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STRUCTURAL EVALUATION FOR THE CORE SAMPLING TRUCKS RMCS OPERATIONS 200 AREA

Pages: 49

MAR 12 1996 Sta. 21 (21)

ENGINEERING DATA TRANSMITTAL

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1	WHC-SD-WM-DA-215	N/A	0	Structural Evaluation for Core Sampling Trucks, RMCS Operations, 200 Area	SQ	1	1	1

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	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.
1	1	Cog.Eng. R.N. Dale	[signature]	3/12/96	S7-12						
1	1	Cog. Mgr. J.S. Schofield	[signature] PER TELECON	3/12/96	S7-12						
1	1	QA M.L. McElroy	[signature]	3/12/96	S7-07						
1	1	Safety J.A. Harvey	[signature]	3/12/96	S7-07						
1	1	C/Str Mgr. M.S. Ruben	[signature]	12/12/95	E6-46						
1	1	J.L. Smalley	[signature]	3/12/96	S7-12						
1	1	R.H. Stubbs	[signature]	3/12/96	S7-12						

18.	19.	20.	21. DOE APPROVAL (if required)
[signature] 12/4/95 Signature of EDT Originator Date M. A. Islam	[signature] 3/12/96 Authorized Representative for Receiving Organization Date R. N. Dale	PER TELECON R.N. DALE for JSS 3/12/96 Cognizant Manager Date J. S. Schofield	Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

BD-7400-172-2 (04/94) GEF097

BD-7400-172-1 (02/89)

Structural Evaluation for the Core Sampling Trucks, RMCS Operations, 200 Area

M. A. Islam
Westinghouse Hanford Company, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-87RL10930

EDT/ECN: 156987 UC: 2020
Org Code: 57200 Charge Code: P1K700
B&R Code: EW3120074 Total Pages: 47

Key Words: Waste Core Sampling, Impact, Drop Energy

Abstract:

This report evaluates the structural adequacy and the integrity of the existing core sampling trucks to withstand impact should the trucks drop off the ramp, either onto the soft ground or onto a non-yielding surface due to operational error, wind, or earthquake. The report also addresses if the allowable tank dome load will be exceeded by the addition of the impact load.

MAR 12 1996
DATE:
STA: 21
HANFORD RELEASE
ID:
21

3/12/96

Release Approval | Date | Release Stamp

Approved for Public Release

STRUCTURAL EVALUATION FOR THE CORE SAMPLING TRUCKS RMCS OPERATIONS, 200 AREA

Prepared by
ICF Kaiser Hanford Company
Richland, Washington
for
Westinghouse Hanford Company

Prepared by: M. A. Islam, Principal Engineer, Civil/Structural Engineering — Date: 12/4/95

Checked by: T. C. Mackey, Principal Engineer, TWRS Analytical Engineering — Date: 12/4/95

Approved by: M. S. Ruben, Manager, Civil/Structural Engineering — Date: 12/5/95

Westinghouse Hanford Company
Hanford Operations and Engineering Contractor
for the
U.S. Department Of Energy Field Office Richland, Washington

DESIGN VERIFICATION METHOD

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

_____x_____ Independent Review

__________ Alternate Calculations

__________ Qualification Testing

__________ Formal Design Review

M. S. Ruben
Cognizant/Project/Design Manager

SD #WHC-SD-WM-DA-215, REV. 0

ECN # N/A

DWG(S) # N/A

TYPICAL CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed Structural Evaluation for Core Sampling Trucks, 200 Area

Author M.A. Islam

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

MANDATORY Software QA Log Number - None

Mark D. Axup
Reviewer - ~~T. C. Mackey~~ M. D. Axup

1/22/96 mdA
~~12/4/95~~
Date

CONTENTS

STRUCTURAL EVALUATION FOR THE CORE SAMPLING TRUCKS RMCS OPERATIONS, 200 AREA

1.0 INTRODUCTION

This report evaluates whether the sampling truck is likely to tip over, slide, or drop off the ramp/platform because of operational error, wind, or design basis earthquake (DBE). This evaluation will also verify if the allowable tank dome load for all single shell tanks (SST) and double shell tanks (DST) is likely to be exceeded by the addition of the impact load. The impact occurs when the tires run off the platform, thereby, allowing the truck rear axle to drop first onto the platform, then, to drop either onto the soft ground or onto a non-yielding surface. The trucks are used for core sampling in Rotary Mode Core Sampling (RMCS) operations in the tank farms of the 200 Area. The evaluation will use Safety Class 3 over 1 loads for wind and DBE.

This report evaluates the following impact scenarios should the truck drop off the ramp/platform:

A. Impact with the non-rigid surface (truck rear axle dropping onto the ramp/platform)

B. Impact with the soft ground

C. Impact with a non-yielding object (concrete pit, riser, etc.)

2.0 SUMMARY OF EVALUATIONS

Impact Scenario A

The results of the evaluations for Impact Scenario A indicate that the bending stress in the platform exceeds the ultimate strength of the material for the platform. Therefore, the platform may fracture, and/or permanently deform. It is complex to assess if the platform would be capable of maintaining its structural integrity. The consequence of this impact scenario could be avoided if a retaining device was connected to the platform or some administrative controls were applied to guarantee that the truck would not fall off the platform. If this impact scenario is prevented, Impact Scenarios B and C would not occur.

The impact load from Impact Scenario A. plus other loads from core sampling equipment have been compared to the allowable tank dome load. The maximum equipment weight including truck and ramp/platform that can be placed on the tank dome is as follows:

75 ft. diameter tank (SST)	-	150,000 pounds
20 ft. diameter tank (SST)	-	55,000 pounds
20 ft. diameter tank (DST)	-	55,000 pounds (assuming 40 psf load remains as uniformly distributed load)

Impact Scenarios B and C

The analyses for these scenarios were performed by using a drop height of 24 inches. The results of the analysis for Impact Scenario B are compatible to those of Impact Scenario A. However, the results of the analysis for Impact Scenario C indicate that the truck bed would collapse and the tank dome would not be capable of supporting any load from sampling equipment. If the Impact Scenario A cannot be avoided, actual drop height needs to be used to determine the actual stresses and the equipment load on tank dome. The calculations with 24 inch drop height are included in Appendix B for information.

Effect of Wind on the Truck

The results of the evaluations indicate that the truck and the platform will not tip over off the dunnage from the wind load alone. Obviously, the truck will not also tip over off the platform if the truck and the platform are strapped together. Therefore, the wind alone has no adverse effect on the truck. Resonance of the truck was not considered in the analysis for wind.

Effect of Earthquake (DBE) on the Truck

The results of the evaluations indicate that the truck and the platform will tend to overturn or slide off the dunnage from the design basis earthquake (DBE) load. If a positive anchorage is provided between the post of the platform and the dunnage, the truck, platform, and the dunnage will remain connected during this event and will not overturn off the ground. However, the truck along with the platform and the dunnage will slide against the ground. The results of the evaluations also indicate that if the dunnage consists of multiple layers of plywood in 3 inch increments, a bolted connection between the layers of plywood or some other device is necessary to keep the dunnage intact.

3.0 DESIGN ANALYSIS

3.1 OBJECTIVE

Core sampling trucks are currently used to obtain waste sample cores from the SSTs and DSTs in the 200 Areas. Sampling is done through various risers which extend from the tank dome upward to ground surface. Many of these risers are located in concrete pits, caissons or other enclosed areas. Because the trucks cannot always get close to the risers, core sampling could not be accomplished through these risers. This difficulty was overcome by using ramp/platform which will permit the trucks to park over the risers for access. This process will significantly increase the number of risers available for obtaining core samples (Reference 1).

The ramp is 24 inch high and consists of a steel deck and supporting beams. During normal core sampling, the truck is backed up to a riser and raised on leveling jacks to make the truck perpendicular to the tank riser being sampled. When using the ramp/platform, the truck will be backed onto the ramp, and then leveled on the elevated platform.

The truck is approximately 26 ft. long, 8 ft. wide, and 17 ft. 6 in. high which includes the height of the sampling equipment (Ref. 10). The truck bed consists of a stationary and a rotating platform. The rotating platform is circular in shape and is approximately 12 ft. in diameter. The stationary platform is narrower than the rotating platform. Therefore, if the truck was to drop off the ramp/platform, the rotating platform would be the first item of the truck above tires that would impact the soft ground or a non-yielding object.

3.2 ANALYSIS LOAD SCENARIOS

The sampling truck may drop off the ramp/platform as a result of either of the following postulated scenarios:

- Operational error
- Wind load
- Earthquake load

The truck may fall off the ramp/platform due to gross operational error at the time of moving the truck. This scenario involves an impact with a non-rigid surface (platform). For this to happen, one of the rear dual tires must come off the ramp/platform, thereby, allowing the axle to drop onto the platform. At that time, because the truck remains in a skewed position, inertia from this drop may tend the truck rear axle to slide off the platform. Thus, the tire would impact the ground and the truck bed might tend to roll-over. If this was to happen, the rotating platform would impact with either the soft ground or a non-yielding surface. However, this scenario could be avoided if a retaining plate is provided with the platform. Section 4.0, Recommendations, has identified this in detail.

The truck and the sampling equipment assembly have significant surface areas and the center of gravity of the unit in the upright position is 64 inches from the bottom of the tire (Ref. 2). In addition, the dunnage consisting of multiple layers of plywood, analyzed in 3 inch increments below each post of the platform, is also provided. Therefore, both wind and earthquake loads are verified to determine if the truck were to tip over off the ramp/platform and the dunnage.

3.3 ENGINEERING ANALYSIS

The engineering evaluations for the sampling truck as it drops off the ramp/platform consist of two sections; first, structural integrity of the truck and the platform, and secondly, satisfying the tank dome load. The requirements for the tank dome loading are included in Table B-5.22-1 of each of the IOSR documents (Ref. 1). This evaluation applied the limits of these loadings in the following way:

DSTs - 50 tons concentrated live load + 40 psf uniform live load

SSTs - 50 tons and 100 tons live loads for 20 ft. and 75 ft. diameter tanks respectively

Based on the above allowable loadings, maximum equipment weight including the truck and the ramp/platform that can be placed on the tank dome was determined.

Truck Impacting Soft Ground (Impact Scenario B)

As mentioned earlier, the truck may drop off the ramp/platform onto a soft ground (yielding) or a non-yielding object. The idea underlying the scenario with the soft ground is to determine the impact force by solving two simultaneous equations. These are:

- The equation of motion where impact force is a function of mass an impact factor being dependent on height of fall and depth of penetration in ground.
- The impact force must equal the soil reaction to maintain equilibrium. The soil reaction is a function of soil compressive strength and area of impact.

The solution of these equations determines the depth of penetration and the impact force. The impact force is then used in the analysis to determine the stress in the rotating platform of the truck bed assembly and the allowable load that can be placed on the dome.

The calculations determining the ability of the truck to resist fracture have been performed according to the energy absorption theory (Refs. 4 and 11). The result of this analysis indicates the amount of distortion of the rotating platform when it impacts the ground. The calculations are included in Appendix B.

Truck Impacting Non-yielding Object (Impact Scenarios A and C)

Reference 3 was used to determine the impact force which is a function of mass, velocity, and stiffness of the falling body. The impact force obtained was again used to determine the stress in the rotating platform of the truck bed assembly. Similar to the impact with the soft ground, the energy absorbing capacity of the rotating platform for Scenario C was determined and compared to the potential energy of the truck (Reference 12). The calculations are included in Appendix B.

Wind and Earthquake

The sampling equipment, the truck, and the ramp/platform are all safety class 3 items, however, these are within the influence of the tank which is a safety class 1 structure. Because of this, safety class 1 loads were used for both wind and the DBE to satisfy safety class 3 over 1 criteria. The wind load was determined from Reference 6 and the DBE was obtained from Reference 8. In both cases, these loads were applied laterally at the center of gravity (c.g.) of the truck and the sampling equipment to determine the overturning moment and the reaction at the base of the platform post.

For wind, the resisting moment was obtained by multiplying the gravity force with the distance from the c.g. and the dunnage. The stability of the truck and the ramp/platform was determined by comparing the resisting and overturning moments.

For DBE, net reactions at the base of the dunnage were determined from the seismic loads in all three orthogonal directions. The stability of the truck and the ramp/platform was determined using energy absorption criteria. The friction between the dunnage and the ground was considered to determine if the truck along with the platform would overturn or slide. The calculations are included in Appendix A.

4.0 RECOMMENDATIONS

The results of the analysis revealed the following deficiencies with the truck, platform, and the dunnage:

- The truck and the platform are not tied together.
- The post of the platform is not anchored to the dunnage.
- The multiple layers of the dunnage are not tied to each other.
- Because the dunnage and the platform are not anchored, the platform will slide due to seismic motion.

Civil/Structural Engineering recommends in implementing the following corrective actions:

- The truck and the platform should be tied together by a strap or chain.
- A retaining plate should be connected to the platform.
- The truck should be winched or lifted by crane onto the ramp/platform.
- The platform post base should be anchored to the dunnage.
- The multiple layers of the dunnage should be bound or anchored by means of bolts or retaining device.
- There should be a contingent plan to handle the sliding of the platform/dunnage unless this sliding is deemed acceptable.

