Dta. 4

JUN 23 2003

ENGINEERING DATA TRANSMITTAL

1. EDT 637312

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) Design Engineering	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: Dome Load	6. Design Authority/Design Agent/Cog. Engr.: L.J. Julyk	7. Purchase Order No.: N/A
8. Originator Remarks: To release document		9. Equip./Component No.: Single-Shell Tanks
		10. System/Bldg./Facility: SX Tank Farm
		12. Major Assm. Dwg. No.: N/A
11. Receiver Remarks: None	11A. Design Baseline Document? ○ Yes ◉ No	13. Permit/Permit Application No.: N/A
		14. Required Response Date: N/A

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	RPP-14004	N/A	0	Sample AOR Calculation	N/A	1	1	1
				Using ANSYS Full				
				Parametric Model for Tank				
				SST-SX				

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
		Design Authority									
1	/	Design Agent L.J. Julyk	L.J. Julyk	6/17/03	R1-14						
		Cog. Eng.									
1	/	Cog. Mgr. C. Defigh-Price	C. Defigh-Price	6-19-03	R2-58						
		QA									
		Safety									
		Env.									

18.	19.	20.	21. DOE APPROVAL (if required)
L.J. Julyk 6/17/03	T.C. Mackey 6/19/03	C. Defigh-Price 6-19-03	Ctrl No. N/A
Signature of EDT Originator / Date	Authorized Representative for Receiving Organization / Date	Design Authority/ Cognizant Manager / Date	○ Approved ○ Approved w/comments ○ Disapproved w/comments

BD-7400-172-2 (10/97)

BD-7400-172-1

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	Design Engineering	Date 6/17/03
Project Title/Work Order: Sample AOR Calculation using ANSYS Full Parametric Model for Tank SST-SX (RPP-14004 Rev. 0)		EDT No. 637312
		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
M.A. Fish	R1-14				x
T.C. Oten	S5-07				x
E.R. Hamm	R1-31				x
M.R. Koch	S7-83				x
C. Defigh-Price	R2-58				x
L.J. Julyk	R1-14	x			
T.C. Mackey	R1-14	x			
A.H. Friberg	R1-14				X
Central Files	A3-88	X			
DOE Reading Room	H2-53	X			

A-6000-135 (10/97)

Sample AOR Calculation using ANSYS Full Parametric Model for Tank SST-SX

L.J. Julyk/T.C. Mackey
CH2M HILL Hanford Group, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC27-99RL14047

EDT/ECN: 637312 UC: N/A
Cost Center: 7G120 Charge Code: 102607
B&R Code: N/A Total Pages: 85

Key Words: single-shell tanks, analysis of record, SX farm, dome load, ANSYS

Abstract: This document documents the ANSYS parametric 360-degree model for single-shell tank SX and provides sample calculation for analysis-of-record mechanical load conditions.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Printed in the United States of America. To obtain copies of this document, contact: Document Control Services, P.O. Box 950, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.

JUN 23 2003
DATE:
STA: 4
HANFORD RELEASE
ID: 21

6/19/03

Release Approval Date Release Stamp

Approved For Public Release

RPP-14004
Revision 0

Sample AOR Calculation using ANSYS Full Parametric Model for Tank SST-SX

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.
Richland, Washington
Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC06-99RL14047

Approved for Public Release; Further Dissemination Unlimited

RPP-14004
Revision 0

Sample AOR Calculation using ANSYS Full Parametric Model for Tank SST-SX

L. J. Julyk / T. C. Mackey
CH2MHILL Hanford Group, Inc.

Xianghong Li / Jim Radochia
JLR The Engineering Solutions Company

Date Published
June 2003

CH2MHILL
Hanford Group, Inc.

P. O. Box 1500
Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC06-99RL14047

Approved for Public Release; Further Dissemination Unlimited

LEGAL DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been reproduced from the best available copy. Available in paper copy and microfiche.

Available electronically at
http://www.doe.gov/bridge. Available for a processing fee to the U.S. Department of Energy and its contractors, in paper, from:
U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865-576-8401
fax: 865-576-5728
email: reports@adonis.osti.gov(423) 576-8401

Available for sale to the public, in paper, from:
U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 800-553-6847
fax: 703-605-6900
email: orders@ ntis.fedworld.gov
online ordering:
http://www.ntis.gov/ordering.htm

Printed in the United States of America

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

Document Reviewed: RPP-14004, Rev. 0, Sample AOR Calculation using ANSYS Full Parametric Model for Tank SST-SX

Analysis performed by: Xianghong Li / Jim Radochia
JLR The Engineering Solutions Company

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

*Default values of changeable parameters in model are for example only. User of model must confirm proper input of parameter values for specific application of model.

An electronic version of model is available from undersigned. See attached ERATA sheet for any known problems with model.

Reviewer/Approver (print) L. J. Julyk / Design Engineering

Reviewer/Approver (signature) _____ 6/17/03
Date

CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed: RPP-14004, Rev. 0, Sample AOR Calculation using ANSYS Full Parametric Model for Tank SST-SX

Author: Xianghong Li / Jim Radochia
JLR The Engineering Solutions Company

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.

* Sample Calculation / Model Development
** Tank Vacuum Loading has error

B. V. Winkel (M&D)
B. V. Winkel — 6-10-03
Reviewer — Date

L. J. Julyk (CHG)
Julyk — 6/17/03
Reviewer — Date

ERRATA

ANSYS Macro	Tracking #	Issue Description	Recommended Action
Parm_sx_360.mac	1	Material properties are set at default values that may or may not be appropriate for specific analysis.	Verify material input values appropriate for specific analysis.
Parm_sx_360.mac and Sst_sx_360_slice.mac (see set material properties)	2	Concrete creep coefficients listed in report are incorrectly specified for implicit user-defined creep. Solid65 elements can only use explicit creep. Error is in report listing only; actual macro files are correct.	See RPP-13990 for proper creep coefficient specification and usage.
Pst_sx_360.mac	3	Resulting section force and moment plot/list may only be valid for 0 degrees in 360 degree full model. Path distances may not be correct; short by the sine of the angle at which the results are requested.	Verify proper operation for other than 0 degree position and correct macro accordingly.
sx_load_360.mac	4	Vacuum pressure is incorrectly applied on all surfaces of tank volume rather then on inside surface only.	Before using, correct macro to specify vacuum pressure on inside tank surface only.

ANSYS is a registered trademark of SAS IP, Inc.

TABLE OF CONTENTS

1.0 Objective/Purpose 4

2.0 Methods of Analysis 4

3.0 Input Data 4

4.0 Results 7

5.0 Remarks and Conclusions 16

6.0 References 17

7.0 Attachments and Appendices 18

sst_sx_360.mac 18

parm_sx_360.mac 51

sx_load_360.mac 55

pst_sx_360.mac 57

get_res_360.mac 73

get_hpfrc.mac 75

axial_path.mac 76

shear_path.mac 76

hoop_path.mac 77

moment_path.mac 77

plpng.mac 78

path_sx.plt 78

FIGURES

Figure 1 - Geometry of SST-SX tank 6

Figure 2 – Soil layers 6

Figure 3 – Total displacement contour of soil and tank 8

Figure 4 – Total displacement contour of tank 8

Figure 5 – Deformed shape of soil 9

Figure 6 – Deformed shape of tank 9

Figure 7 – Equivalent stress contours of tank and soil 10

Figure 8 – Equivalent stress contours of tank 10

Figure 9 – Hoop stress of tank 11

Figure 10 – Rebar stresses in element x direction 12

Figure 11 – Rebar stresses in element y direction 12

Figure 12 – Rebar stresses in element z direction 13

Figure 13 – Close up of rebar stresses in element x direction 13

Figure 14 – Close up of rebar stresses in element y direction 14

Figure 15 – Close up of rebar stresses in element z direction 14

Figure 16 – Unit section axial force 15

Figure 17 – Unit section shear force 15

Figure 18 – Unit section hoop force 16

Figure 19 – Unit section moment 16

TABLES

Table 1 – Input File List.....5

Table 2 – Results from Slice and 360-degree Models 17

1.0 OBJECTIVE/PURPOSE

The purpose of this calculation is to develop a parametric full model for the single shell tank (SST) SX to deal with asymmetric loading conditions and provide a sample analysis of the SST-SX tank based on analysis of record (AOR) loads. The SST-SX model is based on buyer-supplied as-built drawings and information for the AOR for SSTs, encompassing the existing tank load conditions, and evaluates stresses and deformations throughout the tank and surrounding soil mass.

These sample calculations in this document are not to be used for assessing the structural integrity of the SST-SX tanks at the Hanford site.

2.0 METHODS OF ANALYSIS

1. A 360-degree full model of the SST-SX tanks was first developed using the ANSYS Parametric Design Language (APDL) in ANSYS 7.0, a general purpose finite element analysis program [Ref_1]. Compared with the linear model reported in RPP-13991 [Ref_5], the 3D full model includes some non-linear characteristics of the analysis, such as a) contact between the soil and tank with friction, b) plastic soil material. Also, the reinforcement bars embedded in the concrete tank were included for this analysis.

2. The parametric model of the SST-SX tank was then analyzed based on AOR loads. Contour plots showing stress and displacement are provided, as well as path plots showing section force/moment.

3.0 INPUT DATA

All input data, such as tank geometry, backfill depth, material properties, real constants, and element coordinate systems, are the same as stated in RPP-13992 [Ref_6]. This model can be viewed as an extended version of the 3-degree slice model described in RPP-13992 [Ref_6].

The parametric inputs used in this calculation are summarized in the attachments. The files and their functions are listed in Table 1.

Table 1. Input File List

Input File Name	Function	Calling For
sst_sx_360.mac	Main input creating 360-degree parametric model for SST-SX tank and getting solutions	parm_sx_360.mac sx_load_360.mac
parm_sx_360.mac	Set all parametric variables used to create the parametric model	NONE
sx_load_360.mac	Apply boundary conditions and AOR loads	NONE
pst_sx_360.mac	Calculate section forces/moments and generate path plots, output path data to path_sx.dat file	get_res_360.mac get_hpfrc.mac plpng.mac path_sx.plt axial_path.mac shear_path.mac hoop_path.mac moment_path.mac
get_res_360e.mac	Calculate total forces and moments at individual cross section	NONE
get_hpfrc.mac	Calculate hoop force from hoop stress results	NONE
plpng.mac	Create image hard copy in png format	NONE
path_sx.plt	View setting for path plot	NONE
axial_path.mac	Define and plot the path plot of axial force	NONE
shear_path.mac	Define and plot the path plot of shear force	NONE
hoop_path.mac	Define and plot the path plot of hoop force	NONE
moment_path.mac	Define and plot the path plot of moment	NONE

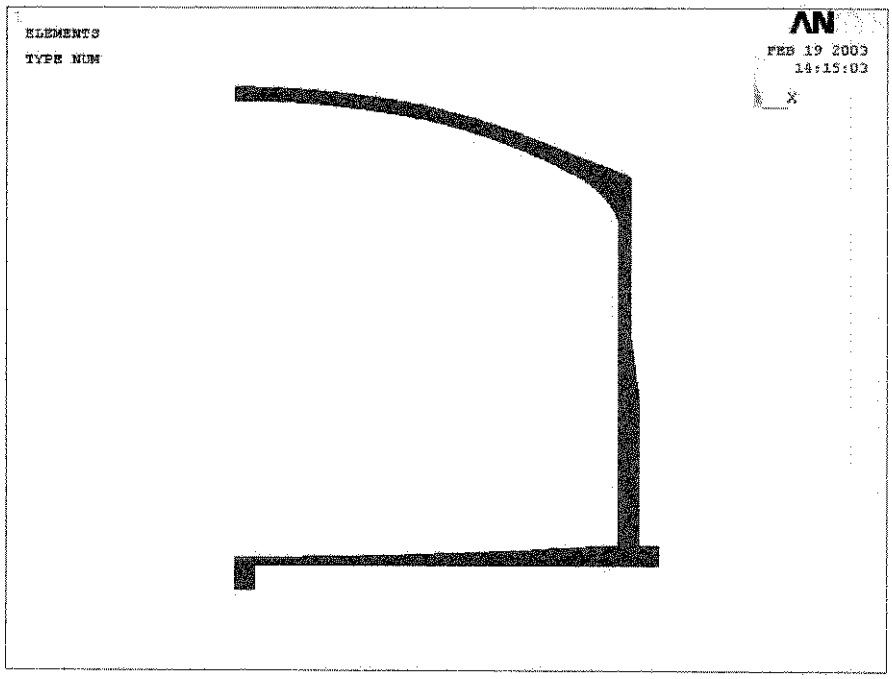

Figure 1. Geometry of SST-SX Tank

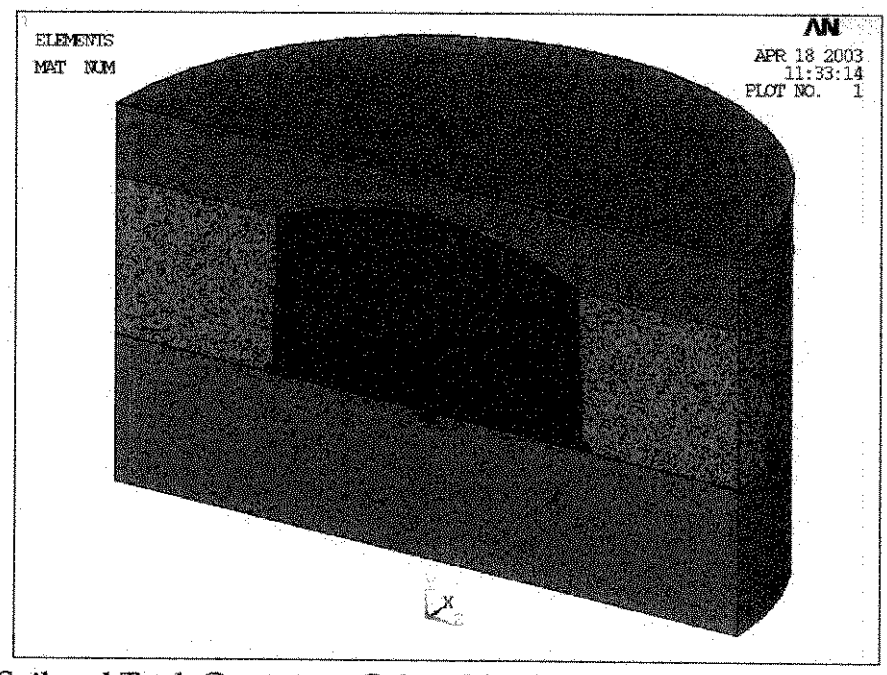

Figure 2. Soil and Tank Geometry, Colored by Material Properties (Only Half Model is Shown)

4.0 RESULTS

The solution can be obtained by running the master input macro **sst_sx_360.mac** (see attachment), which loads the macro defining the parameters, creates the tank/soil geometry and finite element mesh, applies loads, and defines the material properties and real constants.

Figures 3 and 4 summarize the displacement response due to AOR loads identified in Section 3. The peak displacement of the soil mass is 2.08 inches, and this occurs at grade far away from the tank. The peak tank displacement is 1.34 inches at the dome apex. Figures 5 and 6 show exaggerated views of the tank/soil displacement.

The von Mises equivalent stress contours are presented in Figures 7 and 8. The peak equivalent stress in the tank is approximately 2.2 ksi, and this occurs at the joint of the tank wall and slab. The hoop stress of the tank is shown in Figure 9. The maximum hoop stress is about 446 psi at the haunch region, and the minimum hoop stress is -820 psi at the wall/slab joint. The rebar stresses in the first, second, and third rebar directions are plotted in Figures 10 to 15.

Force and moment resultants are calculated in **pst_sx_360b.mac**. The syntax of **pst_sx_360b.mac** is "pst_sx_360b, angle", where parameter "angle" is the location of the cross section in "degree". It can be any real number, but will be rounded to the nearest section lying on element boundaries. In order for **pst_sx_360b.mac** to generate correct results, the tank has to be map meshed. The mapped mesh results in a set of nodes aligned in a straight line, creating a cross section for section force and moment evaluation. Once the cross section nodes and elements attached to one side of the nodes are selected, the macro **get_res_360.mac** then calculates the nodal forces, determines the location of the neutral axis, and evaluates the moment about the neutral axis. The force and moment per unit length are calculated according to the radius of the neutral axis. The section hoop force is calculated in macro **get_hpfrc.mac**. The nodal hoop stresses are retrieved and averaged over the thickness. The hoop force over the meridional length is then obtained from the averaged nodal hoop stress and wall thickness. Figures 16 to 19 show the axial force, shear force, hoop force, and moment, respectively. The wall/slab joint sees the most severe loading, with maximum axial force of about 87 kip/ft, maximum shear force of 41 kip/ft, and maximum moment of 1618 kip-in/ft. Maximum hoop force of 94 kip/ft occurs at the haunch region.

