PROGRESS ENERGY FLORIDA, INC.

CRYSTAL RIVER UNIT 3

DOCKET Number 50-302 /License Number DPR-72

LICENSE AMENDMENT REQUEST #303, Revision 1

Revision to Final Safety Analysis Report Sections 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis"

Attachment B

Calculation S07-0037, Revision 1

Systems	MX
Calc. Sub-Type	-
Priority Code	3
Quality Class	S

NUCLEAR GENERATION GROUP

ANALYSIS / CALCULATION

S07-0037

(Calculation #)

Structural Qualification of Auxiliary Building East and South Walls for Tornado Wind and Missile Loading (per AR 00215432)

(Title including structures, systems, components)

☐ BNP UNIT ______

☒ CR3 ☐ HNP ☐ RNP ☐ NES ☐ ALL

APPROVAL ☐ Electronically Approved

Rev	Prepared By	Reviewed By	Supervisor
1	Signature Martin McDonald	Signature Adam Al-Dabbagh	Signature Chris Sward
	Name Martin McDonald Sargent & Lundy	Name Adam Al-Dabbagh Sargent & Lundy	Name Chris Sward Sargent & Lundy
	Date 4/8/09	Date 4/8/09	Date 04/08/2009

(For Vendor Calculations)

Vendor Sargent & Lundy LLC Vendor Document No. N/A

Owner's Review By C. Glenn Pugh C. Glenn Pugh Date 4/8/09

List Of Effective Pages

Page	Rev	Page	Rev	Page	Rev	Page	Rev
i	1	ii	1	iii	1	iv	1
v	1	vi	1	vii	1	viii	0
1	0	2	0	3	1	4	0
5	0	6	0	7	0	8	0
9	0	10	0	11	0	12	0
13	0	14	0	15	1	16	1
17	1	18	1	19	1	20	1
21	1	22	1	23	1	24	1
25	1						

Attachments

Attach. Number	Rev	Number of Pages	Attach. Number	Rev	Number of Pages	Attach. Number	Rev	Number of Pages
A	0	1	B	0	51	C	0	8
D	0	16	E	0	1	F	0	4
G	1	3						

Amendments

Rev & Letter	No of Pages	Rev & Letter	No of Pages	Rev & Letter	No of Pages	Rev & Letter	No of Pages

Table Of Contents

Revision Summary

Revision #	Revision Summary (Include brief description of revision and a list of EC's and other modifications incorporated into revision)
0	Original Issue in Response to AR 00215432
1	Revised methodology & computations for east wall. Issue in response to RAI for License Amendment Request to Revise FSAR Sections 5.4.3 & 5.4.5.3

Document Indexing Tables

Document Management System Data (For update of PassPort Controlled Document information — Document Service is to delete roll over data only if shown for DELETE in the following tables)

Notes - General

Doc Services Action (Enter ADD, DELETE, or —)	**Text of General Notes**
ADD	GT-STRUDL, Version 27 analysis software was used in the development of this calculation. Software validation is maintained by Sargent & Lundy.
ADD	PCA Column, Version 4.10 analysis software was used in the development of this calculation. Software validation is maintained by Sargent & Lundy.

Reference Numbers – Reference Systems

Doc Services Action (Enter ADD, DELETE, or —)	**System** (Two letter code for systems affected by results)

Reference Numbers – Other References (references to PassPort products)

Doc Services Action (Enter ADD, DELETE, or —)	**Type** (e.g. AR, EC, WO, etc)	**Reference** (e.g. AR No, EC No, WO No, etc)	**Sub** (AR Assign No, WO Task No, etc.)	**Title**

Legend: ADD = New data record to be added to PassPort; REV = Change revision level of a referenced Controlled Document, DELETE = Existing data record to be deleted; — = Existing PassPort data that is to be retained; Bold Faced column heading = PassPort data label

Input **Document References – Controlled Documents with Cross References**

Doc Services Action (Enter ADD, REV, DELETE, or —)	**Doc. Type** (e.g. CALC, DWG, NPAS, POM, etc)	Document **Sub-Type**	**Document** ID (e.g., Calc No., Dwg. No., Procedure No)	**Sheet** (Dwg. sheet number if Applicable)	Doc **Rev**	**Minor Rev** (for Calc Amendments)	**Ref Type** (for NPAS Docs)

Description Codes (Key Words)

Doc Services Action (Enter ADD, DELETE, or —)	**Code** (Codes for Key Words) (To be recorded as document description codes in PassPort)

Output **Document References** (Doc Service is to open listed documents and add or delete this Calc as a reference)

Doc Services Action (Enter ADD, DELETE, or —)	**Document Type** (e.g. CALC, DWG, TAG, PROCEDURE, SOFTWARE)	Document **Sub-Type**	**Document** ID (e.g., Calc No., Dwg. No., Procedure No., Software name and version)	**Revision**	Action Tracking (AR number or EC number that will track revision of affected document for the results of this calculation)

Equipment Database Data (For update of PassPort Equipment Database information)

Equipment Document References

Config Mgt Action (Enter ADD, DELETE, or —)	**Equipment Tag**	**Equipment Type** (includes SFTAPL for analysis software)	Relationship to Calc. (e.g. equipment operation affected by results, equipment design affected by results, analysis software)

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Record of Lead Review

Document **S07-0037** **Revision** **1**

The signature below of the Lead Reviewer records that:
- the review indicated below has been performed by the Lead Reviewer;
- appropriate reviews were performed and errors/deficiencies (for all reviews performed) have been resolved and these records are included in the design package;
- the review was performed in accordance with EGR-NGGC-0003.

☒ **Design Verification Review** ☐ **Engineering Review** ☐ **Owner's Review**
- ☒ Design Review
- ☐ Alternate Calculation
- ☐ Qualification Testing

☐ **Special Engineering Review**________________

☐ YES ☐ N/A **Other Records are attached.**

Adam Al-Dabbagh SEE COVER PAGE	**Civil/Structural**	4/8/09
Lead Reviewer (print/sign)	**Discipline**	**Date**

Item No.	Deficiency	Resolution
1)	Incorrect Reference listed for slab stiffness calculation on pg 21. Should be reference 12.	Updated reference
2)	Add information to description of force pulse on page 22.	Changed description, added diagram depicting rectangular force pulse.
3).	Use conservative dynamic load factor of 2.0 for column check on page 23.	Changed dynamic load factor to 2.0
4)	On page 24, calculate seismic load as an equivalent pressure for comparison to tornado wind loads.	Converted seismic load to an equivalent pressure
5)		
6)		
7)		
8)		

This form is a QA Record when completed and included with a completed design package. Owner's Reviews may be processed as stand alone QA records when Owner's Review is completed.

Record of Lead Review

Document **S07-0037** **Revision** **1**

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☐ **Design Verification Review** ☐ **Engineering Review** ☒ **Owner's Review**

☐ Design Review
☐ Alternate Calculation
☐ Qualification Testing

☐ **Special Engineering Review**________________

☐ YES ☐ N/A **Other Records are attached.**

C. Glenn Pugh [signature]	**Civil/Structural**	4/8/09
Lead Reviewer (print/sign)	**Discipline**	**Date**

Item No.	Deficiency	Resolution
1)	Cover Page- Even though this calculation is being prepared under S&L's QA plan, there still needs to be an owner's review. Remove the "N/A" and add my name	Updated cover page
2)	Revision 0 did not list software, but we should have listed GTStrudl. All software should have software name and version listed on the document indexing table.	Added software information to document indexing table.
3)	On Page 17, the clear cover is listed as ¾" on inside face of wall. Drawings indicate that clear cover is 2" inside and outside.	Changed clear cover to 2" on both wall faces. Calculated new ductility demand to equal 5.2.
4)	On page 19, what is the basis of the leeward wind pressure of 0.081 ksf. Could not find this.	Calculated and used windward pressure (0.183 ksf) in place of 0.081 ksf.
5)	Is PCA-Column applicable to Safety related applications (see comment 2 above also)	PCA column is verified and validated by S&L for all program features.
6)	Reference 16 should be: SP-5209, "CR3 Seismic Qualification," Rev. 0	Edited reference
7)	There are no comments on the Record of Lead Review even through there has been some email comments. Add this page as "owner's review" to the calculation and TOC for Rev. 1	Added comments

This form is a QA Record when completed and included with a completed design package. Owner's Reviews may be processed as stand alone QA records when Owner's Review is completed.

Record of Interdisciplinary Reviews

PART I — DESIGN ASSUMPTION / INPUT REVIEW: APPLICABLE ☐ **Yes** ☒ **No**

The following organizations have reviewed and concur with the design assumptions and inputs used in this calculation:

Systems Engineering

Name | Signature | Date

Operations

Name | Signature | Date

Other

Name | Signature | Date

PART II — RESULTS REVIEW:

The following organizations are aware of the impact of the results of this calculation (on designs, programs and procedures):

Systems Engineering

☐ Yes ☒ NO

Name | Signature | Date

Comments:

Operations

☐ Yes ☒ NO

Name | Signature | Date

Comments:

Other

Name | Signature | Date

Comments:

Other

Name | Signature | Date

Comments:

Other

Name | Signature | Date

Comments:

Purpose

AR 00215432 contains the following problem description:

EXISTING STRUCTURAL CALCULATIONS RELATED TO THE EAST AND SOUTH AUXILIARY BUILDING WALLS DO NOT REFLECT LOADING RELATED TO TORNADO DRIVEN MISSILES. GILBERT AND ASSICIATES CALCULATION 2:01 CONCLUDES WIND LOADING IS ACCEPTABLE BUT DOES NOT INCLUDE THE SPECTRUM OF TORNADO MISSILES DEFINED IN THE FSAR SECTION 5.2.1.2.6. ADDITIONALLY, THE CALCULATION DID NOT ADDRESS THE TORNADO WIND LOAD COMBINATION (WIND PRESSURE + EXTERNAL PRESSURE DROP) AS DETAILED IN SECTION 5.2.3.2.1. PRELIMINARY ASSESSMENT OF THE LOADS INDICATES THAT THE BUILDING WILL WITHSTAND THE LOADING WITHOUT FAILURE (SEE ATTRIBUTE 6A). THIS EVALUATION APPLIED A METHODOLOGY NOT CURRENTLY CONTAINED IN THE FSAR AND WILL REQUIRE RECONCILIATION.

This calculation provides the appropriate evaluation to show that both the east and south walls are operable and also determines the walls can be qualified using standard structural analysis techniques. As also stated in the above problem statement these techniques are not currently identified in the existing CR3 design and licensing basis. However, revision to the Design Basis Document and FSAR are being pursued as a follow-up to this calculation.

This calculation will determine the capacity of the Auxiliary Building (South and East walls) to resist the spectrum of tornado missiles in the licensing and design basis. This calculation also determines the capacity of the Auxiliary building walls to resist the wind pressure and depressurization resulting from a tornado.

Body of Calculation

From the investigation of AR 00215432 the following loading is applicable to this calculation:

The tornado loads are defined in FSAR Section 5.2.1.2.6 for all Class I structures. The required loads are:

- External wind pressure due to a 300 mph tangential wind velocity. There is no clarification as which direction the wind is on the buildings or what the required design pressure is. The original design basis, Gilbert Calculations (Ref. 4) have calculated a pressure of 297 pounds per square foot (psf) acting on vertical surfaces and -274 psf acting as uplift on windward edge of roofs. This design pressure is also listed in the Design Basis Document for Major Class I Structures (Tab 1/3), Revision 2, Page 12. The DBD defines this wind pressure as $W_{w.}$ The FSAR defines this wind pressure as $W_{t.}$

  This calculation will use Wt with a design pressure of 297 psf

- An external pressure drop of 3 psig. As further defined in the DBD this is a 3 psig tornado differential pressure. It is a suction experienced by the outside of the structure corresponding to the drop in atmospheric pressure characteristic of the center vortex of a tornado. The pressure occurs because the structure is relatively airtight and there is little opportunity for contained air to escape and reach equilibrium with the outside. The Gilbert Calculations (Ref. 4) have calculated that this 3 psig pressure drop acts as a 432 psf pressure acting outwards. This design pressure is also listed in the Design Basis Document for Major Class I Structures (Tab 1/3), Revision 2, Page 12. The DBD defines this outward pressure as W_p. The FSAR defines this outward pressure as P_t

This calculation will use Pt with a design pressure of 432 psf

- The Tornado Missiles to be included in the design of a Class I structure are listed in Section 5.2.1.2.6 of the FSAR. The two main tornado missiles to be designed for include a 14" diameter utility pole and a compact automobile. The required design kinetic energy's are listed in the FSAR. The Gilbert Calculations use the kinetic energy and various analysis techniques to derive the following design loads:
    - Utility Pole= 148 kips on a 14" diameter area
    - Compact Auto = 270 kips on a 2.5' x 2.5' area

  The other missiles listed in Section 5.2.1.2.6 are discounted as being bounded by the utility pole and automobile. The two missiles listed above are also listed in the DBD Design Basis Document for Major Class I Structures (Tab 1/3), Revision 2, Page 12. The DBD defines these missile loads as W_m.

The FSAR (Section 5.2.1.2.6) already has determined that a minimum of 2 feet of concrete provides sufficient resistance to the above tornado missile spectrum that no further penetration calculations are required. This calculation applies the loading shown to verify the capacity of the overall wall.

The AR also discussed an apparent discrepancy between the load combinations (using the above tornado loadings) between the FSAR and DBD. The following load combinations will be used for this calculation. These load combinations are a realistic application of the various loads. A follow-up to this calculation will be EC/CMU 68758 to document a change to the DBD and a license amendment request will be filed to request a change to the FSAR for the change in analysis methodology and load combinations.

Abnormal Condition:

C = (D + L + Wt + Pt)

NOTE: Applied to leeward wall. Applies a pressure load from inside towards the outside the building. i.e. suction on the leeward wall; negative moment reinforcement would be on outside face of wall. Concrete reinforcement is typically installed on both faces of the wall; therefore loading is generic to all walls

C = Wm

NOTE: Applied to windward wall. Applies a point load from outside towards the inside of the building. i.e. negative moment reinforcement would be on inside face of wall.

Where

D = Dead Load (conservatively omitted; combination of D+W < W loading)

L = Live Load (no floor live load)

Wt = Tornado wind load

P_t = Internal pressure due to tornado wind
W_m = Tornado missile
E' = Maximum Hypothetical Earthquake (Safe Shutdown Earthquake)

1. <u>Methodology</u>

The following methodologies are applied in this calculation:

- Ultimate strength design per ACI code (see Attachment B and D)
- Yield Line Theory (see Attachment C)
- Strain Energy
- Method of Unit Loads
- Ductility Ratio Evaluation

2. <u>Design Inputs</u>

2.1 Design inputs used in this calculation.

- Concrete density = 150 pcf (Ref. 1)
- Poisson's ratio for concrete = 0.17
- Reinforcing steel yield strength, fy = 40 ksi
- Dynamic Increase Factor for Shear = 1.1 (Ref. 13)
- Dynamic Increase Factor for 40 ksi reinforcing steel = 1.2 (Ref. 13)

3. <u>Assumptions</u>

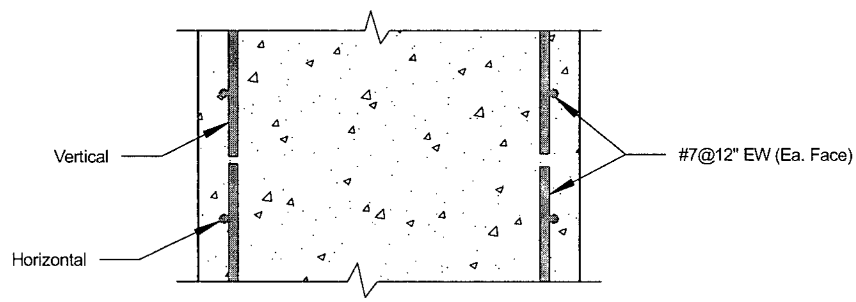
3.1 All assumptions in the calculation are directly based on references.

3.2 No engineering judgments were required.

4. Detailed Calculations

4.1 DETERMINE THE ULTIMATE LOAD CAPACITY OF THE 3-FT THICK SOUTH AUXILIARY BLDG WALL USING YIELD LINE THEORY FOR SLABS AND VERIFY THAT THE WALL IS ADEQUATE FOR TORNADO WIND + DEPRESSURIZATION

Yield line theory offers a simplified analytical method that that can determine the ultimate bending capacity of flat reinforced concrete plates subject to distributed and concentrated loads. Alternately, yield line theory, combined with hinge rotation limits can determine the energy absorption capacity of plates subject to impulsive and impact loads. This method is especially useful in evaluating existing structures that can not be qualified using conservative simplifying analytical assumptions. Typical components analyzed by yield line theory are basemats, floor and roof slabs subject to vertical loads along with walls subject to out of plane loads.



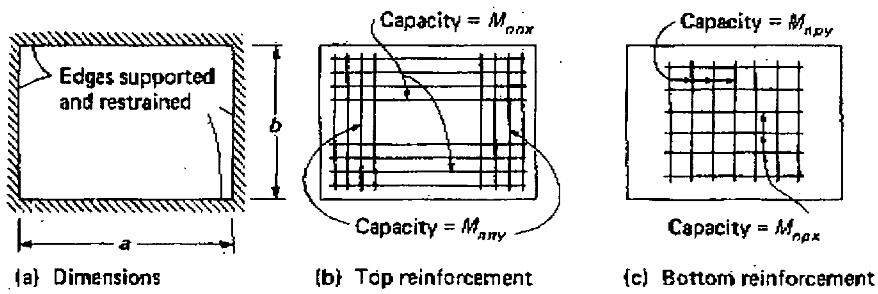


Figure 16.9.1 A rectangular two-way slab panel.

Determine moment capacity of reinforcement

Concrete compressive strength, f'_c =	3	ksi
Rebar yield stress, f_y =	40	ksi
Wall thickness, t =	36	in
Rebar cover, c =	2	in
Unit width, b ' =	12	in
Flexure ratio, ϕ =	0.9	

Reinforcement in both directions

Rebar Direction	Location	Rebar #	Sp, s (in)	A_s (in^2)	Dia., in.	d (in)	d ' (in)
in a-direction	Top	7	12	0.6	0.875		33.5625
	Bottom	7	12	0.6	0.875	33.5625	
in b-direction	Top	7	12	0.6	0.875		32.6875
	Bottom	7	12	0.6	0.875	32.6875	

Unit bending moment for rebar in a-direction (top and bottom)

$A'_s = b' A_s / s$

$= 12 * 0.60 / 12$
$= 0.600 \quad in^2 / in$

$a = f_y A'_s / (0.85 f'_c b')$
$= 40 * 0.600 / (0.85 * 3 * 12)$
$= 0.784 \quad in / in$

$M_{nnx} = M_{npx} = \phi A'_s f_y (d - a / 2)$
$= 0.9 * 0.600 * 40 * (33.563 - 0.784 / 2)$
$= 716.48 \quad in - kip$
$= 59.71 \quad ft - kip$

Bending moment for rebar in b-direction (top and bottom)

$a = f_y A'_s / (0.85 f'_c b')$
$= 40 * 0.600 / (0.85 * 3 * 12)$
$= 0.784 \quad in$

$M_{nny} = M_{npy} = \phi A'_s f_y (d' - a / 2)$
$= 0.9 * 0.600 * 40 * (32.688 - 0.784 / 2)$
$= 697.58 \quad in - kip$
$= 58.13 \quad ft - kip$

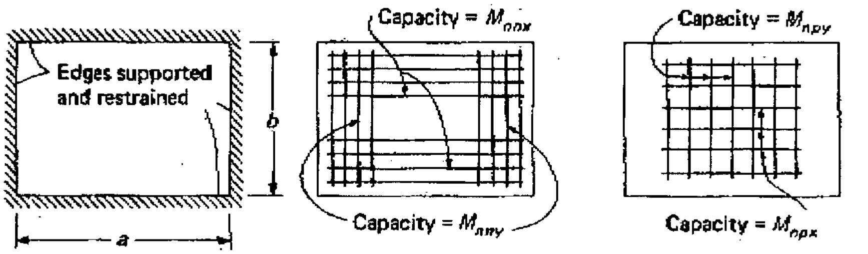


Figure 18.9.1 A rectangular two-way slab panel.

Parameters

Dimensions

a =	79	ft
b =	24	ft

Reinforcement

Top capacity, M_{nnx} =	59.71	ft - kip / ft
Top capacity, M_{nny} =	58.13	ft - kip / ft
Bottom capacity, M_{npx} =	59.71	ft - kip / ft
Bottom capacity, M_{npy} =	58.13	ft - kip / ft

Determine applicable yield line pattern (Ref. 3, Chapter 18)

Calculate the sum of positive and negative moment in the a-direction divided by the sum of the positive and negative moment reinforcement in the b-direction

$K_{rebar} = (M_{nnx} + M_{npx}) / (M_{nny} + M_{npy})$
$= (59.71 + 59.71) / (58.13 + 58.13)$
$= 1.027$

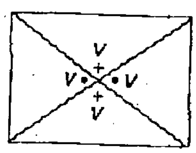
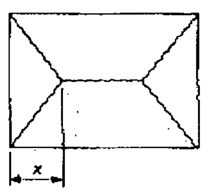
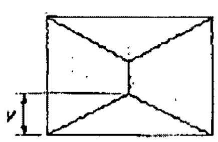
Calculate the ratio of the squares of a and b dimensions

$K_{a/b} = a^2 / b^2$
$= 79 ^2 / 24 ^2$

= 10.835

Yield Pattern	Limitation	Controlling Identity	Status
1	Compare the ratio of ($M_{nnx} + M_{npx}$) to ($M_{nny} + M_{npy}$) with the ratio a^2 to b^2. Yield Pattern No. 1 will control.	$K_{rebar} = K_{a/b}$	DOES NOT GOVERN
2	Reinforcement in the “a direction” is less than that for Yield Pattern No.1	$K_{rebar} < K_{a/b}$	GOVERNS
3	Reinforcement in the “a direction” is more than that for Yield Pattern No.1	$K_{rebar} > K_{a/b}$	DOES NOT GOVERN

Determine the uniform load w_u / ϕ at the collapse condition

No.	Yield Pattern	Ref. #4 EQN	Calculation
1	 (a) Yield pattern No. 1	18.9.3	$w_u / \phi = 12 [(M_{nnx} + M_{npx}) / a^2 + (M_{nny} + M_{npy}) / b^2]$
2	 (b) Yield pattern No. 2	18.9.9 18.9.11	Determine x in the following quadratic equation. $4 a (M_{nny} + M_{npy}) x^2 + 4 b^2 (M_{nnx} + M_{npx}) x - [3 a b^2 (M_{nnx} + M_{npx})] =$ 0 4 * 79 * (58.13 + 58.13) * x ^2 + 4 * 24 ^2 * (59.71 + 59.71) * x – [3 * 79 * 24 ^2 * (59.71 + 59.71)] = 0 EXCEL SOLVER solution or Trial & error solution x = 17.6502 ft 4 * 79 * (58.13 + 58.13) * 17.6502 ^2 + 4 * 24 ^2 * (59.71 + 59.71) * 17.6502 - [3 * 79 * 24 ^2 * (59.71 + 59.71)] = 1.92E-07 $w_u / \phi = 6 (M_{nnx} + M_{npx}) / x^2$ = 6 * (59.71 + 59.71) / 17.6502 ^2 = 2.300 ksf **GOVERNS**
3	 (c) Yield pattern No. 3	18.9.14	Determine y in the following quadratic equation. $4 b (M_{nnx} + M_{npx}) y^2 + 4 a^2 (M_{nny} + M_{npy}) y - [3 b a^2 (M_{nny} + M_{npy})] =$ 0 $w_u / \phi = 6 (M_{nny} + M_{npy}) / y^2$

Tornado wind pressure = 0.297 ksf
Vacuum pressure = 0.432 ksf
Total Tornado Wind Pressure = 0.729 ksf **OK < 2.30 ksf**

The applied pressure load on the 3-foot thick wall does not exceed the collapse pressure load; therefore, the 3-foot is structurally adequate to withstand tornado wind and depressurization.

4.2 OVERALL RESPONSE TO MISSILE IMPACT

The methodology stated in ASCE Manuals and Reports on Eng'g Practice No. 58 "Struct'l Analysis and Design of Nuclear Plant Facilities", Chapter 6, "Design Against Impulse and Impact Loads" will be used for this evaluation (Ref. 8).

4.2.1 CALCULATE COLLAPSE LOAD R_m (Per Ref. #8, Table 6.4)

Concentrated collapse load at center of slab with 100% fixity at all sides, $R_m = 2\pi(M_{u+} + M_{u-})$

where

M_{u+} = Ultimate positive moment capacity

M_{u-} = Ultimate negative moment capacity

Since $M_{u+} = M_{u-}$

Let $M_u = M_{u+} = M_{u-}$

$R_m = 4\pi M_u$

Since $A_s = A'_s$

$M_u = \phi[A'_s f_y (d - d')]\,DIF$

where

f_y = Re-bar yield strength

d = Distance from extreme compression fiber to centroid of tension reinforcement

d' = Distance from extreme compression fiber to centroid of compression reinforcement

$= c_c + d_s / 2$

$= 2.000 + 0.875 / 2$

$= 2.4375$ in

DIF = Dynamic increase factor for re-bar. Ref. ASCE Manuals and Reports on Engineering Practice No. 58, "Structural Analysis and Design of Nuclear Plant Facilities", page 317, Table 6.2.

f_y	DIF
40	1.2
60	1.1

DIF = 1.2

Dynamic Increase Factor

The dynamic material strength shall be computed by applying a dynamic increase factor that accounts for the increase in material strength due to strain rate effects. The dynamic variation due to increase in strain rate increases the yield stress of steel and compressive strength of concrete. It is common to take credit for the dynamic strength increase.

For reinforced concrete structures subjected to blast effects, response at very high strain rates is often sought. At these high strain rates, the reinforcing bars yield stress can increase by 100%, or more, depending on the grade of steel used. The dynamic increase factor (DIF), i.e. the ratio of the dynamic to static value, is normally reported as function of strain rate. DIF curves for both yield and ultimate strengths have been derived and published in manuals by the Tri-Services, the Defense Special Weapons Agency, the Air Force, and the Department of Energy. Ref. http://www.kcse.com/pdfs/P-98-31_f.pdf

In Regulatory Position 10.6, increase in the material strength (i.e., dynamic increase factor, DIF) could be realized only when the material is subjected to very high strain rates of loading, normally associated with impactive loadings. If a structure is found to be responding in a static or semi-static manner to a dynamic loading (i.e., dynamic load factor (DLF) <1.2), the materials of the structure would not undergo very high strain rate that would increase the material strength. Though there is no direct relationship between DLF and DIF, Regulatory Position 10 restricts the use of DIF when the DLF is lower than 1.2.

