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Project Title/Work Order Laydown Pad Analysis for Crane and Rigging / E 22011		Date 09/14/94
		EDT No. 142178
		ECN No.

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ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 142178

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W. S. Peterson		C. E. Brewer			R. B. Pan			

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Document Title: Laydown Pad Analysis for Crane and Rigging

Release Date: October 12, 1994

* * * * *

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W. S. Peterson 9/26/94
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Stress Analysis/E22011 8D430

7. Abstract

This report evaluates the slab-on-grade design specified in drawing H-6-979 and recommends a slab thickness to accomodate the specified loadings.

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LAYDOWN PAD ANALYSIS FOR CRANE AND RIGGING

September 1994

PREPARED BY: W. S. Peterson DATE: 9/26/94
W. S. Peterson, Principal Engineer
Equipment Stress Analysis

REVIEWED BY: S. M. Miller DATE: 9/26/94
S. M. Miller, Engineer
Equipment Stress Analysis

APPROVED BY: R. B. Pan DATE: 9/27/94
R. B. Pan, Manager
Equipment Stress Analysis

Westinghouse Hanford Company
Hanford Operations and Engineering Contractor
for the
U.S. Department of Energy

CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed WHC-SD-LL-DA-038, Rev. 0

Author W. S. Peterson

Yes No NA

☒	☐	☐	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 94-17

Reviewer - S. M. Miller

9/27/94
Date

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09/22/93

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DESIGN VERIFICATION METHOD

The need for design verification has been reviewed with the method selected as indicated below: (ESR/Work Plan # WP-8D430-323).

<u> X </u>	Independent Review
<u> X </u>	Alternative Calculations
<u> </u>	Qualification Testing
<u> </u>	Formal Design Review

R. B. Pan 9/27/94
Cognizant/Project/Design Manger

SD # WHC-SD-LL-DA-038

ECN #

DWG(S) # H-6-979

ENGINEERING ANALYSIS SOFTWARE REPORT FORM

08/29/94 - 09/08/94
DATE ANALYSIS PERFORMED

8D430/94-17
SOFTWARE LOG NUMBER

SOFTWARE APPLICATION: ANSYS (Rev. 5.0a) on SECC computer

W. S. Peterson W.S. Peterson 9/26/94
ANALYST DATE
EQUIPMENT STRESS ANALYSIS

ANALYST DATE
R. B. Pan 9/27/94
ANALYST'S MANAGER R. B. Pan
EQUIPMENT STRESS ANALYSIS DATE

DESCRIPTION OF ANALYSIS:

ANSYS Stiff-63 finite elements were used to model a flat slab. The foundation stiffness option was used to simulate the stiffness of the foundation. Static loads were applied to the finite element model. The model was verified using an independent, closed form solution from De/Caase analysis package. The ANSYS and De/Caase solutions agreed to within 0.4%.

Scott M. Miller 9/26/94
REVIEWER DATE

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LAYDOWN PAD ANALYSIS FOR CRANE AND RIGGING

1.0 INTRODUCTION

The Crane and Rigging organization needs new concrete laydown pads, but has not specified maximum loads for crane lifts or for pad storage. This analysis determines a slab thickness that will permit acceptable load capacities to be obtained.

Section 3.0 below provides maximum loads for laydown pad storage that include a maximum concentrated load, a maximum line load, and a maximum uniform load. It also specifies maximum loads if relatively rigid pad load supports are used to distribute the load.

Section 4.0 provides maximum loads for crane lifts. These loads are applied through the outriggers, which rest on the slab. If the crane outriggers are not placed on the slab during the lift, then these lift load limits need not be considered.

The following analysis approach was used:

1. Developed ANSYS finite-element model (Appendix D)
2. Selected slab thickness of 15 in. so that the acceptable load capacities could be achieved
3. Selected a concentrated load and load geometry so that the capacity was not exceeded and chose load geometries to maximize the slab stress
4. Selected a uniform line load and chose load geometries to maximize the slab stress
5. Selected a uniformly distributed load and chose load geometries to maximize the slab stress
6. Selected pad loads distributed over 4- by 4-ft, 2- by 2-ft, and a 1- by 1-ft rigid pad and chose pad load placement geometries to maximize the slab stress.
7. Summarized the storage load capacity and placement geometry from steps 2 through 6 (see Section 3.0)
8. Determined maximum crane outrigger loads for a 4- by 4-ft and a 2- by 2-ft load pad that could be placed on the slab
9. Determined the crane lift weight so that the maximum outrigger loads in step 8 were not exceeded (see Section 4.0)

2.0 SUMMARY AND RECOMMENDATIONS

New concrete laydown pads for Crane and Rigging (Building 6290) have been detailed in drawing H-6-979. The design has been checked for crane outrigger reaction loads and storage loads. The slab design should be modified so that the total slab thickness is 15 in. with a corresponding subgrade modulus of 100 lb/in³. A concrete strength of 4,500 lb/in², specified on drawing H-6-979, was used in the analysis. Also, the crane-load model was based on the Grove AT1100 crane (see Appendix A). A target safety factor of two was used in the design (Packard 1976, Spears 1978).

Both top and bottom reinforcing mats (#6 rebars, yield strength = 60,000 lb/in.², 10-in. center each way) should be used. Top cover should be 2 in. and bottom cover should be 3 in. (ACI-318-89 1989). Control joints for shrinkage cracks are not needed (see Section 7).

The sub-grade modulus must be at least 100 lb/in³. Sub-grade compaction and preparation must follow acceptable practice (see *Standard Specifications for Road, Bridge and Municipal Construction*, 1991). Sub-grade modulus value ought to be verified via field tests.

3.0 LAYDOWN PAD LOAD LIMITS

The following storage load limits are specified for the 15-in.-thick slab:

- Maximum concentrated load = 12,000 lb with a spacing between loads equal to or greater than 5 ft and a bearing area of 20 in².
- Maximum uniform line load = 5,000 lb/ft with a spacing between loads equal to or greater than 5 ft and a bearing width of at least 0.7 in.
- Maximum uniformly distributed load = 1,400 lb/ft² placed over any desired location and distribution layout.

A combination of the above loads can be supported as long as the spacing limitations are maintained. The uniformly distributed load given above can be exceeded if the following maximum load limits and rigid pad distributions are observed:

- Maximum distributed load on a 4- by 4-ft rigid pad = 44,000 lb spaced at 4-ft clear distance
- Maximum distributed load on a 2- by 2-ft rigid pad = 15,000 lb spaced at 2-ft clear distance
- Maximum distributed load on a 1- by 1- ft rigid pad = 4,500 lb spaced at 1-ft clear distance

The bending/shear stiffness of the rigid pad must be rigid relative to the 15-in.-thick concrete slab so as to distribute the pad load over the required area.

Bearing and shear stress checks are given in Appendix C.

4.0 CRANE LIFT LOAD LIMITS

Crane tire loads were found not to control the slab design, but crane outrigger loads did control the slab design.

A crane outrigger load model was developed (see Appendix A) to determine the outrigger load distribution for given crane lift loads, lift radii (measured in the horizontal plane), and load angle locations. Maximum lift loads as a function of lift radius were determined. Maximum outrigger loads were determined from the finite-element model. The maximum permissible outrigger loads are 49,700 lb distributed over a 4- by 4-ft rigid pad or 29,000 lb distributed over a 2- by 2-ft rigid pad for a 15-in.-thick concrete pad. Table 1 gives the maximum allowable lift weights as a function of lift radius for the outrigger load limits on the 2- by 2- and 4- by 4-ft rigid pads. The maximum allowable lift loads are limited by the concrete pad capacity.

Table 1. Maximum Crane Lift Loads.

Rigid pad dimensions (ft)	Lift radius (ft)	Maximum crane lift weight (lb)	Maximum outrigger reaction load (lb)	Minimum outrigger reaction load (lb)
4x4	10	16,663	49,600	25,000
4x4	25	8,965	49,700	21,000
4x4	30	7,768	49,700	20,000
4x4	40	6,132	49,700	20,000
2x2*	10	7,783	29,000	25,000
2x2*	25	4,489	29,000	23,000
2x2*	30	3,934	29,000	22,000
2x2*	40	3,154	29,000	22,000

*Only rear outriggers are allowed on the slab.

Maximum allowable outrigger reaction loads of 49,700 lb for the 4- by 4-ft pad and 29,000 lb for the 2- by 2-ft pad were specified to remain constant for the range of lift radii addressed in the table above. The maximum lift load then was determined so that the maximum specified outrigger reaction load was not exceeded. The minimum reaction load also was checked to ensure crane stability. The minimum outrigger crane load was not allowed to become negative.

5.0 FINITE-ELEMENT MODEL

An ANSYS finite-element model of the 30- by 60-ft storage pad was developed. Results for the 30- by 60-ft pad also apply to the two smaller pads 30 by 33 and 30 by 33 ft 6 in. (see drawing H-6-979). Handbook design guides could not be used (Packard 1976, Spears 1978), as the crane outrigger load geometry exceeded handbook limits.

The ANSYS finite-element model was used to determine the maximum load limits that could be placed on the slab (see Section 3.0). The model consisted of Stiff-63 (ANSYS 1992) finite elements with a thickness of 15 in. and a foundation stiffness of 100 lb/in² per inch of deflection. In-plane boundary conditions were specified so that the model would be stable in the in-plane directions. Out-of-plane boundary conditions were not specified as the foundation stiffness provided the necessary stability for that direction. Bearing and shear stress checks (Appendix C) show that bearing and shear stresses are below the maximum design allowables (Packard 1976, Spears 1978). Bending stress limits from the finite-element model showed stresses below the design allowables with a target safety factor of 2.

6.0 MATERIAL PROPERTIES

A concrete strength of 4,500 lb/in² was specified (see drawing H-6-979). Concrete modulus of rupture (tensile strength in bending) was computed to be 604 lb/in² (Packard 1976, Spears 1978). A safety factor of 2 resulted in an allowable tensile stress of 302 lb/in², an allowable shear stress of 81.5 lb/in², and an allowable bearing stress of 634.2 lb/in² (see Appendix B; Packard 1976, Spears 1978). A Young's modulus of 3,800,000 lb/in² and a Poisson's ratio of 0.15 were used in the finite-element model.

7.0 CONCRETE SLAB CRACK CONTROL

The slab reinforcement is specified on drawing H-6-979 to be #6 bars spaced 10 in. center to center each way. The rebar mat can be placed 2-in. from the top of the slab to control top surface crack widths. Reinforcement area requirements and joint spacing to control crack width can be determined from the following equation (Spears 1978).

$$A_s = \frac{FLw}{2f_s}$$

in which

A_s = effective cross-sectional area of steel, in square inches per foot of width of section.

L = distance between free ends, in feet. (A free end is any joint free to move in a horizontal plane.)

w = weight of slab, in pounds per square foot. (Based on concrete weighing 150 lb per cubic foot.)

F = coefficient of subgrade friction. (This may vary from 1.0 to 2.5; 1.5 is recommended for concrete floors on ground.)

f_s = allowable unit tensile stress in the reinforcement, in psi.

The #6 bars spaced on 10-in. centers results in

$$L = (.528)^2 (30,000) / 1.5 / 187.5$$
$$L = 112.6 \text{ ft free (and joint) length,}$$

where

$$A_s = .528 \text{ in.}^2/\text{ft of width}$$

$$f_s = 30,000 \text{ lb/in}^2 \text{ (conservative if rebar yield strength } f_y = 60,000 \text{ lb/in}^2 \text{)}$$

$$w = (150 \text{ lb/ft}^3) 1.25 \text{ ft} = 187.5 \text{ lb/ft}^2$$
$$\text{slab thickness} = 15 \text{ in.} = 1.25 \text{ ft}$$

$$F = 1.5$$

The maximum joint spacing/slab free end is 112.6 ft. The maximum slab length is 60 ft, which is less than the 112.6 ft. The specified reinforcement, therefore, is adequate to control cracking. Control joints for shrinkage cracks are not needed. The slab design was also checked with a slab-on-grade design program (SOG) and found to be acceptable (see Appendix F, Thoma 1992).

8.0 MODEL VERIFICATION

The ANSYS finite-element model results were verified by comparison to an independent calculation. The De/Caase software package was used for this verification effort and provides a closed form solution for a beam on an elastic foundation (De/Caase 1993). The Poisson's ratio in the ANSYS finite-element model was specified to be zero so that beam behavior could be simulated. ANSYS and De/Caase results appear in Appendices D and E, respectively. The following table compares the results, which show good agreement between the two methods with a maximum difference of 0.4 percent.

Table 2. ANSYS and De/Caase Comparison.

Program	Maximum Deflection (in.)	Maximum Stress (lb/in ²)
Ansys	0.055514	318.77
De/Caase	0.055656	317.38
%Diff	-0.3%	0.4%

9.0 REFERENCES

- ACI, 1989, *Building Code Requirements for Reinforced Concrete*, ACI-318-89, American Concrete Institute, Detroit, Michigan.
- ANSYS, 1992, *ANSYS User's Manual*, Swanson Analysis Systems, Inc., Houston, Pennsylvania.
- De/Caase, 1993, *De/Caase User's Manual*, Desktop Engineering International, Inc., Mahwah, New Jersey.
- Packard, R. G., 1976, *Slab Thickness Design for Industrial Concrete Floors on Grade*, Portland Cement Association, Skokie, Illinois.
- Spears, R. E., 1978, *Concrete Floors on Ground*, Portland Cement Association, Skokie, Illinois.
- Thoma, R. J., 1992, *SOG-Reinforcing Steel in Slab M Grade*, Roberts and Thoma, Inc., Lubbock, Texas.
- Washington State Department of Transportation, 1991, *Standard Specification For Road, Bridge, and Municipal Construction*.

APPENDIX A

Grove AT1100 Crane Load Model

ANALYTICAL CALCULATIONS

Page A2 of 37Subject crane Rigging slabOriginator W.S. PetersonDate Sept 15 1994Checker S.M. MILLER & M. MillerDate 9/22/94

- 1) The outrigger model determines Loads applied to the crane outriggers
- 2) The crane outrigger Loads are limited by the slab strength and load area.
- 3) A finite element model was used to get maximum allowable outrigger loads
- 4) The out Rigger Lift weight (w) and Lift Radius (R) will be selected so that the maximum out Rigger load (R_1, R_2, R_3 or R_4) will not exceed the maximum allowable out Rigger load that can be placed on the slab.
- 5) The equations on pg A9, A12 were used to get the maximum outrigger Lift weight (w) for a given pad size and Lift Radius. The crane model used is the 310K HT1100 (see pg. A36).