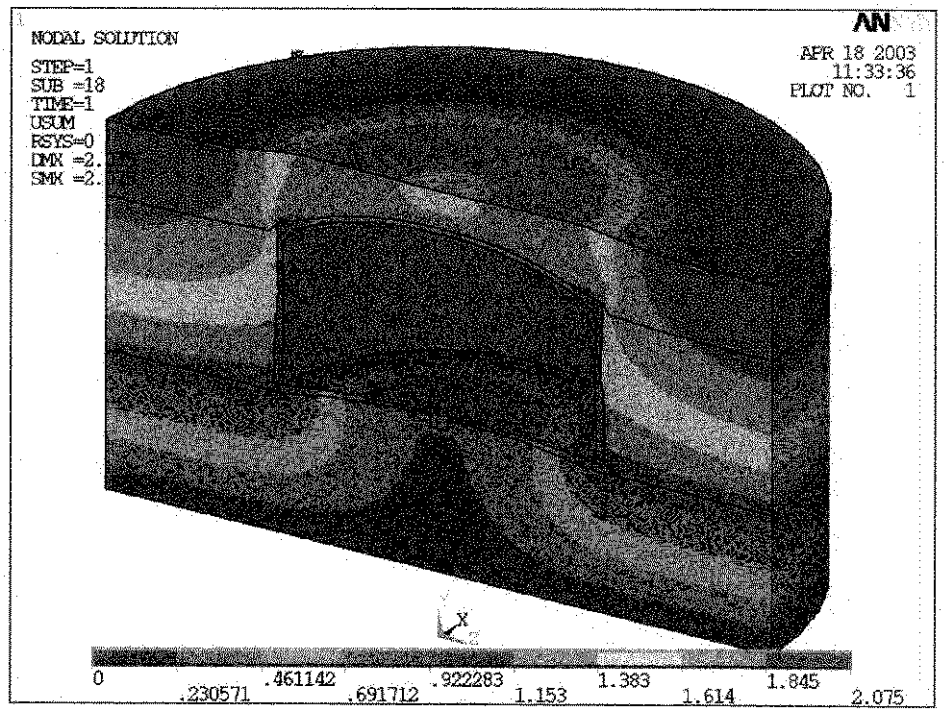

Figure 3. Total displacement contour of soil and tank

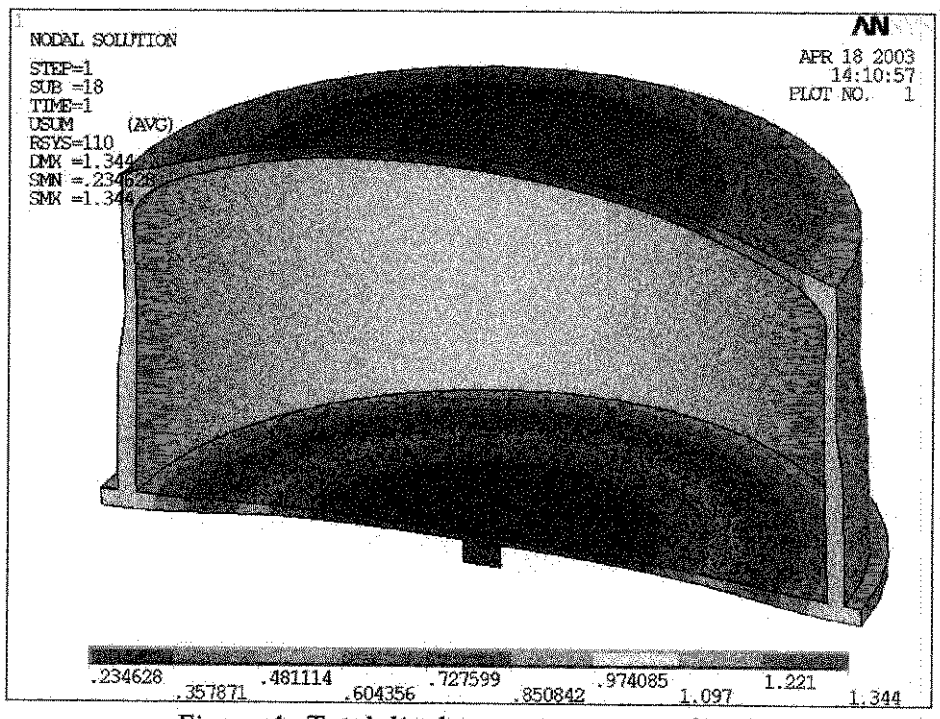

Figure 4. Total displacement contour of tank

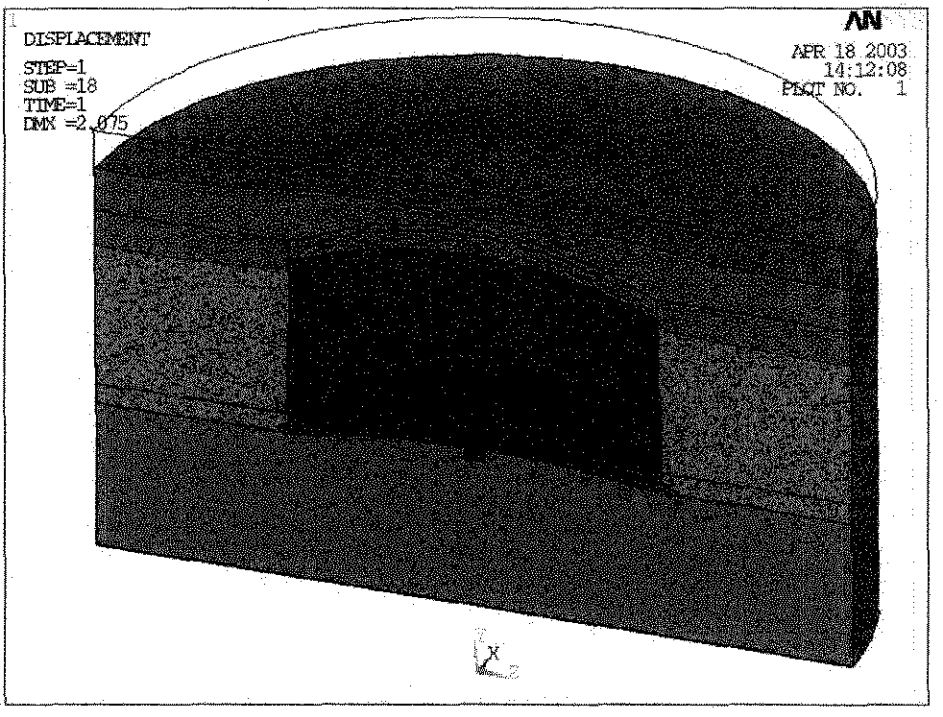

Figure 5. Deformed shape of soil

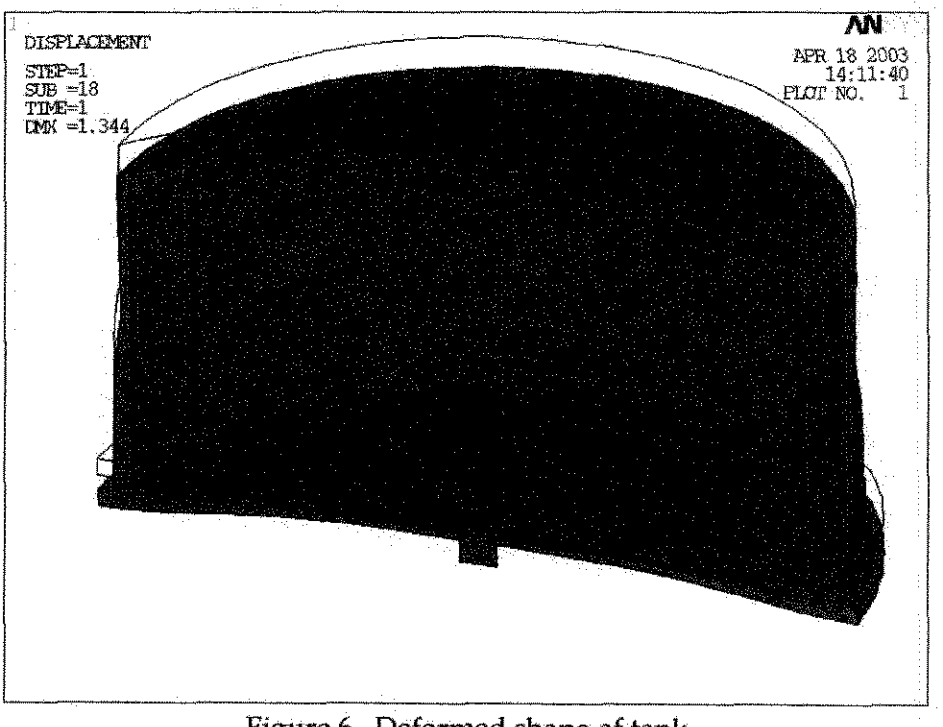

Figure 6. Deformed shape of tank

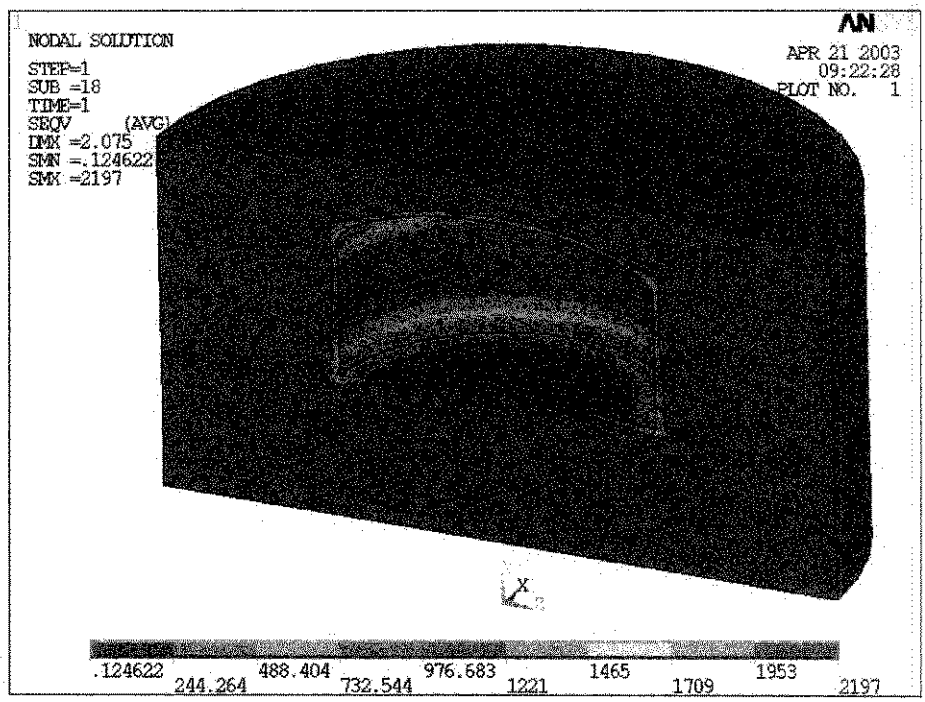

Figure 7. Equivalent stress contours of tank and soil (psi).

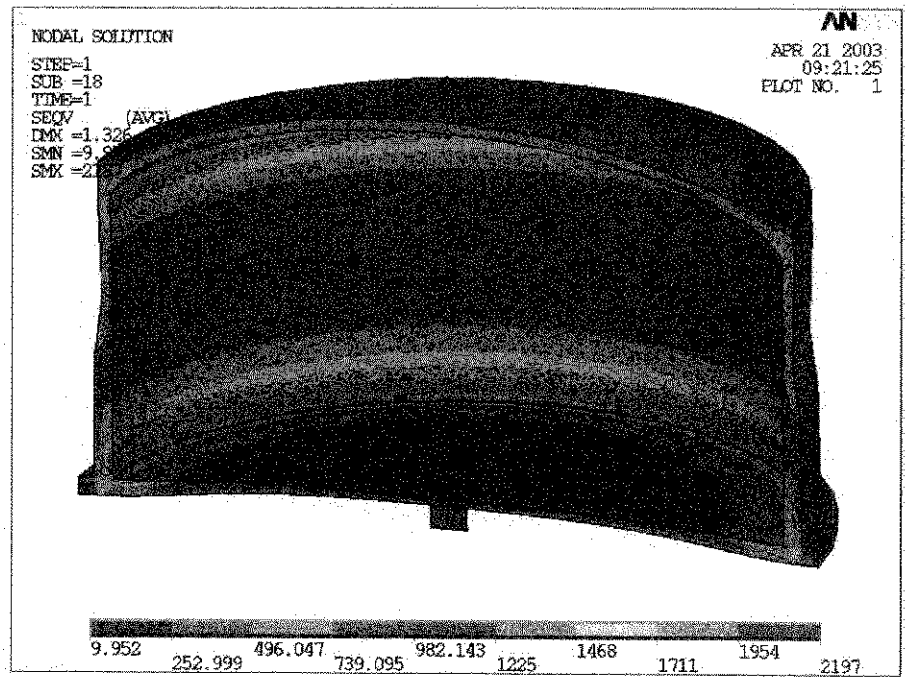

Figure 8. Equivalent stress contours of tank (psi).

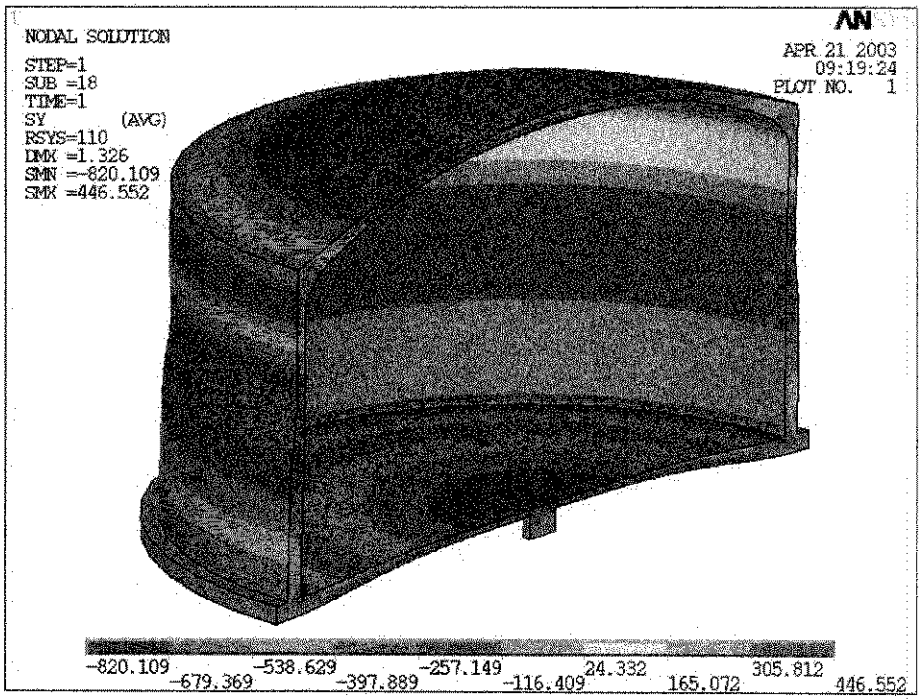

Figure 9. Hoop stress of tank (psi)

