-160.1	-608.8	-4353.	-33.68

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1313	1		475.9	-2582.	-59.08	-2.497	-436.9	498.1	4029.	-56.47

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1317	1		-1711.	1399.	-1899.	-556.2	-249.1	1.4787E+04	4307.	5893.

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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1321	1		-2521.	7914.	-1238.	-575.1	-76.10	3.1313E+04	947.5	4000.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1325	1		-2781.	7548.	-478.4	820.8	34.30	2.9918E+04	-1.0682E+04	1522.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1329	1		-3223.	2846.	-201.4	449.3	.1729	1.3636E+04	-2421.	456.0

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THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1333	1		-3389.	625.6	-150.8	277.1	-8.716	2259.	-2247.	146.7

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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1337	1		-3479.	-782.7	-101.5	145.0	-5.274	-4333.	-2772.	9.545

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1341	1		-3586.	-1993.	-72.03	-11.84	-4.419	-6629.	-2791.	-79.44

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1345	1		-3680.	-2833.	-26.26	-76.31	-6.361	-5215.	-2035.	-117.5

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1349	1		-3717.	-3251.	-23.00	-49.87	-5.315	-2896.	-1181.	-40.73

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 21-Jun-94 TIME 10:29:33 PAGE 8
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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

1353	1	-3725.	-3425.	-.6333	-32.14	-5.119	-1354.	-666.8	-30.71

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1357	1		-1330.	-2331.	-284.4	101.7	66.67	-1124.	-7767.	1096.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
1	1		-1251.	-1220.	-.1764	5.150	9.4179E-02	662.8	491.2	.3000
2	1		-1206.	-1214.	3.840	22.56	3.003	205.5	415.0	-57.46
4	1		-1202.	-1192.	-.5293	12.03	-.3267	150.9	198.4	.4728
6	1		-1263.	-1201.	-4.047	-6.856	-1.888	110.9	189.7	-13.26
9	1		-1267.	-1204.	-.2694	-2.585	1.018	96.89	97.43	-.2058
12	1		-1378.	-1219.	-7.061	-18.47	-.3282	593.2	169.0	19.36
16	1		-1411.	-1258.	31.82	-13.63	6.094	626.3	242.1	-16.58

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
19	1		-3808.	-3603.	17.08	1.035	1.859	-552.9	-314.9	-19.45

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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
23	1		-3798.	-3493.	24.56	-.8153	-5.212	-563.1	-471.0	-26.19

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
25	1		-3839.	-3550.	24.49	15.84	11.70	51.05	-203.2	16.46
28	1		-3850.	-3615.	13.76	14.60	2.729	.1248	-225.5	-48.17

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

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29	1	-4004.	-4110.	-15.52	-17.87	3.509	279.0	-456.3	-120.0
31	1	-3969.	-3827.	5.299	-14.86	15.56	368.9	-178.3	-8.378

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
32	1		-3803.	-3822.	-3.233	15.35	-.6453	-736.7	-713.3	-.5112

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 21-Jun-94 TIME 10:29:33 PAGE 10
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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
324	1		-1451.	-1293.	-37.51	9.477	1.861	625.4	260.5	7.269
328	1		-1448.	-1281.	30.00	10.84	2.432	175.8	194.9	-6.068
332	1		-1442.	-1261.	-43.68	-31.82	-2.274	725.5	273.5	4.374

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
336	1		-1474.	-1292.	48.14	59.35	-3.605	-20.13	117.0	-23.51
340	1		-1482.	-1245.	-84.38	-47.46	-50.68	-24.05	45.42	-34.04

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
344	1		-1468.	-1211.	27.32	109.1	-44.39	-1426.	-270.3	-22.62

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
348	1		-2174.	-1341.	8.915	-735.1	36.69	1.5232E+04	-3077.	610.4

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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 1'
TIME COMPLETED IN THIS STEP

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
352	1		1236.	-2787.	-87.29	-41.36	787.7	4109.	2.3746E+04	217.1

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
356	1		512.0	-2678.	160.9	-9.780	533.1	1141.	8591.	116.0

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
360	1		-277.9	-2611.	-115.1	4.320	327.1	-113.2	-591.5	20.72

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
364	1		-1177.	-2587.	67.18	8.525	132.8	-1036.	-7041.	19.26

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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
368	1		-2580.	-2518.	-63.61	9.940	1.390	-1309.	-8928.	-9.944

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
372	1		-2437.	-2463.	72.24	6.923	-83.09	-1113.	-7793.	-44.86

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

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ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
376	1		-1115.	-2412.	-49.21	2.667	-214.1	-480.5	-3641.	-30.13

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
380	1		978.2	-2384.	71.14	-.6995	-430.8	825.5	5380.	-23.12

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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
384	1		-1480.	1966.	2025.	512.0	-242.7	1.5473E+04	4827.	-6015.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
388	1		-2343.	8721.	1351.	548.4	-80.83	3.1259E+04	2760.	-3920.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
392	1		-2628.	8027.	529.9	-822.9	35.80	2.9655E+04	-1.2774E+04	-1852.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
396	1		-3067.	2848.	247.0	-529.5	19.25	1.2366E+04	-3514.	-714.1

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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT
TIME COMPLETED IN THIS STEP J0

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THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
400	1		-3323.	455.4	173.6	-287.9	7.724	-308.8	-3482.	-135.3

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
404	1		-3506.	-951.2	97.21	-77.82	-1.527	-6054.	-3718.	93.31

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
408	1		-3614.	-2102.	67.21	34.67	-5.171	-6957.	-3223.	149.2

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
412	1		-3691.	-2917.	25.25	73.56	-6.400	-5243.	-2263.	126.4

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PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
416	1		-3728.	-3323.	22.12	52.87	-4.927	-2991.	-1360.	56.44

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
420	1		-3740.	-3473.	-.6766	36.88	-5.516	-1351.	-735.4	41.68

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TITLE : Appendix M

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-N1 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
424	1		-1277.	-2760.	292.7	-97.29	64.83	-1048.	-8201.	-1129.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
161	1		-1257.	-1213.	-2.422	-1.948	4.760	661.7	488.6	1.576
162	1		-1251.	-1170.	-5.774	-3.684	22.29	585.2	43.54	60.03
164	1		-1225.	-1164.	-.5610	1.108	11.97	357.0	-10.83	2.045
166	1		-1235.	-1229.	3.092	2.403	-6.212	347.3	-57.80	16.18
169	1		-1235.	-1233.	-2.231	4.078	-1.563	248.0	-75.01	-.8163
172	1		-1251.	-1346.	5.568	2.287	-18.72	320.7	413.9	-22.08
176	1		-1287.	-1378.	-33.59	-5.963	-14.23	406.9	448.6	16.82

1

ABAQUS PRODUCTION VERSION 4-9-1 DATE 21-Jun-94 TIME 10:29:33 PAGE 16
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
179	1		-3611.	-3796.	-20.06	2.506	-1.077	-327.9	-567.8	29.14
183	1		-3505.	-3787.	-26.93	-5.050	.8053	-479.2	-578.1	35.97

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
185	1		-3554.	-3831.	-28.13	11.64	-16.07	-212.9	50.56	-10.97
188	1		-3624.	-3844.	-13.91	3.359	-15.03	-236.9	-2.213	56.26

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
189	1		-4114.	-3998.	13.87	4.192	17.70	-475.6	294.8	123.1
191	1		-3831.	-3963.	-6.605	15.54	14.79	-192.1	383.2	12.93

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

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		NOTE								
192	1		-3825.	-3800.	4.172	-.1856	-15.55	-732.1	-711.0	2.401

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 21-Jun-94 TIME 10:29:33 PAGE 17
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
844	1		-1323.	-1421.	36.05	-1.967	9.432	429.2	454.4	-7.920
848	1		-1307.	-1421.	-30.81	-2.658	10.82	362.5	4.526	6.534
852	1		-1285.	-1417.	43.49	1.931	-31.77	443.5	552.1	-5.005

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
856	1		-1313.	-1452.	-46.58	3.299	58.85	285.9	-183.1	23.64
860	1		-1259.	-1465.	85.92	50.89	-47.31	208.9	-178.3	35.48

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
864	1		-1222.	-1450.	-24.65	45.33	109.1	-119.0	-1583.	23.33

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
868	1		-1397.	-2159.	-4.109	-36.83	-742.0	-3154.	1.5252E+04	-625.5

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 21-Jun-94 TIME 10:29:33 PAGE 18
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
872	1		1203.	-2828.	-52.61	-43.84	782.7	4151.	2.3630E+04	209.1

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
876	1		493.5	-2707.	189.5	-11.79	529.2	1168.	8578.	100.3

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
880	1		-292.0	-2637.	-87.77	2.071	325.3	-72.27	-542.6	10.46

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
884	1		-1183.	-2604.	87.52	5.922	133.6	-1002.	-6962.	27.70

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 21-Jun-94 TIME 10:29:33 PAGE 19
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
888	1		-2579.	-2541.	-50.62	8.234	3.662	-1318.	-8872.	20.79

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
892	1		-2438.	-2486.	81.86	7.241	-78.57	-1189.	-7809.	-4.371

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
896	1		-1118.	-2449.	-43.30	5.520	-210.5	-613.6	-3758.	-2.351

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
900	1		969.6	-2425.	87.39	3.578	-434.8	692.6	5267.	-37.93

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 21-Jun-94 TIME 10:29:33 PAGE 20
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
904	1		2881.	-2454.	-63.54	-10.16	-571.1	2039.	1.8181E+04	40.16

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
908	1		8875.	-2541.	-33.14	-17.54	-558.3	2107.	3.1880E+04	522.0

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
912	1		8053.	-2650.	-394.3	29.18	824.2	-1.2558E+04	2.9806E+04	1407.

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
916	1		2850.	-3068.	-176.6	15.88	529.3	-3507.	1.2413E+04	546.8

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 21-Jun-94 TIME 10:29:33 PAGE 21
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3

920	1	442.6	-3314.	-132.8	5.466	287.7	-3451.	-307.7	96.35

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
924	1		-965.4	-3493.	-69.11	-2.217	78.79	-3688.	-6081.	-88.74

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
928	1		-2122.	-3600.	-52.42	-5.109	-34.49	-3205.	-7002.	-128.9

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
932	1		-2934.	-3679.	-19.03	-6.219	-73.88	-2256.	-5280.	-109.8

1

ABAQUS PRODUCTION VERSION 4-9-1 DATE 21-Jun-94 TIME 10:29:33 PAGE 22
FOR USE BY WESTINGHOUSE HANFORD COMPANY UNDER LICENSE FROM HKS, INC.

PPS-U2.ABDAT (6/20/94), UNFACTORED LOAD CASE 2 WITH PPS SPECIFIC LIVE LOADS STEP 4 INCREMENT 10
TIME COMPLETED IN THIS STEP 1.00

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
936	1		-3340.	-3716.	-21.08	-4.765	-52.69	-1358.	-3017.	-42.60

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
940	1		-3485.	-3729.	-.5738	-5.351	-36.94	-743.9	-1374.	-31.82

THE FOLLOWING TABLE IS PRINTED FOR ELSET AXIS-P2 AND ELEMENT TYPE S4R5

ELEMENT	PT	FOOT-NOTE	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
944	1		-2805.	-1263.	-312.7	-65.85	-86.27	-8268.	-890.2	1119.

THE ANALYSIS HAS BEEN COMPLETED

END OF RUN

RUN SUMMARY:

TOTAL OF	0	INCREMENTS
	0	CUTBACKS IN AUTOMATIC INCREMENTATION
	0	ITERATIONS
	0	PASSES THROUGH THE EQUATION SOLVER OF WHICH
	0	REPRESENT(S) DECOMPOSITION OF THE MASS MATRIX

	A	B	C	D	E	F	G	H	I	J
1	POSTPROCESSING OF PPS-U1A RUN (Unfactored Load Case 1a)									
2				All Values are Per Foot of Width						
3	ELSET AXIS-P1: along the positive 1-axis									
4			positive is compression			absolute value		absolute value		
5	ELEME	PT F	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
6		NO	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)	
7										
8	floor elements									
9	289	1	14868	14892	-27	58	15	7952	5888	6
10	291	1	14244	14508	8	169	58	1750	2164	24
11	295	1	15108	14652	-23	1	89	859	781	32
12	301	1	16860	15288	-404	168	116	7486	2831	207
13	1257	1	17412	15720	468	122	26	7584	3113	102
14	1261	1	17400	15552	-372	128	33	2036	2332	78
15	1265	1	17364	15300	545	385	25	8743	3292	57
16	1269	1	17796	15648	-596	720	41	324	1384	291
17	1273	1	17952	15024	1042	581	624	234	511	423
18	1277	1	17724	14580	-333	1360	550	17928	3455	286
19	1281	1	26400	15756	-90	9142	454	189132	37476	7606
20										
21	wall elements									
22	1285	1	-15396	35232	1052	513	9521	49668	285972	2640
23	1289	1	-6193	33888	-2026	127	6432	13788	102900	1386
24	1293	1	3583	33084	1410	41	3959	1283	8052	196
25	1297	1	14628	32784	-840	90	1610	12420	86136	281
26	1301	1	31428	31992	812	111	46	15876	109368	37
27	1305	1	29316	31344	-872	81	994	13764	96132	411
28	1309	1	12612	30792	646	36	2618	6253	45624	294
29	1313	1	-13800	30468	-882	1	5398	9934	66540	289
30										
31	haunch elements (see r384-1a.mcd & r388-1a.mcd for transformed demands on elements 1317, 1321)									
32	1317	1	-39480	30840	622	134	7121	28080	227200	0
33	1321	1	-119500	32030	2171	81	7124	39680	400000	0
34	1325	1	33960	-111936	-7166	10397	451	373836	139992	22428
35										
36	dome elements									
37	1329	1	40068	-41400	-3407	6638	241	155376	43764	8850
38	1333	1	43848	-10732	-2485	3535	94	2530	43260	1728
39	1337	1	46824	6592	-1586	877	23	71760	45972	1034
40	1341	1	49164	20244	-1254	533	74	79008	39840	1561
41	1345	1	51444	29628	-764	1102	103	50460	28224	985
42	1349	1	54072	33984	-1000	1104	60	6035	18624	951
43	1353	1	57384	36516	-660	567	15	33984	17268	1463
44	308	1	62340	38448	-1115	735	149	33636	22116	34
45	305	1	63204	47136	-452	797	204	29184	39744	4814
46	314	1	65760	47724	-1379	593	57	7680	45180	1324
47	312	1	66660	56532	-662	505	234	10966	63804	4596
48	318	1	70080	60528	-879	883	481	54252	72552	621
49	317	1	71520	71544	42	919	19	60492	103500	6900
50	320	1	68820	67560	-144	204	97	111180	109920	64
51										
52	footing element									
53	1357	1	15384	31248	-3490	786	831	6862	96120	13920
54										

	A	B	C	D	E	F	G	H	I	J
55										
56										
57	ELSET AXIS-N1: along the negative 1-axis									
58			positive is compression			absolute value		absolute value		
59	ELEME	PT F	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
60		NO	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)	
61										
62	floor elements									
63	1	1	14856	14916	0	62	3	7930	5920	3
64	4	1	14280	14544	-8	145	3	1742	2368	5
65	9	1	15096	14664	-5	32	13	1116	1147	4
66	16	1	16884	15300	397	165	76	7496	2887	210
67	324	1	17388	15720	-466	113	22	7500	3114	93
68	328	1	17388	15552	373	133	31	2060	2326	75
69	332	1	17364	15288	-546	387	26	8718	3284	57
70	336	1	17796	15648	596	721	42	319	1385	289
71	340	1	17940	15036	-1041	582	623	234	516	423
72	344	1	17724	14592	333	1360	550	17928	3452	287
73	348	1	26400	15756	90	9142	454	189132	37476	7603
74										
75	wall elements									
76	352	1	-15396	35232	-1053	513	9521	49668	285972	2642
77	356	1	-6192	33888	2026	126	6431	13788	102900	1385
78	360	1	3584	33072	-1410	41	3959	1285	8054	196
79	364	1	14628	32784	840	90	1610	12420	86136	280
80	368	1	31440	31992	-812	111	46	15876	109368	37
81	372	1	29316	31344	872	81	994	13764	96132	411
82	376	1	12612	30792	-646	36	2617	6253	45612	294
83	380	1	-13800	30468	882	1	5398	9932	66540	290
84										
85	haunch elements (384,388 demands are transformed via Mathcad)									
86	384	1	-39480	30840	622	134	7121	28080	227200	0
87	388	1	-119500	32030	2171	81	7124	39680	400000	0
88	392	1	33960	-111924	7166	10397	451	373812	139992	22428
89										
90	dome elements									
91	396	1	40056	-41400	3407	6638	241	155364	43764	8849
92	400	1	43836	-10727	2484	3535	94	2548	43260	1727
93	404	1	46812	6594	1586	877	23	71784	45972	1037
94	408	1	49164	20256	1253	532	74	79044	39828	1562
95	412	1	51432	29628	763	1102	103	50508	28224	988
96	416	1	54048	33984	999	1109	61	6034	18564	933
97	420	1	57384	36504	662	565	18	34020	17184	1463
98	23	1	62340	38424	1108	747	62	33732	22056	27
99	19	1	63192	47112	460	735	33	29304	39624	4794
100	28	1	65700	47700	1403	650	228	7420	45036	1313
101	25	1	66624	56508	656	521	390	10723	63708	4608
102	31	1	70116	60516	894	876	253	54324	72492	618
103	29	1	71508	71532	42	891	261	60660	103824	6984
104	32	1	68784	67536	199	244	26	111540	110268	99
105										
106	footing element									
107	424	1	15384	31248	3490	786	831	6864	96120	13920
108										

	A	B	C	D	E	F	G	H	I	J
109										
110										
111	ELSET AXIS-P2: along the positive 2-axis									
112			positive is compression			absolute value		absolute value		
113	ELEME	PT F	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
114		NO	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)	
115										
116	floor element									
117	161	1	14904	14856	-17	18	58	7939	5900	8
118	164	1	14520	14268	8	12	145	4241	177	16
119	169	1	14652	15108	-7	48	20	2930	943	9
120	176	1	15300	16860	-392	74	173	4855	5401	207
121	844	1	15720	17400	463	23	114	5116	5477	99
122	848	1	15540	17400	-372	32	132	4309	17	79
123	852	1	15288	17364	541	25	386	5279	6664	59
124	856	1	15624	17796	-593	42	716	3350	2297	289
125	860	1	15000	17952	1035	622	579	2452	2174	424
126	864	1	14544	17736	-330	548	1339	1556	19476	286
127	868	1	15804	26400	-108	465	9167	37548	188832	7310
128										
129	wall elements									
130	872	1	-15372	35244	-1044	542	9527	49980	286176	2842
131	876	1	-6179	33900	2022	136	6434	13896	102996	1432
132	880	1	3584	33084	-1409	37	3961	1204	7998	242
133	884	1	14628	32784	842	89	1612	12372	86100	295
134	888	1	31428	31992	-813	111	47	15852	109356	28
135	892	1	29316	31356	872	81	994	13740	96120	418
136	896	1	12600	30804	-651	36	2618	6216	45612	310
137	900	1	-13800	30480	873	5	5398	9980	66516	320
138										
139	haunch elements									
140	904	1	-39504	30900	-1044	181	7121	28176	227232	1073
141	908	1	-119520	32100	-911	245	7122	40248	399984	7237
142	912	1	-112056	34116	-5719	344	10404	140112	374472	17364
143										
144	dome elements									
145	916	1	-41448	40116	-2815	191	6641	43860	155556	7387
146	920	1	-10762	43872	-2138	71	3536	43248	2521	1477
147	924	1	6572	46836	-1358	28	877	45948	71796	893
148	928	1	20232	49176	-1112	72	533	39804	79068	1376
149	932	1	29616	51444	-687	99	1102	28212	50520	914
150	936	1	33972	54060	-951	58	1107	18576	6062	910
151	940	1	36492	57384	-627	16	567	17196	33996	1384
152	183	1	38424	62340	-1085	63	747	22044	33780	69
153	179	1	47124	63192	-428	30	734	39588	29352	4736
154	188	1	47712	65724	-1375	224	644	44964	7190	1304
155	185	1	56508	66636	-646	400	516	63372	10451	4549
156	191	1	60516	70092	-889	266	863	73104	53604	617
157	189	1	71544	71496	-19	223	886	104436	59856	6952
158	192	1	67548	68784	-167	7	232	110940	110352	112
159										
160	footing element									
161	944	1	31320	15372	-3514	830	785	96168	6944	14004
162										

	A	B	C	D	E	F	G	H	I	J
1	POSTPROCESSING OF PPS-U1B RUN (Unfactored Load Case 1b)									
2				All Values are Per Foot of Width						
3	ELSET AXIS-P1: along the positive 1-axis									
4			positive is compression			absolute value		absolute value		
5	ELEME	PT FO	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
6		NOT	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)	
7										
8	floor elements									
9	289	1	15108	14664	-22	60	13	7945	5856	5
10	291	1	14520	14244	9	166	56	1772	2152	23
11	295	1	15396	14364	-25	2	83	929	775	26
12	301	1	17172	14964	-415	163	114	7428	2766	209
13	1257	1	17772	15348	477	116	23	7576	3060	106
14	1261	1	17856	15144	-386	133	31	2040	2288	78
15	1265	1	17904	14832	555	390	25	8760	3260	62
16	1269	1	18456	15108	-623	723	39	289	1378	284
17	1273	1	18708	14436	1052	580	625	268	506	425
18	1277	1	18564	13848	-361	1358	545	17940	3492	297
19	1281	1	27420	12816	-55	9328	459	194808	35724	7118
20										
21	wall elements									
22	1285	1	-18444	36096	1387	520	9850	49836	292080	2737
23	1289	1	-7871	35076	-1778	124	6564	13596	103320	1367
24	1293	1	2302	34632	1776	36	3990	1576	9233	64
25	1297	1	13812	34944	-512	72	1555	12480	87060	153
26	1301	1	31140	34656	1217	70	97	15780	110220	171
27	1305	1	29520	34584	-479	37	1059	13704	96636	184
28	1309	1	13212	34620	1202	12	2464	6822	47280	1
29	1313	1	-13032	34440	-544	14	5749	9221	67764	150
30										
31	haunch elements (1317,1321 demands are transformed via Mathcad)									
32	1317	1	-36640	30020	666	139	6972	26650	224100	5
33	1321	1	-111100	31090	2062	86	6875	30810	392200	48
34	1325	1	36336	-97632	-6754	11603	576	375456	204960	27264
35										
36	dome elements									
37	1329	1	42348	-31560	-3293	6679	350	144564	60984	9776
38	1333	1	45060	-1835	-2012	3418	220	10064	54060	2983
39	1337	1	46584	16392	-1324	2010	212	92748	60276	160
40	1341	1	48468	31188	-669	397	88	120696	59532	2138
41	1345	1	50124	39036	-53	2176	86	78540	39492	3480
42	1349	1	49416	41136	25	888	103	22920	16512	1428
43	1353	1	48396	42024	24	153	77	4856	8033	392
44	308	1	48624	42372	-183	43	65	3191	6696	211
45	305	1	48756	43920	-97	27	8	3160	4147	280
46	314	1	49020	44052	-80	185	28	1784	3301	656
47	312	1	48888	43512	-218	234	152	2585	2317	334
48	318	1	50148	46812	-55	243	211	5584	2136	20
49	317	1	50628	50640	240	252	15	4222	6268	1723
50	320	1	48024	47148	78	168	54	9702	9582	80
51										
52	footing element									
53	1357	1	15732	25380	-3275	772	862	6889	89532	13908
54										

	A	B	C	D	E	F	G	H	I	J
55										
56										
57	ELSET AXIS-N1: along the negative 1-axis									
58			positive is compression			absolute value		absolute value		
59	ELEME	PT FO	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
60		NOT	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)	
61										
62	floor elements									
63	1	1	15072	14736	0	62	2	7970	5916	4
64	4	1	14472	14388	-6	146	4	1759	2360	6
65	9	1	15264	14532	-3	32	13	1115	1137	3
66	16	1	17028	15192	391	166	76	7524	2887	208
67	324	1	17520	15612	-459	114	23	7514	3113	92
68	328	1	17496	15468	368	131	30	2080	2324	75
69	332	1	17436	15228	-536	385	27	8722	3277	56
70	336	1	17844	15600	589	718	43	297	1382	287
71	340	1	17976	15012	-1028	576	617	306	510	417
72	344	1	17772	14604	330	1333	543	17520	3366	279
73	348	1	26364	16032	106	9017	448	186900	37332	7499
74										
75	wall elements									
76	352	1	-15084	34464	-1054	506	9523	49644	286968	2621
77	356	1	-6134	33132	1981	123	6440	13824	103788	1386
78	360	1	3545	32328	-1408	44	3964	1313	7319	220
79	364	1	14544	32016	825	95	1606	12468	85428	265
80	368	1	31428	31212	-805	114	34	15864	108456	79
81	372	1	29520	30564	873	81	1006	13620	94908	4[illegible]
82	376	1	13224	29976	-638	33	2606	6028	44424	3[illegible]
83	380	1	-12516	29640	871	7	5312	9986	66372	282
84										
85	haunch elements (384,388 demands are transformed via Mathcad)									
86	384	1	-36640	30020	666	139	6972	26650	224100	5
87	388	1	-111100	31090	2062	86	6875	30810	392200	48
88	392	1	32568	-100944	6593	10160	438	366000	153036	22728
89										
90	dome elements									
91	396	1	38076	-35652	3103	6517	236	152628	43824	8761
92	400	1	41292	-5911	2142	3546	95	3457	43128	1687
93	404	1	43584	11552	1247	966	17	74316	45996	1143
94	408	1	44964	25800	836	429	62	85476	39948	1807
95	412	1	45996	35892	351	905	77	64260	28164	1544
96	416	1	46512	40980	277	647	59	36540	17112	666
97	420	1	46728	42924	23	443	67	16548	9517	504
98	23	1	47532	43224	308	15	65	7204	6346	319
99	19	1	47652	44676	222	8	23	7104	4506	264
100	28	1	48252	44844	190	179	33	455	3432	604
101	25	1	48120	44088	319	195	148	169	3233	192
102	31	1	49848	47460	83	190	196	3844	2982	95
103	29	1	50268	50916	-174	227	51	2689	6631	1518
104	32	1	47904	47424	-35	206	5	10205	9799	3
105										
106	footing element									
107	424	1	15468	32328	3515	987	806	9854	97740	137[illegible]
108										

~~p. 2 of 3~~ PPS-U1BP.XLS

	A	B	C	D	E	F	G	H	I	J
109										
110										
111	ELSET AXIS-P2: along the positive 2-axis									
112			positive is compression			absolute value		absolute value		
113	ELEME	PT FO	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
114		NOT	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)	
115										
116	floor element									
117	161	1	15132	14652	-24	22	58	7952	5885	18
118	164	1	14748	14064	2	13	145	4260	181	22
119	169	1	14880	14904	-16	48	20	2946	947	10
120	176	1	15504	16668	-399	75	173	4865	5388	211
121	844	1	15948	17196	461	24	113	5135	5461	97
122	848	1	15756	17196	-363	32	132	4324	14	82
123	852	1	15516	17160	557	25	385	5304	6648	58
124	856	1	15852	17592	-556	41	715	3377	2296	292
125	860	1	15240	17748	1079	622	579	2473	2154	426
126	864	1	14796	17532	-267	553	1342	1547	19500	296
127	868	1	16680	26196	-31	454	9134	38124	187788	7711
128										
129	wall elements									
130	872	1	-14532	35136	-660	537	9464	50004	285312	2599
131	876	1	-5734	33636	2382	143	6402	14016	103272	1277
132	880	1	3917	32832	-1054	28	3943	990	7212	141
133	884	1	14820	32424	1159	77	1607	12156	84924	299
134	888	1	31596	31620	-544	102	47	15780	108072	76
135	892	1	29616	30912	1125	80	979	13920	94944	247
136	896	1	13284	30360	-426	46	2586	6637	45036	201
137	900	1	-12528	30012	1144	14	5341	9386	65868	384
138										
139	haunch elements									
140	904	1	-36708	30324	-746	160	7007	26460	224424	712
141	908	1	-111828	31440	-465	237	6914	31728	393288	6859
142	912	1	-102120	32856	-4922	349	10192	149364	367836	17352
143										
144	dome elements									
145	916	1	-36120	38244	-2183	189	6532	43416	153096	6928
146	920	1	-6098	41364	-1460	66	3552	42768	3628	1220
147	924	1	11482	43608	-669	28	974	45744	74820	1168
148	928	1	25872	44928	-327	63	428	39744	86124	1721
149	932	1	36084	45888	106	75	908	28008	64884	1540
150	936	1	41292	46296	165	56	645	16944	37140	675
151	940	1	43332	46392	382	63	446	9412	17160	508
152	183	1	43704	47040	60	59	12	6172	7667	370
153	179	1	45252	47160	134	41	11	4302	7576	331
154	188	1	45420	47652	134	51	187	3188	676	712
155	185	1	44736	47484	-58	163	200	2980	60	79
156	191	1	48132	49044	125	214	182	2726	4021	260
157	189	1	51720	49440	293	107	216	6554	2882	1655
158	192	1	48204	47028	121	28	204	9713	9616	158
159										
160	footing element									
161	944	1	33048	15324	-3786	833	798	97956	7234	13536
162										