ANALYTICAL CALCULATIONS

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Page A3 of 39Subject C & R SlabOriginator W.S. PetersonDate Sept 10 1994Checker [Signature]Date 9/22/941) CRANE LOAD GEOMETRY

crane vehicle

FrmT

2) $W_1, W_2, W_3, W_4, W_5 = \text{axle LOADS}$
 $(2.2)(12,000)(5) \text{ each} = 26,455 \text{ lb}$
 GVW TOTAL $= (60,000)(2.2) = 132,275 \text{ lb}$

3) $R_1, R_2, R_3, R_4 = \text{OUTRIGGER REACTION LOADS}$

4) $R = \text{LIFT Radius}$, $\theta = \text{LIFT Angle Location}$
 crane pivot = CP, lift weight = W

$\theta = \text{HORIZONTAL lift angle (X-Y plane)}$

ANALYTICAL CALCULATIONS

Page 24 of 39Subject C&R SlabOriginator W. S. PetersonDate Sept 22, 94Checker A. M. MillerDate 9/22/945) Distribute w_1, w_2, w_3, w_4, w_5 to R_1, R_2, R_3, R_4 Find C.G. of $\sum w_i$

$$X_{C.G.} = \frac{26,455(-11 + 56 + 124 + 229 - 78)}{5(26,455)} = 65 \text{ INCHES}$$

$$X_{C.G. \text{ from } R_3 \text{ \& } R_4} \quad X_{34} = 65 + 120 + 8 = 193'$$

$$X_{C.G. \text{ from } R_1 \text{ \& } R_2} \quad X_{12} = 114 = 176 - 65 = 307 - 193''$$

$$\uparrow R_{34} = 5(26,455) \frac{114}{307} = 49,118 \text{ Lb}$$

$$\uparrow R_{12} = 5(26,455) \frac{193}{307} = (16,631)5 \text{ Lb}$$

$$\uparrow R_{12} = 83,155$$

$$\uparrow R_1 = R_2 = 41,576 \text{ Lb}$$

$$\uparrow R_3 = R_4 = 24,559 \text{ Lb}$$

$$\downarrow \sum w_i = 5(26,455) = 132,275 \text{ Lb} \checkmark$$

$$\uparrow \sum R_i = 132,270 \text{ Lb} \quad \text{OK}$$

GVW

ANALYTICAL CALCULATIONS

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Subject C+R slab

Originator M.B. Peterson

Date SEPT 22 94

Checker A.M. Miller

Date 9/22/94

6) distribute the lift weight to R_1, R_2, R_3, R_4

Translate W to C.P. location

$$\text{MOMENT about } y \text{ axis} = W \cdot R \cos \theta = MW_y$$

$$\text{MOMENT about } x \text{ axis} = W \cdot R \sin \theta = MW_x$$

static equivalent load = (W, MW_y, MW_x)

ANALYTICAL CALCULATIONS

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Subject C-S R slab

Originator W.B. Peterson

Date Sept 22, 94

Checker L.M. Miller

Date 9/22/94

7) Distribute w to R_1, R_2, R_3, R_4

$$\sum M_{R_{34}} = 0 : \uparrow R_{12} = \frac{128}{307} w = R_1 + R_2$$

$$\sum M_{12} = 0 : \uparrow R_{34} = \frac{179}{307} w = R_3 + R_4$$

$$\uparrow R_1 = R_2 = \left(\frac{128}{307} \right) \frac{w}{2}$$

$$\uparrow R_3 = R_4 = \left(\frac{179}{307} \right) \frac{w}{2}$$

ANALYTICAL CALCULATIONS

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Subject C & R Slab

Originator W. B. PETERSON

Date 9/22/94

Checker A. M. Smith

Date 9/22/94

8) distribute MWY to R_1, R_2, R_3, R_4

$$\downarrow R_{12} = R_{34} \uparrow$$

$$\sum M_{R_{34}} = 0 \quad \downarrow R_{12} \cdot 307 = MWY$$

$$R_{12} = \frac{MWY}{307} = R_1 + R_2$$

$$R_1 = R_2$$

$$\downarrow R_1 = \frac{MWY}{2(307)} = R_2 \downarrow$$

$$R_{34} = R_{12}$$

$$\uparrow R_3 = \frac{MWY}{2(307)} = R_4 \uparrow$$

ANALYTICAL CALCULATIONS

Page A8 of 39

Subject C&R slab

Originator W.S. Peterson

Date 9/22/94

Checker A. M. Miller

Date 9/22/94

9) distribute M_{WX} to R_1, R_2, R_3, R_4

$$\sum M_{R_{23}} = 0 : \downarrow R_{14} = \frac{M_{WX}}{301} = R_1 + R_4, R_1 = R_4$$

$$\downarrow R_1 = R_4 = \frac{M_{WX}}{2(301)}$$

$$\sum M_{R_{14}} = 0 : \uparrow R_{23} = \frac{M_{WX}}{(301)} = R_2 + R_3, R_2 = R_3$$

$$\uparrow R_2 = R_3 = \frac{M_{WX}}{2(301)}$$

10) ADD all contributions up due to
The axle loads and lift weight
see steps 5, 7, 8, 9

ANALYTICAL CALCULATIONS

Page A9 of 39

Subject C & R Slab

Originator W.S. Peterson

Date 9/22/94

Checker L.M. Miller

Date 9/22/94

$$\begin{array}{cccc} \text{STEP 5} & \text{STEP 7} & \text{STEP 8} & \text{STEP 9} \\ \downarrow & \downarrow & \downarrow & \downarrow \\ \uparrow R_1 = 41,576 + \frac{128 \cdot W}{307 \cdot 2} - \frac{MWY}{(307)^2} - \frac{MWX}{2(307)} \end{array}$$

$$\uparrow R_2 = 41,576 + \frac{128 \cdot W}{307 \cdot 2} - \frac{MWY}{(307)^2} + \frac{MWX}{2(307)}$$

$$\uparrow R_3 = 24,559 + \frac{179 \cdot W}{307 \cdot 2} + \frac{MWY}{(307)^2} + \frac{MWX}{2(307)}$$

$$\uparrow R_4 = 24,559 + \frac{179 \cdot W}{(307)^2} + \frac{MWY}{(307)^2} - \frac{MWX}{2(307)}$$

$$MWX = W \cdot R \cdot \sin \theta \quad (\text{STEP 6})$$

$$MWY = W \cdot R \cdot \cos \theta \quad (\text{STEP 6})$$

11. solve for the lift weight

consider R_1

$$R_1 = 41,576 + \frac{128W}{307 \cdot 2} - \frac{W \cdot R \cdot \cos \theta}{(307)^2} - \frac{W \cdot R \cdot \sin \theta}{(307)^2}$$

$$W = \frac{R_1 - 41,576}{\frac{128}{(307)^2} - \frac{R \cos \theta}{(307)^2} - \frac{R \sin \theta}{(307)^2}}$$

ANALYTICAL CALCULATIONS

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Subject C&R slab

Originator W.S. Pitzer

Date 9/22/94

Checker J.M. Miller

Date 9/22/94

12. Find lift angle which makes the denominator of 11 maximum. R_1 will be selected as the maximum allowable slab load, P_{all} . W will then be the maximum allowable lift load, $R =$ lift radius

$$\text{maximize } \left[\frac{128}{(307)^2} - \frac{R \cos \theta}{(307)^2} - \frac{R \sin \theta}{(307)^2} \right]$$

OR

$$\text{maximize } \left[\frac{-\cos \theta}{(307)^2} - \frac{\sin \theta}{(307)^2} \right]$$

choose θ $0 < \theta < 360^\circ$
but max + $180^\circ < \theta < 270^\circ$

13. Look at $F = a \cos \theta + b \sin \theta$

$$\frac{dF}{d\theta} = 0 = -a \sin \theta + b \cos \theta$$

$$\text{max at } \tan \theta = b/a$$

$$b = \frac{-1}{(307)^2}, a = -\frac{1}{(307)^2}$$

ANALYTICAL CALCULATIONS

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Subject C & R CLAS
Originator W.S. Peterson Date 9/22/94
Checker L.M. Miller Date 9/22/94

$$14. \quad \theta = \tan^{-1}\left(\frac{b}{a}\right) = \tan^{-1}\left(\frac{307}{301}\right) = \tan^{-1}(1.0199..)$$

$$\theta_i = 45^\circ, 135^\circ, 225^\circ, 315^\circ$$

$$\theta_1 = 225^\circ \text{ for } R_1 \text{ (maximize } R_1)$$

$$\theta_2 = 135^\circ \text{ for } R_2 \text{ (maximize } R_2)$$

$$\theta_3 = 45^\circ \text{ for } R_3 \text{ (maximize } R_3)$$

$$\theta_4 = 315^\circ \text{ for } R_4 \text{ (maximize } R_4)$$

$$\cos(\theta) = \sin(\theta) = \pm .707$$

15. SUBSTITUTE θ_i INTO 10, 11 AND SOLVE FOR THE MAXIMUM LIFT WEIGHTS

$$W = \frac{R_1 - 41576}{\frac{128}{(307)^2} + \frac{R(707)}{(307)^2} + \frac{R(707)}{(301)^2}}$$

$$W = \frac{R_2 - 41576}{\frac{128}{(307)^2} + \frac{R \cdot 707}{(307)^2} + \frac{R(707)}{301 \cdot 2}}$$

same function
 $R_1 = R_2 = \text{Pail}$

$$W = \frac{R_3 - 24,554}{\frac{179}{307 \cdot 2} + \frac{R(707)}{(307)^2} + \frac{R(707)}{301 \cdot 2}} = \frac{R_4 - 24,554}{\frac{179}{307 \cdot 2} + \frac{R(707)}{(307)^2} + \frac{R(707)}{301 \cdot 2}}$$

ANALYTICAL CALCULATIONS

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Subject CTR slab
Originator NLP Date 9/22/94
Checker L. M. Miller Date 9/22/94

16. simplify 15

$$W = \frac{(R_1 - 41,576)(307)^2}{128 + R(.707 + .707 \frac{307}{301})}$$

$$W = \frac{2 \cdot (307)(R_1 - 41,576)}{128 + R(1.428)}$$

$$W = \frac{2 \cdot (307)(R_2 - 41,576)}{128 + R(1.428)}$$

} same ($R_1 = R_2$)

$$W = \frac{2 \cdot (307)(R_3 - 24,559)}{179 + R(1.428)}$$

$$W = \frac{2 \cdot (307)(R_4 - 24,559)}{179 + R(1.428)}$$

} same ($R_3 = R_4$)

where θ is selected to maximize
the out rigger reaction loads.

ANALYTICAL CALCULATIONS

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Subject CCR slab
Originator WBP Date 9/22/94
Checker J. M. Chilton Date 9/22/94

17. select R_1, R_2, R_3, R_4 = allowable
Load, Pall

for 4'x4' pad $P_{all} = 49,700 \text{ Lb}$
see Appendix F

select Radius to be 10

$$R = 10' = 120''$$

$$W = \frac{(49,700 - 41,576) (307)^2}{128 + 120 (1.428)} \quad \text{for } R_1 \& R_2$$

$$W = \frac{8,124 (307)^2}{299.36} = 16,663 \text{ Lb for } R_1 \& R_2$$

$$W = \frac{(49,700 - 24,559) (307)^2}{179 + 120 (1.428)} \quad \text{for } R_3 \& R_4$$

$$W = \frac{25,141 (307)^2}{350.36} = 44,059 \text{ Lb for } R_3 \& R_4$$

MAX LIFT weight = 16,663 Lb

for $R = 120''$, $P_{all} = 49,700 \text{ Lb}$

ANALYTICAL CALCULATIONS

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Subject C & R slab
Originator WGP Date 9/22/94
Checker A. M. Miller Date 7/22/94

18. select $R=25'$, $P_{all} = 49,700 \text{ Lb}$

$$W = \frac{(49700 - 41576)(307)^2}{128 + 300(1.428)} \quad \text{for } R_1 \& R_2$$

$$W = \frac{8124(307)^2}{556.4} = 8,965 \text{ Lb for } R_1 \& R_2$$

$$W = \frac{25141(307)^2}{179 + 300(1.428)} = \quad \text{for } R_3 \& R_4$$

$$W = \frac{25141(307)^2}{607.4} = 25,414 \text{ Lb for } R_3 \& R_4$$

Max Lift weight = $8,965 \text{ Lb}$
 $R = 300"$, $P_{all} = 49,700 \text{ Lb}$

19. select $R = 30'$, $P_{all} = 49,700 \text{ Lb}$

$$W = \frac{8124(307)^2}{128 + 360(1.428)} = \frac{8124(307)^2}{642} \quad \text{for } R_1 \& R_2$$

$$W = 7,768.7 \text{ Lb MAX LIFT LOAD}$$

$R = 360"$, $P_{all} = 49,700 \text{ Lb}$
 W for $R_3 \& R_4$ will be higher
than for $R_1 \& R_2$ & need not be
checked.

ANALYTICAL CALCULATIONS

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Subject C & R slab
Originator NGP Date 9/22/94
Checker L.M. Miller Date 9/22/94

20. select $R = 40'$, $P_{all} = 49700 \text{ lb}$

$$W = \frac{8124 (307)^2}{128 + 480 (1.428)} = \frac{8124 (307)^2}{813}$$

$W = 6132 \text{ lb}$ MAX LIFT LOAD.

21. From 17, 18, 19, 20

$P_{all} = 49,700 \text{ lb}$ FOR A $4' \times 4'$ PAD

R	W MAX LIFT LOAD
10'	16,663
25'	8,965
30'	7,768
40'	6132

ANALYTICAL CALCULATIONS

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Subject C&R Slab
Originator WSP Date 9/22/94
Checker A. M. Miller Date 9/22/94

22. Select $P_{all} = 29,000lb$ for $2' \times 2'$ pad.
(see Appendix F)

$$W = \frac{(P_{all} - 41576)(307) \cdot 2}{129 + R(1.428)} \quad \begin{array}{l} \text{for } R_1 \& R_2 \\ \text{see step 16} \\ \text{Frm \& Outriggers} \end{array}$$

$$W = \frac{(P_{all} - 24559)(307) \cdot 2}{179 + R(1.428)} \quad \begin{array}{l} \text{for } R_3 \& R_4 \\ \text{see step 16} \\ \text{Rear outriggers} \end{array}$$

23. Inspection of 22 reveals that
W from $R_1 \& R_2$ will be negative
so $W = 0$ (FRONT OUTRIGGERS)

* Only the REAR outriggers will be
allowed on the slab.

$$W = \frac{(29000 - 24559)(307) \cdot 2}{179 + R(1.428)}$$

$$W = \frac{(4441)(307) \cdot 2}{179 + R(1.428)}$$

ANALYTICAL CALCULATIONS

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Subject C & R slab
Originator ISP Date 9/22/94
Checker X. M. Miller Date 9/22/94

24. select $R = 10', 25', 30', 40'$
from step 23 & Pull = 29,000 lb

R	W MAX LIFT LOAD
10'	7,783 lb
25'	4,489 lb
30'	3,934 lb
40'	3,154 lb.

ANALYTICAL CALCULATIONS

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Subject C & R slab
Originator WSP Date 9/22/94
Checker L.M. Miller Date 9/22/94

25. computer out put verifications

hand calcs in steps 21 & 24

PALL=	49700.0		
P-ALLOWABLE=	49700.0	LIFT RADIUS=	120.000
MAXIMIZE FRONT	OUTRIGGER	REACTION: LIFT W=	16662.0 - X
MAXIMIZE REAR	OUTRIGGER	REACTION: LIFT W=	44057.8
P-ALLOWABLE=	49700.0	LIFT RADIUS=	300.000
MAXIMIZE FRONT	OUTRIGGER	REACTION: LIFT W=	8964.57 - X
MAXIMIZE REAR	OUTRIGGER	REACTION: LIFT W=	25413.0
P-ALLOWABLE=	49700.0	LIFT RADIUS=	360.000
MAXIMIZE FRONT	OUTRIGGER	REACTION: LIFT W=	7768.31 - X
MAXIMIZE REAR	OUTRIGGER	REACTION: LIFT W=	22271.3
P-ALLOWABLE=	49700.0	LIFT RADIUS=	480.000
MAXIMIZE FRONT	OUTRIGGER	REACTION: LIFT W=	6131.81 - X
MAXIMIZE REAR	OUTRIGGER	REACTION: LIFT W=	17856.4
PALL=	29000.0		
P-ALLOWABLE=	29000.0	LIFT RADIUS=	120.000
MAXIMIZE FRONT	OUTRIGGER	REACTION: LIFT W=	-25792.9
MAXIMIZE REAR	OUTRIGGER	REACTION: LIFT W=	7782.53 - X
P-ALLOWABLE=	29000.0	LIFT RADIUS=	300.000
MAXIMIZE FRONT	OUTRIGGER	REACTION: LIFT W=	-13877.2
MAXIMIZE REAR	OUTRIGGER	REACTION: LIFT W=	4489.05 - X
P-ALLOWABLE=	29000.0	LIFT RADIUS=	360.000
MAXIMIZE FRONT	OUTRIGGER	REACTION: LIFT W=	-12025.4
MAXIMIZE REAR	OUTRIGGER	REACTION: LIFT W=	3934.09 - X
P-ALLOWABLE=	29000.0	LIFT RADIUS=	480.000
MAXIMIZE FRONT	OUTRIGGER	REACTION: LIFT W=	-9492.08
MAXIMIZE REAR	OUTRIGGER	REACTION: LIFT W=	3154.22 - X

ANALYTICAL CALCULATIONS

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Subject C+R slab
 Originator WSP Date 9/22/94
 Checker L. M. Miller Date 9/22/94

26. The following computer output verifies steps 21 and 25 and also finds the minimum reaction load if the maximum allowable lift weight is selected and positioned at various (R, θ) values.

When $P_{all} = 49,652 \text{ lb}$

$R = 10', 25', 30', 40'$

$\theta = 0^\circ, 360^\circ$ in 11.25° steps

solution accuracy is within a specified iteration tolerance

Since steps 21 & 25 agree with lift weights computed in step 26. These calcs are verified for minimum reaction loads also as the same set of equations are used for both min & max load calcs.

DOS Extender Technology
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VEHICLE WEIGHT= 132270.