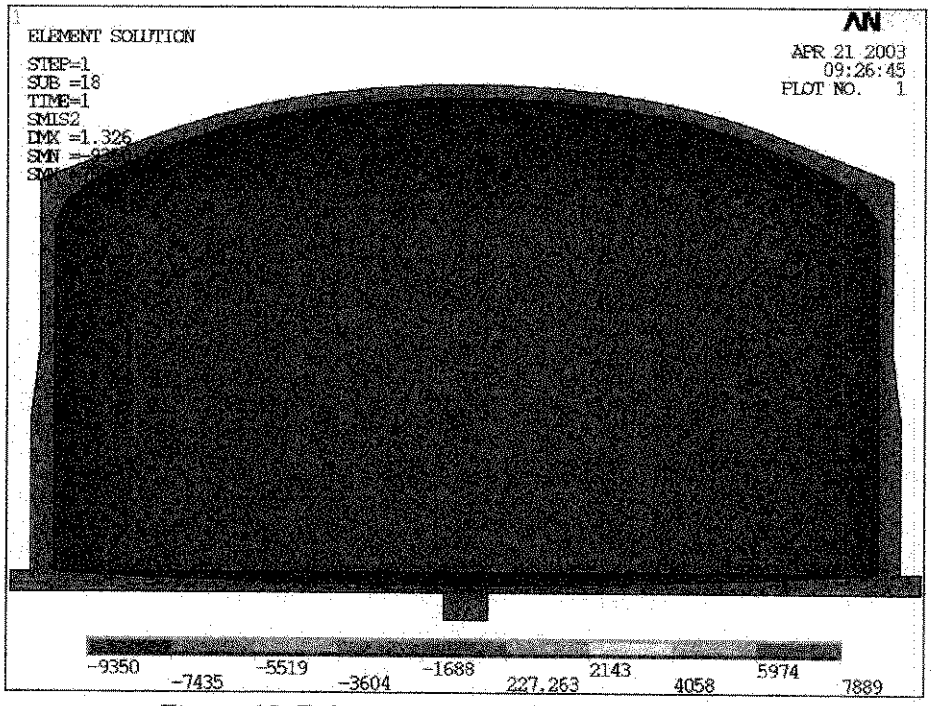

Figure 10. Rebar stresses in first rebar direction

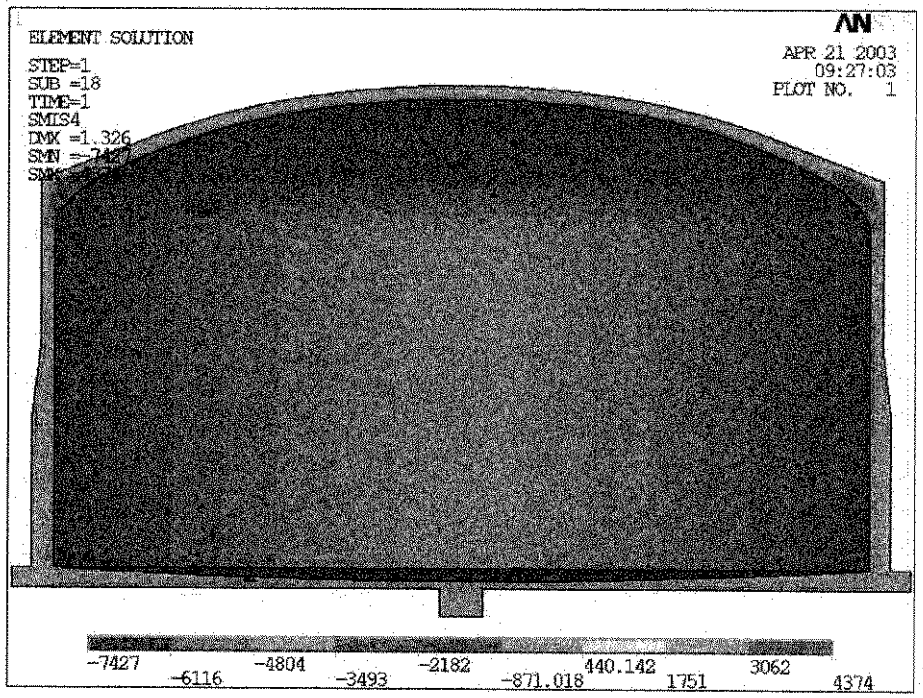

Figure 11. Rebar stresses in second rebar direction

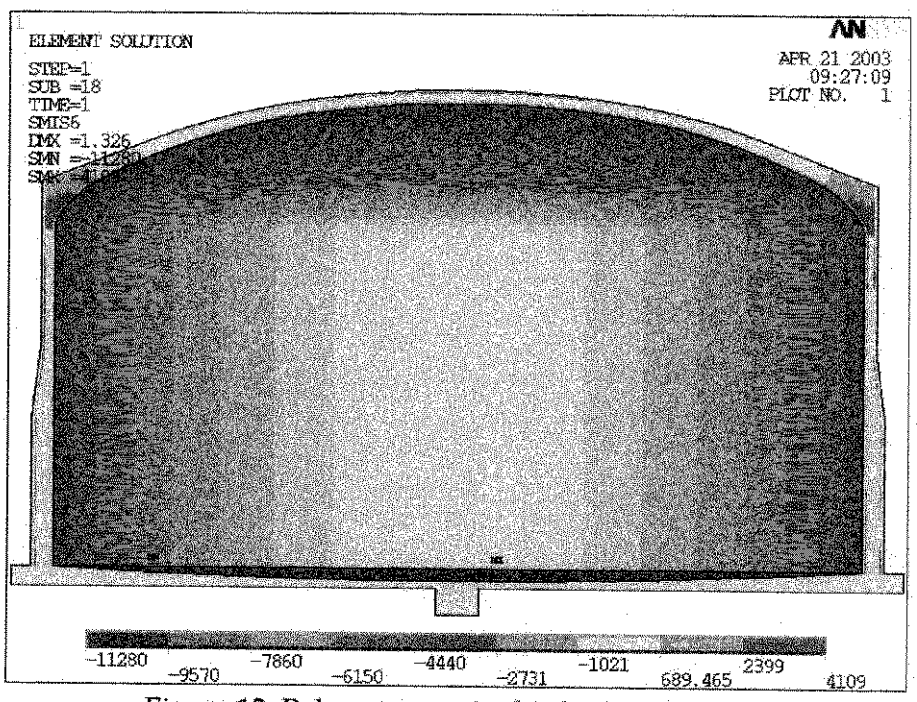

Figure 12. Rebar stresses in third rebar direction

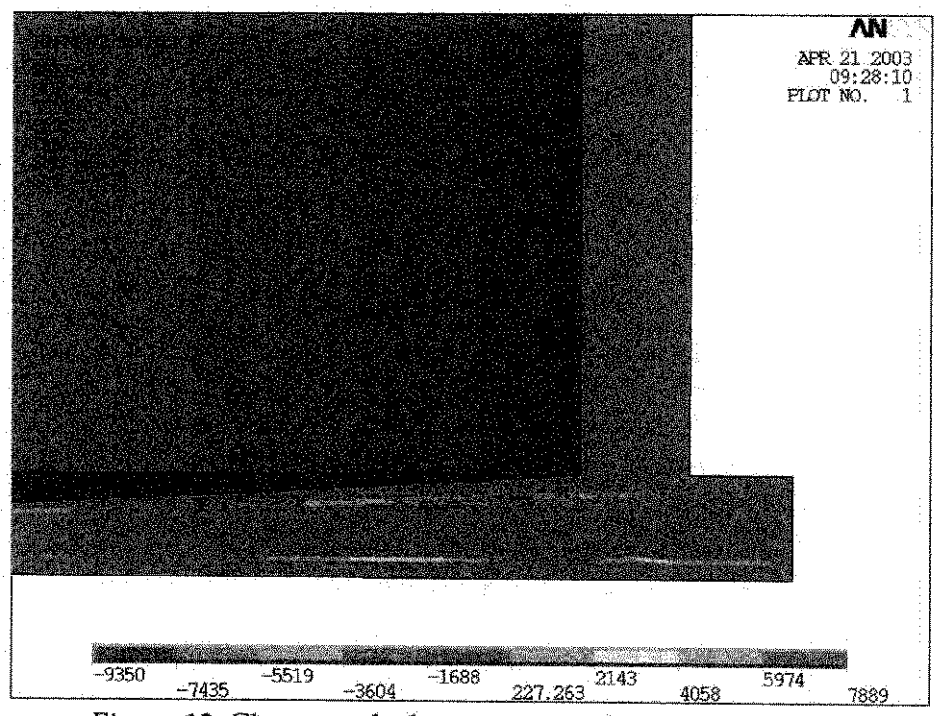

Figure 13. Close up of rebar stresses in first rebar direction

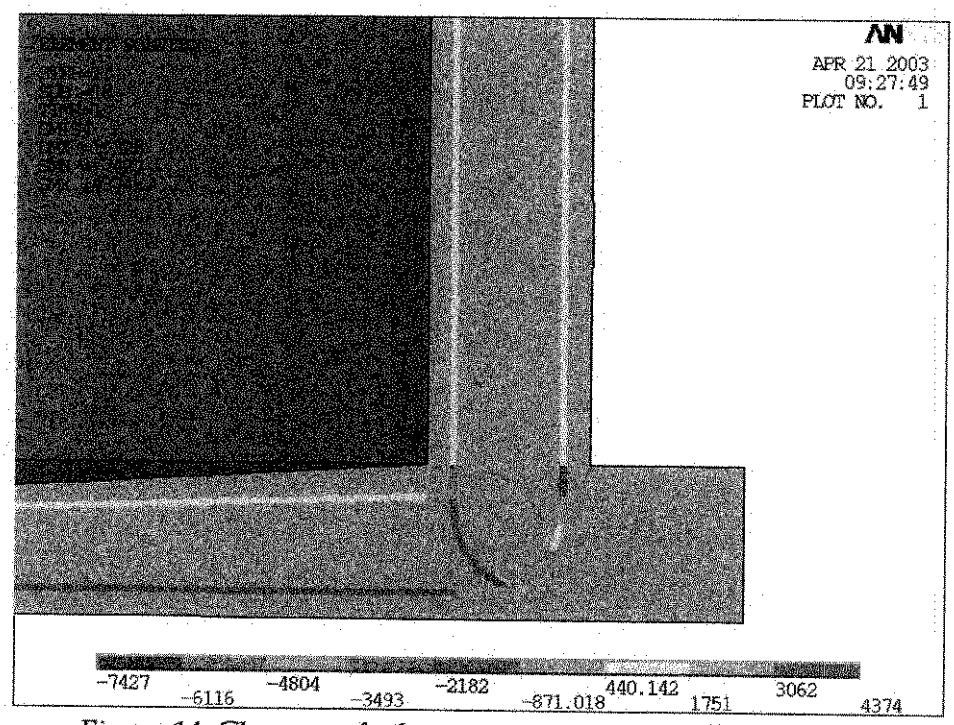

Figure 14. Close up of rebar stresses in second rebar direction

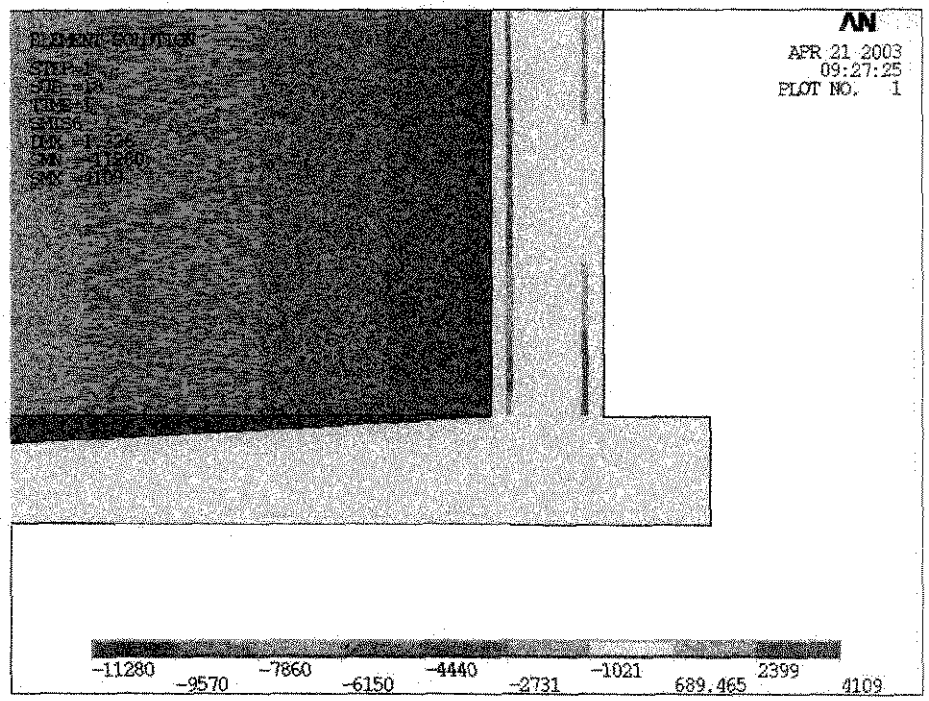

Figure 15. Close up of rebar stress in third rebar direction

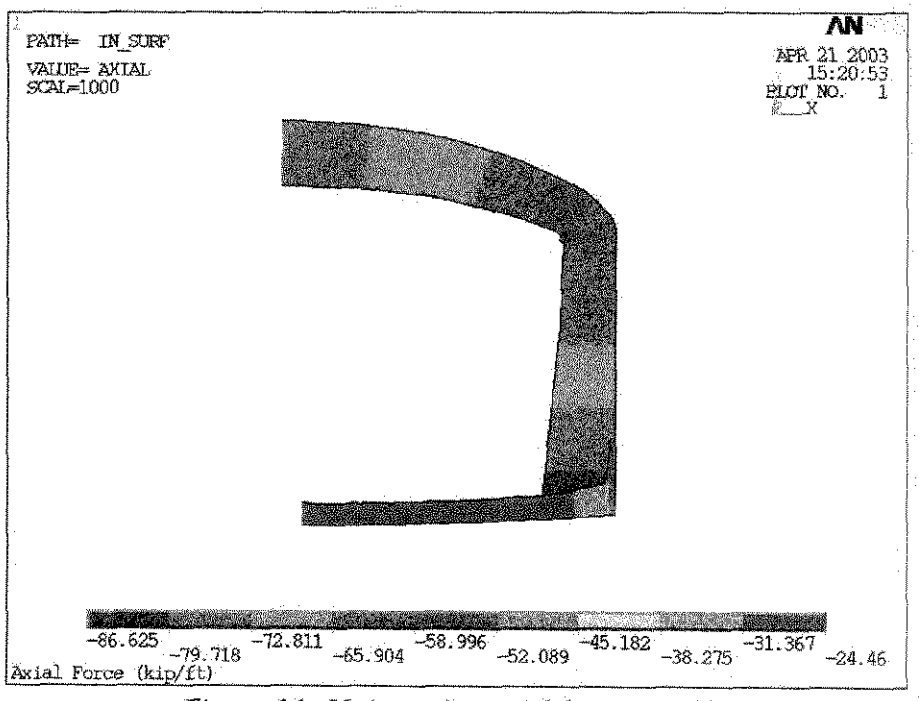

Figure 16. Unit section axial force (kip/ft)

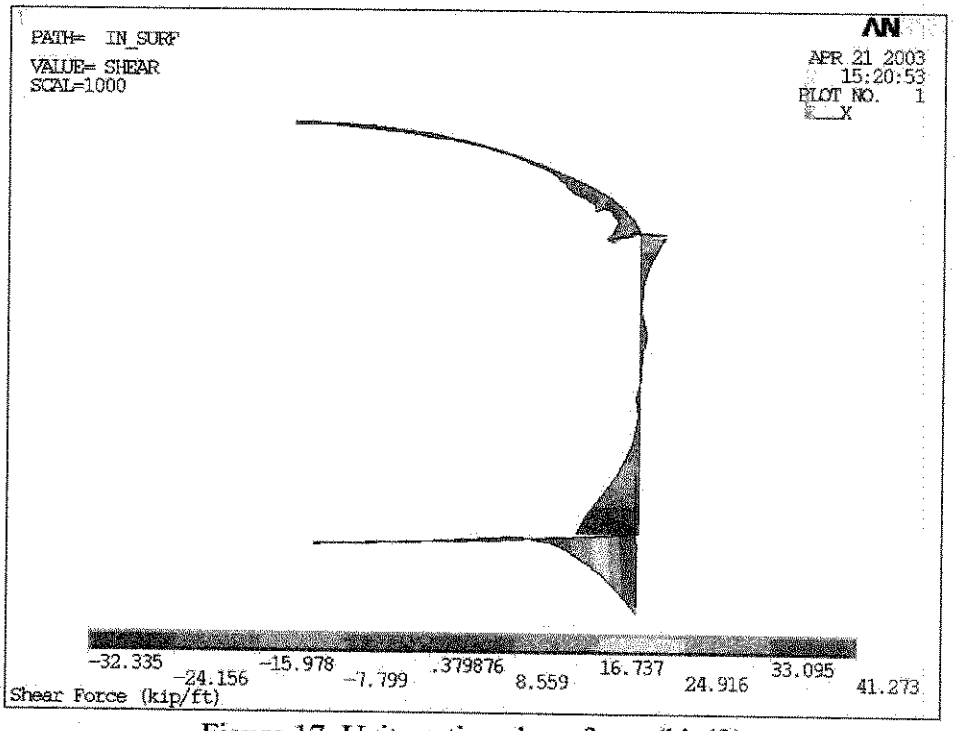

Figure 17. Unit section shear force (kip/ft)