Ref. RegGuide 1.142 Rev 2 Nov 2001

$M_p = \phi [A'_s f_y (d - d')] DIF$
$= 0.90 * [0.0500 * 40000 * (33.563 - 2.438)] * 1.20$
$= 67230$ in - lb / in

Collapse Load
$R_m = 4 * 3.142 * 67230$
$= 844837$ lb

4.2.2 DETERMINE CONCRETE PROPERTIES

Determine reinforced concrete section properties; use average of cracked and uncracked moment of inertia.

Depth to re-bar, $d = t - c_c - d_s / 2$
where
$d_s =$ re-bar diameter
$= 0.875$ in
$d = 36.00 - 2.00 - 0.875 / 2$
$= 33.5625$ in

Average moment of inertia, $I_a = 0.5 (I_g + I_c)$ Ref. EQN (6.29) page 327
where
$I_g =$ Gross moment of inertia (uncracked)
$= b t^3 / 12$
where
$b =$ width of concrete section
$= 1$ in
$I_g = 1.00 * 36.00$ ^3 / 12
$= 3888$ in^4 / in
$I_c =$ Cracked moment of inertia
$= F b d^3$
where
$F =$ Coefficient of moment of inertia of cracked section

Ratio of tensile reinforcement to effective area of concrete in rectangular beam, $\rho = A_s / b d$
where
$A_s =$ Area of tensile reinforcement / spacing
$= 0.60 / 12.00$
$= 0.0500$ in^2 / in

$\rho = 0.0500 / (1.0 * 33.563)$
$= 0.00149$

Ratio of compr. re-bar to eff. conc. area, $\rho' = \rho$

Ratio $\rho' / \rho = 1.0$

Elastic modulus of concrete, $E_c = w^{1.5}\, 33\, SQRT(f'_c)$ Ref. ACI Std 318-63 Sect 1102 where

w = 150 lb / ft ^{3} (concrete weight)

E_c = 150 ^1.5 * 33 * SQRT (3000)
= 3320561 psi

Elastic modulus of steel, E_s = 29000000 psi

Modulus of elasticity ratio, n = E_s / E_c
= 29000000 / 3320561
= 8.7

Ratio ρ n = 0.00149 * 8.7
= 0.0130

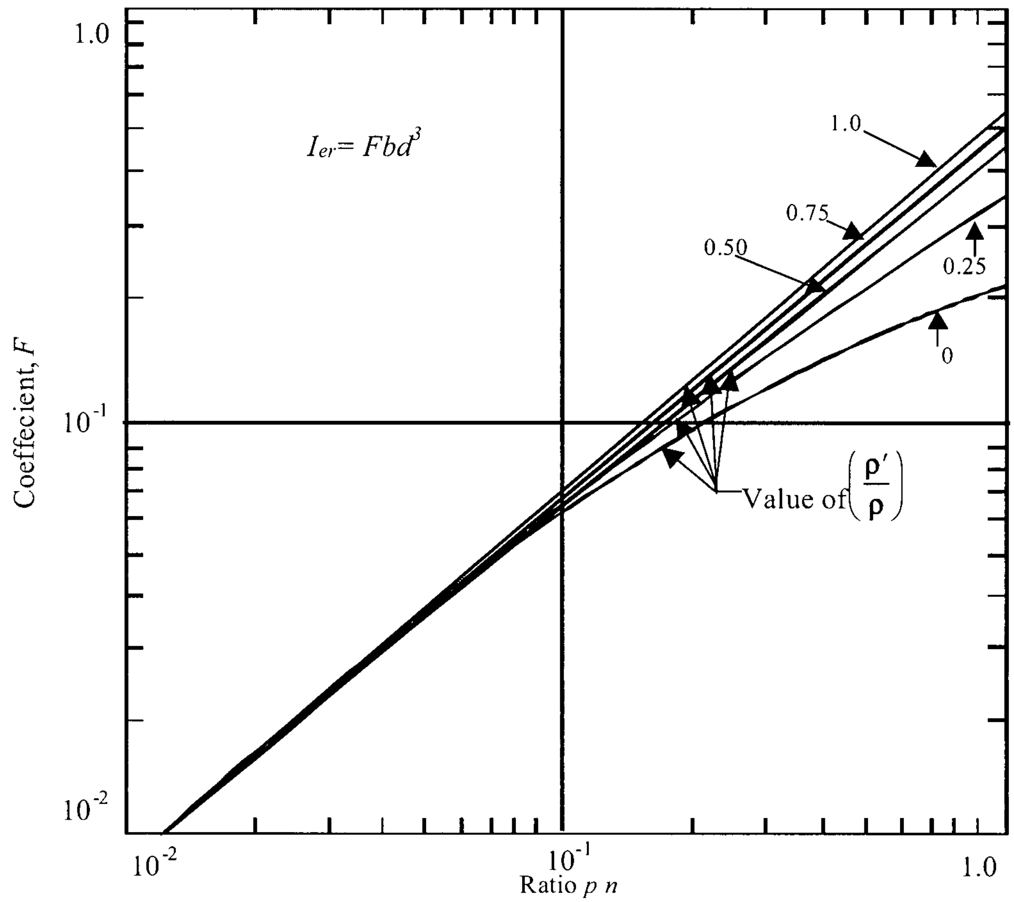


Figure 15 – Coefficient for Moment of Cracked Sections
(Source Document 8)

Determine F-coefficient by interpolate for ρ n and ρ ' / ρ

ρ n	Coefficient F				
	ρ ' / ρ =1.0	ρ ' / ρ =0.75	ρ ' / ρ =0.50	ρ ' / ρ =0.25	ρ ' / ρ = 0
0.02	0.017	0.017	0.017	0.017	0.017
0.0127	0.01	0.01	0.01	0.01	0.01
0.0130	0.0103	0.0103	0.0103	0.0103	0.0103

For ρ n = 0.0130 and ρ ' / ρ = 1.0 F = 0.0103

Cracked section moment of inertia, I_c = $F\ b\ d^3$
= 0.0103 * 1.0 * 33.563 ^3
= 389.3 in^4 / in

Alternate solution for cracked section moment of inertia without compression steel

B = $b\ (n\ A_s)$
= 1 * (8.73 * 0.0500)
= 0.437

kd = [SQRT (2 d B + 1) - 1) / B
= [SQRT (2 * 33.563 * 0.437 + 1) - 1] / 0.437
= 10.32

I_c = $b\ (kd)^2 / 3 + n\ A_s\ (d - kd)^2$
= 1 * (10.32) ^2 / 3 + 8.73 * 0.0500 * (33.56 - 10.32) ^2
= 271.4 in^4 / in

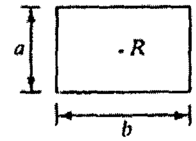
Ref. US Army Corps of Engineers, "Structures to Resist the Effects of Accidental Explosions", TM 5-1300, July 1965.

In calculating the stiffness of reinforced concrete sections, the moment of inertia must account for cracking of concrete. It is recommended that the average moment of inertia be used which is based on the following expression:

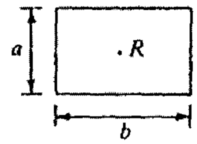
Average moment of inertia, I_a = $0.5\ (I_g + I_c)$
= 0.5 * (3888 + 389)
= 2139 in^4 / in

4.2.3 CALCULATE ELASTIC STIFFNESS OF SLAB (Ref. 8) UNDER CONCENTRATED LOAD

Table 6.4 Stiffness and resisting values for plates and slabs under concentrated loads

Description	Resistance	Stiffness
(a) Simply supported on all four sides with load at center		
	$R_M = 2\pi M_u$	$K = \dfrac{12EI}{\alpha a^2(1-\nu^2)}$

b/a	1.0	1.1	1.2	1.4	1.6	1.8	2.0	3.0	∞
α	0.1390	0.1518	0.1624	0.1781	0.1884	0.1944	0.1981	0.2029	0.2031

Description	Resistance	Stiffness
(b) Fixed supports on all four sides with load at center		
	$R_M = 2\pi(M_u^+ + M_u^-)$	$K = \dfrac{12EI}{\alpha a^2(1-\nu^2)}$

b/a	1.0	1.2	1.4	1.6	1.8	2.0	∞
α	0.0671	0.0776	0.0830	0.0854	0.0864	0.0866	0.0871

Note: ν = Poisson's ratio; t = thickness in inches (millimeters); E = modulus of elasticity, in pounds per square inch (kilopascals); I = moment of inertia per unit width, inches fourth power per inch (millimeters-fourth power per millimeter); M_u^+ = ultimate positive moment capacity, in inches per pound per inch (millimeters per newton per millimeter); M_u^- = ultimate negative moment capacity, in inches per pound per inch (millimeters per newton per millimeter).

Compute elastic stiffness of slab under concentrated loads

b / a = 79.000 / 24.000
= 3.292

α = 0.0871

Stiffness, $k_e = 12\, E_c\, I_a / [\,\alpha\, a^2 (1 - u^2)\,]$

where

Poisson ratio for concrete, υ = 0.17

υ = 0.15 ~ 0.25 for concrete [ACI Committee 435 1991]

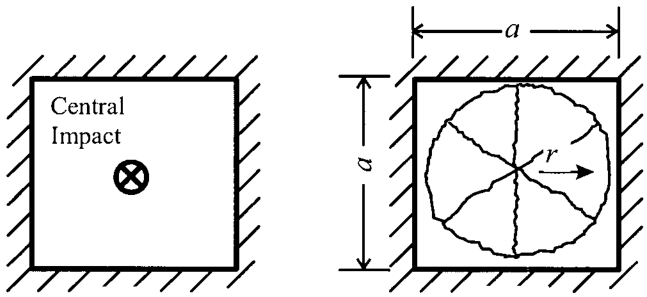
Case (b) k_e = 12 * 3320561 * 2139 / [0.0871 * (12 * 24) ^2 * (1 - 0.17 ^2)]
= 12146974 lb / in
= 1.21E+07 lb / in

4.2.4 CALCULATE EFFECTIVE MASS FOR CIRCULAR FAN YIELD LINE PATTERN

Compute effective mass of slab

For concentrated load, the load factor

K_L = 1 (Ref. 8, page 355)



(a) (b)

R = 12 ft Ref. 8, page 355

Effective mass of slab, $M_e = m \pi R^2 / 6$

where

m = mass per unit area

= w t / g

g = 32.174 ft / sec ^{2}

m = 150 * 3.00 * 1 * 1 / 32.2

= 13.99 lb sec ^{2} / ft ^{3}

= 0.00809 lb sec ^{2} / in ^{3}

M_e = 0.00809 * 3.142 * (12 * 12) ^2 / 6

= 87.9 lb sec ^{2} / in ^{3}

4.2.5 NATURAL PERIOD OF VIBRATION (Ref. 8, pages 355 & 361)

Determine Natural Period of Vibration

$T = 2 \pi$ SQRT ($M_e / K_L k_e$)

where

$K_m M_t = M_e$

Case (b) T = 2 * 3.142 * SQRT [87.9 / (1.0 * 12146974)]

= 0.017

4.2.6 IMPACT FORCE (F_i) and DURATION OF IMPACT (t_d)

Note: Ref. 8 states that due to significant deformation of the auto, the effects of an impact are based on the impact time history. Methods are given to investigate this time history function; however, the CR-3 DBD for Class 1 Structures and Attachment #2 (page 17, from Gilbert Calc 4.01.1) state that the equivalent static load is 270K and duration of impact is 0.081 sec.

Determine Impact Force

F_i = 270000 lb See Attachment A

Determine Duration of Impact Force

t_d = 0.081 sec See Attachment A

4.2.7 DETERMINE SLAB DUCTILITY FOR CIRCULAR FAN FAILURE

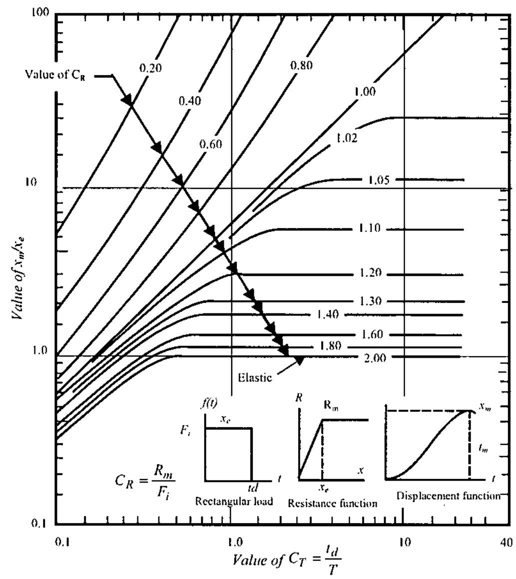
Ductility Ratio

The limits applied to deformation under impulse and impact loads are generally specified in terms of ductility ratios. The allowable ductility ratio is defined as the maximum permissible deflection of a structural system to the deflection at "effective yield" for the system. Recommended values for allowable ductility are given in the following table per Ref. ASCE – Manuals and Reports on Engineering Practice No. 58 "Structural Analysis and Design of Nuclear Plant Facilities"

Table 6.1 Allowable ductility ratios for impulse and impact load

Material	Ductility Ratio
Reinforced concrete:	
flexure (beams)	$\frac{0.10}{\rho - \rho'} \leq 10$
flexure (slabs)	$\frac{0.10}{\rho - \rho'} \leq 30$
compression (walls and columns)	1.3
shear (beams and slabs)	
-carried by concrete only	1.0
-carried by concrete and stirrups	1.3
-carried completely by stirrups	3.0
Structural steel:	
beams (local and lateral buckling prevented)	20
columns ($\frac{Kl}{r} < 30$ and local buckling prevented	5
columns ($\frac{Kl}{r} \geq 30$)	≤ 1
axial tension members	$0.5\frac{\epsilon_u}{\epsilon_y}$

The maximum displacement curve for a rectangular impulse load is used for this calculation.



case (b)

$C_T = t_d / T$
$= 0.081 / 0.017$
$= 4.7929$

$C_R = R_m / F_i$
$= 844837 / 270000$
$= 3.1290 \quad > 2.0$ **ELASTIC RANGE**

The 3-ft wall is qualified within elastic limits.

Case	C_T	C_R	X_m / X_e
(b)	4.7929	2.000	1.000
		2.000	1.000
		3.129	1.000

Notes:

X_m = Maximum displacement under load
X_e = Effective yield deflection

The maximum permissible deflection is the allowable ductility ratio times the effective yield deflection. The maximum permissible deflection governs peak response in a time history dynamic analysis or strain energy capacity in an energy balance analysis.

Allowable ductility, $\mu = 0.10 / (\rho - \rho') \leq 30$
$\mu = 30$ since $\rho = \rho'$

SINCE X_m / X_e = **1.000** < μ = **30**

No overall failure

Using μ = 30 and t_d = 0.081 sec, an iterative analysis was performed to determine F_i .

Iterative Procedure

The term F_i is used to determine C_R

$$C_R = R_m / F_i$$

The term C_R is used to determine X_m / X_e which is μ

Vary F_i input until X_m / X_e equals 30; therefore, μ = 30.

F_i = 890663 lb

$F_{missile} / F_i$ = 270000 / 890663

= 0.303

4.3 DETERMINE THE ULTIMATE LOAD CAPACITY OF THE 2-FT THICK EAST AUXILIARY BUILDING WALL USING ULTIMATE STRENGTH DESIGN PER ACI 349-97 AND VERIFY THAT THE WALL IS ADEQUATE FOR TORNADO WIND + DEPRESSURIZATION

Consistent with Nuclear Regulatory Commision review guidelines in the Standard Review Plan (NUREG-0800, Revision 3 - March 2007), Section 3.8.4, "Other Seismic Category 1 Structures, the east wall of the CR3 Auxiliary Building will be evaluated to the requirements of ACI 349-97, "Code Requirements for Nuclear Safety Related Concrete Structures," as endorsed, and supplemented by regulatory positions, in Revision 2 (November 2001) of Regulatory Guide 1.142, "Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)" for all design basis loads and load combinations as described in the FSAR.

The Auxiliary Building east wall is 24" thick and it is reinforced with #6 reinforcing bars at each face and each direction. Design f'c = 3000 psi and design yield strength is 40 ksi. (Ref. 9 and 10)

Reinforcing Bar Information:

Wall is reinforced with #6 bars @ 12" on both faces in each direction.

$d_b := .750\text{in}$ Diameter of #6 reinforcing bar

$A_s := .44\frac{\text{in}^2}{\text{ft}}$ Cross sectional area of #6 reinforcing bar

The percent reinforcement on each face, considering gross concrete area, is

$$\rho_{wall} := \frac{0.44}{12 \cdot 24} \qquad = 0.0015 = 0.15\%$$

Appendix C of ACI 349-97 does not specify any requirements for minimum reinforcement so Section 10.5.3 is applied for minimum reinforcement of flexural members which refers to Section 7.12 for structural slabs of uniform thickness. Section 7.12.5 requires that the ratio of reinforcement area be provided at the tension face to gross area of concrete not be less than 0.0018 unless the area of reinforcement provided is at least one-third greater than that required by analysis. The ratio provided in the CR3 Auxiliary Building east wall is 0.0015. In order to satisfy Section 7.12.5 for a lower ratio of reinforcement, the requirements of Appendix C have been checked for a wall with a reduced area of reinforcement which is three-quarters of the actual reinforcement area in the east wall.

$A_{s\_red} := \frac{3}{4} \cdot A_s$ $\quad A_{s\_red} = 0.33\frac{\text{in}^2}{\text{ft}}$ Steel area to be considered as that required by this analysis to satisfy the requirements of ACI 349-97 (Ref. 13) Section 7.12.5

$f_y := 40\text{ksi}$

$E_s := 29000\text{ksi}$

Concrete Information:

Section 7.7.1 of ACI 349-97 (Ref. 13) requires a clear cover of 3/4" on the inside face of the wall. However, drawing sections indicate that the clear cover may be 2" on both sides of the Auxiliary Building walls. Conservatively, a clear cover of 2" will be used for both faces of the wall.

$f'_c := 3000psi$ Concrete strength

$c_c := 2in$ Concrete clear cover on both faces of wall

$\nu := 0.17$ Poisson's Ratio for concrete

$w := 150pcf$ Concrete weight

$E_c := \left(\frac{w}{pcf}\right)^{1.5} \cdot 33 \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi$ $E_c = 3320561\,psi$ Modulus of elasticity (Ref. 13, Section 8.5.1)

Wall section information:

$t := 2ft$ Wall thickness

$b := 12in$ Unit width of evaluated section

$l_{panel} := 24ft$ Length of the square wall panel considered in analysis

$d := t - c_c - d_b$ $d = 21.25\,in$ Effective depth from either wall face to average steel layer on opposite face

4.3.1 COMPUTE ULTIMATE MOMENT STRENGTH FOR REDUCED REINFORCEMENT AREA

Consider a singly reinforced concrete section with reduced reinforcement area. In order to satisfy the requirements of ACI 349-97 (Ref. 13) Article 7.12.5, the collapse load is calculated with a reduced area of steel to determine the ductility demand of the section crediting only 75% of the provided steel area.

$a := \frac{A_{s\_red} \cdot f_y}{0.85 \cdot f'_c}$ $a = 0.43\,in$ Height of concrete compression stress block

$\phi := 0.9$ Tension-controlled section

$\phi M_{nr} := \phi \cdot A_{s\_red} \cdot f_y \cdot \left(d - \frac{a}{2}\right)$ $\phi M_{nr} = 20.82\,\frac{kip \cdot ft}{ft}$ Reduced ultimate moment strength of AB east wall

4.3.2 CHECK TORNADO WIND PLUS DEPRESSURIZATION

Determine the maximum applied moment on the wall due to tornado wind plus depressurization load ($W_t + P_t$).

$P_t := 0.432\text{ksf}$ Tornado 3 psi pressure drop

$W_t := 0.297\text{ksf}$ Tornado wind pressure

It is apparent from the development in ASCE Paper 3269 (Ref. 5) that this is the overall wind pressure on the building (i.e. p = 1.3 x 0.002558 x 300^2 = 297 psf). For local designs, this should be broken into windward and leeward components with 0.8 and 0.5 shape coefficients, respectively.

$W_{tW} := 0.8 \cdot \left(\frac{W_t}{1.3}\right)$ $W_{tW} = 0.18\,\text{ksf}$ Windward pressure

$W_{tL} := 0.5 \cdot \left(\frac{W_t}{1.3}\right)$ $W_{tL} = 0.11\,\text{ksf}$ Leeward pressure

Although windward pressure acts in the opposite direction of the tornado pressure drop, which is a vacuum on the building and thus acts outward on all exterior panels, they will be combined conservatively. Leeward pressure and suction on side walls will be additive with the pressure drop, but will be of lower magnitude than the windward pressure and thus will be enveloped.

$q := P_t + W_{tW}$ $q = 0.61\,\text{ksf}$ Tornado windward plus pressure drop

Table 30 of Reference 15 provides equation for maximum moment calculation of a flat plate under uniform pressure and fixed on all four edges (b/a = 1.0)

$M_{u\_wind} := -0.0513 \cdot q \cdot l_{panel}^2$ $M_{u\_wind} = -18.17\,\frac{\text{kip}\cdot\text{ft}}{\text{ft}}$ Maximum applied moment under tornado wind plus depressurization

$IC_{wind} := \frac{|M_{u\_wind}|}{\phi M_{nr}}$ $IC_{wind} = 0.87$ < 1.0 OK

Therefore, the AB east wall is acceptable for tornado wind + depressurization loading.

4.3.3 CHECK SEISMIC LOADING ON THE WALL PANEL

In order to determine wether the tornado wind loads govern the design of the wall for local effects, the local seismic loading will be checked below.

$T := 0.022\text{sec}$ First natural period of the wall, calculated on page 22

$f := \frac{1}{T}$ $f = 45.45\,\text{Hz}$ Wall frequency

Using the response spectra in Figure 12A of Reference 16 for Horizontal SSE of the Auxiliary Building at Elevation 143.0', the following wall acceleration is obtained. Since the frequency of the wall is above 33Hz (rigid zone), amplification factor due to higher modes is not required. This acceleration will be multiplied by the weight of the wall per unit area to find an equivalent pressure that can be compared to the wind loading.

$a_{SSE} := 0.21g$ Acceleration for frequency of 45 Hz and 2% damping (Ref. 16)

$q_{eq} := \frac{w \cdot t}{g} \cdot a_{SSE}$ $q_{eq} = 63.00\,\text{psf}$ Equivalent wall pressure under SSE seismic loading

This equivalent pressure is significantly lower than the 510 psf for the load combination regarding tornado wind plus depressurization. Based on the comparison, tornado wind and missile loading govern the wall design. Therefore, the wall is qualified for SSE loading combination based on the qualification of the higher loading of the wind plus depressurization.

4.4 OVERALL RESPONSE TO MISSILE IMPACT

The methodology described in References 8, 12 and 14 are used to qualify the wall for the requirements of ACI 349-97 (Ref. 13).

4.4.1 COMPUTE ULTIMATE MOMENT STRENGTH

The ultimate moment strength of the east wall with full area of reinforcement considered is required in order to check the shear resistance of the slab per section C.3.6 in ACI 349-97. Consider a singly reinforced concrete section with actual reinforcement area.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f'_c}$ $a = 0.58\,\text{in}$ Height of concrete compression stress block

$M_n := A_s \cdot f_y \cdot \left(d - \frac{a}{2}\right)$ $M_n = 30.74 \frac{\text{kip} \cdot \text{ft}}{\text{ft}}$

4.4.2 COMPUTE COLLAPSE LOAD, R_m

$DIF_f := 1.2$ Dynamic Increase Factor for 40 ksi reinforcing steel per Ref. 13, Appendix C

$M_{u\_pos} := \phi \cdot M_n \cdot DIF_f$ $M_{u\_pos} = 33.20 \frac{\text{kip} \cdot \text{ft}}{\text{ft}}$

$M_{u\_neg} := \phi \cdot M_n \cdot DIF_f$ $M_{u\_neg} = 33.20 \frac{\text{kip} \cdot \text{ft}}{\text{ft}}$

$R_m := 2 \cdot \pi \cdot \left(M_{u\_pos} + M_{u\_neg}\right)$ $R_m = 417\,\text{kip}$ Reference 12, Table 5.3

4.4.3 CHECK SHEAR RESISTANCE

According to ACI 349-97 (Ref. 13), Article C.3.6, the wall resistance to shear must exceed the load capacity of the wall in flexure by at least 20% in order for flexure to control the design.