	A	B	C	D	E	F	G	H	I	J
1	POSTPROCESSING OF PPS-U2 RUN (Unfactored Load Case 2)									
2				All Values are Per Foot of Width						
3	ELSET AXIS-P1: along the positive 1-axis									
4			positive is compression			absolute value		absolute value		
5	ELEMEN	PT FO	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
6		NOT	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)	
7										
8	floor elements									
9	289	1	15048	14568	-19	60	10	7928	5838	3
10	291	1	14484	14136	8	163	53	1828	2192	22
11	295	1	15360	14244	-29	4	72	1016	810	19
12	301	1	17068	14832	-404	157	105	7385	2729	193
13	1257	1	17688	15216	462	111	20	7529	3036	105
14	1261	1	17784	15000	-374	132	28	2098	2298	72
15	1265	1	17844	14712	537	384	23	8682	3275	68
16	1269	1	18420	15000	-609	705	32	102	1495	263
17	1273	1	18660	14340	1017	558	600	272	613	428
18	1277	1	18612	13776	-377	1291	525	16884	3228	295
19	1281	1	27300	13188	-75	8950	432	187632	35184	6786
20										
21	wall elements									
22	1285	1	-17844	33924	1253	497	9770	49764	290700	2564
23	1289	1	-7975	32784	-1696	110	6466	13776	103608	1151
24	1293	1	1675	32268	1643	41	3818	587	5819	157
25	1297	1	12852	32652	-445	58	1475	10535	80220	64
26	1301	1	30888	32280	1048	33	141	13584	102828	215
27	1305	1	31116	32148	-362	3	891	12156	91956	12[illegible]
28	1309	1	17748	32040	973	14	1921	7306	52236	40[illegible]
29	1313	1	-5711	30984	-709	30	5243	5977	48348	678
30										
31	haunch elements 1317,1321 demands are transformed via Mathcad)									
32	1317	1	-34820	28980	650	135	6798	25410	218200	90
33	1321	1	-106600	30040	1974	81	6652	26770	381500	7
34	1325	1	33372	-90576	-5741	9850	412	359016	128184	18264
35										
36	dome elements									
37	1329	1	38676	-34152	-2417	5392	2	163632	29052	5472
38	1333	1	40668	-7507	-1810	3325	105	27108	26964	1760
39	1337	1	41748	9392	-1218	1740	63	51996	33264	115
40	1341	1	43032	23916	-864	142	53	79548	33492	953
41	1345	1	44160	33996	-315	916	76	62580	24420	1410
42	1349	1	44604	39012	-276	598	64	34752	14172	489
43	1353	1	44700	41100	-8	386	61	16248	8002	369
44	308	1	45420	41520	-306	2	58	7577	5482	373
45	305	1	45588	42996	-161	19	37	7435	3713	262
46	314	1	46176	43152	-126	177	1	511	2602	602
47	312	1	46020	42456	-284	229	173	149	2273	237
48	318	1	47580	45780	-77	207	231	4319	1913	82
49	317	1	48036	49284	220	217	25	3214	5378	1450
50	320	1	45660	45840	63	176	51	8837	8450	15
51										
52	footing element									
53	1357	1	15960	27972	-3413	1220	800	13488	93204	1315[illegible]
54										

	A	B	C	D	E	F	G	H	I	J
55										
56										
57	ELSET AXIS-N1:		along the negative 1-axis							
58			positive is compression			absolute value		absolute value		
59	ELEMEN	PT FO	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
60		NOT	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)	
61										
62	floor elements									
63	1	1	15012	14640	-2	62	1	7954	5894	4
64	4	1	14424	14304	-6	144	4	1811	2381	6
65	9	1	15204	14448	-3	31	12	1163	1169	2
66	16	1	16932	15096	382	164	73	7516	2905	199
67	324	1	17412	15516	-450	114	22	7505	3126	87
68	328	1	17376	15372	360	130	29	2110	2339	73
69	332	1	17304	15132	-524	382	27	8706	3282	52
70	336	1	17688	15504	578	712	43	242	1404	282
71	340	1	17784	14940	-1013	570	608	289	545	408
72	344	1	17616	14532	328	1309	533	17112	3244	271
73	348	1	26088	16092	107	8821	440	182784	36924	7325
74										
75	wall elements									
76	352	1	-14832	33444	-1047	496	9452	49308	284952	2605
77	356	1	-6144	32136	1931	117	6397	13692	103092	1392
78	360	1	3335	31332	-1381	52	3925	1358	7098	249
79	364	1	14124	31044	806	102	1594	12432	84492	231
80	368	1	30960	30216	-763	119	17	15708	107136	119
81	372	1	29244	29556	867	83	997	13356	93516	538
82	376	1	13380	28944	-591	32	2569	5766	43692	362
83	380	1	-11738	28608	854	8	5170	9906	64560	277
84										
85	haunch elements (384,388 demands are transformed via Mathcad)									
86	384	1	-34820	28980	650	135	6798	25410	218200	90
87	388	1	-106600	30040	1974	81	6652	26770	381500	7
88	392	1	31536	-96324	6359	9875	430	355860	153288	22224
89										
90	dome elements									
91	396	1	36804	-34176	2964	6354	231	148392	42168	8569
92	400	1	39876	-5465	2083	3455	93	3706	41784	1624
93	404	1	42072	11414	1167	934	18	72648	44616	1120
94	408	1	43368	25224	807	416	62	83484	38676	1790
95	412	1	44292	35004	303	883	77	62916	27156	1517
96	416	1	44736	39876	265	634	59	35892	16320	677
97	420	1	44880	41676	-8	443	66	16212	8825	500
98	23	1	45576	41916	295	10	63	6757	5652	314
99	19	1	45696	43236	205	12	22	6635	3779	233
100	28	1	46200	43380	165	175	33	1	2706	578
101	25	1	46068	42600	294	190	140	613	2438	198
102	31	1	47628	45924	64	178	187	4427	2140	101
103	29	1	48048	49320	-186	214	42	3348	5476	1440
104	32	1	45636	45864	-39	184	8	8840	8560	6
105										
106	footing element									
107	424	1	15324	33120	3512	1167	778	12576	98412	13548
108										

	A	B	C	D	E	F	G	H	I	J
109										
110										
111	ELSET AXIS-P2:		along the positive 2-axis							
112			positive is compression			absolute value		absolute value		
113	ELEMEN	PT FO	SF1	SF2	SF3	SF4	SF5	SM1	SM2	SM3
114		NOT	(P1)	(P2)		(V13)	(V23)	(M22)	(M11)	
115										
116	floor element									
117	161	1	15084	14556	-29	23	57	7940	5863	19
118	164	1	14700	13968	-7	13	144	4284	130	25
119	169	1	14820	14796	-27	49	19	2976	900	10
120	176	1	15444	16536	-403	72	171	4883	5383	202
121	844	1	15876	17052	433	24	113	5150	5453	95
122	848	1	15684	17052	-370	32	130	4350	54	78
123	852	1	15420	17004	522	23	381	5322	6625	60
124	856	1	15756	17424	-559	40	706	3431	2197	284
125	860	1	15108	17580	1031	611	568	2507	2140	426
126	864	1	14664	17400	-296	544	1309	1428	18996	280
127	868	1	16764	25908	-49	442	8904	37848	183024	7506
128										
129	wall elements									
130	872	1	-14436	33936	-631	526	9392	49812	283560	2509
131	876	1	-5922	32484	2274	141	6350	14016	102936	1204
132	880	1	3504	31644	-1053	25	3904	867	6511	126
133	884	1	14196	31248	1050	71	1603	12024	83544	332
134	888	1	30948	30492	-607	99	44	15816	106464	249
135	892	1	29256	29832	982	87	943	14268	93708	52
136	896	1	13416	29388	-520	66	2526	7363	45096	2[illegible]
137	900	1	-11635	29100	1049	43	5218	8311	63204	455
138										
139	haunch elements									
140	904	1	-34572	29448	-762	122	6853	24468	218172	482
141	908	1	-106500	30492	-398	210	6700	25284	382560	6264
142	912	1	-96636	31800	-4732	350	9890	150696	357672	16884
143										
144	dome elements									
145	916	1	-34200	36816	-2119	191	6352	42084	148956	6562
146	920	1	-5311	39768	-1594	66	3452	41412	3692	1156
147	924	1	11585	41916	-829	27	945	44256	72972	1065
148	928	1	25464	43200	-629	61	414	38460	84024	1547
149	932	1	35208	44148	-228	75	887	27072	63360	1318
150	936	1	40080	44592	-253	57	632	16296	36204	511
151	940	1	41820	44748	-7	64	443	8927	16488	382
152	183	1	42060	45444	-323	61	10	5750	6937	432
153	179	1	43332	45552	-241	30	13	3935	6814	350
154	188	1	43488	46128	-167	40	180	2843	27	675
155	185	1	42648	45972	-338	140	193	2555	607	132
156	191	1	45972	47556	-79	186	177	2305	4598	155
157	189	1	49368	47976	166	50	212	5707	3538	1477
158	192	1	45900	45600	50	2	187	8785	8532	29
159										
160	footing element									
161	944	1	33660	15156	-3752	790	1035	99216	10682	13428
162										

APPENDIX N

CALCULATION OF WASTE MASS

Horizontal Excitation

In the SASSI analyses, the impulsive effect of the waste in the tank for a horizontal excitation is approximated by prescribing lumped masses at nodes on the tank wall. Each lumped mass corresponds to a tributary volume of waste. The tributary volume is computed as follows:

$$V_i = Rw\cos^2\Theta_i \times l_i$$

- i = node number
- R = tank radius = 451 in
- w = tributary width of node in hoop direction = Rsin(4.5°) = 35.4 in
- Θ_i = angle between excitation direction and line connecting node *i* and tank axis
- l_i = tributary length of node *i* in vertical direction (in.)

Thus as Θ approaches 90°, the lumped mass goes to zero. Table N-1 is a spreadsheet which calculates the lumped masses representing the waste for the baseline quarter model. The in situ waste level is considered to be 7.33 ft above the inside bottom of the tank at the tank centerline. For simplicity, it is assumed that the tank is flat-bottomed and the waste is 84 in. deep. In global model coordinates, the z-coordinate at the top of the waste is 96.0 in. The specific gravity of the waste is taken to be 2.0.

This approach to modeling tank waste is approximate and typically conservative since waste mass is distributed around the full circumference of the tank. In reality, impulsive waste forces are applied to only one-half of the tank wall at any given point in time. Further, the effects of dynamic earth pressures and impulsive waste forces, rather than being additive, are counteracting to some degree (assuming small or zero phasing differences in the two loads). Using the approximate approach described above, the counteracting effect of impulsive waste forces on dynamic earth pressures tends to be underestimated.

Vertical Excitation

Using an approach similar to that described for a horizontal excitation, the impulsive effects of waste associated with a vertical seismic excitation is approximated by increasing the density of the tank floor material to include the waste mass.

The incremental value of unit weight added to the tank base (floor) material to account for the mass of the waste is calculated as follows:

$$\Delta\gamma = \frac{(2.0 \times 62.4\frac{lbf}{ft^3}) \times (7.0\ ft\ deep)}{144\frac{in^2}{ft^2}} \times \frac{1}{t_{shl}} = \frac{6.07\frac{lbf}{in^2}}{t_{shl}}$$

The variable t_{shl} is the thickness (in units of inches) of a shell element representing the base of the tank. The specific gravity of the waste is 2.0.

Table N-2 is a spreadsheet that calculates the in situ shell element section and material properties for a vertical excitation model. The weight density in the last column of the table includes the incremental value of unit weight to account for waste impulsive mass.

Table N-1
Lumped Masses Representing Waste in the Baseline Quarter Model (Horizontal Excitation)

Angle (degrees)	Tributary height (in)	Node	Weight (lbf)
0	25.4	608	14,639
4.5	25.4	607	29,098
9	25.4	606	28,562
13.5	25.4	605	27,683
18	25.4	604	26,483
22.5	25.4	784	24,991
27	25.4	783	23,244
31.5	25.4	782	21,285
36	25.4	781	19,163
40.5	25.4	924	16,929
45	25.4	923	14,639
49.5	25.4	922	12,349
54	25.4	921	10,116
58.5	25.4	1064	7,993
63	25.4	1063	6,035
67.5	25.4	1062	4,288
72	25.4	1061	2,796
76.5	25.4	1204	1,596
81	25.4	1203	717
85.5	25.4	1202	180
90	25.4	1201	0
0	22	613	12,680
4.5	22	612	25,203
9	22	611	24,739
13.5	22	610	23,977
18	22	609	22,938
22.5	22	788	21,646
27	22	787	20,133
31.5	22	786	18,436
36	22	785	16,598
40.5	22	928	14,663
45	22	927	12,680
49.5	22	926	10,696
54	22	925	8,762
58.5	22	1068	6,923
63	22	1067	5,227
67.5	22	1066	3,714
72	22	1065	2,422
76.5	22	1208	1,382
81	22	1207	621
85.5	22	1206	156
90	22	1205	0
0	22.6	618	13,026
4.5	22.6	617	25,891
9	22.6	616	25,414

1 of 2

sassi\LMASSQ7.XLS

Table N-1
Lumped Masses Representing Waste in the Baseline Quarter Model (Horizontal Excitation)

Angle (degrees)	Tributary height (in)	Node	Weight (lbf)
13.5	22.6	615	24,631
18	22.6	614	23,563
22.5	22.6	792	22,236
27	22.6	791	20,682
31.5	22.6	790	18,939
36	22.6	789	17,051
40.5	22.6	932	15,063
45	22.6	931	13,026
49.5	22.6	930	10,988
54	22.6	929	9,001
58.5	22.6	1072	7,112
63	22.6	1071	5,369
67.5	22.6	1070	3,815
72	22.6	1069	2,488
76.5	22.6	1212	1,420
81	22.6	1211	638
85.5	22.6	1210	160
90	22.6	1209	0
0	14	623	8,069
4.5	14	622	16,038
9	14	621	15,743
13.5	14	620	15,258
18	14	619	14,597
22.5	14	796	13,775
27	14	795	12,812
31.5	14	794	11,732
36	14	793	10,562
40.5	14	936	9,331
45	14	935	8,069
49.5	14	934	6,807
54	14	933	5,576
58.5	14	1076	4,406
63	14	1075	3,326
67.5	14	1074	2,363
72	14	1073	1,541
76.5	14	1216	879
81	14	1215	395
85.5	14	1214	99
90	14	1213	0
			Total = 968,273

Notes:
1. Assumptions: waste height = 84" (top of waste at z=96"); specific gravity of waste is 2.0.
2. Check: weight = dens x ht x area = 968,859 lbf.

Table N-2
Shell Element Section and Material Properties for Vertical Excitation (Best-Estimate Tank Stiffness)

						Best-est, 55 yrs					
tank region	1/2 model shell el. # (180 deg)	1/4 model shell el. # (180 deg)	nominal thickness, t [in]	Merid. coord. of centroid [in]	ABAQUS solid ele. # (Julyk 1994)	E c [lbf/in^2]	Temp [deg F]	E st [lbf/in^2]	As/inch [in^2]	d' [in]	As'/inch [in^2]
floor	1	1	6.00	R= 23.8	4	2.144E+06	157.3	2.78E+07	0.0170	1.750	0.0000
floor	4	4	6.00	53.6	10	2.147E+06	157	2.78E+07	0.0170	1.750	0.0000
floor	9	9	6.00	89.4	16	2.156E+06	156.4	2.78E+07	0.0170	1.750	0.0000
floor	16	16	6.00	125	22	2.168E+06	155.6	2.78E+07	0.0170	1.750	0.0000
floor	324	164	6.00	165	28	2.185E+06	154.3	2.78E+07	0.0170	1.750	0.0000
floor	328	168	6.00	209	34	2.210E+06	152.5	2.79E+07	0.0170	1.750	0.0000
floor	332	172	6.00	253	42	2.242E+06	150.2	2.79E+07	0.0170	1.750	0.0000
floor	336	176	6.00	297	48	2.283E+06	147.2	2.79E+07	0.0170	1.750	0.0000
floor	340	180	6.00	341	56	2.341E+06	142.9	2.79E+07	0.0170	1.750	0.0000
floor	344	184	6.00	385	64	2.420E+06	137.6	2.79E+07	0.0170	1.750	0.0000
knuckle	348	188	14.49	432	108	2.597E+06	129.1	2.80E+07	0.0550	3.130	0.0000
knuckle	352	192	18.30	Z= 37.4	131	2.624E+06	125.3	2.80E+07	0.0367	2.375	0.0367
wall	356	196	12.30	59.4	122	2.843E+06	113	2.81E+07	0.0367	2.375	0.0367
wall	360	200	12.00	82	140	3.155E+06	103.1	2.81E+07	0.0367	2.375	0.0367
wall	364	204	12.00	110	149	3.632E+06	95.15	2.82E+07	0.0367	2.375	0.0367
wall	368	208	12.00	138	151	3.739E+06	94.02	2.82E+07	0.0367	2.375	0.0367
wall	372	212	12.00	166	161	3.771E+06	92.75	2.82E+07	0.0367	2.375	0.0367
wall	376	216	12.00	194	163	3.825E+06	92.16	2.82E+07	0.0367	2.375	0.0367
wall	380	220	12.00	222	172	3.835E+06	91.64	2.82E+07	0.0367	2.375	0.0367
wall	384	224	12.00	247.9	188	3.959E+06	90.77	2.82E+07	0.0367	2.375	0.0367
haunch	388	228	27.29	271.15	190	4.100E+06	89.57	2.82E+07	0.0367	2.375	0.0367
haunch	392	232	31.62	R= 436.45	192	4.050E+06	89.52	2.82E+07	0.0960	4.375	0.0370
haunch	396	236	21.31	410.2	195	3.972E+06	89.86	2.82E+07	0.0780	4.375	0.0400
dome	400	240	18.08	380.7	232	3.943E+06	89.97	2.82E+07	0.0490	4.375	0.0430
dome	404	244	17.38	351.95	234	4.036E+06	89.2	2.82E+07	0.0470	4.375	0.0470
dome	408	248	16.91	318.4	235	3.958E+06	89.74	2.82E+07	0.0530	4.375	0.0530
dome	412	252	16.38	279.85	237	4.068E+06	88.84	2.82E+07	0.0600	4.375	0.0600
dome	416	256	15.83	240.65	238	3.983E+06	89.47	2.82E+07	0.0460	1.625	0.0460
dome	420	260	15.28	200.95	240	4.090E+06	88.59	2.82E+07	0.0430	1.625	0.0430
dome	23	23	15.00	158.5	241	4.022E+06	89.11	2.82E+07	0.0570	1.625	0.0570
dome	28	28	15.00	113.4	243	4.025E+06	89.07	2.82E+07	0.0480	1.625	0.0480
dome	31	31	15.00	68.1	245	4.100E+06	88.46	2.82E+07	0.0480	3.375	0.0480
dome	32	32	15.00	30.3	246	3.998E+06	89.26	2.82E+07	0.0370	3.375	0.0370
footing	424	264	24.00	R= 472	111	3.188E+06	121.5	2.80E+07	0.0550	3.130	0.0000

						Uncracked section		Cracked section					
tank region	1/2 model shell el. # (180 deg)	d" [in]	d [in]	n=E st/E c	I gross [in^4]	X na [in]	I eff [in^4]	(X na)tr [in]	X na [in]	I eff [in^4]	Is section cracked?	Axial stiff. (EA) shl [lbf]	Bend. stiff. (12EI) shl [lbf-in^2]
floor	1	0.000	4.250	12.983	18.00	3.04	18.31	1.167	1.167	2.63	N	1.330E+07	4.709E+08
floor	4	0.000	4.250	12.963	18.00	3.04	18.31	1.166	1.166	2.62	N	1.332E+07	4.717E+08
floor	9	0.000	4.250	12.913	18.00	3.04	18.31	1.164	1.164	2.62	N	1.337E+07	4.735E+08
floor	16	0.000	4.250	12.842	18.00	3.04	18.30	1.161	1.161	2.60	N	1.344E+07	4.762E+08
floor	324	0.000	4.250	12.746	18.00	3.04	18.30	1.158	1.158	2.59	N	1.354E+07	4.798E+08
floor	328	0.000	4.250	12.602	18.00	3.04	18.30	1.152	1.152	2.57	N	1.370E+07	4.854E+08
floor	332	0.000	4.250	12.429	18.00	3.04	18.29	1.145	1.145	2.54	N	1.389E+07	4.922E+08
floor	336	0.000	4.250	12.212	18.00	3.04	18.29	1.137	1.137	2.50	N	1.414E+07	5.011E+08
floor	340	0.000	4.250	11.920	18.00	3.04	18.28	1.125	1.125	2.45	N	1.448E+07	5.136E+08
floor	344	0.000	4.250	11.542	18.00	3.04	18.27	1.110	1.110	2.39	N	1.496E+07	5.307E+08
knuckle	348	0.000	11.360	10.777	253.53	7.39	262.31	3.125	3.125	50.37	Y	9.652E+06	1.569E+09
knuckle	352	8.675	15.925	10.673	510.71	9.27	526.80	3.633	3.675	85.06	N	4.987E+07	1.659E+10
wall	356	2.675	9.925	9.875	155.07	6.16	163.64	2.379	2.382	25.14	Y	8.829E+06	8.574E+08
wall	360	2.375	9.625	8.913	144.00	6.00	151.63	2.220	2.222	21.57	N	3.969E+07	5.741E+09
wall	364	2.375	9.625	7.755	144.00	6.00	150.51	2.101	2.105	19.21	N	4.538E+07	6.559E+09
wall	368	2.375	9.625	7.534	144.00	6.00	150.30	2.077	2.081	18.75	N	4.666E+07	6.744E+09
wall	372	2.375	9.625	7.472	144.00	6.00	150.24	2.070	2.074	18.62	N	4.704E+07	6.799E+09
wall	376	2.375	9.625	7.368	144.00	6.00	150.14	2.058	2.063	18.40	N	4.768E+07	6.891E+09
wall	380	2.375	9.625	7.349	144.00	6.00	150.12	2.056	2.061	18.36	N	4.781E+07	6.909E+09
wall	384	2.375	9.625	7.121	144.00	6.00	149.90	2.030	2.035	17.88	Y	1.012E+07	8.494E+08
haunch	388	2.375	24.915	6.876	1693.67	13.65	1748.40	3.248	3.248	129.95	N	1.137E+08	8.603E+10
haunch	392	1.625	27.245	6.961	2634.54	15.92	2753.39	5.269	5.269	374.43	N	1.313E+08	1.338E+11
haunch	396	1.625	16.935	7.097	806.43	10.69	845.05	3.695	3.695	114.91	N	8.751E+07	4.028E+10
dome	400	1.625	13.705	7.150	492.51	9.01	513.59	2.678	2.678	49.29	N	7.352E+07	2.430E+10
dome	404	1.625	13.005	6.986	437.49	8.65	456.74	2.525	2.525	41.65	N	7.242E+07	2.212E+10
dome	408	1.625	12.535	7.123	402.95	8.40	423.44	2.616	2.616	43.43	N	6.950E+07	2.011E+10
dome	412	1.625	12.005	6.932	366.24	8.13	386.70	2.654	2.654	42.98	N	6.953E+07	1.888E+10
dome	416	4.375	14.205	7.079	330.57	7.96	345.10	2.868	2.888	50.45	N	6.528E+07	1.649E+10
dome	420	4.375	13.655	6.895	297.30	7.68	309.14	2.708	2.730	42.97	N	6.457E+07	1.517E+10
dome	23	4.375	13.375	7.010	281.25	7.56	296.36	3.031	3.051	52.76	N	6.309E+07	1.430E+10
dome	28	4.375	13.375	7.006	281.25	7.55	293.98	2.826	2.847	45.75	N	6.269E+07	1.420E+10
dome	31	3.375	11.625	6.879	281.25	7.50	290.85	2.543	2.555	32.95	N	6.381E+07	1.431E+10
dome	32	3.375	11.625	7.052	281.25	7.50	288.87	2.310	2.324	27.04	N	6.177E+07	1.386E+10
footing	424	6.250	20.870	8.791	1152.00	12.16	1185.12	4.035	4.035	158.93	N	7.787E+07	4.534E+10

(wt density) nom = 0.0870

tank region	1/2 model shell el. # (180 deg)	Effective shell properties		
		E shl [lbf/in^2]	t shl [in]	(weight density) shl [lbf/in^3]
floor	1	2.235E+06	5.95	1.1370
floor	4	2.238E+06	5.95	1.1370
floor	9	2.247E+06	5.95	1.1369
floor	16	2.259E+06	5.95	1.1369
floor	324	2.276E+06	5.95	1.1368
floor	328	2.301E+06	5.95	1.1367
floor	332	2.333E+06	5.95	1.1365
floor	336	2.374E+06	5.95	1.1364
floor	340	2.432E+06	5.96	1.1361
floor	344	2.511E+06	5.96	1.1358
knuckle	348	7.569E+05	12.75	0.5885
knuckle	352	2.735E+06	18.24	0.0873
wall	356	8.960E+05	9.85	0.1086
wall	360	3.301E+06	12.03	0.0868
wall	364	3.774E+06	12.02	0.0868
wall	368	3.881E+06	12.02	0.0868
wall	372	3.913E+06	12.02	0.0868
wall	376	3.966E+06	12.02	0.0868
wall	380	3.977E+06	12.02	0.0868
wall	384	1.105E+06	9.16	0.1140
haunch	388	4.132E+06	27.51	0.0863
haunch	392	4.112E+06	31.93	0.0862
haunch	396	4.079E+06	21.46	0.0864
dome	400	4.044E+06	18.18	0.0865
dome	404	4.144E+06	17.48	0.0865
dome	408	4.086E+06	17.01	0.0865
dome	412	4.220E+06	16.48	0.0865
dome	416	4.107E+06	15.90	0.0866
dome	420	4.212E+06	15.33	0.0867
dome	23	4.190E+06	15.06	0.0867
dome	28	4.166E+06	15.05	0.0867
dome	31	4.261E+06	14.97	0.0871
dome	32	4.123E+06	14.98	0.0871
footing	424	3.227E+06	24.13	0.0865

APPENDIX O

MATRIX OF C-106 SASSI ANALYSES

Table O-1 summarizes the set of SASSI analyses completed in support of the C-106 seismic evaluation.

Table O-1
C-106 SASSI Analyses

Run ID	Model Type [1]	Concrete Section Properties	Soil Properties	Waste Mass	Control Motion	Excit. Direc.	No. Freqs / Max. Freq.	# of Soil Layers in Excav.	% Struc. Damping	Incompat. Displ. Modes Included	"R" in POINT (inches)
9	half	Uniform, fc = 3000 lbf/in^2	SY-101	no	SY-101	horiz.	12 / 13 hz	4	4	yes	130
9a	half [4]	Uniform, fc = 3000 lbf/in^2	SY-101	no	SY-101	horiz.	12 / 13 hz	4	4	yes	130
9b	half [4]	Uniform, fc = 3000 lbf/in^2	SY-101	no	SY-101	horiz.	12 / 13 hz	4	4	yes	130
Q2	quarter [2]	Uniform, fc = 3000 lbf/in^2	SY-101	no	SY-101	horiz.	12 / 13 hz	4	4	yes	130
Q3	quarter [2]	In situ (best-estimate, 55 years)	SY-101	no	SY-101	horiz.	12 / 13 hz	4	4	yes	130
Q4	quarter [2]	In situ (best-estimate, 55 years)	SY-101	no	SY-101	horiz.	24 / 13 hz	4	4	yes	130
Q5	quarter [2]	In situ (best-estimate, 55 years)	SY-101	yes	SY-101	horiz.	12 / 13 hz	4	4	yes	130
Q5.5	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (best-est.)	yes	SY-101	horiz.	12 / 13 hz	4	4	yes	130
Q6	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (best-est.)	yes	Rohay, Weiner	horiz.	12 / 13 hz	4	4	yes	130
Q7	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (best-est.)	yes	Rohay, Weiner	horiz.	12 / 13 hz	8	4	yes	130
Q7-2	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (best-est.)	yes	Rohay, Weiner	horiz.	12 / 13 hz	8	7	yes	130
Q7B	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (best-est.)	yes	Rohay, Weiner	horiz.	18 / 24 hz	8	4	yes	130
Q7V	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (best-est.)	no	2/3 x Rohay, Weiner	vert.	18 / 24 hz	8	7	yes	130
Q8	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (best-est.)	yes	Rohay, Weiner	horiz.	12 / 13 hz	4	7	yes	130
Q8V	quarter [3]	In situ (best-estimate, 55 years)	Grout Vault (best-est.)	no	2/3 x Rohay, Weiner	vert.	12 / 13 hz	4	4	yes	130

Table O-1
C-106 SASSI Analyses

Run ID	Comments	Location of Input Files	Location of Output Files (LANL cfs runs only)
9	Basis for preliminary seismic evaluation	jxd380/sh106 on cfs	
9a	Soil mesh does not extend to antisym. plane	jxd380/ac106 on cfs	
9b	Soil mesh extends to antisym. plane	jxd380 on cfs	
Q2	Equivalent to Run 9	jxd380/q2 on cfs	
Q3	Shell properties updated to simulate in situ condition	jxd380/q3 on cfs	
Q4	Same as Q3 but with twice as many frequencies within the same range	jxd380/q4 on cfs	
Q5	Same as Q4 but with waste modeled via lumped masses on tank walls	jxd380/q5 on cfs	
Q5.5	Control motions used in SHAKE and SASSI are not congruent.	jxd380/q5.5 on cfs	
Q6	Updated control motion	jxd380/q6 on cfs	
Q7	Same as Q6 but with tighter spacing of interaction nodes	jxd380/q7 on cfs	
Q7-2	Same as Q7 above but 7% struc. damping & run on LANL	u0/570422/q7 on LANL	570422/q7/d3ge17.tar.Z (7 freqs) & ebt6n8.tar.Z (18 freq)
Q7B	Same as Q7 but includes higher frequencies	jxd380/q7b on cfs (house in /q7)	
Q7V	Same as Q7B but with vertical rather than horizon. excitation; also 7% struc. damping	u3/jxd380/q7v on INEL	
Q8	Same as Q6 but with higher structural damping	jxd380/q8 on cfs (also u3/jxd380/q8 on INEL)	
Q8V	Same as Q8 but with vertical rather than horizontal excitation	jxd380/q8v on cfs (also u3/jxd380/q8v on INEL)	

Table O-1
C-106 SASSI Analyses

Run ID	Model Type [1]	Concrete Section Properties	Soil Properties	Waste Mass	Control Motion	Excit. Direc.	No. Freqs / Max. Freq.	# of Soil Layers in Excav.	% Struc. Damping	Incompat. Displ. Modes Included	"R" in POINT (inches)
Q9	quarter [2]	In situ concrete (lower-bound); all sections cracked	Grout Vault (best-est.)	yes	Rohay, Weiner	horiz.	12 / 13 hz	4	7	yes	130
TTT	half [4]	In situ (best-estimate, 55 years)	Grout Vault (best-est.)	yes	Rohay, Weiner	horiz.	12 / 13 hz	4	7	yes	130
QHI	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (upper-bound)	yes	Rohay, Weiner	horiz.	18 / 24 hz	4	7	yes	130
QHI-V	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (upper-bound)	no	2/3 x Rohay, Weiner	vert.	18 / 24 hz	4	7	yes	130
50H	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner	horiz.	12 / 13 hz	4	7	yes	130
QLOW	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner	horiz.	18 / 24 hz	8	7	yes	130
QLOW (4% damp)	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner	horiz.	7 / 13 hz	8	4	yes	130
QLOW-20	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner	horiz.	20 / 24 hz	8	7	yes	130
cmot50 QLOW	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner @ outcrop of 2nd layer	horiz.	18 / 24 hz	8	7	yes	130
cmot50 QLOW-sup	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner @ outcrop of 2nd layer	horiz.	7 / 13 hz	8	7	no	130
QLOWpnt2	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner	horiz.	7 / 13 hz	8	7	yes	42
QLOW4pt2	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner	horiz.	7 / 13 hz	8	4	yes	42
QLOWpnt3	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner	horiz.	7 / 13 hz	8	7	yes	84
QLOWpnt4	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner	horiz.	7 / 13 hz	8	7	yes	72
cmot50 QLOW4pt4	quarter [2]	In situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner @ outcrop of 2nd layer	horiz.	7 / 13 hz	8	4	no	72