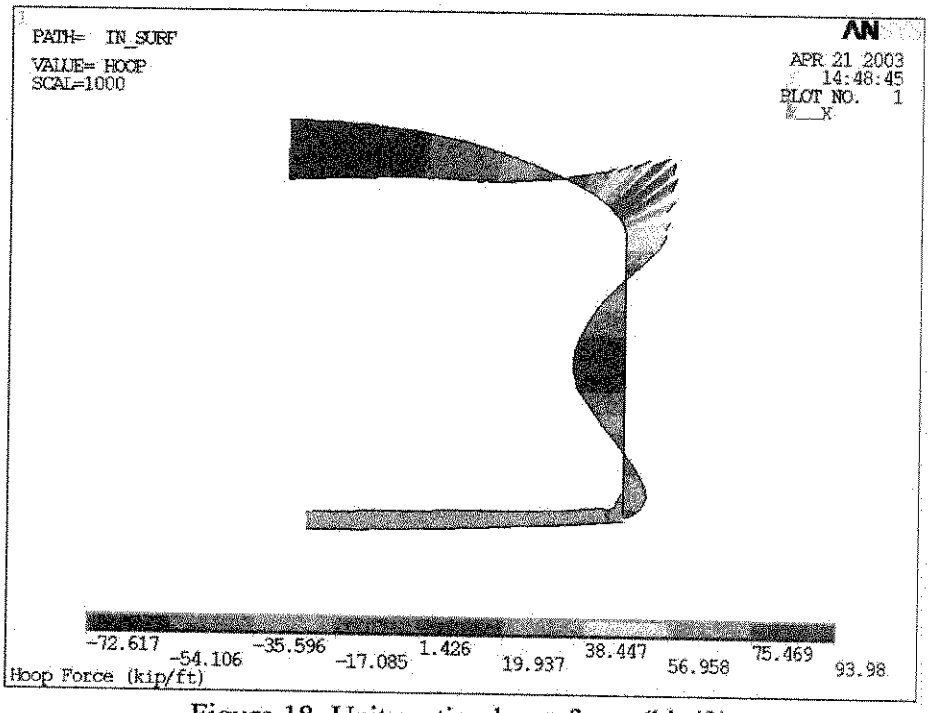

Figure 18. Unit section hoop force (kip/ft)

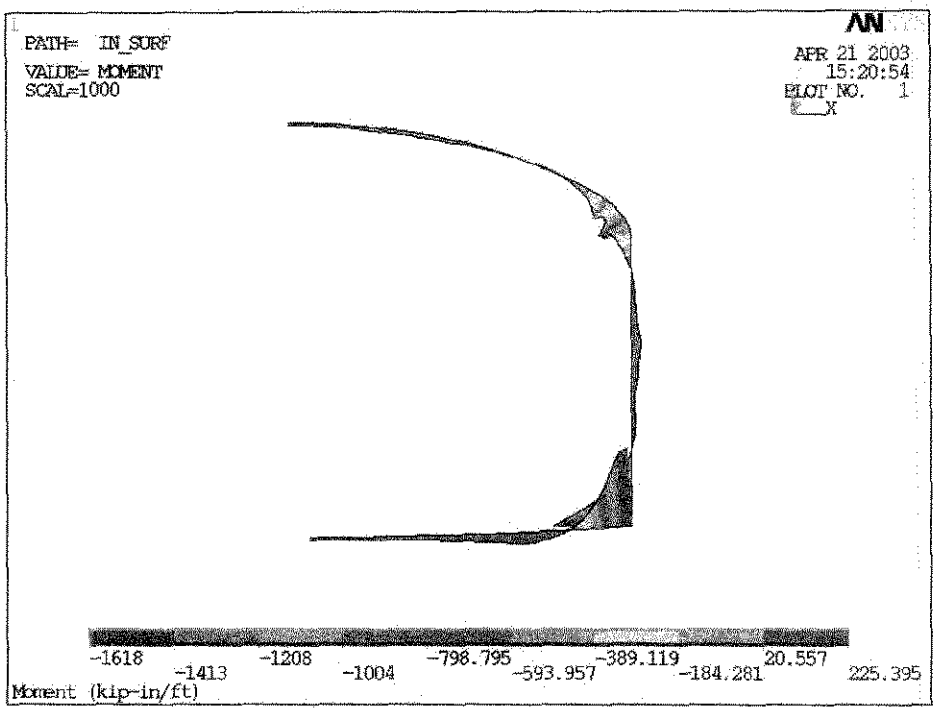

Figure 19. Unit section moment (kip-in/ft)

5.0 REMARKS AND CONCLUSIONS

The results obtained for the AOR loading using the 360-degree parametric model (full model) are slightly different from those using the slice model. Table 2 lists the results from the two models. The largest variation occurred for maximum shear force results, which decreased 12.7% in the full model. The difference is mainly caused by the element size difference in the two models. The full model has a much coarser mesh than the slice model to reduce the total run time. The coarsening occurs in both the cross section and circumferential directions. For the purpose of this calculation, current mesh density is adequate to validate the capability of the full model.

Table 2. Results From Slice and 360-degree Models

Model	Tank Max. Displacement (in)	Max. Stress (ksi)	Max. Axial Force (kip/ft)	Max. Shear Force (kip/ft)	Max. Hoop Force (kip/ft)	Max. Moment (kip-in/ft)
slice	1.33	2.3	85	47	97	1786
full	1.34	2.2	87	41	94	1618
Variation	+.75%	-4.3%	+2.3%	-12.7%	-3.1%	-9.4%

The 360-degree parametric model is capable of giving a complete estimate on various loading condition, axisymmetric or asymmetric, compared with the slice model which can only be used to evaluate axisymmetric loading conditions. A sample calculation demonstrates the use of the parametric model for tank SST-SX, and provides examples of both the types of inputs that can be defined and the types of outputs that can be obtained. The parametric model can be used effectively to evaluate the tank response to a broad range of loading conditions and material properties.

6.0 REFERENCES

[Ref_1] ANSYS 7.0 General-Purpose Finite Element Analysis Program, ANSYS Inc.

[Ref_2] M&D Professional Services, "Dome Load Evaluation for Hanford 241-C Farm 100-Series Tanks", Document Number RPP-14249, January 14, 2003.

[Ref_3] Statement of Work, Requisition #92879, "Development of ANSYS Finite Element Models for SST and DST Tanks," Revision 1, February 24, 2003.

[Ref_4] Drawing H-2-39511, September 2, 1953

[Ref_5] JLR The Engineering Solutions Company, "Sample AOR Calculation Using ANSYS Axisymmetric Parametric Model for Tank SST-SX", RPP-13991, March 11, 2003

[Ref_6] JLR The Engineering Solutions Company, "Sample AOR Calculation Using ANSYS Slice Parametric Model for Tank SST-SX", RPP-13992, April 11, 2003