The recommended items, once implemented, will ensure that the truck will not drop off the ramp/platform for the postulated events described in Section 3.2.

5.0 REFERENCES

1. R. N. Dale, *Use of Elevated Ramps/Platforms for Core Sampling Trucks*, ECN 626601, Westinghouse Hanford Company, Richland, Washington, 1995.

2. H. H. Ziada, *Rollover Analysis of Rotary Mode Core Sampler Truck #2*, WHC-SD-WM-ER-391, Revision 0, EDT 608355, Westinghouse Hanford Company, Richland, Washington, 1994.

3. G. Szuladzinski, *"Dynamics of Structures and Machinery,"* Chapter 13, 1982.

4. E. H. Gaylord & C. N. Gaylord, *"Structural Engineering Handbook,"* Chapter 10, McGraw-Hill Book Company, 1968 Edition.

5. *Manual of Steel Construction*, 8th Edition, American Institute of Steel Construction, Chicago, Illinois.

6. *Minimum Design Loads for Buildings and Other Sructures*, ASCE 7-88, American Society of Civil Engineers, New York, New York, 1990.

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8. *Seismic Design Guide for Safety Class 3 & 4 Equipment at Hanford Site*, WHC-SD-GN-DGS-30006, Revision 1, Richland, Washington, 1993.

9. *Generic Assessment of Unsecured 3/1 and 1/1 Items*, DTRF A-3886, Hanford Engineering Development Laboratory, Richland, Washington, 1980.

10. *Timber Construction Manual*, 4th Edition, Chapter 7, American Institute of Timber Construction, John Wiley & Sons, Inc., New York, New York.

11. *Impact Analysis of Fuel Spacer Burial Box*, WHC-SD-WM-DA-074, Revision 0, EDT 106095, Westinghouse Hanford Company, Richland, Washington, 1990.

12. O. W. Blodgett, *"Design of Welded Structures"*, Section 2.8, 1966.

13. R. J. Roark, *"Formula for Stress and Strain"*, 4th Edition, 1965.

14. M. F. Spotts, *"Design of Machine Elements"*, Chapter 12, 2nd Edition.

15. Hanford Site Drawings, H-2-690000, H-2-690040, H-2-690081, H-2-73252, and H-2-85633 (Preliminary).

APPENDIX A

Engineering Evaluation for Core Sampling Trucks for Impact Scenario A, Wind, and Earthquake Loads

DESIGN ANALYSIS

Client Characterization Field Engr.(CFE)	WO/Job No. P1K700
Subject Impact Analysis for Sampling Truck for RMCS Operation	Date 10/25/95 By M.A. Islam
	Checked 1/22/96 By [illegible]
Location 200 Area Gen.	Revised By

Scope

Prepare an analysis for the sampling truck to be used in RMCS operations. The analysis will determine if the sampling truck will likely to tip over, slide, or fall off the platform due to operational error, wind, and earthquake. The truck falling off the platform due to error, wind, or earthquake will create an impact load to the tank dome. The analysis will provide some recommendations at different load scenarios.

Criteria

Gross wt. of sampling truck incl. equipment, W = 28,500 lbs

Tank dome live load: 50 tons concentrated + 40 psf for DSTs Ref. 1
50 tons concentrated for SSTs (20 ft. dia. tank)
100 tons concentrated for SSTs (75 ft. dia. tank)

Materials: A36 steel for shape; 3,000 psi concrete (Ref. Dwg. H-2-73597)
ASTM B209, 6061-T6, AL (Ref. Dwg. H-2-690080, sht 1 of 2, Rev 2)

References

1. RMCS Operations, ECN 626601
2. Analysis of Rotary Mode Core Sampler Truck #2, WHC-SD-WM-ER-391, Rev. 0
3. Gregory Szuladzinski, 'Dynamics of Structures and Machinery', Chapter 13
4. Gaylord, 'Structural Engineering Handbook', Chapters 5 & 10, 1968 Edition.
5. AISC, 'Manual of Steel Construction', 8th Edition
6. ASCE 7-88, 'Minimum Design Loads for Buildings and Other Structures'
7. SDC-4.1, Rev 12, 'Hanford Plant Standards'
8. Seismic Design Guide for Safety Class 3 & 4 Equipment at Hanford Site, WHC-SD-GN-DGS-30006, Revision 1.
9. Generic Assessment of Unsecured 3/1 and 1/1 Items, DTRF A-3886.
10. AIST, 'Timber Construction Manual', 4th Edition, Chapter 7.
11. Drawings H-2-690000, 690040, 690081, H-2-73252, and H-2-85633 (Prel.)

DESIGN ANALYSIS

Client Characterization Field Engr.(CFE) WO/Job No. P1K700
Subject Impact Analysis for Sampling Truck for RMCS Operation Date 10/25/95 By M.A. Islam
Checked 1/22/96 By [signature]
Location 200 Area Gen. Revised By

EXPLANATION FOR THE IMPACT SCENARIO

The truck may fall off the ramp/platform due to gross operational error at the time of moving the truck. For this to happen, one of the rear dual tires must come off the ramp/platform, thereby, allowing the axle to drop onto the ramp/platform. This scenario involves an impact with a non-rigid surface (ramp/platform). During that time, because the truck remains in a skewed position, inertia from this drop may tend the truck rear axle to slide off the ramp/platform, and thereby, the tire drops onto the ground and the truck bed may ~~impact with~~ either the soft ground or the non-yielding surface. The above scenario of the fall involves the following impact load conditions:

A. IMPACT WITH THE NON-RIGID SURFACE (RAMP/PLATFORM)

Height of drop = 15 in. (between axle and platform top)

% of Weight of Truck = 38 (rear dual wheel per Ref. 1)

If the impact at Scenario A. is sustained by the ramp/platform, the following additional impact scenarios may follow:

B. IMPACT WITH THE SOFT GROUND

Height of drop = 20 to 35 inches which include 3 to 18 inches of dunnage (Height of drop is betn. truck bed and grade)

% of Weight of Truck = 50 (conservatively use half - other half on tire and the axle)

C. IMPACT WITH NON-YIELDING OBJECT (CONC. PIT, RISER ETC.)

Same data as in B.

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DESIGN ANALYSIS

Calc. No. WHC-SD-WM-DA-21
Revision 0
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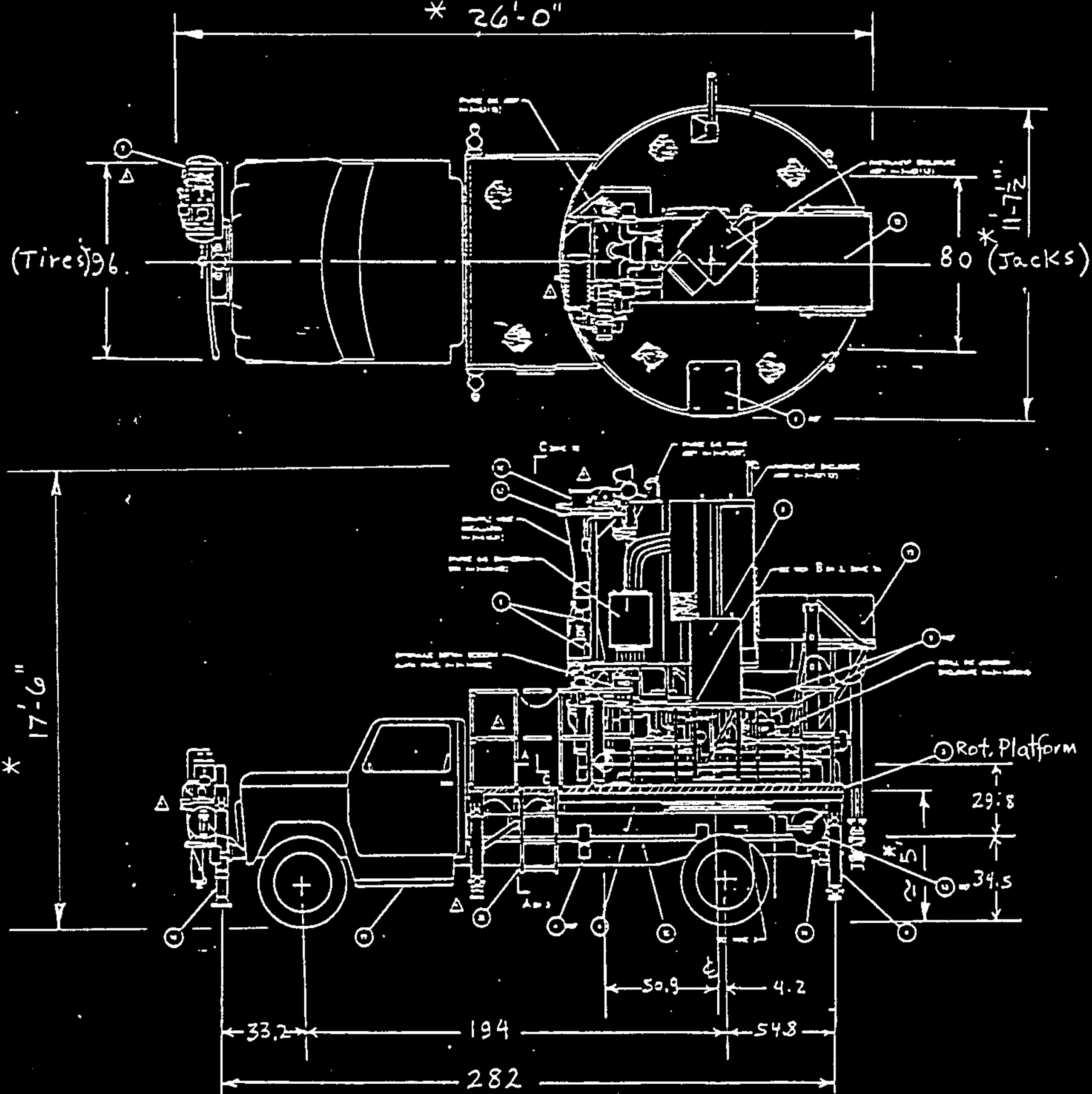
Client	Characterization Field Engr. (CFE)	WO/Job No.	POD400 / PIK700		
Subject	Impact Analysis for Sampling Truck for RMCS operation	Date	10/25/95	By	M. A. ISLAM
		Checked	12-4-95	By	[illegible signature]
Location	200 Area (Gen)	Revised		By	



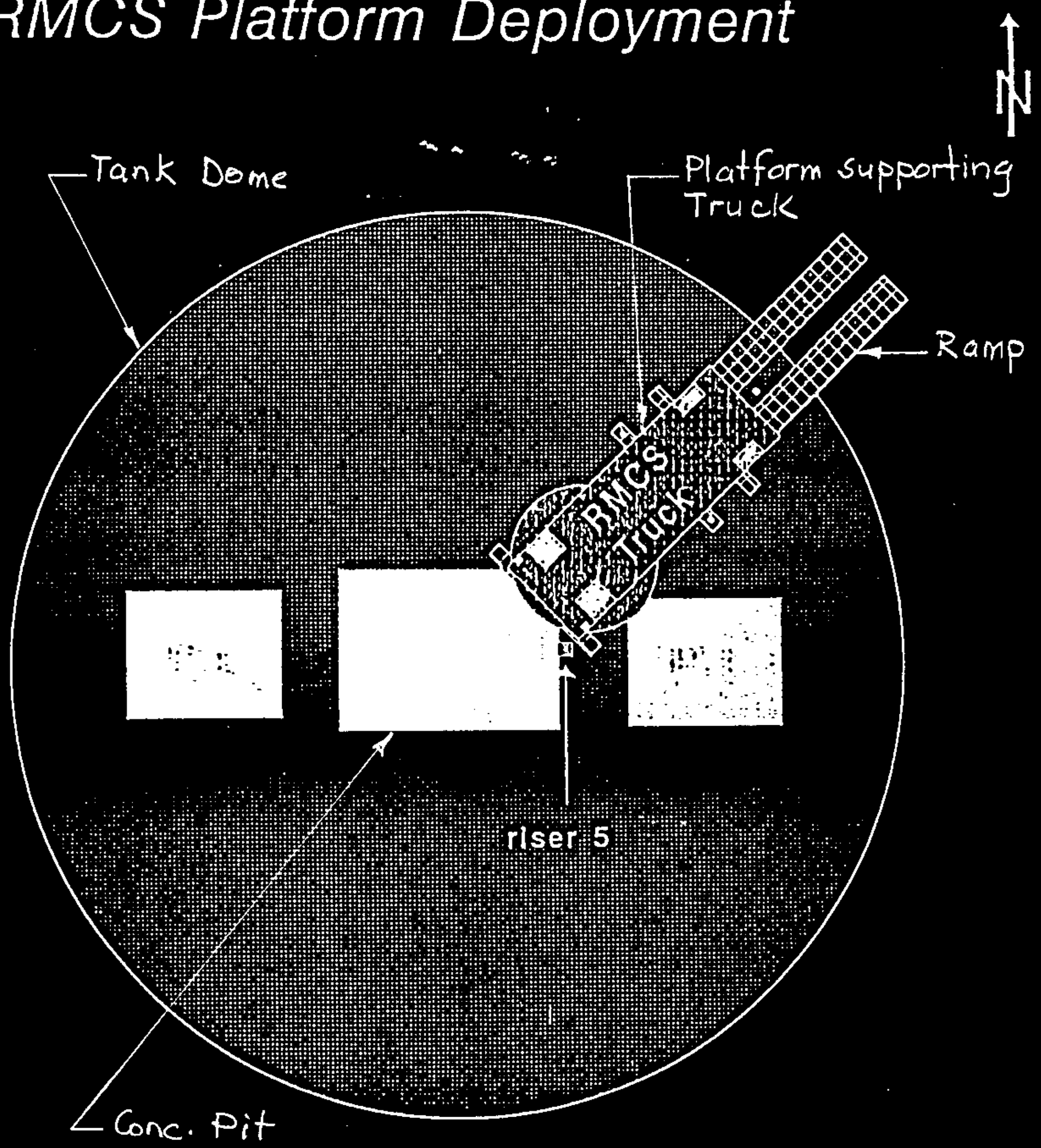
SAMPLING TRUCK PLAN & ELEVATION

(Dimensions shown correspond to Truck # 2, Ref. 2, WHC-SD-WM-ER-391, Rev 0., except for the one shown by * which are applicable to Truck # 3 & # 4, Ref. Dwg. H-2-690000, Rev 0.)