$\phi_v := 0.85$

$V_c := 2 \cdot \phi_v \cdot \sqrt{\frac{f'_c}{\text{psi}}} \cdot l_{panel} \cdot d \cdot \text{psi}$ $V_c = 570\,\text{kip}$ Shear resistance of one edge of the wall panel

$DIF_v := 1.1$ Dynamic increase factor for concrete shear from Section C.2.1 of Ref. 13

$R_v := DIF_v \cdot V_c$ $R_v = 627\,\text{kip}$ Concentrated Collapse Load Capacity in Shear

$IC := \frac{R_v}{R_m}$ $IC = 1.50$ > 1.2 Therefore, the section meets the requirements of Ref. 13, Article C3.6 to use the ductility ratio prescribed in Article C3.3 of Ref. 13

4.4.4 COMPUTE COLLAPSE LOAD, $R_{m\_reduced}$ FOR REDUCED REINFORCEMENT AREA

$DIF := 1.2$ Dynamic Increase Factor for 40 ksi reinforcing steel per Ref. 13, Appendix C

$R_{m\_reduced} := 2 \cdot \pi \cdot DIF \cdot (\phi M_{nr} + \phi M_{nr})$ $R_{m\_reduced} = 314 kip$ Ref. 12, Table 5.3

4.4.5 DETERMINE CONCRETE SECTION PROPERTIES FOR REDUCED REINFORCEMENT AREA

$I_g := \frac{t^3}{12}$ $I_g = 1152 \frac{in^4}{in}$ Gross moment of inertia (uncracked)

$\rho := \frac{A_{s\_red}}{d}$ $\rho = 0.00129$ Ratio of tensile steel to effective concrete area

$\rho' := \rho$ $\rho' = 0.00129$ Ratio of compression steel to effective concrete area

$n := \frac{E_s}{E_c}$ $n = 8.73$ Modulus of elasticity ratio

$\frac{\rho'}{\rho} = 1.00$

$\rho \cdot n = 0.01130$

Use Figure 3.1.10 of Reference 12 to determine coefficient, F, for moment of inertia of cracked sections:

$F := 0.011$ Coefficient for moment of inertia of cracked section

$I_c := F \cdot d^3$ $I_c = 105.6 \frac{in^4}{in}$ Moment of inertia of cracked section

$I_a := 0.5 \cdot (I_g + I_c)$ $I_a = 628.8 \frac{in^4}{in}$ Average moment of inertia

4.4.6 CALCULATE STIFFNESS OF SLAB UNDER CONCENTRATED LOAD

Using Table 5.3 of Ref. 12, Calculate stiffness:

$\alpha := 0.0671$ Stiffness coefficient for square panel with fixed edges

$K := \frac{12 \cdot E_c \cdot I_a}{\alpha \cdot l_{panel}^2 \cdot (1 - \nu^2)}$ $K = 4635723 \frac{lb}{in}$

4.4.7 CALCULATE EFFECTIVE MASS FOR CIRCULAR FAN YIELD PATTERN

$R := \frac{l_{panel}}{2}$ $R = 12.00\,ft$ Radius of fan yield pattern

$m := \frac{w \cdot t}{g}$ $m = 0.00540 \frac{lb \cdot sec^2}{in^3}$ Mass per unit area

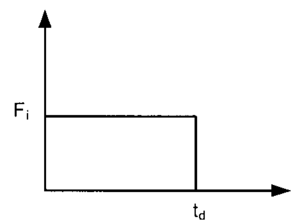
$M_e := \frac{m \cdot \pi \cdot R^2}{6}$ $M_e = 58.59 \frac{lb \cdot sec^2}{in}$ Effective mass is one-sixth of mass in the circular yield line pattern (Ref. 8, Section 6.4.2.1.4)

4.4.8 NATURAL PERIOD OF VIBRATION

$T := 2 \cdot \pi \cdot \sqrt{\frac{M_e}{K}}$ $T = 0.022\,sec$ First natural period

4.4.9 IMPACT FORCE AND DURATION OF IMPACT

The 1 ton automobile load of 270 kips envelopes the utility pole missile load of 148 kips. The resulting missile load is a rectangular force pulse as shown to the right. The impact force and duration of impact are obtained from Reference 4.



RECTANGULAR FORCE PULSE

$F_i := 270000lb$

$t_d := 0.081sec$

4.4.10 DETERMINE REQUIRED DUCTILITY RATIO FOR THE SLAB DUE TO IMPULSE

$\frac{t_d}{T} = 3.63$

$\frac{R_{m\_reduced}}{F_i} = 1.16$

$\mu := 5.2$ Ductility demand (Reference 14, Figure 2.23)

Section C.3.3 of ACI 349-97 (Ref. 13) requires that the permissible ductility ratio be taken as 10 when the area of steel tension reinforcement equals the area of compression reinforcement and flexure controls design.

The calculated ductility demand of 5.2 is well below the limit of 10. This result satisfies the requirement of Section 7.12.5 of ACI 349-97 (Ref. 13), that the area of reinforcement provided on the tension face is at least one third greater than that required by analysis.

4.4.11 CHECK COLUMNS FOR MISSILE IMPACT

The smallest columns adjacent to any of the wall panels under consideration for missile impact are located on column lines L, M_1, N_1, and O_1. The governing column on column line O_1 is 36" wide by 50.25" deep with 8 - #18 vertical bars and two sets of 2-#4 ties @ 24". The following loads, used in the original design of this column, were obtained from Section 2.01.55-12 of Reference 4. Conservatively, only the dead load is considered for the combination including tornado missile loading.

$DL_{col} := 340.6kip$ — Column design dead load (Ref. 4)

$e := 0.5938ft$ — Column axial load eccentricity (Ref. 4)

$P_{axial} := DL_{col}$ — $P_{axial} = 340.6\,kip$ — Column design axial load under dead load

$M_e := e \cdot P_{axial}$ — $M_e = 202.2\,kip \cdot ft$ — Column design moment due to eccentricity of dead load

The additional moment introduced to the column is calculated by considering the missle impact to occur at the midspan of the column between floors. The ends are assumed fixed by the three foot thick slabs. A dynamic load factor of 2 is conservatively used for the missile impact.

$DLF := 2$ — Conservative dynamic load factor

$$M_{missile} := DLF \frac{F_i \cdot l_{panel}}{8} \qquad M_{missile} = 1620.0\,kip \cdot ft$$

$$M_{col} := M_e + M_{missile} \qquad M_{col} = 1822.2\,kip \cdot ft$$

PCAcolumn software was used to generate a P-M interaction diagram for the combined loads listed above. The results are attached in Appendix G. The analysis determined that the loading gives a factor of safety of 1.642, or IC = 0.61. Therefore, the columns are OK under tornado missile loading.

Computer Programs

Mathcad
MathSoft Mathcad Version 11.2a (S&L Program No. 03.7.548-11.2)

PCAColumn
PCAColumn Version 3.61 (S&L Program No. 03.7.198-4.10)

These programs (run on PC No. ZD2055) are accessed using the S&L LAN and have been validated per the S&L Software Verification and Validation procedues for the program functions used in this calculation.

5. Results

South Wall:

(1) The South Wall is qualified in accordance with ACI 318-63.

(2) The ultimate strength of the South Wall exceeds the applied tornado wind and pressure drop loads (refer to Alternate Calculation in Attachment D). The load combination, $C = D + L + 1.0\ W_t + 1.0\ P_t$ is satisfied.

(3) The ultimate strength of the South Wall exceeds the loading from missile impact (refer to Alternate Calculations in Attachment B).

East Wall:

(4) The East Wall is qualified in accordance with ACI 349-97.

(5) The design of the East Wall is governed by tornado wind and missile loading by comparison to SSE loading.

(6) The ultimate strength of the East Wall exceeds the applied tornado wind and pressure drop loads. The load combination, $C = D + L + 1.0\ W_t + 1.0\ P_t$ is satisfied.

(7) Overall failure of the East Wall will not occur due to missile impact.

Conclusions

The south and east walls of the CR3 Auxiliary Building are adequate for loading from the design basis tornado loads and load combinations.

References

1. FSAR Section 5

2. DBD for Major Class I Structures (TAB: 1/3)

3. Wang and Salmon, "Reinforced Concrete Design", 4th Edition

4. G/C Calc Book 4.01.1 to 4.01.7 and 2.01.55

5. ASCE Paper 3269, "Wind Forces on Structures", Vol 126, Part II, 1961

6. SER dated 7-5-1974

7. DBD for the Containment (TAB: 1/1)

8. ASCE Manuals and Reports on Engineering Practice No. 58, “Structural Analysis and Design of Nuclear Plant Facilities”

9. Dwg SC-422-019

10. Dwg SC-422-021

11. ACI Standard 318-63

12. ASCE, "Civil Engineering and Nuclear Power, Vol. V: Report of the ASCE Committee on Impactive and Impulsive Loads"

13. ACI 349-97, “Code Requirements for Nuclear Safety Related Concrete Structures and Commentary”

14. Biggs, "Introduction to Structural Dynamics"

15. Timoshenko, "Theory of Plates and Shells", 1940

16. SP-5209, "CR-3 Seismic Qualification," Rev. 0

17. NUREG-0800, "U.S. Nuclear Regulatory Commission Standard Review Plan," Revision 3, March 2007

18. Regulatory Guide 1.142, "Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)," Revision 2, November 2001

Florida	MADE [illegible] / CHKD [illegible] / BO. OF.	GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PENNA.
Control Building	CH. OFN. / ENG.	4203 (WORK ORDER) · 4.01.1 (SIZE DRAWING) · 17
Tornado Analysis	REV. CH. APP. DATE	

Reference: Engineer (Engineers Joint Council) May-June 1969.
"Auto Safety Engineering Moves to the Side of the Road": describes energy absorbing barriers - reference to work at Tex. A & M Univ., Texas Transportation Institute under Dr. Teddy J. Hirsch. Called Dr. Hirsch, 9-4-69:

Ref: Analytical Approach to Auto Collisions by Richard I. Emori, U. of Calif., SAE Paper 680016, Jan. '68

This author sees the car as a lumped mass and a spring. His conclusion for a car travelling up to 60 mph. hitting an immovable barrier is that the max. deceleration in g's = 0.9 V (V is velocity in mph). Since the variation is sinusoidal, the average g force is the max. $\times \frac{2}{\pi}$ = .574 V

These conclusions are regardless of make or size of car and have been verified ±20% in tests by Hirsch.

Our case of a 2000 lb car at 150 mph requires some extrapolation:

Max. Accel. = .9 V = .9 × 150 = 135 g

Avg. Accel. = $135 \times \frac{2}{\pi}$ = 86 g

Max. Force = $\frac{w}{g}a$ = 2000 × 135 = 270,000 lb, varies sinusoidally

Avg. Force = $270{,}000 \times \frac{2}{\pi}$ = 172,000 lb

also: spring stiffness k = 12.5 × wt of vehicle
= 12.5 × 2000 = 25,000 lb/ft

duration of force, t = 0.081 sec (constant for all collisions) - ?

Dr. Hirsch also suggests that the probability of the pole hitting end-on and straight (axial velocity) is very remote and that the wood would crush before the concrete.

ATTACHMENT B

Description

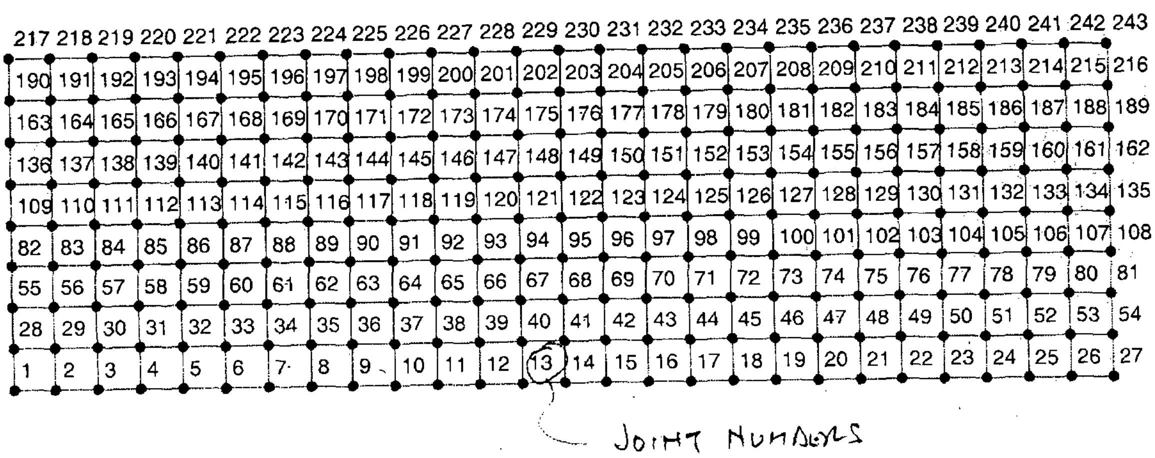
This attachment contains an alternative method to check the Auxiliary Bldg 3-ft South Wall for missile impact only. This alternative method was generated by the Design Verifier.

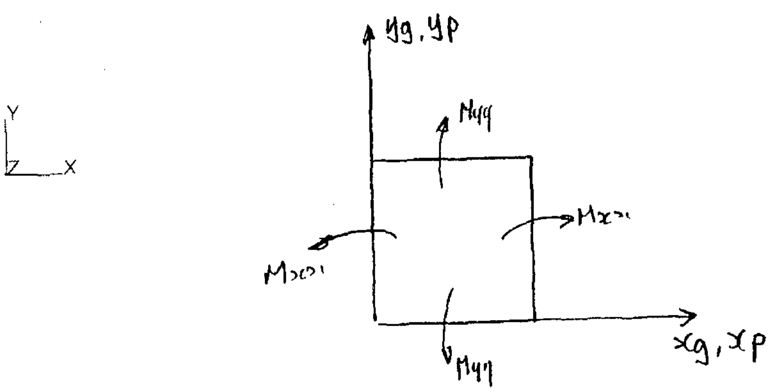
A GT STRUDL Finite Element Model was generated of the wall and the static impact load of 270 kip was distributed over an impact area of 6' x 6'.

Conclusion

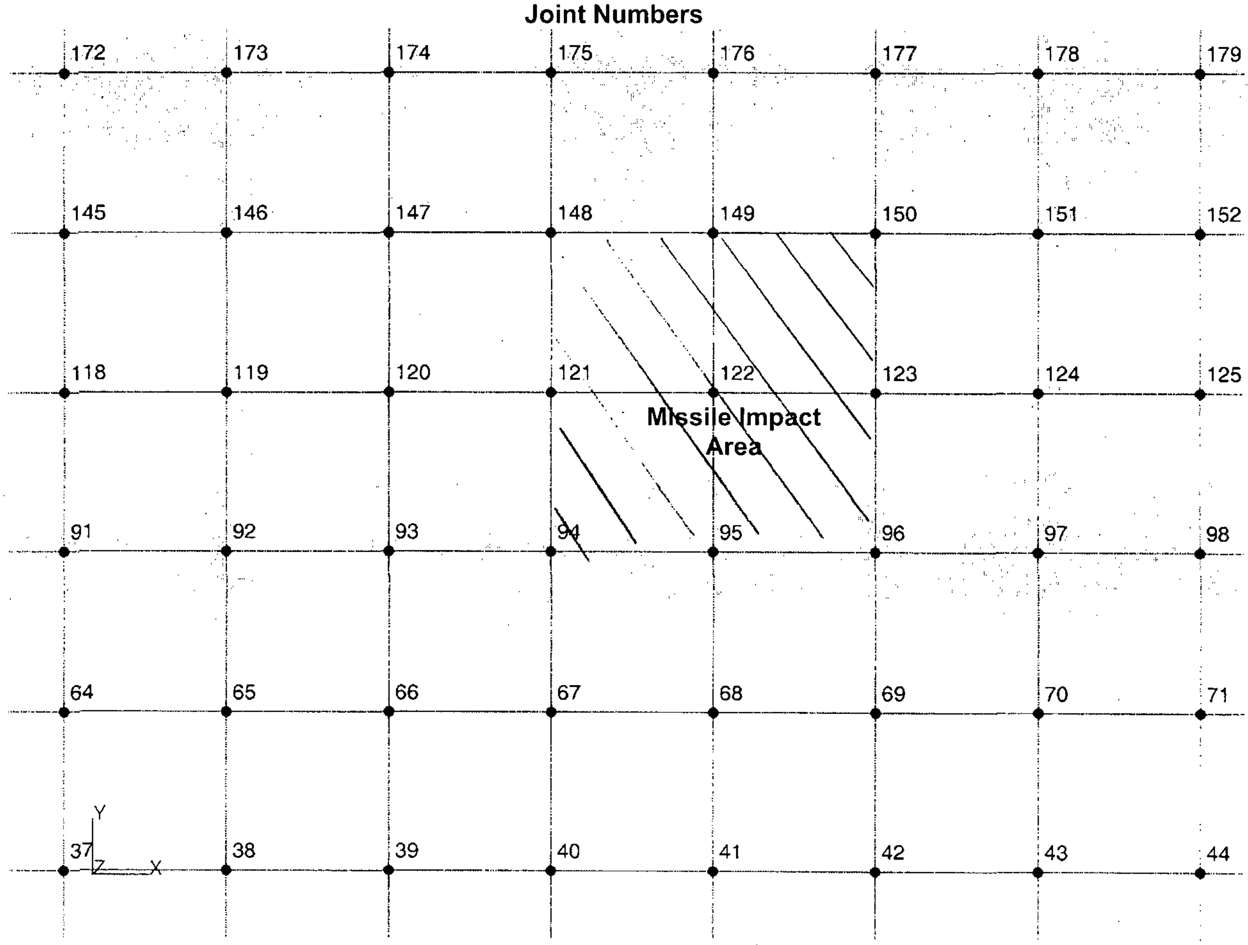
The 3-ft thick South Auxiliary Bldg Wall is adequate to resist the missile impact load within the elastic limits.

Finite Element Model for 3' thick South Aux Building Wall





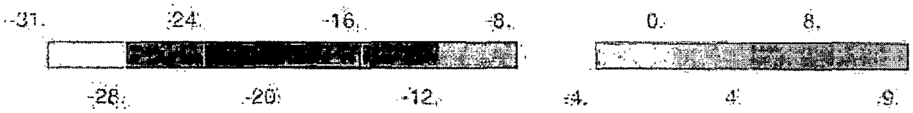
Finite Element Model for 3' thick South Aux Building Wall
Joint Numbers



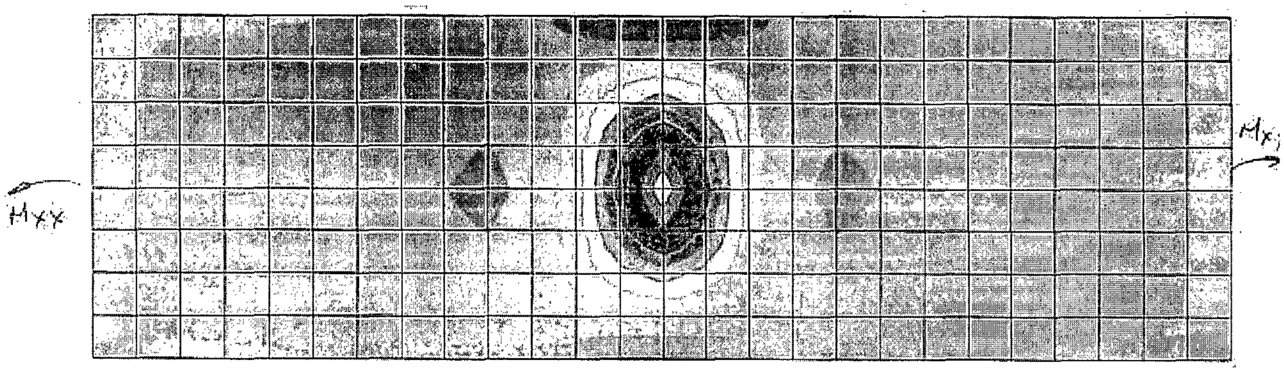
Finite Element Model for 3' thick South Aux Building Wall

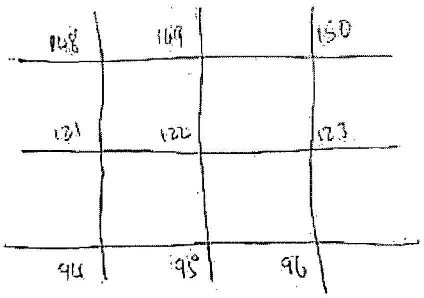
$M_{NX} = 59.71\ k'/i$

$$M_u \simeq \begin{bmatrix} 149 \\ 122 \\ 95 \end{bmatrix}_{\text{NODE}} \begin{bmatrix} 24.11 \\ 31.20 \\ 24.11 \end{bmatrix}_{k'/i} \rightarrow \begin{bmatrix} 27.66 \\ 27.66 \end{bmatrix}_{\text{AVERAGE}}$$



SINCE 27.66 k'/i < 59.71 k'/i O.K.

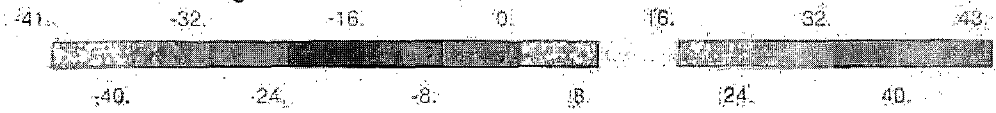




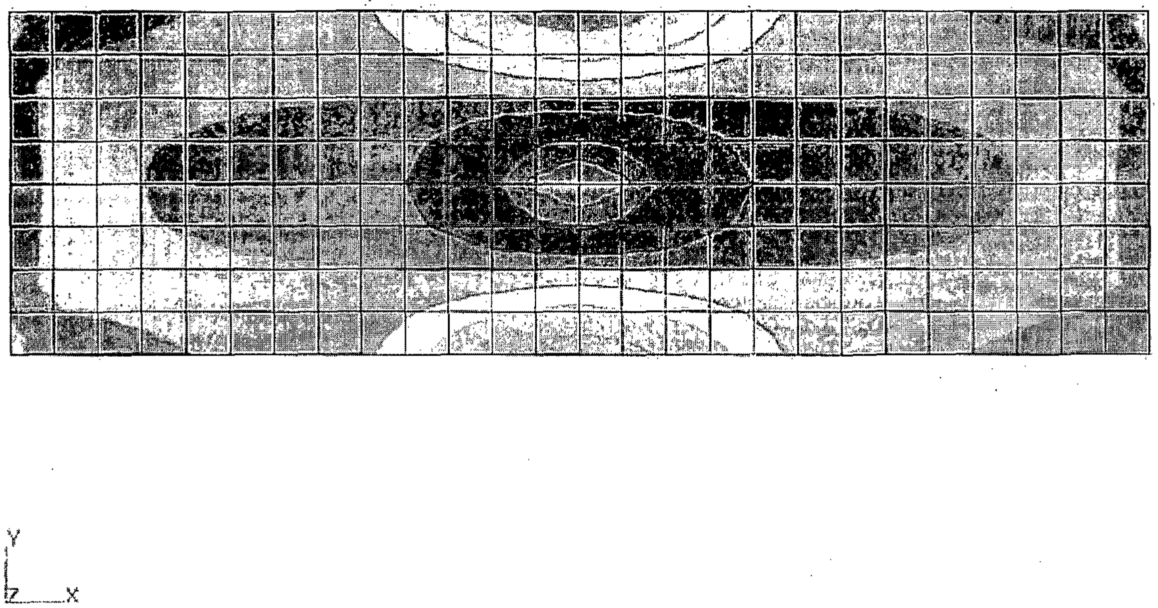
Finite Element Model for 3' thick South Aux Building Wall

$M_{NY} = 58.13$ k'/l

	Node	k'/l		Average
M_u =	121	34.35	→	37.66
	122	40.96		37.66
	123	34.35		



Since 37.66 k'/l < 58.13 k'/l O.K.



DESIGN VERIFICATION REVIEW: ALTERNATE CALCULATION METHOD FOR MISSILE LOAD

This attachment presents the GT STRUDL analysis for a 3-ft thick flat plate with an impact loading on a 6-ft square area.

As per FSAR Section 5.2.1.2.6, the tornado missile (compact auto) impact area is

A = 6.25 ft^2

Equivalent square dimension, S = SQRT (A)
= SQRT (6.25)
= 2.5 ft
= 30 in

Conservatively using a 3-ft thick wall and a 45 degree line from periphery of the load to the rebar

Face of wall to re-bar, d = 2.75 ft
Distributed load dimension, L = S + 2 d
= 2.5 + 2 * 2.75
= 8.0 ft
USE = 6.0 ft — 3-ft square element nos. 91, 92, 117 and 118 (see page B17)

Impact force for Compact Auto Missile, F = 270.0 kips — See Attachment A
Surface load, p_z = F / L^2
= 270.0 / 6.0 ^2
= 7.5 k/ ft^3 (see page B17)

The maximum bending stress occurs at Joint 122 (see page B46). The average nodal bending stress is at the centroid of each element which is tabulated below.

Jt No.	M_{YY}	AVG M_{YY}	Ref. Page
120	-22.3739		B46
		-28.3610	
121	-34.3482		B46
		-37.6556	
122	-40.963		B46
		-37.6556	
123	-34.3482		B46
		-28.3610	
124	-22.3739		B46
MAX		-37.7	

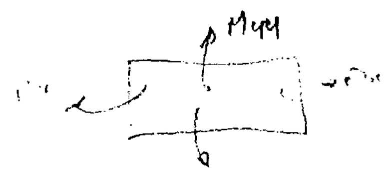
Jt No.	M_{XX}	AVG M_{XX}	Ref. Page
176	-10.6514		B49
		-17.3808	
149	-24.1102		B47
		-27.65	
122	-31.1898		B46
		-27.65	
95	-24.1102		B44
		-17.3808	
68	-10.6514		B43
MAX		-27.7	

The maximum bending moment due to impact of Automobile Missile is 37.7 ft-kip / ft. **Use 37.5 ft-kip / ft.**

$W_{MISSILE}$ = 37.5 ft-kip / ft

This attachment contains the following application:

a. The analysis is in accordance with the Ultimate Strength Design presented in the ACI Code; therefore, the Auxiliary Build South Wall is qualified by elastic (linear) analysis.