7.0 ATTACHMENTS AND APPENDICES

sst_sx_360.mac

```
!--Create cross section of SST SX tank
finish
/clear
/prep7

SHPP,MODIF,1,1000,
/INPUT,'parm_sx_360','mac'

!--Create dome
/TRIAD,RTOP
k,1,
wpcsys,-1,0
wpoff,,dm_r1,
csys,4
k
*get,k_max,kp,,num,max
*get,x_loc,kp,k_max,loc,x
*get,y_loc,kp,k_max,loc,y
k,,,dm_r2-dm_r1
k,,x_loc-dm_dr1,y_loc-dm_oh1
k,,x_loc-dm_dr3-dm_dr1,y_loc-dm_oh2
k,,x_loc-tk_or1,y_loc-hnch_h1

*get,x_loc,kp,3,loc,x
*get,y_loc,kp,3,loc,y
k,,x_loc-dm_dr2,y_loc-dm_ih1
*get,x_loc,kp,7,loc,x
*get,y_loc,kp,7,loc,y
k,,x_loc-dm_dr4,y_loc-dm_ih2
*get,x_loc,kp,8,loc,x
*get,y_loc,kp,8,loc,y
k,,x_loc-hnch_dr3,y_loc-hnch_h3
*get,x_loc,kp,9,loc,x
*get,y_loc,kp,9,loc,y
k,,x_loc-hnch_dr4,y_loc-hnch_h4

*get,x_loc,kp,6,loc,x
*get,y_loc,kp,6,loc,y
k,,x_loc,y_loc-hnch_h2

*get,x_loc,kp,11,loc,x
*get,y_loc,kp,11,loc,y
k,,x_loc,y_loc-tk_h1

*get,x_loc,kp,12,loc,x
*get,y_loc,kp,12,loc,y
```

```
k,,x_loc-(tk_t2-tk_t1),y_loc-tk_h2

*get,x_loc,kp,13,loc,x
*get,y_loc,kp,13,loc,y
k,,x_loc,y_loc-tk_h3

*get,x_loc,kp,14,loc,x
*get,y_loc,kp,14,loc,y
k,,x_loc-slb_dr,y_loc

*get,x_loc,kp,15,loc,x
*get,y_loc,kp,15,loc,y
k,,x_loc,y_loc-slb_t1

*get,x_loc,kp,3,loc,x
*get,y_loc,kp,16,loc,y
k,,x_loc-slb_dr2,y_loc

*get,x_loc,kp,17,loc,x
*get,y_loc,kp,17,loc,y
k,,x_loc,y_loc-slb_dt1

*get,x_loc,kp,3,loc,x
*get,y_loc,kp,18,loc,y
k,,x_loc,y_loc

*get,x_loc,kp,3,loc,x
*get,y_loc,kp,19,loc,y
k,,x_loc,y_loc+slb_dt1+slb_dt2+slb_dt3

*get,x_loc,kp,10,loc,x
*get,y_loc,kp,10,loc,y
k,,x_loc,y_loc-tk_h4+slb_dh2

lstr,2,3

larc,2,4,1,dm_r1
larc,4,5,1,dm_r3
larc,3,7,1,dm_r2
larc,7,8,1,dm_r4
lstr,5,6
larc,8,9,1,hnch_r1
larc,9,10,1,hnch_r2
lstr,6,11
lstr,11,12
lstr,12,13
lstr,13,14
lstr,14,15
lstr,15,16
lstr,16,17
lstr,17,18
```

```
lstr,18,19
lstr,19,20
larc,20,21,3,liner_r1
lstr,10,21
al,all

*get,x_loc,kp,21,loc,x
*get,y_loc,kp,21,loc,y
k,,x_loc-slb_dr3,y_loc

*get,x_loc,kp,22,loc,x
*get,y_loc,kp,21,loc,y
k,,x_loc-slb_dr4,y_loc-slb_dh

*get,x_loc,kp,20,loc,x
*get,y_loc,kp,20,loc,y
k,,x_loc,y_loc-slb_dt3

lstr,21,22
larc,23,24,3,slb_r1
lstr,23,14
lsel,s,,,22,23
asel,s,,,1
asbl,all,all

lsel,none
lstr,21,23
*get,l_num,line,,num,min
asel,s,,,3
lsel,s,,,l_num
asbl,all,all

allsel
lsel,none
lstr,10,11
*get,l_num,line,,num,min
asel,s,,,4
lsel,s,,,l_num
asbl,all,all

allsel
lwplan,-1,7
asbw,5

wpcsys,-1,0
kwpave,2
wpoff,,depth
csys,4
rectng,0,-soil_r,0,-soil_h,
allsel
aovlp,all
```

```
adele,7,,,1

allsel
wpcsys,-1,0
wprot,,90
cswpla,11,0
cswpla,12,1

kwpave,2
wprot,,90
wprot,,,90
off_set1=5*12
off_set2=3*12
wpoff,,,-tk_or1-off_set1
asbw,8
kwpave,19
wprot,,90
wpoff,,,-off_set2
asbw,5
asbw,7

csys,0
arsym,x,all,,,,1,0
asel,s,loc,x,0,-99999
adele,all,,,1
allsel
numcmp,all
wpcsys,-1,0
wprot,,,90
kwpave,35
wpoff,,,cload_1
lsbw,41

!--cut soil for different soil properties
kwpave,20
wprot,,90
asbw,8
asbw,9
kwpave,11
asbw,10
asbw,12
wprot,,-90

!------- Cut tank for mesh
allsel
asel,u,,,7,11
asel,u,,,5
asel,u,,,13,14
allsel,below,area
kwpave,10
wprot,,90
```

```
asbw,2
kwpave,13
wprot,,-90
asbw,15
kwpave,7
asbw,16
kwpave,10
asbw,17
wprot,,90
kwpave,15
asbw,3
kwpave,16
asbw,19
adele,1,,,1
lcomb,4,5
cm,a_tank,area

!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
!
!    Cut dome for rbar regions
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]

rbar_dep=2  !clearance for rbar @dome
rbar_t=1.
rbar_dep2=3.375 !clearance for interior rebar @ wall
rbar_dep3=3.625 !clearance for exterior rebar @ wall
rbar_dep4=3.5     !clearance for bottomr rebar @ slab
rbar_dep5=11.75 !distance from top slab rbar to slab bottom(int. end)
rbar_dep6=19.25   !distance from top slab rbar to slab bottom(ext. end)

csys,4
lwpla,-1,27
wpoff,,,rbar_dep
k
wpoff,,,rbar_t
k
lwpla,-1,27,1
wpoff,,,-rbar_dep
k
wpoff,,,-rbar_t
k

kwpla,-1,28,30
wpoff,rbar_dep
k
wpoff,rbar_t
k
kwpla,-1,30,28
wpoff,rbar_dep
k
```

```
wpoff,rbar_t
k

lwpla,-1,31,1
lsbw,29
wpoff,rbar_dep
k
wpoff,rbar_t
k
kwpave,53
wpoff,-rbar_dep
k
wpoff,-rbar_t
k


lwpla,-1,22
wpoff,,,rbar_dep
k
wpoff,,,rbar_t
k
kwpave,21
wpoff,,,-rbar_dep
k
wpoff,,,-rbar_t
k

lstr,4,5
lstr,47,48
larc,4,51,8,dm_r1-rbar_dep
larc,5,52,8,dm_r1-rbar_dep-rbar_t
larc,51,54,8,dm_r3-rbar_dep
larc,52,55,8,dm_r3-rbar_dep-rbar_t
lstr,54,60
lstr,55,61
lstr,60,61

lstr,47,48
larc,48,50,8,dm_r2+rbar_dep+rbar_t
larc,47,49,8,dm_r2+rbar_dep
larc,50,57,8,dm_r4+rbar_dep+rbar_t
larc,49,56,8,dm_r4+rbar_dep
larc,57,59,8,dm_r4+rbar_dep+rbar_t
larc,56,58,8,dm_r4+rbar_dep

lwpla,-1,18,1
wpoff,-rbar_dep
k
wpoff,-rbar_t
k
larc,59,63,8,hnch_r1+rbar_dep+rbar_t
```

```
larc,58,62,8,hnch_r1+rbar_dep


lwpla,-1,17
wpoff,,,rbar_dep2
k
wpoff,,,rbar_t
k
lwpla,-1,17,1
wpoff,,,-rbar_dep3
k
wpoff,,,-rbar_t
k
larc,63,65,8,hnch_r2+rbar_dep+rbar_t
larc,62,64,8,hnch_r2+rbar_dep

lextnd,67,60,60
lextnd,68,61,60
ldele,67,,,1
ldele,68,,,1

lsbw,81
ldele,68,,,1
kwpave,66
lsbw,80
ldele,81,,,1

lsbw,13
kwpave,67
lsbw,81
kwpave,65
lsbw,13
kwpave,64
lsbw,81

lstr,66,69
lstr,67,70
lstr,66,68
lstr,67,71
lstr,65,72
lstr,64,73

lwpla,-1,60
wpoff,,,rbar_dep3
lsbw,12
lsbw,60
wpoff,,,rbar_t
lsbw,90
lsbw,92

kwpave,45
```

```
wpoff,,,-rbar_dep2
lsbw,60
lsbw,90
wpoff,,,-rbar_t
lsbw,95
lsbw,96

lstr,72,81
lstr,73,79

lstr,68,75
lstr,71,77
lstr,75,74
lstr,76,77
lstr,80,81
lstr,78,79

lwpla,-1,53,1
wpoff,,,-rbar_dep4
asbw,2
asbw,15
asbw,16
asbw,18
wpoff,,,-rbar_t
asbw,19
asbw,21
asbw,22
asbw,23

kwpave,41
wpoff,282,,-rbar_dep5
k
kwpave,11
wpoff,-4.5,,-rbar_dep6
k
lstr,92,93
wpoff,,,-rbar_t
k
kwpave,92
wpoff,,,-rbar_t
k
lstr,94,95
lstr,92,95
lstr,93,94
al,115,125,126,127
al,97,98,104,105
al,93,94,102,103
al,84,96,98,99
al,82,94,100,101

lstr,64,65
```

```
lstr,66,67
al,84,88,89,128
al,82,86,87,129
aovlp,all

lstr,69,70
lstr,58,59
lstr,53,29
lstr,28,30

cm,l_temp,line
cm,a_temp,area

al,17,81,85,129

lsel,s,,,29
lsel,a,,,70,79
lsel,a,,,128
al,all

cmsel,a,l_temp
cmsel,a,a_temp

lsel,s,,,5
lsel,a,,,17
lsel,a,,,61
lsel,a,,,64,68
al,all

cmsel,a,l_temp
cmsel,a,a_temp

asbl,6,120
asbl,20,116
aovlp,all

wprot,,,90
asbw,15
asbw,26
asbw,48

lcomb,76,78
lcomb,77,79
lcomb,18,19

ksll
nummrg,kp

kwpave,78
asbw,2
asbw,19
```

```
asbw,43
asbw,46
asbw,49

kwpave,80
asbw,50
asbw,68
asbw,69
asbw,70
asbw,71

kwpave,76
asbw,69
asbw,72
asbw,73
asbw,74
asbw,76

kwpave,74
asbw,69
asbw,71
asbw,72
asbw,73
asbw,81

kwpave,94
asbw,1
asbw,24
asbw,47

wprot,,,90
asbw,90
kwpave,93
asbw,91

ksll
nummrg,kp

!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
!
!        Cut division for different rbar length along
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]

!----dome radial direction
cut_r1=5*12
cut_r2=6.25*12
cut_r3=10*12
cut_r4=20*12
cut_r5=31*12+6
cut_dr6=54
```

```
wpcsys,-1,0
wprot,,,90
kwpave,26
wpoff,,,cut_r1
lsbw,32
wpoff,,,cut_r2-cut_r1
lsbw,216
wpoff,,,cut_r3-cut_r2
lsbw,32
wpoff,,,cut_r4-cut_r3
lsbw,31
wpoff,,,cut_r5-cut_r4
lsbw,30
lwpla,-1,21
wpoff,,,cut_dr6
lsbw,21

lwpla,-1,213,1
asbw,25
asbw,52
asbw,53
asbw,56
asbw,57

lwpla,-1,217,1
asbw,25
asbw,93
asbw,95
asbw,96
asbw,97

lwpla,-1,218,1
asbw,25
asbw,57
asbw,96
asbw,100
asbw,101

lwpla,-1,219,1
asbw,23
asbw,55
asbw,58
asbw,59
asbw,60

lwpla,-1,220,1
asbw,20
asbw,54
asbw,61
asbw,62
asbw,63
```

```
lwpla,-1,261
kwpave,132
asbw,51
asbw,64
asbw,65
asbw,66
asbw,67


!----Rebar regions in tank wall
!----interior surface
cut_vi1=3
cut_vi2=4
cut_vi3=11
cut_vi4=5
cut_vi5=4*12+8
cut_vi6=5*12
cut_vi7=19*12+1.5

lwpla,-1,63
wpoff,,,cut_vi1
asbw,all
wpoff,,,cut_vi2
asbw,all
wpoff,,,cut_vi3
asbw,all
wpoff,,,cut_vi4
asbw,all
wpoff,,,cut_vi5
asbw,all
wpoff,,,cut_vi6
asbw,all
wpoff,,,cut_vi7
asbw,all

!---cut exterior wall rebar areas
cut_vo1=3
cut_vo2=4
cut_vo3=11
cut_vo4=9
cut_vo5=4*12
cut_vo6=7
cut_vo7=4*12+6
cut_vo8=5.25
cut_vo9=19*12+1.5

lwpla,-1,297
wpoff,,,cut_vo1
wpoff,,,cut_vo2
```

```
wpoff,,,cut_vo3
wpoff,,,cut_vo4
asbw,all
wpoff,,,cut_vo5
asbw,all
wpoff,,,cut_vo6
asbw,all
wpoff,,,cut_vo7
asbw,all
wpoff,,,cut_vo8
asbw,all
wpoff,,,cut_vo9
asbw,all

!---rebar in top footing/slab
cut_tp_r1=23*12+6
cut_tp_r2=29*12+6

lwpla,-1,52,1
wpoff,,,-cut_tp_r2
asbw,6
asbw,17
asbw,18
asbw,21
asbw,44

!--- bottom footing rbars
cut_bt_r1=29*12+6+1.5*12
cut_bt_r2=cut_bt_r1+1.5*12
cut_bt_dr3=6*12

lwpla,-1,52,1
wpoff,,,-cut_bt_r1
asbw,6
asbw,17
asbw,18
asbw,21
asbw,36

lwpla,-1,52,1
wpoff,,,-cut_bt_r2
asbw,6
asbw,17
asbw,18
asbw,21
asbw,44

kwpave,121
wpoff,,,cut_bt_dr3
asbw,6
asbw,18
```

```
asbw,21
asbw,36
asbw,200

!---Misc. cut
wpcsys,-1,0
kwpave,18
wpoff,,-42.25
wprot,,90
lsbw,277

lwpla,-1,468,1
asbw,119
asbw,121
asbw,122
asbw,3
asbw,120

lwpla,-1,361
wpoff,,,15/2
asbw,30
asbw,31
asbw,158
asbw,159
asbw,161

kwpave,13
wpoff,,,-18
asbw,213
asbw,214
asbw,215
asbw,216
asbw,217

cm,a_tank,area
!-cut curved rebar at wall/slab joint
asel,s,,,50
asel,a,,,68
asel,a,,,79
asel,a,,,84,85
aadd,all
asel,a,,,80
aadd,all

asel,s,,,2
asel,a,,,19
asel,a,,,48,50
asel,a,,,71,72
asel,a,,,76,78,2
asel,a,,,82
aadd,all
```

```
cmsel,a,a_tank
lsla
lsel,s,,,19
lsel,a,,,173
lsel,a,,,189
lsel,a,,,193,196,3
lcomb,all
lsla
wpcsys,-1,0
wprot,,,90
kwpave,100
asbw,68
kwpave,109
asbw,19
kwpave,111
asbw,49
kwpave,118
asbw,50
wprot,,90
kwpave,88
asbw,19
kwpave,83
asbw,48
asbw,49
asbw,50
cm,a_tank,area

LFILLT,177,176,12, ,
lcomb,176,193
LFILLT,178,194,12, ,
lcomb,179,173
lfillt,201,183,12+rbar_t
lcomb,188,173
lfillt,190,503,12+rbar_t

asel,s,,,71
asel,a,,,76,78,2
lsel,s,,,178
lsel,a,,,190
lsel,a,,,194,195
lsel,a,,,503,504
asbl,all,all
cmsel,a,a_tank
cm,a_tank,area

asel,s,,,50
asel,a,,,72

asel,a,,,79,80
asel,a,,,82
```

```
asel,a,,,84,85
asel,a,,,217
lsel,s,,,175,177
lsel,a,,,183
lsel,a,,,201
lsel,a,,,501
asbl,all,all

aadd,227,228
aadd,223,231
aadd,82,226
cmsel,a,a_tank
cm,a_tank,area

aadd,233,71
aadd,232,76
aadd,49,78
asbw,68
asbw,2
kwpave,88
asbw,78
asbw,85
asbw,82
asbw,230
aadd,223,226
aadd,84,217
aadd,224,227
aadd,223,225
cm,a_tank,area

lsel,s,,,183
lsel,a,,,523
lsel,a,,,531
lcomb,all
lsla
lcomb,177,529
lcomb,178,526
lsel,s,,,190
lsel,a,,,513
lsel,a,,,525
lcomb,all
lsla
lcomb,515,521
lcomb,197,520
lcomb,517,532
lcomb,196,524
lcomb,194,503
lcomb,514,518
lsla

!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
```

```
!
!--Set Elelment types
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]

r_liner=1
r,1,liner_t

!mat_liner=1
mat_conc=2  !structural concrete in tank
mat_tsoil=3 !for top soil
mat_msoil=4     !for mid soil
mat_bsoil=5 !for bottom soil
mat_rebar=6
mat_srebar=7

type_2d_liner=1
type_2d_conc=2
type_2d_soil=3
type_2d_rebar=4

type_3d_conc=type_2d_conc+10
type_3d_soil=type_2d_soil+10
type_3d_rebar=type_2d_rebar+10

!et,type_liner,shell61
et,type_2d_conc,plane42
et,type_2d_soil,plane42
et,type_2d_rebar,plane42

et,type_3d_conc,solid65

et,type_3d_soil,solid45
et,type_3d_rebar,solid65


!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
!
!-----set material properties
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]

![1]                steel (for liner)
mp,ex,mat_liner,steel_ex
mp,dens,mat_liner,steel_dens
mp,prxy,mat_liner,steel_prxy
mp,alpx,mat_liner,steel_alpx
mp,kxx,mat_liner,steel_kx
mp,c,mat_liner,steel_c

![2]                structural concrete
```

```
mp,ex,mat_conc,conc_ex
mp,dens,mat_conc,conc_dens
mp,prxy,mat_conc,conc_prxy
mp,alpx,mat_conc,conc_alpx
mp,kxx,mat_conc,conc_kx
mp,c,mat_conc,conc_c

*if,crush_id,eq,1,then
   tb,concr,mat_conc
   tbdata,1,conc_open,conc_closed,conc_crack,conc_crush
*endif

*if,usr_crp_id,eq,1,then
   tb,creep,mat_conc,,,100
   tbdata,1,c1,c2,c3,c4,c5
   tbdata,6,c6,c7,c8,c9,c10,c11
*endif

![3]                top soil
mp,ex,mat_tsoil,tsoil_ex
mp,dens,mat_tsoil,tsoil_dens
mp,prxy,mat_tsoil,tsoil_prxy
tb,dp,mat_tsoil,,,0
tbdata,1,tsoil_cohesion,tsoil_friction,tsoil_dilat


![4]                mid soil
mp,ex,mat_msoil,msoil_ex
mp,dens,mat_msoil,msoil_dens
mp,prxy,mat_msoil,msoil_prxy
tb,dp,mat_msoil,,,0
tbdata,1,msoil_cohesion,msoil_friction,msoil_dilat

![5]                bottom soil
mp,ex,mat_bsoil,bsoil_ex
mp,dens,mat_bsoil,bsoil_dens
mp,prxy,mat_bsoil,bsoil_prxy
tb,dp,mat_bsoil,,,0
tbdata,1,bsoil_cohesion,bsoil_friction,bsoil_dilat

![6]                rebar
mp,ex,mat_rebar,rebar_ex
mp,dens,mat_rebar,rebar_dens
mp,prxy,mat_rebar,rebar_prxy

![7]                slab rebar
mp,ex,mat_srebar,srebar_ex
mp,dens,mat_srebar,srebar_dens
mp,prxy,mat_srebar,srebar_prxy
```

```
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
!
!---Assign attribute to areas, real constants will be defined later
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
cmsel,s,a_tank
aatt,2,700,type_2d_conc

!-- slab rebar
asel,s,,,15
asel,a,,,27
asel,a,,,41
asel,a,,,193
aatt,mat_conc,100,type_2d_rebar

asel,s,,,202
aatt,mat_conc,101,type_2d_rebar

asel,s,,,205
aatt,mat_conc,102,type_2d_rebar

asel,s,,,18
asel,a,,,85
aatt,mat_conc,103,type_2d_rebar

asel,s,,,71,72
asel,a,,,78,82,2
aatt,mat_conc,104,type_2d_rebar

asel,s,,,2
asel,a,,,88
aatt,mat_conc,105,type_2d_rebar

asel,s,,,192
aatt,mat_conc,106,type_2d_rebar

asel,s,,,17
asel,a,,,36
asel,a,,,43
asel,a,,,196
asel,a,,,207
aatt,mat_conc,107,type_2d_rebar

asel,s,,,77
aatt,mat_conc,108,type_2d_rebar

asel,s,,,69
asel,a,,,45
aatt,mat_conc,109,type_2d_rebar

asel,s,,,50
```

```
asel,a,,,70
asel,a,,,75
asel,a,,,79
asel,a,,,83,86,3
cuv_real_i=110
aatt,mat_conc,cuv_real_i,type_2d_rebar

!---interior Wall rebar
asel,s,,,136
aatt,mat_conc,200,type_2d_rebar

asel,s,,,141
aatt,mat_conc,201,type_2d_rebar

asel,s,,,146
aatt,mat_conc,202,type_2d_rebar


asel,s,,,163,171,4
aatt,mat_conc,203,type_2d_rebar

asel,s,,,126
asel,a,,,166
asel,a,,,176
asel,a,,,181
aatt,mat_conc,204,type_2d_rebar

asel,s,,,182,186,4
aatt,mat_conc,205,type_2d_rebar

asel,s,,,159
asel,a,,,216
aatt,mat_conc,206,type_2d_rebar

asel,s,,,222
aatt,mat_conc,207,type_2d_rebar

asel,s,,,187
asel,a,,,191
aatt,mat_conc,208,type_2d_rebar

!---exterior wall rebar
asel,s,,,134
aatt,mat_conc,200,type_2d_rebar

asel,s,,,139
aatt,mat_conc,201,type_2d_rebar

asel,s,,,42
asel,a,,,144
aatt,mat_conc,209,type_2d_rebar
```

```
asel,s,,,169
aatt,mat_conc,203,type_2d_rebar

asel,s,,,150
asel,a,,,174
aatt,mat_conc,210,type_2d_rebar

asel,s,,,124
asel,a,,,164
asel,a,,,174
aatt,mat_conc,204,type_2d_rebar

asel,s,,,179
asel,a,,,184
aatt,mat_conc,211,type_2d_rebar

asel,s,,,152
aatt,mat_conc,212,type_2d_rebar

asel,s,,,31
asel,a,,,214
aatt,mat_conc,206,type_2d_rebar

asel,s,,,220
asel,a,,,190
aatt,mat_conc,207,type_2d_rebar

asel,s,,,155
aatt,mat_conc,208,type_2d_rebar

asel,s,,,127,128
aatt,mat_conc,213,type_2d_rebar


!---External dome rebar
asel,s,,,91,99,8
aatt,mat_conc,300,type_2d_rebar

asel,s,,,103
aatt,mat_conc,301,type_2d_rebar

asel,s,,,97
asel,a,,,110
aatt,mat_conc,302,type_2d_rebar


asel,s,,,55
aatt,2,303,type_2d_rebar

asel,s,,,117
```

```
aatt,mat_conc,304,type_2d_rebar

asel,s,,,62
asel,a,,,118
aatt,mat_conc,305,type_2d_rebar

!---Interna dome rebar
asel,s,,,52
asel,a,,,93
aatt,mat_conc,300,type_2d_rebar

asel,s,,,106
aatt,mat_conc,301,type_2d_rebar

asel,s,,,96
asel,a,,,112
aatt,mat_conc,302,type_2d_rebar

asel,s,,,59
aatt,mat_conc,303,type_2d_rebar

asel,s,,,115
aatt,mat_conc,304,type_2d_rebar

asel,s,,,54
asel,a,,,65
aatt,mat_conc,306,type_2d_rebar

!----External haunch rebar
asel,s,,,63
aatt,mat_conc,400,type_2d_rebar

asel,s,,,122
asel,a,,,211
aatt,mat_conc,401,type_2d_rebar

!----Internal haunch rebar
asel,s,,,119
asel,a,,,209
aatt,mat_conc,402,type_2d_rebar

!----Haunch interior region
asel,s,,,121
asel,a,,,210
aatt,mat_conc,500,type_2d_rebar

allsel

!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
!
!     2D Meshing
```

```
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]

!-- tank mesh
cmsel,s,a_tank
lsla
esize,tank_size
lccat,272,475
lccat,30,479
lccat,85,271
lsel,s,,,121
lsel,a,,,126
lsel,a,,,167
lccat,all
lsla
mshkey,1
asel,u,,,212
asel,u,,,76
asel,u,,,84
asel,u,,,217
lesize,133,,,4
lesize,134,,,4
lesize,177,,,4
lesize,178,,,4
lesize,183,,,4
lesize,190,,,4

amesh,all
asel,a,,,212
esize,6
amesh,212

asel,a,,,76
asel,a,,,84
asel,a,,,217
mshkey,0
esize,4
amesh,76
amesh,84
amesh,217

!--delete concat lines
CM,_Y,LINE
*SET,_Z1,LSINQR(0,13)
*IF,_z1,ne,0,then
LSEL,R,LCCA
*SET,_Z2,LSINQR(0,13)
LDELE,ALL
*SET,_Z3,_Z1-_Z2
*IF,_Z3,NE,0,THEN
CMSEL,S,_Y
```

```
CMDELE,_Y
*ENDIF
*ELSE
CMSEL,S,_Y
CMDELE,_Y
*ENDIF

!-- soil mesh
asel,s,,,7,11
asel,a,,,5
asel,a,,,13,14
cm,a_soil,area
lsla
esize,soil_esize
lesize,43,,,10
lesize,42,,,25,.25
lesize,25,,,25,.25
lesize,40,,,12,5

lesize,46,,,10,.25
lesize,50,,,35
lesize,38,,,7

lesize,47,,,10,.25
lesize,51,,,15
lesize,48,,,7


mopt,trans,1.25
mopt,expnd,1.25

lesize,37,,,8,.5
lesize,34,,,8,.5
lesize,33,,,8,.5
lesize,45,,,8,2
lesize,49,,,8,2
lesize,26,,,8,.3
lesize,35,,,8,.3
lesize,24,,,8,.3
lesize,23,,,25,4

type,type_2d_soil
mat,mat_tsoil
asel,s,,,8
mshkey,0
mopt,expnd,1.25
mopt,trans,1.25
amesh,all
asel,s,,,11
mshkey,1
amesh,all
```

```
mat,mat_msoil
asel,s,,,13,14
mshkey,0
amesh,all

mat,mat_bsoil
mopt,expnd,1.25
mopt,trans,1.25
asel,s,,,10
amesh,all

asel,s,,,5,9,2
mshkey,1
amesh,all

![[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[[
!
!     3D mesh by rotation, reassign general elem. attr.
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
allsel
type,type_3d_soil
extopt,attr,1,1,1
extopt,esize,div_num
vrotat,all,,,,,,35,22,slice_ang

asel,s,mat,,mat_conc
vsla
eslv
emodif,all,type,type_3d_conc
nsle

asel,s,type,,type_2d_rebar
vsla
eslv
emodif,all,type,type_3d_rebar

esel,s,type,,type_3d_soil
vsle
allsel,below,volu
cm,junk,volu
vgen,2,all
cm,v_soil,volu
cmsel,s,junk
allsel,below,volu
aclear,all
vclear,all
vdele,all,,,1
allsel
```

```
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
!
!    Create local coordinate systems
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
slice_ang=90/div_num
!--- csys 100 spheroid: for internal dome/haunch rebar/interior haunch
!    the x and y radius are from error-and-try process
!
a=453
b=160
wpcsys,-1,0
kwpave,47
wpoff,,-b
cswpla,100,2,b/a,
wprot,,,-slice_ang/2

tot_cs=4*div_num
*do,i,201,200+tot_cs
    wprot,,,slice_ang
    cswpla,i,2,b/a
*enddo

!--- csys for external dome/haunch
a=600
b=300
wpcsys,-1,0
kwpave,5
wpoff,,-b
cswpla,101,2,b/a
wprot,,,-slice_ang/2

tot_cs=4*div_num
*do,i,401,400+tot_cs
    wprot,,,slice_ang
    cswpla,i,2,b/a
*enddo

!--- csys 110 cylindrical: wall and slab rebars
wpcsys,-1,0
wprot,,-90
cswpla,110,1

!


!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
!
!     Define real constants for rebars
```

```
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
mat_null=0

!slab
vrx=
vrz=
vry=
rc=
*dim,vrx,,20
*dim,vry,,20
*dim,vrz,,20
*dim,rc,,20
vrx(1)=.0256,.0714,.0671,.0622,.0589,.0565,.0855,.0675,.0589,.0565
vry(1)=.0256,.0256,.0256,.0256,.0256,.0256,.0256,.0256,.0256,.0256
rc(1)=100,101,102,103,104,105,106,107,108,109
*do,i,1,10
      r,rc(i),mat_srebar,vrx(i),0,0,mat_srebar,vry(i)
      rmore,90,0,mat_null,0,90,90
*enddo

!--define real constants for curved rebars
allsel
asel,s,,,75
asel,a,,,83
lsla
nsla,,1
esln
esel,r,real,,110
cm,ele_r110,elem
r,cuv_real_i,mat_null,0,0,0,mat_srebar,.0552
rmore,0,90,mat_srebar,.0,90,90

wpcsys,-1,0
kwpave,433,473
nsle
csys,4

esln
esel,r,real,,cuv_real_i
cmsel,u,ele_r110
nsle
nsel,r,loc,x,0,-99999
esln,,1
cm,ele_r111,elem
emodif,all,real,111
r,111,mat_null,0,0,0,mat_srebar,.0552
rmore,0,110,mat_srebar,.0,90,90

esln
esel,r,real,,110
```

```
cmsel,u,ele_r110
nsle
cm,ele_r112,elem
emodif,all,real,112
r,112,mat_null,0,0,0,mat_srebar,.0552
rmore,0,130,mat_srebar,.0,90,90

esln
esel,r,real,,110
cmsel,u,ele_r110

nsle
cm,ele_r113,elem
emodif,all,real,113
r,113,mat_null,0,0,0,mat_srebar,.0552
rmore,0,160,mat_srebar,.0,90,90

cmsel,s,ele_r110
nsle
nsel,r,loc,x,0,9999
esln,,1
nsle
esln
esel,r,real,,110
cmsel,u,ele_r110
nsle
cm,ele_r114,elem
emodif,all,real,114
r,114,mat_null,0,0,0,mat_srebar,.0552
rmore,0,70,mat_srebar,.0,90,90

esln
esel,r,real,,110
cmsel,u,ele_r110
nsle
cm,ele_r115,elem
emodif,all,real,115
r,115,mat_null,0,0,0,mat_srebar,.0552
rmore,0,50,mat_srebar,.0,90,90

esln
esel,r,real,,110
cmsel,u,ele_r110
nsle
cm,ele_r116,elem
emodif,all,real,116
r,116,mat_null,0,0,0,mat_srebar,.0552
rmore,0,20,mat_srebar,.0,90,90

!wall
vrz(1)=.0276,.0276,.0276,.0276,.0276,.0276,.0552,.0552,.0552,.0276,
```

```
vrz(11)=.0276,.0276,.0276,.0276
vry(1)=.1963,.0714,.1571,.0982,.1309,.1745,.1745,.1745,.0552,.0873
vry(11)=.1122,.1496,.1745,.132
rc(1)=200,201,202,203,204,205,206,207,208,209,210,211,212,213
*do,i,1,14
      r,rc(i),mat_null,0,0,0,mat_rebar,vry(i)
      rmore,90,0,mat_rebar,vrz(i),90,90
*enddo

!redefine the inclined rebars
r,rc(12),mat_null,0,0,0,mat_rebar,vry(12)
rmore,90,0,mat_rebar,vrz(12),0,97.1

r,rc(13),mat_null,0,0,0,mat_rebar,vry(13)
rmore,90,0,mat_rebar,vrz(13),0,97.1


!dome
vry(1)=.0736,.0433,.0469,.0577,.0467,.0426,.0426
vrz(1)=.0736,.0368,.0368,.0368,.0654,.1735,.1735
rc(1)=300,301,302,303,304,305,306
*do,i,1,7
      r,rc(i),mat_null,0,0,0,mat_rebar,vry(i)
      rmore,90,0,mat_rebar,vrz(i),0,90
*enddo


!haunch
vry(1)=.0773,.3203,.0386
vrz(1)=.2192,.0276,.1438
rc(1)=400,401,402
*do,i,1,3
      r,rc(i),mat_null,0,0,0,mat_rebar,vry(i)
      rmore,90,0,mat_rebar,vrz(i),90,90
*enddo

!haunch core
r,500,mat_rebar,.0011,0,0,mat_rebar,0.002
rmore,45,0,mat_rebar,.0349,90,90

!real constants for curved rebars at wall/slab joint
r,600,mat_rebar,,
allsel


!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
!
!     Assign esys to rebar elem.
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
```

```
!--- dome rebar
asel,s,,,52
asel,a,,,93
asel,a,,,96
asel,a,,,106
asel,a,,,54
asel,a,,,59
asel,a,,,112
asel,a,,,115
asel,a,,,209,210
asel,a,,,65
asel,a,,,119,121,2
vsla
aslv
csys,0
asel,r,loc,x,-.1,.1
vsla
eslv
cm,esys200,elem

*do,i,1,tot_cs
cmsel,s,esys200
nsle
csys,110
nsel,s,loc,y,(i-1)*slice_ang-.1,i*slice_ang+.1
esln,r,1
emodif,all,esys,200+i
*enddo

asel,s,,,91
asel,a,,,97
asel,a,,,99
asel,a,,,103
asel,a,,,55
asel,a,,,110
asel,a,,,117

asel,a,,,62,63
asel,a,,,118

vsla
aslv
csys,0
asel,r,loc,x,-.1,.1
vsla
eslv
cm,esys400,elem

*do,i,1,tot_cs
cmsel,s,esys400
nsle
```

```
csys,110
nsel,s,loc,y,(i-1)*slice_ang-.1,i*slice_ang+.1
esln,r,1
emodif,all,esys,400+i
*enddo

esel,s,type,,type_3d_rebar
esel,u,esys,,200,1000
emodif,all,esys,110

!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
!
!     Assign real constants to 3D elements
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
*do,i,100,105
    asel,s,real,,i
    vsla
    eslv
    emodif,all,real,i
*enddo

*do,i,200,220
    asel,s,real,,i

    vsla
    eslv
    emodif,all,real,i
*enddo

*do,i,300,320
    asel,s,real,,i
    vsla
    eslv
    emodif,all,real,i
*enddo

*do,i,400,410
    asel,s,real,,i
    vsla
    eslv
    emodif,all,real,i
*enddo

asel,s,real,,500
vsla
eslv
emodif,all,real,500

allsel
```

```
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
!
!     Define contact between soil and tank
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
et,21,170
et,22,173
r,21,,,100,.1
mp,mu,21,.3

esel,s,mat,,mat_conc
vsle
aslv
asel,u,ext
cm,a_int,area

asel,s,,,981
*do,i,1,50
    lsla
    asll
    cmsel,u,a_int
*enddo

cm,tk_cnt_area,area
lsla
nsla,,1
esln
!type,21
type,22
real,21
mat,21
esurf

esel,s,type,,type_3d_soil
vsle
aslv
asel,u,ext
cm,a_int,area

asel,s,,,2884
*do,i,1,50
    lsla
    asll
    cmsel,u,a_int
*enddo

cm,soil_cnt_area,area
lsla
nsla,,1
esln
```

```
!type,22
type,21
esurf

allsel
aclear,all

/pnum,real,1
/num,1

csys,110
nrotat,all
eplot

!-----modify esys for elements using esys100 and esys101

sx_load_360
finish
/filname,sst_sx_360
/config,nproc,4
/solu
neqit,50
time,1
nlgeom,on
cnvtol,f,,.001,2
nsubst,1000,1000,5
allsel
save
solve
```