RI' 'S *6

Table O-1
C-106 SASSI Analyses

Run ID	Comments	Location of Input Files	Location of Output Files (LANL cfs runs only)
Q9	Same as Q8 but lower-bound rather than best-estimate tank stiffness	u3/jxd380/q9 on INEL	
TTT	Same as Q8 but includes tank-to-tank interaction	w81646/tttc106 on cfs (also u3/jxd380/ttt on INEL)	
QHI	Same as Q8 except soil data increased by 100%	u0/570422/qhi on LANL	570422/qhi/d3gtsr.tar.Z
QHI-V	Not run (QHI showed 200% soil properties do not govern)	u0/570422/qhi-v on LANL	n/a
50H	Same as Q8 except soil data reduced by 50%	u3/jxd380/50h on INEL	
QLOW	Same as 50H except tighter spacing of interaction nodes; also effect of higher frequencies examined	u0/570422/qlow on LANL	570422/qlow/di9eku.tar.Z, combin.tar.Z (7 freqs) & ejvbdu.tar.Z, 18freq.tar.Z (18 freq)
QLOW (4% damp)	Same as QLOW except reduced structural damping	u0/570422/qlow on LANL (house4.inp)	570422/qlow/fc9evh.tar.Z
QLOW-20	Same as QLOW except 2 frequencies added	u0/570422/qlow on LANL (*add.inp)	570422/qlow/i9z5mw.tar.Z
cmot50 QLOW	Same as QLOW except control motion based on incompetent 1st soil layer	u0/570422/qlow/cmot50 on LANL	570422/qlow/cmot50/fwevx6.tar.Z (7 freq) & hzksmv.tar.Z (18 freq)
cmot50 QLOW-sup	Same as QLOW-cmot50 except 9 incompat. displ. modes are suppressed	u0/570422/qlow/cmot50 on LANL (housesup.inp)	570422/qlow/cmot50/i85z87.tar.Z
QLOWpnt2	Same as QLOW except reduced "R" in POINT used (based on floor node spacing)	u0/570422/qlow on LANL	570422/qlow/nkwztl.tar.Z
QLOW4pt2	Same as QLOWpnt2 except reduced damping used.	u0/570422/qlow on LANL	570422/qlow/nuj7db.tar.Z
QLOWpnt3	Same as QLOW except reduced "R" used (based on avg. I.N. spacing)	u0/570422/qlow on LANL	570422/qlow/nuk42d.tar.Z
QLOWpnt4	Same as QLOW except reduced "R" used (based on avg. 85% I.N. spacing)	u0/570422/qlow on LANL	570422/qlow/n5navx.tar.Z
cmot50 QLOW4pt4	Same as QLOW (4% damped) except "R" = 72" & 9 incompat. displ. modes are suppressed	u0/570422/qlow/cmot50 on LANL	570422/qlow/cmot50/pb2j6k.tar.Z

Table O-1
C-106 SASSI Analyses

Run ID	Model Type [1]	Concrete Section Properties	Soil Properties	Waste Mass	Control Motion	Excit. Direc.	No. Freqs / Max. Freq.	# of Soil Layers in Excav.	% Struc. Damping	Incompat. Displ. Modes Included	"R" in POINT (inches)
cmot50 QLOWpnt4	quarter [2]	in situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner @ outcrop of 2nd layer	horiz.	19 / 24 hz	8	7	no	72
QLOW-V	quarter [2]	in situ (best-estimate, 55 years)	Grout Vault (lower-bound)	no	2/3 x Rohay, Weiner @ outcrop of 2nd layer	vert.	19 / 24 hz	8	7	no	72
TTTLOW	half [4]	in situ (best-estimate, 55 years)	Grout Vault (lower-bound)	yes	Rohay, Weiner @ outcrop of 2nd layer	horiz.	15 / 24 hz	8	7	no	72
QLOWVMAS	quarter [2]	in situ (best-estimate, 55 years)	Grout Vault (lower-bound)	YES	2/3 x Rohay, Weiner @ outcrop of 2nd layer	vert.	19 / 24 hz	8	7	no	72
QLOWVLIV	quarter [2]	in situ (best-estimate, 55 years)	Grout Vault (lower-bound)	YES	2/3 x Rohay, Weiner @ outcrop of 2nd layer	vert.	19 / 24 hz	8	7	no	72
Q7pnt4	quarter [2]	in situ (best-estimate, 55 years)	Grout Vault (best-est.)	yes	Rohay, Weiner	horiz.	7 / 13 hz	8	7	yes	72
Q8pnt5	quarter [2]	in situ (best-estimate, 55 years)	Grout Vault (best-est.)	yes	Rohay, Weiner	horiz.	7 / 13 hz	4	7	yes	156
Q7VMAS	quarter [2]	in situ (best-estimate, 55 years)	Grout Vault (best-est.)	YES	2/3 x Rohay, Weiner	vert.	19 / 24 hz	8	7	no	72
Q7TTT	half [4]	in situ (best-estimate, 55 years)	Grout Vault (best-est.)	yes	Rohay, Weiner	horiz.	11 / 24 hz	8	7	no	72
cmot50 QLOWFIL	quarter [2]	in situ (best-estimate, 55 years)	G.V. (lower-bound) (except near-field)	yes	Rohay, Weiner @ outcrop of 2nd layer	horiz.	7 / 13 hz	8	7	no	72
Q7risers	quarter [2]	in situ (best-estimate, 55 years)	Grout Vault (best-est.)	yes	Rohay, Weiner	horiz. (x)	12 / 13 hz	8	7	yes	130
Q7risers ydir	quarter [2]	in situ (best-estimate, 55 years)	Grout Vault (best-est.)	yes	Rohay, Weiner	horiz. (y)	12 / 13 hz	8	7	yes	130
Q7risers zdir	quarter [2]	in situ (best-estimate, 55 years)	Grout Vault (best-est.)	no	2/3 x Rohay, Weiner	vert.	12 / 13 hz	8	7	yes	130

Notes:
1. All models employ a symmetry plane along the x-axis.
2. Employs an antisymmetry plane along the y-axis.
3. Employs a symmetry plane along the y-axis.
4. Employs an antisymmetry plane at x = 600 inches to simulate tank-to-tank interaction.

Table O-1
C-106 SASSI Analyses

Run ID	Comments	Location of Input Files	Location of Output Files (LANL cfs runs only)
cmot50 QLOWpnt4	Same as QLOW4pt4 except 7% damping used.	u0/570422/qlow/cmot50 on LANL	570422/qlow/cmot50/n5wji5.tar.Z (1st 7 freq); n5zewx (next 11 freq); png4cs (19th)
QLOW-V	Vertical excitation (50% soil properties case)	u0/570422/qlow-v on LANL	570422/qlow-v/pnpfzi.tar.Z (also pb26y1)
TTTLOW	Includes tank-to-tank interaction (50% soil properties case)	u0/570422/tttlow on LANL (also 570422/tttlow on LANL cfs)	570422/tttlow/r5tivi.tar.Z (also p9irs7, rfd3p3, rfec6u, rm753r, rpcy2h, rz7xk8, fort8_12f)
QLOWVMAS	Same as QLOW-V but with waste mass considered	u0/570422/qlow-v on LANL	570422/qlow-v/rmz4ju.tar.Z
QLOWVLIV	Same as QLOWVMAS but with 100 ton live load	u0/570422/qlow-v on LANL	570422/qlow-v/ar3a42.tar.Z
Q7pnt4	Same as Q7 except reduced "R" in POINT	u0/570422/q7 on LANL	570422/q7/pnmfcn.tar.Z
Q8pnt5	Same as Q8 except increased "R" (based on I.N. spacing)	u0/570422/q8 on LANL	570422/q8/pnxkcw.tar.Z
Q7VMAS	Same as Q7pnt4 but with waste mass considered	u0/570422/q7v on LANL	570422/q7v/sdmfcv.tar.Z
Q7TTT	Includes tank-to-tank interaction (best-est. soil properties case)	u0/570422/q7ttt on LANL	570422/q7ttt/b84mb4.tar.Z (also a7sscr, bzrzjl)
cmot50 QLOWFIL	Same as QLOWpnt4 except near-field soil moduli = free-field soil moduli times 0.707	u0/570422/qlow/cmot50 on LANL (housefil.inp)	570422/qlow/cmot50/pa5ghz.tar.Z (1st 7 freq)
Q7risers	Includes beams for risers, smeared representation of pits	570422/q7risers/inputs.tar.Z on cfs	570422/q7risers/h8xkfn.tar.Z, motion.out
Q7risers ydir	Includes beams for risers, smeared representation of pits. Sym., antisym. planes switched.	570422/q7risers/inputs.tar.Z on cfs (*y.inp)	570422/q7risers/ydir/lywaz6.tar.Z
Q7risers zdir	Includes beams for risers, smeared representation of pits	570422/q7risers/inputs.tar.Z on cfs (*z.inp)	570422/q7risers/zdir/lynfls.tar.Z

APPENDIX P

CORRESPONDENCE REGARDING SASSI ANALYSIS FREQUENCIES

To: John Lysmer

From: Jim Day
ADVENT Engineering Services, Inc.

Date: 2/24/94

Prof. Lysmer:

I'll call you on Monday to discuss the following questions.

1. For the case of a vertically propagating P- or S-wave, should the cutoff frequency of the analysis (f_{NF}) be limited by the horizontal spacing of the interaction nodes as well as the vertical spacing (soil layer thickness)? If so, what are the implications of violating the $V_s/5(f_{NF})$ rule for maximum horizontal spacing (but remaining less than $V_s/2(f_{NF})$)?

2. How important is it to choose analysis frequencies equal to or very close to the dominant frequencies of the structure? The dominant frequencies of an underground structure are not readily determined: therefore, we potentially have the situation where the analysis frequencies may not correspond well to the dominant frequencies of the structure. Is it reasonable to assert that because soil-structure interaction tends to "flatten the sharp peaks and sometimes eliminate some of the structural peaks", the close proximity of the analysis frequencies to the dominant structural frequencies is of little importance? If not, is there a means of identifying the dominant structural frequencies from the SASSI results so that analysis frequencies can be subsequently added?

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FAX TRANSMISSION

This transmission consists of 1 page(s) including this sheet

File: ADV921D.WP

March 1, 1994

Jim Day
ADVENT Engineering Services

Fax: 743-0414

Dear Jim:

Since I have not heard from you with regard to your fax dated 2/24/94, here are the answers to your questions:

1. As you suggest, for vertically propagating waves it is the vertical dimension of elements that matters. The implications of violating the wavelength rule for the horizontal dimension of elements are minor. I would suggest that you do not exceed $\lambda/2.5$ in the horizontal direction near the structure. The selection of the correct vertical dimension is most important within the depth of embedment. At greater depths you can gradually increase the vertical dimension of elements beyond that specified by the wavelength rule.

2. For underground tank analyses the natural frequences of the external concrete structure are completely irrelevant and they will not show up in your computed response. If the tank has an internal lining which can vibrate relative to the exterior shell, the fixed-base frequency of this lining may show up in the response. The frequencies used in the SASSI calculations need not be close to the frequencies of the structure. What matters is that you should not develop more than two peaks within each 5-point interpolation range. The best way of identifying peaks in the response of an underground structure is to let SASSI produce printer plots of some of the transfer functions. Modes in the usual sense do not exist in soil-structure interaction respons.

Sincerely yours,

John Lysmer

APPENDIX Q

MODELING DETAILS FOR PITS AND RISERS

C-106 has three reinforced-concrete pits located above the tank dome and embedded in the soil. The three pits include the Heel Pit, the Pump Pit, and the Sluicing Pit. Each box-shaped pit is separated from the tank dome by a layer of soil. Steel pipes (risers) span vertically from the floor of each pit to the tank dome. The top end of each riser is coupled with the pit floor in the horizontal direction but not in the vertical direction. These coupling conditions are consistent with the absence of structural attachment between the risers and the pits.

The Young's modulus (E) and the shear modulus (G) used in modeling the pit concrete have been halved to approximately account for the empty volume inside the pit. These values of pit moduli greatly exceed the corresponding moduli for the first two layers of soil. The Poisson's ratio (ν) used for the pit concrete is 0.15. Based on the mass density (ρ), Poisson's ratio, and Young's modulus, the compression wave speed (V_p) and the shear wave speed (V_s) are computed for use in SASSI. The key formulae used are as follows:

(1) $G = E / (2 (1 + \nu))$

(2) $V_s = (G / \rho)^{1/2}$

(3) $V_p = V_s [2(\nu - 1) / (2\nu - 1)]^{1/2}$

The key material properties of concrete are as follows:

Concrete unit weight	=	150	lbf/ft^3
	=	0.08681	lbf/in^3
Nominal concrete E	=	$57,000 (f_c)^{1/2}$	
	=	3.122E6	lbf/in^2
where f_c	=	3,000	lbf/in^2
Modeled concrete E	=	1.561E6	lbf/in^2
Poisson's ratio, ν	=	0.15	
Modeled concrete G	=	1.561E6 / [2(1 + 0.15)]	
	=	678,696	lbf/in^2

Heel Pit Modeling Details:

The Heel Pit is modeled as a cylindrical pit over the apex of the dome. The minimum distance between the underside of the pit and the top surface of the dome in the model is 20.5 in., the same as the "actual" soil layer thickness between the pit and the dome.

The weight of the pit (accounting for the void) and the estimated weight of equipment is computed. The modeled unit weight is computed by dividing the computed weight by the modeled volume.

The heel pit riser connects the dome (Node I) to the pit (Node J). Node J has been end released to prohibit transfer of moments and vertical force at the top of the riser.

The following summarizes the properties used for the Heel Pit:

Concrete unit weight	=	150	lbf/ft^3
	=	0.08681	lbf/in^3
Total concrete volume	=	(144 x 108 x 73.375) - (108 x 72 x 25.875)	
	=	1,141,128 - 201,204	
	=	939,924	in^3
Total concrete weight	=	0.08681 x 939,924	
	=	81,595	lbf
Equipment weight	=	3,000	lbf
Total weight	=	84,595	lbf
Weight (for 1/4 model)	=	84,595 / 4	
	=	21,149	lbf
Modeled volume	=	$(\pi r^2 h_2) / 4$	
	=	$\pi (0.4)^2 (54) / 4$	
	=	210,198	in^3
Unit weight	=	21,149 / 210,198	
	=	0.10061	lbf/in^3
Mass density	=	260.6E-6	$lbf\text{-}s^2/in^4$
V_s	=	$(678,696 / 0.00026059)^{1/2}$	
	=	51,034	in/s
V_p	=	$51,034\ [2(0.15 - 1)/(0.3 - 1)]^{1/2}$	
	=	79,531	in/s

The riser is 12 in. Sch. 40 pipe of Grinnel low carbon steel (Drawing No. H-2-41295). The material and section properties of the riser are as follows:

E	=	27.9E6	lbf/in^2
G	=	10.8E6	lbf/in^2
A, cross-section area	=	15.75	in^2
A_s, shear area	=	7.87	in^2
I, moment of inertia	=	300.3	in^4
J, polar moment of inertia	=	600.4	in^4
S, section modulus	=	47.1	in^3

Since the beam is located at the intersection of 2 symmetry planes, the above section properties are divided by 4.

<u>Pump Pit / Sluicing Pit Modeling Details:</u>

Since the SASSI model is a 1/4 model and the Pump Pit and the Sluicing Pit are located on opposite sides of the projected dome area, either the Pump Pit or the Sluicing Pit should be modeled. The Pump Pit is selected for two primary reasons; the Pump Pit is larger and is likely to have more interaction with the tank; and, the Pump Pit has 3 risers, i.e., the 4 in. and the 12 in. risers which are common to both pits and the 36 in. riser which is unique to the Pump Pit.

To take advantage of the existing soil modeling geometry, the Pump Pit is modeled with the walls running in radial and circumferential directions. The distance between the inside corner of the pit bottom and the top of the dome has been modeled as 10 in., the "actual" soil layer thickness between the pit and the dome.

The weight of the pit (accounting for the void) and estimated weight of equipment is computed. The modeled unit weight is computed by dividing the computed weight by the modeled volume.

The compression wave speed and the shear wave speed used for the Pump Pit are the same as for the Heel Pit.

The 4 in. riser is assumed to be 4 in. Sch. 40 pipe and the 12 in. riser is assumed to be 12 in. Sch. 40 pipe. The pump column riser (Drawing No. H-2-41267) has a 36.75 in. OD and thickness of 0.375 in. The risers span vertically from the dome (Node I) to the pit (Node J). Node J has been end released to prohibit transfer of moments and vertical force at the top of riser.

The following summarizes the properties used for the Pump Pit:

Total concrete volume	=	(216 x 168 x 116.5) + (216 x 7 x 30) + (216 x 11 x 36) - (174.5 x 132 x 69)
	=	4,227,552 + 45,360 + 85,536 - 1,589,346
	=	2,769,102 in^3
Total concrete weight	=	0.08681 x 2,769,102
	=	240,386 lbf
Equipment weight	=	6,000 lbf
Total weight	=	246,386 lbf
Weight (for 1/4 model)	=	246,386/2
	=	123,193 lbf
Modeled volume	=	$\pi\, h\, (r_o^2 - r_i^2) / 20$
	=	$\pi\, (95.6)\, (427.25^2 - 260.4^2) / 20$
	=	1,722,945 in^3

Unit weight	=	123,193 / 1,722,945	
	=	0.07150	lbf/in^3
Mass density	=	185.0E-6	$lbf\text{-}s^2/in^4$
V_s	=	51,034	in/s
V_p	=	79,531	in/s

The 4 in. riser is comprised of Grinnel low carbon steel. The material and section properties of the riser are as follows:

E	=	27.9E6	lbf/in^2
G	=	10.8E6	lbf/in^2
A	=	3.17	in^2
A_s	=	1.59	in^2
I	=	7.23	in^4
J	=	14.47	in^4
S	=	3.21	in^3

Since the beam is located on a symmetry plane, the above section properties are divided by 2.

The 12 in. riser is comprised of A53 Gr. A steel. The material and section properties of the riser are as follows:

E	=	27.9E6	lbf/in^2
G	=	10.8E6	lbf/in^2
A	=	15.75	in^2
A_s	=	7.87	in^2
I	=	300.21	in^4
J	=	600.42	in^4
S	=	47.1	in^3

Since the beam is located on a symmetry plane, the above section properties are divided by 2.

The 36 in. riser is comprised of A285 Gr. C steel. The material and section properties of the riser are as follows:

E	=	27.9E6	lbf/in^2
G	=	10.8E6	lbf/in^2
A	=	42.85	in^2
A_s	=	21.43	in^2
I	=	7088	in^4
J	=	14177	in^4
S	=	772	in^3

Since the beam is located on a symmetry plane, the above section properties are divided by 2.

The SASSI quarter model which incorporates the Heel Pit and the Pump / Sluicing Pit is shown in Figure Q-1.

APPENDIX R

COMPUTER PROGRAM FOR GENERATING SASSI HALF MODEL FROM BASELINE QUARTER MODEL

The listing of a FORTRAN computer program (MGEN) written to generate the bulk of the HOUSE input for the TTI half model is provided in this appendix. MGEN uses excerpts from the baseline quarter model HOUSE input file as input. The half model finite element mesh thus mirrors the mesh of the baseline quarter model. The input files for MGEN (n1.in, n2.in, e1.in, e2.in, e3.in, and e4.in) are included in this appendix.

FILENAME : mgen.for DATE : 342 04-2 TIME : 94 3 PAGE 1
TITLE : Converts Q7 quarter model (558 I.N.) to half model

```
c  Compile by typing "fl /Gt1000 mgen.for"
      dimension qn(350),hcoor(3),qe1(386),qe2(136),iord(386),
     & mt1(386),mt2(136),thk(136),hbc(6),r(350),tang(350),
     & qbc(350,6),qcoor(350,3),solcon(386,8),shlcon(136,4),
     & node(746,10)
c  746 is the last node number in the file "n2.in"
      integer qn,qe1,qe2,qbc,solcon,shlcon,etyp,hbc
      open(21,file='n1.in')
      open(22,file='n2.in')
      open(31,file='e1.in')
      open(32,file='e2.in')
      open(33,file='e3.in')
      open(34,file='e4.in')
      open(41,file='nodes.out')
      open(42,file='solids.out')
      open(43,file='shells.out')
      open(44,file='debug.out')
c
c  nn1 = no. of nodes per slice in excavation
c  nn2 = no. of add'l nodes per slice in near-field soil
c  ne1 = no. of solid elements per slice in excavation
c  ne2 = no. of solid elements per slice in near-field soil
c  ne3 = no. of triangular tank shells per slice
c  ne4 = no. of quad tank shells per slice
c
      nn1=162
      nn2=188
      ne1=96
      ne2=290
      ne3=32
      ne4=104
      imov=0
c  18 degree slice in radians
      slrad=18./57.29578
      tol=.011
      tol2=1./57.29578
c  read data for excavation nodes (1st slice)
      do i=1,nn1
        read(21,*)qn(i),(qbc(i,j),j=1,6),(qcoor(i,k),k=1,3)
      end do
c  read data for remaining nodes (1st slice)
      do i=nn1+1,nn1+nn2
        read(22,*)qn(i),(qbc(i,j),j=1,6),(qcoor(i,k),k=1,3)
      end do
c *********************************
c  generate half model nodes
      nnod=1
c  half model excavation nodes
c   j = slice number
      do j=1,10
        dang=(j-1)*slrad
        do i=1,nn1
          r(i)=sqrt(qcoor(i,1)**2 + qcoor(i,2)**2)
          if(qcoor(i,1).eq.0.) then
c  node is on axis of rotation
            hcoor(1)=0.
            hcoor(2)=0.
            if(j.eq.1) then
              node(qn(i),j)=nnod
            else
              node(qn(i),j)=node(qn(i),1)
            end if
          else
            tang(i)=atan(qcoor(i,2)/(-qcoor(i,1)))
            hcoor(1)=-r(i)*cos(dang+tang(i))
            hcoor(2)=r(i)*sin(dang+tang(i))
          end if
c  z-coord remains the same (except move bottom of 1st soil layer)
          hcoor(3)=qcoor(i,3)
c  if node falls directly on dang subsequent to 1st slice, it was
```

```
c    defined in previous slice
         if(j.gt.1.and.qcoor(i,2).eq.0.) then
c  identify 1st slice quarter model node (l) located +dang from 1st slice
c    quarter model node i
           do l=i-1,1,-1
             if(r(l).le.(r(i)+tol) .and. r(l).ge.(r(i)-tol) .and.
     &       qcoor(l,3).eq.qcoor(i,3) .and.
     &       tang(l).le.(slrad+tol2) .and. tang(l).ge.(slrad-tol2))then
               node(qn(i),j)=node(qn(l),j-1)
c               write(*,99)i,l,tang(l),qcoor(i,3),qcoor(l,3),r(i),r(l)
c   99          format(2i5,5f10.4)
               go to 150
             end if
           end do
  150      go to 100
         end if
c  associate 1st slice node number and slice number with half model node
         node(qn(i),j)=nnod
c  logic to define boundary conditions (sym plane at y = 0)
         if(hcoor(2).le.tol.and.hcoor(2).ge.-tol) then
           hbc(1)=0
           hbc(2)=1
           hbc(3)=0
           hbc(4)=1
           hbc(5)=0
           hbc(6)=1
         else
           hbc(1)=0
           hbc(2)=0
           hbc(3)=0
           hbc(4)=0
           hbc(5)=0
           hbc(6)=0
         end if
c  if all rotations fixed in 1st slice of quarter model, then half model
c  node is not part of a shell and all rotations can be fixed
         if(qbc(i,4).eq.1.and.qbc(i,5).eq.1.and.qbc(i,6).eq.1)then
           hbc(4)=1
           hbc(5)=1
           hbc(6)=1
         end if
         if(hcoor(3).eq.405.)then
           hcoor(3)=384.5
           imov=imov+1
         end if
         write(41,30)nnod,(hbc(k),k=1,6),(hcoor(k),k=1,3)
   30    format(7i5,3f10.2)
         nnod=nnod+1
  100  end do
     end do
c  half model remaining nodes
     do j=1,10
       dang=(j-1)*slrad
       do i=nn1+1,nn1+nn2
         r(i)=sqrt(qcoor(i,1)**2 + qcoor(i,2)**2)
         if(qcoor(i,1).eq.0.) then
c  node is on axis of rotation
           hcoor(1)=0.
           hcoor(2)=0.
           if(j.eq.1) then
             node(qn(i),j)=nnod
           else
             node(qn(i),j)=node(qn(i),1)
           end if
         else
           tang(i)=atan(qcoor(i,2)/(-qcoor(i,1)))
           hcoor(1)=-r(i)*cos(dang+tang(i))
           hcoor(2)=r(i)*sin(dang+tang(i))
         end if
c  z-coord remains the same (except at bottom of 1st soil layer)
```

```
          hcoor(3)=qcoor(i,3)
c  if node falls directly on dang subsequent to 1st slice, it is already defined
          if(j.gt.1.and.qcoor(i,2).eq.0.) then
c  identify 1st slice quarter model node (l) located +dang from 1st slice
c    quarter model node i
            do l=i-1,nn1-1,-1
              if(r(l).le.(r(i)+tol) .and. r(l).ge.(r(i)-tol) .and.
     &        qcoor(l,3).eq.qcoor(i,3) .and.
     &        tang(l).le.(slrad+tol2) .and. tang(l).ge.(slrad-tol2))then
                node(qn(i),j)=node(qn(l),j-1)
                go to 160
              end if
            end do
  160       go to 200
          end if
c  associate 1st slice node number and slice number with half model node
          node(qn(i),j)=nnod
c  logic to define boundary conditions (sym plane at y = 0)
          if(hcoor(2).le.tol.and.hcoor(2).ge.-tol) then
            hbc(1)=0
            hbc(2)=1
            hbc(3)=0
            hbc(4)=1
            hbc(5)=0
            hbc(6)=1
          else
            hbc(1)=0
            hbc(2)=0
            hbc(3)=0
            hbc(4)=0
            hbc(5)=0
            hbc(6)=0
          end if
c  if all rotations fixed in 1st slice of quarter model, then half model
c  node is not part of a shell and all rotations can be fixed
          if(qbc(i,4).eq.1.and.qbc(i,5).eq.1.and.qbc(i,6).eq.1)then
            hbc(4)=1
            hbc(5)=1
            hbc(6)=1
          end if
          if(hcoor(3).eq.405.)then
            hcoor(3)=384.5
            imov=imov+1
          end if
          write(41,30)nnod,(hbc(k),k=1,6),(hcoor(k),k=1,3)
          nnod=nnod+1
  200   end do
      end do
c ***********************************
      write(44,55) (i,i=1,10)
   55 format(4x,'slice',10i7)
      do i=1,350
        write(44,60) qn(i),(node(qn(i),j),j=1,10)
   60   format(i5,5x,10i7)
      end do
c ***********************************
c  read data for excavation elements
      do i=1,ne1
        read(31,10) qe1(i),(solcon(i,j),j=1,8),iord(i),
     &    mt1(i)
   10   format(10i5,5x,i5)
      end do
c  read data for remaining soil elements
      do i=ne1+1,ne1+ne2
        read(32,10) qe1(i),(solcon(i,j),j=1,8),iord(i),
     &     mt1(i)
      end do
c  read data for triangular shell elements
      do i=1,ne3
        read(33,20) qe2(i),(shlcon(i,j),j=1,4),mt2(i),
```

```
     &    thk(i)
  20   format(5i5,5x,i5,5x,f10.4)
        end do
c  read data for quad shell elements
        do i=ne3+1,ne3+ne4
          read(34,20) qe2(i),(shlcon(i,j),j=1,4),mt2(i),
     &    thk(i)
        end do
c ************************************************
c  generate excavation elements
        nel=1
        etyp=-1
        do j=1,10
          do i=1,ne1
            n1=node(solcon(i,1),j)
            n2=node(solcon(i,2),j)
            n3=node(solcon(i,3),j)
            n4=node(solcon(i,4),j)
            n5=node(solcon(i,5),j)
            n6=node(solcon(i,6),j)
            n7=node(solcon(i,7),j)
            n8=node(solcon(i,8),j)
            write(42,40) nel,n1,n2,n3,n4,n5,n6,n7,n8,iord(i),etyp,mt1(i)
  40        format(12i5)
            nel=nel+1
          end do
        end do
c  generate remaining soil elements
        etyp=1
        do j=1,10
          do i=ne1+1,ne1+ne2
            n1=node(solcon(i,1),j)
            n2=node(solcon(i,2),j)
            n3=node(solcon(i,3),j)
            n4=node(solcon(i,4),j)
            n5=node(solcon(i,5),j)
            n6=node(solcon(i,6),j)
            n7=node(solcon(i,7),j)
            n8=node(solcon(i,8),j)
            write(42,40) nel,n1,n2,n3,n4,n5,n6,n7,n8,iord(i),etyp,mt1(i)
            nel=nel+1
          end do
        end do
c ************************************************
c  generate tank shell elements
        nel=1
c  triangles
        do j=1,10
          do i=1,ne3
            n1=node(shlcon(i,1),j)
            n2=node(shlcon(i,2),j)
            n3=node(shlcon(i,3),j)
            write(43,50) nel,n1,n2,n3,mt2(i),thk(i)
  50        format(4i5,10x,i5,5x,f10.4)
            nel=nel+1
          end do
        end do
c  quads
        do j=1,10
          do i=ne3+1,ne3+ne4
            n1=node(shlcon(i,1),j)
            n2=node(shlcon(i,2),j)
            n3=node(shlcon(i,3),j)
            n4=node(shlcon(i,4),j)
            write(43,70) nel,n1,n2,n3,n4,mt2(i),thk(i)
  70        format(5i5,5x,i5,5x,f10.4)
            nel=nel+1
          end do
        end do
c  write interation node numbers to node.out
```

```
      nl=1053/16 + 1
      do i=1,nl
        ii=(i-1)*16
        write(41,999) (ii+jj,jj=1,16)
  999   format(16i5)
      end do
      write(*,*)imov
      stop
      end
```

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************ n1.in ***************