37.5 K'/1 M44
27.6 K'/1 Mxx


```
# Thu Sep 20 07:56:46 2007


IGTICES/C-NP 2.5.0 MD-NT 2.0, January 1995.
 Proprietary to Georgia Tech Research Corporation, U.S.A.

Reading password file D:\GTStrudl\27\password27.pwd
 CI-i-audfile, Command AUDIT file FILE0756.aud has been activated.

 *** G T S T R U D L ***
    RELEASE DATE          VERSION              COMPLETION NO.
    June, 2003            27.0                     4449

 **** ACTIVE UNITS -  LENGTH   WEIGHT   ANGLE    TEMPERATURE   TIME
 **** ASSUMED TO BE     INCH    POUND   RADIAN    FAHRENHEIT   SECOND


 {     1} > $ -----------------------------------------------------------
 {     2} > $ This is the Common Startup Macro; put your company-wide startup commands here.
 {     3} > $ You can edit this file from Tools -- Macros.  Click "Startup" and then "Edit".
 {     4} > $ -----------------------------------------------------------
 {     5} > CINPUT 'T:\Gtstrudl\in\SouthWall_missile.txt'
 {     6} > *TITLE 'AB south wall missile'
 {     7} > STRUDL 'FILENAME=AB South wall missile'



  **********************************************************************
  *                                                                    *
  *    ******                     G T S T R U D L                      *
  *   ********                                                         *
```

Calculation No. S07-0037 Revision 0
Attachment B
Page B6

```
*  **    **                                                          *
*  **             *****  ******  *****   **  **  *****   **          *
*  **  ********** ****** ******  ******  **  **  ******  **          *
*  **  ********** **       **    **  **  **  **  **  **  **          *
*  **     ****    *****    **    ******  **  **  **  **  **          *
*  **********      *****   **    *****   **  **  **  **  **          *
*   ****** **         **   **    ** **   **  **  **  **  **          *
*          **     ******   **    **  **  ******  ******  ******      *
*          **     *****    **    **  **   ****   *****   ******      *
*          **                                                        *
*          **              OWNED BY AND PROPRIETARY TO THE           *
*          **              GEORGIA TECH RESEARCH CORPORATION         *
*                                                                    *
*  RELEASE DATE          VERSION             COMPLETION NO.          *
*  June, 2003            27.0                     4449               *
*                                                                    *
**********************************************************************
```

```
**** ACTIVE UNITS -  LENGTH   WEIGHT   ANGLE     TEMPERATURE   TIME
**** ASSUMED TO BE    INCH     POUND   RADIAN     FAHRENHEIT   SECOND

{    8} > TYP plate
{    9} > UNIT ft LBS DEG
{   10} > JOI COO
{   11} > generate 27 joints id 1 1 x 0.0 INCR 3
```

/------- CARTESIAN COORDINATES FREE, GLOBAL -------/

JOINT	X	Y	Z
1	0.000	0.000	0.000
2	3.000	0.000	0.000
3	6.000	0.000	0.000
4	9.000	0.000	0.000
5	12.000	0.000	0.000
6	15.000	0.000	0.000
7	18.000	0.000	0.000
8	21.000	0.000	0.000
9	24.000	0.000	0.000
10	27.000	0.000	0.000
11	30.000	0.000	0.000
12	33.000	0.000	0.000
13	36.000	0.000	0.000
14	39.000	0.000	0.000
15	42.000	0.000	0.000
16	45.000	0.000	0.000
17	48.000	0.000	0.000
18	51.000	0.000	0.000
19	54.000	0.000	0.000
20	57.000	0.000	0.000
21	60.000	0.000	0.000

22	63.000	0.000	0.000
23	66.000	0.000	0.000
24	69.000	0.000	0.000
25	72.000	0.000	0.000
26	75.000	0.000	0.000
27	78.000	0.000	0.000

{ 12} > repeat 8 times id incr 27 y incr 3

/------- CARTESIAN COORDINATES FREE, GLOBAL -------/

JOINT	X	Y	Z
28	0.000	3.000	0.000
29	3.000	3.000	0.000
30	6.000	3.000	0.000
31	9.000	3.000	0.000
32	12.000	3.000	0.000
33	15.000	3.000	0.000
34	18.000	3.000	0.000
35	21.000	3.000	0.000
36	24.000	3.000	0.000
37	27.000	3.000	0.000
38	30.000	3.000	0.000
39	33.000	3.000	0.000
40	36.000	3.000	0.000
41	39.000	3.000	0.000
42	42.000	3.000	0.000
43	45.000	3.000	0.000
44	48.000	3.000	0.000
45	51.000	3.000	0.000
46	54.000	3.000	0.000
47	57.000	3.000	0.000
48	60.000	3.000	0.000
49	63.000	3.000	0.000
50	66.000	3.000	0.000
51	69.000	3.000	0.000
52	72.000	3.000	0.000
53	75.000	3.000	0.000
54	78.000	3.000	0.000
55	0.000	6.000	0.000
56	3.000	6.000	0.000
57	6.000	6.000	0.000
58	9.000	6.000	0.000
59	12.000	6.000	0.000
60	15.000	6.000	0.000
61	18.000	6.000	0.000
62	21.000	6.000	0.000
63	24.000	6.000	0.000
64	27.000	6.000	0.000
65	30.000	6.000	0.000
66	33.000	6.000	0.000
67	36.000	6.000	0.000

Calculation No. S07-0037 Revision 0
Attachment B
Page B8

68	39.000	6.000	0.000
69	42.000	6.000	0.000
70	45.000	6.000	0.000
71	48.000	6.000	0.000
72	51.000	6.000	0.000
73	54.000	6.000	0.000
74	57.000	6.000	0.000
75	60.000	6.000	0.000
76	63.000	6.000	0.000
77	66.000	6.000	0.000
78	69.000	6.000	0.000
79	72.000	6.000	0.000
80	75.000	6.000	0.000
81	78.000	6.000	0.000
82	0.000	9.000	0.000
83	3.000	9.000	0.000
84	6.000	9.000	0.000
85	9.000	9.000	0.000
86	12.000	9.000	0.000
87	15.000	9.000	0.000
88	18.000	9.000	0.000
89	21.000	9.000	0.000
90	24.000	9.000	0.000
91	27.000	9.000	0.000
92	30.000	9.000	0.000
93	33.000	9.000	0.000
94	36.000	9.000	0.000
95	39.000	9.000	0.000
96	42.000	9.000	0.000
97	45.000	9.000	0.000
98	48.000	9.000	0.000
99	51.000	9.000	0.000
100	54.000	9.000	0.000
101	57.000	9.000	0.000
102	60.000	9.000	0.000
103	63.000	9.000	0.000
104	66.000	9.000	0.000
105	69.000	9.000	0.000
106	72.000	9.000	0.000
107	75.000	9.000	0.000
108	78.000	9.000	0.000
109	0.000	12.000	0.000
110	3.000	12.000	0.000
111	6.000	12.000	0.000
112	9.000	12.000	0.000
113	12.000	12.000	0.000
114	15.000	12.000	0.000
115	18.000	12.000	0.000
116	21.000	12.000	0.000
117	24.000	12.000	0.000
118	27.000	12.000	0.000
119	30.000	12.000	0.000

120	33.000	12.000	0.000
121	36.000	12.000	0.000
122	39.000	12.000	0.000
123	42.000	12.000	0.000
124	45.000	12.000	0.000
125	48.000	12.000	0.000
126	51.000	12.000	0.000
127	54.000	12.000	0.000
128	57.000	12.000	0.000
129	60.000	12.000	0.000
130	63.000	12.000	0.000
131	66.000	12.000	0.000
132	69.000	12.000	0.000
133	72.000	12.000	0.000
134	75.000	12.000	0.000
135	78.000	12.000	0.000
136	0.000	15.000	0.000
137	3.000	15.000	0.000
138	6.000	15.000	0.000
139	9.000	15.000	0.000
140	12.000	15.000	0.000
141	15.000	15.000	0.000
142	18.000	15.000	0.000
143	21.000	15.000	0.000
144	24.000	15.000	0.000
145	27.000	15.000	0.000
146	30.000	15.000	0.000
147	33.000	15.000	0.000
148	36.000	15.000	0.000
149	39.000	15.000	0.000
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151	45.000	15.000	0.000
152	48.000	15.000	0.000
153	51.000	15.000	0.000
154	54.000	15.000	0.000
155	57.000	15.000	0.000
156	60.000	15.000	0.000
157	63.000	15.000	0.000
158	66.000	15.000	0.000
159	69.000	15.000	0.000
160	72.000	15.000	0.000
161	75.000	15.000	0.000
162	78.000	15.000	0.000
163	0.000	18.000	0.000
164	3.000	18.000	0.000
165	6.000	18.000	0.000
166	9.000	18.000	0.000
167	12.000	18.000	0.000
168	15.000	18.000	0.000
169	18.000	18.000	0.000
170	21.000	18.000	0.000
171	24.000	18.000	0.000

172	27.000	18.000	0.000
173	30.000	18.000	0.000
174	33.000	18.000	0.000
175	36.000	18.000	0.000
176	39.000	18.000	0.000
177	42.000	18.000	0.000
178	45.000	18.000	0.000
179	48.000	18.000	0.000
180	51.000	18.000	0.000
181	54.000	18.000	0.000
182	57.000	18.000	0.000
183	60.000	18.000	0.000
184	63.000	18.000	0.000
185	66.000	18.000	0.000
186	69.000	18.000	0.000
187	72.000	18.000	0.000
188	75.000	18.000	0.000
189	78.000	18.000	0.000
190	0.000	21.000	0.000
191	3.000	21.000	0.000
192	6.000	21.000	0.000
193	9.000	21.000	0.000
194	12.000	21.000	0.000
195	15.000	21.000	0.000
196	18.000	21.000	0.000
197	21.000	21.000	0.000
198	24.000	21.000	0.000
199	27.000	21.000	0.000
200	30.000	21.000	0.000
201	33.000	21.000	0.000
202	36.000	21.000	0.000
203	39.000	21.000	0.000
204	42.000	21.000	0.000
205	45.000	21.000	0.000
206	48.000	21.000	0.000
207	51.000	21.000	0.000
208	54.000	21.000	0.000
209	57.000	21.000	0.000
210	60.000	21.000	0.000
211	63.000	21.000	0.000
212	66.000	21.000	0.000
213	69.000	21.000	0.000
214	72.000	21.000	0.000
215	75.000	21.000	0.000
216	78.000	21.000	0.000
217	0.000	24.000	0.000
218	3.000	24.000	0.000
219	6.000	24.000	0.000
220	9.000	24.000	0.000
221	12.000	24.000	0.000
222	15.000	24.000	0.000
223	18.000	24.000	0.000

224	21.000	24.000	0.000
225	24.000	24.000	0.000
226	27.000	24.000	0.000
227	30.000	24.000	0.000
228	33.000	24.000	0.000
229	36.000	24.000	0.000
230	39.000	24.000	0.000
231	42.000	24.000	0.000
232	45.000	24.000	0.000
233	48.000	24.000	0.000
234	51.000	24.000	0.000
235	54.000	24.000	0.000
236	57.000	24.000	0.000
237	60.000	24.000	0.000
238	63.000	24.000	0.000
239	66.000	24.000	0.000
240	69.000	24.000	0.000
241	72.000	24.000	0.000
242	75.000	24.000	0.000
243	78.000	24.000	0.000

```
{    13} >
{    14} > type plate
{    15} > generate 26 elements id 1 1 from 1 incr 1 to 2 incr 1 to 29 incr 1 to 28 incr 1
```

/---------------- ELEMENT INCIDENCES ----------------/

ELEMENT	INCIDENCES			
1	1	2	29	28
2	2	3	30	29
3	3	4	31	30
4	4	5	32	31
5	5	6	33	32
6	6	7	34	33
7	7	8	35	34
8	8	9	36	35
9	9	10	37	36
10	10	11	38	37
11	11	12	39	38
12	12	13	40	39
13	13	14	41	40
14	14	15	42	41
15	15	16	43	42
16	16	17	44	43
17	17	18	45	44
18	18	19	46	45
19	19	20	47	46
20	20	21	48	47
21	21	22	49	48
22	22	23	50	49
23	23	24	51	50
24	24	25	52	51
25	25	26	53	52

26	26	27	54	53

```
(    16) > repeat 7 id incr 26 from incr 27 to incr 27
```

/---------------- ELEMENT INCIDENCES ----------------/

ELEMENT	INCIDENCES			
27	28	29	56	55
28	29	30	57	56
29	30	31	58	57
30	31	32	59	58
31	32	33	60	59
32	33	34	61	60
33	34	35	62	61
34	35	36	63	62
35	36	37	64	63
36	37	38	65	64
37	38	39	66	65
38	39	40	67	66
39	40	41	68	67
40	41	42	69	68
41	42	43	70	69
42	43	44	71	70
43	44	45	72	71
44	45	46	73	72
45	46	47	74	73
46	47	48	75	74
47	48	49	76	75
48	49	50	77	76
49	50	51	78	77
50	51	52	79	78
51	52	53	80	79
52	53	54	81	80
53	55	56	83	82
54	56	57	84	83
55	57	58	85	84
56	58	59	86	85
57	59	60	87	86
58	60	61	88	87
59	61	62	89	88
60	62	63	90	89
61	63	64	91	90
62	64	65	92	91
63	65	66	93	92
64	66	67	94	93
65	67	68	95	94
66	68	69	96	95
67	69	70	97	96
68	70	71	98	97
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Calculation No. S07-0037 Revision 0
Attachment B
Page B14

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Calculation No. S07-0037 Revision 0
Attachment B
Page B15

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193	200	201	228	227
194	201	202	229	228
195	202	203	230	229
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203	210	211	238	237
204	211	212	239	238
205	212	213	240	239
206	213	214	241	240
207	214	215	242	241
208	215	216	243	242

```
>
> status supports 1 to 27 217 to 243 28 55 82 109 136 163 190 217 -
> 54 81 108 135 162 189 216 243
>
> element properties
> 1 to 208 type 'SBHQ6' THICKNESS 3.0
> material concrete all
> $CONSTANTS
> $E 3.6E6 ALL
> $DEN 0.087 ALL
> $POI 0.2 ALL
> units ft kips deg
> $
> $loading 1 'dead load'
> $element loads
> $1 to 208 body force global uniform by -0.150 $ (k/ft**3)
> $
>
> loading 2 'missile'
```

Calculation No. S07-0037 Revision 0
Attachment B
Page B16

```
{   36} > element loads
{   37} > 91 to 92 117 to 118 surface force global pz -7.5 $ (k/ft**2)
{   38} >
{   39} > $
{   40} > units ft kips deg
{   41} > print structural data

****************************************
*  PROBLEM DATA FROM INTERNAL STORAGE  *
****************************************
```

JOB ID - FILENAME   JOB TITLE - NONE GIVEN

ACTIVE UNITS -	LENGTH	WEIGHT	ANGLE	TEMPERATURE	TIME
	FEET	KIP	DEG	DEGF	SEC

********** STRUCTURAL DATA **********

JOINT COORDINATES---------------------------------------/ STATUS---/

JOINT	X	Y	Z	CONDITION		
1	0.000	0.000	0.000	SUPPORT	ACTIVE	GLOBAL
2	3.000	0.000	0.000	SUPPORT	ACTIVE	GLOBAL
3	6.000	0.000	0.000	SUPPORT	ACTIVE	GLOBAL
4	9.000	0.000	0.000	SUPPORT	ACTIVE	GLOBAL
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6	15.000	0.000	0.000	SUPPORT	ACTIVE	GLOBAL
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25	72.000	0.000	0.000	SUPPORT	ACTIVE	GLOBAL
26	75.000	0.000	0.000	SUPPORT	ACTIVE	GLOBAL
27	78.000	0.000	0.000	SUPPORT	ACTIVE	GLOBAL
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30	6.000	3.000	0.000	FREE	ACTIVE	GLOBAL
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Calculation No. S07-0037 Revision 0
Attachment B
Page B18

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242	75.000	24.000	0.000	SUPPORT	ACTIVE	GLOBAL
243	78.000	24.000	0.000	SUPPORT	ACTIVE	GLOBAL

ELEMENT INCIDENCES--/

0ELEMENT	NODES				
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38	39	40	67	66	ACTIVE
39	40	41	68	67	ACTIVE
40	41	42	69	68	ACTIVE
41	42	43	70	69	ACTIVE
42	43	44	71	70	ACTIVE
43	44	45	72	71	ACTIVE
44	45	46	73	72	ACTIVE
45	46	47	74	73	ACTIVE
46	47	48	75	74	ACTIVE

Calculation No. S07-0037 Revision 0
Attachment B
Page B22

47	48	49	76	75	ACTIVE
48	49	50	77	76	ACTIVE
49	50	51	78	77	ACTIVE
50	51	52	79	78	ACTIVE
51	52	53	80	79	ACTIVE
52	53	54	81	80	ACTIVE
53	55	56	83	82	ACTIVE
54	56	57	84	83	ACTIVE
55	57	58	85	84	ACTIVE
56	58	59	86	85	ACTIVE
57	59	60	87	86	ACTIVE
58	60	61	88	87	ACTIVE
59	61	62	89	88	ACTIVE
60	62	63	90	89	ACTIVE
61	63	64	91	90	ACTIVE
62	64	65	92	91	ACTIVE
63	65	66	93	92	ACTIVE
64	66	67	94	93	ACTIVE
65	67	68	95	94	ACTIVE
66	68	69	96	95	ACTIVE
67	69	70	97	96	ACTIVE
68	70	71	98	97	ACTIVE
69	71	72	99	98	ACTIVE
70	72	73	100	99	ACTIVE
71	73	74	101	100	ACTIVE
72	74	75	102	101	ACTIVE
73	75	76	103	102	ACTIVE
74	76	77	104	103	ACTIVE
75	77	78	105	104	ACTIVE
76	78	79	106	105	ACTIVE
77	79	80	107	106	ACTIVE
78	80	81	108	107	ACTIVE
79	82	83	110	109	ACTIVE
80	83	84	111	110	ACTIVE
81	84	85	112	111	ACTIVE
82	85	86	113	112	ACTIVE
83	86	87	114	113	ACTIVE
84	87	88	115	114	ACTIVE
85	88	89	116	115	ACTIVE
86	89	90	117	116	ACTIVE
87	90	91	118	117	ACTIVE
88	91	92	119	118	ACTIVE
89	92	93	120	119	ACTIVE
90	93	94	121	120	ACTIVE
91	94	95	122	121	ACTIVE
92	95	96	123	122	ACTIVE
93	96	97	124	123	ACTIVE
94	97	98	125	124	ACTIVE
95	98	99	126	125	ACTIVE
96	99	100	127	126	ACTIVE
97	100	101	128	127	ACTIVE
98	101	102	129	128	ACTIVE
99	102	103	130	129	ACTIVE
100	103	104	131	130	ACTIVE

101	104	105	132	131	ACTIVE
102	105	106	133	132	ACTIVE
103	106	107	134	133	ACTIVE
104	107	108	135	134	ACTIVE
105	109	110	137	136	ACTIVE
106	110	111	138	137	ACTIVE
107	111	112	139	138	ACTIVE
108	112	113	140	139	ACTIVE
109	113	114	141	140	ACTIVE
110	114	115	142	141	ACTIVE
111	115	116	143	142	ACTIVE
112	116	117	144	143	ACTIVE
113	117	118	145	144	ACTIVE
114	118	119	146	145	ACTIVE
115	119	120	147	146	ACTIVE
116	120	121	148	147	ACTIVE
117	121	122	149	148	ACTIVE
118	122	123	150	149	ACTIVE
119	123	124	151	150	ACTIVE
120	124	125	152	151	ACTIVE
121	125	126	153	152	ACTIVE
122	126	127	154	153	ACTIVE
123	127	128	155	154	ACTIVE
124	128	129	156	155	ACTIVE
125	129	130	157	156	ACTIVE
126	130	131	158	157	ACTIVE
127	131	132	159	158	ACTIVE
128	132	133	160	159	ACTIVE
129	133	134	161	160	ACTIVE
130	134	135	162	161	ACTIVE
131	136	137	164	163	ACTIVE
132	137	138	165	164	ACTIVE
133	138	139	166	165	ACTIVE
134	139	140	167	166	ACTIVE
135	140	141	168	167	ACTIVE
136	141	142	169	168	ACTIVE
137	142	143	170	169	ACTIVE
138	143	144	171	170	ACTIVE
139	144	145	172	171	ACTIVE
140	145	146	173	172	ACTIVE
141	146	147	174.	173	ACTIVE
142	147	148	175	174	ACTIVE
143	148	149	176	175	ACTIVE
144	149	150	177	176	ACTIVE
145	150	151	178	177	ACTIVE
146	151	152	179	178	ACTIVE
147	152	153	180	179	ACTIVE
148	153	154	181	180	ACTIVE
149	154	155	182	181	ACTIVE
150	155	156	183	182	ACTIVE
151	156	157	184	183	ACTIVE
152	157	158	185	184	ACTIVE
153	158	159	186	185	ACTIVE
154	159	160	187	186	ACTIVE

155	160	161	188	187	ACTIVE
156	161	162	189	188	ACTIVE
157	163	164	191	190	ACTIVE
158	164	165	192	191	ACTIVE
159	165	166	193	192	ACTIVE
160	166	167	194	193	ACTIVE
161	167	168	195	194	ACTIVE
162	168	169	196	195	ACTIVE
163	169	170	197	196	ACTIVE
164	170	171	198	197	ACTIVE
165	171	172	199	198	ACTIVE
166	172	173	200	199	ACTIVE
167	173	174	201	200	ACTIVE
168	174	175	202	201	ACTIVE
169	175	176	203	202	ACTIVE
170	176	177	204	203	ACTIVE
171	177	178	205	204	ACTIVE
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173	179	180	207	206	ACTIVE
174	180	181	208	207	ACTIVE
175	181	182	209	208	ACTIVE
176	182	183	210	209	ACTIVE
177	183	184	211	210	ACTIVE
178	184	185	212	211	ACTIVE
179	185	186	213	212	ACTIVE
180	186	187	214	213	ACTIVE
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182	188	189	216	215	ACTIVE
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184	191	192	219	218	ACTIVE
185	192	193	220	219	ACTIVE
186	193	194	221	220	ACTIVE
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190	197	198	225	224	ACTIVE
191	198	199	226	225	ACTIVE
192	199	200	227	226	ACTIVE
193	200	201	228	227	ACTIVE
194	201	202	229	228	ACTIVE
195	202	203	230	229	ACTIVE
196	203	204	231	230	ACTIVE
197	204	205	232	231	ACTIVE
198	205	206	233	232	ACTIVE
199	206	207	234	233	ACTIVE
200	207	208	235	234	ACTIVE
201	208	209	236	235	ACTIVE
202	209	210	237	236	ACTIVE
203	210	211	238	237	ACTIVE
204	211	212	239	238	ACTIVE
205	212	213	240	239	ACTIVE
206	213	214	241	240	ACTIVE
207	214	215	242	241	ACTIVE
208	215	216	243	242	ACTIVE

ELEMENT PROPERTIES--(* THE PROPERTIES OF THE CABLE ELEMENT ARE LENGTH AND AX *)-------/

0ELEMENT	TYPE	THICKNESS OR LENGTH	/-----CURVATURES OR AX-----/ K1	K2	K12	/-------------THERMAL EXPANSION COEFFICIENTS---------------/ CAX	CAY	CAZ	CSXY	CSXZ	CSYZ
1	SBHQ6	3.000									
2	SBHQ6	3.000									
3	SBHQ6	3.000									
4	SBHQ6	3.000									
5	SBHQ6	3.000									
6	SBHQ6	3.000									
7	SBHQ6	3.000									
8	SBHQ6	3.000									
9	SBHQ6	3.000									
10	SBHQ6	3.000									
11	SBHQ6	3.000									
12	SBHQ6	3.000									
13	SBHQ6	3.000									
14	SBHQ6	3.000									
15	SBHQ6	3.000									
16	SBHQ6	3.000									
17	SBHQ6	3.000									
18	SBHQ6	3.000									
19	SBHQ6	3.000									
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36	SBHQ6	3.000									
37	SBHQ6	3.000									
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201	SBHQ6	3.000
202	SBHQ6	3.000
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204	SBHQ6	3.000
205	SBHQ6	3.000
206	SBHQ6	3.000
207	SBHQ6	3.000
208	SBHQ6	3.000

MEMBER CONSTANTS---/

0CONSTANT	STANDARD VALUE	DOMAIN	VALUE	MEMBER LIST
E	0.518400E+06	ALL		
G	0.207360E+06	ALL		
DENSITY	0.149990E+00	ALL		
CTE	0.550000E-05	ALL		
BETA	0.000000E+00	ALL		
POISSON	0.170000E+00	ALL		
DAMP STI	0.000000E+00	ALL		
DAMP INE	0.000000E+00	ALL		

CURVED ELEMENT DATA---/

CURVED ELEMENT SPECIFICATIONS---/

ELEMENT TYPE SPECIFICATIONS--/

**** NO SHAPE DATA FOUND FOR MEMBER LIST SPECIFIED

CURVED ELEMENT PROPERTIES---/

ELEMENT TYPE PROPERTIES--/

CURVED ELEMENT END CONDITIONS---/

ELEMENT TYPE ECCENTRICITIES--/

		START			END	
	X	Y	Z	X	Y	Z

Calculation No. S07-0037 Revision 0
Attachment B
Page B30

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****************************************
*  END OF DATA FROM  INTERNAL STORAGE  *
****************************************

{    42} > STIFFNESS ANALYSIS


BANDWIDTH INFORMATION BEFORE RENUMBERING.


THE MAXIMUM BANDWIDTH IS      26 AND OCCURS AT JOINT 57
THE AVERAGE BANDWIDTH IS                       22.389
THE STANDARD DEVIATION OF THE BANDWIDTH IS      8.750
                                           ----------
                                               31.139
                                           ==========


BANDWIDTH INFORMATION AFTER  RENUMBERING.