parm_sx_360.mac

```
!--Define parameters for SST-SX tank
!--dimensions are in INCH and DEG

dm_r1=1155  !inch, radius of outer inboard dome surface
dm_r2=1140  !inch, radius of inner inboard dome surface
dm_r3=804   !inch, radius of outer outboard dome surface
dm_r4=720   !inch, radius of inner outboard dome surface
dm_theta1=9.084722  !deg, angle of outer inboard dome surface
dm_theta2=9.084722  !deg, angle of inner inboard dome surface
dm_theta3=12.05972  !deg, angle of outer outboard dome surface
dm_theta4=18.581944 !deg, angle of inner outboard dome surface
dm_oh1=14.5  !vrtcal dist. from dome top to end of out radius 1
dm_oh2=58.5  !vrtcal dist. from dome top to end of out radius 2
dm_ih1=14.3125 !vrtcal dist. from dome top to end of inner radius 1
dm_ih2=73.3125 !vrtcal dist. between end of inner radius 1 and 2
dm_dr1=182.375
dm_dr2=180
dm_dr3=163.0625 !horizontal span of outer radius 2
dm_dr4=220.625  !horizontal span of inner radius 2


hnch_r1=120 !inch, big haunch radius
hnch_r2=26.5      !inch, small haunch radius
hnch_theta1=30.09583    !deg, angle of big haunch radius
hnch_theta2=32.2375     !deg, angle of big haunch radius
hnch_h1=104.9375  !vrtcl. dist between dome top and haunch corner
hnch_h2=54.0625   !vrtcl. dist between haunch corner and haunch bot.
hnch_h3=42.25     !vrtcl. span of big haunch radius
hnch_dr3=45.8125  !horizontal span of big haunch radius
hnch_h4=14.125    !vrtcl. span of small haunch radius
hnch_dr4=4.0625

tk_or1=465.5  !radius of out tank surface (top)
tk_t1=15   !top tank thickness
tk_t2=24   !bot. tank thickness
tk_h1=133 !vtcl dist between haunch bot. to start of tank slope
tk_h2=72  !vtcl dist of tank slope
tk_h3=170.625  !vtcl dist between end of slope to bot. of tank
tk_h4=387.875

slb_t1=23  !outer slab thickness
slb_dt1=30
slb_dt2=8
slb_dt3=2.75
slb_dr=22.5 !radius difference between out tank and slab
slb_dr2=24
slb_r1=569.82*12 !radius of top slab surface
slb_dr3=1
slb_dr4=-1  !=1 in drawing, simplied to 0
```

```
slb_dh=2.625
slb_dh2=14.875

liner_r1=569.59*12  !radius of bottom steel liner

depth=8.52*12
soil_r=80*12
soil_h=90*12

!---Control parameters for materials
crush_id=0  !=0, no crush capability, =1, with crush capability
usr_crp_id=0 !=0, no user creep; =1, with user creep

!---Parameters for materials
!-----Liner steel
steel_ex=27.7e6   !elastic modulus [psi]
steel_prxy=0.3    !Poisson ratio
steel_alpx=6.38   !thermal expansion coefficient [microstrain/degree F]
steel_gamma=490   !unit weight [lbf/ft^3]
steel_kx=1        !thermal conductivity [BTU/hr/ft/degreeF]
steel_c=1         !specific heat [BTU/R-lbf/(in/sec^2)]
steel_alpx=steel_alpx*1e-6          !in/in/F
steel_dens=steel_gamma/1728/386     !lb-sec^2/in^4
steel_kx=steel_kx/3600/12           !BTU/sec-in-degreeF
steel_yield=36000 !yield strength [psi]

!---- Structural Concrete
conc_ex=3.1e6     !elastic modulus [psi]
conc_prxy=0.2     !Poisson ratio
conc_alpx=6.38    !thermal expansion coefficient [microstrain/degree F]
conc_gamma=150    !unit weight [lbf/ft^3]
conc_kx=1         !thermal conductivity [BTU/hr/ft/degreeF]
conc_c=1          !specific heat [BTU/R-lbf/(in/sec^2)]
conc_alpx=conc_alpx*1e-6            !in/in/F
conc_dens=conc_gamma/1728/386 !lb-sec^2/in^4
conc_kx=conc_kx/3600/12       !BTU/sec-in-degreeF
conc_open=0.1     !shear transfer coefficient for open crack
conc_closed=0.98  !shear transfer coefficient for closed crack
conc_crush=3000   !uniaxial crushing stress [psi]
conc_crack=0.1*conc_crush     !tensile cracking stress [psi]

!--bottom soil
bsoil_ex=20e3     !elastic modulus [psi]
bsoil_prxy=0.27   !Poisson ratio
bsoil_alpx=0            !thermal expansion coefficient [me/F]
bsoil_gamma=125   !unit weight [lbf/ft^3]
bsoil_kx=1        !thermal conductivity [BTU/hr/ft/F]
bsoil_c=1         !specific heat [BTU/R/(lbf-sec^2/in)]
bsoil_cohesion=0  !drucker-prager constant (assume small number) [psi]
bsoil_friction=35.4!internal friction angle [deg]
bsoil_dilat=35.4  !dilatancy angle [deg]
```

```
bsoil_alpx=bsoil_alpx*1e-6    !in/in/F
bsoil_dens=bsoil_gamma/1728/386     !lb-sec^2/in^4
bsoil_kx=bsoil_kx/3600/12           !BTU/sec-in-degreeF

!--mid soil
msoil_ex=13e3
msoil_prxy=0.27
msoil_dens=125/1728/386
msoil_cohesion=0  !drucker-prager constant (assume small number) [psi]
msoil_friction=35.4
msoil_dilat=35.4  !dilatancy angle [deg]

!-top soil
tsoil_ex=7e3
tsoil_prxy=0.27
tsoil_dens=125/1728/386
tsoil_cohesion=0  !drucker-prager constant (assume small number) [psi]
tsoil_friction=35.4
tsoil_dilat=35.4  !dilatancy angle [deg]

!----rebar steel
rebar_ex=27.7e6         !elastic modulus [psi]
rebar_prxy=0.3          !Poisson ratio
rebar_alpx=6.38*1e-6    !thermal expansion coefficient
[microstrain/degree F]
rebar_gamma=490   !unit weight [lbf/ft^3]
rebar_kx=1        !thermal conductivity [BTU/hr/ft/degreeF]
rebar_c=1         !specific heat [BTU/R-lbf/(in/sec^2)]
rebar_yield=60000 !yield strength [psi]
rebar_tan=0       !rebar tangent modulus [psi]
rebar_dens=rebar_gamma/1728/386  !lb-sec^2/in^4
rebar_kx=rebar_kx/3600/12  !BTU/sec-in-F


!---Slab rbar steel
srebar_ex=27.7e6  !elastic modulus [psi]
srebar_prxy=0.3         !Poisson ratio
srebar_alpx=6.38*1e-6   !thermal expansion coefficient
[microstrain/degree F]
srebar_gamma=490  !unit weight [lbf/ft^3]
srebar_kx=1       !thermal conductivity [BTU/hr/ft/degreeF]
srebar_c=1        !specific heat [BTU/R-lbf/(in/sec^2)]
srebar_yield=40000      !yield strength [psi]
srebar_tan=0            !rebar tangent modulus [psi]
srebar_dens=srebar_gamma/1728/386  !lb-sec^2/in^4
srebar_kx=srebar_kx/3600/12  !BTU/sec-in-F


!---Element size control
liner_size=5
tank_size=15
```

```
soil_esize=25
!slice_ang=3 !deg
slice_ang=360 !deg
div_num=10


!---liner thickness
liner_t=3/8

!--Load
p_uniform=40/144
ff=200000
cload_l=10*12

vac_pres=-0.217  !-6" w.g. vacuum
```