1	0	1	1	1	1	1	0.00	0.00	-24.00
2	0	0	0	1	1	1	-68.00	22.09	-24.00
3	0	1	0	1	1	1	-71.50	0.00	-24.00
4	0	0	0	1	1	1	-136.00	44.19	-24.00
5	0	0	0	1	1	1	-141.24	22.37	-24.00
6	0	1	0	1	1	1	-143.00	0.00	-24.00
7	0	0	0	1	1	1	-219.69	71.38	-24.00
8	0	0	0	1	1	1	-228.16	36.14	-24.00
9	0	1	0	1	1	1	-231.00	0.00	-24.00
10	0	0	0	1	1	1	-303.39	98.58	-24.00
11	0	0	0	1	1	1	-315.07	49.90	-24.00
12	0	1	0	1	1	1	-319.00	0.00	-24.00
13	0	0	0	1	1	1	-392.79	127.62	-24.00
14	0	0	0	1	1	1	-407.92	64.61	-24.00
15	0	1	0	1	1	1	-413.00	0.00	-24.00
16	0	0	0	1	1	1	-482.19	156.67	-24.00
17	0	0	0	1	1	1	-500.76	79.31	-24.00
18	0	1	0	1	1	1	-507.00	0.00	-24.00
19	0	1	1	1	1	1	0.00	0.00	39.00
20	0	0	0	1	1	1	-68.00	22.09	39.00
21	0	1	0	1	1	1	-71.50	0.00	39.00
22	0	0	0	1	1	1	-136.00	44.19	39.00
23	0	0	0	1	1	1	-141.24	22.37	39.00
24	0	1	0	1	1	1	-143.00	0.00	39.00
25	0	0	0	1	1	1	-219.69	71.38	39.00
26	0	0	0	1	1	1	-228.16	36.14	39.00
27	0	1	0	1	1	1	-231.00	0.00	39.00
28	0	0	0	1	1	1	-303.39	98.58	39.00
29	0	0	0	1	1	1	-315.07	49.90	39.00
30	0	1	0	1	1	1	-319.00	0.00	39.00
31	0	0	0	1	1	1	-392.79	127.62	39.00
32	0	0	0	1	1	1	-407.92	64.61	39.00
33	0	1	0	1	1	1	-413.00	0.00	39.00
34	0	0	0	1	1	1	-482.19	156.67	39.00
35	0	0	0	1	1	1	-500.76	79.31	39.00
36	0	1	0	1	1	1	-507.00	0.00	39.00
37	0	1	1	1	1	1	0.00	0.00	68.00
38	0	0	0	1	1	1	-68.00	22.09	68.00
39	0	1	0	1	1	1	-71.50	0.00	68.00
40	0	0	0	1	1	1	-136.00	44.19	68.00
41	0	0	0	1	1	1	-141.24	22.37	68.00
42	0	1	0	1	1	1	-143.00	0.00	68.00
43	0	0	0	1	1	1	-219.69	71.38	68.00
44	0	0	0	1	1	1	-228.16	36.14	68.00
45	0	1	0	1	1	1	-231.00	0.00	68.00
46	0	0	0	1	1	1	-303.39	98.58	68.00
47	0	0	0	1	1	1	-315.07	49.90	68.00
48	0	1	0	1	1	1	-319.00	0.00	68.00
49	0	0	0	1	1	1	-392.79	127.62	68.00
50	0	0	0	1	1	1	-407.92	64.61	68.00
51	0	1	0	1	1	1	-413.00	0.00	68.00
52	0	0	0	1	1	1	-482.19	156.67	68.00
53	0	0	0	1	1	1	-500.76	79.31	68.00
54	0	1	0	1	1	1	-507.00	0.00	68.00
55	0	1	1	1	1	1	0.00	0.00	124.00
56	0	0	0	1	1	1	-68.00	22.09	124.00
57	0	1	0	1	1	1	-71.50	0.00	124.00
58	0	0	0	1	1	1	-136.00	44.19	124.00
59	0	0	0	1	1	1	-141.24	22.37	124.00
60	0	1	0	1	1	1	-143.00	0.00	124.00
61	0	0	0	1	1	1	-219.69	71.38	124.00
62	0	0	0	1	1	1	-228.16	36.14	124.00
63	0	1	0	1	1	1	-231.00	0.00	124.00
64	0	0	0	1	1	1	-303.39	98.58	124.00
65	0	0	0	1	1	1	-315.07	49.90	124.00
66	0	1	0	1	1	1	-319.00	0.00	124.00
67	0	0	0	1	1	1	-392.79	127.62	124.00
68	0	0	0	1	1	1	-407.92	64.61	124.00
69	0	1	0	1	1	1	-413.00	0.00	124.00

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70	0	0	0	1	1	1	-482.19	156.67	124.00
71	0	0	0	1	1	1	-500.76	79.31	124.00
72	0	1	0	1	1	1	-507.00	0.00	124.00
73	0	1	1	1	1	1	0.00	0.00	180.00
74	0	0	0	1	1	1	-68.00	22.09	180.00
75	0	1	0	1	1	1	-71.50	0.00	180.00
76	0	0	0	1	1	1	-136.00	44.19	180.00
77	0	0	0	1	1	1	-141.24	22.37	180.00
78	0	1	0	1	1	1	-143.00	0.00	180.00
79	0	0	0	1	1	1	-219.69	71.38	180.00
80	0	0	0	1	1	1	-228.16	36.14	180.00
81	0	1	0	1	1	1	-231.00	0.00	180.00
82	0	0	0	1	1	1	-303.39	98.58	180.00
83	0	0	0	1	1	1	-315.07	49.90	180.00
84	0	1	0	1	1	1	-319.00	0.00	180.00
85	0	0	0	1	1	1	-392.79	127.62	180.00
86	0	0	0	1	1	1	-407.92	64.61	180.00
87	0	1	0	1	1	1	-413.00	0.00	180.00
88	0	0	0	1	1	1	-482.19	156.67	180.00
89	0	0	0	1	1	1	-500.76	79.31	180.00
90	0	1	0	1	1	1	-507.00	0.00	180.00
91	0	1	1	1	1	1	0.00	0.00	236.00
92	0	0	0	1	1	1	-68.00	22.09	236.00
93	0	1	0	1	1	1	-71.50	0.00	236.00
94	0	0	0	1	1	1	-136.00	44.19	236.00
95	0	0	0	1	1	1	-141.24	22.37	236.00
96	0	1	0	1	1	1	-143.00	0.00	236.00
97	0	0	0	1	1	1	-219.69	71.38	236.00
98	0	0	0	1	1	1	-228.16	36.14	236.00
99	0	1	0	1	1	1	-231.00	0.00	236.00
100	0	0	0	1	1	1	-303.39	98.58	236.00
101	0	0	0	1	1	1	-315.07	49.90	236.00
102	0	1	0	1	1	1	-319.00	0.00	236.00
103	0	0	0	1	1	1	-392.79	127.62	236.00
104	0	0	0	1	1	1	-407.92	64.61	236.00
105	0	1	0	1	1	1	-413.00	0.00	236.00
106	0	0	0	1	1	1	-482.19	156.67	236.00
107	0	0	0	1	1	1	-500.76	79.31	236.00
108	0	1	0	1	1	1	-507.00	0.00	236.00
109	0	1	1	1	1	1	0.00	0.00	307.00
110	0	0	0	1	1	1	-68.00	22.09	307.00
111	0	1	0	1	1	1	-71.50	0.00	307.00
112	0	0	0	1	1	1	-136.00	44.19	307.00
113	0	0	0	1	1	1	-141.24	22.37	307.00
114	0	1	0	1	1	1	-143.00	0.00	307.00
115	0	0	0	1	1	1	-219.69	71.38	307.00
116	0	0	0	1	1	1	-228.16	36.14	307.00
117	0	1	0	1	1	1	-231.00	0.00	307.00
118	0	0	0	1	1	1	-303.39	98.58	307.00
119	0	0	0	1	1	1	-315.07	49.90	307.00
120	0	1	0	1	1	1	-319.00	0.00	307.00
121	0	0	0	1	1	1	-392.79	127.62	307.00
122	0	0	0	1	1	1	-407.92	64.61	307.00
123	0	1	0	1	1	1	-413.00	0.00	307.00
124	0	0	0	1	1	1	-482.19	156.67	307.00
125	0	0	0	1	1	1	-500.76	79.31	307.00
126	0	1	0	1	1	1	-507.00	0.00	307.00
127	0	1	1	1	1	1	0.00	0.00	405.00
128	0	0	0	1	1	1	-68.00	22.09	405.00
129	0	1	0	1	1	1	-71.50	0.00	405.00
130	0	0	0	1	1	1	-136.00	44.19	405.00
131	0	0	0	1	1	1	-141.24	22.37	405.00
132	0	1	0	1	1	1	-143.00	0.00	405.00
133	0	0	0	1	1	1	-219.69	71.38	405.00
134	0	0	0	1	1	1	-228.16	36.14	405.00
135	0	1	0	1	1	1	-231.00	0.00	405.00
136	0	0	0	1	1	1	-303.39	98.58	405.00
137	0	0	0	1	1	1	-315.07	49.90	405.00
138	0	1	0	1	1	1	-319.00	0.00	405.00
139	0	0	0	1	1	1	-392.79	127.62	405.00

FILENAME : print2.fil DATE : 08-08-94 TIME : 8:43a PAGE 3
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140	0	0	0	1	1	1	-407.92	64.61	405.00
141	0	1	0	1	1	1	-413.00	0.00	405.00
142	0	0	0	1	1	1	-482.19	156.67	405.00
143	0	0	0	1	1	1	-500.76	79.31	405.00
144	0	1	0	1	1	1	-507.00	0.00	405.00
145	0	1	1	1	1	1	0.00	0.00	462.00
146	0	0	0	1	1	1	-68.00	22.09	462.00
147	0	1	0	1	1	1	-71.50	0.00	462.00
148	0	0	0	1	1	1	-136.00	44.19	462.00
149	0	0	0	1	1	1	-141.24	22.37	462.00
150	0	1	0	1	1	1	-143.00	0.00	462.00
151	0	0	0	1	1	1	-219.69	71.38	462.00
152	0	0	0	1	1	1	-228.16	36.14	462.00
153	0	1	0	1	1	1	-231.00	0.00	462.00
154	0	0	0	1	1	1	-303.39	98.58	462.00
155	0	0	0	1	1	1	-315.07	49.90	462.00
156	0	1	0	1	1	1	-319.00	0.00	462.00
157	0	0	0	1	1	1	-392.79	127.62	462.00
158	0	0	0	1	1	1	-407.92	64.61	462.00
159	0	1	0	1	1	1	-413.00	0.00	462.00
160	0	0	0	1	1	1	-482.19	156.67	462.00
161	0	0	0	1	1	1	-500.76	79.31	462.00
162	0	1	0	1	1	1	-507.00	0.00	462.00

FILENAME : print2.fil DATE : 08-08-94 TIME : 8:43a PAGE 4
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******************* n2.in *******************

559	0	1	1	1	0	1	0.00	0.00	4.00
560	0	0	0	0	0	0	-34.00	11.05	4.25
561	0	1	0	1	0	1	-35.75	0.00	4.25
562	0	0	0	0	0	0	-68.00	22.09	4.50
563	0	0	0	0	0	0	-70.62	11.19	4.50
564	0	1	0	1	0	1	-71.50	0.00	4.50
565	0	0	0	0	0	0	-102.00	33.14	4.75
566	0	0	0	0	0	0	-104.91	22.30	4.75
567	0	0	0	0	0	0	-106.66	11.21	4.75
568	0	1	0	1	0	1	-107.25	0.00	4.75
569	0	0	0	0	0	0	-136.00	44.19	5.00
570	0	0	0	0	0	0	-139.05	33.38	5.00
571	0	0	0	0	0	0	-141.24	22.37	5.00
572	0	0	0	0	0	0	-142.56	11.22	5.00
573	0	1	0	1	0	1	-143.00	0.00	5.00
574	0	0	0	0	0	0	-177.85	57.79	6.83
575	0	0	0	0	0	0	-181.83	43.65	6.83
576	0	0	0	0	0	0	-184.70	29.25	6.83
577	0	0	0	0	0	0	-186.42	14.67	6.83
578	0	1	0	1	0	1	-187.00	0.00	6.83
579	0	0	0	0	0	0	-219.69	71.38	8.67
580	0	0	0	0	0	0	-224.62	53.93	8.67
581	0	0	0	0	0	0	-228.16	36.14	8.67
582	0	0	0	0	0	0	-230.29	18.12	8.67
583	0	1	0	1	0	1	-231.00	0.00	8.67
584	0	0	0	0	0	0	-261.54	84.98	10.50
585	0	0	0	0	0	0	-267.40	64.20	10.50
586	0	0	0	0	0	0	-271.61	43.02	10.50
587	0	0	0	0	0	0	-274.15	21.58	10.50
588	0	1	0	1	0	1	-275.00	0.00	10.50
589	0	0	0	0	0	0	-303.39	98.58	12.33
590	0	0	0	0	0	0	-310.19	74.47	12.33
591	0	0	0	0	0	0	-315.07	49.90	12.33
592	0	0	0	0	0	0	-318.02	25.03	12.33
593	0	1	0	1	0	1	-319.00	0.00	12.33
594	0	0	0	0	0	0	-345.23	112.17	14.17
595	0	0	0	0	0	0	-352.97	84.74	14.17
596	0	0	0	0	0	0	-358.53	56.79	14.17
597	0	0	0	0	0	0	-361.88	28.48	14.17
598	0	1	0	1	0	1	-363.00	0.00	14.17
599	0	0	0	0	0	0	-387.08	125.77	16.00
600	0	0	0	0	0	0	-395.75	95.01	16.00
601	0	0	0	0	0	0	-401.99	63.67	16.00
602	0	0	0	0	0	0	-405.75	31.93	16.00
603	0	1	0	1	0	1	-407.00	0.00	16.00
604	0	0	0	0	0	0	-434.63	141.22	24.00
605	0	0	0	0	0	0	-444.37	106.68	24.00
606	0	0	0	0	0	0	-451.37	71.49	24.00
607	0	0	0	0	0	0	-455.59	35.86	24.00
608	0	1	0	1	0	1	-457.00	0.00	24.00
609	0	0	0	0	0	0	-434.63	141.22	50.80
610	0	0	0	0	0	0	-444.37	106.68	50.80
611	0	0	0	0	0	0	-451.37	71.49	50.80
612	0	0	0	0	0	0	-455.59	35.86	50.80
613	0	1	0	1	0	1	-457.00	0.00	50.80
614	0	0	0	0	0	0	-434.63	141.22	68.00
615	0	0	0	0	0	0	-444.37	106.68	68.00
616	0	0	0	0	0	0	-451.37	71.49	68.00
617	0	0	0	0	0	0	-455.59	35.86	68.00
618	0	1	0	1	0	1	-457.00	0.00	68.00
619	0	0	0	0	0	0	-434.63	141.22	96.00
620	0	0	0	0	0	0	-444.37	106.68	96.00
621	0	0	0	0	0	0	-451.37	71.49	96.00
622	0	0	0	0	0	0	-455.59	35.86	96.00
623	0	1	0	1	0	1	-457.00	0.00	96.00
624	0	0	0	0	0	0	-434.63	141.22	124.00
625	0	0	0	0	0	0	-444.37	106.68	124.00
626	0	0	0	0	0	0	-451.37	71.49	124.00
627	0	0	0	0	0	0	-455.59	35.86	124.00

FILENAME : print2.fil DATE : 08-08-94 TIME : 8:43a PAGE 5
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628	0	1	0	1	0	1	-457.00	0.00	124.00
629	0	0	0	0	0	0	-434.63	141.22	152.00
630	0	0	0	0	0	0	-444.37	106.68	152.00
631	0	0	0	0	0	0	-451.37	71.49	152.00
632	0	0	0	0	0	0	-455.59	35.86	152.00
633	0	1	0	1	0	1	-457.00	0.00	152.00
634	0	0	0	0	0	0	-434.63	141.22	180.00
635	0	0	0	0	0	0	-444.37	106.68	180.00
636	0	0	0	0	0	0	-451.37	71.49	180.00
637	0	0	0	0	0	0	-455.59	35.86	180.00
638	0	1	0	1	0	1	-457.00	0.00	180.00
639	0	0	0	0	0	0	-434.63	141.22	208.00
640	0	0	0	0	0	0	-444.37	106.68	208.00
641	0	0	0	0	0	0	-451.37	71.49	208.00
642	0	0	0	0	0	0	-455.59	35.86	208.00
643	0	1	0	1	0	1	-457.00	0.00	208.00
644	0	0	0	0	0	0	-434.63	141.22	236.00
645	0	0	0	0	0	0	-444.37	106.68	236.00
646	0	0	0	0	0	0	-451.37	71.49	236.00
647	0	0	0	0	0	0	-455.59	35.86	236.00
648	0	1	0	1	0	1	-457.00	0.00	236.00
649	0	0	0	0	0	0	-432.64	140.57	259.80
650	0	0	0	0	0	0	-442.33	106.19	259.80
651	0	0	0	0	0	0	-449.30	71.16	259.80
652	0	0	0	0	0	0	-453.50	35.69	259.80
653	0	1	0	1	0	1	-454.90	0.00	259.80
654	0	0	0	0	0	0	-425.60	138.29	282.50
655	0	0	0	0	0	0	-435.14	104.47	282.50
656	0	0	0	0	0	0	-441.99	70.00	282.50
657	0	0	0	0	0	0	-446.12	35.11	282.50
658	0	1	0	1	0	1	-447.50	0.00	282.50
659	0	0	0	0	0	0	-404.58	131.46	294.20
660	0	0	0	0	0	0	-413.65	99.31	294.20
661	0	0	0	0	0	0	-420.16	66.55	294.20
662	0	0	0	0	0	0	-424.09	33.38	294.20
663	0	1	0	1	0	1	-425.40	0.00	294.20
664	0	0	0	0	0	0	-375.67	122.06	307.80
665	0	0	0	0	0	0	-384.09	92.21	307.80
666	0	0	0	0	0	0	-390.14	61.79	307.80
667	0	0	0	0	0	0	-393.78	30.99	307.80
668	0	1	0	1	0	1	-395.00	0.00	307.80
669	0	0	0	0	0	0	-348.47	113.22	319.70
670	0	0	0	0	0	0	-356.28	85.53	319.70
671	0	0	0	0	0	0	-361.89	57.32	319.70
672	0	0	0	0	0	0	-365.27	28.75	319.70
673	0	1	0	1	0	1	-366.40	0.00	319.70
674	0	0	0	0	0	0	-320.98	104.29	331.00
675	0	0	0	0	0	0	-328.17	78.79	331.00
676	0	0	0	0	0	0	-333.34	52.80	331.00
677	0	0	0	0	0	0	-336.46	26.48	331.00
678	0	1	0	1	0	1	-337.50	0.00	331.00
679	0	0	0	0	0	0	-284.65	92.49	344.70
680	0	0	0	0	0	0	-291.03	69.87	344.70
681	0	0	0	0	0	0	-295.62	46.82	344.70
682	0	0	0	0	0	0	-298.38	23.48	344.70
683	0	1	0	1	0	1	-299.30	0.00	344.70
684	0	0	0	0	0	0	-247.66	80.47	356.40
685	0	0	0	0	0	0	-253.21	60.79	356.40
686	0	0	0	0	0	0	-257.19	40.74	356.40
687	0	0	0	0	0	0	-259.60	20.43	356.40
688	0	1	0	1	0	1	-260.40	0.00	356.40
689	0	0	0	0	0	0	-210.09	68.26	366.00
690	0	0	0	0	0	0	-214.80	51.57	366.00
691	0	0	0	0	0	0	-218.18	34.56	366.00
692	0	0	0	0	0	0	-220.22	17.33	366.00
693	0	1	0	1	0	1	-220.90	0.00	366.00
694	0	0	0	0	0	0	-172.14	55.93	373.50
695	0	0	0	0	0	0	-176.00	42.25	373.50
696	0	0	0	0	0	0	-178.77	28.31	373.50
697	0	0	0	0	0	0	-180.44	14.20	373.50

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698	0	1	0	1	0	1	-181.00	0.00	373.50
699	0	0	0	0	0	0	-129.34	42.03	379.70
700	0	0	0	0	0	0	-133.03	28.28	379.70
701	0	0	0	0	0	0	-135.26	14.22	379.70
702	0	1	0	1	0	1	-136.00	0.00	379.70
703	0	0	0	0	0	0	-86.36	28.06	384.10
704	0	0	0	0	0	0	-89.68	14.20	384.10
705	0	1	0	1	0	1	-90.80	0.00	384.10
706	0	0	0	0	0	0	-43.18	14.03	386.70
707	0	1	0	1	0	1	-45.40	0.00	386.70
708	0	1	1	1	0	1	0.00	0.00	387.50
709	0	0	0	0	0	0	-463.16	150.49	24.00
710	0	0	0	0	0	0	-473.54	113.69	24.00
711	0	0	0	0	0	0	-481.00	76.18	24.00
712	0	0	0	0	0	0	-485.50	38.21	24.00
713	0	1	0	1	0	1	-487.00	0.00	24.00
714	0	0	0	1	1	1	-375.67	122.06	347.00
715	0	0	0	1	1	1	-390.14	61.79	347.00
716	0	1	0	1	1	1	-395.00	0.00	347.00
717	0	0	0	1	1	1	-320.98	104.29	371.00
718	0	0	0	1	1	1	-333.34	52.80	371.00
719	0	1	0	1	1	1	-337.50	0.00	371.00
720	0	0	0	1	1	1	-246.56	80.11	396.00
721	0	0	0	1	1	1	-256.06	40.56	396.00
722	0	1	0	1	1	1	-259.25	0.00	396.00
723	0	0	0	1	1	1	-172.14	55.93	407.00
724	0	0	0	1	1	1	-178.77	28.31	407.00
725	0	1	0	1	1	1	-181.00	0.00	407.00
726	0	0	0	1	1	1	-86.07	27.97	407.00
727	0	1	0	1	1	1	-90.50	0.00	407.00
728	0	1	1	1	1	1	0.00	0.00	407.00
729	0	1	1	1	1	1	0.00	0.00	462.00
730	0	0	0	1	1	1	-86.36	28.06	462.00
731	0	1	0	1	1	1	-90.80	0.00	462.00
732	0	0	0	1	1	1	-172.14	55.93	462.00
733	0	0	0	1	1	1	-178.77	28.31	462.00
734	0	1	0	1	1	1	-181.00	0.00	462.00
735	0	0	0	1	1	1	-247.66	80.47	462.00
736	0	0	0	1	1	1	-257.19	40.74	462.00
737	0	1	0	1	1	1	-260.40	0.00	462.00
738	0	0	0	1	1	1	-320.98	104.29	462.00
739	0	0	0	1	1	1	-333.34	52.80	462.00
740	0	1	0	1	1	1	-337.50	0.00	462.00
741	0	0	0	1	1	1	-375.67	122.06	420.00
742	0	0	0	1	1	1	-390.14	61.79	420.00
743	0	1	0	1	1	1	-395.00	0.00	420.00
744	0	0	0	1	1	1	-375.67	122.06	462.00
745	0	0	0	1	1	1	-390.14	61.79	462.00
746	0	1	0	1	1	1	-395.00	0.00	462.00

TITLE : Input files for MGEN.for

**************** e1.in ****************

1	1	2	3	3	19	20	21	21	4	-1	8
2	19	20	21	21	37	38	39	39	4	-1	7
3	37	38	39	39	55	56	57	57	4	-1	6
4	55	56	57	57	73	74	75	75	4	-1	5
5	73	74	75	75	91	92	93	93	4	-1	4
6	91	92	93	93	109	110	111	111	4	-1	3
7	109	110	111	111	127	128	129	129	4	-1	2
8	127	128	129	129	145	146	147	147	4	-1	1
9	3	5	6	6	21	23	24	24	4	-1	8
10	21	23	24	24	39	41	42	42	4	-1	7
11	39	41	42	42	57	59	60	60	4	-1	6
12	57	59	60	60	75	77	78	78	4	-1	5
13	75	77	78	78	93	95	96	96	4	-1	4
14	93	95	96	96	111	113	114	114	4	-1	3
15	111	113	114	114	129	131	132	132	4	-1	2
16	129	131	132	132	147	149	150	150	4	-1	1
17	3	2	5	5	21	20	23	23	4	-1	8
18	21	20	23	23	39	38	41	41	4	-1	7
19	39	38	41	41	57	56	59	59	4	-1	6
20	57	56	59	59	75	74	77	77	4	-1	5
21	75	74	77	77	93	92	95	95	4	-1	4
22	93	92	95	95	111	110	113	113	4	-1	3
23	111	110	113	113	129	128	131	131	4	-1	2
24	129	128	131	131	147	146	149	149	4	-1	1
25	2	4	5	5	20	22	23	23	4	-1	8
26	20	22	23	23	38	40	41	41	4	-1	7
27	38	40	41	41	56	58	59	59	4	-1	6
28	56	58	59	59	74	76	77	77	4	-1	5
29	74	76	77	77	92	94	95	95	4	-1	4
30	92	94	95	95	110	112	113	113	4	-1	3
31	110	112	113	113	128	130	131	131	4	-1	2
32	128	130	131	131	146	148	149	149	4	-1	1
33	5	8	9	6	23	26	27	24	3	-1	8
34	23	26	27	24	41	44	45	42	3	-1	7
35	41	44	45	42	59	62	63	60	3	-1	6
36	59	62	63	60	77	80	81	78	3	-1	5
37	77	80	81	78	95	98	99	96	3	-1	4
38	95	98	99	96	113	116	117	114	3	-1	3
39	113	116	117	114	131	134	135	132	3	-1	2
40	131	134	135	132	149	152	153	150	3	-1	1
41	4	7	8	5	22	25	26	23	3	-1	8
42	22	25	26	23	40	43	44	41	3	-1	7
43	40	43	44	41	58	61	62	59	3	-1	6
44	58	61	62	59	76	79	80	77	3	-1	5
45	76	79	80	77	94	97	98	95	3	-1	4
46	94	97	98	95	112	115	116	113	3	-1	3
47	112	115	116	113	130	133	134	131	3	-1	2
48	130	133	134	131	148	151	152	149	3	-1	1
49	8	11	12	9	26	29	30	27	3	-1	8
50	26	29	30	27	44	47	48	45	3	-1	7
51	44	47	48	45	62	65	66	63	3	-1	6
52	62	65	66	63	80	83	84	81	3	-1	5
53	80	83	84	81	98	101	102	99	3	-1	4
54	98	101	102	99	116	119	120	117	3	-1	3
55	116	119	120	117	134	137	138	135	3	-1	2
56	134	137	138	135	152	155	156	153	3	-1	1
57	7	10	11	8	25	28	29	26	3	-1	8
58	25	28	29	26	43	46	47	44	3	-1	7
59	43	46	47	44	61	64	65	62	3	-1	6
60	61	64	65	62	79	82	83	80	3	-1	5
61	79	82	83	80	97	100	101	98	3	-1	4
62	97	100	101	98	115	118	119	116	3	-1	3
63	115	118	119	116	133	136	137	134	3	-1	2
64	133	136	137	134	151	154	155	152	3	-1	1
65	11	14	15	12	29	32	33	30	3	-1	8
66	29	32	33	30	47	50	51	48	3	-1	7
67	47	50	51	48	65	68	69	66	3	-1	6
68	65	68	69	66	83	86	87	84	3	-1	5
69	83	86	87	84	101	104	105	102	3	-1	4

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70	101	104	105	102	119	122	123	120	3	-1	3
71	119	122	123	120	137	140	141	138	3	-1	2
72	137	140	141	138	155	158	159	156	3	-1	1
73	10	13	14	11	28	31	32	29	3	-1	8
74	28	31	32	29	46	49	50	47	3	-1	7
75	46	49	50	47	64	67	68	65	3	-1	6
76	64	67	68	65	82	85	86	83	3	-1	5
77	82	85	86	83	100	103	104	101	3	-1	4
78	100	103	104	101	118	121	122	119	3	-1	3
79	118	121	122	119	136	139	140	137	3	-1	2
80	136	139	140	137	154	157	158	155	3	-1	1
81	14	17	18	15	32	35	36	33	3	-1	8
82	32	35	36	33	50	53	54	51	3	-1	7
83	50	53	54	51	68	71	72	69	3	-1	6
84	68	71	72	69	86	89	90	87	3	-1	5
85	86	89	90	87	104	107	108	105	3	-1	4
86	104	107	108	105	122	125	126	123	3	-1	3
87	122	125	126	123	140	143	144	141	3	-1	2
88	140	143	144	141	158	161	162	159	3	-1	1
89	13	16	17	14	31	34	35	32	3	-1	8
90	31	34	35	32	49	52	53	50	3	-1	7
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18	700	696	701	30	15.06
19	701	697	702	30	15.06
20	699	694	695	30	15.06
21	700	695	696	30	15.06
22	701	696	697	30	15.06
23	702	697	698	30	15.06
24	703	700	704	31	15.05
25	704	701	705	31	15.05
26	703	699	700	31	15.05
27	704	700	701	31	15.05
28	705	701	702	31	15.05
29	706	704	707	32	14.97
30	706	703	704	32	14.97
31	707	704	705	32	14.97
32	708	706	707	33	14.98

********************* e4.in *******************

161	569	570	575	574	5	5.95
162	570	571	576	575	5	5.95
163	571	572	577	576	5	5.95
164	572	573	578	577	5	5.95
165	574	575	580	579	6	5.95
166	575	576	581	580	6	5.95
167	576	577	582	581	6	5.95
168	577	578	583	582	6	5.95
169	579	580	585	584	7	5.95
170	580	581	586	585	7	5.95
171	581	582	587	586	7	5.95
172	582	583	588	587	7	5.95
173	584	585	590	589	8	5.95
174	585	586	591	590	8	5.95
175	586	587	592	591	8	5.95
176	587	588	593	592	8	5.95
177	589	590	595	594	9	5.96
178	590	591	596	595	9	5.96
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182	595	596	601	600	10	5.96
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188	602	603	608	607	11	12.75
189	604	605	610	609	12	18.24
190	605	606	611	610	12	18.24
191	606	607	612	611	12	18.24
192	607	608	613	612	12	18.24
193	609	610	615	614	13	9.85
194	610	611	616	615	13	9.85
195	611	612	617	616	13	9.85
196	612	613	618	617	13	9.85
197	614	615	620	619	14	12.03