R=LIFT RADIUS, A= LIFT ANGLE, WMAX= MAX LIFT WEIGHT

RMAX=MAX OUTRIGGER REACTION LOAD

P-ALL= ALLOWABLE SLAB REACTION LOAD

RMIN=MIN REACTION LOAD

A=LIFT ANGLE

GET WEIGHT SOLUTION

R= 120.000	WMAX= 16559.0	RMAX= 49648.9	P-ALL=
49652.0			
RMIN= 24764.0			
R= 300.000	WMAX= 8914.30	RMAX= 49658.8	P-ALL=
49652.0			
RMIN= 20935.2			
R= 360.000	WMAX= 7726.14	RMAX= 49661.7	P-ALL=
49652.0			
RMIN= 20338.7			
R= 480.000	WMAX= 6097.99	RMAX= 49660.4	P-ALL=
49652.0			
RMIN= 19525.1			

VERIFY CRANE WEIGHT AND RADIUS

W,R= 16559.0 120.000

A= 0.000000	W,R= 16559.0	120.000	
R1,R2,R3,R4= 41791.8	41791.8	32622.7	32622.7
A= 11.2500	W,R= 16559.0	120.000	
R1,R2,R3,R4= 41210.0	42497.9	33204.5	31916.6
A= 22.5000	W,R= 16559.0	120.000	
R1,R2,R3,R4= 40774.9	43301.3	33639.5	31113.2
A= 33.7500	W,R= 16559.0	120.000	
R1,R2,R3,R4= 40503.3	44171.0	33911.1	30243.5
A= 45.0000	W,R= 16559.0	120.000	
R1,R2,R3,R4= 40405.6	45073.6	34008.9	29340.8
A= 56.2500	W,R= 16559.0	120.000	
R1,R2,R3,R4= 40485.5	45974.6	33928.9	28439.9
A= 67.5000	W,R= 16559.0	120.000	
R1,R2,R3,R4= 40740.0	46839.1	33674.5	27575.4
A= 78.7500	W,R= 16559.0	120.000	
R1,R2,R3,R4= 41159.3	47634.0	33255.2	26780.5
A= 90.0000	W,R= 16559.0	120.000	
R1,R2,R3,R4= 41727.2	48328.8	32687.2	26085.7
A= 101.250	W,R= 16559.0	120.000	
R1,R2,R3,R4= 42422.0	48896.8	31992.5	25517.7
A= 112.500	W,R= 16559.0	120.000	
R1,R2,R3,R4= 43217.0	49316.0	31197.5	25098.4
A= 123.750	W,R= 16559.0	120.000	
R1,R2,R3,R4= 44081.5	49570.5	30333.0	24844.0
A= 135.000	W,R= 16559.0	120.000	
R1,R2,R3,R4= 44982.4	49650.4	29432.1	24764.0
A= 146.250	W,R= 16559.0	120.000	
R1,R2,R3,R4= 45885.1	49552.7	28529.4	24861.8
A= 157.500	W,R= 16559.0	120.000	
R1,R2,R3,R4= 46754.8	49281.1	27659.7	25133.4
A= 168.750	W,R= 16559.0	120.000	
R1,R2,R3,R4= 47558.2	48846.1	26856.3	25568.4
A= 180.000	W,R= 16559.0	120.000	
R1,R2,R3,R4= 48264.3	48264.3	26150.2	26150.2
A= 191.250	W,R= 16559.0	120.000	
R1,R2,R3,R4= 48846.1	47558.2	25568.4	26856.3

A=	202.500	W,R=	16559.0	120.000	
R1,R2,R3,R4=	49281.1		46754.8	25133.4	27659.7
A=	213.750	W,R=	16559.0	120.000	
R1,R2,R3,R4=	49552.7		45885.1	24861.8	28529.4
A=	225.000	W,R=	16559.0	120.000	
R1,R2,R3,R4=	49650.4		44982.4	24764.0	29432.1
A=	236.250	W,R=	16559.0	120.000	
R1,R2,R3,R4=	49570.5		44081.5	24844.0	30333.0
A=	247.500	W,R=	16559.0	120.000	
R1,R2,R3,R4=	49316.0		43217.0	25098.4	31197.5
A=	258.750	W,R=	16559.0	120.000	
R1,R2,R3,R4=	48896.8		42422.0	25517.7	31992.5
A=	270.000	W,R=	16559.0	120.000	
R1,R2,R3,R4=	48328.8		41727.2	26085.7	32687.2
A=	281.250	W,R=	16559.0	120.000	
R1,R2,R3,R4=	47634.0		41159.3	26780.5	33255.2
A=	292.500	W,R=	16559.0	120.000	
R1,R2,R3,R4=	46839.1		40740.0	27575.4	33674.5
A=	303.750	W,R=	16559.0	120.000	
R1,R2,R3,R4=	45974.6		40485.5	28439.9	33928.9
A=	315.000	W,R=	16559.0	120.000	
R1,R2,R3,R4=	45073.6		40405.6	29340.8	34008.9
A=	326.250	W,R=	16559.0	120.000	
R1,R2,R3,R4=	44171.0		40503.3	30243.5	33911.1
A=	337.500	W,R=	16559.0	120.000	
R1,R2,R3,R4=	43301.3		40774.9	31113.2	33639.5
A=	348.750	W,R=	16559.0	120.000	
R1,R2,R3,R4=	42497.9		41210.0	31916.6	33204.5
A=	360.000	W,R=	16559.0	120.000	
R1,R2,R3,R4=	41791.8		41791.8	32622.7	32622.7

MAXIUMS

CRANE WEIGHT AND RADIUS

W,R= 16559.0 120.000
PALLOW= 49652.0

AM1,2,3,4= LIFT ANGLE AT MAX REACTION LOAD RM1,2,3,4
RM1,2,3,4= MAX OUTRIGGER REACTION LOAD
RL1,2,3,4=MIN OUTRIGGER REACTION LOAD

AM1,2,3=	225.000	135.000	45.0000	315.000
MAX RM1,2,3,4=	49650.4	49650.4	34008.9	34008.9
MIN RL1,2,3,4=	40405.6	40405.6	24764.0	24764.0 - X

VERIFY CRANE WEIGHT AND RADIUS

W,R= 8914.30 300.000

A=	0.000000	W,R=	8914.30	300.000	
R1,R2,R3,R4=	39078.8		39078.8	31513.3	31513.3
A=	11.2500	W,R=	8914.30	300.000	
R1,R2,R3,R4=	38295.9		40029.2	32296.3	30563.0
A=	22.5000	W,R=	8914.30	300.000	
R1,R2,R3,R4=	37710.4		41110.4	32881.8	29481.8
A=	33.7500	W,R=	8914.30	300.000	
R1,R2,R3,R4=	37344.8		42280.9	33247.3	28311.2
A=	45.0000	W,R=	8914.30	300.000	
R1,R2,R3,R4=	37213.3		43495.7	33378.8	27096.4
A=	56.2500	W,R=	8914.30	300.000	
R1,R2,R3,R4=	37320.9		44708.2	33271.3	25883.9
A=	67.5000	W,R=	8914.30	300.000	
R1,R2,R3,R4=	37663.4		45871.8	32928.8	24720.4
A=	78.7500	W,R=	8914.30	300.000	
R1,R2,R3,R4=	38227.7		46941.6	32364.5	23650.5
A=	90.0000	W,R=	8914.30	300.000	

R1,R2,R3,R4=	38992.0	47876.7	31600.1	22715.5
A= 101.250	W,R=	8914.30	300.000	
R1,R2,R3,R4=	39927.1	48641.1	30665.1	21951.1
A= 112.500	W,R=	8914.30	300.000	
R1,R2,R3,R4=	40997.0	49205.3	29595.2	21386.8
A= 123.750	W,R=	8914.30	300.000	
R1,R2,R3,R4=	42160.5	49547.8	28431.7	21044.3
A= 135.000	W,R=	8914.30	300.000	
R1,R2,R3,R4=	43373.0	49655.4	27219.2	20936.8
A= 146.250	W,R=	8914.30	300.000	
R1,R2,R3,R4=	44587.8	49523.9	26004.3	21068.3
A= 157.500	W,R=	8914.30	300.000	
R1,R2,R3,R4=	45758.3	49158.3	24833.8	21433.8
A= 168.750	W,R=	8914.30	300.000	
R1,R2,R3,R4=	46839.5	48572.8	23752.6	22019.3
A= 180.000	W,R=	8914.30	300.000	
R1,R2,R3,R4=	47789.9	47789.9	22802.3	22802.3
A= 191.250	W,R=	8914.30	300.000	
R1,R2,R3,R4=	48572.8	46839.5	22019.3	23752.6
A= 202.500	W,R=	8914.30	300.000	
R1,R2,R3,R4=	49158.3	45758.3	21433.8	24833.8
A= 213.750	W,R=	8914.30	300.000	
R1,R2,R3,R4=	49523.9	44587.8	21068.3	26004.3
A= 225.000	W,R=	8914.30	300.000	
R1,R2,R3,R4=	49655.4	43373.0	20936.8	27219.2
A= 236.250	W,R=	8914.30	300.000	
R1,R2,R3,R4=	49547.8	42160.5	21044.3	28431.7
A= 247.500	W,R=	8914.30	300.000	
R1,R2,R3,R4=	49205.3	40996.9	21386.8	29595.2
A= 258.750	W,R=	8914.30	300.000	
R1,R2,R3,R4=	48641.1	39927.1	21951.1	30665.1
A= 270.000	W,R=	8914.30	300.000	
R1,R2,R3,R4=	47876.7	38992.0	22715.5	31600.1
A= 281.250	W,R=	8914.30	300.000	
R1,R2,R3,R4=	46941.6	38227.7	23650.5	32364.5
A= 292.500	W,R=	8914.30	300.000	
R1,R2,R3,R4=	45871.8	37663.4	24720.4	32928.8
A= 303.750	W,R=	8914.30	300.000	
R1,R2,R3,R4=	44708.2	37320.9	25883.9	33271.3
A= 315.000	W,R=	8914.30	300.000	
R1,R2,R3,R4=	43495.7	37213.3	27096.4	33378.8
A= 326.250	W,R=	8914.30	300.000	
R1,R2,R3,R4=	42280.9	37344.8	28311.2	33247.3
A= 337.500	W,R=	8914.30	300.000	
R1,R2,R3,R4=	41110.4	37710.4	29481.8	32881.8
A= 348.750	W,R=	8914.30	300.000	
R1,R2,R3,R4=	40029.2	38295.9	30563.0	32296.3
A= 360.000	W,R=	8914.30	300.000	
R1,R2,R3,R4=	39078.8	39078.8	31513.3	31513.3

MAXIUMS

CRANE WEIGHT AND RADIUS

W,R= 8914.30 300.000

PALLOW= 49652.0

AM1,2,3,4= LIFT ANGLE AT MAX REACTION LOAD RM1,2,3,4

RM1,2,3,4= MAX OUTRIGGER REACTION LOAD

RL1,2,3,4,=MIN OUTRIGGER REACTION LOAD

AM1,2,3=	225.000	135.000	45.0000	315.000
MAX RM1,2,3,4=	49655.4	49655.4	33378.8	33378.8
MIN RL1,2,3,4=	37213.3	37213.3	20936.8	20936.8

VERIFY CRANE WEIGHT AND RADIUS

W,R=	7726.14	360.000		
A=	0.000000	W,R=	7726.14	360.000
R1,R2,R3,R4=	38656.7		38656.7	31341.4
A=	11.2500	W,R=	7726.14	360.000
R1,R2,R3,R4=	37842.3		39645.1	32155.7
A=	22.5000	W,R=	7726.14	360.000
R1,R2,R3,R4=	37233.4		40769.6	32764.7
A=	33.7500	W,R=	7726.14	360.000
R1,R2,R3,R4=	36853.2		41987.0	33144.8
A=	45.0000	W,R=	7726.14	360.000
R1,R2,R3,R4=	36716.4		43250.5	33281.6
A=	56.2500	W,R=	7726.14	360.000
R1,R2,R3,R4=	36828.3		44511.6	33169.8
A=	67.5000	W,R=	7726.14	360.000
R1,R2,R3,R4=	37184.5		45721.7	32813.5
A=	78.7500	W,R=	7726.14	360.000
R1,R2,R3,R4=	37771.4		46834.4	32226.7
A=	90.0000	W,R=	7726.14	360.000
R1,R2,R3,R4=	38566.4		47806.9	31431.7
A=	101.250	W,R=	7726.14	360.000
R1,R2,R3,R4=	39538.9		48601.9	30459.2
A=	112.500	W,R=	7726.14	360.000
R1,R2,R3,R4=	40651.6		49188.8	29346.4
A=	123.750	W,R=	7726.14	360.000
R1,R2,R3,R4=	41861.8		49545.0	28136.3
A=	135.000	W,R=	7726.14	360.000
R1,R2,R3,R4=	43122.8		49656.9	26875.3
A=	146.250	W,R=	7726.14	360.000
R1,R2,R3,R4=	44386.3		49520.1	25611.8
A=	157.500	W,R=	7726.14	360.000
R1,R2,R3,R4=	45603.7		49139.9	24394.4
A=	168.750	W,R=	7726.14	360.000
R1,R2,R3,R4=	46728.2		48531.0	23269.8
A=	180.000	W,R=	7726.14	360.000
R1,R2,R3,R4=	47716.6		47716.6	22281.4
A=	191.250	W,R=	7726.14	360.000
R1,R2,R3,R4=	48531.0		46728.2	21467.1
A=	202.500	W,R=	7726.14	360.000
R1,R2,R3,R4=	49139.9		45603.7	20858.1
A=	213.750	W,R=	7726.14	360.000
R1,R2,R3,R4=	49520.1		44386.3	20478.0
A=	225.000	W,R=	7726.14	360.000
R1,R2,R3,R4=	49656.9		43122.8	20341.2
A=	236.250	W,R=	7726.14	360.000
R1,R2,R3,R4=	49545.0		41861.8	20453.1
A=	247.500	W,R=	7726.14	360.000
R1,R2,R3,R4=	49188.8		40651.6	20809.3
A=	258.750	W,R=	7726.14	360.000
R1,R2,R3,R4=	48601.9		39538.9	21396.1
A=	270.000	W,R=	7726.14	360.000
R1,R2,R3,R4=	47806.9		38566.4	22191.1
A=	281.250	W,R=	7726.14	360.000
R1,R2,R3,R4=	46834.4		37771.4	23163.7
A=	292.500	W,R=	7726.14	360.000
R1,R2,R3,R4=	45721.7		37184.5	24276.4
A=	303.750	W,R=	7726.14	360.000
R1,R2,R3,R4=	44511.6		36828.3	25486.5
A=	315.000	W,R=	7726.14	360.000
R1,R2,R3,R4=	43250.5		36716.4	26747.6
A=	326.250	W,R=	7726.14	360.000
R1,R2,R3,R4=	41987.0		36853.2	28011.1
A=	337.500	W,R=	7726.14	360.000
R1,R2,R3,R4=	40769.6		37233.4	29228.5
A=	348.750	W,R=	7726.14	360.000

R1,R2,R3,R4=	39645.1	37842.3	30353.0	32155.7
A= 360.000	W,R=	7726.14	360.000	
R1,R2,R3,R4=	38656.7	38656.7	31341.4	31341.4

MAXIUMS

CRANE WEIGHT AND RADIUS

W,R= 7726.14 360.000
PALLOW= 49652.0

AM1,2,3,4= LIFT ANGLE AT MAX REACTION LOAD RM1,2,3,4

RM1,2,3,4= MAX OUTRIGGER REACTION LOAD

RL1,2,3,4=MIN OUTRIGGER REACTION LOAD

AM1,2,3=	225.000	135.000	45.0000	315.000
MAX RM1,2,3,4=	49656.9	49656.9	33281.6	33281.6
MIN RL1,2,3,4=	36716.4	36716.4	20341.2	20341.2