sx_load_360.mac

```
finish
/prep7
!--set BCs
csys,110
asel,s,loc,x,soil_r-.1,soil_r+.1
lsla
nsla,,1
d,all,uy,0
d,all,ux,0

allsel
ksll
*get,mnz,kp,,mnloc,z
asel,s,loc,z,mnz-.1,mnz+.1
lsla
nsla,,1
d,all,uz,0

nsel,s,loc,x,-.1,.1
d,all,ux,0
d,all,uy,0

allsel
ksll
*get,mxz,kp,,mxloc,z
asel,s,loc,z,mxz-.1,mxz+.1
lsla
nsla,,1
sf,all,pres,p_uniform

p_cload=ff/(3.14159*cload_l**2)
lsla
ksll
ksel,r,loc,x,0,cload_l+.1
lslk,,1
asll,,1
lsla
nsla,,1
sf,all,pres,p_cload+p_uniform
allsel

acel,,386

!Apply -6" w.g. to dome
esel,s,mat,,mat_conc
vsle
aslv
asel,u,ext
cm,a_int,area
```

```
asel,s,,,2535
*do,i,1,30
    lsla
    asll
    cmsel,u,a_int
*enddo

lsla
nsla,,1
sf,all,pres,vac_pres

allsel
```

		Page	57 of 78
Subject	Sample AOR Calculation using ANSYS Full Parametric Model for Tank SST-SX		
Originator	Xianghong Li	Date	4/23/03
Checker	Jim Radochia	Date	4/23/03

pst_sx_360b.mac

```
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
!
!     post processing macro to obtain the section
!     force forces and moments
!
!]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
finish
/clear
/filname,sst_sx_360
/prep7
resume
allsel
*afun,deg

/post1
set,last

sec_ang=arg1
slc_ang=90/div_num
rmdr=mod(sec_ang,slc_ang)
*if,rmdr,lt,slc_ang/2,then
    sec_ang=sec_ang-rmdr
*else
    sec_ang=sec_ang+(slc_ang-rmdr)
*endif

csys,110
esel,s,mat,,2
vsle
aslv
asel,r,loc,y,-slice_ang-.1,-slice_ang+.1
cm,a_tank2,area

csys,0
nsel,s,loc,x,-.1,99999
esln,,1
cm,half_tot,elem

esel,r,mat,,2
cm,half_tank,elem

esel,s,mat,,2
nsle
cm,tk_nd,node

vsle
aslv
lsla
ksll
```

```
cm,tk_kp,kp

!-----Displacement contours
cmsel,s,half_tot
nsle
/gresume,soil_360,plt
plpng
plnsol,u,sum
plpng

cmsel,s,half_tank
nsle
/gresume,tank_360,plt
plnsol,u,sum
plpng

/dscale
cmsel,s,half_tot
nsle
/gresume,soil_360,plt
/pnum,mat,1
/num,1
/edge,,1
pldisp,2
plpng


cmsel,s,half_tank
nsle
/gresume,tank_360,plt
/pnum,mat,1
/num,1
/edge,,1
pldisp,2
plpng

cmsel,s,half_tot
nsle
/gresume,soil_360,plt
/dscale,,1
plnsol,s,eqv
plpng

cmsel,s,half_tank
nsle
/gresume,tank_360,plt
/rep
plpng

rsys,110
plnsol,s,y
```

```
plpng

/dscale,,1
/edge
plesol,smisc,2
plpng

plesol,smisc,4
plpng

plesol,smisc,6
plpng

!--------------------SECTION FORCE/MOMENT

*dim,path_nd,,1000       !path node definition
*dim,path_fa,,1000       !axial force
*dim,path_ft,,1000       !transverse force
*dim,path_mz,,1000       !moment
*dim,path_fh,,1000

csys,110
pstart=0  !starting point of consequent path points

!=========================dome region
lsel,s,,,31,32
lsel,a,,,213
lsel,a,,,216,221
nsll,,1
cm,nd_out,node

lsel,s,,,61
lsel,a,,,148
lsel,a,,,227
lsel,a,,,234
lsel,a,,,247
lsel,a,,,251
lsel,a,,,254
lsel,a,,,261
lsel,a,,,264
nsll,,1
cm,nd_in,node

!--unselect end nodes
cmsel,s,nd_out
*get,x_min,node,,mnloc,x
nsel,u,loc,x,x_min-.1,x_min+.1
cm,nd_out,node

cmsel,s,nd_in
*get,x_min,node,,mnloc,x
```

```
nsel,u,loc,x,x_min-.1,x_min+.1
cm,nd_in,node

!--reorder nodes according x-coord.
cmsel,s,nd_out
*get,out_num,node,,count
*dim,nodeout,,out_num
*do,i,1,out_num
    cmsel,s,nd_out
    *get,x_min,node,,mnloc,x
    nsel,r,loc,x,x_min-.1,x_min+.1
    *get,ndnum,node,,num,min
    *get,nd_x,node,ndnum,loc,x
    *get,nd_y,node,ndnum,loc,y
    *get,nd_z,node,ndnum,loc,z
    cmsel,s,tk_nd
    nsel,r,loc,x,nd_x-.1,nd_x+.1
    nsel,r,loc,y,nd_y+sec_ang-.1,nd_y+sec_ang+.1
    nsel,r,loc,z,nd_z-.1,nd_z+.1
    *get,ndnum_sec,node,,num,min
    nodeout(i)=ndnum_sec
    cmsel,s,nd_out
    nsel,u,,,ndnum
    cm,nd_out,node
*enddo

cmsel,s,nd_in
*get,in_num,node,,count
*dim,nodein,,in_num
*do,i,1,in_num

    cmsel,s,nd_in
    *get,x_min,node,,mnloc,x
    nsel,r,loc,x,x_min-.1,x_min+.1
    *get,ndnum,node,,num,min
    *get,nd_x,node,ndnum,loc,x
    *get,nd_y,node,ndnum,loc,y
    *get,nd_z,node,ndnum,loc,z
    cmsel,s,tk_nd
    nsel,r,loc,x,nd_x-.1,nd_x+.1
    nsel,r,loc,y,nd_y+sec_ang-.1,nd_y+sec_ang+.1
    nsel,r,loc,z,nd_z-.1,nd_z+.1
    *get,ndnum_sec,node,,num,min
    nodein(i)=ndnum_sec
    cmsel,s,nd_in
    nsel,u,,,ndnum
    cm,nd_in,node
*enddo

cmsel,s,a_tank
wpcsys,-1,0
```

```
kwpave,160
csys,4
asel,r,loc,y,0,99999
asel,u,,,63
lsla
nsla,,1
cm,dome_area,area

cm,sec_nd,node
*get,numsec_nd,node,,count

nsel,none
cm,dome_nd,node

nn=0
csys,110
*do,i,1,numsec_nd
    cmsel,s,sec_nd
    nnxt=ndnext(nn)
    *get,sn_x,node,nnxt,loc,x
    *get,sn_y,node,nnxt,loc,y
    *get,sn_z,node,nnxt,loc,z
    cmsel,s,tk_nd
    nsel,r,loc,x,sn_x-.2,sn_x+.2
    *if,abs(sn_x),gt,.1,then
        nsel,r,loc,y,sn_y+sec_ang-.2,sn_y+sec_ang+.2
    *endif
    nsel,r,loc,z,sn_z-.2,sn_z+.2
    *get,sn_num,node,,num,min
    cmsel,s,dome_nd
    nsel,a,,,sn_num
    cm,dome_nd,node
    nn=nnxt
*enddo
csys,4

/view,,sin(sec_ang),,cos(sec_ang)
csys,0
!--for line equation for each pair of in/out nodes
*do,ii,1,in_num
    nsel,s,,,nodeout(ii)
    nsel,a,,,nodein(ii)
    path_nd(pstart+ii)=nodein(ii)
    csys,110
    *get,x_out,node,nodeout(ii),loc,x
    *get,y_out,node,nodeout(ii),loc,z
    *get,x_in,node,nodein(ii),loc,x
    *get,y_in,node,nodein(ii),loc,z

    *if,ii,ne,in_num,then
          *get,xplus_in,node,nodein(ii+1),loc,x
```

```
        *get,yplus_in,node,nodein(ii+1),loc,z
        ds=sqrt((xplus_in-x_in)**2+(yplus_in-y_in)**2)
    *endif

    nwpla,-1,nodeout(ii),nodein(ii)
    csys,4
    cmsel,s,dome_nd
    nsel,r,loc,y,-2,2
    cm,ntemp,node
    csys,4
    esln
    esel,r,mat,,2
    nsle
    nsel,r,loc,y,-tank_size/3,99999
    esln,,1
    cm,etemp,elem
    cmsel,s,ntemp
    cmsel,s,etemp
    csys,0
    get_res_360

    cmsel,s,ntemp
    ttt=sqrt((x_out-x_in)**2+(y_out-y_in)**2)
    get_hpfrc

    path_fa(pstart+ii)=unit_fsumy
    path_ft(pstart+ii)=unit_fsumx
    path_mz(pstart+ii)=unit_mz
    path_fh(pstart+ii)=hp_f


*enddo


pstart=pstart+in_num

!==============haunch
lsel,s,,,30
lsel,a,,,81
lsel,a,,,479
nsll,,1
cm,nd_out,node

lsel,s,,,468,469
nsll,,1
cm,nd_in,node

cmsel,s,a_tank
cmsel,u,dome_area
wpcsys,-1,0
kwpave,17
```

```
csys,4
asel,r,loc,y,0,9999
cm,hnch_area,area
lsla
nsla,,1

cm,sec_nd,node
*get,numsec_nd,node,,count

nsel,none
cm,hnch_nd,node

nn=0
csys,110
*do,i,1,numsec_nd
    cmsel,s,sec_nd
    nnxt=ndnext(nn)
    *get,sn_x,node,nnxt,loc,x
    *get,sn_y,node,nnxt,loc,y
    *get,sn_z,node,nnxt,loc,z
    cmsel,s,tk_nd
    nsel,r,loc,x,sn_x-.1,sn_x+.1
    *if,abs(sn_x),gt,.1,then
        nsel,r,loc,y,sn_y+sec_ang-.1,sn_y+sec_ang+.1
    *endif
    nsel,r,loc,z,sn_z-.1,sn_z+.1
    *get,sn_num,node,,num,min
    cmsel,s,hnch_nd
    nsel,a,,,sn_num
    cm,hnch_nd,node
    nn=nnxt
*enddo
csys,4

csys,0
!--unselect end nodes
cmsel,s,nd_out
*get,y_max,node,,mxloc,y
nsel,u,loc,y,y_max-.1,y_max+.1
cm,nd_out,node

cmsel,s,nd_in
*get,y_max,node,,mxloc,y
nsel,u,loc,y,y_max-.1,y_max+.1
cm,nd_in,node

!--reorder nodes according y-coord.
cmsel,s,nd_out
*get,out_num,node,,count
*dim,nodeout,,out_num
*do,i,1,out_num
```

```
    cmsel,s,nd_out
    *get,y_max,node,,mxloc,y
    nsel,r,loc,y,y_max-.1,y_max+.1
    *get,ndnum,node,,num,min
    csys,110
    *get,nd_x,node,ndnum,loc,x
    *get,nd_y,node,ndnum,loc,y
    *get,nd_z,node,ndnum,loc,z
    cmsel,s,tk_nd
    nsel,r,loc,x,nd_x-.1,nd_x+.1
    nsel,r,loc,y,nd_y+sec_ang-.1,nd_y+sec_ang+.1
    nsel,r,loc,z,nd_z-.1,nd_z+.1
    *get,ndnum_sec,node,,num,min
    csys,0
    nodeout(i)=ndnum_sec
    cmsel,s,nd_out
    nsel,u,,,ndnum
    cm,nd_out,node
*enddo

cmsel,s,nd_in
*get,in_num,node,,count
*dim,nodein,,in_num
*do,i,1,in_num
    cmsel,s,nd_in
    *get,y_max,node,,mxloc,y
    nsel,r,loc,y,y_max-.1,y_max+.1
    *get,ndnum,node,,num,min
    csys,110
    *get,nd_x,node,ndnum,loc,x
    *get,nd_y,node,ndnum,loc,y
    *get,nd_z,node,ndnum,loc,z
    cmsel,s,tk_nd
    nsel,r,loc,x,nd_x-.1,nd_x+.1
    nsel,r,loc,y,nd_y+sec_ang-.1,nd_y+sec_ang+.1
    nsel,r,loc,z,nd_z-.1,nd_z+.1
    *get,ndnum_sec,node,,num,min
    csys,0
    nodein(i)=ndnum_sec
    cmsel,s,nd_in
    nsel,u,,,ndnum
    cm,nd_in,node
*enddo

wpcsys,-1,0
wprot,,,sec_ang
!--for line equation for each pair of in/out nodes
*do,ii,1,in_num
    nsel,s,,,nodeout(ii)
    nsel,a,,,nodein(ii)
    path_nd(pstart+ii)=nodein(ii)
```

```
    csys,110
    *get,x_out,node,nodeout(ii),loc,x
    *get,y_out,node,nodeout(ii),loc,z
    *get,x_in,node,nodein(ii),loc,x
    *get,y_in,node,nodein(ii),loc,z

    *if,ii,ne,in_num,then
          *get,xplus_in,node,nodein(ii+1),loc,x
          *get,yplus_in,node,nodein(ii+1),loc,z
          ds=sqrt((xplus_in-x_in)**2+(yplus_in-y_in)**2)
    *endif

    nwpla,-1,nodeout(ii),nodein(ii)
    csys,4
    cmsel,s,hnch_nd
    nsel,r,loc,y,-1,1
    cm,ntemp,node
    esln
    esel,r,mat,,2
    nsle
    nsel,r,loc,y,-tank_size/3,99999
    esln,,1
    cm,etemp,elem
    cmsel,s,ntemp
    cmsel,s,etemp
    csys,0
    get_res_360

    cmsel,s,ntemp
    ttt=sqrt((x_out-x_in)**2+(y_out-y_in)**2)
    get_hpfrc

    path_fa(pstart+ii)=unit_fsumy
    path_ft(pstart+ii)=unit_fsumx
    path_mz(pstart+ii)=unit_mz
    path_fh(pstart+ii)=hp_f

*enddo

pstart=pstart+in_num


!==============wall
lsel,s,,,20
lsel,a,,,105
lsel,a,,,297,298
lsel,a,,,305
lsel,a,,,309
lsel,a,,,316
lsel,a,,,327
lsel,a,,,341
```

```
lsel,a,,,343
lsel,a,,,367
lsel,a,,,382
lsel,a,,,393
lsel,a,,,402
lsel,a,,,408
lsel,a,,,423
lsel,a,,,490
lsel,a,,,493
nsll,,1
cm,nd_out,node

lsel,s,,,4
lsel,a,,,15
lsel,a,,,103
lsel,a,,,281
lsel,a,,,296
lsel,a,,,303
lsel,a,,,314
lsel,a,,,325
lsel,a,,,336
lsel,a,,,339
lsel,a,,,345
lsel,a,,,391
lsel,a,,,404
lsel,a,,,415
lsel,a,,,419
lsel,a,,,426
lsel,a,,,482
lsel,a,,,496
nsll,,1
cm,nd_in,node

cmsel,s,a_tank
cmsel,u,dome_area
cmsel,u,hnch_area
wpcsys,-1,0
kwpave,7
csys,4
asel,r,loc,y,0,9999
cm,wall_area,area
lsla
nsla,,1

cm,sec_nd,node
*get,numsec_nd,node,,count

nsel,none
cm,wall_nd,node

nn=0
```

```
csys,110
*do,i,1,numsec_nd
    cmsel,s,sec_nd
    nnxt=ndnext(nn)
    *get,sn_x,node,nnxt,loc,x
    *get,sn_y,node,nnxt,loc,y
    *get,sn_z,node,nnxt,loc,z
    cmsel,s,tk_nd
    nsel,r,loc,x,sn_x-.1,sn_x+.1
    *if,abs(sn_x),gt,.1,then
        nsel,r,loc,y,sn_y+sec_ang-.1,sn_y+sec_ang+.1
    *endif
    nsel,r,loc,z,sn_z-.1,sn_z+.1
    *get,sn_num,node,,num,min
    cmsel,s,wall_nd
    nsel,a,,,sn_num
    cm,wall_nd,node
    nn=nnxt
*enddo
csys,4

csys,0
!--unselect end nodes
cmsel,s,nd_out
*get,y_max,node,,mxloc,y
nsel,u,loc,y,y_max-.1,y_max+.1
cm,nd_out,node

cmsel,s,nd_in
*get,y_max,node,,mxloc,y
nsel,u,loc,y,y_max-.1,y_max+.1
cm,nd_in,node

!--reorder nodes according y-coord.
cmsel,s,nd_out
*get,out_num,node,,count
*dim,nodeout,,out_num
*do,i,1,out_num
    cmsel,s,nd_out
    *get,y_max,node,,mxloc,y
    nsel,r,loc,y,y_max-.1,y_max+.1
    *get,ndnum,node,,num,min
    csys,110
    *get,nd_x,node,ndnum,loc,x
    *get,nd_y,node,ndnum,loc,y
    *get,nd_z,node,ndnum,loc,z
    cmsel,s,tk_nd
    nsel,r,loc,x,nd_x-.1,nd_x+.1
    nsel,r,loc,y,nd_y+sec_ang-.1,nd_y+sec_ang+.1
    nsel,r,loc,z,nd_z-.1,nd_z+.1
    *get,ndnum_sec,node,,num,min
```

```
    csys,0
    nodeout(i)=ndnum_sec
    cmsel,s,nd_out
    nsel,u,,,ndnum
    cm,nd_out,node
*enddo

cmsel,s,nd_in
*get,in_num,node,,count
*dim,nodein,,in_num
*do,i,1,in_num
    cmsel,s,nd_in
    *get,y_max,node,,mxloc,y
    nsel,r,loc,y,y_max-.1,y_max+.1
    *get,ndnum,node,,num,min
    csys,110
    *get,nd_x,node,ndnum,loc,x
    *get,nd_y,node,ndnum,loc,y
    *get,nd_z,node,ndnum,loc,z
    cmsel,s,tk_nd
    nsel,r,loc,x,nd_x-.1,nd_x+.1
    nsel,r,loc,y,nd_y+sec_ang-.1,nd_y+sec_ang+.1
    nsel,r,loc,z,nd_z-.1,nd_z+.1
    *get,ndnum_sec,node,,num,min
    csys,0
    nodein(i)=ndnum_sec
    cmsel,s,nd_in
    nsel,u,,,ndnum
    cm,nd_in,node
*enddo


!--for line equation for each pair of in/out nodes
*do,ii,1,in_num
    nsel,s,,,nodeout(ii)
    nsel,a,,,nodein(ii)
    path_nd(pstart+ii)=nodein(ii)
    csys,110
    *get,x_out,node,nodeout(ii),loc,x
    *get,y_out,node,nodeout(ii),loc,z
    *get,x_in,node,nodein(ii),loc,x
    *get,y_in,node,nodein(ii),loc,z

    *if,ii,ne,in_num,then
          *get,xplus_in,node,nodein(ii+1),loc,x
          *get,yplus_in,node,nodein(ii+1),loc,z
          ds=sqrt((xplus_in-x_in)**2+(yplus_in-y_in)**2)
    *endif

    nwpla,-1,nodeout(ii),nodein(ii)
    csys,4
```

```
    cmsel,s,wall_nd
    nsel,r,loc,y,-1,1
    cm,ntemp,node
    esln
    esel,r,mat,,2
    nsle
    nsel,r,loc,y,-1,99999
    esln,,1
    cm,etemp,elem
    cmsel,s,ntemp
    cmsel,s,etemp
    csys,0
    get_res_360

    cmsel,s,ntemp
    ttt=sqrt((x_out-x_in)**2+(y_out-y_in)**2)
    get_hpfrc

    path_fa(pstart+ii)=unit_fsumy
    path_ft(pstart+ii)=unit_fsumx
    path_mz(pstart+ii)=unit_mz
    path_fh(pstart+ii)=hp_f

*enddo

pstart=pstart+in_num

!==========================slab region
lsel,s,,,22
lsel,a,,,68
lsel,a,,,357
lsel,a,,,446
lsel,a,,,457
lsel,a,,,463
nsll,,1
cm,nd_out,node

lsel,s,,,168
lsel,a,,,432
lsel,a,,,435
lsel,a,,,443
lsel,a,,,452
lsel,a,,,460
nsll,,1
cm,nd_in,node

csys,110
!--unselect end nodes
cmsel,s,nd_out
*get,x_max,node,,mxloc,x
nsel,u,loc,x,x_max-.1,x_max+.1
```

```
cm,nd_out,node

cmsel,s,nd_in
*get,x_max,node,,mxloc,x
nsel,u,loc,x,x_max-.1,x_max+.1
cm,nd_in,node

!--reorder nodes according x-coord.
cmsel,s,nd_out
*get,out_num,node,,count
*dim,nodeout,,out_num
*do,i,1,out_num
    cmsel,s,nd_out
    *get,x_max,node,,mxloc,x
    nsel,r,loc,x,x_max-.1,x_max+.1
    *get,ndnum,node,,num,min
    csys,110
    *get,nd_x,node,ndnum,loc,x
    *get,nd_y,node,ndnum,loc,y
    *get,nd_z,node,ndnum,loc,z
    cmsel,s,tk_nd
    nsel,r,loc,x,nd_x-.1,nd_x+.1
    nsel,r,loc,y,nd_y+sec_ang-.1,nd_y+sec_ang+.1
    nsel,r,loc,z,nd_z-.1,nd_z+.1
    *get,ndnum_sec,node,,num,min
    nodeout(i)=ndnum_sec
    cmsel,s,nd_out
    nsel,u,,,ndnum
    cm,nd_out,node
*enddo

cmsel,s,nd_in
*get,in_num,node,,count
*dim,nodein,,in_num
*do,i,1,in_num
    cmsel,s,nd_in
    *get,x_max,node,,mxloc,x
    nsel,r,loc,x,x_max-.1,x_max+.1
    *get,ndnum,node,,num,min
    *get,nd_x,node,ndnum,loc,x
    *get,nd_y,node,ndnum,loc,y
    *get,nd_z,node,ndnum,loc,z
    cmsel,s,tk_nd
    nsel,r,loc,x,nd_x-.1,nd_x+.1
    nsel,r,loc,y,nd_y+sec_ang-.1,nd_y+sec_ang+.1
    nsel,r,loc,z,nd_z-.1,nd_z+.1
    *get,ndnum_sec,node,,num,min

    nodein(i)=ndnum_sec
    cmsel,s,nd_in
    nsel,u,,,ndnum
```

```
    cm,nd_in,node
*enddo

cmsel,s,a_tank
cmsel,u,dome_area
cmsel,u,hnch_area
cmsel,u,wall_area
cm,slab_area,area
lsla
nsla,,1

cm,sec_nd,node
*get,numsec_nd,node,,count

nsel,none
cm,slab_nd,node

nn=0
csys,110
*do,i,1,numsec_nd
    cmsel,s,sec_nd
    nnxt=ndnext(nn)
    *get,sn_x,node,nnxt,loc,x
    *get,sn_y,node,nnxt,loc,y
    *get,sn_z,node,nnxt,loc,z
    cmsel,s,tk_nd
    nsel,r,loc,x,sn_x-.1,sn_x+.1
    *if,abs(sn_x),gt,.1,then
       nsel,r,loc,y,sn_y+sec_ang-.1,sn_y+sec_ang+.1
    *endif
    nsel,r,loc,z,sn_z-.1,sn_z+.1
    *get,sn_num,node,,num,min
    cmsel,s,slab_nd
    nsel,a,,,sn_num
    cm,slab_nd,node
    nn=nnxt
*enddo
csys,4

cm,slab_nd,node

!--for line equation for each pair of in/out nodes
*do,ii,1, in_num-1
    nsel,s,,,nodeout(ii)
    nsel,a,,,nodein(ii)
    path_nd(pstart+ii)=nodein(ii)
    csys,110
    *get,x_out,node,nodeout(ii),loc,x
    *get,y_out,node,nodeout(ii),loc,z
    *get,x_in,node,nodein(ii),loc,x
    *get,y_in,node,nodein(ii),loc,z
```

```
    *if,ii,ne,in_num,then
          *get,xplus_in,node,nodein(ii+1),loc,x
          *get,yplus_in,node,nodein(ii+1),loc,z
          ds=sqrt((xplus_in-x_in)**2+(yplus_in-y_in)**2)
    *endif

    nwpla,-1,nodeout(ii),nodein(ii)
    csys,4
    cmsel,s,slab_nd
    nsel,r,loc,y,-1,1
    cm,ntemp,node
    esln
    esel,r,mat,,2
    nsle
    nsel,r,loc,y,-1,99999
    esln,,1
    cm,etemp,elem
    cmsel,s,ntemp
    cmsel,s,etemp
    csys,0
    get_res_360

    cmsel,s,ntemp
    ttt=sqrt((x_out-x_in)**2+(y_out-y_in)**2)
    get_hpfrc

    path_fa(pstart+ii)=unit_fsumy
    path_ft(pstart+ii)=unit_fsumx
    path_mz(pstart+ii)=unit_mz
    path_fh(pstart+ii)=hp_f

*enddo

pstart=pstart+in_num-1

rsys,0

/gresume,path_sx,plt
/view,,sin(sec_ang),,cos(sec_ang)
axial_path
!plpng

shear_path
!plpng

hoop_path
!plpng

moment_path
!plpng
```

```
!----Output path data to file
/sys,del path_sx.dat
*dim,pl,,pstart
ss=0
*do,i,1,pstart
     *get,path_x,path,,point,i,x
     *get,path_y,path,,point,i,y
     *if,i,gt,1,then
         ss=ss+sqrt((path_x-path_x0)**2+(path_y-path_y0)**2)
     *endif
     pl(i)=ss
     path_x0=path_x
     path_y0=path_y
*enddo

i=1
/output,path_sx,dat,,
*vwrite,pl(i),path_fa(i),path_ft(i),path_fh(i),path_mz(i)
(5e12.4)
/output
```