Client	Characterization Field Engr. (CFE)	WO/Job No.	POD400 / P1K700		
Subject	Impact Analysis for Sampling Truck for RMCS operation	Date	10/25/95	By	M. A. ISLAM
		Checked	12/4/95	By	[signature]
Location	200 Area (Gen)	Revised		By	

Location Map

RMCS Platform Deployment



Platform & truck location on BY-104

PLAN

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DESIGN ANALYSIS

Calc. No. WHC-SD-WM-DA-215
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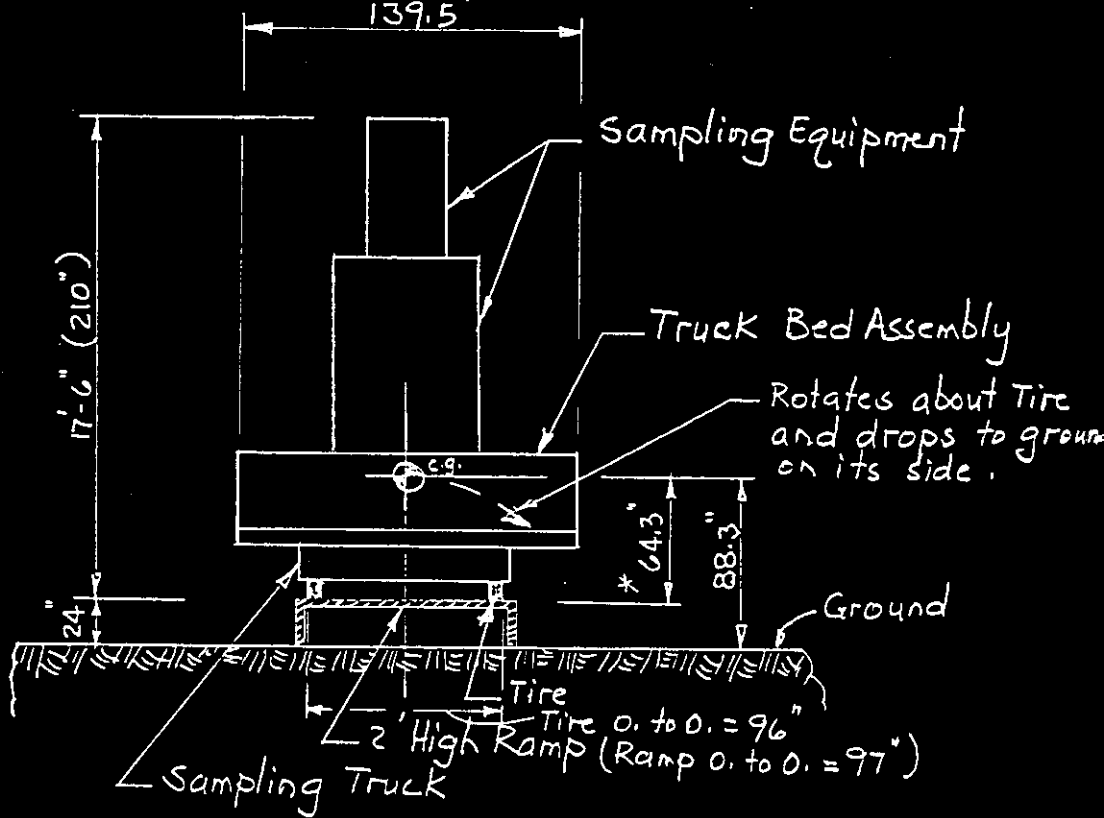
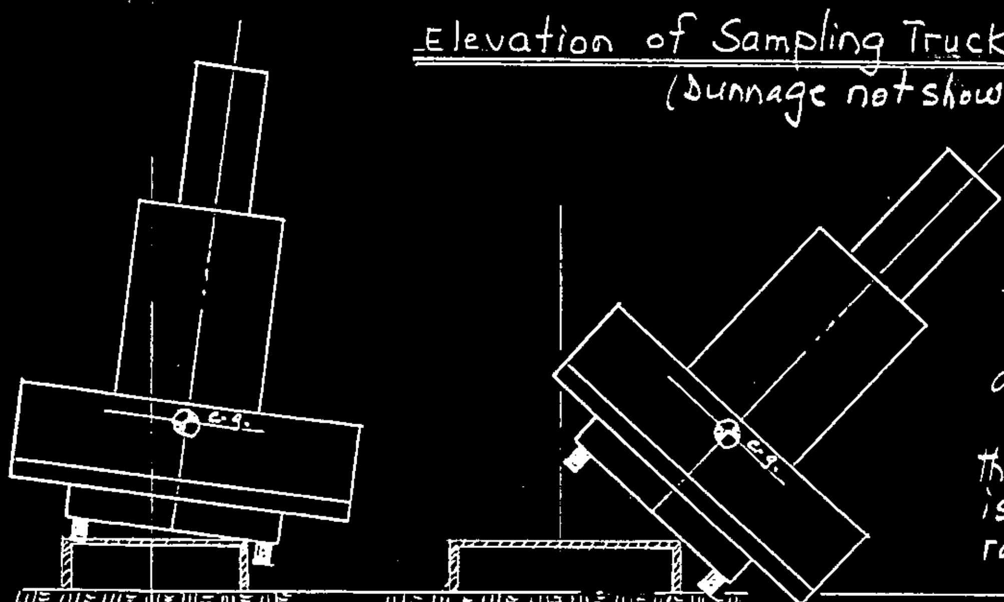
Client	Characterization Field Engr. (CFE)	WO/Job No.	POD400/PIK700		
Subject	Impact Analysis for Sampling Truck for RMCS operation	Date	10/26/95	By	M. A. ISLAM
		Checked	11/22/96	By	Mark Aney
Location	200 Area (Gen)	Revised		By	

A. IMPACT WITH NON-RIGID SURFACE



Elevation of Sampling Truck as it rest on Ramp
(Dunnage not shown)



Note
The impact scenario at B & C is hypothetical and may occur if the impact at Scenario A is sustained by the ramp/platform.

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DESIGN ANALYSIS

Calc. No.	WHC-SD-WM-DA-215
Revision	0
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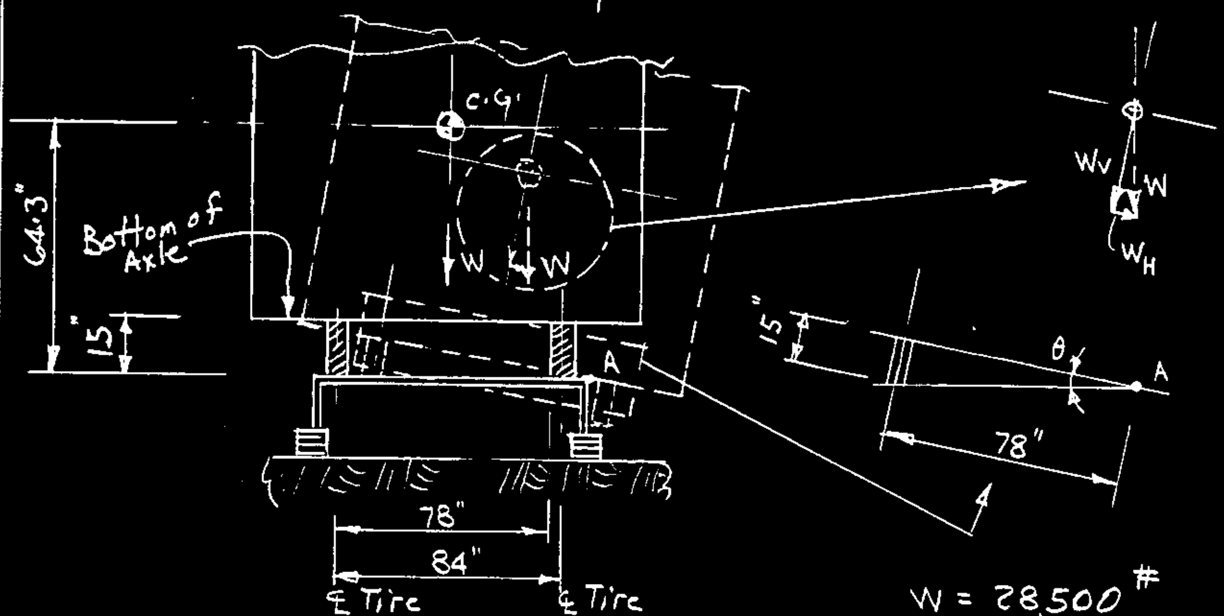
Client	CFE	WO/Job No.	P1K700		
Subject	Truck/Ramp Impact Analysis for RMCS Operations	Date	12/21/95	By	M.A. ISLAM
		Checked	1/22/96	By	Mark Aamp
Location	200 Area	Revised		By	

Stability of Truck/Ramp @ Scenario A



W = 28,500 #

$\theta = \tan^{-1}\frac{15}{78} \approx 11^\circ$

$W_V = W\cos\theta = 28500 \times \cos 11^\circ = 27{,}976\ \#$

$W_H = W\sin\theta = 28500 \times \sin 11^\circ = 5{,}438\ \#$

Taking moment about A

Overturning Moment, $M_O = W_H(64.3 - \frac{15}{2}) = 5438 \times (64.3 - \frac{15}{2})$
$= 308{,}878\ \#\text{-in}$

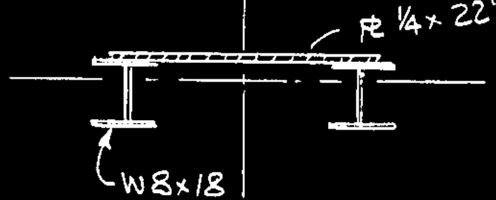
Resisting Moment, $M_R = W_V(78/2) = 27{,}976 \times 39$
$= 1{,}091{,}064\ \#\text{-in} > 308{,}878\ \#\text{-in}$ OK.

Conclusion

If a tire comes off the platform due to gross operational error, rear axle falls on platform. From above geometry, it appears that the truck will not drop onto ground ($M_R \gg M_O$), however, impact inertia or some unknown reason may cause the truck to fall onto ground at angular motion.