VERIFY CRANE WEIGHT AND RADIUS

W,R= 6097.99 480.000

A= 0.000000	W,R=	6097.99	480.000	
R1,R2,R3,R4=	38080.1	38080.1	31103.9	31103.9
A= 11.2500	W,R=	6097.99	480.000	
R1,R2,R3,R4=	37223.1	39120.2	31960.9	30063.8
A= 22.5000	W,R=	6097.99	480.000	
R1,R2,R3,R4=	36582.3	40303.6	32601.7	28880.4
A= 33.7500	W,R=	6097.99	480.000	
R1,R2,R3,R4=	36182.2	41584.8	33001.8	27599.2
A= 45.0000	W,R=	6097.99	480.000	
R1,R2,R3,R4=	36038.3	42914.4	33145.7	26269.6
A= 56.2500	W,R=	6097.99	480.000	
R1,R2,R3,R4=	36156.0	44241.5	33028.0	24942.5
A= 67.5000	W,R=	6097.99	480.000	
R1,R2,R3,R4=	36530.9	45515.0	32653.1	23669.0
A= 78.7500	W,R=	6097.99	480.000	
R1,R2,R3,R4=	37148.5	46686.0	32035.5	22498.0
A= 90.0000	W,R=	6097.99	480.000	
R1,R2,R3,R4=	37985.1	47709.4	31198.9	21474.6
A= 101.250	W,R=	6097.99	480.000	
R1,R2,R3,R4=	39008.5	48546.0	30175.5	20638.0
A= 112.500	W,R=	6097.99	480.000	
R1,R2,R3,R4=	40179.5	49163.6	29004.5	20020.4
A= 123.750	W,R=	6097.99	480.000	
R1,R2,R3,R4=	41453.0	49538.5	27731.0	19645.5
A= 135.000	W,R=	6097.99	480.000	
R1,R2,R3,R4=	42780.1	49656.2	26403.9	19527.8
A= 146.250	W,R=	6097.99	480.000	
R1,R2,R3,R4=	44109.7	49512.3	25074.3	19671.7
A= 157.500	W,R=	6097.99	480.000	
R1,R2,R3,R4=	45390.8	49112.2	23793.1	20071.8
A= 168.750	W,R=	6097.99	480.000	
R1,R2,R3,R4=	46574.2	48471.4	22609.8	20712.6
A= 180.000	W,R=	6097.99	480.000	
R1,R2,R3,R4=	47614.4	47614.4	21569.6	21569.6
A= 191.250	W,R=	6097.99	480.000	
R1,R2,R3,R4=	48471.4	46574.2	20712.6	22609.8
A= 202.500	W,R=	6097.99	480.000	
R1,R2,R3,R4=	49112.2	45390.8	20071.8	23793.2
A= 213.750	W,R=	6097.99	480.000	
R1,R2,R3,R4=	49512.3	44109.7	19671.7	25074.3
A= 225.000	W,R=	6097.99	480.000	
R1,R2,R3,R4=	49656.2	42780.0	19527.8	26403.9
A= 236.250	W,R=	6097.99	480.000	
R1,R2,R3,R4=	49538.5	41453.0	19645.5	27731.0

A=	247.500	W,R=	6097.99	480.000	
R1,R2,R3,R4=	49163.6		40179.5	20020.4	29004.5
A=	258.750	W,R=	6097.99	480.000	
R1,R2,R3,R4=	48546.0		39008.5	20638.0	30175.5
A=	270.000	W,R=	6097.99	480.000	
R1,R2,R3,R4=	47709.4		37985.1	21474.6	31198.9
A=	281.250	W,R=	6097.99	480.000	
R1,R2,R3,R4=	46686.0		37148.5	22498.0	32035.5
A=	292.500	W,R=	6097.99	480.000	
R1,R2,R3,R4=	45515.0		36530.9	23669.0	32653.1
A=	303.750	W,R=	6097.99	480.000	
R1,R2,R3,R4=	44241.5		36156.0	24942.5	33028.0
A=	315.000	W,R=	6097.99	480.000	
R1,R2,R3,R4=	42914.4		36038.3	26269.6	33145.7
A=	326.250	W,R=	6097.99	480.000	
R1,R2,R3,R4=	41584.8		36182.2	27599.2	33001.8
A=	337.500	W,R=	6097.99	480.000	
R1,R2,R3,R4=	40303.6		36582.3	28880.4	32601.7
A=	348.750	W,R=	6097.99	480.000	
R1,R2,R3,R4=	39120.2		37223.1	30063.8	31960.9
A=	360.000	W,R=	6097.99	480.000	
R1,R2,R3,R4=	38080.1		38080.1	31103.9	31103.9

MAXIUMS

CRANE WEIGHT AND RADIUS

W,R= 6097.99 480.000
PALLOW= 49652.0

AM1,2,3,4= LIFT ANGLE AT MAX REACTION LOAD RM1,2,3,4

RM1,2,3,4= MAX OUTRIGGER REACTION LOAD

RL1,2,3,4,=MIN OUTRIGGER REACTION LOAD

AM1,2,3=	225.000	135.000	45.0000	315.000
MAX RM1,2,3,4=	49656.2	49656.2	33145.7	33145.7
MIN RL1,2,3,4=	36038.3	36038.3	19527.8	19527.8

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ANALYTICAL CALCULATIONS

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Subject G & R Slab
Originator WSP Date 9/22/94
Checker L. M. McPhee Date 9/22/94

27. The following verifies
STEPS 24 & 25 and also
FINDS the minimum Reaction
Load IF The maximum allowable
Lift weight is selected and
positioned at various (R, θ) values
where $P_{all} = 29,000$ lb
 $R = 10', 25', 30', 40'$
 $\theta = 0^\circ, 360^\circ$ in 11.25° steps

solution accuracy is within
a specified iteration tolerance

DOS Extender Technology
Copyright (c) 1986-1991 Ergo Computing, Inc. v2.1.06A for Lahey

VEHICLE WEIGHT= 132270.

R=LIFT RADIUS, A= LIFT ANGLE, WMAX= MAX LIFT WEIGHT

RMAX=MAX OUTRIGGER REACTION LOAD

P-ALL= ALLOWABLE SLAB REACTION LOAD

RMIN=MIN REACTION LOAD

A=LIFT ANGLE

GET WEIGHT SOLUTION

R=	120.000	WMAX=	7786.29	RMAX=	29004.9	P-ALL=
	29000.0					
	RMIN=	24655.5				
R=	300.000	WMAX=	4491.79	RMAX=	29006.4	P-ALL=
	29000.0					
	RMIN=	22732.5				
R=	360.000	WMAX=	3938.01	RMAX=	29009.8	P-ALL=
	29000.0					
	RMIN=	22406.8				
R=	480.000	WMAX=	3156.90	RMAX=	29008.6	P-ALL=
	29000.0					
	RMIN=	21951.8				

VERIFY CRANE WEIGHT AND RADIUS

W,R= 7786.29 120.000

A=	0.000000	W,R=	7786.29	120.000	
R1,R2,R3,R4=	41677.4		41677.4	28350.7	28350.7
A=	11.2500	W,R=	7786.29	120.000	
R1,R2,R3,R4=	41403.9		42009.5	28624.3	28018.7
A=	22.5000	W,R=	7786.29	120.000	
R1,R2,R3,R4=	41199.3		42387.2	28828.8	27640.9
A=	33.7500	W,R=	7786.29	120.000	
R1,R2,R3,R4=	41071.6		42796.2	28956.5	27231.9
A=	45.0000	W,R=	7786.29	120.000	
R1,R2,R3,R4=	41025.7		43220.6	29002.5	26807.5
A=	56.2500	W,R=	7786.29	120.000	
R1,R2,R3,R4=	41063.3		43644.3	28964.9	26383.9
A=	67.5000	W,R=	7786.29	120.000	
R1,R2,R3,R4=	41182.9		44050.8	28845.2	25977.4
A=	78.7500	W,R=	7786.29	120.000	
R1,R2,R3,R4=	41380.1		44424.6	28648.1	25603.6
A=	90.0000	W,R=	7786.29	120.000	
R1,R2,R3,R4=	41647.1		44751.3	28381.0	25276.9
A=	101.250	W,R=	7786.29	120.000	
R1,R2,R3,R4=	41973.8		45018.3	28054.3	25009.8
A=	112.500	W,R=	7786.29	120.000	
R1,R2,R3,R4=	42347.6		45215.5	27680.5	24812.7
A=	123.750	W,R=	7786.29	120.000	
R1,R2,R3,R4=	42754.1		45335.1	27274.0	24693.0
A=	135.000	W,R=	7786.29	120.000	
R1,R2,R3,R4=	43177.8		45372.7	26850.4	24655.4
A=	146.250	W,R=	7786.29	120.000	
R1,R2,R3,R4=	43602.2		45326.8	26425.9	24701.4
A=	157.500	W,R=	7786.29	120.000	
R1,R2,R3,R4=	44011.2		45199.1	26017.0	24829.1
A=	168.750	W,R=	7786.29	120.000	
R1,R2,R3,R4=	44388.9		44994.5	25639.2	25033.6
A=	180.000	W,R=	7786.29	120.000	
R1,R2,R3,R4=	44720.9		44720.9	25307.2	25307.2
A=	191.250	W,R=	7786.29	120.000	
R1,R2,R3,R4=	44994.5		44388.9	25033.6	25639.2
A=	202.500	W,R=	7786.29	120.000	

R1,R2,R3,R4=	45199.1	44011.2	24829.1	26017.0
A=	213.750	W,R=	7786.29	120.000
R1,R2,R3,R4=	45326.8	43602.2	24701.4	26425.9
A=	225.000	W,R=	7786.29	120.000
R1,R2,R3,R4=	45372.7	43177.8	24655.4	26850.4
A=	236.250	W,R=	7786.29	120.000
R1,R2,R3,R4=	45335.1	42754.1	24693.0	27274.0
A=	247.500	W,R=	7786.29	120.000
R1,R2,R3,R4=	45215.5	42347.6	24812.7	27680.5
A=	258.750	W,R=	7786.29	120.000
R1,R2,R3,R4=	45018.3	41973.8	25009.8	28054.3
A=	270.000	W,R=	7786.29	120.000
R1,R2,R3,R4=	44751.3	41647.1	25276.9	28381.0
A=	281.250	W,R=	7786.29	120.000
R1,R2,R3,R4=	44424.6	41380.1	25603.6	28648.1
A=	292.500	W,R=	7786.29	120.000
R1,R2,R3,R4=	44050.8	41182.9	25977.4	28845.2
A=	303.750	W,R=	7786.29	120.000
R1,R2,R3,R4=	43644.3	41063.3	26383.9	28964.9
A=	315.000	W,R=	7786.29	120.000
R1,R2,R3,R4=	43220.6	41025.7	26807.5	29002.5
A=	326.250	W,R=	7786.29	120.000
R1,R2,R3,R4=	42796.2	41071.6	27231.9	28956.5
A=	337.500	W,R=	7786.29	120.000
R1,R2,R3,R4=	42387.2	41199.3	27640.9	28828.8
A=	348.750	W,R=	7786.29	120.000
R1,R2,R3,R4=	42009.5	41403.9	28018.7	28624.3
A=	360.000	W,R=	7786.29	120.000
R1,R2,R3,R4=	41677.4	41677.4	28350.7	28350.7

MAXIUMS

CRANE WEIGHT AND RADIUS

W,R= 7786.29 120.000
 PALLOW= 29000.0

AM1,2,3,4= LIFT ANGLE AT MAX REACTION LOAD RM1,2,3,4
 RM1,2,3,4= MAX OUTRIGGER REACTION LOAD
 RL1,2,3,4= MIN OUTRIGGER REACTION LOAD

AM1,2,3,4=	225.000	135.000	45.0000	315.000
MAX RM1,2,3,4=	45372.7	45372.7	29002.5	29002.5
MIN RL1,2,3,4=	41025.7	41025.7	24655.4	24655.4

VERIFY CRANE WEIGHT AND RADIUS

W,R= 4491.79 300.000

A=	0.000000	W,R=	4491.79	300.000	
R1,R2,R3,R4=	40317.7	40317.7	28063.2		28063.2
A=	11.2500	W,R=	4491.79	300.000	
R1,R2,R3,R4=	39923.2	40796.6	28457.7		27584.3
A=	22.5000	W,R=	4491.79	300.000	
R1,R2,R3,R4=	39628.2	41341.4	28752.7		27039.5
A=	33.7500	W,R=	4491.79	300.000	
R1,R2,R3,R4=	39444.0	41931.2	28936.9		26449.7
A=	45.0000	W,R=	4491.79	300.000	
R1,R2,R3,R4=	39377.7	42543.3	29003.2		25837.6
A=	56.2500	W,R=	4491.79	300.000	
R1,R2,R3,R4=	39431.9	43154.3	28949.0		25226.6
A=	67.5000	W,R=	4491.79	300.000	
R1,R2,R3,R4=	39604.5	43740.6	28776.4		24640.3
A=	78.7500	W,R=	4491.79	300.000	
R1,R2,R3,R4=	39888.8	44279.7	28492.1		24101.2
A=	90.0000	W,R=	4491.79	300.000	
R1,R2,R3,R4=	40274.0	44750.8	28106.9		23630.1

A=	101.250	W,R=	4491.79	300.000	
R1,R2,R3,R4=	40745.1		45136.0	27635.8	23244.9
A=	112.500	W,R=	4491.79	300.000	
R1,R2,R3,R4=	41284.2		45420.3	27096.7	22960.6
A=	123.750	W,R=	4491.79	300.000	
R1,R2,R3,R4=	41870.5		45592.9	26510.4	22788.0
A=	135.000	W,R=	4491.79	300.000	
R1,R2,R3,R4=	42481.5		45647.1	25899.4	22733.8
A=	146.250	W,R=	4491.79	300.000	
R1,R2,R3,R4=	43093.6		45580.8	25287.3	22800.1
A=	157.500	W,R=	4491.79	300.000	
R1,R2,R3,R4=	43683.4		45396.6	24697.5	22984.3
A=	168.750	W,R=	4491.79	300.000	
R1,R2,R3,R4=	44228.2		45101.6	24152.7	23279.3
A=	180.000	W,R=	4491.79	300.000	
R1,R2,R3,R4=	44707.1		44707.1	23673.8	23673.8
A=	191.250	W,R=	4491.79	300.000	
R1,R2,R3,R4=	45101.6		44228.2	23279.3	24152.7
A=	202.500	W,R=	4491.79	300.000	
R1,R2,R3,R4=	45396.6		43683.4	22984.3	24697.5
A=	213.750	W,R=	4491.79	300.000	
R1,R2,R3,R4=	45580.8		43093.6	22800.1	25287.3
A=	225.000	W,R=	4491.79	300.000	
R1,R2,R3,R4=	45647.1		42481.5	22733.8	25899.4
A=	236.250	W,R=	4491.79	300.000	
R1,R2,R3,R4=	45592.9		41870.5	22788.0	26510.4
A=	247.500	W,R=	4491.79	300.000	
R1,R2,R3,R4=	45420.3		41284.2	22960.6	27096.7
A=	258.750	W,R=	4491.79	300.000	
R1,R2,R3,R4=	45136.0		40745.1	23244.9	27635.8
A=	270.000	W,R=	4491.79	300.000	
R1,R2,R3,R4=	44750.8		40274.0	23630.1	28106.9
A=	281.250	W,R=	4491.79	300.000	
R1,R2,R3,R4=	44279.7		39888.8	24101.2	28492.1
A=	292.500	W,R=	4491.79	300.000	
R1,R2,R3,R4=	43740.6		39604.5	24640.3	28776.4
A=	303.750	W,R=	4491.79	300.000	
R1,R2,R3,R4=	43154.3		39431.9	25226.6	28949.0
A=	315.000	W,R=	4491.79	300.000	
R1,R2,R3,R4=	42543.3		39377.7	25837.6	29003.2
A=	326.250	W,R=	4491.79	300.000	
R1,R2,R3,R4=	41931.2		39444.0	26449.7	28936.9
A=	337.500	W,R=	4491.79	300.000	
R1,R2,R3,R4=	41341.4		39628.2	27039.5	28752.7
A=	348.750	W,R=	4491.79	300.000	
R1,R2,R3,R4=	40796.6		39923.2	27584.3	28457.7
A=	360.000	W,R=	4491.79	300.000	
R1,R2,R3,R4=	40317.7		40317.7	28063.2	28063.2

MAXIUMS

CRANE WEIGHT AND RADIUS

W,R= 4491.79 300.000
PALLOW= 29000.0

AM1,2,3,4= LIFT ANGLE AT MAX REACTION LOAD RM1,2,3,4
RM1,2,3,4= MAX OUTRIGGER REACTION LOAD
RL1,2,3,4=MIN OUTRIGGER REACTION LOAD

AM1,2,3,4=	225.000	135.000	45.0000	315.000
MAX RM1,2,3,4=	45647.1	45647.1	29003.2	29003.2
MIN RL1,2,3,4=	39377.7	39377.7	22733.8	22733.8