get_res_360.mac

```
cm,etemp,elem
cm,ntemp,node
*get,nelem,elem,,count
*get,nnode,node,,count

xx(1)=
yy(1)=
zz(1)=
ffx(1)=
ffy(1)=
ffz(1)=

*dim,xx,,nnode
*dim,yy,,nnode
*dim,zz,,nnode
*dim,ffx,,nnode
*dim,ffy,,nnode
*dim,ffz,,nnode

xmean=0
ymean=0
zmean=0

fsumx=0
fsumy=0
fsumz=0
```

```
cm,nn0,node
csys,0
*do,i,1,nnode
      *get,inode,node,,num,min
      nsel,s,,,inode
      xx(i)=nx(inode)
      yy(i)=ny(inode)
      zz(i)=nz(inode)
      xmean=xmean+xx(i)
      ymean=ymean+yy(i)
      zmean=zmean+zz(i)
      cmsel,s,nn0
      nsel,u,,,inode
      cm,nn0,node
*enddo

xmean=xmean/nnode
ymean=ymean/nnode
zmean=zmean/nnode

cmsel,s,ntemp
cmsel,s,etemp
spoint,,xmean,ymean,zmean

rsys,4
fsum,rsys

*get,fsumx,fsum,fx
*get,fsumy,fsum,fy
*get,fsumz,fsum,fz
*get,mmzz,fsum,mz


fsumx=fsumx/1000     !kip
fsumy=fsumy/1000     !kip
fsumz=fsumz/1000
mmzz=mmzz/1000       !kip-in

fct=90/div_num/360

arc_length=abs(3.14159*xmean*2)*fct

unit_fsumx=fsumx/arc_length*12 ! kip/ft
unit_fsumy=fsumy/arc_length*12 ! kip/ft
unit_mz=mmzz/arc_length*12     ! kip-in/ft
```

get_hpfrc.mac

```
cm,ntemp,node
*get,nnode,node,,count

rsys,110
csys,110

hp_f=0
sy_sum=0
nn=0
*do,i,1,nnode
      ndnxt=ndnext(nn)
      nsel,s,,,ndnxt
        esln
        esel,r,mat,,mat_conc
        cm,etemp,elem
        *get,s_y,node,ndnxt,s,y
        sy_sum=sy_sum+s_y
        cmsel,s,ntemp
        nn=ndnxt
*enddo

sy_sum=sy_sum/nnode

hp_f=sy_sum*ttt/1000*12  !kip/ft
```

axial_path.mac

```
!=======Define path
allsel
PADEL,ALL
path,in_surf,pstart,,1
*do,i,1,pstart
       ppath,i,path_nd(i)
       dnsol,path_nd(i),u,x,path_fa(i)
*enddo

allsel
PDEF,axial,u,x,AVG
/PBC,PATH, ,0


PLPAGM,axial,1000,Blank
/title,Axial Force (kip/ft)
/rep
```

shear_path.mac

```
!=======Define path
allsel
rsys,0
PADEL,ALL
path,in_surf,pstart,,1
*do,i,1,pstart
       ppath,i,path_nd(i)
       dnsol,path_nd(i),u,x,path_ft(i)
*enddo

allsel
PDEF,shear,u,x,AVG
/PBC,PATH, ,0


PLPAGM,shear,1000,Blank
/title,Shear Force (kip/ft)
/rep
```

hoop_path.mac

```
!=======Define path
allsel
PADEL,ALL
path,in_surf,pstart,,1
*do,i,1,pstart
       ppath,i,path_nd(i)
       dnsol,path_nd(i),u,x,path_fh(i)
*enddo

allsel
PDEF,hoop,u,x,AVG
/PBC,PATH, ,0


PLPAGM,hoop,1000,Blank
/title,Hoop Force (kip/ft)
/rep
```

moment_path.mac

```
!=======Define path
allsel
PADEL,ALL
path,in_surf,pstart,,1
*do,i,1,pstart
       ppath,i,path_nd(i)
       dnsol,path_nd(i),u,x,path_mz(i)
*enddo

allsel
PDEF,moment,u,x,AVG
/PBC,PATH, ,0


PLPAGM,moment,1000,Blank
/title,Moment (kip-in/ft)
/rep
```

plpng.mac

```
/SHOW,PNG
PNGR,COMP,1,-1
PNGR,ORIENT,HORIZ
PNGR,COLOR,2
PNGR,TMOD,1
/GFILE,600,
!*
/CMAP,_TEMPCMAP_,CMP,,SAVE
/RGB,INDEX,100,100,100,0
/RGB,INDEX,0,0,0,15
/REPLOT
/CMAP,_TEMPCMAP_,CMP
/DELETE,_TEMPCMAP_,CMP
/SHOW,CLOSE
/DEVICE,VECTOR,0
```

path_sx.plt

```
/NOPR
/RESET
/DEVICE,VECT,OFF
! General Graphics Settings
/NUM,  1
/PLOP,INFO, 3
/TRIAD,RTOP
/GTHIC,CURV,  2
/GROPT,CGRI,ON
/GROPT,CURL,  1
/PNUM,MAT , 1
/COL, NUM ,ORAN, 2
/TRLCY,ON
/TXTRE,ON
! Window Settings
/VIEW,1,  0.0000    ,  0.0000    ,  1.0000
/FOC, 1,  241.31    ,  836.95    ,  13.005
/DIST,1,  446.41
/TYPE,1, 6
/EDG, 1, 0,  45.000
/CONT,1,  9,AUTO
/GO
```