198	615	616	621	620	14	12.03
199	616	617	622	621	14	12.03
200	617	618	623	622	14	12.03
201	619	620	625	624	15	12.02
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203	621	622	627	626	15	12.02
204	622	623	628	627	15	12.02
205	624	625	630	629	16	12.02
206	625	626	631	630	16	12.02
207	626	627	632	631	16	12.02
208	627	628	633	632	16	12.02
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216	637	638	643	642	18	12.02
217	639	640	645	644	19	12.02
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259	691	692	697	696	29	15.33
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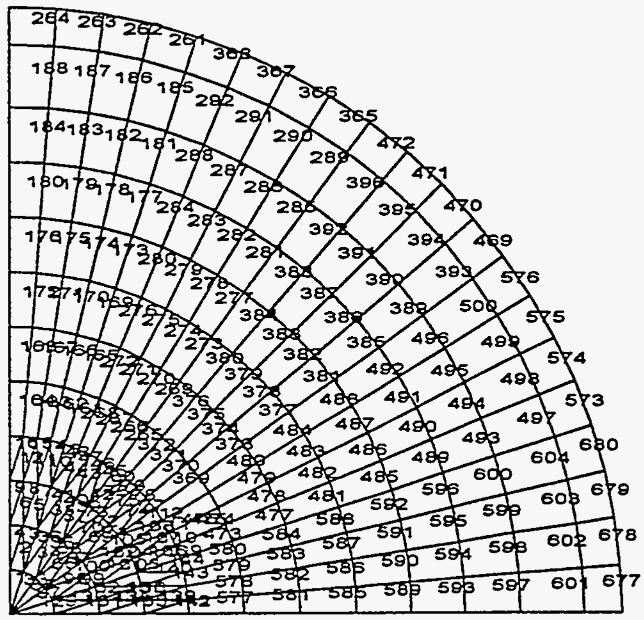
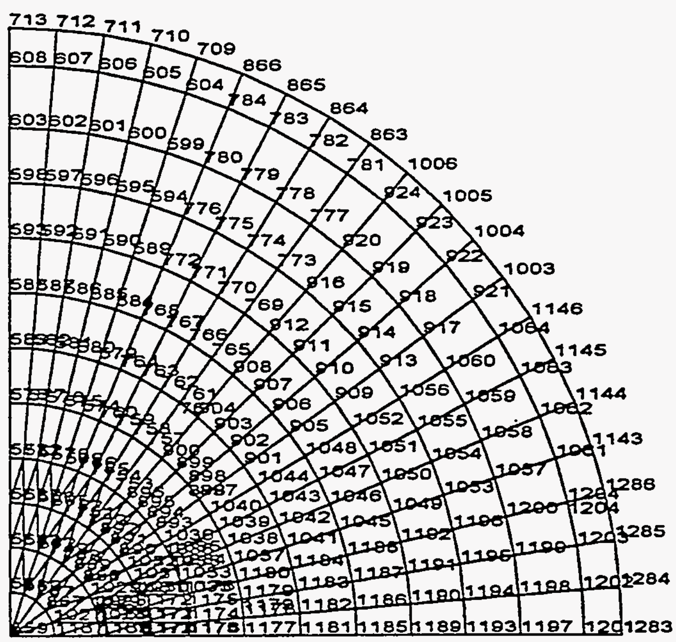
262	605	710	711	606	34	24.13
263	606	711	712	607	34	24.13
264	607	712	713	608	34	24.13

APPENDIX S

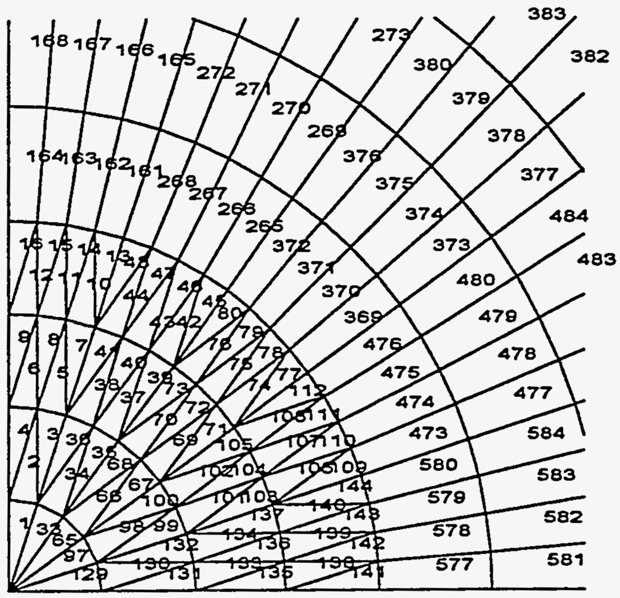
NODE AND ELEMENT NUMBERS IN TANK MESH OF BASELINE QUARTER MODEL



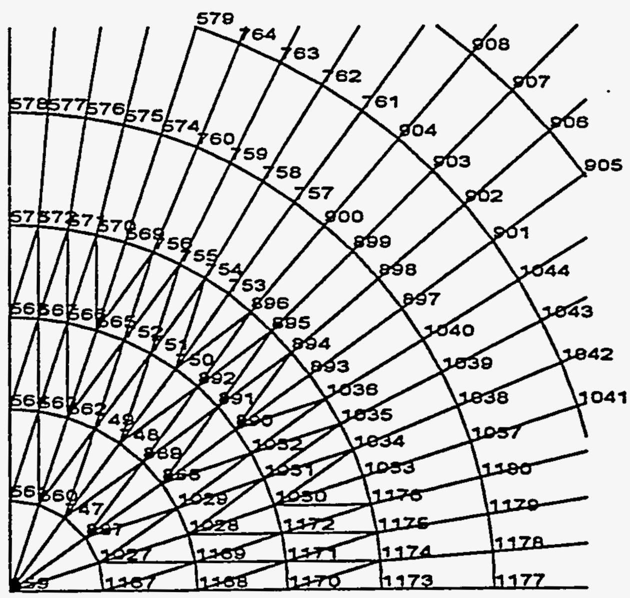
Base Elements in Baseline Quarter Model



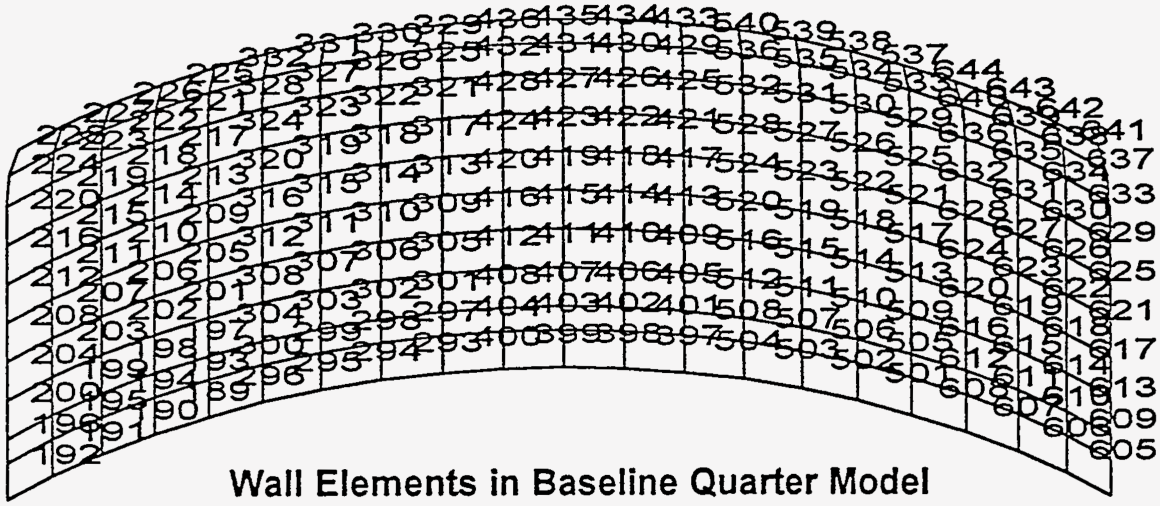
Base Nodes in Baseline Quarter Model



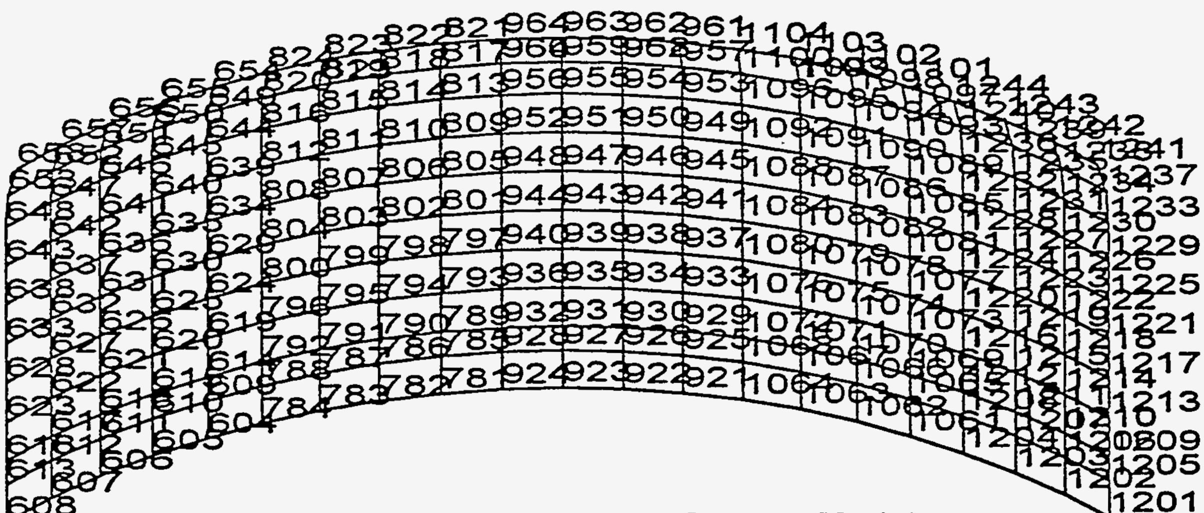
Base Elements in Baseline Quarter Model



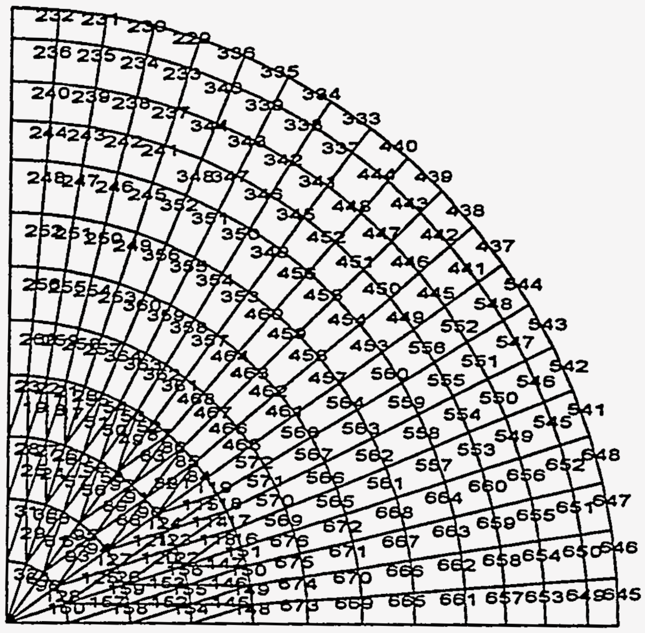
Base Nodes in Baseline Quarter Model



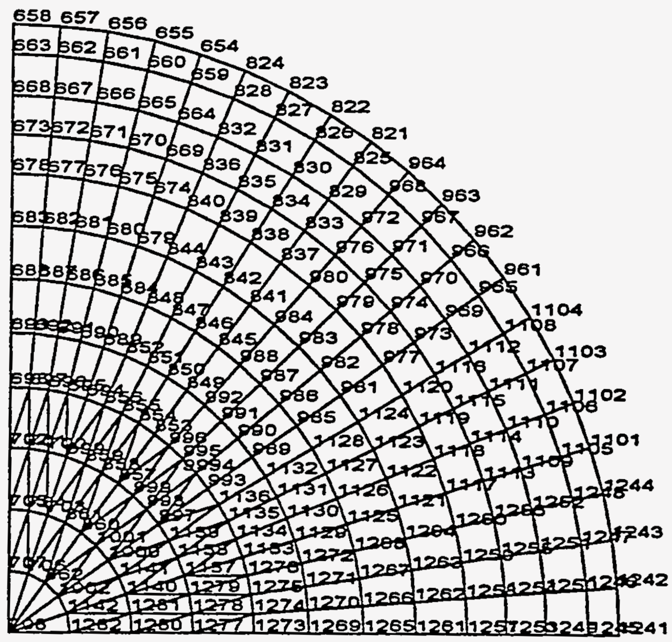
Wall Elements in Baseline Quarter Model



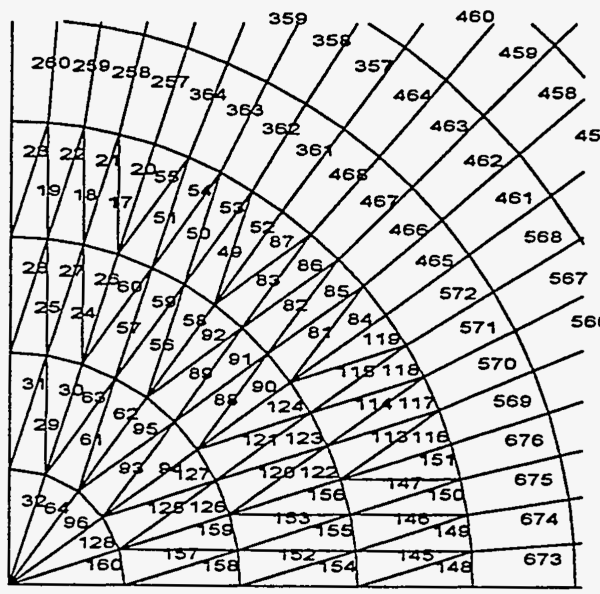
Wall Nodes in Baseline Quarter Model



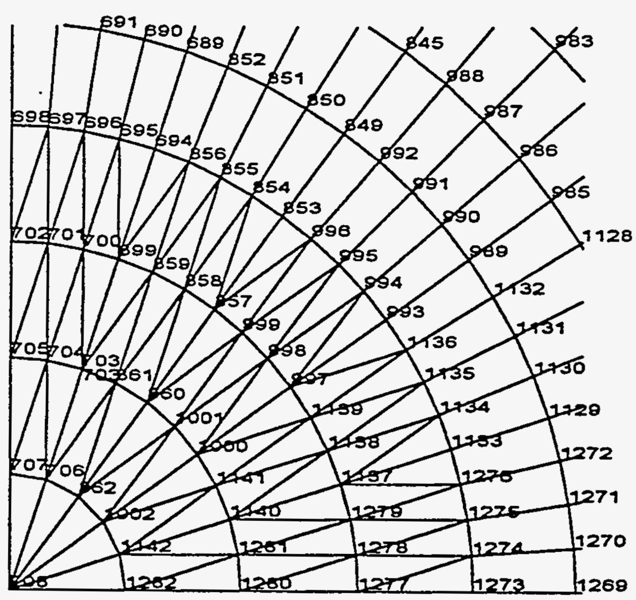
Dome Elements in Baseline Quarter Model



Dome Nodes in Baseline Quarter Model



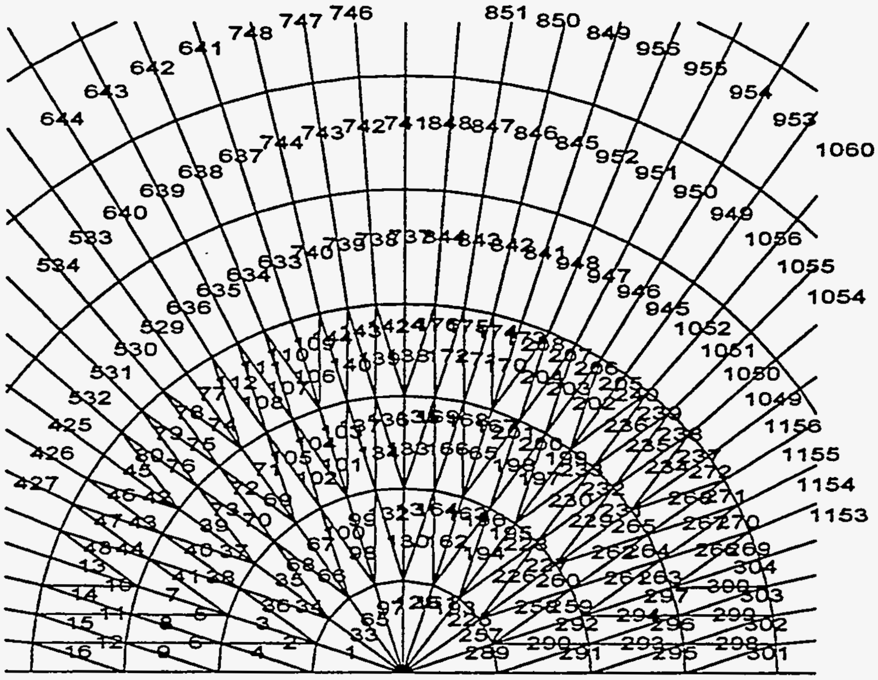
Dome Elements in Baseline Quarter Model



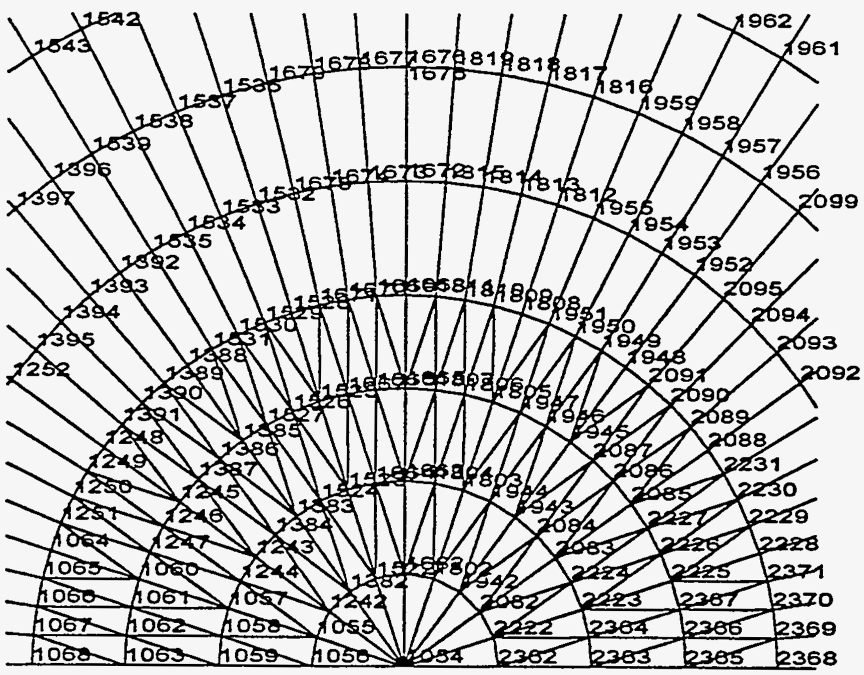
Dome Nodes in Baseline Quarter Model

APPENDIX T

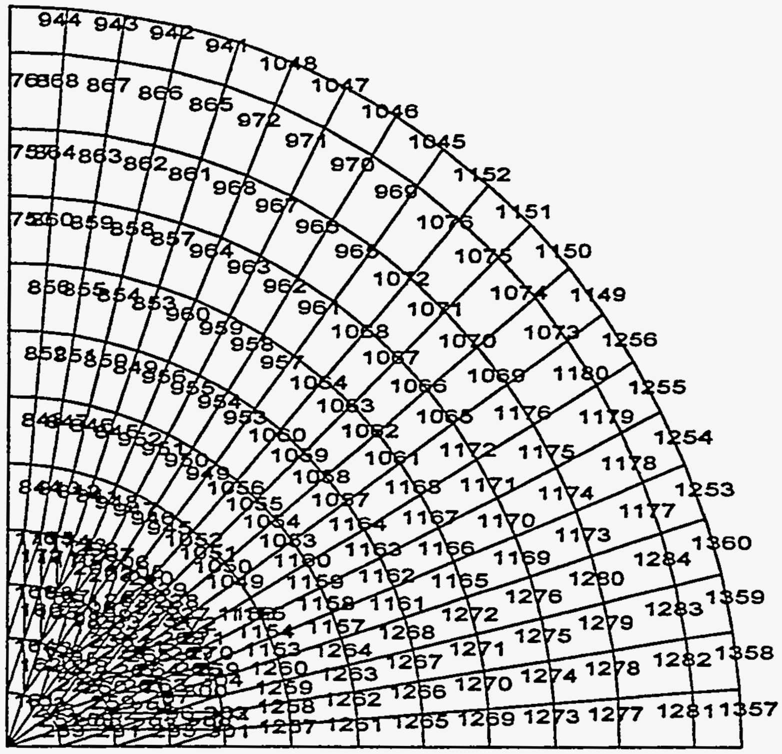
NODE AND ELEMENT NUMBERS IN TANK MESH OF TTI HALF MODEL



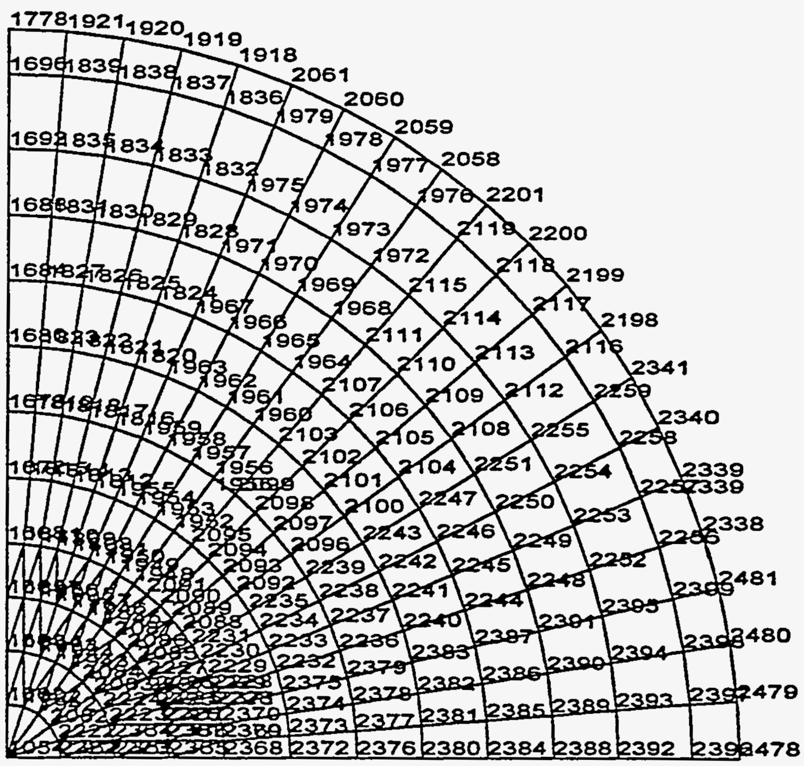
Base Elements in TTI Half Model



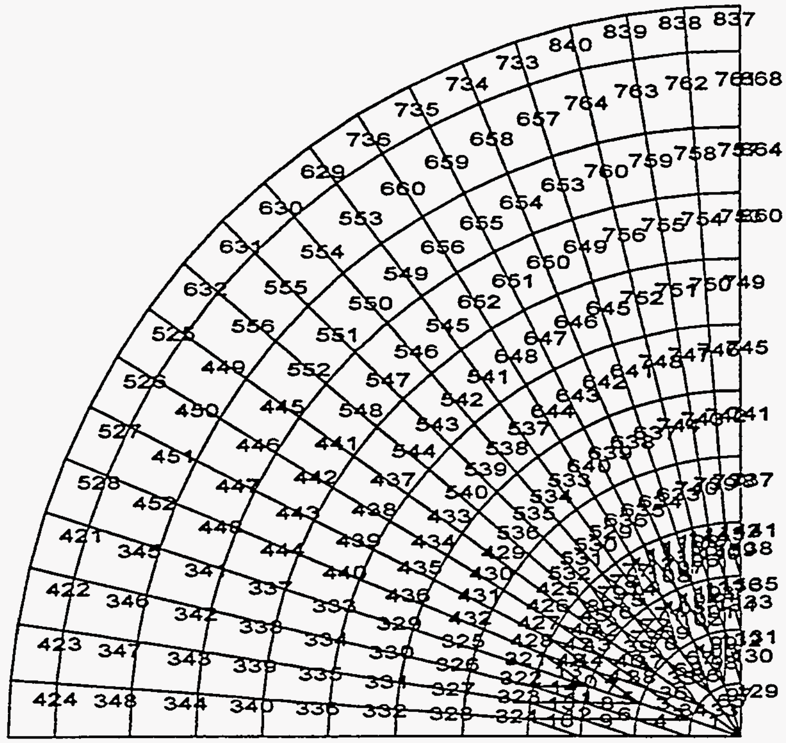
Base Nodes in TTI Half Model



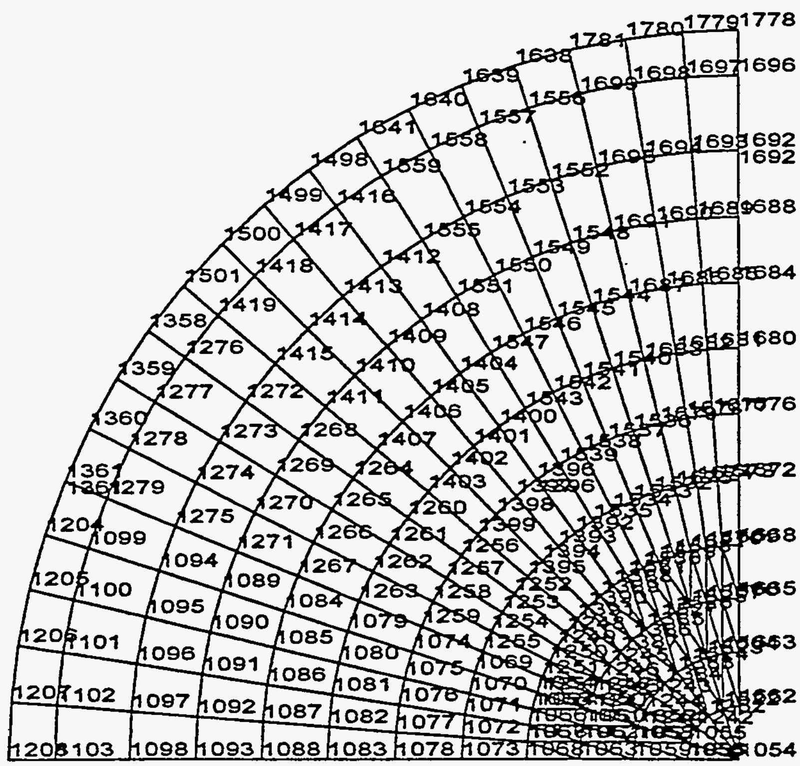
Base Elements in TTI Half Model (0 to 90 deg)



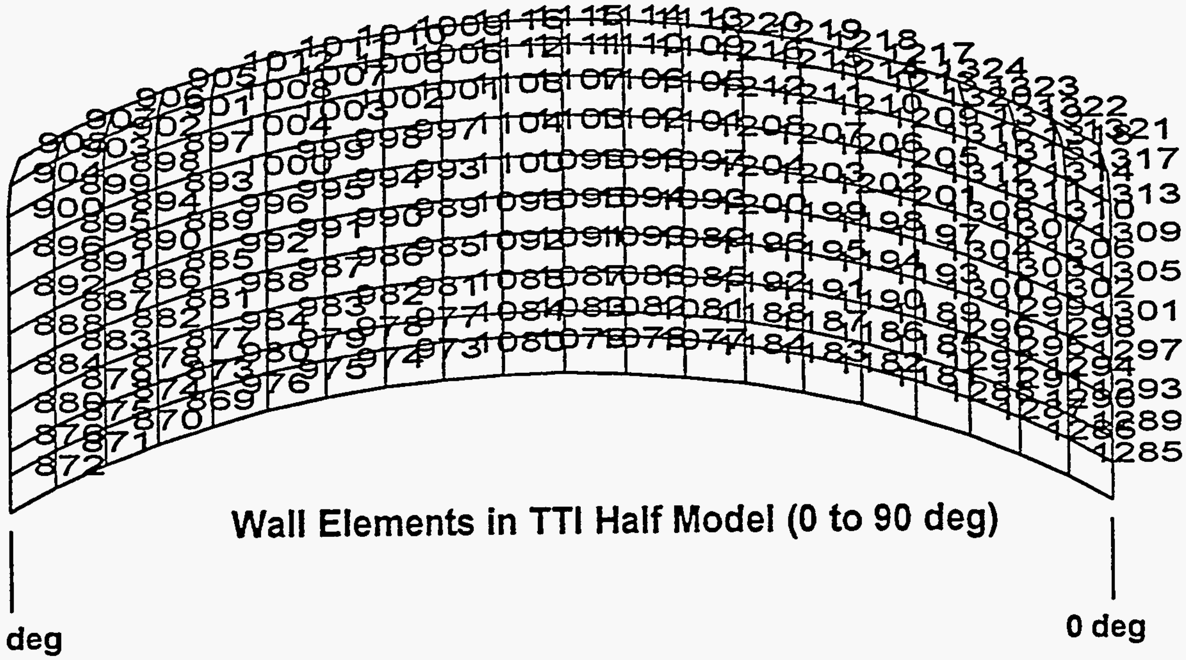
Base Nodes in TTI Half Model (0 to 90 deg)



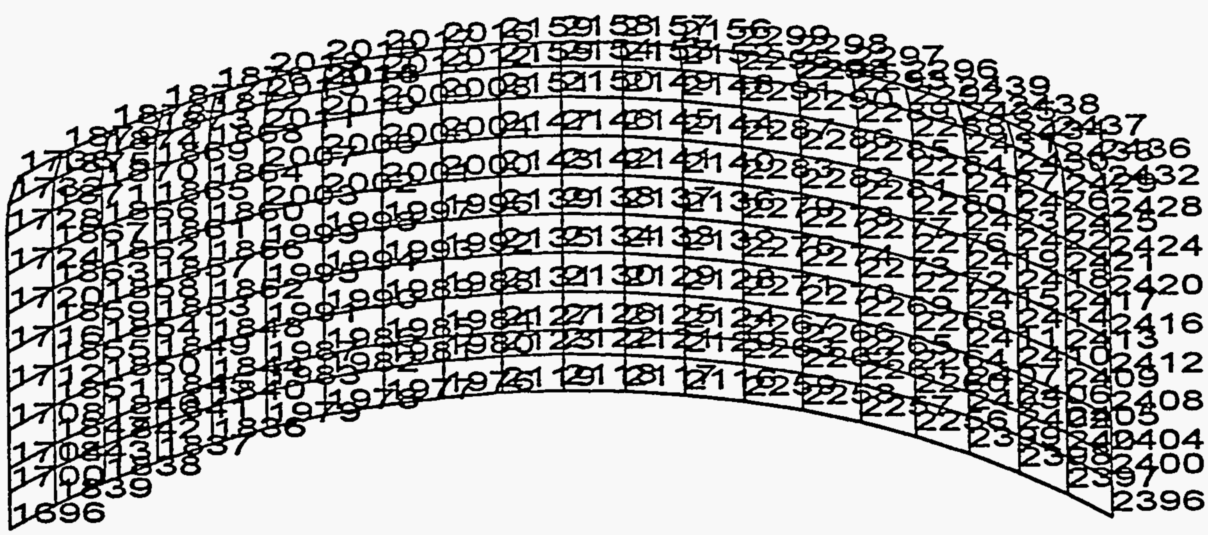
Base Elements in TTI Half Model (90 to 180 deg)