Bending stiffness of Ramp/Platform

Refer to Dwg. H-2-85633, Rev 0 (Preliminary)

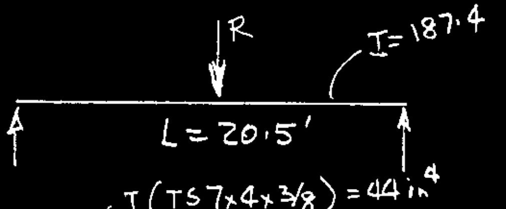


A = 5.26 ; d = 8.14"
I = 61.9, I_{min} = 7.97 in⁴
S = 15.2 in³

5.26 x 2 x 4.07 = 42.8
.25 x 22 x (8.14 + .125) = 45.4
16.02 — 88.2

$\bar{y} = \frac{88.2}{16.02} = 5.5"$

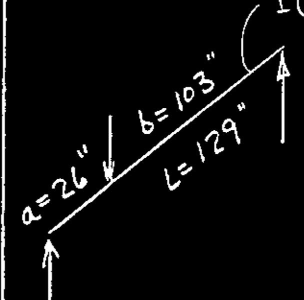
$I = 2\times 61.9 + 2\times 5.26\times(5.5-4.07)^2 + .25\times 22\,(8.14+.125-5.5)^2$
$= 187.4\ in^4 \ ; \quad S = 187.4/5.5 = 34.1\ in^3$



Bending Stiffness, K_{b1}

$= \frac{48EI}{L^3} = \frac{48\times 29\times 10^6\times 187.4}{(20.5'\times 12)^3}$

$= 1.75\,E4\ \#/in$



$K_{b2} = \frac{3\times 29\times 10^6\times 44\times 129}{26^2\times 103^2} = 6.89\,E4\ \#/in.$

$K_b\,(Equivalent) = \frac{1}{\frac{1}{K_{b1}}+\frac{1}{K_{b2}}+\frac{1}{K_{b2}}} = 1.16\,E4$

From Ref. 3

Impact Reaction, $R = V\sqrt{MK}$ where $M = \frac{W}{g} = \frac{.38\times 28500}{386.4}$
$= 28\ \#\text{-}s^2/in$

$V = \sqrt{2gh} = \sqrt{2\times 386.4\times 12}$
$= 96.3\ in/s$

h = 15" if free fall
Use h = 12" (due to sliding action)

$R = 96.3\sqrt{28\times 1.16E4} = 54{,}882\ \#$

Check Adequacy of Ramp/Platform

2 W8x18 w/PL

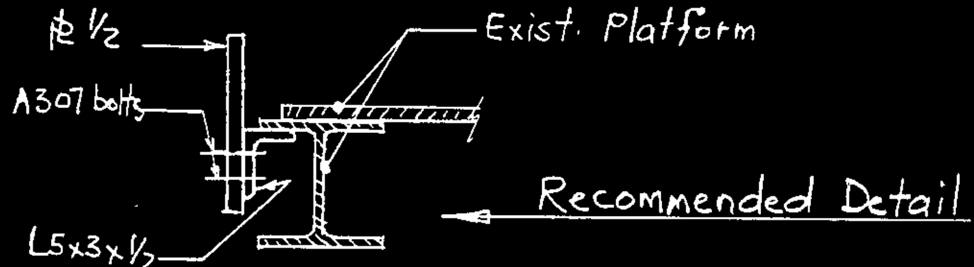
$$M_{max} = \frac{PL}{4} = \frac{54882 \times 246}{4} = 3{,}375{,}243 \text{ \#-in}$$

$$\sigma_b = \frac{3{,}375{,}243}{34.1} = 98{,}981 \text{ Psi} \gg \sigma_{yield} = 36{,}000 \text{ Psi}$$

$$\sigma_{ult.} = 58{,}500 \text{ Psi}$$

{N.G.}

Because the stress exceeds the yield and the ultimate strengths of steel, the platform might fracture and fail to maintain its shape and form. To avoid this situation, we recommend a retaining plate to be connected with W8 as shown below.



This scenario could be eliminated if the retaining plate (Angle/plate) is connected as shown above or some administrative controls are applied to guarantee that the tire will not get off the platform.

Conclusion

Because the retaining plate or the administrative controls will prevent the truck to fall off the platform, Impact Scenarios at B & C are not likely to occur. However, analyses for B and C, using height of drop = 24", are enclosed in Appendix B.

Dome Load Calculations Assuming Platform Sustains Impact
(@ Scenario A)

Total Impact = 54,882#

Net Impact = 54,882 - .38 x 28500 = 44,052#

75 Ft. Dia. Tank (SST)

Ref. 1, Allowable Dome Load (concentrated) = 100 Tons = 200,000#

Max. *Equipment weight that can be placed on the dome

= 200,000 - 44052 = 155948 Say 150,000# or 75 Tons

* incl. truck & ramp/platform

20 Ft. Dia. Tank (SST)

Ref. 1, Allowable Dome Load = 50 Tons = 100,000#

Max. Equipment weight (incl. truck & ramp/platform) that can be placed on the dome

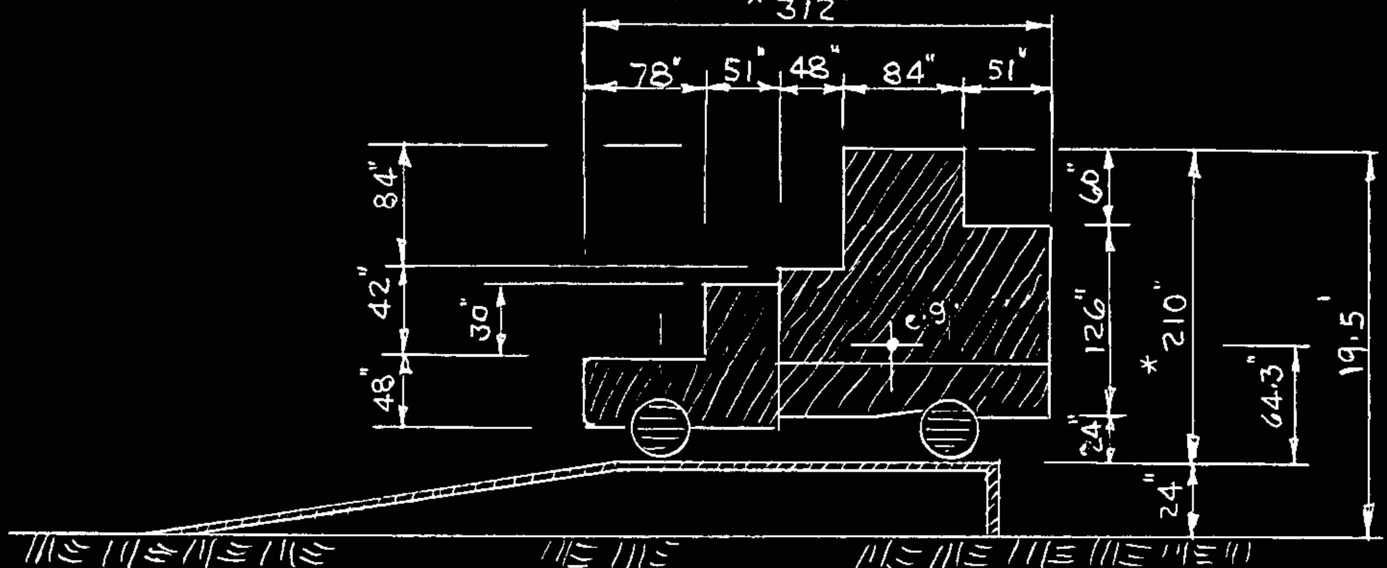
= 100,000 - 44052 = 55,948#

Say 55,000#

All DST's

Same as 20 Ft. Dia. Tank (SST)

Effect of Wind on Sampling Truck



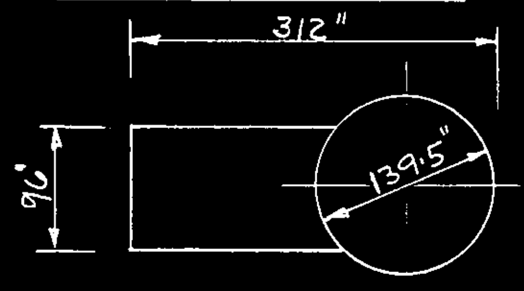
All dimensions except shown by * are conservative and scaled from Dwg. H-2-690000, Rev 0.

Surface Area of Truck (shaded)

$$A = 48 \times 78 + 51 \times (48+30) + 48 \times (42+48) + 84 \times (126+60) + 51 \times 126 + 2 \times \frac{\pi 36^2}{4} \quad \text{(Tire)}$$

$$= 36{,}128 \text{ in}^2$$

Truck Bottom Area



$$A_b = \frac{\pi}{4} \times 139.5^2 + 96 \times (312 - 139.5) \quad \text{(approx.)}$$

$$= 31{,}844 \text{ in}^2$$

DESIGN ANALYSIS

Client	CFE	WO/Job No.	P1K700		
Subject	Impact Analysis	Date	11/2/95	By	M.A. ISLAM
		Checked	12/4/95	By	Mark Axup
Location	200 Area Gen.	Revised		By	

Refer to ASCE 7-88 (Ref. 6)

Wind Pressure, $q_z = .00256\, K_z\, (IV)^2$

where $K_z = .87$, Exposure C, Table 6

$I = 1.0$
$V = 90$ mph } Safety Class 1 SDC 4.1, Rev 12 (Ref. 7)

$\therefore\ q_z = .00256 \times .87 \times (1.0 \times 90)^2 = 18.0\ \#/SF$

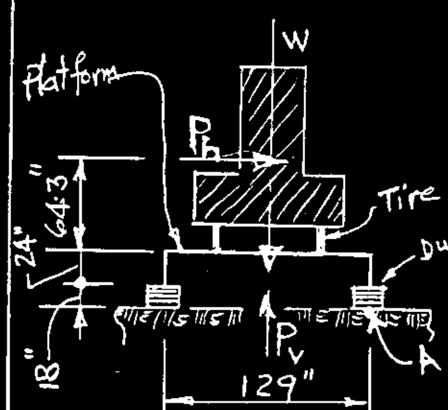
Add effects of gust response (G_h) and external and internal Pressure coefficients (C_p and GC_{pi} respectively).

$\therefore\ P = q_z G_h C_p \pm q_z (GC_{pi})$

where P = Net Pressure
$q_h = q_z$ for 1-story bldg.

From Fig. 2, $C_p = .8$
From Table 8, $G_h = 1.29$
" Table 9, $GC_{pi} = \pm .25$

$\therefore\ P = 18.0\,(1.29 \times .8 + .25) = 23.08\ \#/SF = .16$ Psi



$P_h = .16 \times 36128 = 5780\#$; $P_v = .16 \times 31844 = 5095\#$

Moment about A, $P_h(64.3+24+18) + P_v(\frac{129}{2})$

$M_A = 5780 \times 106.3 + 5095 \times 64.5 = 943{,}042$ #-in

Resisting Moment, $M_R = W(\frac{129}{2})$ #-in

$M_R = 28500 \times 64.5 = 1{,}838{,}250 > M_A$ OK

$\therefore$ No tipping of truck occurs due to Wind

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DESIGN ANALYSIS

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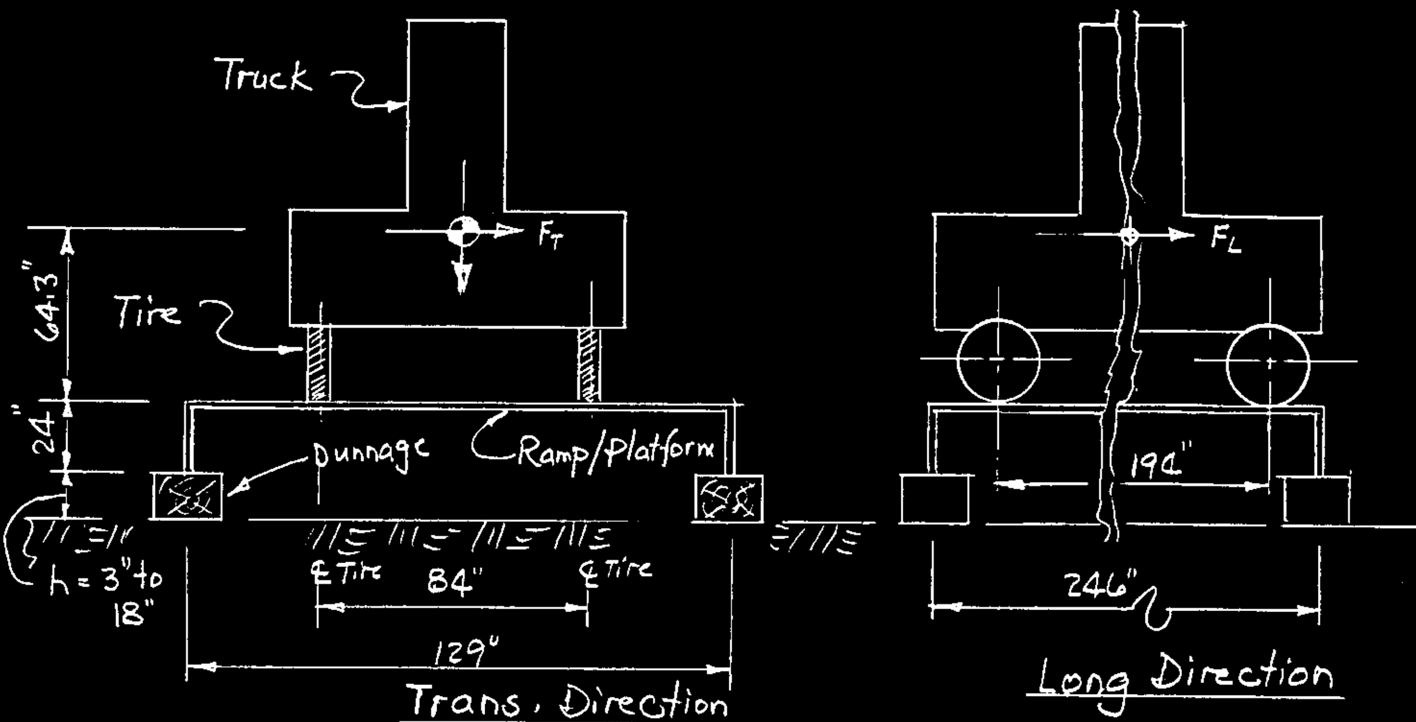
Client	CFE	WO/Job No.	P1K700
Subject	Impact Analysis for RMCS Operations	Date 1/3/96	By M.A. ISLAM
		Checked 1/22/96	By Mark Arend
Location	200 Area	Revised	By

Seismic Analysis for Safety Class 3/1 Item

Reference 8, Design Guideline WHC-SD-GN-DGS-30006, Rev 1



Ref. 8, Table 2.5

For Flexible equipment located at or below grade, Accln., $g_h = .68\,g$

$\therefore\; g_{vert.} = 2/3 \times .68 = .45\,g$

Because friction is ignored to resist seismic load, a Tie-down device between truck and platform is recommended. Therefore, tipping of truck off the platform will not be looked into.