THE MAXIMUM BANDWIDTH IS       8 AND OCCURS AT JOINT 57
THE AVERAGE BANDWIDTH IS                        7.577
THE STANDARD DEVIATION OF THE BANDWIDTH IS      1.416
                                           ----------
                                                8.993
                                           ==========
TIME FOR CONSISTENCY CHECKS FOR    208 MEMBERS       0.01 SECONDS
TIME FOR BANDWIDTH REDUCTION                         0.02 SECONDS
TIME TO GENERATE     208 ELEMENT STIF. MATRICES      0.17 SECONDS
TIME TO PROCESS         4 MEMBER LOADS               0.00 SECONDS
TIME TO ASSEMBLE THE STIFFNESS MATRIX                0.06 SECONDS
TIME TO PROCESS    243 JOINTS                        0.00 SECONDS
TIME TO SOLVE WITH   25 PARTITIONS                   0.10 SECONDS
TIME TO PROCESS    243 JOINT DISPLACEMENTS           0.00 SECONDS
TIME TO PROCESS    208 ELEMENT STRESSES              0.03 SECONDS
TIME TO PROCESS    208 ELEMENT REACTIONS             0.03 SECONDS
TIME FOR STATICS CHECK                               0.00 SECONDS
{    43} > $
{    44} > LOAD LIST ALL
{    45} > OUTPUT DEC 3
{    46} > OUTPUT BY loading
{    47} > LIST REA ALL
1
   ****************************
   *RESULTS OF LATEST ANALYSES*
   ****************************
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PROBLEM - FILENAME TITLE - NONE GIVEN

ACTIVE UNITS FEET KIP DEG DEGF SEC

--- LOADING - 2 missile ---

RESULTANT JOINT LOADS SUPPORTS

JOINT		FORCE			MOMENT		
		X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
1	GLOBAL	0.000	0.000	0.034	0.009	-0.009	0.000
2	GLOBAL	0.000	0.000	-0.012	-0.093	-0.009	0.000
3	GLOBAL	0.000	0.000	-0.163	-0.293	0.010	0.000
4	GLOBAL	0.000	0.000	-0.342	-0.373	0.097	0.000
5	GLOBAL	0.000	0.000	-0.557	-0.089	0.285	0.000
6	GLOBAL	0.000	0.000	-0.786	0.987	0.635	0.000
7	GLOBAL	0.000	0.000	-0.937	3.601	1.234	0.000
8	GLOBAL	0.000	0.000	-0.780	8.952	2.174	0.000
9	GLOBAL	0.000	0.000	0.169	18.775	3.497	0.000
10	GLOBAL	0.000	0.000	2.779	35.138	5.062	0.000
11	GLOBAL	0.000	0.000	8.249	59.432	6.335	0.000
12	GLOBAL	0.000	0.000	17.177	89.790	6.309	0.000
13	GLOBAL	0.000	0.000	27.116	117.673	4.075	0.000
14	GLOBAL	0.000	0.000	31.741	129.408	0.000	0.000
15	GLOBAL	0.000	0.000	27.116	117.673	-4.075	0.000
16	GLOBAL	0.000	0.000	17.177	89.790	-6.309	0.000
17	GLOBAL	0.000	0.000	8.249	59.432	-6.335	0.000
18	GLOBAL	0.000	0.000	2.779	35.138	-5.062	0.000
19	GLOBAL	0.000	0.000	0.169	18.775	-3.497	0.000
20	GLOBAL	0.000	0.000	-0.780	8.952	-2.174	0.000
21	GLOBAL	0.000	0.000	-0.937	3.601	-1.234	0.000
22	GLOBAL	0.000	0.000	-0.786	0.987	-0.635	0.000
23	GLOBAL	0.000	0.000	-0.557	-0.089	-0.285	0.000
24	GLOBAL	0.000	0.000	-0.342	-0.373	-0.097	0.000
25	GLOBAL	0.000	0.000	-0.163	-0.293	-0.010	0.000
26	GLOBAL	0.000	0.000	-0.012	-0.093	0.009	0.000
27	GLOBAL	0.000	0.000	0.034	0.009	0.009	0.000
28	GLOBAL	0.000	0.000	-0.008	0.012	0.087	0.000
54	GLOBAL	0.000	0.000	-0.008	0.012	-0.087	0.000
55	GLOBAL	0.000	0.000	-0.101	0.017	0.252	0.000
81	GLOBAL	0.000	0.000	-0.101	0.017	-0.252	0.000
82	GLOBAL	0.000	0.000	-0.136	0.008	0.341	0.000
108	GLOBAL	0.000	0.000	-0.136	0.008	-0.341	0.000
109	GLOBAL	0.000	0.000	-0.143	0.000	0.365	0.000
135	GLOBAL	0.000	0.000	-0.143	0.000	-0.365	0.000

136	GLOBAL	0.000	0.000	-0.136	-0.008	0.341	0.000
162	GLOBAL	0.000	0.000	-0.136	-0.008	-0.341	0.000
163	GLOBAL	0.000	0.000	-0.101	-0.017	0.252	0.000
189	GLOBAL	0.000	0.000	-0.101	-0.017	-0.252	0.000
190	GLOBAL	0.000	0.000	-0.008	-0.012	0.087	0.000
216	GLOBAL	0.000	0.000	-0.008	-0.012	-0.087	0.000
217	GLOBAL	0.000	0.000	0.034	-0.009	-0.009	0.000
218	GLOBAL	0.000	0.000	-0.012	0.093	-0.009	0.000
219	GLOBAL	0.000	0.000	-0.163	0.293	0.010	0.000
220	GLOBAL	0.000	0.000	-0.342	0.373	0.097	0.000
221	GLOBAL	0.000	0.000	-0.557	0.089	0.285	0.000
222	GLOBAL	0.000	0.000	-0.786	-0.987	0.635	0.000
223	GLOBAL	0.000	0.000	-0.937	-3.601	1.234	0.000
224	GLOBAL	0.000	0.000	-0.780	-8.952	2.174	0.000
225	GLOBAL	0.000	0.000	0.169	-18.775	3.497	0.000
226	GLOBAL	0.000	0.000	2.779	-35.138	5.062	0.000
227	GLOBAL	0.000	0.000	8.249	-59.432	6.335	0.000
228	GLOBAL	0.000	0.000	17.177	-89.790	6.309	0.000
229	GLOBAL	0.000	0.000	27.116	-117.673	4.075	0.000
230	GLOBAL	0.000	0.000	31.741	-129.408	0.000	0.000
231	GLOBAL	0.000	0.000	27.116	-117.673	-4.075	0.000
232	GLOBAL	0.000	0.000	17.177	-89.790	-6.309	0.000
233	GLOBAL	0.000	0.000	8.249	-59.432	-6.335	0.000
234	GLOBAL	0.000	0.000	2.779	-35.138	-5.062	0.000
235	GLOBAL	0.000	0.000	0.169	-18.775	-3.497	0.000
236	GLOBAL	0.000	0.000	-0.780	-8.952	-2.174	0.000
237	GLOBAL	0.000	0.000	-0.937	-3.601	-1.234	0.000
238	GLOBAL	0.000	0.000	-0.786	-0.987	-0.635	0.000
239	GLOBAL	0.000	0.000	-0.557	0.089	-0.285	0.000
240	GLOBAL	0.000	0.000	-0.342	0.373	-0.097	0.000
241	GLOBAL	0.000	0.000	-0.163	0.293	-0.010	0.000
242	GLOBAL	0.000	0.000	-0.012	0.093	0.009	0.000
243	GLOBAL	0.000	0.000	0.034	-0.009	0.009	0.000

{ 48} > LIST DISP ALL

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*RESULTS OF LATEST ANALYSES*
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PROBLEM - FILENAME TITLE - NONE GIVEN

ACTIVE UNITS FEET KIP DEG DEGF SEC

--- LOADING - 2 missile ---

RESULTANT JOINT DISPLACEMENTS SUPPORTS

JOINT		DISPLACEMENT X DISP.	DISPLACEMENT Y DISP.	DISPLACEMENT Z DISP.	ROTATION X ROT.	ROTATION Y ROT.	ROTATION Z ROT.
1	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
2	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
3	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
4	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
5	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
6	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
7	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
8	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
9	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
10	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
11	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
12	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
13	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
14	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
15	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
16	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
17	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
18	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
19	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
20	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
21	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
22	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
23	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
24	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
25	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
26	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
27	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
28	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
54	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
55	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
81	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
82	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
108	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
109	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
135	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
136	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
162	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
163	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
189	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
190	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
216	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
217	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
218	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
219	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
220	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
221	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
222	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000

223	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
224	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
225	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
226	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
227	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
228	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
229	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
230	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
231	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
232	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
233	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
234	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
235	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
236	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
237	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
238	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
239	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
240	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
241	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
242	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
243	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000

RESULTANT JOINT DISPLACEMENTS FREE JOINTS

JOINT		DISPLACEMENT			ROTATION		
		X DISP.	Y DISP.	Z DISP.	X ROT.	Y ROT.	Z ROT.
29	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
30	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
31	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
32	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
33	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
34	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
35	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
36	GLOBAL	0.000	0.000	0.000	-0.001	0.000	0.000
37	GLOBAL	0.000	0.000	0.000	-0.001	0.000	0.000
38	GLOBAL	0.000	0.000	0.000	-0.002	0.000	0.000
39	GLOBAL	0.000	0.000	0.000	-0.003	0.001	0.000
40	GLOBAL	0.000	0.000	0.000	-0.004	0.000	0.000
41	GLOBAL	0.000	0.000	0.000	-0.004	0.000	0.000
42	GLOBAL	0.000	0.000	0.000	-0.004	0.000	0.000
43	GLOBAL	0.000	0.000	0.000	-0.003	-0.001	0.000
44	GLOBAL	0.000	0.000	0.000	-0.002	0.000	0.000
45	GLOBAL	0.000	0.000	0.000	-0.001	0.000	0.000
46	GLOBAL	0.000	0.000	0.000	-0.001	0.000	0.000
47	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
48	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
49	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
50	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
51	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
52	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
53	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000

56	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
57	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
58	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
59	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
60	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
61	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
62	GLOBAL	0.000	0.000	0.000	-0.001	0.000	0.000
63	GLOBAL	0.000	0.000	0.000	-0.001	0.001	0.000
64	GLOBAL	0.000	0.000	0.000	-0.002	0.001	0.000
65	GLOBAL	0.000	0.000	0.000	-0.003	0.002	0.000
66	GLOBAL	0.000	0.000	0.000	-0.004	0.002	0.000
67	GLOBAL	0.000	0.000	0.000	-0.005	0.001	0.000
68	GLOBAL	0.000	0.000	0.000	-0.006	0.000	0.000
69	GLOBAL	0.000	0.000	0.000	-0.005	-0.001	0.000
70	GLOBAL	0.000	0.000	0.000	-0.004	-0.002	0.000
71	GLOBAL	0.000	0.000	0.000	-0.003	-0.002	0.000
72	GLOBAL	0.000	0.000	0.000	-0.002	-0.001	0.000
73	GLOBAL	0.000	0.000	0.000	-0.001	-0.001	0.000
74	GLOBAL	0.000	0.000	0.000	-0.001	0.000	0.000
75	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
76	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
77	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
78	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
79	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
80	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
83	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
84	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
85	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
86	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
87	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
88	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
89	GLOBAL	0.000	0.000	0.000	0.000	0.001	0.000
90	GLOBAL	0.000	0.000	0.000	-0.001	0.001	0.000
91	GLOBAL	0.000	0.000	0.000	-0.001	0.002	0.000
92	GLOBAL	0.000	0.000	0.000	-0.002	0.003	0.000
93	GLOBAL	0.000	0.000	0.000	-0.003	0.003	0.000
94	GLOBAL	0.000	0.000	-0.001	-0.004	0.002	0.000
95	GLOBAL	0.000	0.000	-0.001	-0.005	0.000	0.000
96	GLOBAL	0.000	0.000	-0.001	-0.004	-0.002	0.000
97	GLOBAL	0.000	0.000	0.000	-0.003	-0.003	0.000
98	GLOBAL	0.000	0.000	0.000	-0.002	-0.003	0.000
99	GLOBAL	0.000	0.000	0.000	-0.001	-0.002	0.000
100	GLOBAL	0.000	0.000	0.000	-0.001	-0.001	0.000
101	GLOBAL	0.000	0.000	0.000	0.000	-0.001	0.000
102	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
103	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
104	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
105	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
106	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
107	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
110	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
111	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
112	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
113	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000

Calculation No. S07-0037 Revision 0
Attachment B
Page B36

114	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
115	GLOBAL	0.000	0.000	0.000	0.000	0.001	0.000
116	GLOBAL	0.000	0.000	0.000	0.000	0.001	0.000
117	GLOBAL	0.000	0.000	0.000	0.000	0.002	0.000
118	GLOBAL	0.000	0.000	0.000	0.000	0.002	0.000
119	GLOBAL	0.000	0.000	0.000	0.000	0.003	0.000
120	GLOBAL	0.000	0.000	-0.001	0.000	0.004	0.000
121	GLOBAL	0.000	0.000	-0.001	0.000	0.003	0.000
122	GLOBAL	0.000	0.000	-0.001	0.000	0.000	0.000
123	GLOBAL	0.000	0.000	-0.001	0.000	-0.003	0.000
124	GLOBAL	0.000	0.000	-0.001	0.000	-0.004	0.000
125	GLOBAL	0.000	0.000	0.000	0.000	-0.003	0.000
126	GLOBAL	0.000	0.000	0.000	0.000	-0.002	0.000
127	GLOBAL	0.000	0.000	0.000	0.000	-0.002	0.000
128	GLOBAL	0.000	0.000	0.000	0.000	-0.001	0.000
129	GLOBAL	0.000	0.000	0.000	0.000	-0.001	0.000
130	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
131	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
132	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
133	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
134	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
137	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
138	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
139	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
140	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
141	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
142	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
143	GLOBAL	0.000	0.000	0.000	0.000	0.001	0.000
144	GLOBAL	0.000	0.000	0.000	0.001	0.001	0.000
145	GLOBAL	0.000	0.000	0.000	0.001	0.002	0.000
146	GLOBAL	0.000	0.000	0.000	0.002	0.003	0.000
147	GLOBAL	0.000	0.000	0.000	0.003	0.003	0.000
148	GLOBAL	0.000	0.000	-0.001	0.004	0.002	0.000
149	GLOBAL	0.000	0.000	-0.001	0.005	0.000	0.000
150	GLOBAL	0.000	0.000	-0.001	0.004	-0.002	0.000
151	GLOBAL	0.000	0.000	0.000	0.003	-0.003	0.000
152	GLOBAL	0.000	0.000	0.000	0.002	-0.003	0.000
153	GLOBAL	0.000	0.000	0.000	0.001	-0.002	0.000
154	GLOBAL	0.000	0.000	0.000	0.001	-0.001	0.000
155	GLOBAL	0.000	0.000	0.000	0.000	-0.001	0.000
156	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
157	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
158	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
159	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
160	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
161	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
164	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
165	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
166	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
167	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
168	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
169	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
170	GLOBAL	0.000	0.000	0.000	0.001	0.000	0.000
171	GLOBAL	0.000	0.000	0.000	0.001	0.001	0.000

172	GLOBAL	0.000	0.000	0.000	0.002	0.001	0.000
173	GLOBAL	0.000	0.000	0.000	0.003	0.002	0.000
174	GLOBAL	0.000	0.000	0.000	0.004	0.002	0.000
175	GLOBAL	0.000	0.000	0.000	0.005	0.001	0.000
176	GLOBAL	0.000	0.000	0.000	0.006	0.000	0.000
177	GLOBAL	0.000	0.000	0.000	0.005	-0.001	0.000
178	GLOBAL	0.000	0.000	0.000	0.004	-0.002	0.000
179	GLOBAL	0.000	0.000	0.000	0.003	-0.002	0.000
180	GLOBAL	0.000	0.000	0.000	0.002	-0.001	0.000
181	GLOBAL	0.000	0.000	0.000	0.001	-0.001	0.000
182	GLOBAL	0.000	0.000	0.000	0.001	0.000	0.000
183	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
184	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
185	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
186	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
187	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
188	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
191	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
192	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
193	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
194	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
195	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
196	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
197	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
198	GLOBAL	0.000	0.000	0.000	0.001	0.000	0.000
199	GLOBAL	0.000	0.000	0.000	0.001	0.000	0.000
200	GLOBAL	0.000	0.000	0.000	0.002	0.000	0.000
201	GLOBAL	0.000	0.000	0.000	0.003	0.001	0.000
202	GLOBAL	0.000	0.000	0.000	0.004	0.000	0.000
203	GLOBAL	0.000	0.000	0.000	0.004	0.000	0.000
204	GLOBAL	0.000	0.000	0.000	0.004	0.000	0.000
205	GLOBAL	0.000	0.000	0.000	0.003	-0.001	0.000
206	GLOBAL	0.000	0.000	0.000	0.002	0.000	0.000
207	GLOBAL	0.000	0.000	0.000	0.001	0.000	0.000
208	GLOBAL	0.000	0.000	0.000	0.001	0.000	0.000
209	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
210	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
211	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
212	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
213	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
214	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000
215	GLOBAL	0.000	0.000	0.000	0.000	0.000	0.000

{ 49} > calculate average resultants at mid surf
**** ELEMENT LIST MISSING - ALL ASSUMED

****
RESULTS OF LATEST ANALYSES
****

PROBLEM - FILENAME TITLE - NONE GIVEN

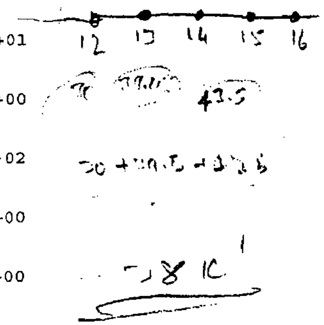
ACTIVE UNITS FEET KIP DEG DEGF SEC

LOADING - 2 missile

AVERAGE RESULTANTS (MEMBRANE/BENDING)

JOINT	NUMBER OF ELEMENTS USED IN AVERAGING	NXX/ MXX	NYY/ MYY	NXY/ MXY	VXX	VYY
1	1	0.000000E+00	0.000000E+00	0.000000E+00		
		0.119979E-01	0.121160E-01	0.940850E-02	-0.182148E-01	-0.178596E-01
2	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.244988E-02	-0.301279E-01	-0.287135E-02	-0.231931E-01	0.688708E-02
3	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.268305E-01	-0.979648E-01	-0.455018E-02	-0.138652E-01	0.442638E-01
4	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.490043E-01	-0.127826E+00	-0.118801E-01	0.416223E-01	0.875596E-01
5	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.626140E-01	-0.383581E-01	-0.267432E-01	0.168932E+00	0.131848E+00
6	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.510768E-01	0.310897E+00	-0.527506E-01	0.416779E+00	0.163392E+00
7	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.204290E-01	0.116549E+01	-0.941022E-01	0.858205E+00	0.146084E+00
8	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.217861E+00	0.292357E+01	-0.153456E+00	0.158155E+01	0.343938E-02
9	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.655636E+00	0.616536E+01	-0.226516E+00	0.265272E+01	-0.406212E+00
10	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.151279E+01	0.115952E+02	-0.292106E+00	0.401029E+01	-0.130997E+01
11	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.301378E+01	0.197192E+02	-0.304626E+00	0.525815E+01	-0.298423E+01

12	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.525148E+01	0.299663E+02	-0.222792E+00	0.548704E+01	-0.551501E+01
13	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.767681E+01	0.394507E+02	-0.906053E-01	0.368062E+01	-0.822759E+01
14	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.880520E+01	0.434584E+02	0.000000E+00	0.000000E+00	-0.947411E+01
15	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.767681E+01	0.394507E+02	0.906053E-01	-0.368062E+01	-0.822759E+01
16	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.525148E+01	0.299663E+02	0.222792E+00	-0.548704E+01	-0.551501E+01
17	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.301378E+01	0.197192E+02	0.304626E+00	-0.525815E+01	-0.298423E+01
18	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.151279E+01	0.115952E+02	0.292106E+00	-0.401029E+01	-0.130997E+01
19	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.655636E+00	0.616536E+01	0.226516E+00	-0.265272E+01	-0.406212E+00
20	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.217861E+00	0.292357E+01	0.153456E+00	-0.158155E+01	0.343938E-02
21	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.204290E-01	0.116549E+01	0.941022E-01	-0.858205E+00	0.146084E+00
22	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.510768E-01	0.310897E+00	0.527506E-01	-0.416779E+00	0.163392E+00
23	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.626140E-01	-0.383581E-01	0.267432E-01	-0.168932E+00	0.131848E+00
24	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.490043E-01	-0.127826E+00	0.118801E-01	-0.416223E-01	0.875596E-01
25	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.268305E-01	-0.979648E-01	0.455018E-02	0.138652E-01	0.442638E-01
26	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.244988E-02	-0.301279E-01	0.287135E-02	0.231931E-01	0.688708E-02
27	1	0.000000E+00	0.000000E+00	0.000000E+00		
		0.119979E-01	0.121160E-01	-0.940850E-02	0.182148E-01	-0.178596E-01
28	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.289654E-01	-0.261273E-02	-0.263598E-02	0.665964E-02	-0.220775E-01
29	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.821133E-02	-0.612804E-02	-0.236812E-01	0.113474E-01	0.763798E-02



30	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.197693E-01	0.107949E-01	-0.117030E-01	0.230642E-01	0.342043E-01
31	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.624722E-01	0.690125E-01	0.461409E-01	0.450592E-01	0.637937E-01
32	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.144713E+00	0.221297E+00	0.174606E+00	0.859148E-01	0.866183E-01
33	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.296303E+00	0.547699E+00	0.422631E+00	0.151771E+00	0.857350E-01
34	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.553854E+00	0.116749E+01	0.862009E+00	0.246883E+00	0.234384E-01
35	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.952900E+00	0.224233E+01	0.158065E+01	0.366753E+00	-0.172259E+00
36	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.150019E+01	0.396021E+01	0.265107E+01	0.485831E+00	-0.624323E+00
37	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.210582E+01	0.648175E+01	0.404287E+01	0.543921E+00	-0.151551E+01
38	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.246581E+01	0.983728E+01	0.543422E+01	0.456561E+00	-0.305373E+01
39	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.205654E+01	0.137531E+02	0.594038E+01	0.208398E+00	-0.530361E+01
40	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.846737E+00	0.172676E+02	0.420713E+01	-0.308155E-02	-0.776190E+01
41	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.109027E+00	0.187441E+02	0.000000E+00	0.000000E+00	-0.892654E+01
42	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.846737E+00	0.172676E+02	-0.420713E+01	0.308155E-02	-0.776190E+01
43	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.205654E+01	0.137531E+02	-0.594038E+01	-0.208398E+00	-0.530361E+01
44	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.246581E+01	0.983728E+01	-0.543422E+01	-0.456561E+00	-0.305373E+01
45	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.210582E+01	0.648175E+01	-0.404287E+01	-0.543921E+00	-0.151551E+01
46	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.150019E+01	0.396021E+01	-0.265107E+01	-0.485831E+00	-0.624323E+00
47	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.952900E+00	0.224233E+01	-0.158065E+01	-0.366753E+00	-0.172259E+00

48	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.553854E+00	0.116749E+01	-0.862009E+00	-0.246883E+00	0.234384E-01
49	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.296303E+00	0.547699E+00	-0.422631E+00	-0.151771E+00	0.857350E-01
50	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.144713E+00	0.221297E+00	-0.174606E+00	-0.859148E-01	0.866183E-01
51	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.624722E-01	0.690125E-01	-0.461409E-01	-0.450592E-01	0.637937E-01
52	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.197693E-01	0.107949E-01	0.117030E-01	-0.230642E-01	0.342043E-01
53	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.821133E-02	-0.612804E-02	0.236812E-01	-0.113474E-01	0.763798E-02
54	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.289654E-01	-0.261273E-02	0.263598E-02	-0.665964E-02	-0.220775E-01
55	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.848464E-01	-0.182589E-01	-0.342747E-03	0.310616E-01	-0.206932E-01
56	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.197526E-02	0.927535E-02	-0.170809E-01	0.312382E-01	0.599517E-02
57	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.771214E-01	0.425428E-01	0.916738E-02	0.383241E-01	0.178143E-01
58	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.193901E+00	0.861106E-01	0.970929E-01	0.585315E-01	0.285531E-01
59	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.387666E+00	0.140397E+00	0.280792E+00	0.916981E-01	0.254221E-01
60	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.702748E+00	0.200381E+00	0.621535E+00	0.135978E+00	-0.891793E-02
61	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.117884E+01	0.246229E+00	0.120460E+01	0.181918E+00	-0.107783E+00
62	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.182267E+01	0.231006E+00	0.213009E+01	0.203928E+00	-0.327746E+00
63	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.254108E+01	0.700263E-01	0.348085E+01	0.148241E+00	-0.757017E+00
64	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.300569E+01	-0.343724E+00	0.524980E+01	-0.751829E-01	-0.152057E+01
65	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.242844E+01	-0.102481E+01	0.719261E+01	-0.563708E+00	-0.278156E+01

66	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.630158E+00	-0.152125E+01	0.846784E+01	-0.124092E+01	-0.475393E+01
67	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.682766E+01	-0.908932E+00	0.681081E+01	-0.127462E+01	-0.768516E+01
68	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.106514E+02	-0.197620E+00	0.000000E+00	0.000000E+00	-0.942166E+01
69	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.682766E+01	-0.908932E+00	-0.681081E+01	0.127462E+01	-0.768516E+01
70	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.630158E+00	-0.152125E+01	-0.846784E+01	0.124092E+01	-0.475393E+01
71	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.242844E+01	-0.102481E+01	-0.719261E+01	0.563708E+00	-0.278156E+01
72	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.300569E+01	-0.343724E+00	-0.524980E+01	0.751829E-01	-0.152057E+01
73	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.254108E+01	0.700263E-01	-0.348085E+01	-0.148241E+00	-0.757017E+00
74	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.182267E+01	0.231006E+00	-0.213009E+01	-0.203928E+00	-0.327746E+00
75	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.117884E+01	0.246229E+00	-0.120460E+01	-0.181918E+00	-0.107783E+00
76	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.702748E+00	0.200381E+00	-0.621535E+00	-0.135978E+00	-0.891793E-02
77	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.387666E+00	0.140397E+00	-0.280792E+00	-0.916981E-01	0.254221E-01
78	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.193901E+00	0.861106E-01	-0.970929E-01	-0.585315E-01	0.285531E-01
79	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.771214E-01	0.425428E-01	-0.916738E-02	-0.383241E-01	0.178143E-01
80	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.197526E-02	0.927535E-02	0.170809E-01	-0.312382E-01	0.599517E-02
81	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.848464E-01	-0.182589E-01	0.342747E-03	-0.310616E-01	-0.206932E-01
82	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.115211E+00	-0.223405E-01	0.150304E-03	0.427607E-01	-0.954680E-02
83	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.581645E-02	0.854795E-02	-0.525381E-02	0.424544E-01	0.226914E-02

		NXY MXY	NYY MYY			
84	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.132476E+00	0.333831E-01	0.162271E-01	0.465097E-01	0.729109E-02
85	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.317603E+00	0.326777E-01	0.781678E-01	0.570537E-01	0.104621E-01
86	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.615131E+00	-0.339162E-01	0.203762E+00	0.675194E-01	0.435197E-02
87	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.108283E+01	-0.235797E+00	0.431534E+00	0.653868E-01	-0.210174E-01
88	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.176466E+01	-0.691081E+00	0.813836E+00	0.243106E-01	-0.842587E-01
89	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.264785E+01	-0.158623E+01	0.141194E+01	-0.105423E+00	-0.216370E+00
90	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.357271E+01	-0.319133E+01	0.228330E+01	-0.410492E+00	-0.466736E+00
91	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.406690E+01	-0.585670E+01	0.346516E+01	-0.103114E+01	-0.914472E+00
92	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.306518E+01	-0.996356E+01	0.497028E+01	-0.217831E+01	-0.170504E+01
93	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.158257E+01	-0.157286E+02	0.677184E+01	-0.414390E+01	-0.318293E+01
94	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.146423E+02	-0.221392E+02	0.688124E+01	-0.581648E+01	-0.762033E+01
95	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.241102E+02	-0.252455E+02	0.000000E+00	0.000000E+00	-0.110850E+02
96	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.146423E+02	-0.221392E+02	-0.688124E+01	0.581648E+01	-0.762033E+01
97	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.158257E+01	-0.157286E+02	-0.677184E+01	0.414390E+01	-0.318293E+01
98	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.306518E+01	-0.996356E+01	-0.497028E+01	0.217831E+01	-0.170504E+01
99	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.406690E+01	-0.585670E+01	-0.346516E+01	0.103114E+01	-0.914472E+00
100	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.357271E+01	-0.319133E+01	-0.228330E+01	0.410492E+00	-0.466736E+00
101	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.264785E+01	-0.158623E+01	-0.141194E+01	0.105423E+00	-0.216370E+00