VERIFY CRANE WEIGHT AND RADIUS

W,R= 3938.01 360.000

A= 0.000000	W,R=	3938.01	360.000	
R1,R2,R3,R4= 40088.0		40088.0	28016.0	28016.0
A= 11.2500	W,R=	3938.01	360.000	
R1,R2,R3,R4= 39673.0		40591.8	28431.1	27512.2
A= 22.5000	W,R=	3938.01	360.000	
R1,R2,R3,R4= 39362.6		41165.0	28741.4	26939.0
A= 33.7500	W,R=	3938.01	360.000	
R1,R2,R3,R4= 39168.8		41785.5	28935.2	26318.5
A= 45.0000	W,R=	3938.01	360.000	
R1,R2,R3,R4= 39099.1		42429.5	29004.9	25674.5
A= 56.2500	W,R=	3938.01	360.000	
R1,R2,R3,R4= 39156.1		43072.3	28947.9	25031.8
A= 67.5000	W,R=	3938.01	360.000	
R1,R2,R3,R4= 39337.7		43689.1	28766.3	24414.9
A= 78.7500	W,R=	3938.01	360.000	
R1,R2,R3,R4= 39636.8		44256.2	28467.2	23847.8
A= 90.0000	W,R=	3938.01	360.000	
R1,R2,R3,R4= 40042.0		44751.9	28062.0	23352.1
A= 101.250	W,R=	3938.01	360.000	
R1,R2,R3,R4= 40537.7		45157.1	27566.3	22946.9
A= 112.500	W,R=	3938.01	360.000	
R1,R2,R3,R4= 41104.8		45456.2	26999.2	22647.8
A= 123.750	W,R=	3938.01	360.000	
R1,R2,R3,R4= 41721.7		45637.8	26382.4	22466.2
A= 135.000	W,R=	3938.01	360.000	
R1,R2,R3,R4= 42364.4		45694.8	25739.6	22409.2
A= 146.250	W,R=	3938.01	360.000	
R1,R2,R3,R4= 43008.4		45625.1	25095.6	22478.9
A= 157.500	W,R=	3938.01	360.000	
R1,R2,R3,R4= 43628.9		45431.3	24475.1	22672.7
A= 168.750	W,R=	3938.01	360.000	
R1,R2,R3,R4= 44202.1		45121.0	23901.9	22983.1
A= 180.000	W,R=	3938.01	360.000	
R1,R2,R3,R4= 44705.9		44705.9	23398.1	23398.1
A= 191.250	W,R=	3938.01	360.000	
R1,R2,R3,R4= 45121.0		44202.1	22983.1	23901.9
A= 202.500	W,R=	3938.01	360.000	
R1,R2,R3,R4= 45431.3		43628.9	22672.7	24475.1
A= 213.750	W,R=	3938.01	360.000	
R1,R2,R3,R4= 45625.1		43008.4	22478.9	25095.6
A= 225.000	W,R=	3938.01	360.000	
R1,R2,R3,R4= 45694.8		42364.4	22409.2	25739.6
A= 236.250	W,R=	3938.01	360.000	
R1,R2,R3,R4= 45637.8		41721.7	22466.2	26382.4
A= 247.500	W,R=	3938.01	360.000	
R1,R2,R3,R4= 45456.2		41104.8	22647.8	26999.2
A= 258.750	W,R=	3938.01	360.000	
R1,R2,R3,R4= 45157.1		40537.7	22946.9	27566.3
A= 270.000	W,R=	3938.01	360.000	
R1,R2,R3,R4= 44751.9		40042.0	23352.1	28062.0
A= 281.250	W,R=	3938.01	360.000	
R1,R2,R3,R4= 44256.2		39636.8	23847.8	28467.2
A= 292.500	W,R=	3938.01	360.000	
R1,R2,R3,R4= 43689.1		39337.7	24414.9	28766.3
A= 303.750	W,R=	3938.01	360.000	
R1,R2,R3,R4= 43072.3		39156.1	25031.8	28947.9
A= 315.000	W,R=	3938.01	360.000	
R1,R2,R3,R4= 42429.5		39099.1	25674.5	29004.9
A= 326.250	W,R=	3938.01	360.000	
R1,R2,R3,R4= 41785.5		39168.8	26318.5	28935.2
A= 337.500	W,R=	3938.01	360.000	
R1,R2,R3,R4= 41165.0		39362.6	26939.0	28741.4
A= 348.750	W,R=	3938.01	360.000	
R1,R2,R3,R4= 40591.8		39673.0	27512.2	28431.1

A= 360.000 W,R= 3938.01 360.000
 R1,R2,R3,R4= 40088.0 40088.0 28016.0

28016.0

MAXIUMS

CRANE WEIGHT AND RADIUS

W,R= 3938.01 360.000

PALLOW= 29000.0

AM1,2,3,4= LIFT ANGLE AT MAX REACTION LOAD RM1,2,3,4

RM1,2,3,4= MAX OUTRIGGER REACTION LOAD

RL1,2,3,4=MIN OUTRIGGER REACTION LOAD

AM1,2,3,4=	225.000	135.000	45.0000	315.000
MAX RM1,2,3,4=	45694.8	45694.8	29004.9	29004.9
MIN RL1,2,3,4=	39099.1	39099.1	22409.2	22409.2

VERIFY CRANE WEIGHT AND RADIUS

W,R= 3156.90 480.000

A=	0.000000	W,R=	3156.90	480.000	
R1,R2,R3,R4=	39766.2		39766.2	27947.3	27947.3
A=	11.2500	W,R=	3156.90	480.000	
R1,R2,R3,R4=	39322.5		40304.7	28390.9	27408.8
A=	22.5000	W,R=	3156.90	480.000	
R1,R2,R3,R4=	38990.8		40917.3	28722.7	26796.1
A=	33.7500	W,R=	3156.90	480.000	
R1,R2,R3,R4=	38783.7		41580.5	28929.8	26132.9
A=	45.0000	W,R=	3156.90	480.000	
R1,R2,R3,R4=	38709.1		42268.9	29004.3	25444.5
A=	56.2500	W,R=	3156.90	480.000	
R1,R2,R3,R4=	38770.1		42955.9	28943.4	24757.5
A=	67.5000	W,R=	3156.90	480.000	
R1,R2,R3,R4=	38964.1		43615.2	28749.3	24098.2
A=	78.7500	W,R=	3156.90	480.000	
R1,R2,R3,R4=	39283.9		44221.4	28429.6	23492.0
A=	90.0000	W,R=	3156.90	480.000	
R1,R2,R3,R4=	39717.0		44751.3	27996.5	22962.2
A=	101.250	W,R=	3156.90	480.000	
R1,R2,R3,R4=	40246.8		45184.4	27466.6	22529.1
A=	112.500	W,R=	3156.90	480.000	
R1,R2,R3,R4=	40853.0		45504.1	26860.4	22209.4
A=	123.750	W,R=	3156.90	480.000	
R1,R2,R3,R4=	41512.3		45698.1	26201.1	22015.3
A=	135.000	W,R=	3156.90	480.000	
R1,R2,R3,R4=	42199.3		45759.1	25514.1	21954.4
A=	146.250	W,R=	3156.90	480.000	
R1,R2,R3,R4=	42887.7		45684.6	24825.8	22028.9
A=	157.500	W,R=	3156.90	480.000	
R1,R2,R3,R4=	43550.9		45477.5	24162.5	22236.0
A=	168.750	W,R=	3156.90	480.000	
R1,R2,R3,R4=	44163.6		45145.7	23549.9	22567.8
A=	180.000	W,R=	3156.90	480.000	
R1,R2,R3,R4=	44702.1		44702.1	23011.4	23011.4
A=	191.250	W,R=	3156.90	480.000	
R1,R2,R3,R4=	45145.7		44163.6	22567.8	23549.9
A=	202.500	W,R=	3156.90	480.000	
R1,R2,R3,R4=	45477.5		43550.9	22236.0	24162.5
A=	213.750	W,R=	3156.90	480.000	
R1,R2,R3,R4=	45684.6		42887.7	22028.9	24825.8
A=	225.000	W,R=	3156.90	480.000	
R1,R2,R3,R4=	45759.1		42199.3	21954.4	25514.1
A=	236.250	W,R=	3156.90	480.000	
R1,R2,R3,R4=	45698.1		41512.3	22015.3	26201.1
A=	247.500	W,R=	3156.90	480.000	

R1,R2,R3,R4=	45504.1	40853.0	22209.4	26860.4
A= 258.750	W,R=	3156.90	480.000	
R1,R2,R3,R4=	45184.4	40246.8	22529.1	27466.6
A= 270.000	W,R=	3156.90	480.000	
R1,R2,R3,R4=	44751.3	39717.0	22962.2	27996.5
A= 281.250	W,R=	3156.90	480.000	
R1,R2,R3,R4=	44221.4	39283.9	23492.0	28429.6
A= 292.500	W,R=	3156.90	480.000	
R1,R2,R3,R4=	43615.2	38964.1	24098.2	28749.3
A= 303.750	W,R=	3156.90	480.000	
R1,R2,R3,R4=	42955.9	38770.1	24757.5	28943.4
A= 315.000	W,R=	3156.90	480.000	
R1,R2,R3,R4=	42268.9	38709.1	25444.6	29004.3
A= 326.250	W,R=	3156.90	480.000	
R1,R2,R3,R4=	41580.5	38783.7	26132.9	28929.8
A= 337.500	W,R=	3156.90	480.000	
R1,R2,R3,R4=	40917.3	38990.8	26796.1	28722.7
A= 348.750	W,R=	3156.90	480.000	
R1,R2,R3,R4=	40304.7	39322.5	27408.8	28390.9
A= 360.000	W,R=	3156.90	480.000	
R1,R2,R3,R4=	39766.2	39766.2	27947.3	27947.3

MAXIUMS

CRANE WEIGHT AND RADIUS

W,R= 3156.90 480.000
PALLOW= 29000.0

AM1,2,3,4= LIFT ANGLE AT MAX REACTION LOAD RM1,2,3,4
RM1,2,3,4= MAX OUTRIGGER REACTION LOAD
RL1,2,3,4=MIN OUTRIGGER REACTION LOAD

AM1,2,3,4=	225.000	135.000	45.0000	315.000
MAX RM1,2,3,4=	45759.1	45759.1	29004.3	29004.3
MIN RL1,2,3,4=	38709.1	38709.1	21954.4	21954.4

!

*

ANALYTICAL CALCULATIONS

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Subject C&R slab

Originator M. B. P.

Date 9/22/94

Checker D. E. Miller

Date 9/22/94

28. MINIMUM REACTION LOADS
are computed in steps 26 & 27.

$$P_{all} = 4,9652 \text{ Lb}$$

Radius	LIFT W	Min Reaction
10'	16559	24,769
25'	8914	20937
30'	7726	20341
40'	6098	19528

$$P_{all} = 29,000 \text{ Lb}$$

Radius	LIFT W	Min Reaction
10'	7786	24655
25'	4492	22734
30'	3938	22409
40'	3157	21954

MINIMUM REACTION LOADS should not
be less than ~~2000~~ for stability

ANALYTICAL CALCULATIONS

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Subject C&R slab
Originator WSP Date 9/22/94
Checker J. M. Miller Date 9/22/94

29. Minimum Reaction Load will be checked with a hand calc. Step 26 lists a minimum reaction load of 19,528 lb for 40' (see also step 28). and $P_{all} = 49,652$

$$W = 6098, R = 480$$

$$R_y = 19528 \quad \theta = 135^\circ$$

$$P_{all} = 49,652$$

see step 10

$$R_y = 24559 + \frac{179W}{(3072)} + \frac{MWX}{(3072)} - \frac{MWX}{2(301)}$$

$$R_y = 24559 + \left[\frac{(179)}{3072} + \frac{R \cos \theta}{3072} - \frac{R \sin \theta}{2(301)} \right] W$$

θ is chosen to minimize R_y $\theta = 135^\circ$

i.e both θ terms are negative

This is the same as the conclusion in step 14 except θ is chosen to minimize the reaction load

ANALYTICAL CALCULATIONS.

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Subject CLR slab

Originator WSP

Date 9/22/94

Checker L. M. Miller

Date 9/22/94

$$R_u = 24,559 + \left[\frac{179}{307(2)} - \frac{R(707)}{307(2)} - \frac{R(707)}{2(307)} \right] w$$

$$R_u = 24,559 + [179 - R(1.429)] \frac{w}{2(307)}$$

$$R_u = 24,559 + [179 - 480(1.429)] \frac{w}{2(307)}$$

$$R_u = 24,559 + [-506.44] \frac{w}{2(307)}$$

$$w = 6098 \text{ lb}$$

$$R_u = 24,559 - 5029.7$$

$$R_u = 19529 \text{ This checks with}$$

The computer output so step 26
is verified.

Also step 27 will be assumed
to be verified since the same
equations are used with different
pull value to get w max lift
load

E22011

WHC-SD-LL-DA-038
Rev. 0

AT1100

All-terrain hydraulic crane

- Maximum on-board tip height 60 metres (196 ft 10 in)
- 10 x 8 wheel drive with eight wheel steer
- Maximum speed 70 kph (43.5 mph)
- Optional *telescopic Swingaway 10.00 – 14.60 – 17.70 metres (32 ft 10 in – 48 ft – 58 ft). Offsettable at 2°, 15° or 30°

Superstructure specifications

WHC-SD-LL-DA-038

Rev. 0

Boom	12.70 to 39.52 m (41 ft 8 in to 129 ft 8 in) four-section, full power Trapezoidal main boom consisting of base and three synchronised sections. Cab operated switch allows synchronised two-section extension to 30.58 m (100 ft 4 in) with fly section retracted. Telescopic sections slide on adjustable and replaceable Nylatron pads. Telescopic cylinders with integral holding valves. Maximum tip height 42.5 m (139 ft 5 in).
Non telescopic offsettable Swingaway extension	10.00 m (32 ft 10 in) lattice Swingaway extension, offsettable at 2°, 15°, or 30°. Stows alongside base boom section when not in use. Maximum tip height 52.5 m (172 ft 3 in).
Optional *telescopic offsettable Swingaway extension	10.00 to 14.60 m or 17.70 m (32 ft 10 in to 48 ft or 58 ft) Swingaway extension with a rectangular roller mounted section which extends/retracts from within the 10.00 m (32 ft 10 in) lattice extension. Offsettable 2°, 15° or 30°. Stows alongside base boom section when not in use. Maximum tip height 60.00 m (196 ft 10 in).
Boom nose	Six sheaves, mounted on heavy duty tapered roller bearings. Removable pin-type rope guards.
Optional *auxiliary boom nose	Pin-mounted, removable auxiliary boom nose for single line lifting.
Boom elevation	Single hydraulic cylinder with integral holding valve provides elevation from -3° to +80°.
Load-moment indicator and anti-two block system	Audio visual type warning with control lever lockout.
Cab	Aluminium, acoustically treated, fully enclosed with safety glass, hinged skylight with electric wiper, windscreen wiper, horn, heater, air circulation fan, crane level indicator, lockable sliding door, instrumentation, pilot type crane controls and travel controls.
Swing	Ball-bearing swing circle with 360° continuous rotation, Planetary gearbox with Glideswing, spring-applied multi-disc foot brake and holding brake. Plunger-type house lock operated from the cab. Maximum speed 2.0 rpm.
Counterweight	5200 kg (11,465 lb) counterweight including 1100 kg (2,425 lb) in lieu of auxiliary hoist. Hydraulic removal system. *Optional 7200 kg (15,875 lb) additional counterweight to give a total of 12,400 kg (27,340 lb).
Engine	Deutz BF6L913C six-cylinder turbocharged, air-cooled diesel, 6.1 litres. 141 kw (192 hp) at 2500 rpm. Maximum torque 600 Nm (442 lb ft) at 1700 rpm. Fuel tank capacity 226 litres (60 US gallons)
Electrical system	24 V (including starting).

HYDRAULIC SYSTEM

Pumps	Four main gear pumps, combined capacity 518 litres/minute (153 US gallons/minute). Maximum pressure 245 kg/cm ² (3500 psi).
Valves	Precision, four-way, double-acting pilot-operated control valves with four individual valve banks, permitting simultaneous control of multiple crane functions.
Filters	Return line filter with 25 micron rated replaceable cartridge and filter service indicator. Three pressure line filters with 10 micron rated replaceable elements.
Reservoir	864 litres (228 US gallons) capacity. Internal baffles, particle magnet, clean out access and exterior oil level gauge.
Oil cooler	Thermostatically controlled, electric motor driven fan.
Pressure check panel	System pressure test panel with quick-release couplings.
HOIST SPECIFICATIONS	Variable displacement axial piston motor with two position control, driving through planetary gear reduction with integral spring-applied brake provides high line pull and speed ranges. Electronic hoist-drum rotation indicator over lower limit switch.