Only scenario will be considered is the tipping of the platform off the dunnage or ground.

Seismic Forces

Transverse, $F_T = .68 \times 28{,}500^{\#} = 19{,}380^{\#}$ (Truck)

$F_T = .68 \times 3000^{\#} = 2{,}040^{\#}$ (Platform)

(use half of ramp/platform weight

Longitudinal, $F_L = 19{,}380 \times .4 = 7{,}752^{\#}$ (Truck)

$F_L = 2040 \times .4 = 816^{\#}$ (Platform)

Vertical, $F_V = .45 \times 28500 \times .4 = 5{,}130^{\#}$ (Truck)

$F_V = .45 \times 3000 \times .4 = 540^{\#}$ (Platform)

Tipping off Dunnage

Axial load @ Platform Post (Top of Dunnage)

Transverse : $\frac{19380}{2} \times \frac{(64.3+24)}{129} + \frac{2040}{2} \times \frac{24}{129} = 6823^{\#}/\text{Post}$ (2 = sets of posts)

Longitudinal : $\frac{7752}{2} \times \frac{(64.3+24)}{246} + \frac{816}{2} \times \frac{24}{246} = 1431^{\#}/\text{Post}$

Vertical : $\frac{(5130+540)}{4} - \frac{(28500+3000)}{4} = -6{,}458^{\#}/\text{Post}$ (4 = Posts)

∴ Net Tension @ Platform Post base

$= 6823 + 1431 - 6458 = 1{,}796^{\#}$ ↑ {N.G.}

The platform posts in the tension side will bounce off if positive anchorage is not provided.

Shear @ Platform Post

Transverse : $(19380 + 2040)/4 = 5355^{\#}/\text{Post}$

Longitudinal : $(7752 + 816)/4 = 2142^{\#}/\text{Post}$

Resultant Shear $= \sqrt{5355^2 + 2142^2} = 5{,}768^{\#}$

Forces if Dunnage is used

Try 18" dunnage

Axial load @ Post base (bottom of dunnage)

Transverse : $\frac{19380}{2} \times \frac{(64.3+24+18)}{129} + \frac{2040}{2} \times \frac{(24+18)}{129} = 8317^{\#}$

Longitudinal : $\frac{7752}{2} \times \frac{(64.3+24+18)}{246} + \frac{816}{2} \times \frac{(24+18)}{246} = 1745^{\#}$

Net tension $= 8317 + 1745 - 6458 - (1-.45) \times \frac{30 \times 30 \times 18}{12 \times 144} \times 40^{\#}/\text{CF}$ (dunnage)

$= 3398^{\#}$

Shear remains same as $5{,}768^{\#}$

Recommendations

In order to resist tension and shear, a positive anchorage between platform post base and dunnage is recommended. otherwise, platform posts in the tension side will bounce off.

Positive anchorage between tire and platform will be maintained by a tie-down device (strap around).

shear to be restrained $= 5768^{\#}$

From Ref. 10, Table 7.23, shear allowable/bolt $(5/8"\phi) = 1190 \times 1.33 = 1583^{\#}$ (for mixed Maple and pine; seis. increase)

∴ Use 4 - 5/8"φ Lag bolts, $V_{allow.} = 4 \times 1583 = 6332^{\#} > 5768^{\#}$ OK.

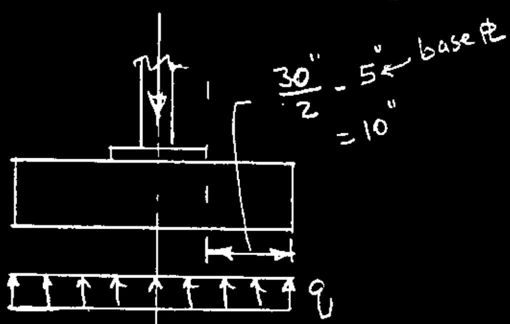
Dunnage

Compressive load on dunnage

$$= 6823 + 1431 + \left[\frac{5130+540}{4} + \frac{28500+3000}{4}\right]$$

$$= 17{,}547\ \#$$

Soil reaction @ base of dunnage, $q = \dfrac{17547}{30 \times 30} = 19.5$ Psi



$$V = (19.5 \times 30)\ \#/\text{in} \times 10 = 5850\ \#$$

$$M = (19.5 \times 30) \times 10^2/2 = 29250\ \#\text{in}$$

Try 3" Dunnage

section modulus, $S = bd^2/6 = 30 \times 3^2/6 = 45\ \text{in}^3$ for plywood per Ref. 4

$$\sigma_b = \frac{M}{S} = \frac{29250}{45} = 650 \text{ Psi} < 1200 \text{ Psi OK}$$

Horizontal Shear Stress, $\tau = \dfrac{VQ}{I}$ where $Q = 1.5 \times 30 \times .75 = 33.75\ \text{in}^3$ (half dunnage)

$I = 30 \times 3^3/12 = 67.5\ \text{in}^4$

$$\tau = \frac{5850 \times 33.75}{67.5} = 2925\ \#/\text{in}$$

For Multiple-layered Dunnage

Try 6",

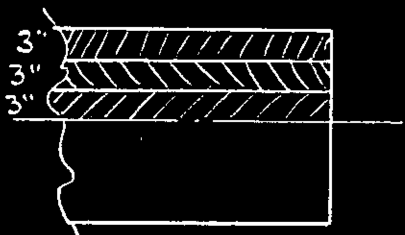
$Q = 3 \times 30 \times 1.5 = 135\ \text{in}^3$

$I = 30 \times 6^3/12 = 540\ \text{in}^4$

$$\tau = \frac{5850 \times 135}{540} = 1462\ \#/\text{in}$$

Client	CFE	WO/Job No.	P1K700		
Subject	Impact Analysis for RMCS Operations	Date	1/9/96	By	M.A-ISLAM
		Checked	1/22/96	By	[signature]
Location	200 Area	Revised		By	

For 18" Dunnage



$$Q = 30 \times 9 \times 4.5 = 1215 \text{ in}^3$$

$$I = 30 \times 18^3/12 = 14{,}580 \text{ in}^4$$

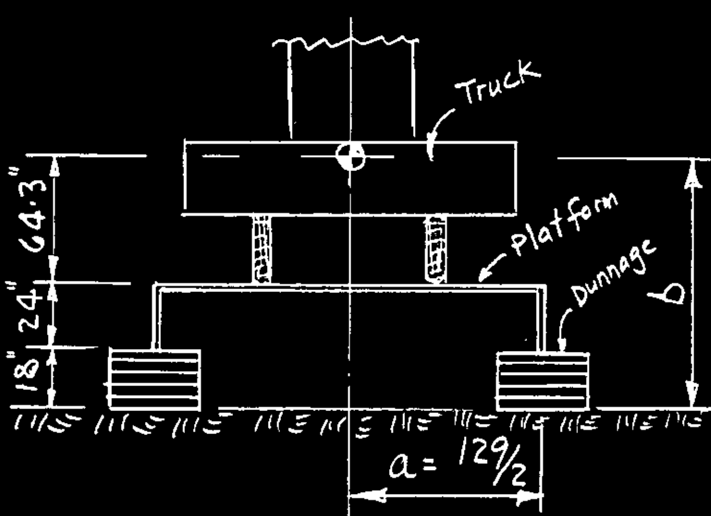
$$v = \frac{5850 \times 1215}{14580} = 487.5 \, \#/\text{in}$$

Therefore, horizontal shear stress decreases as the dunnage increases.

Provide a retainer around the dunnage to prevent slippage of one layer of plywood.

Overturn/Sliding of Platform per Energy Absorption Criteria

Ref. 9, Generic Assessment of Unsecured 3/1 and 1/1 Items, DTRF A-3886



$a = 129/2 = 64.5"$

$b = 64.3 + 24 + 18 = 106.3"$

Ref. 4, Page 5-56

static friction betn. concrete and sand and gravel $= .55$

Refer to this friction, we can safely use the same friction betn. dunnage and sand and gravel.

Overturning

For overturning to occur, friction, $\mu \geq \frac{a}{b}$

$$\mu \geq \frac{64.5}{106.3} = .6$$

Because actual $\mu = .55 < .6$ $\therefore$ overturning will not occur

Sliding

For sliding to occur, friction, $\mu < \frac{g_H}{1 - g_V}$

where $g_H = \sqrt{.68^2 + .68^2}$
$= .96\ g$
$g_V = .45\ g$

$$\therefore \mu = \frac{.96}{1 - .45} = 1.75$$

Actual $\mu = .55 < 1.75$ $\therefore$ Sliding occurs

Sliding Distance

Kinetic Energy, $KE = \frac{1}{2}\left(\frac{W}{g}\right)(\dot{X}_M)^2$

If the forcing function is sinusoidal, then $\dot{X}_M = \frac{g\,(g_H)}{2\pi f}$

where $g_H = .68$; f = fundamental frequency

$$\therefore KE = \frac{1}{2}\left(\frac{W}{g}\right)\left[\frac{g^2 (g_H)^2}{4\pi^2 f^2}\right] = \frac{W g\,(g_H)^2}{8\pi^2 f^2} \text{ ------(i)}$$

The energy in moving the platform against friction, μ

$$PE = \mu\, W\,(1 - g_V)(X_M) \text{ ----(ii)}$$

Equating (i) & (ii)

$$\mu W (1-g_V)(X_M) = \frac{W g (g_H)^2}{8\pi^2 f^2}$$

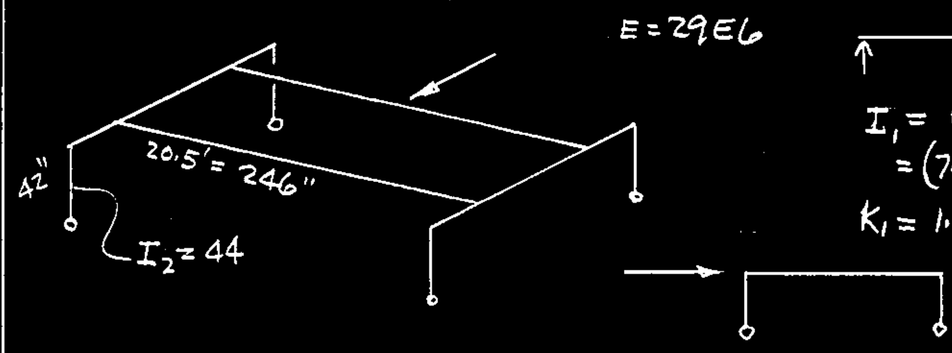
or $$X_M = \frac{g (g_H)^2}{8\pi^2 f^2 \mu (1-g_V)}$$

Because a DBE produces 10 cycles of maximum responses,

$$\therefore X_M = \frac{5 g (g_H)^2}{4\pi^2 f^2 \mu (1-g_V)}$$

Again, $f = 3.13\sqrt{\frac{K}{W}}$ where K = stiffness for Platform @ Hor. dir., W = 28500#

stiffness of platform @ Horizontal



$K_1 = \frac{48EI_1}{246^3}$

I_1 = Refer page A8
$= (7.97 + 5.26 \times 9.3^2)2 + \frac{.25 \times 22^3}{12} = 1148 \text{ in}^4$

$K_1 = 1.07E5$ #/in

Per Ref. 5

$K_2 = \frac{12E44}{42^3} \times 4$ (posts) $= 8.3E5$ #/in

K (Equiv.) = 9.5E4 #/in

$$f = 3.13\sqrt{\frac{9.5E4}{28500}} = 5.7 \text{ Hz} \quad ; \quad g_H = .96$$

$$X_M = \frac{5 \times 386.4 \times (.96)^2}{4\pi^2 \times (5.7)^2 \times .55 (1-.45)} = 4.6 \text{ in}$$

If the dunnage remains unanchored, the platform will slide for a distance of 4.6 inches