102	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.176466E+01	-0.691081E+00	-0.813836E+00	-0.243106E-01	-0.842587E-01
103	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.108283E+01	-0.235797E+00	-0.431534E+00	-0.653868E-01	-0.210174E-01
104	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.615131E+00	-0.339162E-01	-0.203762E+00	-0.675194E-01	0.435197E-02
105	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.317603E+00	0.326777E-01	-0.781678E-01	-0.570537E-01	0.104621E-01
106	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.132476E+00	0.333831E-01	-0.162271E-01	-0.465097E-01	0.729109E-02
107	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.581645E-02	0.854795E-02	0.525381E-02	-0.424544E-01	0.226914E-02
108	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.115211E+00	-0.223405E-01	-0.150304E-03	-0.427607E-01	-0.954680E-02
109	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.122971E+00	-0.224249E-01	0.000000E+00	0.454402E-01	0.000000E+00
110	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.982365E-02	0.650514E-02	0.000000E+00	0.452402E-01	0.000000E+00
111	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.154806E+00	0.242639E-01	0.000000E+00	0.484466E-01	0.000000E+00
112	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.366278E+00	0.131264E-02	0.000000E+00	0.557857E-01	-0.670552E-10
113	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.703691E+00	-0.118060E+00	0.000000E+00	0.592718E-01	0.000000E+00
114	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.122957E+01	-0.427281E+00	0.000000E+00	0.432479E-01	0.000000E+00
115	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.198932E+01	-0.108002E+01	0.000000E+00	-0.235857E-01	0.143051E-08
116	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.296396E+01	-0.231291E+01	0.000000E+00	-0.198737E+00	0.000000E+00
117	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.397499E+01	-0.446723E+01	0.000000E+00	-0.582978E+00	0.000000E+00
118	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.451755E+01	-0.801204E+01	0.000000E+00	-0.135127E+01	0.114441E-07
119	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.347938E+01	-0.136070E+02	0.000000E+00	-0.282901E+01	0.228882E-07

		MXX	MYY			
120	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.141624E+01	-0.223739E+02	-0.381470E-08	-0.575127E+01	0.000000E+00
121	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.181997E+02	-0.343482E+02	0.000000E+00	-0.924844E+01	0.000000E+00
122	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.311898E+02	-0.409630E+02	0.000000E+00	0.000000E+00	0.000000E+00
123	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.181997E+02	-0.343482E+02	0.000000E+00	0.924844E+01	0.000000E+00
124	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.141624E+01	-0.223739E+02	0.000000E+00	0.575127E+01	0.000000E+00
125	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.347938E+01	-0.136070E+02	0.000000E+00	0.282901E+01	0.114441E-07
126	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.451755E+01	-0.801204E+01	0.000000E+00	0.135127E+01	0.572205E-08
127	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.397499E+01	-0.446723E+01	0.000000E+00	0.582978E+00	0.000000E+00
128	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.296396E+01	-0.231291E+01	0.000000E+00	0.198737E+00	0.000000E+00
129	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.198932E+01	-0.108002E+01	0.000000E+00	0.235857E-01	0.107268E-08
130	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.122957E-01	-0.427281E+00	0.000000E+00	-0.432479E-01	-0.894070E-10
131	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.703691E+00	-0.118060E+00	0.000000E+00	-0.592718E-01	0.000000E+00
132	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.366278E+00	0.131264E-02	0.000000E+00	-0.557857E-01	0.000000E+00
133	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.154806E+00	0.242639E-01	0.000000E+00	-0.484466E-01	0.000000E+00
134	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.982365E-02	0.650514E-02	0.149012E-10	-0.452402E-01	-0.558794E-11
135	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.122971E+00	-0.224249E-01	0.000000E+00	-0.454402E-01	0.000000E+00
136	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.115211E+00	-0.223405E-01	-0.150304E-03	0.427607E-01	0.954680E-02
137	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.581645E-02	0.854795E-02	0.525381E-02	0.424544E-01	-0.226914E-02

Mxx

176 10.

149 36

122 31.2

95 24

$\frac{31.2 + 24}{2} = 27.6$ k'/l

$Av = \frac{41 + 34}{2} = 37.5$ k'/l

Calculation No. S07-0037 Revision 0
Attachment B
Page B46

138	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.132476E+00	0.333831E-01	-0.162271E-01	0.465097E-01	-0.729109E-02
139	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.317603E+00	0.326777E-01	-0.781678E-01	0.570537E-01	-0.104621E-01
140	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.615131E+00	-0.339162E-01	-0.203762E+00	0.675194E-01	-0.435197E-02
141	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.108283E+01	-0.235797E+00	-0.431534E+00	0.653868E-01	0.210174E-01
142	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.176466E+01	-0.691081E+00	-0.813836E+00	0.243106E-01	0.842587E-01
143	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.264785E+01	-0.158623E+01	-0.141194E+01	-0.105424E+00	0.216370E+00
144	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.357271E+01	-0.319133E+01	-0.228330E+01	-0.410492E+00	0.466736E+00
145	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.406690E+01	-0.585670E+01	-0.346516E+01	-0.103114E+01	0.914472E+00
146	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.306518E+01	-0.996356E+01	-0.497028E+01	-0.217831E+01	0.170504E+01
147	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.158257E+01	-0.157286E+02	-0.677184E+01	-0.414390E+01	0.318293E+01
148	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.146423E+02	-0.221392E+02	-0.688124E+01	-0.581648E+01	0.762033E+01
149	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.241102E+02	-0.252455E+02	0.000000E+00	0.000000E+00	0.110850E+02
150	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.146423E+02	-0.221392E+02	0.688124E+01	0.581648E+01	0.762033E+01
151	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.158257E+01	-0.157286E+02	0.677184E+01	0.414390E+01	0.318293E+01
152	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.306518E+01	-0.996356E+01	0.497028E+01	0.217831E+01	0.170504E+01
153	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.406690E+01	-0.585670E+01	0.346516E+01	0.103114E+01	0.914472E+00
154	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.357271E+01	-0.319133E+01	0.228330E+01	0.410492E+00	0.466736E+00
155	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.264785E+01	-0.158623E+01	0.141194E+01	0.105423E+00	0.216370E+00

156	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.176466E+01	-0.691081E+00	0.813836E+00	-0.243106E-01	0.842587E-01
157	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.108283E+01	-0.235797E+00	0.431534E+00	-0.653868E-01	0.210174E-01
158	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.615131E+00	-0.339162E-01	0.203762E+00	-0.675194E-01	-0.435197E-02
159	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.317603E+00	0.326777E-01	0.781678E-01	-0.570537E-01	-0.104621E-01
160	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.132476E+00	0.333831E-01	0.162271E-01	-0.465097E-01	-0.729109E-02
161	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.581645E-02	0.854795E-02	-0.525381E-02	-0.424544E-01	-0.226914E-02
162	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.115211E+00	-0.223405E-01	0.150304E-03	-0.427607E-01	0.954680E-02
163	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.848464E-01	-0.182589E-01	0.342747E-03	0.310616E-01	0.206932E-01
164	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.197526E-02	0.927535E-02	0.170809E-01	0.312382E-01	-0.599517E-02
165	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.771214E-01	0.425428E-01	-0.916738E-02	0.383241E-01	-0.178143E-01
166	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.193901E+00	0.861106E-01	-0.970929E-01	0.585315E-01	-0.285531E-01
167	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.387666E+00	0.140397E+00	-0.280792E+00	0.916981E-01	-0.254221E-01
168	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.702748E+00	0.200381E+00	-0.621535E+00	0.135978E+00	0.891793E-02
169	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.117884E+01	0.246229E+00	-0.120460E+01	0.181918E+00	0.107783E+00
170	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.182267E+01	0.231006E+00	-0.213009E+01	0.203928E+00	0.327746E+00
171	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.254108E+01	0.700264E-01	-0.348085E+01	0.148241E+00	0.757017E+00
172	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.300569E+01	-0.343724E+00	-0.524980E+01	-0.751829E-01	0.152057E+01
173	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.242844E+01	-0.102481E+01	-0.719261E+01	-0.563708E+00	0.278156E+01

174	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.630158E+00	-0.152125E+01	-0.846784E+01	-0.124092E+01	0.475393E+01
175	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.682766E+01	-0.908932E+00	-0.681081E+01	-0.127462E+01	0.768516E+01
176	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.106514E+02	-0.197620E+00	0.000000E+00	0.000000E+00	0.942166E+01
177	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.682766E+01	-0.908932E+00	0.681081E+01	0.127462E+01	0.768516E+01
178	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.630158E+00	-0.152125E+01	0.846784E+01	0.124092E+01	0.475393E+01
179	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.242844E+01	-0.102481E+01	0.719261E+01	0.563708E+00	0.278156E+01
180	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.300569E+01	-0.343724E+00	0.524980E+01	0.751829E-01	0.152057E+01
181	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.254108E+01	0.700263E-01	0.348085E+01	-0.148241E+00	0.757017E+00
182	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.182267E+01	0.231006E+00	0.213009E+01	-0.203928E+00	0.327746E+00
183	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.117884E+01	0.246229E+00	0.120460E+01	-0.181918E+00	0.107783E+00
184	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.702748E+00	0.200381E+00	0.621535E+00	-0.135978E+00	0.891793E-02
185	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.387666E+00	0.140397E+00	0.280792E+00	-0.916981E-01	-0.254221E-01
186	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.193901E+00	0.861106E-01	0.970929E-01	-0.585315E-01	-0.285531E-01
187	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.771214E-01	0.425428E-01	0.916738E-02	-0.383241E-01	-0.178143E-01
188	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.197526E-02	0.927535E-02	-0.170809E-01	-0.312382E-01	-0.599517E-02
189	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.848464E-01	-0.182589E-01	-0.342747E-03	-0.310616E-01	0.206932E-01
190	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.289654E-01	-0.261273E-02	0.263598E-02	0.665964E-02	0.220775E-01
191	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.821133E-02	-0.612804E-02	0.236812E-01	0.113474E-01	-0.763798E-02

192	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.197693E-01	0.107949E-01	0.117030E-01	0.230642E-01	-0.342043E-01
193	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.624721E-01	0.690125E-01	-0.461409E-01	0.450592E-01	-0.637937E-01
194	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.144713E+00	0.221297E+00	-0.174606E+00	0.859148E-01	-0.866183E-01
195	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.296303E+00	0.547699E+00	-0.422631E+00	0.151771E+00	-0.857350E-01
196	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.553854E+00	0.116749E+01	-0.862009E+00	0.246883E+00	-0.234384E-01
197	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.952900E+00	0.224233E+01	-0.158065E+01	0.366753E+00	0.172259E+00
198	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.150019E+01	0.396021E+01	-0.265107E+01	0.485831E+00	0.624323E+00
199	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.210582E+01	0.648175E+01	-0.404287E+01	0.543921E+00	0.151551E+01
200	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.246581E+01	0.983728E+01	-0.543422E+01	0.456561E+00	0.305373E+01
201	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.205654E+01	0.137531E+02	-0.594038E+01	0.208398E+00	0.530361E+01
202	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.846737E+00	0.172676E+02	-0.420713E+01	-0.308155E-02	0.776190E+01
203	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.109027E+00	0.187441E+02	0.000000E+00	0.000000E+00	0.892654E+01
204	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.846737E+00	0.172676E+02	0.420713E+01	0.308155E-02	0.776190E+01
205	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.205654E+01	0.137531E+02	0.594038E+01	-0.208398E+00	0.530361E+01
206	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.246581E+01	0.983728E+01	0.543422E+01	-0.456561E+00	0.305373E+01
207	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.210582E+01	0.648175E+01	0.404287E+01	-0.543921E+00	0.151551E+01
208	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.150019E+01	0.396021E+01	0.265107E+01	-0.485831E+00	0.624323E+00
209	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.952900E+00	0.224233E+01	0.158065E+01	-0.366753E+00	0.172259E+00

210	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.553854E+00	0.116749E+01	0.862009E+00	-0.246883E+00	-0.234384E-01
211	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.296303E+00	0.547699E+00	0.422631E+00	-0.151771E+00	-0.857350E-01
212	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.144713E+00	0.221297E+00	0.174606E+00	-0.859148E-01	-0.866183E-01
213	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.624721E-01	0.690125E-01	0.461409E-01	-0.450592E-01	-0.637937E-01
214	4	0.000000E+00	0.000000E+00	0.000000E+00		
		0.197693E-01	0.107949E-01	-0.117030E-01	-0.230642E-01	-0.342043E-01
215	4	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.821133E-02	-0.612804E-02	-0.236812E-01	-0.113474E-01	-0.763798E-02
216	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.289654E-01	-0.261273E-02	-0.263598E-02	-0.665964E-02	0.220775E-01
217	1	0.000000E+00	0.000000E+00	0.000000E+00		
		0.119979E-01	0.121160E-01	-0.940850E-02	-0.182148E-01	0.178596E-01
218	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.244988E-02	-0.301279E-01	0.287135E-02	-0.231931E-01	-0.688708E-02
219	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.268305E-01	-0.979648E-01	0.455018E-02	-0.138652E-01	-0.442638E-01
220	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.490043E-01	-0.127826E+00	0.118801E-01	0.416223E-01	-0.875596E-01
221	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.626140E-01	-0.383581E-01	0.267432E-01	0.168932E+00	-0.131848E+00
222	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.510768E-01	0.310897E+00	0.527506E-01	0.416779E+00	-0.163392E+00
223	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.204290E-01	0.116549E+01	0.941022E-01	0.858205E+00	-0.146084E+00
224	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.217861E+00	0.292357E+01	0.153456E+00	0.158155E+01	-0.343938E-02
225	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.655636E+00	0.616536E+01	0.226516E+00	0.265272E+01	0.406212E+00
226	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.151279E+01	0.115952E+02	0.292106E+00	0.401029E+01	0.130997E+01
227	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.301378E+01	0.197192E+02	0.304626E+00	0.525815E+01	0.298423E+01

228	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.525148E+01	0.299663E+02	0.222792E+00	0.548704E+01	0.551501E+01
229	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.767681E+01	0.394507E+02	0.906053E-01	0.368062E+01	0.822759E+01
230	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.880520E+01	0.434584E+02	0.000000E+00	0.000000E+00	0.947411E+01
231	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.767681E+01	0.394507E+02	-0.906053E-01	-0.368062E+01	0.822759E+01
232	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.525148E+01	0.299663E+02	-0.222792E+00	-0.548704E+01	0.551501E+01
233	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.301378E+01	0.197192E+02	-0.304626E+00	-0.525815E+01	0.298423E+01
234	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.151279E+01	0.115952E+02	-0.292106E+00	-0.401029E+01	0.130997E+01
235	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.655636E+00	0.616536E+01	-0.226516E+00	-0.265272E+01	0.406212E+00
236	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.217861E+00	0.292357E+01	-0.153456E+00	-0.158155E+01	-0.343938E-02
237	2	0.000000E+00	0.000000E+00	0.000000E+00		
		0.204290E-01	0.116549E+01	-0.941022E-01	-0.858205E+00	-0.146084E+00
238	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.510768E-01	0.310897E+00	-0.527506E-01	-0.416779E+00	-0.163392E+00
239	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.626140E-01	-0.383581E-01	-0.267432E-01	-0.168932E+00	-0.131848E+00
240	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.490043E-01	-0.127826E+00	-0.118801E-01	-0.416223E-01	-0.875596E-01
241	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.268305E-01	-0.979648E-01	-0.455018E-02	0.138652E-01	-0.442638E-01
242	2	0.000000E+00	0.000000E+00	0.000000E+00		
		-0.244988E-02	-0.301279E-01	-0.287135E-02	0.231931E-01	-0.688708E-02
243	1	0.000000E+00	0.000000E+00	0.000000E+00		
		0.119979E-01	0.121160E-01	0.940850E-02	0.182148E-01	0.178596E-01

**** MAXIMUM AND MINIMUM SUMMARY OF ABOVE RESULTS ****

```
============================================================
* RESULT *    MAXIMUM      JOINT    *    MINIMUM      JOINT    *
*========*=======================*=======================*
```

Calculation No. S07-0037 Revision 0
Attachment B
Page B52

```
*        *                         *                         *
*  NXX   *  0.000000E+00  1        *  0.000000E+00  1        *
*  NYY   *  0.000000E+00  1        *  0.000000E+00  1        *
*  NXY   *  0.000000E+00  1        *  0.000000E+00  1        *
*  MXX   *  0.880520E+01  14       * -0.311898E+02  122      *
*  MYY   *  0.434584E+02  14       * -0.409630E+02  122      *
*  MXY   *  0.846784E+01  66       * -0.846784E+01  70       *
*  VXX   *  0.924844E+01  123      * -0.924844E+01  121      *
*  VYY   *  0.110850E+02  149      * -0.110850E+02  95       *
*        *                         *                         *
==============================================================

{   50} > plot plane
{   51} >
{   52} >
{   53} >
{   54} > $$
{   55} >
{   56} > FINISH
**** STRUDL MESSAGE PL.31 - SCOPE ENVIRONMENT ENDED.
{   57} > GTMENU

GT STRUDL is initializing GTMenu.  Before returning to this window,
you must End your GTMenu session.
```

ATTACHMENT C REFERENCE

Reinforced Concrete Design, 4th Edition, Chu-Kai Wang & Charles G. Salmon

18.9 YIELD LINE ANALYSIS OF RECTANGULAR TWO-WAY SLABS

A typical rectangular two-way slab panel shown in Fig. 18.9.1 has two-way reinforcement within the panel near the bottom face providing positive moment nominal strengths M_{npx} and M_{npy}, and it also has two-way reinforcement along the edges near the top face providing negative moment nominal strengths M_{nnx} and M_{nny}; these strengths are per unit width of slab. The uniform load to give the collapse condition based on the yield line theory may be determined in terms of the sides a and b, and the absolute values of M_{npx}, M_{npy}, M_{nnx}, and M_{nny}.

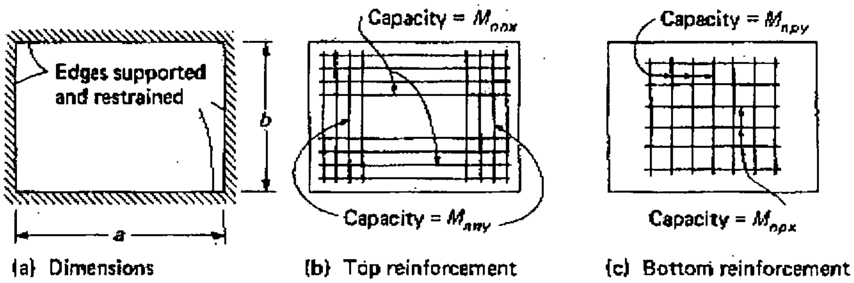


Figure 18.9.1 A rectangular two-way slab panel.

Yield Line Pattern. Three possible yield line patterns are shown in Fig. 18.9.2. There is no unknown position in yield line pattern No. 1 of Fig. 18.9.2(a); consequently the nodal forces V need not be predetermined and their value is dictated by statics alone. The unknowns x and y in yield line patterns Nos. 2 and 3 of Figs. 18.9.2(b) and (c) must be determined by means of differential calculus in the virtual work method; but for the equilibrium method, in this particular case the nodal forces to define the yield lines are all zero because the moment strengths under a set of three intersecting yield lines are identical.

Analysis for Yield Pattern No. 1. Assuming a vertical deflection of Δ at the intersection of the diagonal yield lines in Fig. 18.9.3, the deflection at the centroids of the four triangles A–B–C–D is $\Delta/3$. The work done at the

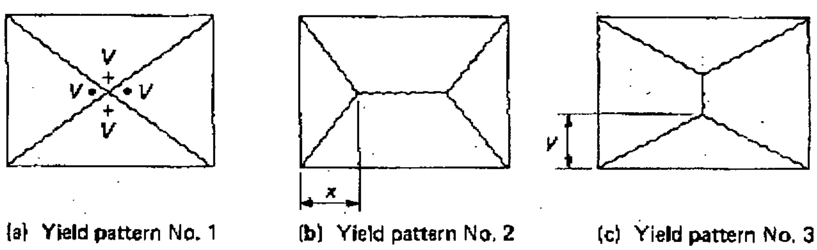


Figure 18.9.2 Yield line patterns for a rectangular two-way slab panel.

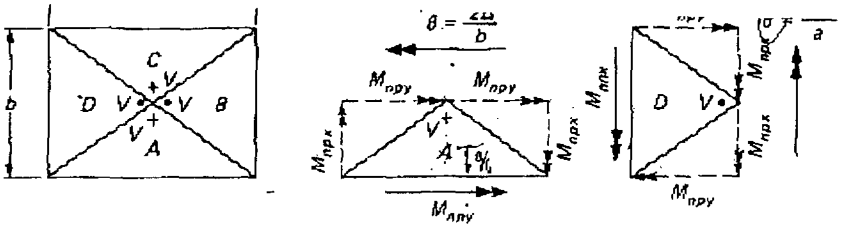


Figure 18.9.3 Analysis for yield pattern No. 1.

collapse condition by the uniform load is the product of the total load on the entire panel and $\Delta/3$; thus

$$W = \frac{w_u}{\phi}ab\left(\frac{\Delta}{3}\right) \qquad (18.9.1)$$

The work done by the yield moments on the boundaries of all four slab segments is, referring to Fig. 18.9.3,

$$W = 2(M_{nny} + M_{npy})(a)\left(\frac{2\Delta}{b}\right) + 2(M_{nnx} + M_{npx})(b)\left(\frac{2\Delta}{a}\right) \qquad (18.9.2)$$

Equating Eq. (18.9.1) to Eq. (18.9.2) and solving for w_u,

$$\frac{w_u}{\phi} = 12\left(\frac{M_{nnx} + M_{npx}}{a^2} + \frac{M_{nny} + M_{npy}}{b^2}\right) \qquad (18.9.3)$$

Taking moments about the lower edge of slab segment A in Fig. 18.9.3,

$$\frac{1}{2}\left(\frac{w_u}{\phi}\right)a\left(\frac{b}{2}\right)\left(\frac{b}{6}\right) + V\left(\frac{b}{2}\right) = (M_{nny} + M_{npy})(a) \qquad (18.9.4)$$

Taking moments about the left edge of slab segment D in Fig. 18.9.3,

$$\frac{1}{2}\left(\frac{w_u}{\phi}\right)b\left(\frac{a}{2}\right)\left(\frac{a}{6}\right) = (M_{nnx} + M_{npx})(b) + V\left(\frac{a}{2}\right) \qquad (18.9.5)$$

Eliminating V between Eqs. (18.9.4) and (18.9.5) and solving for w_u/ϕ, the same expression for w_u/ϕ as Eq. (18.9.3) is obtained.

Analysis for Yield Pattern No. 2. Assuming a vertical deflection of Δ at the two points of intersection of the yield lines in Fig. 18.9.4, the work done at the collapse condition by the uniform load on the entire panel is

$$\begin{aligned} W &= 2W_D + 2W_{A1} + 4W_{A2} \\ &= 2\left[\frac{1}{2}\left(\frac{w_u}{\phi}\right)bx\right]\left(\frac{\Delta}{3}\right) + 2\left(\frac{w_u}{\phi}\right)(a - 2x)\left(\frac{b}{2}\right)\left(\frac{\Delta}{2}\right) + 4\left[\frac{1}{2}\left(\frac{w_u}{\phi}\right)x\frac{b}{2}\right]\left(\frac{\Delta}{3}\right) \\ &= \frac{w_u}{\phi}\left(\frac{\Delta}{6}\right)(3ab - 2bx) \end{aligned} \qquad (18.9.6)$$

The work done by the yield moments on the boundaries of all four slab

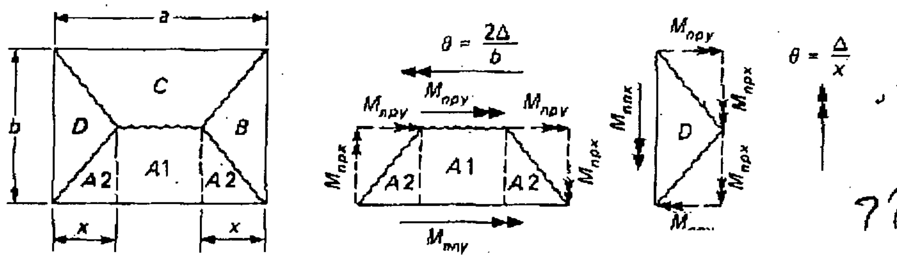


Figure 18.9.4 Analysis for yield pattern No. 2.

segments is, referring to Fig. 18.9.4,

$$W = 2(M_{nny} + M_{npy})(a)\left(\frac{2\Delta}{b}\right) + 2(M_{nnx} + M_{npx})(b)\left(\frac{\Delta}{x}\right) \qquad (18.9.7)$$

Equating Eq. (18.9.6) to Eq. (18.9.7) and solving for w_u/ϕ,

$$\frac{w_u}{\phi} = \frac{12[b^2(M_{nnx} + M_{npx}) + 2ax(M_{nny} + M_{npy})]}{b^2(3ax - 2x^2)} \qquad (18.9.8)$$

Setting to zero the derivative of Eq. (18.9.8) with respect to x gives the quadratic equation in x,

$$4a(M_{nny} + M_{npy})x^2 + 4b^2(M_{nnx} + M_{npx})x - [3ab^2(M_{nnx} + M_{npx})] = 0 \qquad (18.9.9)$$

Taking moments about the lower edge of slab segment A in Fig. 18.9.4,

$$2\left[\frac{1}{2}\left(\frac{w_u}{\phi}\right)x\frac{b}{2}\right]\left(\frac{b}{6}\right) + \frac{w_u}{\phi}(a - 2x)\left(\frac{b}{2}\right)\left(\frac{b}{4}\right) = (M_{nny} + M_{npy})(a)$$

$$\frac{w_u}{\phi} = \frac{24a(M_{nny} + M_{npy})}{2b^2x + 3b^2(a - 2x)} \qquad (18.9.10)$$

Taking moments about the left edge of slab segment D in Fig. 18.9.4,

$$\frac{1}{2}\left(\frac{w_u}{\phi}\right)bx\left(\frac{x}{3}\right) = (M_{nnx} + M_{npx})(b)$$

$$\frac{w_u}{\phi} = \frac{6(M_{nnx} + M_{npx})}{x^2} \qquad (18.9.11)$$

Equating Eq. (18.9.10) to Eq. (18.9.11) gives the same quadratic equation in x as Eq. (18.9.9).