	Main hoist		*Auxiliary hoist	
	Low Range	High Range	Low Range	High Range
Maximum single line speed				
Bottom layer	58 m/min (190 fpm)	100 m/min (328 fpm)	51 m/min (167 fpm)	120 m/min (394 fpm)
Intermediate layer	66 m/min (216 fpm)	112 m/min (367 fpm)	57 m/min (187 fpm)	135 m/min (443 fpm)
Top layer	73 m/min (239 fpm)	124 m/min (406 fpm)	63 m/min (207 fpm)	149 m/min (489 fpm)
Maximum single line pull				
Bottom layer	12,000 kg (26,460 lb)	4000 kg (8820 lb)	7000 kg (15,435 lb)	3300 kg (7277 lb)
Intermediate layer	10,700 kg (23,594 lb)	3570 kg (7872 lb)	6250 kg (13,781 lb)	2900 kg (6395 lb)
Top layer	9640 kg (21,256 lb)	3220 kg (7100 lb)	5700 kg (12,569 lb)	2700 kg (5954 lb)
Maximum permissible line pull	9250 kg (20,400 lb)		5500 kg (12,125 lb)	
Maximum rope stowage	272 m x 25 mm (892 ft x 1 in)		259 m x 19 mm (850 ft x 3/4 in)	
Standard rope supplied	250 m x 25 mm (820 ft x 1 in)		230 m x 19 mm (755 ft x 3/4 in)	

*Indicates optional item.

Carrier specifications

WHC-SD-LL-DA-038
Rev. 0

Frame	High-strength alloy steel, all-welded box section design with integral outrigger housings and incorporating towing/lie down bracket.	Suspension	Integral hydrogas suspension all round. Hydraulic lockout and automatic levelling system operated from cab.
Outrigger system	Two stage, hydraulic telescopic beam and jack outriggers with integral holding valves. Quick-release outrigger floats 715 mm (28 in) diameter.	Brakes	Dual-line air system operating on all wheels. Spring-applied air-released park brake acting on three rear axles. Engine exhaust brake.
Outrigger controls	Located in the superstructure cab and on both sides of the carrier frame. Push-button electric controls requiring two-handed operation for safety. Crane level indicator adjacent to each set of controls.	Tyres	16.00 x 25 on-off highway radials all round. Tyre inflation kit. Optional *20.50 x 25 on-off highway radials
Engine	Deutz BF10L513, 10-cylinder, turbocharged air-cooled diesel with cold start aid. 16 litres, 294 kw (400 hp) at 2300 rpm. Maximum torque 1460 Nm (1076 lb ft) at 1500 rpm.	Lights	Full lighting including head, tail, braking, reversing, fog, directional and hazard warning lights.
Fuel tank capacity	432 litres (114 US gallons).	Cab	Aluminium with safety glass, acoustically treated, two man, left-hand drive, windscreen wipers and washers, heater and demister, mirrors, full instrumentation and travel controls. Tachograph.
Electrical system	24 v (including starting).	Maximum speed	70 kph (43 mph).
Drive	10 x 4 on-highway, 10 x 8 off-highway, selected from cab.	Gross vehicle weight and axle loads	Machine to standard specification plus *telescopic Swingaway and 5200 kg (11,465 lb) of counterweight. Axle 1: 12,000 kg (26,455 lb) Axle 2: 12,000 kg (26,455 lb) Axle 3: 12,000 kg (26,455 lb) Axle 4: 12,000 kg (26,455 lb) Axle 5: 12,000 kg (26,455 lb) GVW: 60,000 kg (132,275 lb) — *
Steering	Power assisted, semi-integral type on axles. 1, 2, 4 and 5. Steering linkage disconnects to give independent steering of rear axles, and axle 3 raises to allow for co-ordinated or crab steering modes.	Optional *equipment	Superstructure * Auxiliary hoist * Spotlights * Rotating beacon * Hookblocks Carrier * Spare wheel assembly, stowage and handling system * Rotating beacons * Hookblock stowage
Transmission	Engine mounted torque converter and mid-mounted powershift gearbox with front wheel drive disconnect. Eight forward and four reverse speeds.		
Axles	1: Drive-steer 2: Drive-steer 3: Non-drive, non-steer 4: Drive-steer 5: Drive-steer All drive axles are of planetary reduction type, with cross differential locks.		

*Indicates optional equipment.

65 psi
20.5" width
25" Rim

ATT100

WHC-SD-LL-DA-038
Rev. 0

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Constant improvement and engineering progress make it necessary that the company reserves the right to make specification, equipment and price changes without notice. Illustrations shown may include optional equipment and accessories and may not include all standard equipment. Optional equipment is designated by (*) in specifications (if order).

Two Cokes Limited Registered in England No 1845128 Registered Office Crown Works Sunderland England S74 6TT

Specification No. GR1 100/0389/10M Printed in England CSA3070

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APPENDIX B
Material Properties

MATERIAL PROPERTIES

f_c' (compressive strength) = 4,500 psi
MR (modulus of rupture) = $9\sqrt{f_c'}$ = $9\sqrt{4500}$ = 604 psi
Vu (shear strength) = $.27 \cdot MR$ = 163 psi
Fa (bearing strength) = $2.1 \cdot MR$ = 1268.4 psi

Young's modulus = $57,000 \sqrt{f_c'}$ = $57000 \sqrt{4500}$ = 3,800,000 psi
Poisson's ratio = 0.15

Safety Factor = 2

allowable tensile stress = $604/2$ = 302 psi
allowable shear stress = 81.5 psi
allowable bearing stress = 634 psi

References:

Drawing H-6-979
Packard 1976
Spears 1978

APPENDIX C
Bearing and Shear Stress Checks

BEARING AND SHEAR CHECKS

Loads are from Section 3 and 4

Bearing stress checks (neglect foundation stiffness)

concentrated load= 12,000 lbs, load area=20 sq. in.
 $f_a = 12,000/20 = 600 \text{ psi} < 634 \text{ psi}$ ok

uniform line load= 5,000 lb/ft, load width = 0.7 inches
 $f_a = 5,000/12/0.7 = 595 \text{ psi} < 634 \text{ psi}$ ok

4 by 4 foot outrigger pad load = 49,700 lb
 $f_a = 49700/4/4/144 = 19.1 \text{ psi} < 634 \text{ psi}$ ok

2 by 2 foot outrigger pad load = 29,000 lb
 $f_a = 29,000/2/2/144 = 26 \text{ psi} < 634 \text{ psi}$ ok

1 by 1 foot pad load = 4,500 lbs
 $f_a = 4,500/144 = 31 \text{ psi} < 634 \text{ psi}$ ok

distributed load of 1,400 lb/sq. ft causes low bearing stresses

Shear stress checks

concentrated load= 12,000 lbs, load side, $s = 0$ in.
 $f_a = 12,000/(s+s+7.5+7.5)/15 = 53.3 \text{ psi} < 81.5 \text{ psi}$ ok

uniform line load= 5,000 lb/ft, load width = 0.7 inches
 $f_a = 5,000/(12+7.5+7.5)/15 = 12.3 \text{ psi} < 81.5 \text{ psi}$ ok

4 by 4 foot outrigger pad load = 49,700 lb
 $f_a = 49,700/(48+48+7.5+7.5)/15 = 29.8 \text{ psi} < 81.5 \text{ psi}$ ok

2 by 2 foot outrigger pad load = 29,000 lb
 $f_a = 29,000/(24+24+7.5+7.5)/15 = 30.7 \text{ psi} < 81.5 \text{ psi}$ ok

1 by 1 foot pad load = 5,760 lbs
 $f_a = 4,500/(12+12+7.5+7.5)/15 = 7.7 \text{ psi} < 81.5 \text{ psi}$ ok

distributed load of 1,700 lbs/ sq. ft causes low shear stresses

APPENDIX D

ANSYS Verification Model

Displacement

$w = 1.9 \text{ in/ft}^2$
 LOAD length
 along entire
 slab width

SLAB WITH CENTER LOAD

ANSYS 5.0 A
 SEP 6 1994
 14:05:24
 PLOT NO. 4
 NODAL SOLUTION
 STEP=1
 SUB =1
 TIME=1
 UZ
 TOP
 RSYS=0
 DMX =0.055514
 SEPC=3.809
 SMN =-0.055514
 SMX =0.002486
 -0.055514
 -0.04907
 -0.042625
 -0.036181
 -0.029736
 -0.023292
 -0.016847
 -0.010403
 -0.003959
 0.002486

Plate with center strip load of 1.9 K/ft^2 ,
 load length = 30 ft, load width = 6 feet
 $K = 100 \text{ pci}$
 $E = 3.8 \times 10^6 \text{ psi}$
 $\nu = 0$
 $t = 15''$

1

STRESS

SLAB WITH CENTER LOAD

ANSYS 5.0 A
SEP 6 1994
14:04:31
PLOT NO. 3
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SX (NOAVG)
TOP
RSYS=0
DMX =0.055514
SMN =-315.822
SMNB=-318.769
SMX =99.303
SMXB=99.762
-315.822
-269.697
-223.572
-177.447
-131.322
-85.197
-39.072
7.053
53.178
99.303

D-3

WHC-SD-LL-DA-038
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APPENDIX E

De/Caase Verification Model

DE/CAASE Version 4.0.9
Module B-5: Beams on Elastic Foundations - Finite Length
Desktop Engineering Int'l Inc.
Copyright (C) 1985-1993 (All Rights Reserved)
Date: Sep 6 1994 Time: 12:30:23

LOADING CONDITION: TYPE 2 - UNIFORMLY DISTRIBUTED LOAD

BOUNDARY CONDITION: TYPE 6 - FREE / FREE

INPUT DATA:

L = 6.0000E+01
X = 2.7000E+01
X1 = 3.3000E+01
E = 5.4720E+05
I = 4.8830E+00
K = 5.1840E+03
W = 5.7000E+01

Beam Length = 60 ft
Beam width = 30 ft
L = 60 feet
 $W = 57 \text{ Kips/foot} = (1.9 \text{ Kips/ft}^2) \cdot (30 \text{ ft})$
 $K = (100 \frac{\text{lb}}{\text{in}^2}) / \text{in} = \frac{100 \text{ lb} \cdot (30 \text{ ft})}{\text{in}^3} \frac{1728 \text{ in}^3}{\text{ft}^3}$
 $K = (5184 \text{ Kips/ft}) / \text{ft deflection}$

* * * RESULTS * * *

REACTIONS/END CONDITIONS:

Va = 0.0000E+00 Ma = 0.0000E+00 ya = 7.3217E-05
Vb = 1.0170E-13 Mb = -3.9293E-12 yb = 7.3217E-05

MAXIMUM (+ OR -) FORCES AND DEFLECTIONS:

	SHEAR (kip)	MOMENT (kip-ft)	DEFLECTION (ft)
MAXIMUM ==>	1.0185E+02	3.5707E+02	-4.6383E-03
LOCATION ==>	2.7000E+01	3.0000E+01	3.0000E+01

FORCES AND DEFLECTIONS:

LOCATION	SHEAR	MOMENT	DEFLECTION
0.0000E+00	0.0000E+00	0.0000E+00	7.3217E-05
1.2000E+00	-5.3474E-01	-3.0499E-01	9.8694E-05
2.4000E+00	-1.2275E+00	-1.3466E+00	1.2397E-04
3.6000E+00	-2.0756E+00	-3.3133E+00	1.4849E-04
4.8000E+00	-3.0712E+00	-6.3872E+00	1.7117E-04
6.0000E+00	-4.1980E+00	-1.0737E+01	1.9034E-04
7.2000E+00	-5.4273E+00	-1.6504E+01	2.0367E-04
8.4000E+00	-6.7135E+00	-2.3785E+01	2.0804E-04
9.6000E+00	-7.9890E+00	-3.2612E+01	1.9952E-04
1.0800E+01	-9.1592E+00	-4.2917E+01	1.7335E-04
1.2000E+01	-1.0098E+01	-5.4502E+01	1.2400E-04
1.3200E+01	-1.0641E+01	-6.6994E+01	4.5233E-05
1.4400E+01	-1.0586E+01	-7.9801E+01	-6.9652E-05
1.5600E+01	-9.6853E+00	-9.2062E+01	-2.2752E-04
1.6800E+01	-7.6521E+00	-1.0259E+02	-4.3493E-04
1.8000E+01	-4.1596E+00	-1.0984E+02	-6.9748E-04
1.9200E+01	1.1481E+00	-1.1185E+02	-1.0190E-03
2.0400E+01	8.6428E+00	-1.0621E+02	-1.4004E-03
2.1600E+01	1.8690E+01	-9.0086E+01	-1.8387E-03
2.2800E+01	3.1619E+01	-6.0204E+01	-2.3248E-03
2.4000E+01	4.7681E+01	-1.2947E+01	-2.8426E-03
2.5200E+01	6.6999E+01	5.5535E+01	-3.3665E-03
2.6400E+01	8.9502E+01	1.4913E+02	-3.8593E-03
2.7000E+01	1.0185E+02	2.0650E+02	-4.0788E-03

2.7600E+01	8.0646E+01	2.6122E+02	-4.2705E-03
2.8800E+01	3.9744E+01	3.3328E+02	-4.5431E-03
3.0000E+01	1.3133E-13	3.5707E+02	-4.6383E-03
3.1200E+01	-3.9744E+01	3.3328E+02	-4.5431E-03
3.2400E+01	-8.0646E+01	2.6122E+02	-4.2705E-03
3.3000E+01	-1.0185E+02	2.0650E+02	-4.0788E-03
3.3600E+01	-8.9502E+01	1.4913E+02	-3.8593E-03
3.4800E+01	-6.6999E+01	5.5535E+01	-3.3665E-03
3.6000E+01	-4.7681E+01	-1.2947E+01	-2.8426E-03
3.7200E+01	-3.1619E+01	-6.0204E+01	-2.3248E-03
3.8400E+01	-1.8690E+01	-9.0086E+01	-1.8387E-03
3.9600E+01	-8.6428E+00	-1.0621E+02	-1.4004E-03
4.0800E+01	-1.1481E+00	-1.1185E+02	-1.0190E-03
4.2000E+01	4.1596E+00	-1.0984E+02	-6.9748E-04
4.3200E+01	7.6521E+00	-1.0259E+02	-4.3493E-04
4.4400E+01	9.6853E+00	-9.2062E+01	-2.2752E-04
4.5600E+01	1.0586E+01	-7.9801E+01	-6.9652E-05
4.6800E+01	1.0641E+01	-6.6994E+01	4.5233E-05
4.8000E+01	1.0098E+01	-5.4502E+01	1.2400E-04
4.9200E+01	9.1592E+00	-4.2917E+01	1.7335E-04
5.0400E+01	7.9890E+00	-3.2612E+01	1.9952E-04
5.1600E+01	6.7135E+00	-2.3785E+01	2.0804E-04
5.2800E+01	5.4273E+00	-1.6504E+01	2.0367E-04
5.4000E+01	4.1980E+00	-1.0737E+01	1.9034E-04
5.5200E+01	3.0712E+00	-6.3872E+00	1.7117E-04
5.6400E+01	2.0756E+00	-3.3133E+00	1.4849E-04
5.7600E+01	1.2275E+00	-1.3466E+00	1.2397E-04
5.8800E+01	5.3474E-01	-3.0499E-01	9.8694E-05
6.0000E+01	-1.0170E-13	-3.9293E-12	7.3217E-05

NOTES:

1. MAXIMUM (+ OR -) indicates that the value shown is the largest signed value of the absolute values of a set of real numbers

DE/CADSE Module B-5: Beams on Elastic Foundations - Finite Length

File A:Property B:Beams C:Frames D:Plates E:Frequency F:Stress G:Cables H:Utility Help

	Input Data
L	60
x	27
x1	33
w	57
E	547200
I	4.883
k	5184

Reference Figure

Enter Input Data and Solve

Redo Cancel Restart Close

Default input data can be set

Solve Defaults Help

E-5

APPENDIX F
Finite Element Load Cases

awb 9/23/04

This appendix presents the finite element stress results for the following load cases:

laydown pad storage loads
concentrated load
uniform line load
uniformly distributed load
4 ft by 4 ft pad load
2 ft by 2 ft pad load
1 ft by 1 ft pad load

crane outrigger loads
4 ft by 4 ft pad load
2 ft by 2 ft pad load

The load placement and geometry was selected to maximize the slab stress. Various load cases were run. The various load cases were selected based on engineering judgement and experience gained from evaluating the finite element solutions. The following load summary is a result of the finite element analyses that were run:

- 1) concentrated load = 12,000 lb at a clear distance spacing of 5 feet
max stress= 307.35 psi close to 302 psi allowable therefore ok
- 2) uniform line load= 5320 lb/ft at a clear distance spacing of 5 feet
max stress=312.27 psi

*reduce line load to 5000 lb/ft,
max stress=312*5000/5320=293 psi <302 psi therefore ok
- 3) uniformly distributed load = 1700 lb/ft/ft
max stress= 362.98 psi

*reduce distributed load to 1400 lb/ft/ft
max stress= 362.98*1400/1700=299 psi <302 psi therefore ok
- 4) 4 ft by 4 ft pad load= 44,000 lb at a clear distance spacing of 4 feet
max stress= 293.6 psi < 302 psi therefore ok
- 5) 2 ft by 2 ft pad load= 15,000 lb at a clear distance spacing of 2 feet
max stress =270.87 psi < 302 psi therefore ok
- 6) 1 ft by 1 ft pad load= 5,000 lb at a clear distance spacing of 1 feet
max stress= 312.95 psi

*reduce load to 4500 lb
max stress=312.95*4500/5000= 282 psi < 302 psi therefore ok
- 7) 4 ft by 4 ft pad outrigger load= 49,652 lb
max stress=306 psi close to 302 psi therefore ok
- 8) 2 ft by 2 ft pad outrigger load= 29,000 lb
max stress=303 psi close to 302 psi therefore ok

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/BATCH
/PREP7
K,,0,0,0
K,,720,0,0
K,,720,360,0
K,,0,360,0
A,P50X, 4

60' x 30'
Slab model

1
2
3
4
ESIZE,12
MAT,1
REAL,1
TYPE,1
ET,1,63
R,1,15
R,1,15,,,,,100
MP,EX,1,3800000
MP,NUXY,1,.15
AMESH,1

soil subgrade modulus stiffness
stiff 63

$t = 15"$, $EF = 100 \text{ lb/in}^3$
 $E = 3.8 \times 10^6 \text{ psi}$
 $\nu = .15$

FINISH
/SOLU
D,P50X,UY,0
1
D,P50X,UY,0
2
D,P50X,UX,0
1
D,P50X,UX,0
92
F,P50X,FZ,-12000
1036
SOLVE
FINISH
/exit

← 12,000 lb vertical load

This loading is only an example
numerous loading cases were run
so as to generate maximum stress
values.