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DESIGN ANALYSIS

Calc. No: WHC-SD-WM-DA-215
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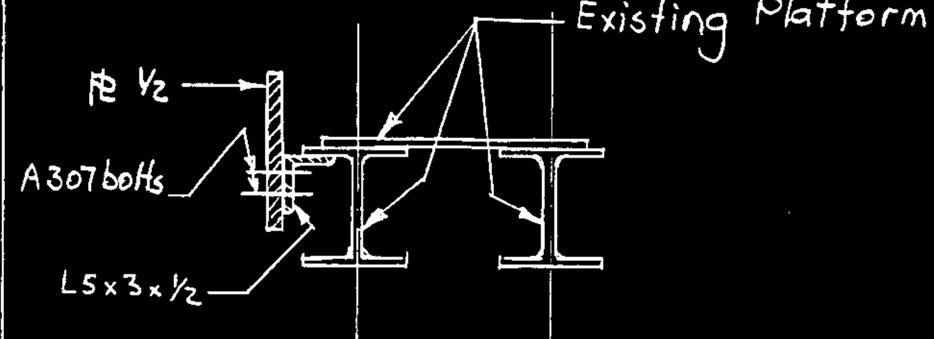
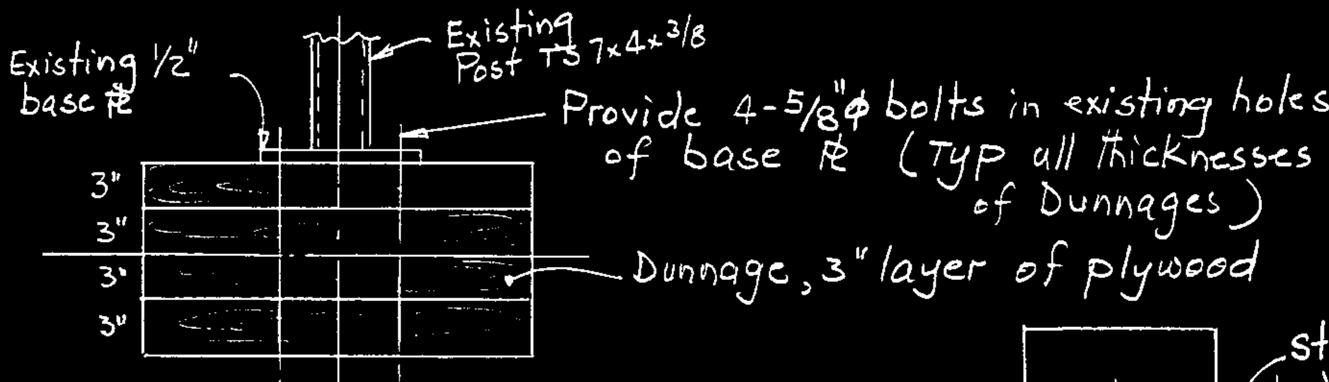
Client	CFE	WO/Job No.	P1K700		
Subject	Impact Analysis for	Date	1/4/96	By	MA ISLAM
	RMCS Operations	Checked	1/22/96	By	[signature]
Location	200 Area	Revised		By	

Recommendations

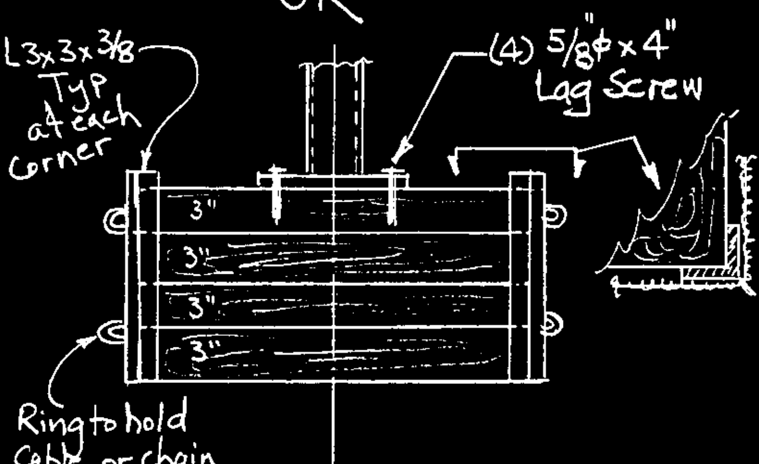


① Recommended Detail for Retaining Truck

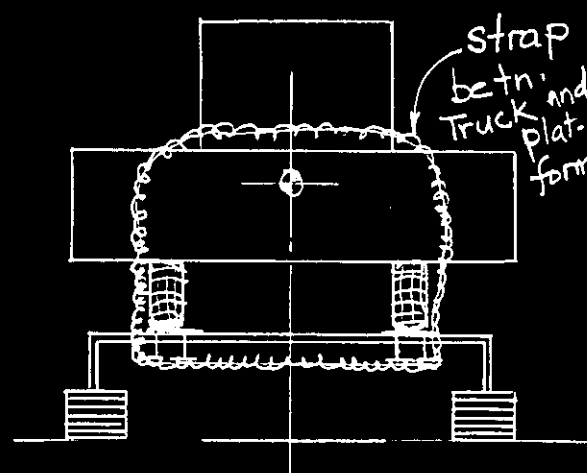


② Recommended Detail for Dunnage

OR



③ Recommended Detail for Dunnage



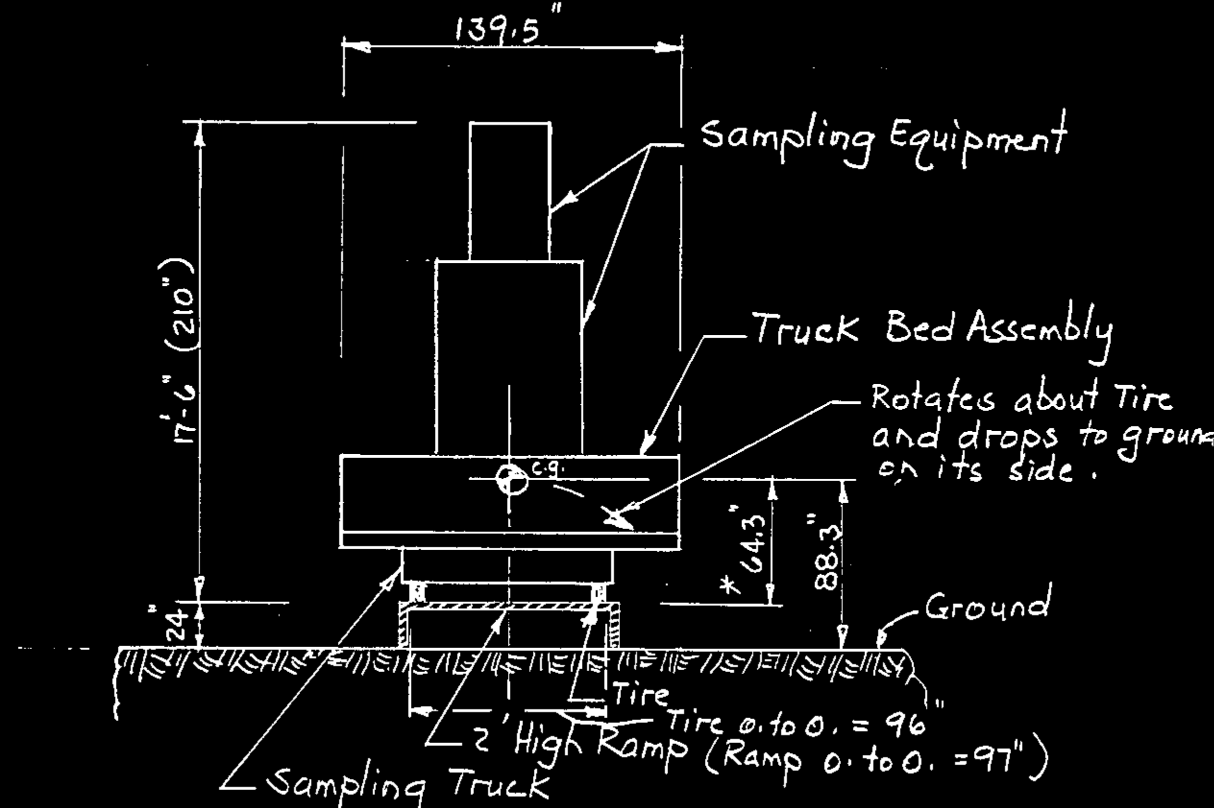
④ Recommended Detail (Tie-Down betn. Truck & Platform)

APPENDIX B

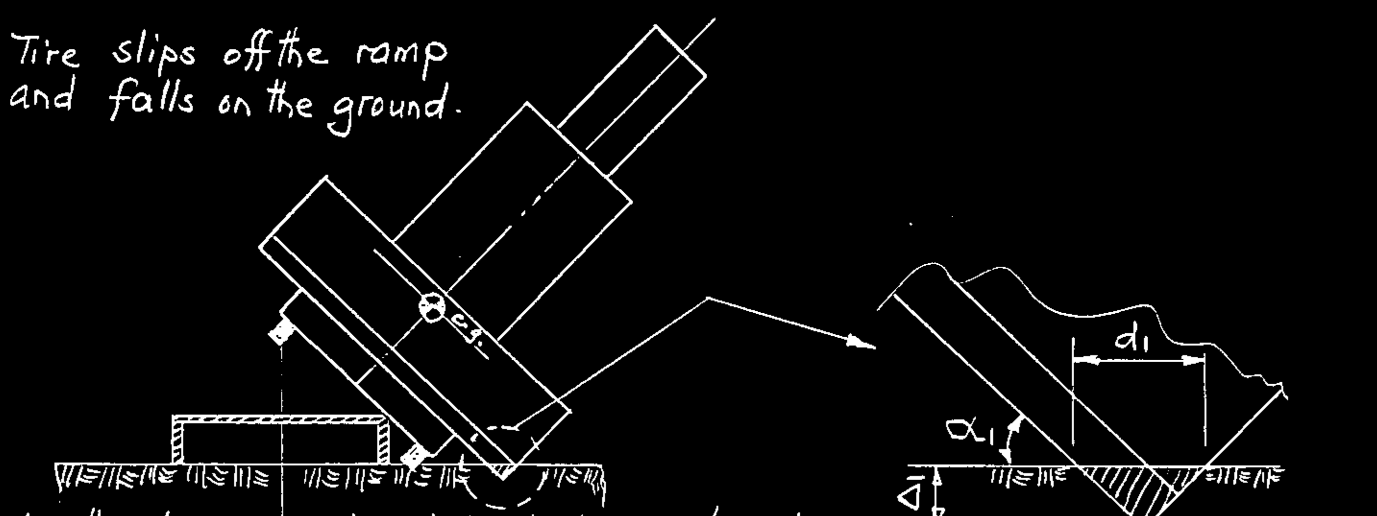
Engineering Evaluations for Core Sampling Trucks for Impact Scenarios B and C

Client Characterization Field Engr. (CFE) WO/Job No. POD400
Subject Impact Analysis for Sampling Truck for RMCS operation Date 10/26/95 By M. A. ISLAM
Checked 12/4/95 By [signature]
Location 200 Area (Gen) Revised By

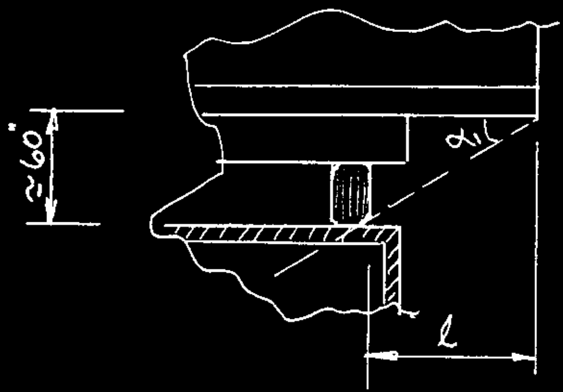
A. IMPACT WITH SOFT GROUND



Elevation of Sampling Truck as it rest on Ramp



As the truck falls, stability is maintained thru support from truck bed, tire, and truck bottom (as shown above)



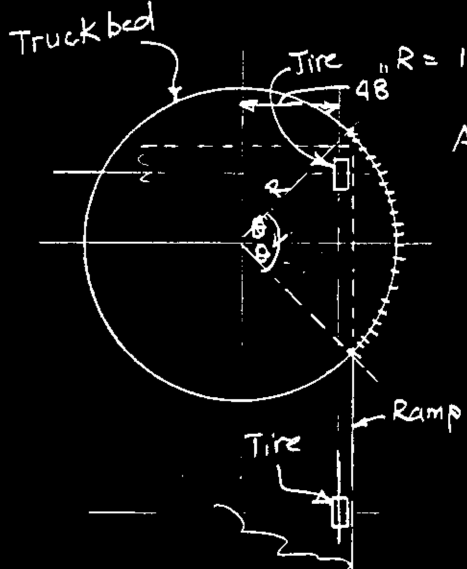
$\ell = (139.5 - 96)/2 = 21.75"$

At the end of the impact, the edge of the truck bed assembly penetrates "Δ_1" into the ground.