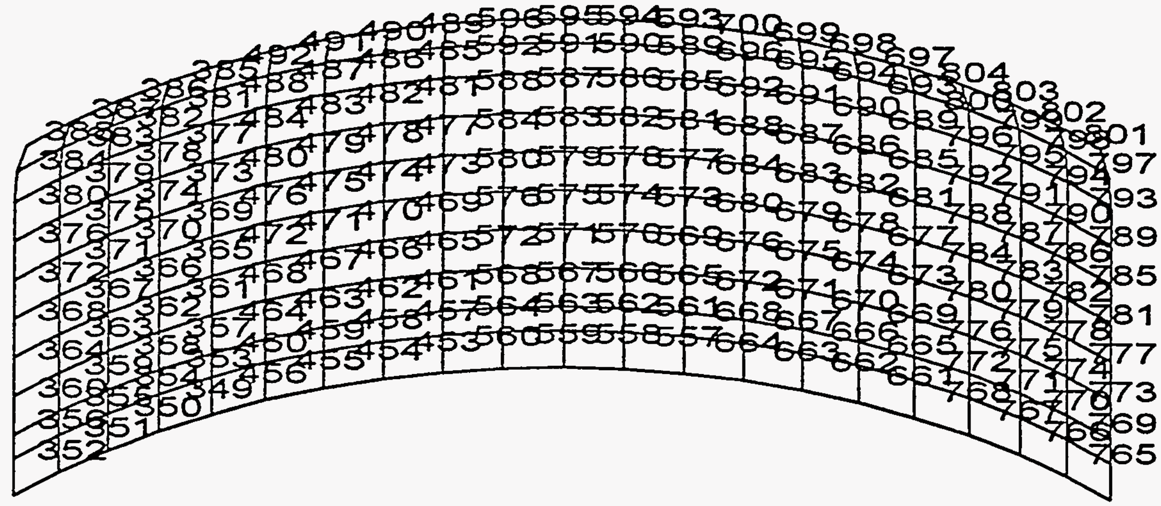
Base Nodes in TTI Half Model (90 to 180 deg)



Wall Elements in TTI Half Model (0 to 90 deg)

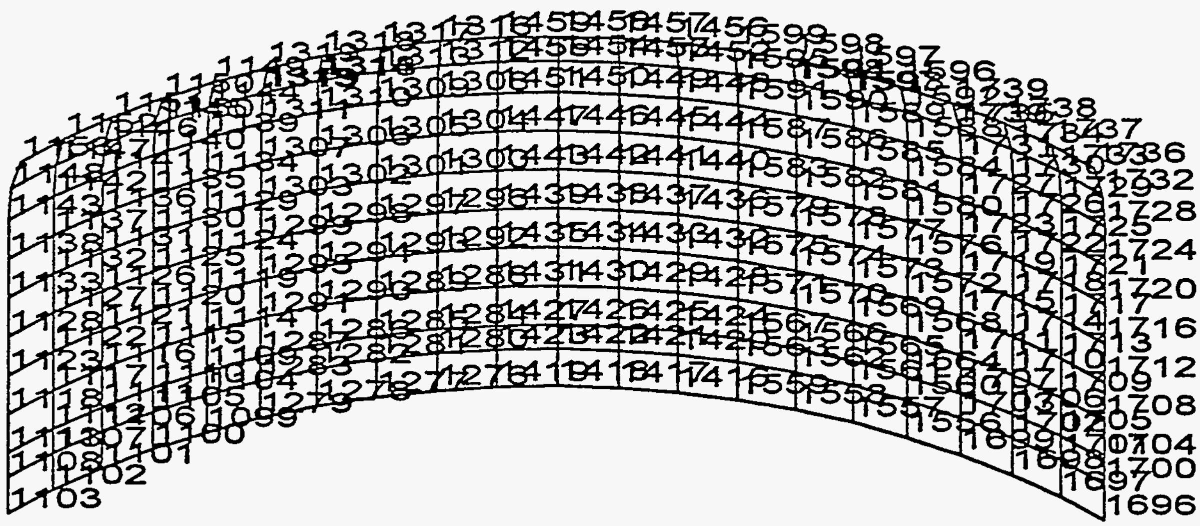


Wall Nodes in TTI Half Model (0 to 90 deg)

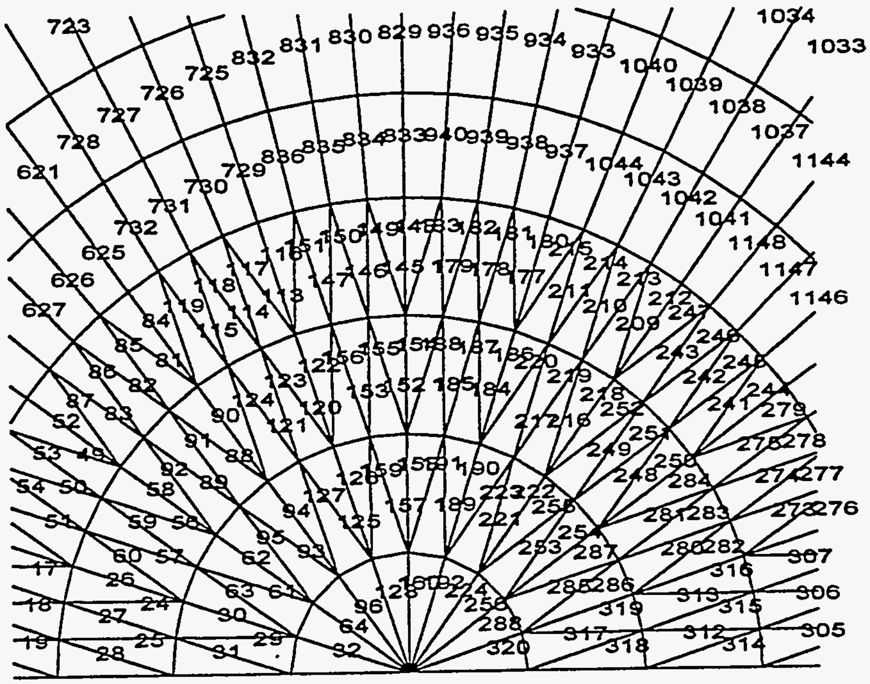


Wall Elements in TTI Half Model (90 to 180 deg)

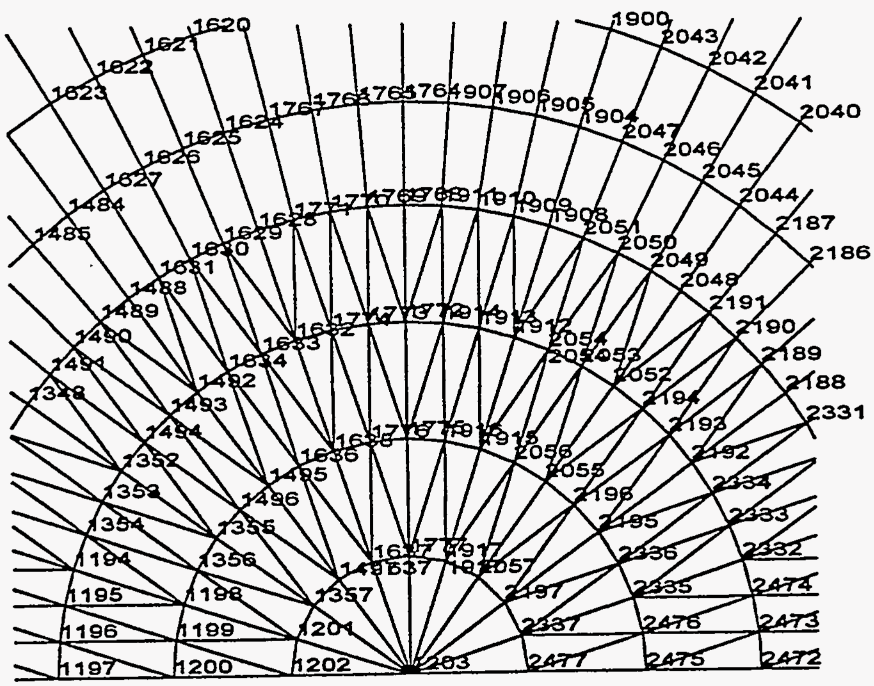
180 deg   90 deg



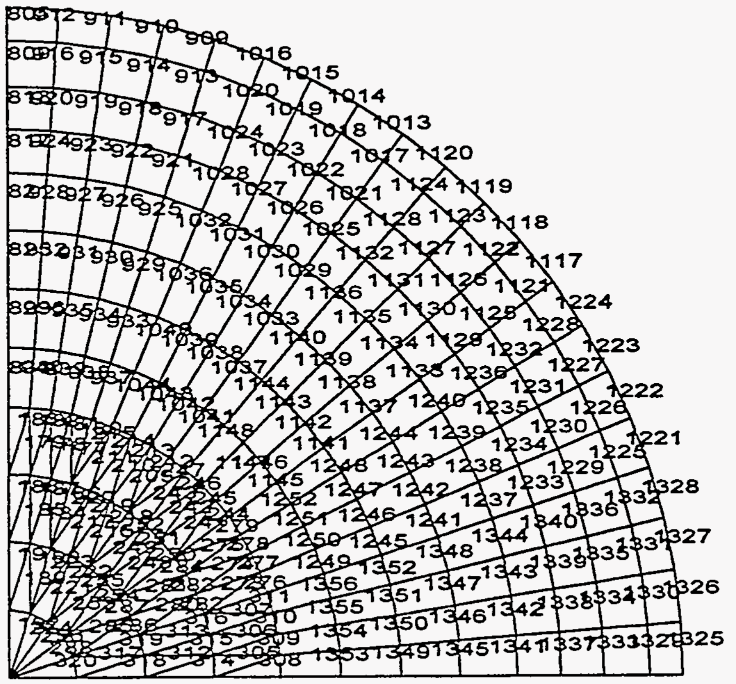
Wall Nodes in TTI Half Model (90 to 180 deg)



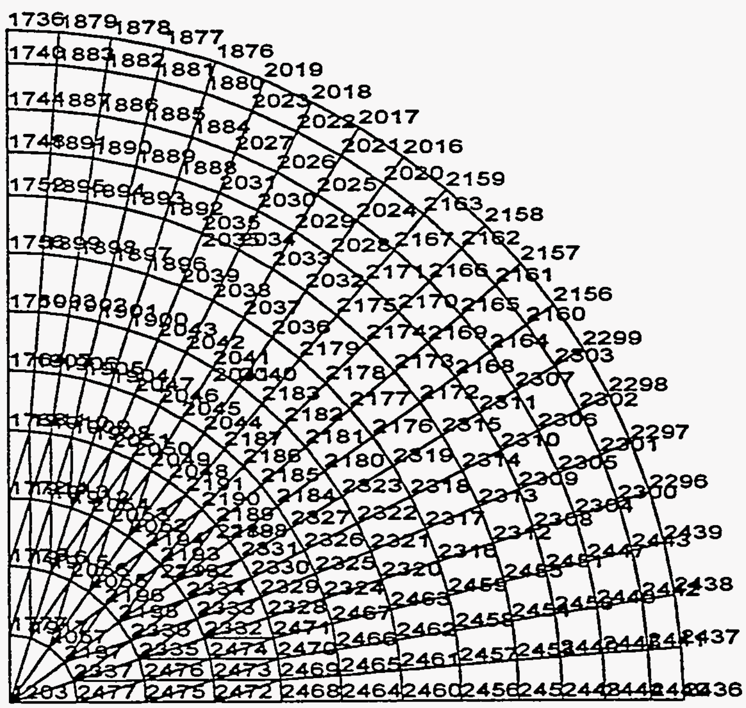
Dome Elements in TTI Half Model



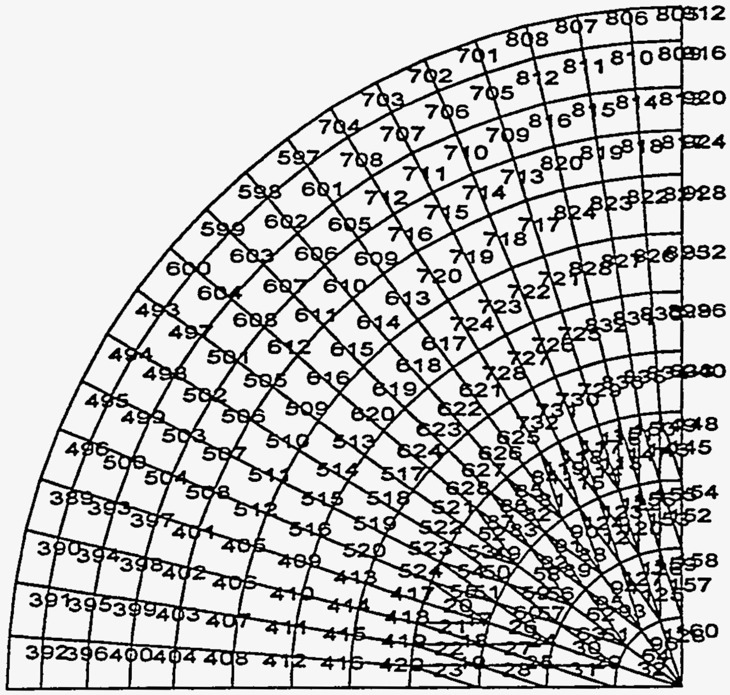
Dome Nodes in TTI Half Model



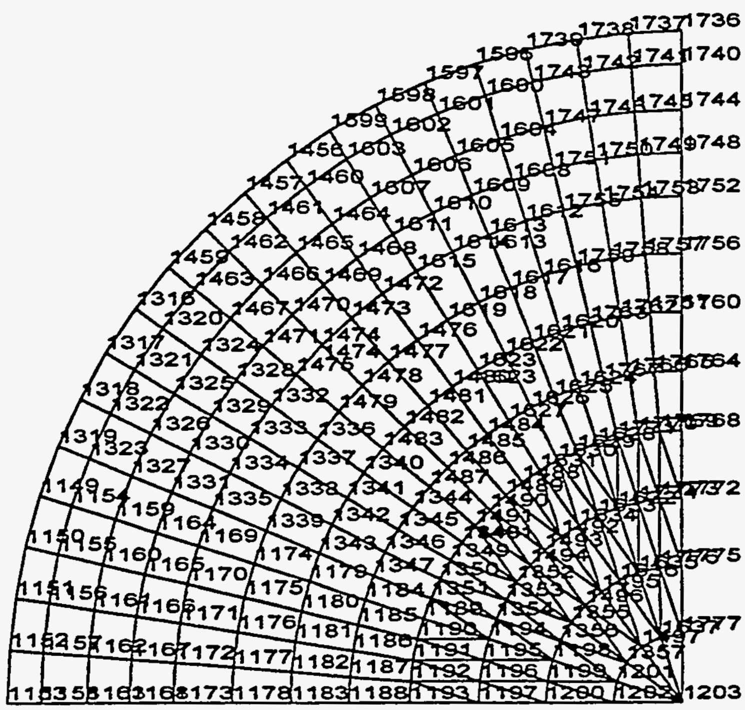
Dome Elements in TTI Half Model (0 to 90 deg)



Dome Nodes in TTI Half Model (0 to 90 deg)



Dome Elements in TTI Half Model (90 to 180 deg)



Dome Nodes in TTI Half Model (90 to 180 deg)

APPENDIX U

DEVELOPMENT OF IN SITU CONCRETE SECTION PROPERTIES

For the seismic analyses, the tank is modeled with shell elements of elastic, isotropic material. By "tuning" the thickness and Young's modulus of each shell element as described below, the effect of reinforcement, the state of cracking, and the "true" stiffness of concrete and reinforcement including degradation with time and temperature are taken into account. In effect, the axial and bending stiffnesses of the shell elements are matched with the corresponding stiffnesses of the in situ tank sections as calculated in the nonseismic analysis (Julyk 1994).

The effective shell thickness and effective Young's modulus for each shell element are calculated via a spreadsheet shown in Table U-1. This table is identical to Table 5.2.2-1. The approach for calculating these quantities is described as follows by referring to the spreadsheet columns.

Tank Region: a general description of the shell element location.

1/2 Model Shell Element Number: the element number of the shell element alongside the 180° meridian in the SASSI half model. Shell properties do not vary in the circumferential direction.

1/4 Model Shell Element Number: the element number of the shell element alongside the 180° meridian in the SASSI baseline quarter model. Shell properties do not vary in the circumferential direction.

Nominal Thickness, t: the average thickness (inches) of the reinforced concrete in the portion of the tank modeled by the shell element.

Meridional Coordinate of Centroid: the radial coordinate of the shell element centroid for shells in the tank base and tank dome; the axial coordinate (global Z) of the shell element centroid for shells in the tank wall.

ABAQUS Solid Element Number: the element number of the ABAQUS solid element nearest the SASSI shell element centroid. The axisymmetric ABAQUS model to which this item refers is documented in WHC-SD-W320-ANAL-001 (Julyk 1994).

E_c: the in situ value of Young's modulus of the concrete (lbf/in^2) as calculated by the Hanford "best-estimate" concrete model in the 55 year ABAQUS analysis. The ABAQUS postprocessing input and output files ("modulus.abd" and "modulus.abo", respectively) used to obtain the values of E_c and Temp (described below) are attached.

Temp: the temperature (°F) of the ABAQUS solid element (integration point nearest the SASSI shell element centroid) at 55 years.

E_{st}: Young's modulus (lbf/in^2) of the Grade 40 steel reinforcement at the temperature tabulated in the previous column. Linear interpolation is used between E_{st} = 28.3E6 lbf/in^2 at 70 °F and E_{st} = 27.6E6 lbf/in^2 at 200 °F.

A_s/inch: area of reinforcement (in^2) on the tension side of the section per inch of section width.

d': distance (in) from the extreme tension fiber of the section to the centroid of the tension reinforcement (Figure U-1).

A_s'/inch: area of reinforcement (in^2) on the compression side of the section per inch of section width.

d'': distance (in) from the extreme compression fiber of the section to the centroid of the compression reinforcement.

d: distance (in) from the extreme compression fiber of the section to the centroid of the tension reinforcement.

$$d = t - d'$$

n: ratio of Young's modulus for steel to Young's modulus for concrete.

$$n = E_{st}/E_c$$

I_{gross}: moment of inertia (in^4) of the uncracked concrete section neglecting reinforcement.

$$I_{gross} = t^3/12$$

X_{na} (uncracked section): distance (in) from the extreme compression fiber to the neutral axis (axis where strain is zero) of the uncracked section including the effect of reinforcement. Since the net axial forces on the tank sections are generally small relative to the axial capacities, the effect of axial load on the location of the neutral axis is neglected. X_{na} is computed by finding the centroid of the uncracked, transformed section. In defining the uncracked (or cracked) transformed sections as shown in Figure U-1, reinforcement is replaced with an equivalent area of concrete equal to the area of reinforcement times the ratio n.

$$X_{na} = [t^2/2 + (n-1)(A_s d + A_s'd'')] / [t + (n-1)(A_s + A_s')]$$

Alternately, the neutral axis can be calculated by assuming a linear strain profile with strain equal to zero at the neutral axis and setting the sum of forces to zero. The two approaches are equivalent and give the same value of X_{na}.

I_{eff} (uncracked section): moment of inertia (in^4) of the uncracked section about its neutral axis.

$$I_{eff} = t^3/12 + t(t/2 - X_{na})^2 + (n-1)[A_s(d - X_{na})^2 + A_s'(X_{na} - d'')^2]$$

$(X_{na})_{tr}$ (cracked section): distance (in) from the extreme compression fiber to the neutral axis (axis where strain is zero) of the cracked section including the effect of reinforcement. The effect of net axial load on the location of the neutral axis is neglected. X_{na} is computed by finding the centroid of the cracked, transformed section. In the transformed section (Figure U-1), the concrete is assumed to be cracked on the tension side all the way to the neutral axis. In other words, concrete on the tension side is neglected in defining the transformed section. It is assumed in the following quadratic equation that X_{na} is greater than d'', i.e., the steel A_s' is in compression.

$$X_{na} = [X_{na}^2/2 + nA_sd + (n-1)A_s'd''] / [X_{na} + nA_s + (n-1)A_s']$$

Alternately, the neutral axis can be calculated by assuming a linear strain profile with strain equal to zero at the neutral axis and setting the sum of forces to zero. The two approaches are equivalent and give the same value of X_{na}.

X_{na} (cracked section): same as $(X_{na})_{tr}$ if $(X_{na})_{tr}$ is greater than d''. If $(X_{na})_{tr}$ is less than d'', then the steel A_s' is in tension (considering only bending action) and the above equation for X_{na} of a cracked section must be modified by replacing the quantity (n-1) with n.

I_{eff} (cracked section): moment of inertia (in^4) of the cracked section about its neutral axis.

$$I_{eff} = X_{na}^3/3 + nA_s(d - X_{na})^2 + (n-1)A_s'(X_{na} - d'')^2$$

Is section cracked?: the answer to this question is yes if meridional cracks are indicated by the crack plot (Figure U-2) corresponding to the 55 year in situ state with best-estimate concrete (Julyk 1994). For shell elements in locations where cracking is evident, I_{eff} (cracked) is considered in subsequent calculations. Otherwise, I_{eff} (uncracked) is used.

Axial stiffness $(EA)_{shl}$: the axial (membrane) stiffness (lbf) of the shell element must be equal to the axial stiffness of the appropriate transformed section.

For an uncracked section:

$$(EA)_{shl} = E_{shl}t_{shl} = E_c[t + (n-1)(A_s + A_s')]$$

For a cracked section:

$$(EA)_{shl} = E_{shl}t_{shl} = E_c[X_{na} + nA_s + (n-1)A_s'] \qquad \text{if } X_{na} > d''$$

$$(EA)_{shl} = E_{shl}t_{shl} = E_c[X_{na} + n(A_s + A_s')] \qquad \text{if } X_{na} < d''$$

Bending stiffness $(12EI)_{shl}$: the bending stiffness ($lbf\text{-}in^2$) of the shell element must be equal to the bending stiffness of the appropriate transformed section.

$$(12EI)_{shl} = E_{shl}t_{shl}^3 = 12E_cI_{eff}$$

E_{shl}: the effective value of Young's modulus (lbf/in^2) for the shell element material. The equations given above for axial stiffness and bending stiffness are solved simultaneously to obtain the expression for E_{shl}.

$$E_{shl} = [(EA)_{shl}^3/(12EI)_{shl}]^{1/2}$$

t_{shl}: the effective thickness (in) of the shell element.

$$t_{shl} = (EA)_{shl}/E_{shl}$$

γ_{shl}: the effective weight density (lbf/in^3) of the shell element material. By prescribing this density for the shell element, the true weight of the tank is retained even though the effective shell thickness may be different than the nominal thickness.

$$\gamma_{shl} = (t/t_{shl})\gamma_{nom}$$

γ_{nom} is the nominal weight density of concrete (0.087 lbf/in^3), thus the effect of reinforcement on density is neglected. As the nominal thicknesses of the tank base sections do not include the 2" thick layer of grout, values of γ_{shl} along the tank base are increased to include the weight of the grout layer.

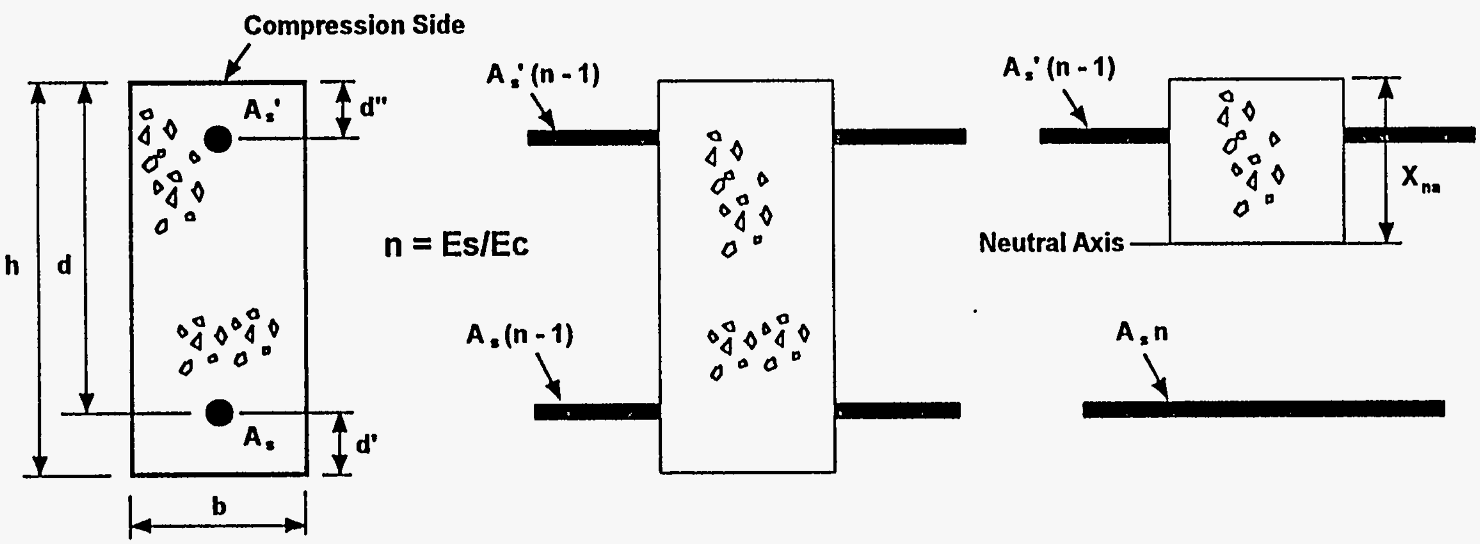
Quantity and/or placement of steel reinforcement in the tank are different in the two orthogonal directions. Table U-2 summarizes the major differences in quantity of steel; the differences in bar placement (cover) are relatively minor. It is noted from the table that the overall differences in reinforcement in the two directions are small in the base and the dome, large in the footing and wall (approximately twice as much steel in the hoop direction), and very large in the haunch (approximately ten to fifteen times as much steel in the hoop direction). These differences in circumferential and meridional reinforcement cause the reinforced concrete to behave in an orthotropic manner; however, the analysis software is limited to isotropic representations. Because meridional demands generally control over circumferential demands, the effective shell properties are computed based on meridional reinforcement. In effect, the shell element model is an idealization of the actual tank where the circumferential reinforcement is the same as the meridional reinforcement. The error associated with this modeling approximation is relatively insignificant given that the quantity of reinforcement has only a secondary effect on the stiffness of an uncracked section and most of the tank is uncracked.

An additional approximation applies to sections where meridional reinforcement is not symmetrical with respect to the midplane of the section. Such nonsymmetry occurs in the base, footing, haunch, and dome. In these regions, it becomes necessary to make a judgement as to which face of a section is in tension due to bending. The effective shell properties are then calculated accordingly. The assumptions made are as follows:

- the top face of the tank base is in tension
- the bottom face of the footing is in tension
- the outside face of the haunch is in tension
- the inside face of the dome from R = 0 to R = 260 in. is in tension
- the outside face of the dome from R = 260 in. to the haunch is in tension.

Figure U-3 summarizes the variation of meridional reinforcement in the dome. As the tank radius increases, bar spacing increases until new bars are added. The new bars become fully effective after one development length l_d. Such complications spurred the generation and use of a graphical aid for calculating areas of steel for given shell elements in the dome. An average area of steel over the length of a given shell was approximated using Figure U-3. This area of reinforcement is used in Table U-1 as A_s and A_s' for the corresponding dome section. For convenience, shell locations are indicated to scale at the top of Figure U-3.