AUSYS 5.0 A
SEP 19 1994
10:25:57
PLOT NO. 2
ELEMENTS
TYPE NUM

F

XV = -0.170
YV = -0.0867
ZV = -1.126
*DIST=458.195
*XF = 364.526
*YF = 174.458
*ZF = -88.756
A-ZS=-13.142
VSCA=2

F-5

12,000 lb concentrated load

ANSYS 5.0 A
SEP 19 1994
10:37:20
PLOT NO. .3
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.004661
SMNB=-0.017412
SMX =116.259
SMXB=124.243
0
12.918
25.835
38.753
51.67
64.588
77.506
90.423
103.341
116.259

F-6

12,000 lb. concentrated load

ANSYS 5.0 A
SEP 19 1994
10:44:29
PLOT NO. 4
ELEMENT SOLUTION
STEP=2
SUB =1
TIME=3
S1 (NOAVG)
BOTTOM
DMX =0.015529
SMNB=-1.36
SMX =247.255
SMXB=272.826

F
0
27.473
54.946
82.418
109.891
137.364
164.837
192.309
219.782
247.255

ANSYS 5.0 A
 SEP 19 1994
 10:55:34
 PLOT NO. 7
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=4
 S1 (NOAVG)
 TOP
 DMX =0.043639
 SMNB=-0.038763
 SMX =166.123
 SMXB=177.475

F
 0
 18.458
 36.916
 55.374
 73.833
 92.291
 110.749
 129.207
 147.665
 166.123

12,000 lb concentrated load

F-8

ANSYS 5.0 A
SEP 19 1994
10:54:29
PLOT NO. 6
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=4
S1 (NOAVG)
BOTTOM
DMX =0.043639
SMNB=-5.874
SMX =143.538
SMXB=154.919

0
15.949
31.897
47.846
63.795
79.743
95.692
111.641
127.589
143.538

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Rev. 0

F-9

12,000 lb concentrated load

ANSYS 5.0 A
 SEP 19 1994
 10:56:26
 PLOT NO. 8
 ELEMENT SOLUTION
 STEP=2
 SUB =1
 TIME=5
 S1 (NOAVG)
 TOP
 DMX =0.037155
 SMNB=-25.555
 SMX =78.449
 SMXB=95.864

F	0
	8.717
	17.432
	26.15
	34.866
	43.582
	52.299
	61.016
	69.732
	78.449

$SMX = 307.353 \text{ psi}$

ANSYS 5.0 A
 SEP 19 1994
 10:57:04
 PLOT NO. 9
 ELEMENT SOLUTION
 STEP=2
 SUB =1
 TIME=5
 S1 (NOAVG)
 BOTTOM
 DMX =0.037155
 SMNB=-2.496
 SMX =281.798
 SMXB=307.353

F	
0	
31.311	
62.622	
93.933	
125.244	
156.555	
187.866	
219.176	
250.487	
281.798	

ANSYS 5.0 A
SEP 19 1994
13:59:48
PLOT NO. 1
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SI
BOTTOM (NOAVG)
DMX =0.052115
SMNB=-3.575
SMX =278.112
SMXB=303.524
F

0
30.901
61.803
92.704
123.605
154.507
185.408
216.309
247.211
278.112

12,000 lb concentrated load

ANSYS 5.0 A
SEP 19 1994
14:03:11
PLOT NO. 2
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SI
BOTOM
DMX =0.051251
SMNB=-5.163
SMX =279.422
SMXB=304.895
F
0
31.047
62.094
93.141
124.188
155.234
186.281
217.328
248.375
279.422

12,000 lb concentrated load

ANSYS 5.0 A
SEP 19 1994
11:23:39
PLOT NO. 1
ELEMENTS
TYPE NUM
1

XV =-0.1702
YV =-0.0867
ZV =-1.326
DIST=458.195
*XF =364.526
*YF =174.458
*ZF =-88.756
A-ZS=-13.142
VSCA=2

5320 lb/ft line load

F-14

5320 lbf/ft line load

ANSYS 5.0 A
SEP 19 1994
11:33:50
PLOT NO. 3
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=4
S1 (NOAVG)
TOP
DMX =0.031548
SMNB=-12.438
SMX =57.748
SMXB=58.876

F
0
6.416
12.833
19.249
25.666
32.082
38.499
44.915
51.331
57.748

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5320 lb/ft Line Load

ANSYS 5.0 A
SEP 19 1994
11:33:08
PLOT NO. 2
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=4
S1 (NOAVG)
BOTTOM
DMX =0.031548
SMNB=-3.858
SMX =293.579
SMXB=305.845

F
0
32.62
65.24
97.86
130.48
163.1
195.719
228.339
260.959
293.579

ANSYS 5.4 A
SEP 19 1994
11:36:53
PLOT NO. 4
ELEMENTS
TYPE NUM
F

XV = -0.5170
YV = -0.9867
ZV = -1.126
*DIST=458.195
*XF = 364.526
*YF = 174.458
*ZF = -88.756
A-ZS=-13.142
VSCA=2

5426 lb/ft line load

ANSYS 5.0 A
 SEP 19 1994
 11:39:58
 PLOT NO. 6
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=4
 S1 (NOAVG)
 BOTTOM
 DMX =0.073713
 SMNB=-8.138
 SMX =302.265
 SMXB=312.273

F
 0
 33.585
 67.17
 100.755
 134.34
 167.925
 201.51
 235.095
 268.68
 302.265

σ_{max} = 312.273 psi

5320 lb/ft line load

F-18

5320 lb/ft line load

ANSYS 5.0 A
SEP 19 1994
11:40:34
PLOT NO. 7
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=4
S1 (NOAVG)
TOP
DMX =0.073713
SMNE=-13.199
SMX =124.586
SMXB=126.805

F	
0	13.843
13.843	27.686
27.686	41.529
41.529	55.372
55.372	69.215
69.215	83.057
83.057	96.9
96.9	110.743
110.743	124.586

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uniform load of 1700lb/sq. ft

ANSYS 5.0 A
SEP 19 1994
11:59:52
PLOT NO. 1
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=4
S1 (NOAVG)
BOTTOM
DMX =0.001998
SMNB=-0.165605
SMX =19.815
SMXB=27.34
PRES
0
2.202
4.403
6.605
8.807
11.008
13.21
15.412
17.614
19.815

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Rev. 0

uniform load of 1700lb/sq. ft

ANSYS 5.0
 SEP 19 1994
 12:05:59
 PLOT NO. 2
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=4
 S1 (NOAVG)
 BOTTOM
 DMX =0.027422
 SMNB=-2.687
 SMX =185.097
 SMXB=189.579
 PRES
 0
 20.566
 41.132
 61.699
 82.266
 102.832
 123.398
 143.965
 164.531
 185.097

uniform load of 1700lb/sq. ft

ANSYS 5.0 A
SEP 19 1994
12:11:27
PLOT NO. 3
ELEMENTS
TYPE NUM
PRES

XV = -0.51702
YV = -0.98675
ZV = -1.326
DIST=414.922
XF = 360
YF = 180
A-ZS=-13.142
VSCA=2

uniform load of 1/001b/sq. ft

ANSYS 5.0 A
 SEP 19 1994
 12:12:21
 PLOT NO. 4
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NOAVG)
 BOTTOM
 DMX =0.060617
 SMNB=-5.501
 SMX =314.961
 SMXB=319.797
 0
 34.996
 69.991
 104.987
 139.983
 174.978
 209.974
 244.97
 279.966
 314.961

uniform load of 1700lb/sq. ft

ANSYS 5.0 A
 SEP 19 1994
 12:12:58
 PLOT NO. 5
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NCAVG)
 BOTTOM
 DMX =0.060617
 SMNB=-5.501
 SMX =314.961
 SMXB=319.797
 PRES

0
34.996
69.991
104.987
139.983
174.978
209.974
244.97
279.966
314.961

F-24

uniform load of 1700lb/sq. ft

ANSYS 5.4 A
SEP 19 1994
12:15:19
PLOT NO. 6
ELEMENTS
TYPE NUM
PRES

XV =-0.1700
YV =-0.9867
ZV =-1.326
DIST=414.922
XF =360
YF =180
A-ZS=-13.142
VSCA=2

WHC-SD-LL-DA-038
Rev. 0

uniform load of 1700lb/sq. ft

ANSYS 5.0 A
 SEP 19 1994
 12:17:43
 PLOT NO. 7
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NOAVG)
 BOTTOM
 DMX =0.093572
 SMNB=-7.815
 SMX =343.711
 SMXB=348.213
 0
 38.19
 76.38
 114.57
 152.761
 190.951
 229.141
 267.331
 305.521
 343.711

uniform load of 1700lb/sq. ft

ANSYS 5.0 A
 SEP 19 1994
 12:25:17
 PLOT NO. 10
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NOAVG)
 BOTTOM
 DMX =0.107612
 SMNB=-8.766
 SMX =318.671
 SMXB=322.621
 PRES

0
35.408
70.816
106.224
141.631
177.039
212.447
247.855
283.263
318.671

ANSYS 5.0 A
 SEP 19 1994
 12:19:30
 PLOT NO. 9
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NOAVG)
 TOP
 DMX =0.093572
 SMNB=-11.434
 SMX =154.096
 SMXB=156.222
 PRES
 0
 17.122
 34.244
 51.365
 68.487
 85.609
 102.731
 119.853
 136.975
 154.096

uniform load of 1700lb/sq. ft

uniform load of 1700lb/sq. ft

ANSYS 5.0 A
 SEP 19 1994
 12:54:30
 PLOT NO. 1
 NODAL SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (AVG)
 BOTTOM
 DMX =0.01981
 SMNB=-1.704
 SMX =71.537
 SMXB=77.439
 PRES

	0
	7.949
	15.897
	23.846
	31.794
	39.743
	47.691
	55.64
	63.588
	71.537

ANSYS 5.0 A
SEP 19 1994
13:10:38
PLOT NO. 3
ELEMENTS
TYPE NUM
PREC:

XV =-0.482767
YV =1.025
ZV =-1.31
*DIST=458.195
*XF =360
*YF =180
A-ZS=9.139
VSCA=2

uniform load of 1700lb/sq. ft

ANSYS 5.0 A
SEP 19 1994
13:10:20
PLOT NO. 2
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.080848
SMNB=-9.554
SMX =338.213
SMXB=347.758
PRES

0
37.579
75.158
112.738
150.317
187.896
225.475
263.054
300.633
338.213

uniform load of 1760lb/sq. ft

ANSYS 5.0 A
SEP 19 1994
13:21:56
PLOT NO. 6
ELEMENTS
TYPE NUM
PRES

XV =-0.153E-10
YV =0
ZV =-1
*DIST=458.195
*XF =360
*YF =180
A-ZS=-180
VSCA=2

Load 1

uniform load of 1700lb/sq. ft

ANSYS 5.0 A
SEP 19 1994
13:19:08
PLOT NO. 4
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.109259
SMNB=-6.285
SMX =359.8
SMXB=362.982
PRES
0
39.978
79.955
119.933
159.911
199.889
239.866
279.844
319.822
359.8

Index = 362.982

11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840. 841. 842. 843. 844. 845. 846. 847. 848. 849. 850. 851. 852. 853. 854. 855. 856. 857. 858. 859. 860. 861. 862. 863. 864. 865. 866. 867. 868. 869. 870. 871. 872. 873. 874. 875. 876. 877. 878. 879. 880. 881. 882. 883. 884. 885. 886. 887. 888. 889. 890. 891. 892. 893. 894. 895. 896. 897. 898. 899. 900. 901. 902. 903. 904. 905. 906. 907. 908. 909. 910. 911. 912. 913. 914. 915. 916. 917. 918. 919. 920. 921. 922. 923. 924. 925. 926. 927. 928. 929. 930. 931. 932. 933. 934. 935. 936. 937. 938. 939. 940. 941. 942. 943. 944. 945. 946. 947. 948. 949. 950. 951. 952. 953. 954. 955. 956. 957. 958. 959. 960. 961. 962. 963. 964. 965. 966. 967. 968. 969. 970. 971. 972. 973. 974. 975. 976. 977. 978. 979. 980. 981. 982. 983. 984. 985. 986. 987. 988. 989. 990. 991. 992. 993. 994. 995. 996. 997. 998. 999. 1000.

max. stress = 1000 lb/sq. ft

uniform load of 1700lb/sq. ft

ANSYS 5.0 A
SEP 19 1994
13:19:59
PLOT NO. 5
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
TOP
DMX =0.109259
SMNB=-11.363
SMX =137.92
SMXB=140.587
PRES

0
15.324
30.649
45.973
61.298
76.622
91.947
107.271
122.596
137.92

uniform load of 1700lb/sq. ft

F-34

1400 lb/sq. ft. uniform load

ANSYS 5.0 A
SEP 20 1994
15:18:12
PLOT NO. 1,
ELEMENTS
TYPE NUM
PRES

XV =0.679E 12
YV =-0.087156
ZV =-0.996195
*DIST=396.00?
*XF =360
*YF =180
A-ZS=-180
CENTROID HIDDEN

WHC-SD-LL-DA-038
Rev. 0

ANSYS 5.0 A
SEP 20 1994
15:17:29
PLOT NO. 14
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.089666
SMNB=-5.987
SMX =296.066
SMXB=298.729
PRES

0
32.896
65.793
98.689
131.585
164.481
197.378
230.274
263.17
296.066

J400 lb/sq. ft. uniform load

ANSYS 5.0 A
SEP 20 1994
15:11:11
PLANT NO. 13
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.064455
SMNB=-7.407
SMX =282.273
SMXB=285.218
PRES

0
31.364
62.727
94.091
125.454
156.818
188.182
219.545
250.909
282.273

1400 lb/sq. ft. uniform load

ANSYS 5.0 A
SEP 20 1994
10:19:49
PLOT NO. 2
ELEMENTS
TYPE NUM
PRES

XV =0.5
YV =0.4301
ZV =-0.75
*DIST=458.191
*XF =360
*YF =180
A-ZS=163.898
VSCA=2

*p = 44,000 : 14011872
444444*

4ft by 4ft 44,000 lb pad load

F-38

4ft by 4ft 44,000 lb pad load

ANSYS 5.0 A
SEP 20 1994
10:25:39
PLOT NO. 4
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
TOP
DMX =0.091902
SMNB=-12.535
SMX =212.993
SMXB=221.383
PRES
0
23.666
47.332
70.998
94.664
118.33
141.996
165.661
189.327
212.993

WHC-SD-LL-DA-038
Rev. 0

F-39

4ft by 4ft 44,000 lb pad load

ANSYS 5.0 A
SEP 20 1994
10:28:36
PLOT NO. 5
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.091902
SMNB=-9.448
SMX =264.939
SMXB=276.991
PEES
0
29.438
58.875
88.313
117.751
147.188
176.626
206.063
235.501
264.939