Thus, the impact angle, $\alpha_1 = Tan^{-1} \frac{60}{21.75} = 70°$

$\therefore\ d_1 = 2\Delta_1 / \sin 2\alpha_1$;

Area of Impact (shaded) = (d_1) (width)



R = 139.5/2 = 69.75" ;

As the tires get off the ramp, assume a segment of the truck bed beyond tire will be penetrated into soil. $\therefore\ \theta = Cos^{-1} 48/69.75 = 46.5°$

$\therefore$ use $\theta = 45°$ (< 46.5° ok)

$\therefore$ width $= 2\pi R/4 = 2\pi \times 69.75/4 = 109.6"$

Area of impact, $A_1 = (d_1)(109.6)$

$A_1 = (2\Delta_1/\sin 2\alpha_1)(109.6) = 219.2\ \Delta_1/\sin 140°$

$= 341 \times (\Delta_1)$

From Ref. 14

Impact Force, $F_I = W \left[1 + \sqrt{1 + \frac{2h}{*(\Delta_1/2)}}\right]$ where W = 28500/2
h = height of drop = 24"
Δ_1 = penetration in soil
* Average penetration

$\therefore\ F_I = 14250 \left[1 + \sqrt{\frac{2 \times 24 \times 2}{\Delta_1}}\right]$

$= 14,250 \left[1 + \sqrt{96/\Delta_1}\right]$

The subgrade reaction force due to the compressive strength of the soil, F_s

$F_s = q_u A_1$ where q_u is the ultimate compressive strength of soil

A_1 is the area of impact $= 341\,(\Delta_1)$

In order to maintain equilibrium, F_I must equal F_s

$\therefore\ F_I = F_s$

$$14{,}250\left[1+\sqrt{96/\Delta_1}\right] = q_u A_1 = (q_u)(341\ \Delta_1) \cdots\cdots \text{Eqn } ①$$

Find q_u

$$q_u = 1.3\,c\,N_c + q\,N_q + .4\,\gamma\,B\,N_\gamma \cdots\cdots \text{Eqn } ②$$

where c = cohesion factor, for sand, $c = 0$

$N_c = 30$ *

$N_q = 15$ *

$N_\gamma = 12$ *

Ref. 11

γ = unit wt. of soil, $90\ \#/CF = .0521\ \#/in^3$

B = width of embedded truck bed $= d_1$

q = compressive strength of soil

$= \gamma\,(\Delta_1/2) = .02605\,(\Delta_1)\ \#/in^2$

└ Average

* based on angle of internal friction, $\phi = 27°$

$$\therefore\ q_u = 0 + .02605(\Delta_1)(15) + .4 \times .0521 \times \left(\frac{2\Delta_1}{\sin 2\alpha_1}\right)(12)$$

$$= 1.17\,(\Delta_1)$$

Substitute the value of q_u in Eqn. ①

$$14{,}250\left[1+\sqrt{96/\Delta_1}\right] = (q_u)(341.0\Delta_1) \quad \ldots\ldots \text{Eqn.}①$$

$$14{,}250\left[1+\sqrt{96/\Delta_1}\right] = 1.17(\Delta_1)(341.0\,\Delta_1) = 399.\,\Delta_1^2$$

$$1+\sqrt{96/\Delta_1} = .028\,(\Delta_1)^2$$

$$\text{or}\quad 1 = .028(\Delta_1)^2 - \sqrt{96/\Delta_1}$$

Try $\Delta_1 = 10''$, R.H.S. = $-.29$

$= 10.5''$, " $= .063$ ⟸

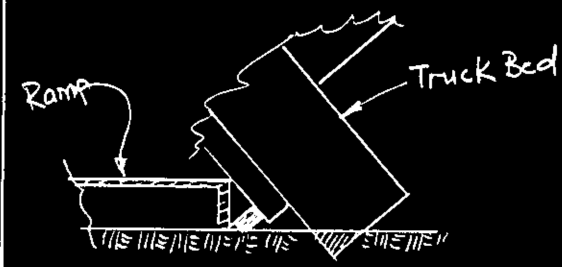
∴ Depth of Penetration, $\Delta_1 = 10.5''$

$q_u = 1.17\,\Delta_1 = 12.3$ Psi; $d_1 = 2\Delta_1/\sin 2\alpha_1 = 32.7''$

Impact Force, $F_I = 14{,}250\left[1+\sqrt{96/\Delta_1}\right]$

$= \underline{57{,}338 \text{ lbs}}$

Impact Factor, $g = \dfrac{F_I}{W} = \dfrac{57338}{14250} = \underline{4.0}$



From the 'drop pattern', it appears that at the impact time, the edge of the truck bed will be embedded to soil while the tire and the truck bottom will maintain support from the soil and the ramp respectively.

∴ Net Impact = 57338 − 14250 = 43,088 #

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DESIGN ANALYSIS

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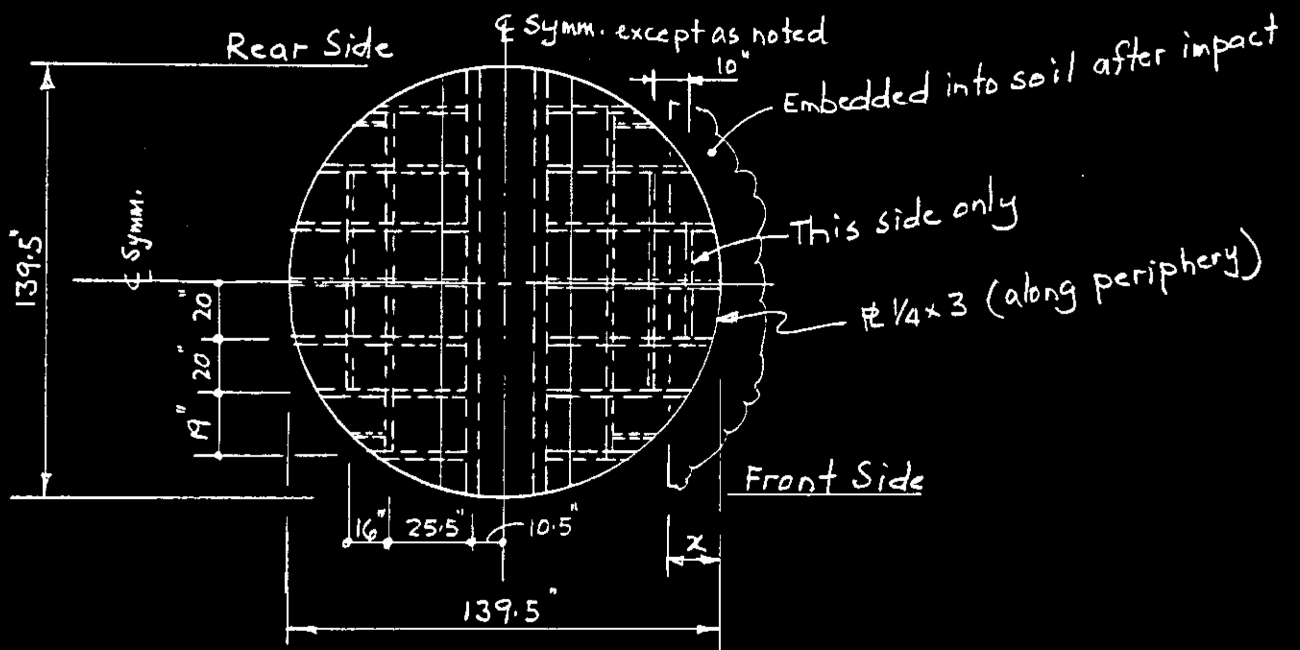
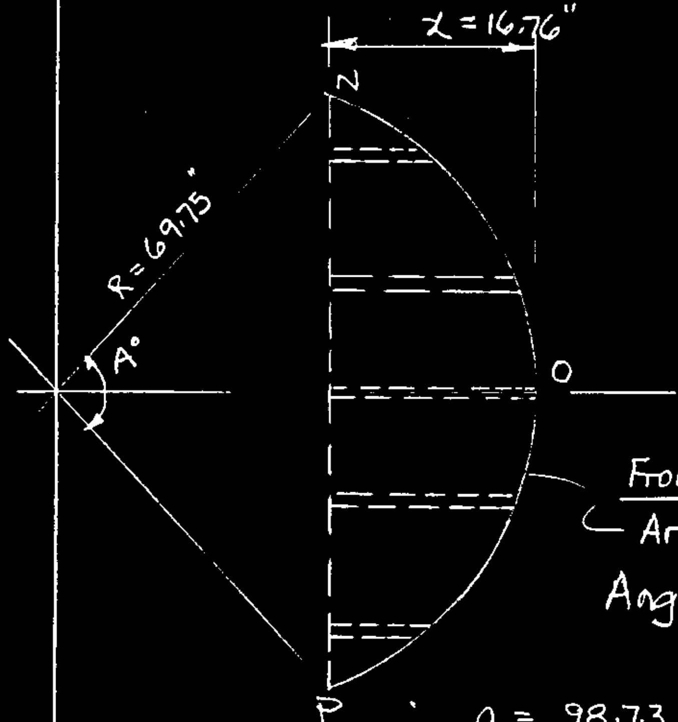
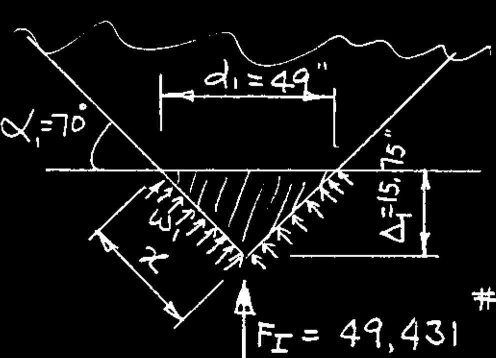
Client	CFE	WO/Job No.	
Subject	Impact Analysis	Date 10/30/95	By M.A. ISLAM
		Checked 12/4/95	By Mark Arnp
Location	200 Area Gen.	Revised	By

Truck Bed Assembly Section Properties (Refer Dwg. H-2-690081)







$x = 49 \cos 70° = 16.76"$

From AISC 6-18 (Ref. 5)

Arc $a = .017453\, r A°$

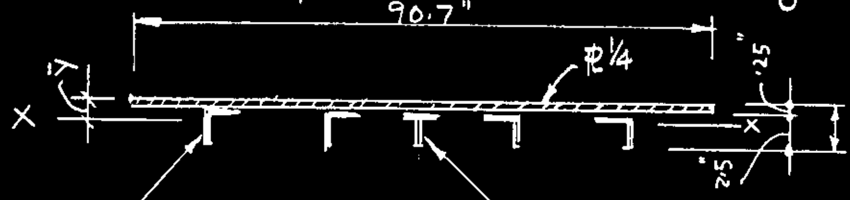
Angle A° (after the impact) $= \left[\cos^{-1} \frac{69.75 - 16.76}{69.75}\right] \times 2$
$= 81.1°$

$\therefore a = 98.73"$; chord, $c = 2r \sin\frac{A}{2} = 90.7"$

Area of segment NOP $= \frac{98.73 \times 69.75 - 90.7(69.75 - 16.76)}{2} = 1040 \text{ in}^2$

Intensity of uniform load, $\omega_1 = \frac{F_I \cos\alpha_1}{\text{Area NOP}} = \frac{49431 \times \cos 70°}{1040}$
$= 16.3$ #/in^2

<u>Section Properties of Truck bed segment @ PN</u>



PL 1/4 x 2 1/2 (typ)
For analysis, use L 2 1/2 x 2 1/2 x 1/4
(Typ 4 plcs)
A = 1.19 in²
I = .703 in⁴

PL 1/4 x 2 1/2, $A = 2 \times 2.5 \times .25 = 1.25 \text{ in}^2$

$$I = \frac{5td^3}{24} = \frac{5 \times .25 \times 2.5^3}{24} = .81 \text{ in}^4$$

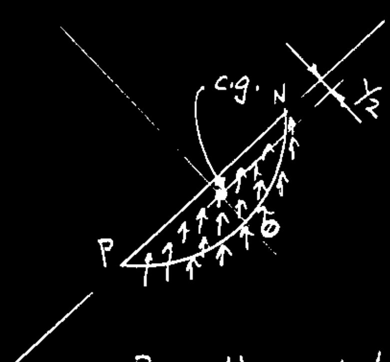
(approx. c.g.)

$$\bar{Y} = \frac{90.7 \times .25 \times .125 + 4 \times 1.19(.25 + .717) + 1.25 \times (.25 + .75)}{90.7 \times .25 + 4 \times 1.19 + 1.25} = .303''$$

$$I_x = 90.7 \times .25\,(.303 - .125)^2 + 90.7 \times .25^3/12 + 4 \times .703 + 4 \times 1.19\,(.717 + .25 - .303)^2 + .81 + 1.25\,(.75 + .25 - .303)^2$$

$$= 7.16 \text{ in}^4$$

$$S_x = 7.16/(2.5 + .25 - .303) = 2.93 \text{ in}^3$$



Refer Roark's 4th Ed. Table 1, Case 10 (Ref. 13)

$$y_2 = R\left(\frac{4 \sin^3 A/2}{6 A/2 - 3 \sin 2\frac{A}{2}} - \cos\frac{A}{2}\right)$$

$$= 69.75\left(\frac{4 \sin^3 40.55^\circ}{6 \times \frac{40.55}{180} \times \pi - 3 \sin 81.1^\circ} - \cos 40.55^\circ\right)$$

$$= 6.77 \text{ in}$$

Bending Moment for the segment NPO along PN

$= 12.3 \times 1040 \times 6.77$

$= 86,602$ #-in

Bending stress, $\sigma_b = \frac{M}{S} = \frac{86,602}{2.93} = 29,557$ Psi

$< \sigma_y = 35,000$ Psi | Ref. 4
$< \sigma_u = 38,000$ Psi |

OK

Client CFE | WO/Job No.
Subject Impact Analysis | Date 10/31/95 By M. A. ISLAM
Checked 12/4/95 By Mark Axup
Location 200 Area Gen. | Revised By

Failure / Damage Analysis (Ref. 11)

The Energy per unit volume which can be absorbed by the truck.

$e = \varepsilon_u \sigma_f$ where e = energy/unit vol.