Figure U-1
Transformed Reinforced Concrete Sections



Meridional Cross-Section | **Uncracked, Transformed Section** | **Cracked, Transformed Section**

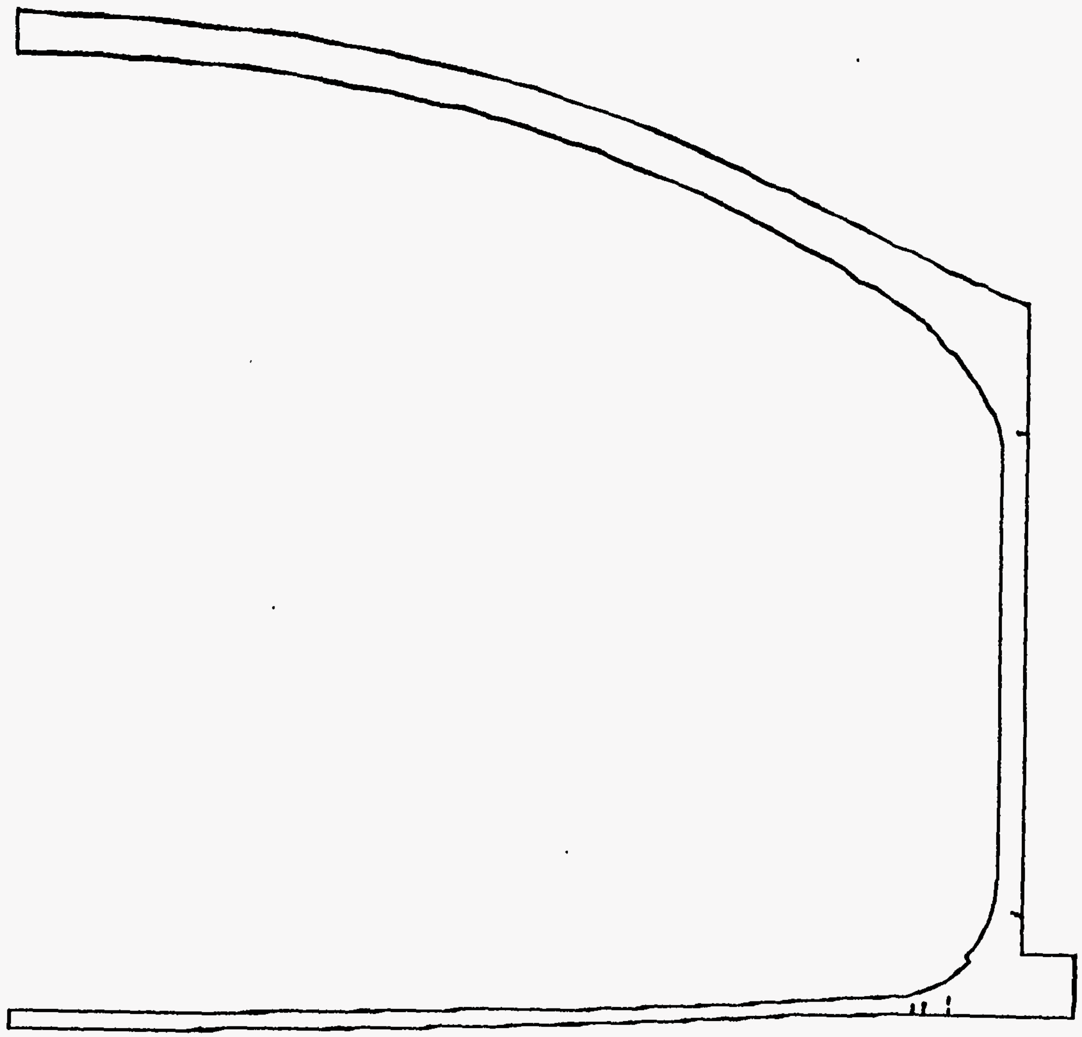


Figure U-2
Crack Pattern of 241-C-106 (Best-Estimate Concrete Strength at 55 Years) (Julyk 1994)

Figure U-3
Meridional Dome Reinforcement

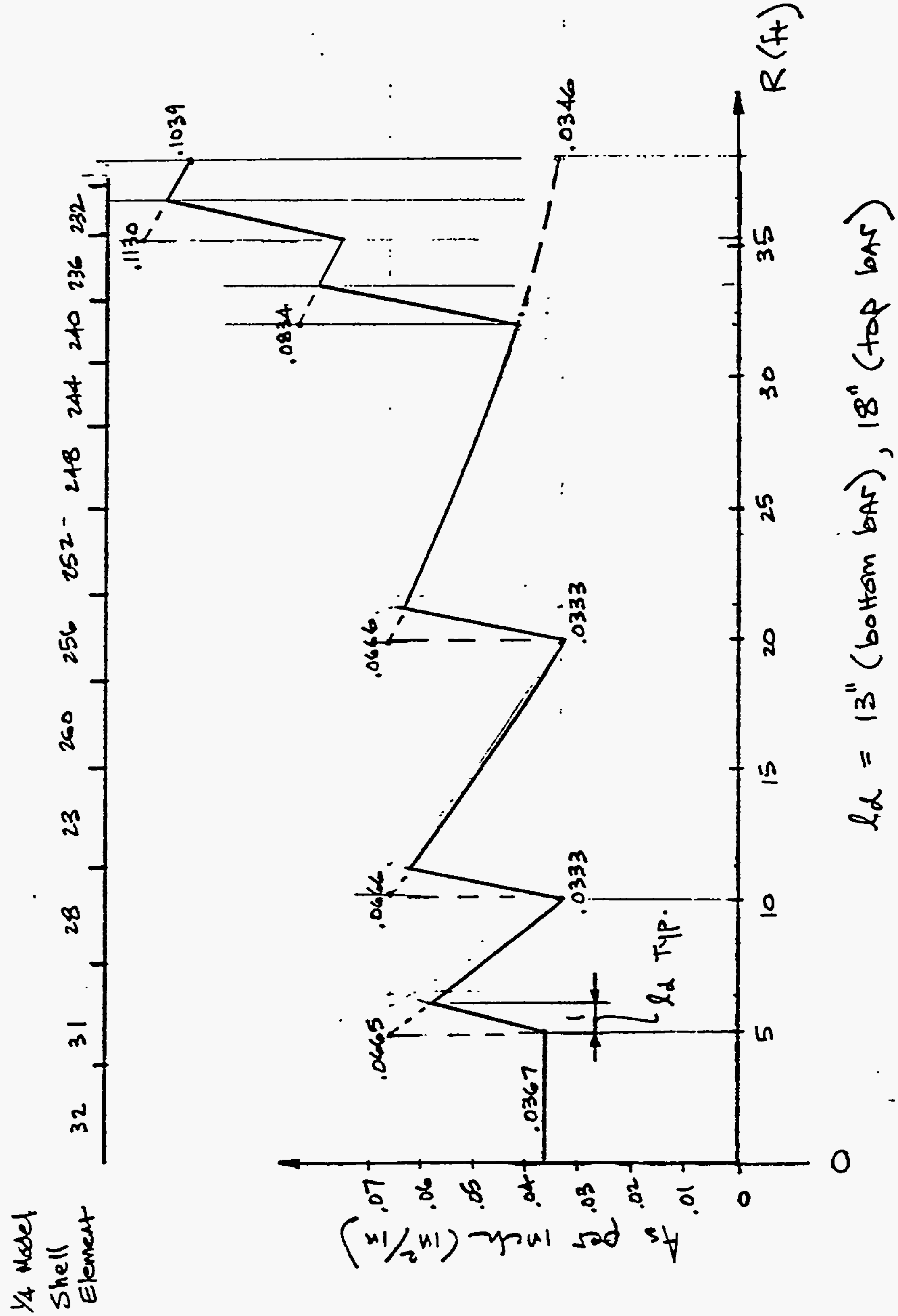


Table U-1
Shell Element Section and Material Properties (Best-Estimate Tank Stiffness)

tank region	1/2 model shell el. # (180 deg)	1/4 model shell el. # (180 deg)	nominal thickness, t [in]	Merid. coord. of centroid [in]	ABAQUS solid ele. # (Julyk 1994)	Best-est, 55 yrs		E st [lbf/in^2]
						E c [lbf/in^2]	Temp [deg F]	
floor	1	1	6.00	R= 23.8	4	2.144E+06	157.3	2.78E+07
floor	4	4	6.00	53.6	10	2.147E+06	157	2.78E+07
floor	9	9	6.00	89.4	16	2.156E+06	156.4	2.78E+07
floor	16	16	6.00	125	22	2.168E+06	155.6	2.78E+07
floor	324	164	6.00	165	28	2.185E+06	154.3	2.78E+07
floor	328	168	6.00	209	34	2.210E+06	152.5	2.79E+07
floor	332	172	6.00	253	42	2.242E+06	150.2	2.79E+07
floor	336	176	6.00	297	48	2.283E+06	147.2	2.79E+07
floor	340	180	6.00	341	56	2.341E+06	142.9	2.79E+07
floor	344	184	6.00	385	64	2.420E+06	137.6	2.79E+07
knuckle	348	188	14.49	432	108	2.597E+06	129.1	2.80E+07
knuckle	352	192	18.30	Z= 37.4	131	2.624E+06	125.3	2.80E+07
wall	356	196	12.30	59.4	122	2.843E+06	113	2.81E+07
wall	360	200	12.00	82	140	3.155E+06	103.1	2.81E+07
wall	364	204	12.00	110	149	3.632E+06	95.15	2.82E+07
wall	368	208	12.00	138	151	3.739E+06	94.02	2.82E+07
wall	372	212	12.00	166	161	3.771E+06	92.75	2.82E+07
wall	376	216	12.00	194	163	3.825E+06	92.16	2.82E+07
wall	380	220	12.00	222	172	3.835E+06	91.64	2.82E+07
wall	384	224	12.00	247.9	188	3.959E+06	90.77	2.82E+07
haunch	388	228	27.29	271.15	190	4.100E+06	89.57	2.82E+07
haunch	392	232	31.62	R= 436.45	192	4.050E+06	89.52	2.82E+07
haunch	396	236	21.31	410.2	195	3.972E+06	89.86	2.82E+07
dome	400	240	18.08	380.7	232	3.943E+06	89.97	2.82E+07
dome	404	244	17.38	351.95	234	4.036E+06	89.2	2.82E+07
dome	408	248	16.91	318.4	235	3.958E+06	89.74	2.82E+07
dome	412	252	16.38	279.85	237	4.068E+06	88.84	2.82E+07
dome	416	256	15.83	240.65	238	3.983E+06	89.47	2.82E+07
dome	420	260	15.28	200.95	240	4.090E+06	88.59	2.82E+07
dome	23	23	15.00	158.5	241	4.022E+06	89.11	2.82E+07
dome	28	28	15.00	113.4	243	4.025E+06	89.07	2.82E+07
dome	31	31	15.00	68.1	245	4.100E+06	88.46	2.82E+07
dome	32	32	15.00	30.3	246	3.998E+06	89.26	2.82E+07
footing	424	264	24.00	R= 472	111	3.188E+06	121.5	2.80E+07

Table U-1
Shell Element Section and Material Properties (Best-Estimate Tank Stiffness)

							Uncracked section	
As/inch [in^2]	*d' [in]*	*As'/inch [in^2]*	*d" [in]*	*d [in]*	*n=E st/E c*	*I gross [in^4]*	*X na [in]*	*I eff [in^4]*
0.0170	1.750	0.0000	0.000	4.250	12.983	18.00	3.04	18.31
0.0170	1.750	0.0000	0.000	4.250	12.963	18.00	3.04	18.31
0.0170	1.750	0.0000	0.000	4.250	12.913	18.00	3.04	18.31
0.0170	1.750	0.0000	0.000	4.250	12.842	18.00	3.04	18.30
0.0170	1.750	0.0000	0.000	4.250	12.746	18.00	3.04	18.30
0.0170	1.750	0.0000	0.000	4.250	12.602	18.00	3.04	18.30
0.0170	1.750	0.0000	0.000	4.250	12.429	18.00	3.04	18.29
0.0170	1.750	0.0000	0.000	4.250	12.212	18.00	3.04	18.29
0.0170	1.750	0.0000	0.000	4.250	11.920	18.00	3.04	18.28
0.0170	1.750	0.0000	0.000	4.250	11.542	18.00	3.04	18.27
0.0550	3.130	0.0000	0.000	11.360	10.777	253.53	7.39	262.31
0.0367	2.375	0.0367	8.675	15.925	10.673	510.71	9.27	526.80
0.0367	2.375	0.0367	2.675	9.925	9.875	155.07	6.16	163.64
0.0367	2.375	0.0367	2.375	9.625	8.913	144.00	6.00	151.63
0.0367	2.375	0.0367	2.375	9.625	7.755	144.00	6.00	150.51
0.0367	2.375	0.0367	2.375	9.625	7.534	144.00	6.00	150.30
0.0367	2.375	0.0367	2.375	9.625	7.472	144.00	6.00	150.24
0.0367	2.375	0.0367	2.375	9.625	7.368	144.00	6.00	150.14
0.0367	2.375	0.0367	2.375	9.625	7.349	144.00	6.00	150.12
0.0367	2.375	0.0367	2.375	9.625	7.121	144.00	6.00	149.90
0.0367	2.375	0.0367	2.375	24.915	6.876	1693.67	13.65	1748.40
0.0960	4.375	0.0370	1.625	27.245	6.961	2634.54	15.92	2753.39
0.0780	4.375	0.0400	1.625	16.935	7.097	806.43	10.69	845.05
0.0490	4.375	0.0430	1.625	13.705	7.150	492.51	9.01	513.59
0.0470	4.375	0.0470	1.625	13.005	6.986	437.49	8.65	456.74
0.0530	4.375	0.0530	1.625	12.535	7.123	402.95	8.40	423.44
0.0600	4.375	0.0600	1.625	12.005	6.932	366.24	8.13	386.70
0.0460	1.625	0.0460	4.375	14.205	7.079	330.57	7.96	345.10
0.0430	1.625	0.0430	4.375	13.655	6.895	297.30	7.68	309.14
0.0570	1.625	0.0570	4.375	13.375	7.010	281.25	7.56	296.36
0.0480	1.625	0.0480	4.375	13.375	7.006	281.25	7.55	293.98
0.0480	3.375	0.0480	3.375	11.625	6.879	281.25	7.50	290.85
0.0370	3.375	0.0370	3.375	11.625	7.052	281.25	7.50	288.87
0.0550	3.130	0.0000	6.250	20.870	8.791	1152.00	12.16	1185.12

Table U-1
Shell Element Section and Material Properties (Best-Estimate Tank Stiffness)

(wt density) nom = 0.0870

Cracked section						*Effective shell properties*		
(X na)tr [in]	*X na [in]*	*I eff [in^4]*	*Is section cracked?*	*Axial stiff. (EA) shl [lbf]*	*Bend. stiff. (12EI) shl [lbf-in^2]*	*E shl [lbf/in^2]*	*t shl [in]*	*(weight density) shl [lbf/in^3]*
1.167	1.167	2.63	N	1.330E+07	4.709E+08	2.235E+06	5.95	0.1170
1.166	1.166	2.62	N	1.332E+07	4.717E+08	2.238E+06	5.95	0.1170
1.164	1.164	2.62	N	1.337E+07	4.735E+08	2.247E+06	5.95	0.1170
1.161	1.161	2.60	N	1.344E+07	4.762E+08	2.259E+06	5.95	0.1169
1.158	1.158	2.59	N	1.354E+07	4.798E+08	2.276E+06	5.95	0.1169
1.152	1.152	2.57	N	1.370E+07	4.854E+08	2.301E+06	5.95	0.1169
1.145	1.145	2.54	N	1.389E+07	4.922E+08	2.333E+06	5.95	0.1169
1.137	1.137	2.50	N	1.414E+07	5.011E+08	2.374E+06	5.95	0.1169
1.125	1.125	2.45	N	1.448E+07	5.136E+08	2.432E+06	5.96	0.1169
1.110	1.110	2.39	N	1.496E+07	5.307E+08	2.511E+06	5.96	0.1168
3.125	3.125	50.37	Y	9.652E+06	1.569E+09	7.569E+05	12.75	0.1125
3.633	3.675	85.06	N	4.987E+07	1.659E+10	2.735E+06	18.24	0.0873
2.379	2.382	25.14	Y	8.829E+06	8.574E+08	8.960E+05	9.85	0.1086
2.220	2.222	21.57	N	3.969E+07	5.741E+09	3.301E+06	12.03	0.0868
2.101	2.105	19.21	N	4.538E+07	6.559E+09	3.774E+06	12.02	0.0868
2.077	2.081	18.75	N	4.666E+07	6.744E+09	3.881E+06	12.02	0.0868
2.070	2.074	18.62	N	4.704E+07	6.799E+09	3.913E+06	12.02	0.0868
2.058	2.063	18.40	N	4.768E+07	6.891E+09	3.966E+06	12.02	0.0868
2.056	2.061	18.36	N	4.781E+07	6.909E+09	3.977E+06	12.02	0.0868
2.030	2.035	17.88	Y	1.012E+07	8.494E+08	1.105E+06	9.16	0.1140
3.248	3.248	129.95	N	1.137E+08	8.603E+10	4.132E+06	27.51	0.0863
5.269	5.269	374.43	N	1.313E+08	1.338E+11	4.112E+06	31.93	0.0862
3.695	3.695	114.91	N	8.751E+07	4.028E+10	4.079E+06	21.46	0.0864
2.678	2.678	49.29	N	7.352E+07	2.430E+10	4.044E+06	18.18	0.0865
2.525	2.525	41.65	N	7.242E+07	2.212E+10	4.144E+06	17.48	0.0865
2.616	2.616	43.43	N	6.950E+07	2.011E+10	4.086E+06	17.01	0.0865
2.654	2.654	42.98	N	6.953E+07	1.888E+10	4.220E+06	16.48	0.0865
2.868	2.888	50.45	N	6.528E+07	1.649E+10	4.107E+06	15.90	0.0866
2.708	2.730	42.97	N	6.457E+07	1.517E+10	4.212E+06	15.33	0.0867
3.031	3.051	52.76	N	6.309E+07	1.430E+10	4.190E+06	15.06	0.0867
2.826	2.847	45.75	N	6.269E+07	1.420E+10	4.166E+06	15.05	0.0867
2.543	2.555	32.95	N	6.381E+07	1.431E+10	4.261E+06	14.97	0.0871
2.310	2.324	27.04	N	6.177E+07	1.386E+10	4.123E+06	14.98	0.0871
4.035	4.035	158.93	N	7.787E+07	4.534E+10	3.227E+06	24.13	0.0865

Table U-2. Tank Reinforcement.

Table U-2
Tank Reinforcement

Region	Meridional Reinforcement (bar size, spacing)	Hoop Reinforcement (bar size, spacing	Meridional Reinforcement (in^2/in)	Hoop Reinforcement (in^2/in)
Base	0.5 in. diameter @ 12 in.	0.5 in. diameter @ 12 in.	0.0167	0.0167
Footing (bottom)	0.75 in. diameter @ 8 in.	1 in. square @ 8 in.	0.0550	0.1250
Wall	0.75 in. diameter @ 12 in.	0.875 in. diameter @ 6 in. min., 10 in. max.	0.0367	0.0600 to 0.1000
Haunch	0.75 in. @ 6 in.	1.25 in. square @ 6 in. with 3 to 7 interior layers	0.0733	0.6510 to 1.170
Dome	0.75 in. @ 13.2 in.	0.75 in. @ 12 in.	0.0333	0.0366

FILENAME : modulus.abd DATE : 11-14-93 TIME : 10:18p PAGE 1
TITLE : ABAQUS postprocessing input file for Ec and temp at 55 years

```
*POST OUTPUT,STEP=64
8
*ELSET,ELSET=SSISHLS
  4, 10, 16, 22, 28, 34, 42, 48, 56, 64,108,131,122,140,149,151,
161,163,172,188,190,192,195,232,234,235,237,238,240,241,243,245,
246,111
*ELPRINT,ELSET=SSISHLS
SDV6,TEMP
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FILENAME : modulus.abo DATE : 11-14-93 TIME : 10:29p PAGE 1
TITLE : ABAQUS postprocessing output file for Ec and Temp a55 years

CPU TIME (SEC) = 0.002 WALL CLOCK TIME (SEC) = 0.000

1

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steps 56 to 64

STEP 0 INCREMENT 0
TIME COMPLETED IN THIS STEP 0.000

E+00

STEP NUMBER 64 INCREMENT NUMBER 8

TIME COMPLETED DURING THIS STEP 730. FRACTION OF STEP IS 1.00
TOTAL ACCUMULATED TIME 2.007E+04

E L E M E N T O U T P U T

THE FOLLOWING TABLE IS PRINTED FOR ELSET SSISHLS AND ELEMENT TYPE CAX8R AT THE INTEGRATION POINTS

ELEMENT	PT	FOOT-NOTE	SDV6	TEMP
4	1		2.1430E+06	157.3
4	2		2.1435E+06	157.3
4	3		2.1358E+06	157.5
4	4		2.1363E+06	157.4
10	1		2.1470E+06	157.0
10	2		2.1484E+06	156.9
10	3		2.1399E+06	157.2
10	4		2.1412E+06	157.1
16	1		2.1555E+06	156.4
16	2		2.1576E+06	156.3
16	3		2.1483E+06	156.6
16	4		2.1504E+06	156.4
22	1		2.1678E+06	155.6
22	2		2.1709E+06	155.3
22	3		2.1607E+06	155.7
22	4		2.1638E+06	155.5
28	1		2.1847E+06	154.3
28	2		2.1888E+06	154.1
28	3		2.1777E+06	154.5
28	4		2.1816E+06	154.2
34	1		2.2057E+06	152.8
34	2		2.2104E+06	152.5
34	3		2.1989E+06	153.0
34	4		2.2033E+06	152.6
42	1		2.2421E+06	150.2
42	2		2.2485E+06	149.8
42	3		2.2353E+06	150.4
42	4		2.2417E+06	149.9
48	1		2.2755E+06	147.8
48	2		2.2833E+06	147.2
48	3		2.2681E+06	148.0
48	4		2.2759E+06	147.4

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steps 56 to 64

STEP 64 INCREMENT 8
TIME COMPLETED IN THIS STEP

FILENAME : modulus.abo DATE : 11-14-93 TIME : 10:29p PAGE 2
TITLE : ABAQUS postprocessing output file for Ec and Temp a55 years

ELEMENT	PT	FOOT-NOTE	SDV6	TEMP
56	1		2.3317E+06	143.6
56	2		2.3413E+06	142.9
56	3		2.3249E+06	143.7
56	4		2.3343E+06	143.0
64	1		2.4204E+06	137.6
64	2		2.4432E+06	136.5
64	3		2.4099E+06	137.7
64	4		2.4308E+06	136.6
108	1		2.5965E+06	129.1
108	2		2.6275E+06	127.4
108	3		2.5735E+06	128.6
108	4		2.6009E+06	126.6
111	1		3.1628E+06	123.1
111	2		3.2089E+06	122.8
111	3		3.1357E+06	121.9
111	4		3.1878E+06	121.5
122	1		2.7787E+06	115.9
122	2		2.8248E+06	115.9
122	3		2.8425E+06	113.0
122	4		2.8824E+06	113.2
131	1		2.6552E+06	126.2
131	2		2.6957E+06	124.8
131	3		2.6236E+06	125.3
131	4		2.6585E+06	123.5
140	1		3.0101E+06	106.9
140	2		3.0575E+06	107.0
140	3		3.1552E+06	103.1
140	4		3.1900E+06	103.5
149	1		3.5195E+06	96.30
149	2		3.5237E+06	97.02
149	3		3.6316E+06	95.15
149	4		3.6294E+06	95.71
151	1		3.7335E+06	93.67
151	2		3.7392E+06	94.02
151	3		3.7491E+06	93.32
151	4		3.7581E+06	93.61
161	1		3.7584E+06	93.08
161	2		3.7695E+06	93.33
161	3		3.7712E+06	92.75
161	4		3.7861E+06	92.93
163	1		3.8010E+06	92.12
163	2		3.8247E+06	92.16
163	3		3.8167E+06	91.88
163	4		3.8450E+06	91.87
172	1		3.8256E+06	91.76
172	2		3.8565E+06	91.72
172	3		3.8351E+06	91.64

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steps 56 to 64

STEP 64 INCREMENT 8
TIME COMPLETED IN THIS STEP 730.

ELEMENT	PT	FOOT-NOTE	SDV6	TEMP
172	4		3.8692E+06	91.57
188	1		3.9162E+06	90.96
188	2		3.9586E+06	90.77
188	3		3.9331E+06	90.79
188	4		3.9919E+06	90.50
190	1		4.0089E+06	90.12
190	2		4.1004E+06	89.57
190	3		4.0756E+06	89.59

FILENAME : modulus.abo DATE : 11-14-93 TIME : 10:29p PAGE 3
TITLE : ABAQUS postprocessing output file for Ec and Temp a55 years

190	4	4.1947E+06	88.79
192	1	4.0734E+06	89.42
192	2	4.1916E+06	88.61
192	3	4.0503E+06	89.52
192	4	4.1668E+06	88.72
195	1	3.9960E+06	89.74
195	2	4.0975E+06	89.02
195	3	3.9723E+06	89.86
195	4	4.0709E+06	89.15
232	1	3.9402E+06	90.01
232	2	4.0402E+06	89.27
232	3	3.9431E+06	89.97
232	4	4.0446E+06	89.21
234	1	3.9479E+06	89.87
234	2	4.0363E+06	89.20
234	3	3.9507E+06	89.83
234	4	4.0368E+06	89.17
235	1	3.9432E+06	89.88
235	2	4.0317E+06	89.19
235	3	3.9582E+06	89.74
235	4	4.0426E+06	89.08
237	1	3.9610E+06	89.68
237	2	4.0678E+06	88.84
237	3	3.9649E+06	89.63
237	4	4.0696E+06	88.81
238	1	3.9737E+06	89.55
238	2	4.0786E+06	88.72
238	3	3.9830E+06	89.47
238	4	4.0719E+06	88.76
240	1	3.9891E+06	89.39
240	2	4.0899E+06	88.59
240	3	3.9772E+06	89.48
240	4	4.0796E+06	88.67
241	1	4.0022E+06	89.28
241	2	4.1022E+06	88.48
241	3	4.0222E+06	89.11
241	4	4.1233E+06	88.31
243	1	4.0050E+06	89.23
243	2	4.1092E+06	88.40

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ABAQUS PRODUCTION VERSION 4-9-1 DATE 11/19/93 TIME 09:53:58 PAGE 4
FOR USE BY WESTINGHOUSE HANFORD CO. UNDER LICENSE FROM HKS, INC.

steps 56 to 64

STEP 64 INCREMENT 8
TIME COMPLETED IN THIS STEP 730.

ELEMENT	PT	FOOT-NOTE	SDV6	TEMP
243	3		4.0246E+06	89.07
243	4		4.1306E+06	88.23
245	1		3.9910E+06	89.33
245	2		4.0995E+06	88.46
245	3		3.9850E+06	89.37
245	4		4.0942E+06	88.50
246	1		3.9863E+06	89.36
246	2		4.0959E+06	88.49
246	3		3.9984E+06	89.26
246	4		4.1083E+06	88.38
MAXIMUM			4.1947E+06	157.5
ELEMENT			190	4
MINIMUM			2.1358E+06	88.23
ELEMENT			4	243

THE ANALYSIS HAS BEEN COMPLETED

END OF RUN