F-40

spaced at
5' intervals

4ft by 4ft 44,000 lb pad load

ANSYS 5.0 A
SEP 20 1994
10:39:12
PLOT NO. 6
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.062183
SMNB=-6.464
SMX =217.809
SMXB=225.611
PRES

0
24.201
48.402
72.603
96.804
121.005
145.206
169.407
193.608
217.809

WHC-SD-LL-DA-038
Rev. 0

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ANSYS 5.0 A
SEP 20 1994
10:54:12
PLOT NO. 7
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.044038
SMNB=-5.874
SMX =271.738
SMXB=282.593
PRES
0
30.193
60.386
90.579
120.772
150.966
181.159
211.352
241.545
271.738

WHC-SD-LL-DA-038
Rev. 0

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4ft by 4ft 44,000 lb pad load

ANSYS 5.0 A
SEP 20 1994
10:55:07
PLOT NO. 8
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
TOP
DMX =0.044038
SMNB=-12.553
SMX =105.781
SMXB=107.151
PRES

0
11.753
23.507
35.26
47.014
58.767
70.521
82.274
94.028
105.781

WHC-SD-LL-DA-038
Rev. 0

ANSYS 5.0 A
SEP 20 1994
11:53:43
PLANT NO. 22
ELEMENTS
TYPE NUM
PRES

XV =0.5
YV =0.43301
ZV =-0.75
*DIST=458.191
*XF =360
*YF =180
A-ZS=163.898
VSCA=2

*speed up
clear it up*

4ft by 4ft 44,000 pad load

F-44

4ft by 4ft 44,000 pad load

ANSYS 5.0 A
SEP 20 1994
11:54:44
PLOT NO. 23
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.065908
SMNB=-9.339
SMX =230.559
SMXB=237.376
PRES
0
25.618
51.235
76.853
102.471
128.088
153.706
179.324
204.941
230.559

WHC-SD-LL-DA-038
Rev. 0

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4ft by 4ft 44,000 pad load

ANSYS 5.0 A
SEP 20 1994
12:03:21
PLOT NO. 24
ELEMENTS
TYPE NUM
PRES

XV =0.5
YV =0.433014
ZV =-0.75
*DIST=458.191
*XF =360
*YF =180
A-ZS=163.898
VSCA=2

ANSYS 5.0 A
SEP 20 1994
12:04:05
PLOT NO. 25
ELEMENT SOLUTION
STEP=3
SUB =1
TIME=3
S1 (NOAVG)
BOTTOM
DMX =0.042168
SMNB=-5.744
SMX =284.334
SMXB=293.613
PRES
0
31.593
63.185
94.778
126.371
157.963
189.556
221.149
252.741
284.334

SMXB = 293.613

4ft by 4ft 44,000 pad load

ANSYS 5.0 A
 SEP 20 1994
 11:18:38
 PLOT NO. 13
 ELEMENTS
 TYPE NUM
 PRES

XV =0.5
 YV =0.43301;
 ZV =-0.75
 *DIST=458.191
 *XF =360
 *YF =180
 A-ZS=163.898
 VSCA=2

Stress at 2'
 clear depth

F-47

$$P = \frac{20,000}{2 \times 2} = 2,500 \text{ psi}$$

2ft by 2ft 20,000 pad load

F-48

2ft by 2ft 20,000 pad load

ANSYS 5.0 A
 SEP 20 1994
 11:22:19
 PLOT NO. 14
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NOAVG)
 BOTTOM
 DMX =0.058782
 SMNB=-8.277
 SMX =262.01
 SMXB=279.366
 PRES

0
29.112
58.224
87.337
116.449
145.561
174.673
203.785
232.898
262.01

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2ft by 2ft 20,000 pad load

ANSYS 5.0 A
SEP 20 1994
11:26:25
PLOT NO. 15
ELEMENTS
TYPE NUM
PRES

XV =0.5
YV =0.433014
ZV =-0.75
*DIST=458.191
*XF =360
*YF =180
A-ZS=163.898
VSCA=2

ANSYS 5.0 A
SEP 20 1994
11:34:14
PLOT NO. 16
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.085857
SMNB=-7.91
SMX =329.444
SMXB=346.805
0
36.605
73.21
109.815
146.42
183.025
219.629
256.234
292.839
329.444

2ft by 2ft 20,000 pad load

ANSYS 5.0 A
SEP 20 1994
11:11:45
PLOT NO. 11
ELEMENTS
TYPE NUM
PRIN

XV = 0.5
YV = 0.4301
ZV = -0.75
*DIST=458.191
*XF = 360
*YF = 180
A-ZS=163.898
VSCA=2

2' C (18)
P (18)

$P = 15,000 \cdot 26.04$
 2.140

2ft by 2ft 15,000 lb pad load

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21ft by 21ft 15,000 lb pad load

ANSYS 5.0 A
SEP 20 1991
11:16:35
PLOT NO. 12
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.044097
SMNB=-6.209
SMX =196.556
SMXB=209.577
PRES
0
21.84
43.679
65.519
87.358
109.198
131.038
152.877
174.717
196.556

F-53

2ft by 2ft 15,000 pad load

ANSYS 5.0 A
SEP 20 1994
11:42:36
PLOT NO. 19
ELEMENTS
TYPE NUM
PRES

XV =0.5
YV =0.433014
ZV =-0.75
*DIST=458.191
*XF =360
*YF =180
A-ZS=163.898
VSCA=2

F-54

$\sigma_{max} = 270.877 \text{ psi}$

21ft by 21ft 15,000 pad load

ANSYS 5.0 A
SEP 20 1994
11:44:55
PLOT NO. 21
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.066365
SMNB=-7.019
SMX =257.856
SMXB=270.877
PRES
0
28.651
57.301
85.952
114.603
143.253
171.904
200.555
229.205
257.856

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1ft by 1ft 5,000 lb pad load

ANSYS 5.0 A
SEP 20 1994
14:17:39
PLOT NO. 1
ELEMENTS
TYPE NUM
PRES

XV =0.121157
YV =-0.464795
ZV =-0.87709
*DIST=396.003
*XF =360
*YF =180
A-ZS=-5.887
CENTROID HIDDEN

WMC-SD-LL-DA-038
Rev. 0

F-56

1ft by 1ft 5,000 lb pad load

ANSYS 5.0 A
SEP 20 1994
14:20:03
PLOT NO. 2
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.044343
SMNB=-4.599
SMX =234.715
SMXB=256.846
PRES
0
26.079
52.159
78.238
104.318
130.397
156.477
182.556
208.636
234.715

WHC-SD-LL-DA-038
Rev. 0

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1ft by 1ft 5,000 lb pad load

ANSYS 5.0 A
SEP 20 1994
14:26:12
PLOT NO. 3
ELEMENTS
TYPE NUM
PRES

XV =0.121157
YV =-0.464795
ZV =-0.87709
*DIST=396.003
*XF =360
*YF =180
A-ZS=-5.887
CENTROID HIDDEN

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ANSYS 5.0 A
SEP 20 1994
14:30:08
PLOT NO. 4
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
BOTTOM
DMX =0.065431
SMNB=-7.603
SMX =289.241
SMXB=311.372
PRES
0
32.138
64.276
96.414
128.551
160.689
192.827
224.965
257.103
289.241

ANSYS 5.0 A
SEP 20 1994
14:32:42
PLOT NO. 5
ELEMENTS
TYPE NUM
PRES
XV =0.121157
YV =-0.464795
ZV =-0.87709
*DIST=396.003
*XF =360
*YF =180
A-ZS=-5.887
CENTROID HIDDEN

1ft by 1ft 5,000 lb pad load

1

F-60

1ft by 1ft 5,000 lb pad load

ANSYS 5.0 A
 SEP 20 1994
 14:36:27
 PLOT NO. 6
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NOAVG)
 BOTTOM
 DMX =0.075908
 SMNB=-9.044
 SMX =287.478
 SMXB=309.609
 PRES
 0
 31.942
 63.884
 95.826
 127.768
 159.71
 191.652
 223.594
 255.536
 287.478

MHC-SD-LL-DA-038
 Rev. 0

1

1ft by 1ft 5,000 lb pad load

ANSYS 5.0 A
 SEP 20 1994
 14:45:38
 PLOT NO. 7
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NOAVG)
 BOTTOM
 DMX =0.080495
 SMNB=-7.179
 SMX =267.054
 SMXB=289.185
 PRES

	0
	29.673
	59.345
	89.018
	118.69
	148.363
	178.036
	207.708
	237.381
	267.054

1

1ft by 1ft 5,000 lb pad load

ANSYS 5.0 A
SEP 20 1994
14:50:28
PLOT NO. 9
ELEMENTS
TYPE NUM
PRES

XV =0.121157
YV =-0.464795
ZV =-0.87709
*DIST=396.003
*XF =360
*YF =180
A-ZS=-5.887
CENTROID HIDDEN

F-62

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1

$\sigma_{max} = 312.95 \text{ psi}$

1ft by 1ft 5,000 lb pad load

ANSYS 5.0 A
 SEP 20 1994
 14:53:59
 PLOT NO. 10
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NOAVG)
 BOTTOM
 DMX =0.07054
 SMNB=-6.776
 SMX =290.822
 SMXB=312.953
 PRES

0
32.314
64.627
96.941
129.254
161.568
193.881
226.195
258.509
290.822

F-63

ANSYS 5.0 A
SEP 20 1994
14:58:42
PLOT NO. 11
ELEMENTS
TYPE NUM
PRES

XV =0.121157
YV =-0.464795
ZV =-0.87709
*DIST=396.003
*XF =360
*YF =180
A-ZS=-5.887
CENTROID HIDDEN

1ft by 1ft 5,000 lb pad load

1

1ft by 1ft 5,000 lb pad load

ANSYS 5.0 A
 SEP 20 1994
 15:00:18
 PLOT NO. 12
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NOAVG)
 BOTTOM
 DMX =0.062346
 SMNB=-6.232
 SMX =281.162
 SMXB=303.293
 0
 31.24
 62.48
 93.721
 124.961
 156.201
 187.441
 218.681
 249.922
 281.162

1

$$\delta_{max} = 306 \text{ psi}$$

ANSYS 5.0 A
 SEP 19 1994
 14:25:05
 PLOT NO. 2
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NOAVG)
 BOTTOM
 DMX =0.104701
 SMNB=-9.727
 SMX =291.935
 SMXB=306.139
 PRES

0
32.437
64.874
97.312
129.749
162.186
194.623
227.061
259.498
291.935

$$P = \frac{49652}{4.4 \times 4.4} = 21.55 \text{ psi}$$

49,652 lb outrigger load on a 4ft by 4ft pad

F-66

WHC-SD-LL-DA-038
 Rev. 0

1

$$p_{max} = 303 \text{ psi}$$

$$p = \frac{29,000}{2.2 \times 1.44} = 50.3 \text{ psi}$$

29,000 lb outrigger load on a 2ft by 2ft pad

ANSYS 5.0 A
 SEP 19 1994
 14:37:05
 PLOT NO. 4
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NOAVG)
 TOP
 DMX =0.081031
 SMNB=-9.602
 SMX =277.479
 SMXB=302.653
 PRES

0
30.831
61.662
92.493
123.324
154.155
184.986
215.817
246.648
277.479

1

29,000 lb outrigger load on a 2ft by 2ft pad

ANSYS 5.0 A
 SEP 19 1994
 14:36:33
 PLOT NO. 3
 ELEMENT SOLUTION
 STEP=1
 SUB =1
 TIME=1
 S1 (NOAVG)
 BOTTOM
 DMX =0.081031
 SMN =-50.347
 SMNB=-88.108
 SMX =211.624
 SMXB=221.111
 PRES
 -50.347
 -21.239
 7.869
 36.976
 66.084
 95.192
 124.3
 153.408
 182.516
 211.624

APPENDIX G

Slab on Grade Design Program Results

The following printout is from the slab on grade design program SOG.
The following input was used:

applied moment per foot=Mapp
 $Mapp = s \cdot i / y = 302 \cdot 15 \cdot 15 \cdot 12 / 12 / 7.5$
Mapp=135900 in-lb =11.3 k-ft per foot of slab width
t=15 inches
As=.527 in*in per foot
fc'=4.5ksi, w=150 lb/ft/ft/ft
fy=60 ksi yield re-bar
fs=40 ksi re-bar working stress

2 Layers of rebar for crack
CONTROL

WHC-SD-LL-DA-038
Rev. 0

REINFORCED SLAB -TOP AND BOTTOM EACH WAY

User: WSP

Page 3

Concrete Slab-on-Grade for CRANE AND RIGGING STORAGE SLAB

Reference: Example Calculations for CRSI

Date: SEPT. 22, 1994

Overall Slab-on-Grade Thickness,	t	=	15 in.
28-Day Concrete Compressive Strength,	f'c	=	4.5 ksi
Unit Weight of Concrete,		=	150 pcf
Concrete Cover taken from the Compression Face to the Interface of the Two Layers of Reinforcing,		=	3 in. (conservative)
Area of Reinforcing Steel per Foot of Width,	As	=	.5264 in. ²
Yield Strength of the Reinforcing Steel,	fy	=	60 ksi
Allowable Working Stress for Reinforcing Steel,	fs	=	40.02 ksi
Allowable Working Stress Factor (fs = fy x Factor),		=	.667
Diameter of Reinforcing Bars or Wire,	db	=	.75 in.
Number of Layers of Reinforcing Bars,		=	2
Coefficient of Friction,	F	=	1.5
Spacing of Control or Construction Joints,	L	=	149.8 ft.
Applied Moment Due to External Loading on Slab,	Mapp	=	11.3 ft.-kips
Cracking Moment of the Unreinforced Slab,	Mcr	=	22.64 ft.-kips
Ultimate Moment Capacity of the Structurally, Reinforced Slab-on-Grade	Mu	=	25.83 ft.-kips
Effective Depth to Center of Reinforcing, (d = t - (Cover + db))	d	=	11.25 in.
Unreinforced Slab Safety Factor (S.F. = Mcr / Mapp)		=	2.003
Reinforced Slab Load Factor (L.F. = Mu / Mapp)		=	2.285
Percentage of Reinforcing		=	0.585 %
Weight of Reinforcing		=	7.164 psf

Bar or Wire Size Selected

#6

Bar or Wire Spacing

10

in.

Area of Steel Reinforcing
Provided in the Slab

.527

sq. in. per ft. of width

TOP COVER 2"

BOTTOM COVER 3"

Mu ≥ 25.83 ft-kips

Mapp = 11.3 ft-kips < Mcr = 22.64 < Mu = 25.83

WHC

Concrete Slab-on-Grade for CRANE AND RIGGING STORAGE SLAB
Reference: Example Calculations for CRSI

User: WSP

Page 1

Date: SEPT. 22, 1994

1 layer of rebar for crack
control

Overall Slab-on-Grade Thickness,	t	=	15 in.
28-Day Concrete Compressive Strength,	f'c	=	4.5 ksi
Unit Weight of Concrete,		=	150 pcf
Concrete Cover taken from the Compression Face to the Interface of the Two Layers of Reinforcing,		=	1.25 in.
Area of Reinforcing Steel per Foot of Width,	As	=	.5264 in. ²
Yield Strength of the Reinforcing Steel,	fy	=	60 ksi
Allowable Working Stress for Reinforcing Steel,	fs	=	40.02 ksi
Allowable Working Stress Factor (fs = fy x Factor),		=	.667
Diameter of Reinforcing Bars or Wire,	db	=	.75 in.
Number of Layers of Reinforcing Bars,		=	1
Coefficient of Friction,	F	=	1.5
* Spacing of Control or Construction Joints,	L	=	149.8 ft.
Applied Moment Due to External Loading on Slab,	Mapp	=	11.3 ft.-kips
* Cracking Moment of the Unreinforced Slab,	Mcr	=	22.64 ft.-kips
Ultimate Moment Capacity of the Structurally, Reinforced Slab-on-Grade	Mu	=	16.94 ft.-kips
Effective Depth to Center of Reinforcing, (d = t/2)	d	=	7.5 in.
* Unreinforced Slab Safety Factor (S.F. = Mcr / Mapp)		=	2.003
Reinforced Slab Load Factor (L.F. = Mu / Mapp)		=	1.499
Percentage of Reinforcing		=	0.292 %
Weight of Reinforcing		=	3.582 psf

Bar or Wire Size Selected

#5

Bar or Wire Spacing

10

in.

Area of Steel Reinforcing
Provided in the Slab

.527

sq. in. per ft. of width

$$M_{app} = 11.3 < M_u = 16.9 < M_{cr} = 22.64 \text{ ft-kips}$$

OK.