ε_u = Ultimate Plastic strain in/in

σ_f = Flow stress

$= .5 (\sigma_y + \sigma_u)$

$= .5 (35+38) \times 10^3 = 36{,}500$ Psi

$\varepsilon_u = .10$; $\sigma_y = 35$ Ksi ; $\sigma_u = 38$ Ksi for Alum. 6061-T6 per Ref. 4

$\therefore e = .10 \times 36500 = 3650$ #-in/in^3

Total Drop Energy, $E = WH = 14250 \times 24 = 342{,}000$ #-in

Volume of material distorted (truck bed), $V = \frac{E}{e}$

$$V = \frac{342000}{3650} = 93.7 \text{ in}^3$$

Volume of material (truck bed) in contact with soil

$= 1040 \times .25 + 4 \times 1.19 \times 10'' + 1 \times 1.25 \times 16.76'' + 3 \times .25 \times 98.73$

$= 402.6$ in^3

$$\% \text{ damage} = \frac{93.7}{402.6} \times 100 = 23\%$$

Conclusion

23% distortion is likely to deform the truck bed.

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DESIGN ANALYSIS

Calc. No. WHC-SD-WM-DA-2
Revision 0
Page No. B-9 of

Client	CFE	WO/Job No.			
Subject	Impact Analysis	Date	10/31/95	By	M. A. ISLAM
		Checked	12/4/95	By	[signature]
Location	200 Area Gen.	Revised		By	

Check Dome Load @ Impact Scenario B

From Ref. 1 & Page B-4

Gross weight of Core Sampling truck and other associated equipment

= 68,000 lbs (incl. 28500# for truck)

Also, Net Impact load = 43,088#

75 Ft. Dia. Tank (SST)

Per Ref. 1, Allow. Dome load = 100 Tons = 200,000# (concentrated)
Max. equipment weight incl. truck, ramp/platform that can be placed on the dome.

= 200,000 - 43,088 = 156,912# ≃ 150,000#

20 Ft. Dia. Tank (SST)

Per Ref. 1, Allow. Dome load = 50 Tons = 100,000# (concentrated)

Max. equipment weight incl. truck, ramp/platform that can be placed on the dome.

= 100,000 - 43,088 = 56,912# ≃ 55,000#

(DSTs)

Same as 20 Ft Dia. Tank (SST)

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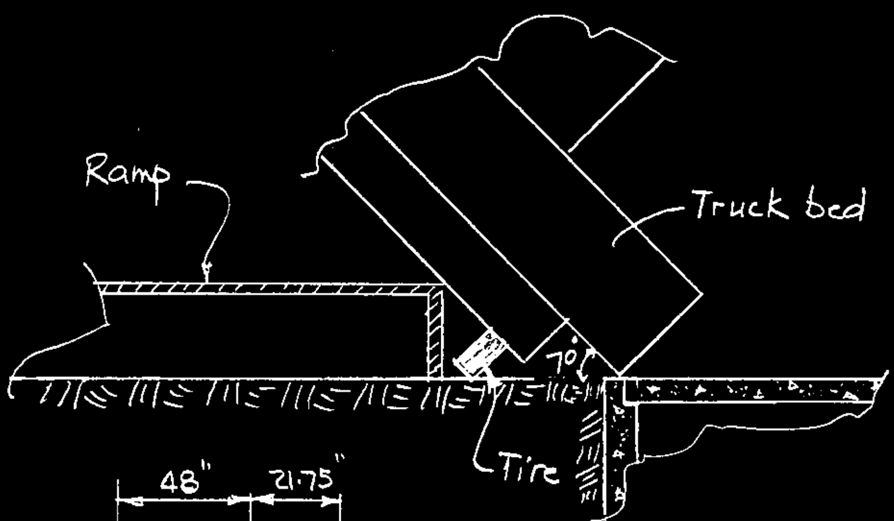
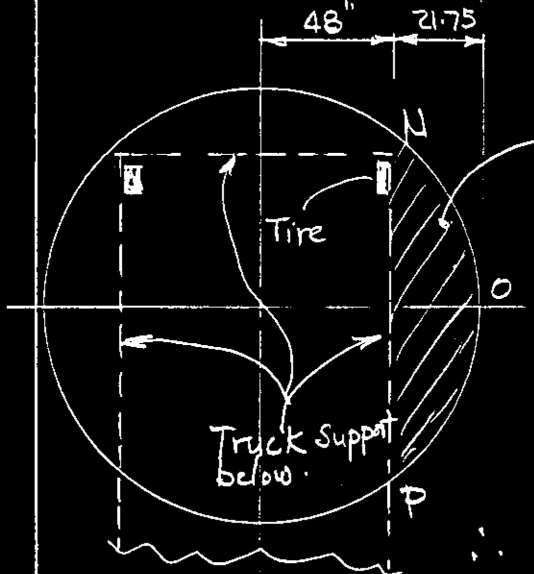
DESIGN ANALYSIS

Calc. No. WHC-SD-WM-DA-21[illegible]
Revision 0
Page No. B-10 of

Client	CFE	WO/Job No.	
Subject	Impact Analysis	Date 10/31/95	By M. A. ISLAM
		Checked 12/4/95	By Mark Aeup
Location	200 Area Gen.	Revised	By

B. IMPACT WITH NON-YIELDING SURFACE (Concrete pit or steel penet.)





This shaded area of the truck bed will resist impact as the truck drops on its side and impacts the non-yielding surface or object

Refer to page B-6 and find Section properties of the shaded segment..

Angle $A^\circ = \left(\cos^{-1}\frac{48}{69.75}\right) \times 2 = 93^\circ$

$\therefore$ Arc $a = .017453\, r A^\circ = .017453 \times 69.75 \times 93$

$= 113.2''$

chord, $c = 2 r \sin\frac{A}{2} = 2 \times 69.75 \times \sin 46.5^\circ = 101.2$ in

From these data, find section properties of the segment @ NP

Again, refer to section on page B-6, All areas and centroidal moment of inertia are identical.

$$\bar{y} = \frac{101.2 \times .25 \times .125 + 4 \times 1.19(.25 + .717) + 1.25 \times (.25 + .75)}{101.2 \times .25 + 4 \times 1.19 + 1.25} = .29''$$

$$I_x = 101.2 \times .25(.29 - .125)^2 + 101.2 \times .25^3/12 + 4 \times .703 + 4 \times 1.19(.717 + .25 - .29)^2 + .81 + 1.25(.75 + .25 - .29)^2$$

$$= 7.25 \text{ in}^4;$$

$$S_x = 7.25/\underbrace{(2.5 + .25 - .29)}_{2.46} = 2.95 \text{ in}^3$$

Bending stiffness of the shaded Area

About PN, Bending stiffness will be critical. Also, ignore axil stiffness.

$$K_b = \frac{3EI}{L^3} = \frac{3 \times 10 \times 10^6 \times 7.25}{21.75^3} = 2.1E4 \ \#/\text{in}$$

$E = 10 \times 10^6$ Psi Per Ref. 4

From Ref. 3

Impact Reaction, $R = V\sqrt{MK}$ where $M = \frac{W}{g} = \frac{28500}{386.4} \times \frac{1}{2} = 36.9 \ \#\text{-s}^2/\text{in}$

$$V = \sqrt{2gh} = \sqrt{2 \times 386.4 \times 24} = 136.2 \text{ in/s}$$

$$R = 136.2\sqrt{36.9 \times 2.1E4} = 119{,}895 \ \#$$

Find Stresses in Truck bed

Bending Moment @ PN = $119{,}895 \times (21.75/2) = 1{,}303{,}858 \ \#\text{-in}$ (Average)

$$\sigma_b = \frac{1{,}303{,}858}{2.95} = 441{,}986 \text{ Psi} >> \sigma_y = 38000 \text{ Psi};$$

{N.G.} (% overstress 1163%)

The truck bed will collapse along PN.

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DESIGN ANALYSIS

Calc. No. WHC-SD-WM-DA-215	Revision 0	Page No. B-12 of B-12	
Client CFE	WO/Job No.		
Subject Impact Analysis	Date 11/1/95	By M. A. ISLAM	
	Checked 12/4/95	By [signature]	
Location 200 Area Gen.	Revised	By	

Energy Absorbing Capacity @ Impact with Non-yield Surface

Ref. 12, Chap. 2

Allowable Energy Load that can be absorbed by the truck bed as it impacts the non-yielding surface

$$U = K \frac{\sigma_y^2 I L}{E c^2}$$ where σ_y = 35000 Psi for 6061-T6 Alum.

I = 7.25 in^4; c = 2.46"

L = 21.75 in

E = 10×10^6 Psi

K = .1667 (Ref. Table 2)

$$\therefore U = .1667 \times \frac{35000^2 \times 7.25 \times 21.75}{10 \times 10^6 \times 2.46^2} = 532 \text{ in-lb}$$

Potential Energy of the truck bed from fall = Wh

$= \frac{28500}{2} \times 24 = 342,000$ in-lb >> 532 in-lb (N.G.)

The truck bed Collapses from Energy Absorption Criteria.

Dome load @ Impact Scenario C

Net Impact = 119,895 − 14250 = 105,645#

75' Ft. dia. Tank (SST), $W_{eqp.}$ = 200,000 − 105,645 = 94,355#

Say 94,000#

20' Ft dia. Tank (SST), W_{eqp} = 100,000 − 105,645 ⇒ Negative

No Good

All DST's − Same as 20 Ft. Dia. Tank (SST)

Conclusion: This scenario is not acceptable

APPENDIX C

Miscellaneous Information

Date: 10/20/95
Rev No: 0

Work Plan No. MAI/95-13
Page 1 of 2

ICF KAISER HANFORD CIVIL/STRUCTURAL ENGINEERING WORK PLAN

TITLE: Impact Analysis for the Sampling Truck for RMCS Operations, 200 Area (General)

ENGR. GROUP/ ORG. CODE: Civil-Struc. Engineering / 57200

CUSTOMER/ ORG CODE: Characterization Field Engr. / 75210

CSE PERFORMER/ SIGNATURE: M.A. Islam / [signature]

COG. ENGR. SIGNATURE: R. N. Dale / [signature]

MANAGER/ SIGNATURE: S. K. Farnworth / [signature]

MANAGER/ SIGNATURE: J. S. Schofield /

E/S/Q/SAFETY CLASS: 3SQ

WORK ORDER/TCPN: / P0D400

UNCLASSIFIED/ B&R CODE: UC- / B&R-

CUSTOMER BUDGET ANALYST:

SCOPE OF WORK:

1. Prepare an impact analysis for the sampling truck to be used in RMCS Operations. The impact will occur when the sampling truck will tip over and falls on the ground off the ramp. The analysis will address two impact conditions:

   a. impacting the soft ground
   b. impacting a non-yielding object e.g. concrete deck or steel riser and penetration

2. The analysis will also address the effect of the wind on the truck.

3. Prepare a supporting document (SD) to incorporate Items 1 and 2.

SCHEDULE/MILESTONES/DUE DATE: December 7, 1995

COST ESTIMATE: $ 16,000. (Does not include G & A and CSP)

REFERENCE INFORMATION:

ECN 626601, EDT 608355, and following drawings:
H-2-1746, H-2-35232, H-2-37104, H-2-73246, H-2-73252

COMMENTS:

DELIVERABLE: Supporting Document for review

CLOSURE:

DATE COMPLETED: ______ ACTUAL COST: ______

DOES THIS WORK PLAN QUALIFY AS A POSSIBLE COST SAVINGS [ ] YES [x] NO
CUSTOMER SATISFACTION SURVEY [x] YES

Author: Robert N (Rob) Dale at ~WHC130
Date: 10/24/1995 19.43
Priority: Normal
Subject: design basis analysis earthquake evaluation for truck pltfrm

WHC-SD-WM-DA-215
Rev 0, Page C-3

-------------------------- Message Contents ---------------------------

Mo,

Please include in your work plan, provisions for determining what would happen if the truck was on a platform and a Design Basis Earthquake was experienced. We are not concerned with what damage the truck would sustain, but what the reaction of the truck would be.

Specifically, we would like to know:

* If the truck is on it's tires, on the platform, will the truck tip over and fall during a DB earthquake?
* If the truck is on it's tires, on the platform, will it slide/bounce off the platform and fall to the ground?
* If the truck is on the jacks (the jacks supporting the truck from the platform/jacking beam and/or from dunnage set on the ground) will the truck slide/bounce off of the platform/dunnage and fall to the ground?

I have placed your previous work plan in the mail and it is on it's way back to you. What you have on your existing work plan is acceptable.

Thank You

DISTRIBUTION SHEET

To	From	Page 1 of 1
R. N. Dale	M. A. Islam Civil/Structural Engineering	Date Dec. 5, 1995

Project Title/Work Order	EDT No. 156987
Structural Evaluation for the Core Sampling Trucks, RMCS Operations, 200 Area	ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
M. D. Axup	S2-03	X			
R. M. Boger	S7-40	X			
R. N. Dale	S7-12	X			
S. K. Farnworth	H5-57				X
G. T. Frater	S7-16	X			
J. A. Harvey	S7-07				X
M. A. Islam	E6-46	X			
M. L. McElory	S7-07				X
T. C. Mackey	S2-03	X			
B. K. Rarig	S3-10				X
M. S. Ruben	E6-46				X
J. S. Schofield	S7-12	X			
J. L. Smalley	S7-12				X
R. H. Stubbs	S7-12	X			
E. A. Vickery	S3-10	X			
Central Files (2 copy)	A3-88 ~~L8-04~~	X			