The conditon for $x = a/2$ in Eq. (18.9.9) can be shown to be

$$\frac{M_{nnx} + M_{npx}}{M_{nny} + M_{npy}} = \frac{a^2}{b^2} \qquad \text{for } x = \frac{a}{2} \qquad (18.9.12)$$

which means that if the sum of positive and negative moment reinforcement

The condition for $x < a/2$ in Eq. (18.9.9) can be shown to be

$$\frac{M_{nnx} + M_{npx}}{M_{nny} + M_{npy}} < \frac{a^2}{b^2} \qquad \text{for } x < \frac{a}{2} \tag{18.9.13}$$

which means that in order for yield pattern No. 2 to prevail, the reinforcement in the a direction is less than that for yield pattern No. 1 to control.

Analysis for Yield Pattern No. 3. By interchanging the subscripts x and y as well as the quantities a and b in Eqs. (18.9.8), (18.9.9), (18.9.10), and (18.9.11), the following equations applicable to yield line pattern No. 3 are obtained. The quadratic equation in y (Fig. 18.9.2) is

$$4b(M_{nnx} + M_{npx})y^2 + 4a^2(M_{nny} + M_{npy})y - [3ba^2(M_{nny} + M_{npy})] = 0 \tag{18.9.14}$$

Three expressions for w_u/ϕ in terms of y are

$$\frac{w_u}{\phi} = \frac{12[a^2(M_{nny} + M_{npy}) + 2by(M_{nnx} + M_{npx})]}{a^2(3by - 2y^2)} \tag{18.9.15}$$

$$\frac{w_u}{\phi} = \frac{24b(M_{nnx} + M_{npx})}{2a^2y + 3a^2(b - 2y)} \tag{18.9.16}$$

$$\frac{w_u}{\phi} = \frac{6(M_{nny} + M_{npy})}{y^2} \tag{18.9.17}$$

The condition for $y < b/2$ in Eq. (18.9.14) can be shown to be

$$\frac{M_{nnx} + M_{npx}}{M_{nny} + M_{npy}} > \frac{a^2}{b^2} \qquad \text{for } y < \frac{b}{2} \tag{18.9.18}$$

which means that in order for yield pattern No. 3 to prevail, the reinforcement in the a direction is more than that for yield pattern No. 1 to control.

EXAMPLE 18.9.1 Determine the controlling yield line pattern and the corresponding collapse condition uniform load for a rectangular two-way slab panel with dimensions as shown in Fig. 18.9.5(a). The slab has reinforcement in the top near the edges and in the bottom within the panel. Obtain solutions for the following three cases:

1. $M_{nnx} + M_{npx} = 6.25$ ft-kips/ft $\qquad M_{nny} + M_{npy} = 4$ ft-kips/ft
2. $M_{nnx} + M_{npx} = 2$ ft-kips/ft $\qquad M_{nny} + M_{npy} = 4$ ft-kips/ft
3. $M_{nnx} + M_{npx} = 8$ ft-kips/ft $\qquad M_{nny} + M_{npy} = 4$ ft-kips/ft

Solution: (a) Case 1. The applicable yield line pattern may be determined by comparing the ratio of $(M_{nnx} + M_{npx})$ to $(M_{nny} + M_{npy})$ with the ratio of a^2 to b^2. In this case

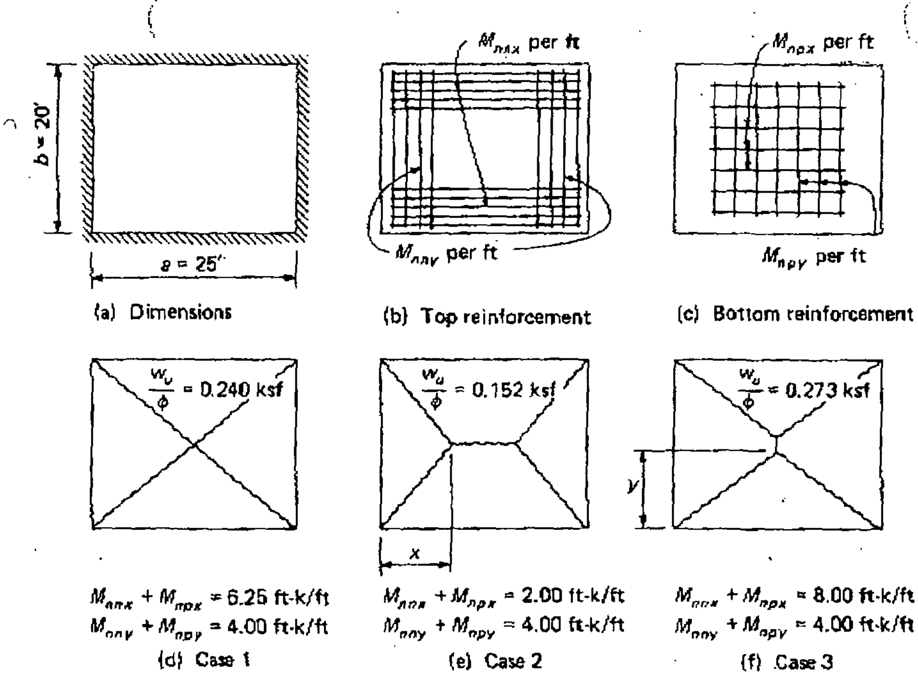


Figure 18.9.5 Rectangular two-way slab of Example 18.9.1.

Since the ratio of reinforcement in direction a to that in direction b per foot slab width is equal to the ratio of a^2 to b^2, the yield pattern is shown in Fig. 18.9.5(d). Then from Eq. (18.9.3),

$$\frac{w_u}{\phi} = 12\left(\frac{M_{nnx} + M_{npx}}{a^2} + \frac{M_{nny} + M_{npy}}{b^2}\right)$$

$$= 12\left(\frac{6.25}{625} + \frac{4}{400}\right) = 0.240 \text{ ksf}$$

(b) Case 2. The ratio of $(M_{nnx} + M_{npx})$ to $(M_{nny} + M_{npy})$ is, in this case,

$$\frac{(M_{nnx} + M_{npx})}{(M_{nny} + M_{npy})} = \frac{2}{4} = 0.5 < \frac{a^2}{b^2} = 1.5625$$

The yield line pattern is as shown in Fig. 18.9.5(e). The quadratic equation (18.9.9) is used to solve for x.

$$4a(M_{nny} + M_{npy})x^2 + 4b^2(M_{nnx} + M_{npx})x - 3ab^2(M_{nnx} + M_{npx}) = 0$$

$$4(25)(4)x^2 + 4(400)(2)x - 3(25)(400)(2) = 0$$

$$x^2 + 8x - 150 = 0$$

$$x = \sqrt{166} - 4 = 8.884 \text{ ft}$$

(18.9.11); the fact that it is so serves as a check on the numerical computation.

$$\frac{w_u}{\phi} = \frac{12[b^2(M_{nnx} + M_{npx}) + 2ax(M_{nny} + M_{npy})]}{b^2(3ax - 2x^2)}$$

$$= \frac{12[400(2) + 2(25)(8.884)(4)]}{400[3(25)(8.884) - 2(8.884)^2]} = 0.152 \text{ ksf}$$

$$\frac{w_u}{\phi} = \frac{24a(M_{nny} + M_{npy})}{2b^2x + 3b^2(a - 2x)}$$

$$= \frac{24(25)(4)}{2(400)(8.884) + 3(400)[25 - 2(8.884)]} = 0.152 \text{ ksf}$$

$$\frac{w_u}{\phi} = \frac{6(M_{nnx} + M_{npx})}{x^2} = \frac{6(2)}{(8.884)^2} = 0.152 \text{ ksf}$$

(c) Case 3. The ratio of $(M_{nnx} + M_{npx})$ to $(M_{nny} + M_{npy})$ is, in this case,

$$\frac{(M_{nnx} + M_{npx})}{(M_{nny} + M_{npy})} = \frac{8}{4} = 2 > \frac{a^2}{b^2} = 1.5625$$

The yield line pattern is as shown in Fig. 18.9.5(f). The quadratic equation (18.9.14) is used to solve for y.

$$4b(M_{nnx} + M_{npx})y^2 + 4a^2(M_{nny} + M_{npy})y - 3ba^2(M_{nny} + M_{npy}) = 0$$

$$4(20)(8)y^2 + 4(625)(4)y - 3(20)(625)(4) = 0$$

$$8y^2 + 125y - 1875 = 0$$

$$y = 9.375 \text{ ft}$$

The same uniform load w_u/ϕ is obtained from Eqs. (18.9.15), (18.9.16), or (18.9.17); the fact that it is so serves as a check on the numerical computation.

$$\frac{w_u}{\phi} = \frac{12[a^2(M_{nny} + M_{npy}) + 2by(M_{nnx} + M_{npx})]}{a^2(3by - 2y^2)}$$

$$= \frac{12[625(4) + 2(20)(9.375)(8)]}{625[3(20)(9.375) - 2(9.375)^2]} = 0.273 \text{ ksf}$$

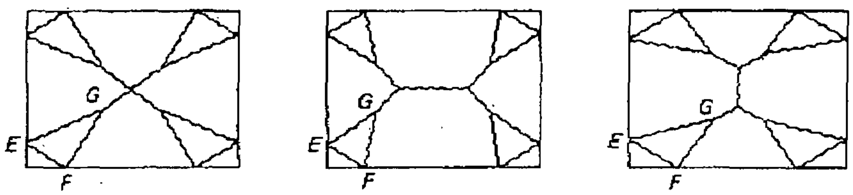
$$\frac{w_u}{\phi} = \frac{24b(M_{nnx} + M_{npx})}{2a^2y + 3a^2(b - 2y)}$$

$$= \frac{24(20)(8)}{2(625)(9.375) + 3(625)[20 - 2(9.375)]} = 0.273 \text{ ksf}$$

$$\frac{w_u}{\phi} = \frac{6(M_{nny} + M_{npy})}{y^2} = \frac{6(4)}{(9.375)^2} = 0.273 \text{ ksf}$$

18.10 CORNER EFFECTS IN RECTANGULAR SLABS

In Sec. 18.4 on method of yield line analysis, it has been stated that there may be more than one possible yield line pattern, in which case solutions to all possible yield line patterns must be sought and the one giving the smallest collapse load would actually happen and thus should be used in design. Although the three typical yield line patterns for a rectangular two-way slab panel have been shown in Fig. 18.9.2 and their analysis has been completely treated in Sec. 18.9, it can be demonstrated that the corner yield patterns 4–5–6 shown in Fig. 18.10.1—in one-to-one correspondence to yield patterns 1–2–3 of Fig. 18.9.2—may indeed give a smaller collapse load and therefore control. These corner patterns are complicated to analyze, either by virtual work method or by equilibrium method. For instance, there are three unknowns E–F–G for the yield line positions; then once the expression for w_u/ϕ is obtained from the virtual work equation as a function of three independent variables, the partial derivative of w_u/ϕ with respect to each of the three unknown variables can be equated to zero. In the equilibrium method the same set of equations for the positions of points E–F–G may be obtained by inserting the predetermined zero or nonzero nodal forces and applying the moment equation of equilibrium to each of the slab segments.

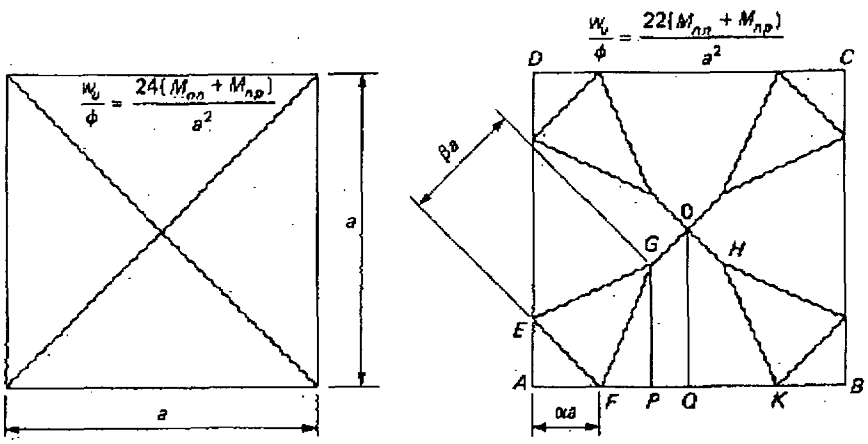


(a) Yield pattern No. 4 (b) Yield pattern No. 5 (c) Yield pattern No. 6

Figure 18.10.1 Corner yield patterns for a rectangular two-way slab panel.

An analysis [6] of a square slab with equal reinforcement in the x and y directions will show that the corner yield pattern No. 4 of Fig. 18.10.2(b) [see also Fig. 18.10.1(a)] results in $w_u/\phi = 22(M_{nn} + M_{np})/a^2$, whereas the regular yield pattern of Fig. 18.10.2(a) indicates $w_u/\phi = 24(M_{nn} + M_{np})/a^2$. M_{nn} and M_{np} are the nominal moment strengths per unit slab width for the negative moment and positive moment regions, respectively, in each direction, and a is the side of the square. Thus the corner pattern is more critical by approximately $(24 - 22)/24 = 8.3\%$. It may be proper then to discount the results of a regular yield pattern analysis as made in Sec. 8.9 for most rectangular slabs by 8 to 10% for reason of corner effects.

It may be pointed out that the yield line EF in Fig. 18.10.2(b) is a negative moment yield line; thus when there is no negative reinforcement, the moment strength along EF is zero. In this case the crack or yield line EF will not form if the corner A is not held down because the corner would simply lift up. ACI-13.4.6 requires the provision of special reinforcement at exterior corners in both top and bottom of the slab, for a distance in each direction from the corner equal to one-fifth the longer span. The use of



(a) Regular yield pattern (b) Corner yield pattern

Figure 18.10.2 Square slab panel with equal reinforcement in two directions.

18.11 APPLICATION OF YIELD LINE ANALYSIS TO SPECIAL CASES

The yield line theory of slabs, as has been developed and illustrated in the preceding sections, is particularly suitable for special cases involving irregular shapes or irregular boundary conditions. Prerequisite to the analysis of these cases is the picturing of an applicable yield line pattern. The governing concept here is that rigid body plane rotations of slab segments separated at yield lines are possible under compatible deflection conditions. To this end the following guides may be provided:

1. Yield lines end at a slab boundary.
2. A yield line (or its prolongation) between two slab segments passes through the intersection of the axes of rotation of the two adjacent slab segments.
3. The axes of rotation lie along lines of supports or pass over column supports.

In addition to those already described, two other yield line patterns to further illustrate the use of the above guides are shown in Fig. 18.11.1.

Special Case. Shown in Fig. 18.11.2 is a rectangular slab simply supported at three edges and free at the upper edge. The positive moment reinforcement parallel to the a dimension provides a nominal moment strength of M_{nx} per unit of the b distance; and the positive moment reinforcement parallel to the b dimension provides strength M_{ny} per unit of the a distance. Two possible yield patterns are shown in Figs. 18.11.2(c) and (d); the unknown is x in yield pattern No. 1 and it is u in yield pattern No. 2

ATTACHMENT D GT STRUDL ANALYSIS FOR 3-FT THICK WALL - DESIGN VERIFICATION REVIEW: ALTERNATE CALCULATION METHOD

This attachment presents the GT STRUDL analysis for an L-shape frame structure with a 3-ft thick wall and 3-ft thick floor slab. Wind loads are applied in different directions and the worst case load combination is determined based on the maximum bending moment in the wall.

The maximum bending stress at Joint 3 due to various wind load combinations are tabulated below.

Load Case	Load Combination	MZ ft-kip / ft	Ref. Page
1	DL+LL	-6.88	D7
2	DL	-4.76	D8
3	W_W	11.02	D8
33	W_L	-0.53	D8
4	P_T	-8.63	D8
5	DL+LL+W_W (+y,+x)+P_T	-4.48	D8
55	DL+LL+W_L (+y,-x)+P_T	-16.03	D8
6	DL+W_W (+y,+x)+P_T	-2.37	D8
66	DL+W_L (+y,-x)+P_T	-13.92	D8
7	DL+LL+W_W (+y,+x)	4.14	D8
77	DL+LL+W_L	-7.40	D8
8	DL+W_W	6.26	D8
88	DL+W_L	-5.29	D8
MAX		-16.03	

DL = Dead load of structure
LL = Live load
W_W = Windward wind loads based on the tornado
W_L = Leeward wind loads based on the tornado
P_T = Pressure load based on an external pressure drop of 3 psig between inside and outside of the building
+y = interior surface of slab
+x = exterior surface of wall
-x = interior surface of wall

The maximum bending moment due to DL + LL + $W_{LEEWARD}$ + P_T, **Max M is 16.03 ft-kip / ft.**

This attachment contains the following applications:

a. The analysis is in accordance with the Ultimate Strength Design presented in the ACI Code; therefore, the Auxiliary Building South Wall is qualified by elastic (linear) analysis.

b. The wind loads for uplift on the roof and suction on the leeward wall are addressed in this attachment.

The area of tension reinforcement equals the area of compression reinforcement.

$A_s = A'_s$

$p = p'$ ACI Std 318-63 Sect 1600

Therefore, the calculated ultimate moment is per ACI Std 318-63 EQN (16-1) which neglects the effects of compression steel.

Re-bar data:

Yield strength, f_y =	40	ksi	Ref. Dwg SC-422-019
Re-bar size # =	7		
Re-bar spacing each way =	12	in	
Concrete cover, c_c =	2	in	Ref. Dwg SC-422-021 Sect 64-64

Parameters

Area of compression re-bar, A'_s = 0.6 in^2

Top cover, d' = 2.0 + 0.875 + 0.875 / 2

= 3.3125 in

Top to tensile re-bar, d = $t - c_c$ - re-bar - re-bar / 2

= 12 * 3.00 - 2.00 - 0.875 - 0.875 / 2

= 32.688 in

Beam width, b = 12 in

$M_u = \phi [A'_s f_y (d - d')]$

where

ϕ = 0.9

Compressive strength, f'_c = 3000 psi Ref. Dwg SC-422-019

Area of compression re-bar, A'_s = 0.6 in^2

Ultimate design resisting moment, $M_u = \phi [A_s f_y (d - a/2)]$ EQN (16-1)

where

$a = A_s f_y / 0.85 f'_c b$

= 0.60 * 40000 / (0.85 * 3000 * 12.0)

= 0.784

M_u = 0.90 * [0.60 * 40000 * (32.688 - 1.176 / 2)]

= 697579 in - lb

= 58132 ft - lb

GT STRUDL RESULTS

For 36-in. thick wall, the worst load case combination (load case no. 55) is

$DL + LL + W_{LEEWARD} + P_T$, Max M = -16.03 ft-kip / ft

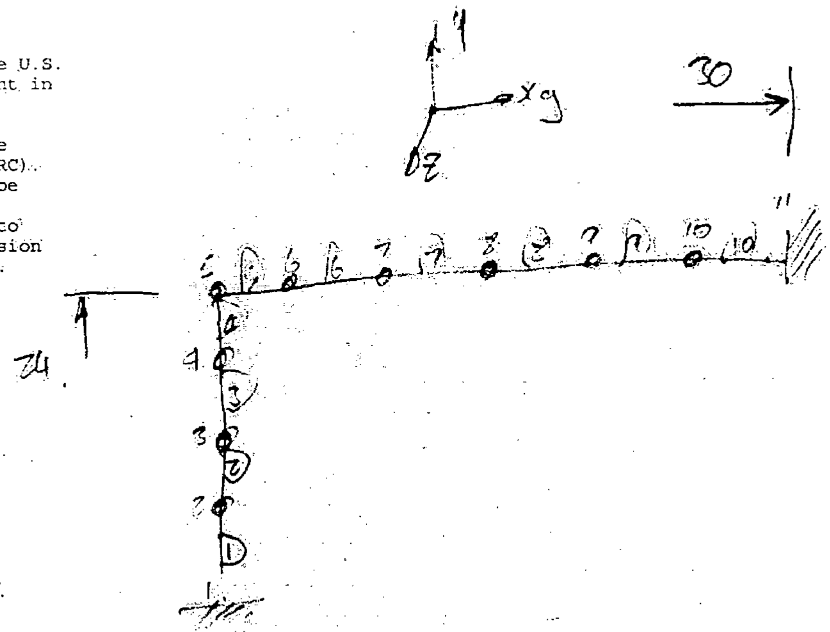
< 58.13 ft-kip / ft **OK**

Worst possible load combination is load case 3 with missile loading

$W_W + W_{MISSILE}$ = 11.02 + 37.5 (See Attachment B for $W_{MISSILE}$)

= 48.5 ft-kip / ft

< 58.13 ft-kip / ft **OK**



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# Thu Sep 20 14:01:05 2007


1GTICES/C-NP 2.5.0 MD-NT 2.0, January 1995.
 Proprietary to Georgia Tech Research Corporation, U.S.A.

Reading password file D:\GTStrudl\27\password27.pwd
 CI-i-audfile, Command AUDIT file FILE1401.aud has been activated.

 *** G T S T R U D L ***
    RELEASE DATE          VERSION              COMPLETION NO.
    June, 2003             27.0                    4449

 **** ACTIVE UNITS -   LENGTH   WEIGHT   ANGLE    TEMPERATURE   TIME
 **** ASSUMED TO BE     INCH     POUND   RADIAN   FAHRENHEIT   SECOND


 {     1} > $ -----------------------------------------------------------
 {     2} > $ This is the Common Startup Macro; put your company-wide startup commands here.
 {     3} > $ You can edit this file from Tools -- Macros.  Click "Startup" and then "Edit".
 {     4} > $ -----------------------------------------------------------
 {     5} > CINPUT 'T:\Gtstrudl\in\ABWALL1.txt'
 {     6} > *TITLE 'abwall'
 {     7} > STRUDL 'FILENAME=CHECKAB Wall'


 ***********************************************************************
 *                                                                     *
 *    ******                     G T S T R U D L                      *
 *   ********                                                          *
```

Calculation No. S07-0037 Revision 0
Attachment D
Page D3

```
OWNED BY AND PROPRIETARY TO THE
GEORGIA TECH RESEARCH CORPORATION

RELEASE DATE        VERSION        COMPLETION NO.
June, 2003          27.0                4449
```

```
**** ACTIVE UNITS -  LENGTH   WEIGHT   ANGLE    TEMPERATURE   TIME
**** ASSUMED TO BE    INCH     POUND   RADIAN   FAHRENHEIT    SECOND

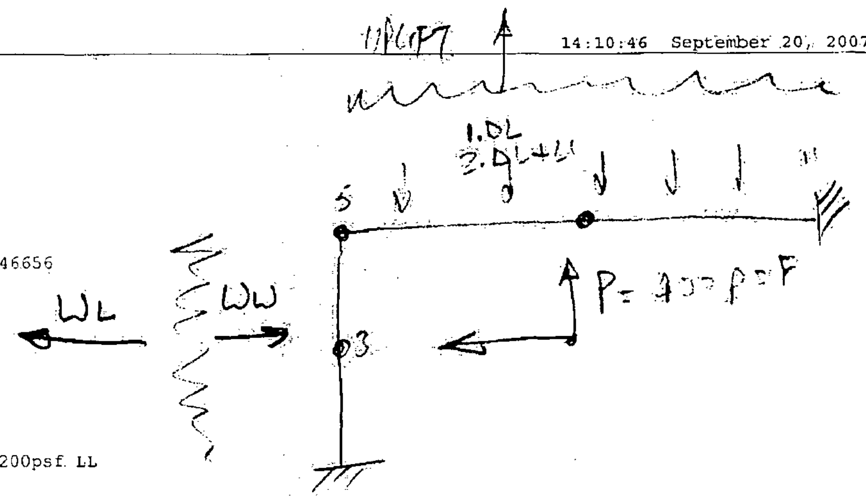
{    8} > TYP space frame
{    9} > UNIT ft LBS DEG
{   10} > JOI COO
{   11} > 1    0.0  0.0 0.0 s
{   12} > 2    0.0  6.0
{   13} > 3    0.0 12.0
{   14} > 4    0.0 18.0
{   15} > 5    0.0 24.0
{   16} > 6    5.0 24.0
{   17} > 7   10.0 24.0
{   18} > 8   15.0 24.0
{   19} > 9   20.0 24.0
{   20} > 10  25.0 24.0
{   21} > 11  30.0 24.0 s
{   22} >
{   23} > generate 10 memb id 1 incr 1 from 1 incr 1 to 2 incr 1

   /----------------  MEMBER INCIDENCES ----------------/

     MEMBER          INCIDENCES

       1             1        2
       2             2        3
       3             3        4
       4             4        5
       5             5        6
       6             6        7
       7             7        8
       8             8        9
       9             9       10
```

Calculation No. S07-0037 Revision 0
Attachment D
Page D4




```
 10            10         11

> unit in lbs
> Mem prop prismatic
> 1 to 10 ax 432 ay 360 az 360 ix 20736 iy 5184 iz 46656
>
> $
> material concrete members 1 to 10
>
> $
> units ft lbs
>
> loading 1 'dead load + LL'
> member loads
> 5 to 10 force y global uniform -650  $ 3 x 150 + 200psf LL
>
> $
> loading 2 'dead load'
> member loads
> 5 to 10 force y global uniform -450  $ 3 x 150
>
> $
> loading 3 'tornado wind (+y,+x)'
> member loads
> 1 to 4 force x global uniform 297
> 5 to 10 force y global uniform 184
>
> $
> loading 33 'tornado wind (+y,-x)'
> member loads
> 1 to 4 force x global uniform -81
> 5 to 10 force y global uniform 184
>
> $
> loading 4 'vacuum'
> member loads
> 1 to 4 force x global uniform -432
> 5 to 10 force y global uniform 432
>
>
>
> STIFFNESS ANALYSIS


BANDWIDTH INFORMATION BEFORE RENUMBERING.