```
RUN SUMMARY:
TOTAL OF        0  INCREMENTS
                0  CUTBACKS IN AUTOMATIC INCREMENTATION
                0  ITERATIONS
                0  PASSES THROUGH THE EQUATION SOLVER OF WHICH
                0  REPRESENT(S) DECOMPOSITION OF THE MASS MATRIX
  CPU TIME (SEC)  =        1.871  WALL CLOCK TIME (SEC)  =        11.099
```

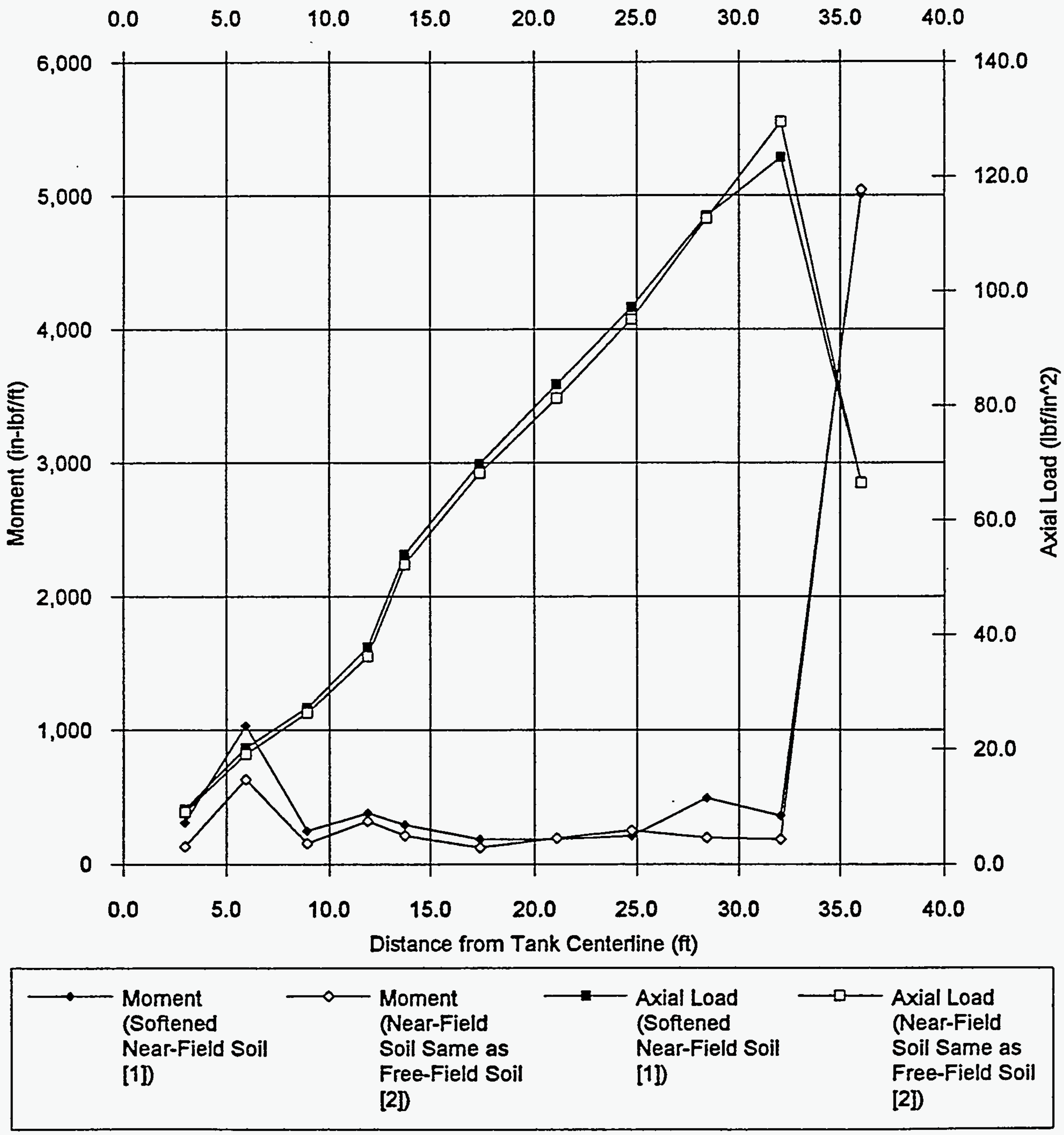
APPENDIX V

SENSITIVITY OF TANK RESPONSE TO NEAR-FIELD SOIL MODULI

Plasticity in the near-field soil and slippage at the soil-tank interface is addressed in this appendix by arbitrarily reducing the shear modulus of the near-field soil by a factor of two. This reduction is equivalent to dividing the shear wave speed and compression wave speed by $\sqrt{2}$. Figures V-1 to V-6 compare bending moments and axial loads in the tank calculated using "softened" near-field soil to the corresponding quantities calculated using "nominal" near-field soil. The near-field soil properties in the "nominal" case are the same as the free-field soil properties. In the "softened" case, wave speeds of the near-field soil are equal to the free-field soil wave speeds divided by $\sqrt{2}$. In both cases, the free-field soil properties are equal to the lower-bound soil properties defined in Section 5.3.2 of the main body of this report. Only the horizontal excitation is considered for purposes of comparison.

The figures reveal only minor differences between the two cases indicating that tank response is relatively insensitive to near-field soil nonlinearities.

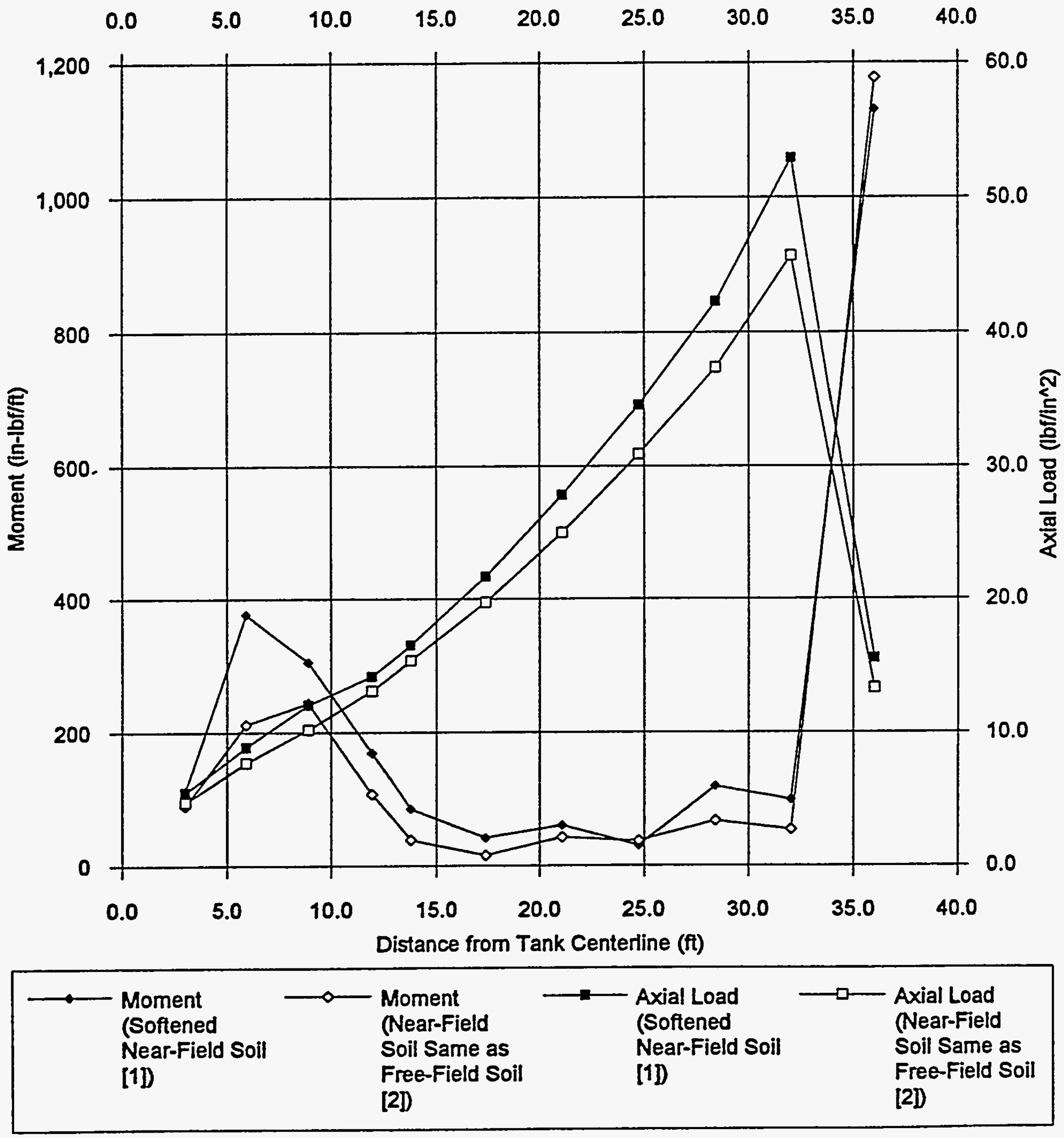
Figure V-1. Meridional Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Near-Field Soil Moduli



Note: [1] = Run ID "cmot50 QLOWFIL", [2] = Run ID "cmot50 QLOWpnt4".

qlow\anl\cmot50\7freq\CBFILI.XLC

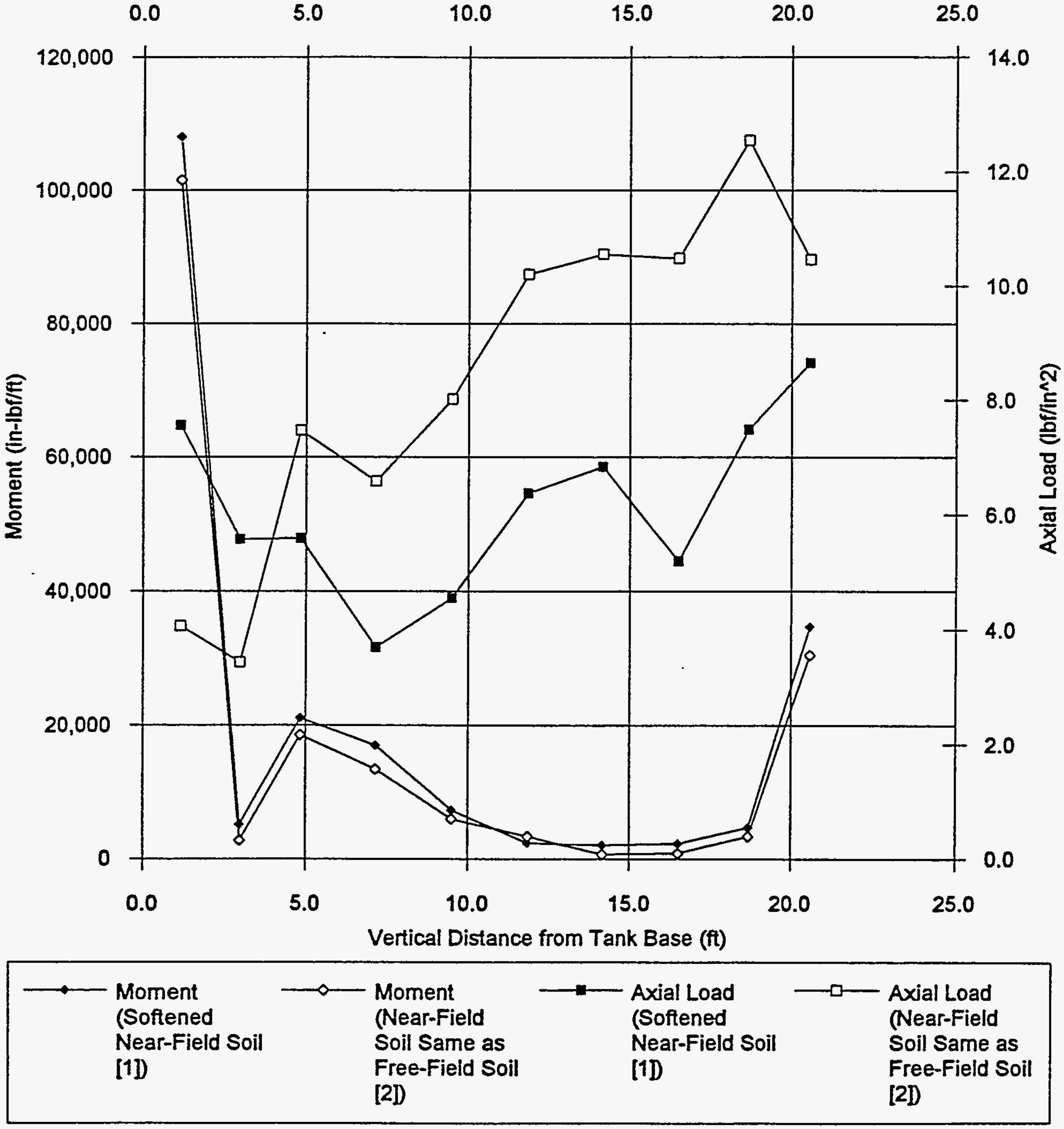
Figure V-2. Circumferential Seismic Response of Tank Base at 180 deg Meridian from Horizontal Excitation: Sensitivity to Near-Field Soil Moduli



Note: [1] = Run ID "cmot50 QLOWFIL", [2] = Run ID "cmot50 QLOWpnt4".

qlow\anl\cmot50\7freq\CBFILO.XLC

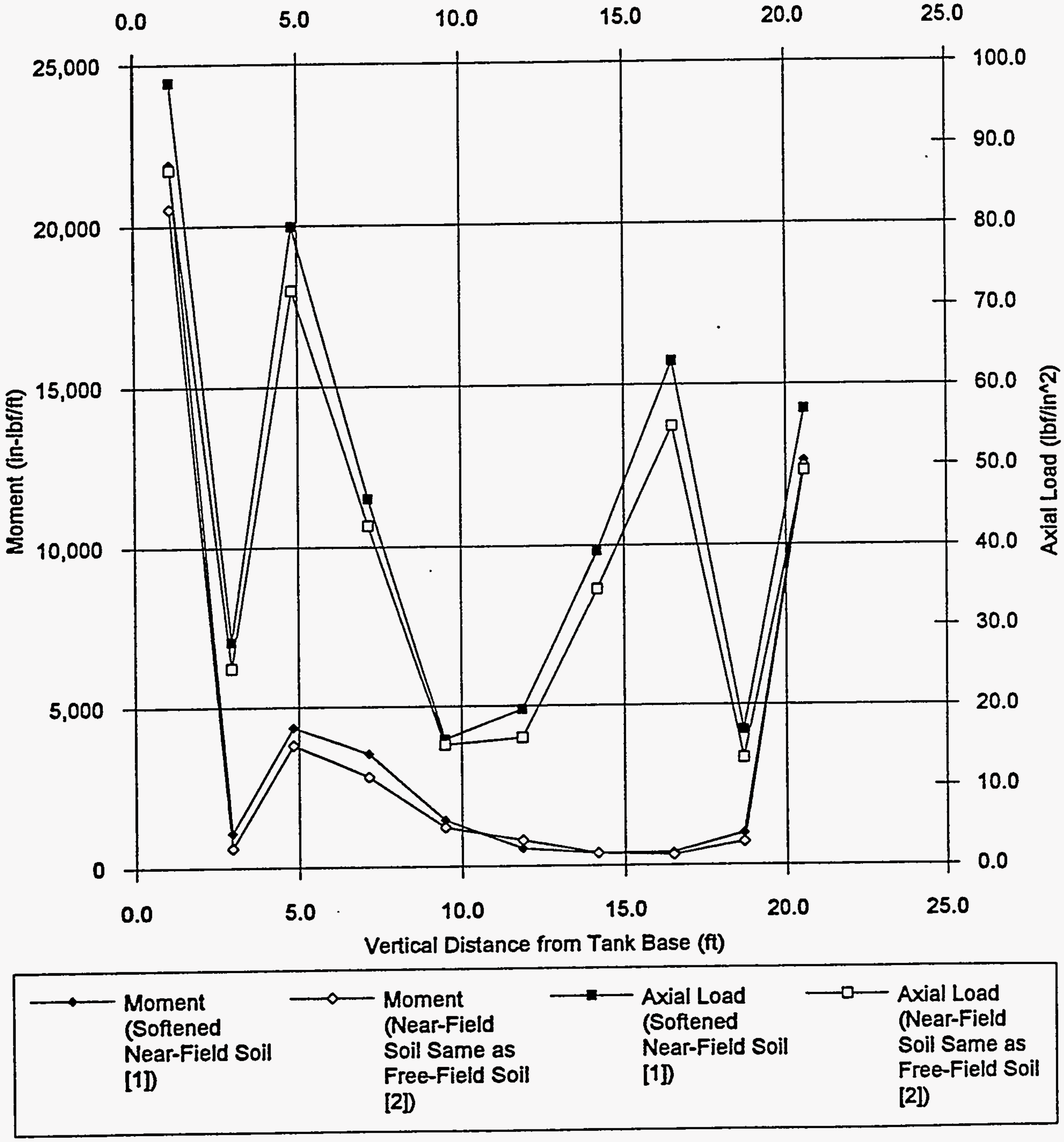
Figure V-3. Meridional Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Near-Field Soil Moduli



Note: [1] = Run ID "cmot50 QLOWFIL", [2] = Run ID "cmot50 QLOWpnt4".

qlow\anl\cmot50\7freq\CWFILI.XLC

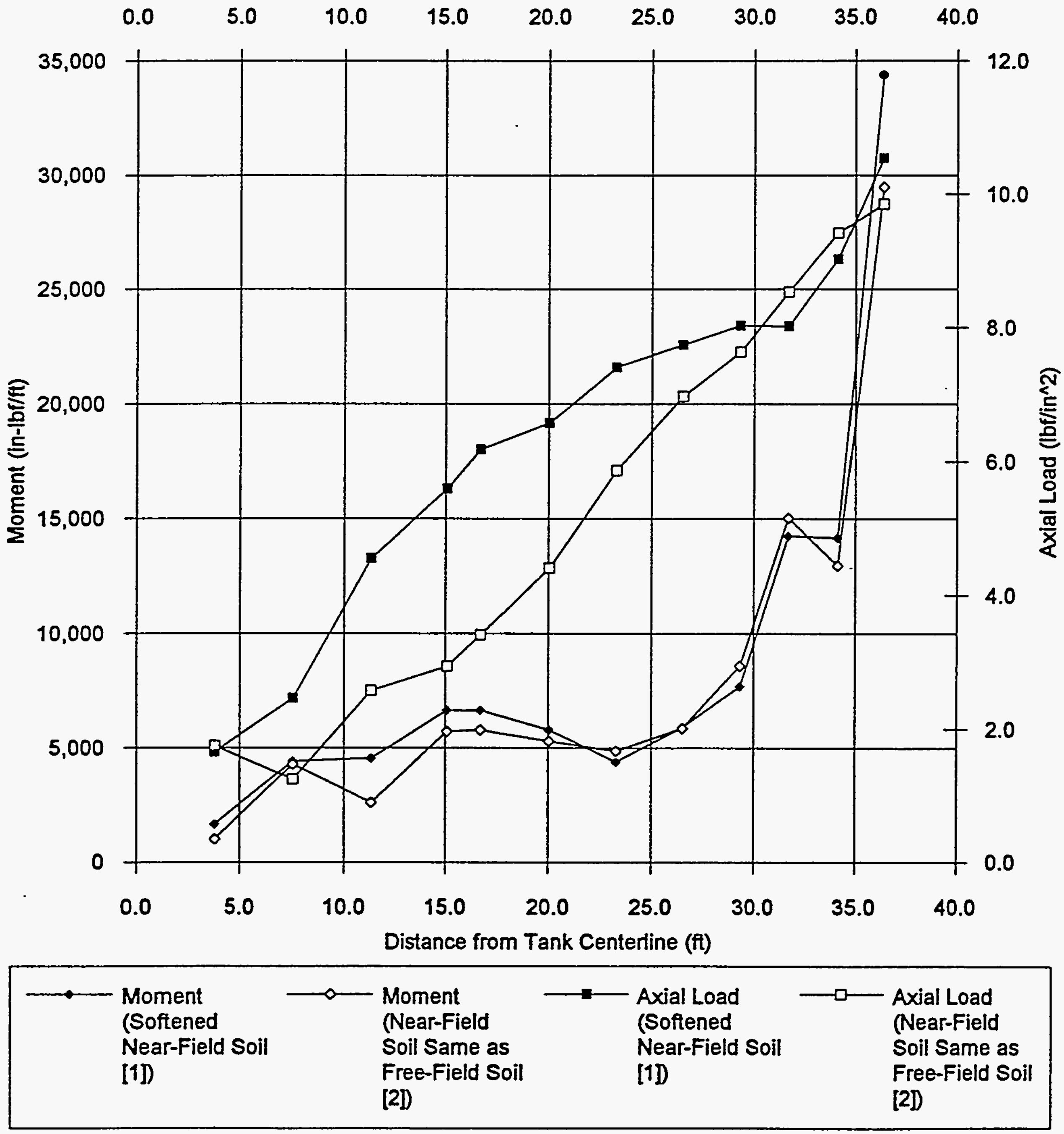
Figure V-4. Circumferential Seismic Response of Tank Wall at 180 deg Meridian from Horizontal Excitation: Sensitivity to Near-Field Soil Moduli



Note: [1] = Run ID "cmot50 QLOWFIL", [2] = Run ID "cmot50 QLOWpnt4".

qlow\anl\cmot50\7freq\CWFILO.XLC

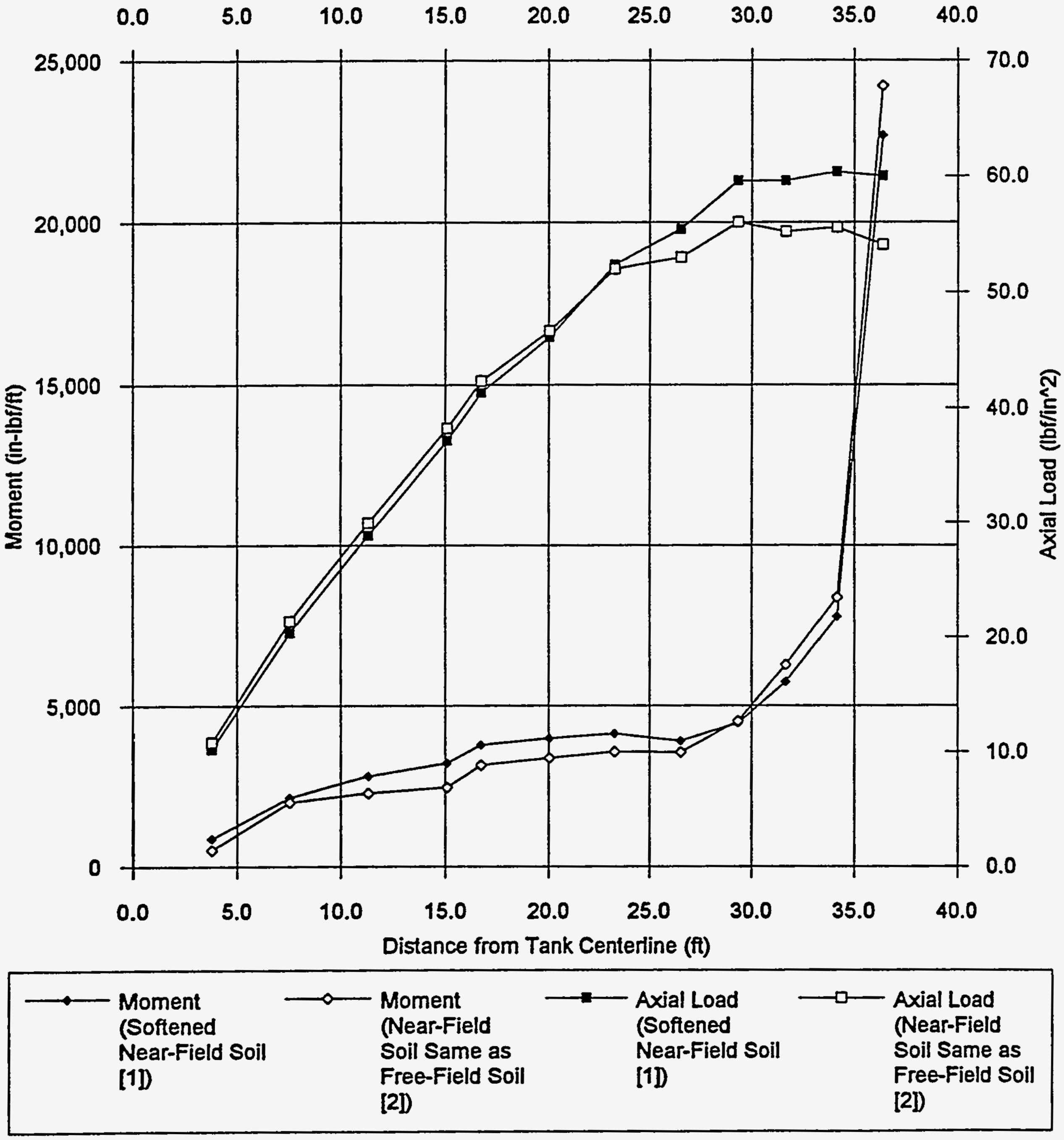
Figure V-5. Meridional Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Near-Field Soil Moduli



Note: [1] = Run ID "cmot50 QLOWFIL", [2] = Run ID "cmot50 QLOWpnt4".

qlow\lanl\cmot50\7freq\CDFILI.XLC

Figure V-6. Circumferential Seismic Response of Tank Dome at 180 deg Meridian from Horizontal Excitation: Sensitivity to Near-Field Soil Moduli



Note: [1] = Run ID "cmot50 QLOWFIL", [2] = Run ID "cmot50 QLOWpnt4".

qlow\anl\cmot50\7freq\CDFILO.XLC

APPENDIX W

CLARIFICATION OF DAMPING TERMS

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File: ADV9210.WP

October 12, 1994

Mr. Jim Day
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3 Crow Canyon Court, Suite 100
San Ramon, CA 94583

Voice 743-7777
Fax 743-0414

Subject: C-106 Tank Seismic Analysis
ADVENT Job No. 90005 EM 26000

Dear Jim:

Here are my comments on Question 10 of your fax dated 10.5.94.

It is indeed true that, strictly speaking, one should distinquish between the concepts of *fraction of critical damping*, as it is used in modal analysis, and *hysteretic damping* (or *damping ratio*), as the latter is used in material definition and in complex response analysis (SHAKE, FLUSH, SASSI, etc.). However, from a practical standpoint, there are no differences between these terms. As explained in the enclosure, Lysmer (1973), the situation is that a standard modal analysis of a structure using a fraction of critical damping equal to β will lead to essentially the same response as a complex response analysis using the complex moduli:

Shear modulus $G^*=G(\sqrt{1-\beta^2}-i\beta)^2$

Constrained modulus $M^*=M(\sqrt{1-\beta^2}-i\beta)^2$

The only difference between the two solutions is a phase shift of the order $\beta/2$ radians which, as shown in the enclosure, is insignificant for practical purposes. The amplitudes at all frequencies are exactly the same for the two solutions.

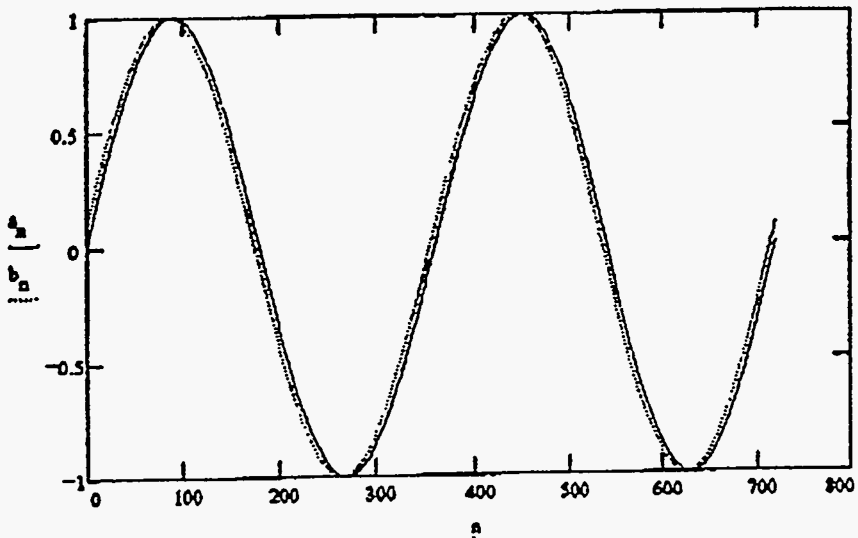
Sincerely yours,

John Lysmer

Enclosure

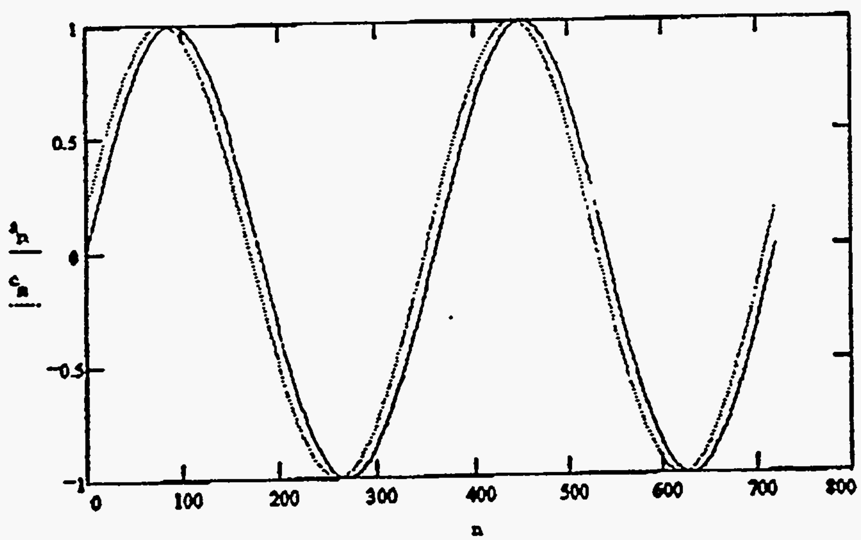
$n := 0, 1 .. 720$ Angle in degrees

$a_n := \sin\left(\frac{\pi}{180} \cdot n\right)$ $b_n := \sin\left[\frac{\pi}{180} \cdot (n + 5)\right]$ $c_n := \sin\left[\frac{\pi}{180} \cdot (n + 10)\right]$



Phase Error

5°



Phase Error

10°

University of California, Berkeley Geotechnical Engineering

MODAL DAMPING AND COMPLEX STIFFNESS

by John Lysmer 8/23/73

This note discusses the relationship between the fraction of critical damping which is commonly used in modal analysis and the concept of complex modulus or stiffness which is used in the method of complex response.

Consider first a simple damped oscillator subjected to a harmonic load with unit amplitude and frequency ω. The equation of motion is

$$m\ddot{x} + c\dot{x} + kx = e^{i\omega t} \tag{1}$$

or, after division with the mass m.

$$\ddot{x} + 2\beta\omega_o\dot{x} + \omega_o^2 x = \frac{1}{m} \cdot e^{i\omega t} \tag{2}$$

where

x = displacement

$\beta = \frac{c}{2\sqrt{km}}$ = fraction of critical damping

$\omega_o = \sqrt{\frac{k}{m}}$ = natural frequency

The steady state solution to Eq. 2 is

$$x = \frac{1/k}{(1-\alpha^2) + i2\beta\alpha} \cdot e^{i\omega t} \tag{3}$$

where α is the tuning ratio $\alpha = \omega/\omega_o$. The amplitude of the motion is

$$|x| = \frac{1/k}{\sqrt{(1-\alpha^2)^2 + (2\beta\alpha)^2}} \tag{4}$$

and the phase lag ϕ_1 between the displacement and the driving force is

$$\tan\phi_1 = \frac{2\beta\alpha}{1-\alpha^2} \tag{5}$$

Since modal analysis is essentially a decomposition of a multi-degree-of-freedom system into simple dampled oscillators the solution Eq. 2 represents a modal solution.

Next consider the use of complex stiffness in the method of complex response. In this method the equation of motion for the simple dampled oscillator is written:

$$m\ddot{x} + k^{*}x = e^{i\omega t} \tag{6}$$

where $k^{*} = k_1 + ik_2$ is a complex stiffness.

The steady state solution to Eq. 6 is:

$$x = \frac{1}{k^{*}-\omega^2 m} \cdot e^{i\omega t} \tag{7}$$

This response is different from the modal response given by Eq. 3 for any constant stiffness k^{*}. However, complete agreement in amplitude at all frequencies can be achieved if the following complex stiffness is choosen

$$\boxed{k^{*} = k(1-2\beta^2 + 2i\beta\sqrt{1-\beta^2})} \quad , \beta \leq 1 \tag{8}$$

Simple substitution into Eq. 7 and division by k will show that the response with this stiffness is

$$x = \frac{1/k}{1-2\beta^2-\alpha^2 + 2i\,\beta\sqrt{1-\beta^2}} \cdot e^{i\omega t} \tag{9}$$

which indeed has the amplitude given by Eq. 4 and the phase lag

$$\tan\phi_2 = \frac{2\,\beta\sqrt{1-\beta^2}}{1-2\beta^2-\alpha^2} \tag{10}$$

The phase difference between the two solutions can be found from Eqs. 5 and 10 which, with a trigonometric formula, yield the relation

$$\tan(\phi_2-\phi_1) = 2\beta \cdot \frac{(1-\alpha^2)\sqrt{1-\beta^2} - \alpha(1-2\beta^2-\alpha^2)}{(1-\alpha^2)(1-2\beta^2-\alpha^2) + 4\alpha\beta^2\sqrt{1-\beta^2}} \tag{11}$$

For the usual small values of β Eq. 12 reduces to

$$\boxed{\phi_2-\phi_1 \simeq \frac{2\beta}{1+\alpha}} \tag{12}$$

Hence, the largest difference in phase, 2β radian, occurs for static loading (α = 0). Near the peak on the response curve (α ≈ 1) the difference in phase is approximately β radian, and at higher frequencies the difference vanishes. A phase difference of β radian at the peak is usually quite insignificant for technical purposes (for β = 10% it corresponds to less then 6°).

TABLE I - DIFFERENCE IN PHASE LAG

(Computed from Eq. 11 . Values are given in degrees)

β	.05	.10	.15	.20	.25
α = 0	5.73°	11.48°	17.25°	23.07°	28.95°
α = .2	4.78°	9.57°	14.38°	19.24°	24.16°
α = .4	4.09°	8.20°	12.33°	16.50°	20.71°
α = .6	3.58°	7.18°	10.79°	14.43°	18.12°
α = .8	3.18°	6.38°	9.59°	12.82°	16.09°
α =1.0	2.87°	5.74°	8.63°	11.54°	14.48°
α =1.2	2.61°	5.22°	7.84°	10.48°	13.15°
α =1.4	2.39°	4.78°	7.19°	9.61°	12.05°
α =1.6	2.20°	4.41°	6.63°	8.87°	11.12°
α =1.8	2.05°	4.10°	6.16°	8.23°	10.32°
α =2.0	1.91°	3.82°	5.75°	7.68°	9.63°

The complex stiffness can also be written in exponential form:

$$k^* = k \cdot e^{i\delta} \tag{13}$$

where δ is called the loss angle. It expresses the phase lag between the causative force and the resulting displacement in the complex plane. It follows from Eq. 8 that:

$$\tan \delta = \frac{2\beta \sqrt{1-\beta^2}}{1-2\beta^2}, \quad \beta \leq 1 \tag{14}$$

which for small damping reduces to

$$\boxed{\delta \simeq 2\beta} \tag{15}$$

The above arguments can be extended to multi-degree-of-freedom systems like those encountered in dynamic finite element analysis. They show that in order to get good agreement between a modal analysis and a complex response analysis with complex moduli one must choose the following relationship between the real modulus G which is used in the modal analysis and the complex modulus G^* used in the complex response analysis

$$G^* = G(1-2\beta^2 + 2i\beta\sqrt{1-\beta^2}) \tag{16}$$

Even with this choice small deviations must be expected in the phase relationship between the two solutions. For small damping Eq. 16 can of course be simplified to

$$G^* \simeq G(1+2i\beta) \tag{17}$$

Similarly the best choice of complex wave velocities are

$$v_s^* = v_s \cdot e^{\frac{1}{2}\delta_s} \simeq v_s \ (1 + i\beta_s) \tag{18}$$

and

$$v_p^* = v_p \cdot e^{\frac{1}{2}\delta_p} \simeq v_p \ (1 + i\beta_p) \tag{19}$$

Where the subscripts S and P correspond to S- and P-waves, respectively.