THE MAXIMUM BANDWIDTH IS        1 AND OCCURS AT JOINT 3
THE AVERAGE BANDWIDTH IS                         0.889
THE STANDARD DEVIATION OF THE BANDWIDTH IS       0.314
                                            ----------
                                                 1.203
                                            ==========
```

Calculation No. S07-0037 Revision 0
Attachment D
Page D5

```
0BANDWIDTH REDUCTION HAS FAILED TO PRODUCE A BETTER NUMBERING.
 ORIGINAL NUMBERING WILL BE USED.

 TIME FOR CONSISTENCY CHECKS FOR      10 MEMBERS         0.00 SECONDS
 TIME FOR BANDWIDTH REDUCTION                            0.00 SECONDS
 TIME TO GENERATE      10 ELEMENT STIF. MATRICES         0.00 SECONDS
 TIME TO PROCESS       42 MEMBER LOADS                   0.00 SECONDS
 TIME TO ASSEMBLE THE STIFFNESS MATRIX                   0.00 SECONDS
 TIME TO PROCESS      11 JOINTS                          0.00 SECONDS
 TIME TO SOLVE WITH    2 PARTITIONS                      0.00 SECONDS
 TIME TO PROCESS      11 JOINT DISPLACEMENTS             0.00 SECONDS
 TIME TO PROCESS      10 ELEMENT DISTORTIONS             0.00 SECONDS
 TIME FOR STATICS CHECK                                  0.00 SECONDS
 {   64} >
 {   65} > create load comb 5  'DL + LL + Tornado wind (+y,+x) + pressure drop' spec 1 1.0 3 1.0 4 1.0
 {   66} > create load comb 55 'DL + LL + Tornado wind (+y,-x) + pressure drop' spec 1 1.0 33 1.0 4 1.0
 {   67} > create load comb 6  'DL + Tornado wind (+y,+x) + pressure drop' spec 2 1.0 3 1.0 4 1.0
 {   68} > create load comb 66 'DL + Tornado wind (+y,-x) + pressure drop' spec 2 1.0 33 1.0 4 1.0
 {   69} > create load comb 7  'DL + LL + Tornado wind (+y,+x)' spec 1 1.0 3 1.0
 {   70} > create load comb 77 'DL + LL + Tornado wind (+y,-x)' spec 1 1.0 33 1.0
 {   71} > create load comb 8  'DL + Tornado wind (+y,+x)' spec 2 1.0 3 1.0
 {   72} > create load comb 88 'DL + Tornado wind (+y,-x)' spec 2 1.0 33 1.0
 {   73} >
 {   74} >
 {   75} > $
 {   76} > LOAD LIST ALL
 {   77} > OUTPUT DEC 3
 {   78} > OUTPUT BY member
 {   79} > LIST forces REA ALL

    *****************************
    *RESULTS OF LATEST ANALYSES*
    *****************************

    PROBLEM - FILENAME  TITLE - NONE GIVEN

    ACTIVE UNITS  FEET  LB   DEG  DEGF  SEC
```

MEMBER FORCES

MEMBER	LOADING	JOINT	FORCE AXIAL	FORCE SHEAR-Y	FORCE SHEAR-Z	MOMENT TORSIONAL	MOMENT BENDING-Y	MOMENT BENDING-Z
1	1	1	8614.876	-1612.101	0.000	0.000	0.000	-12468.596
		2	-8614.876	1612.101	0.000	0.000	0.000	2795.988

Calculation No. S07-0037 Revision 0
Attachment D
Page D6

	2	1	5964.145	-1116.070	0.000	0.000	0.000	-8632.105
		2	-5964.145	1116.070	0.000	0.000	0.000	1935.684
	3	1	-2138.800	4541.694	0.000	0.000	0.000	22096.289
		2	2138.800	-2759.694	0.000	0.000	0.000	-192.125
	33	1	-2520.456	-657.836	0.000	0.000	0.000	-1534.078
		2	2520.456	171.836	0.000	0.000	0.000	-954.940
	4	1	-6161.757	-4870.893	0.000	0.000	0.000	-18719.311
		2	6161.757	2278.893	0.000	0.000	0.000	-2730.045
	5	1	314.319	-1941.300	0.000	0.000	0.000	-9091.618
		2	-314.319	1131.300	0.000	0.000	0.000	-126.182
	55	1	-67.337	-7140.830	0.000	0.000	0.000	-32721.984
		2	67.337	4062.831	0.000	0.000	0.000	-888.997
	6	1	-2336.413	-1445.269	0.000	0.000	0.000	-5255.128
		2	2336.413	635.269	0.000	0.000	0.000	-986.486
	66	1	-2718.069	-6644.799	0.000	0.000	0.000	-28885.495
		2	2718.069	3566.799	0.000	0.000	0.000	-1749.301
	7	1	6476.076	2929.592	0.000	0.000	0.000	9627.693
		2	-6476.076	-1147.592	0.000	0.000	0.000	2603.863
	77	1	6094.420	-2269.938	0.000	0.000	0.000	-14002.674
		2	-6094.420	1783.938	0.000	0.000	0.000	1841.048
	8	1	3825.345	3425.624	0.000	0.000	0.000	13464.184
		2	-3825.345	-1643.624	0.000	0.000	0.000	1743.559
	88	1	3443.688	-1773.906	0.000	0.000	0.000	-10166.183
		2	-3443.688	1287.906	0.000	0.000	0.000	980.744
2	1	2	8614.876	-1612.101	0.000	0.000	0.000	-2795.988
		3	-8614.876	1612.101	0.000	0.000	0.000	-6876.620
	2	2	5964.145	-1116.070	0.000	0.000	0.000	-1935.684
		3	-5964.145	1116.070	0.000	0.000	0.000	-4760.737
	3	2	-2138.800	2759.694	0.000	0.000	0.000	192.125
		3	2138.800	-977.694	0.000	0.000	0.000	11020.038
	33	2	-2520.456	-171.836	0.000	0.000	0.000	954.940
		3	2520.456	-314.164	0.000	0.000	0.000	-527.958
	4	2	-6161.757	-2278.893	0.000	0.000	0.000	2730.045
		3	6161.757	-313.107	0.000	0.000	0.000	-8627.402
	5	2	314.319	-1131.300	0.000	0.000	0.000	126.182
		3	-314.319	321.300	0.000	0.000	0.000	-4483.984
	55	2	-67.337	-4062.831	0.000	0.000	0.000	888.997
		3	67.337	984.831	0.000	0.000	0.000	-16031.979
	6	2	-2336.413	-635.269	0.000	0.000	0.000	986.486
		3	2336.413	-174.731	0.000	0.000	0.000	-2368.101
	66	2	-2718.069	-3566.799	0.000	0.000	0.000	1749.301
		3	2718.069	488.799	0.000	0.000	0.000	-13916.096
	7	2	6476.076	1147.592	0.000	0.000	0.000	-2603.863
		3	-6476.076	634.408	0.000	0.000	0.000	4143.418
	77	2	6094.420	-1783.938	0.000	0.000	0.000	-1841.048
		3	-6094.420	1297.938	0.000	0.000	0.000	-7404.577
	8	2	3825.345	1643.624	0.000	0.000	0.000	-1743.559
		3	-3825.345	138.376	0.000	0.000	0.000	6259.301
	88	2	3443.688	-1287.906	0.000	0.000	0.000	-980.744
		3	-3443.688	801.906	0.000	0.000	0.000	-5288.695
3	1	3	8614.876	-1612.101	0.000	0.000	0.000	6876.620
		4	-8614.876	1612.101	0.000	0.000	0.000	-16549.228

Calculation No. S07-0037 Revision 0
Attachment D
Page D7

	2	3	5964.145	-1116.070	0.000	0.000	0.000	4760.737
		4	-5964.145	1116.070	0.000	0.000	0.000	-11457.158
	3	3	-2138.800	977.694	0.000	0.000	0.000	-11020.038
		4	2138.800	804.306	0.000	0.000	0.000	11540.201
	33	3	-2520.456	314.164	0.000	0.000	0.000	527.958
		4	2520.456	-800.164	0.000	0.000	0.000	2815.024
	4	3	-6161.757	313.107	0.000	0.000	0.000	8627.402
		4	6161.757	-2905.107	0.000	0.000	0.000	1027.241
	5	3	314.319	-321.300	0.000	0.000	0.000	4483.984
		4	-314.319	-488.700	0.000	0.000	0.000	-3981.786
	55	3	-67.337	-984.831	0.000	0.000	0.000	16031.979
		4	67.337	-2093.169	0.000	0.000	0.000	-12706.962
	6	3	-2336.413	174.731	0.000	0.000	0.000	2368.101
		4	2336.413	-984.731	0.000	0.000	0.000	1110.284
	66	3	-2718.069	-488.799	0.000	0.000	0.000	13916.096
		4	2718.069	-2589.201	0.000	0.000	0.000	-7614.892
	7	3	6476.076	-634.408	0.000	0.000	0.000	-4143.418
		4	-6476.076	2416.408	0.000	0.000	0.000	-5009.027
	77	3	6094.420	-1297.938	0.000	0.000	0.000	7404.577
		4	-6094.420	811.938	0.000	0.000	0.000	-13734.203
	8	3	3825.345	-138.376	0.000	0.000	0.000	-6259.301
		4	-3825.345	1920.376	0.000	0.000	0.000	83.043
	88	3	3443.688	-801.906	0.000	0.000	0.000	5288.695
		4	-3443.688	315.906	0.000	0.000	0.000	-8642.133
4	1	4	8614.876	-1612.101	0.000	0.000	0.000	16549.228
		5	-8614.876	1612.101	0.000	0.000	0.000	-26221.836
	2	4	5964.145	-1116.070	0.000	0.000	0.000	11457.158
		5	-5964.145	1116.070	0.000	0.000	0.000	-18153.579
	3	4	-2138.800	-804.306	0.000	0.000	0.000	-11540.201
		5	2138.800	2586.306	0.000	0.000	0.000	1368.364
	33	4	-2520.456	800.164	0.000	0.000	0.000	-2815.024
		5	2520.456	-1286.164	0.000	0.000	0.000	9074.007
	4	4	-6161.757	2905.107	0.000	0.000	0.000	-1027.241
		5	6161.757	-5497.107	0.000	0.000	0.000	26233.885
	5	4	314.319	488.700	0.000	0.000	0.000	3981.786
		5	-314.319	-1298.700	0.000	0.000	0.000	1380.414
	55	4	-67.337	2093.169	0.000	0.000	0.000	12706.962
		5	67.337	-5171.170	0.000	0.000	0.000	9086.056
	6	4	-2336.413	984.731	0.000	0.000	0.000	-1110.284
		5	2336.413	-1794.731	0.000	0.000	0.000	9448.670
	66	4	-2718.069	2589.201	0.000	0.000	0.000	7614.892
		5	2718.069	-5667.201	0.000	0.000	0.000	17154.312
	7	4	6476.076	-2416.408	0.000	0.000	0.000	5009.027
		5	-6476.076	4198.408	0.000	0.000	0.000	-24853.471
	77	4	6094.420	-811.938	0.000	0.000	0.000	13734.203
		5	-6094.420	325.938	0.000	0.000	0.000	-17147.829
	8	4	3825.345	-1920.376	0.000	0.000	0.000	-83.043
		5	-3825.345	3702.376	0.000	0.000	0.000	-16785.215
	88	4	3443.688	-315.906	0.000	0.000	0.000	8642.133
		5	-3443.688	-170.094	0.000	0.000	0.000	-9079.573
5	1	5	1612.101	8614.876	0.000	0.000	0.000	26221.836
		6	-1612.101	-5364.875	0.000	0.000	0.000	8727.541

	2	5	1116.070	5964.145	0.000	0.000	0.000	18153.579
		6	-1116.070	-3714.145	0.000	0.000	0.000	6042.144
	3	5	2586.306	-2138.800	0.000	0.000	0.000	-1368.364
		6	-2586.306	1218.800	0.000	0.000	0.000	-7025.635
	33	5	-1286.164	-2520.456	0.000	0.000	0.000	-9074.007
		6	1286.164	1600.456	0.000	0.000	0.000	-1228.274
	4	5	-5497.107	-6161.757	0.000	0.000	0.000	-26233.885
		6	5497.107	4001.758	0.000	-0.000	0.000	825.097
	5	5	-1298.700	314.319	0.000	0.000	0.000	-1380.414
		6	1298.700	-144.318	0.000	0.000	0.000	2527.003
	55	5	-5171.170	-67.337	0.000	0.000	0.000	-9086.056
		6	5171.170	237.338	0.000	0.000	0.000	8324.364
	6	5	-1794.731	-2336.413	0.000	0.000	0.000	-9448.670
		6	1794.731	1506.413	0.000	0.000	0.000	-158.394
	66	5	-5667.201	-2718.069	0.000	0.000	0.000	-17154.312
		6	5667.201	1888.069	0.000	0.000	0.000	5638.967
	7	5	4198.408	6476.076	0.000	0.000	0.000	24853.471
		6	-4198.408	-4146.076	0.000	0.000	0.000	1701.906
	77	5	325.938	6094.420	0.000	0.000	0.000	17147.829
		6	-325.938	-3764.419	0.000	0.000	0.000	7499.267
	8	5	3702.376	3825.345	0.000	0.000	0.000	16785.215
		6	-3702.376	-2495.345	0.000	0.000	0.000	-983.491
	88	5	-170.094	3443.688	0.000	0.000	0.000	9079.573
		6	170.094	-2113.688	0.000	0.000	0.000	4813.870
6	1	6	1612.101	5364.875	0.000	0.000	0.000	-8727.541
		7	-1612.101	-2114.875	0.000	0.000	0.000	27426.919
	2	6	1116.070	3714.145	0.000	0.000	0.000	-6042.144
		7	-1116.070	-1464.145	0.000	0.000	0.000	18987.867
	3	6	2586.306	-1218.800	0.000	0.000	0.000	7025.635
		7	-2586.306	298.800	0.000	0.000	0.000	-10819.633
	33	6	-1286.164	-1600.456	0.000	0.000	0.000	1228.274
		7	1286.164	680.456	0.000	0.000	0.000	-6930.554
	4	6	-5497.107	-4001.758	0.000	0.000	0.000	-825.097
		7	5497.107	1841.758	0.000	0.000	0.000	-13783.690
	5	6	-1298.700	144.318	0.000	0.000	0.000	-2527.003
		7	1298.700	25.682	0.000	0.000	0.000	2823.596
	55	6	-5171.170	-237.338	0.000	0.000	0.000	-8324.364
		7	5171.170	407.338	0.000	0.000	0.000	6712.675
	6	6	-1794.731	-1506.413	0.000	0.000	0.000	158.394
		7	1794.731	676.413	0.000	0.000	0.000	-5615.456
	66	6	-5667.201	-1888.069	0.000	0.000	0.000	-5638.967
		7	5667.201	1058.069	0.000	0.000	0.000	-1726.377
	7	6	4198.408	4146.076	0.000	0.000	0.000	-1701.906
		7	-4198.408	-1816.076	0.000	0.000	0.000	16607.286
	77	6	325.938	3764.419	0.000	0.000	0.000	-7499.267
		7	-325.938	-1434.419	0.000	0.000	0.000	20496.365
	8	6	3702.376	2495.345	0.000	0.000	0.000	983.491
		7	-3702.376	-1165.345	0.000	0.000	0.000	-8168.234
	88	6	-170.094	2113.688	0.000	0.000	0.000	-4813.870
		7	170.094	-783.689	0.000	0.000	0.000	12057.312
7	1	7	1612.101	2114.875	0.000	0.000	0.000	-27426.919
		8	-1612.101	1135.125	0.000	0.000	0.000	29876.297

	2	7	1116.070	1464.145	0.000	0.000	0.000	-18987.867
		8	-1116.070	785.855	0.000	0.000	0.000	20683.590
	3	7	2586.306	-298.800	0.000	0.000	0.000	10819.633
		8	-2586.306	-621.200	0.000	0.000	0.000	-10013.631
	33	7	-1286.164	-680.456	0.000	0.000	0.000	6930.554
		8	1286.164	-239.544	0.000	0.000	0.000	-8032.834
	4	7	-5497.107	-1841.758	0.000	0.000	0.000	13783.690
		8	5497.107	-318.242	0.000	0.000	0.000	-17592.478
	5	7	-1298.700	-25.682	0.000	0.000	0.000	-2823.596
		8	1298.700	195.682	0.000	0.000	0.000	2270.188
	55	7	-5171.170	-407.338	0.000	0.000	0.000	-6712.675
		8	5171.170	577.338	0.000	0.000	0.000	4250.985
	6	7	-1794.731	-676.413	0.000	0.000	0.000	5615.456
		8	1794.731	-153.587	0.000	0.000	0.000	-6922.519
	66	7	-5667.201	-1058.069	0.000	0.000	0.000	1726.377
		8	5667.201	228.069	0.000	0.000	0.000	-4941.722
	7	7	4198.408	1816.076	0.000	0.000	0.000	-16607.286
		8	-4198.408	513.924	0.000	0.000	0.000	19862.667
	77	7	325.938	1434.419	0.000	0.000	0.000	-20496.365
		8	-325.938	895.580	0.000	0.000	0.000	21843.464
	8	7	3702.376	1165.345	0.000	0.000	0.000	-8168.234
		8	-3702.376	164.655	0.000	0.000	0.000	10669.959
	88	7	-170.094	783.689	0.000	0.000	0.000	-12057.312
		8	170.094	546.311	0.000	0.000	0.000	12650.755
8	1	8	1612.101	-1135.125	0.000	0.000	0.000	-29876.297
		9	-1612.101	4385.125	0.000	0.000	0.000	16075.673
	2	8	1116.070	-785.855	0.000	0.000	0.000	-20683.590
		9	-1116.070	3035.855	0.000	0.000	0.000	11129.312
	3	8	2586.306	621.200	0.000	0.000	0.000	10013.631
		9	-2586.306	-1541.200	0.000	0.000	0.000	-4607.628
	33	8	-1286.164	239.544	0.000	0.000	0.000	8032.834
		9	1286.164	-1159.544	0.000	0.000	0.000	-4535.114
	4	8	-5497.107	318.242	0.000	0.000	0.000	17592.478
		9	5497.107	-2478.242	0.000	0.000	0.000	-10601.266
	5	8	-1298.700	-195.682	0.000	0.000	0.000	-2270.188
		9	1298.700	365.682	0.000	0.000	0.000	866.779
	55	8	-5171.170	-577.338	0.000	0.000	0.000	-4250.985
		9	5171.170	747.338	0.000	0.000	0.000	939.293
	6	8	-1794.731	153.587	0.000	0.000	0.000	6922.519
		9	1794.731	-983.587	0.000	0.000	0.000	-4079.582
	66	8	-5667.201	-228.069	0.000	0.000	0.000	4941.722
		9	5667.201	-601.931	0.000	0.000	0.000	-4007.067
	7	8	4198.408	-513.924	0.000	0.000	0.000	-19862.667
		9	-4198.408	2843.924	0.000	0.000	0.000	11468.044
	77	8	325.938	-895.580	0.000	0.000	0.000	-21843.464
		9	-325.938	3225.581	0.000	0.000	0.000	11540.560
	8	8	3702.376	-164.655	0.000	0.000	0.000	-10669.959
		9	-3702.376	1494.655	0.000	0.000	0.000	6521.684
	88	8	-170.094	-546.311	0.000	0.000	0.000	-12650.755
		9	170.094	1876.311	0.000	0.000	0.000	6594.199
9	1	9	1612.101	-4385.125	0.000	0.000	0.000	-16075.673
		10	-1612.101	7635.125	0.000	0.000	0.000	-13974.948

	2	9	1116.070	-3035.855	0.000	0.000	0.000	-11129.312
		10	-1116.070	5285.855	0.000	0.000	0.000	-9674.965
	3	9	2586.306	1541.200	0.000	0.000	0.000	4607.628
		10	-2586.306	-2461.200	0.000	0.000	0.000	5398.374
	33	9	-1286.164	1159.544	0.000	0.000	0.000	4535.114
		10	1286.164	-2079.544	0.000	0.000	0.000	3562.607
	4	9	-5497.107	2478.242	0.000	0.000	0.000	10601.266
		10	5497.107	-4638.243	0.000	0.000	0.000	7189.946
	5	9	-1298.700	-365.682	0.000	0.000	0.000	-866.779
		10	1298.700	535.681	0.000	0.000	0.000	-1386.628
	55	9	-5171.170	-747.338	0.000	0.000	0.000	-939.293
		10	5171.170	917.338	0.000	0.000	0.000	-3222.395
	6	9	-1794.731	983.587	0.000	0.000	0.000	4079.582
		10	1794.731	-1813.588	0.000	0.000	0.000	2913.355
	66	9	-5667.201	601.931	0.000	0.000	0.000	4007.067
		10	5667.201	-1431.931	0.000	0.000	0.000	1077.588
	7	9	4198.408	-2843.924	0.000	0.000	0.000	-11468.044
		10	-4198.408	5173.924	0.000	0.000	0.000	-8576.574
	77	9	325.938	-3225.581	0.000	0.000	0.000	-11540.560
		10	-325.938	5555.580	0.000	0.000	0.000	-10412.341
	8	9	3702.376	-1494.655	0.000	0.000	0.000	-6521.684
		10	-3702.376	2824.655	0.000	0.000	0.000	-4276.590
	88	9	-170.094	-1876.311	0.000	0.000	0.000	-6594.199
		10	170.094	3206.311	0.000	0.000	0.000	-6112.358
10	1	10	1612.101	-7635.125	0.000	0.000	0.000	13974.948
		11	-1612.101	10885.124	0.000	0.000	0.000	-60275.573
	2	10	1116.070	-5285.855	0.000	0.000	0.000	9674.965
		11	-1116.070	7535.855	0.000	0.000	0.000	-41729.242
	3	10	2586.306	2461.200	0.000	0.000	0.000	-5398.374
		11	-2586.306	-3381.201	0.000	0.000	0.000	20004.378
	33	10	-1286.164	2079.544	0.000	0.000	0.000	-3562.607
		11	1286.164	-2999.544	0.000	0.000	0.000	16260.328
	4	10	-5497.107	4638.243	0.000	0.000	0.000	-7189.946
		11	5497.107	-6798.243	0.000	0.000	0.000	35781.159
	5	10	-1298.700	-535.681	0.000	0.000	0.000	1386.628
		11	1298.700	705.681	0.000	0.000	0.000	-4490.036
	55	10	-5171.170	-917.338	0.000	0.000	0.000	3222.395
		11	5171.170	1087.337	0.000	0.000	0.000	-8234.086
	6	10	-1794.731	1813.588	0.000	0.000	0.000	-2913.355
		11	1794.731	-2643.588	0.000	0.000	0.000	14056.294
	66	10	-5667.201	1431.931	0.000	0.000	0.000	-1077.588
		11	5667.201	-2261.931	0.000	0.000	0.000	10312.245
	7	10	4198.408	-5173.924	0.000	0.000	0.000	8576.574
		11	-4198.408	7503.923	0.000	0.000	0.000	-40271.195
	77	10	325.938	-5555.580	0.000	0.000	0.000	10412.341
		11	-325.938	7885.580	0.000	0.000	0.000	-44015.245
	8	10	3702.376	-2824.655	0.000	0.000	0.000	4276.590
		11	-3702.376	4154.655	0.000	0.000	0.000	-21724.865
	88	10	-170.094	-3206.311	0.000	0.000	0.000	6112.358
		11	170.094	4536.312	0.000	0.000	0.000	-25468.914

Calculation No. S07-0037 Revision 0
Attachment D
Page D11

RESULTANT JOINT LOADS SUPPORTS

JOINT	LOADING	X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
		/----------FORCE----------			//----------MOMENT----------		/
1	GLOBAL						
	1	1612.101	8614.876	0.000	0.000	0.000	-12468.597
	2	1116.070	5964.145	0.000	0.000	0.000	-8632.105
	3	-4541.694	-2138.800	0.000	0.000	0.000	22096.289
	33	657.836	-2520.456	0.000	0.000	0.000	-1534.078
	4	4870.893	-6161.757	0.000	0.000	0.000	-18719.312
	5	1941.300	314.318	0.000	0.000	0.000	-9091.620
	55	7140.831	-67.338	0.000	0.000	0.000	-32721.986
	6	1445.269	-2336.413	0.000	0.000	0.000	-5255.128
	66	6644.799	-2718.069	0.000	0.000	0.000	-28885.496
	7	-2929.593	6476.076	0.000	0.000	0.000	9627.692
	77	2269.938	6094.419	0.000	0.000	0.000	-14002.675
	8	-3425.624	3825.345	0.000	0.000	0.000	13464.184
	88	1773.906	3443.688	0.000	0.000	0.000	-10166.184
11	GLOBAL						
	1	-1612.101	10885.124	0.000	0.000	0.000	-60275.574
	2	-1116.070	7535.855	0.000	0.000	0.000	-41729.242
	3	-2586.306	-3381.201	0.000	0.000	0.000	20004.377
	33	1286.164	-2999.544	0.000	0.000	0.000	16260.328
	4	5497.107	-6798.243	0.000	0.000	0.000	35781.160
	5	1298.700	705.681	0.000	0.000	0.000	-4490.035
	55	5171.169	1087.338	0.000	0.000	0.000	-8234.084
	6	1794.731	-2643.588	0.000	0.000	0.000	14056.295
	66	5667.201	-2261.931	0.000	0.000	0.000	10312.245
	7	-4198.408	7503.924	0.000	0.000	0.000	-40271.195
	77	-325.938	7885.580	0.000	0.000	0.000	-44015.242
	8	-3702.376	4154.655	0.000	0.000	0.000	-21724.865
	88	170.094	4536.311	0.000	0.000	0.000	-25468.914

{ 80} > LIST DISP ALL

****
RESULTS OF LATEST ANALYSES
****

PROBLEM - FILENAME TITLE - NONE GIVEN

ACTIVE UNITS FEET LB DEG DEGF SEC

RESULTANT JOINT DISPLACEMENTS SUPPORTS

JOINT	LOADING	X DISP.	Y DISP.	Z DISP.	X ROT.	Y ROT.	Z ROT.
		/----------DISPLACEMENT----------			//----------ROTATION----------		/

1	GLOBAL						
	1	0.000	0.000	0.000	0.000	0.000	0.000
	2	0.000	0.000	0.000	0.000	0.000	0.000
	3	0.000	0.000	0.000	0.000	0.000	0.000
	33	0.000	0.000	0.000	0.000	0.000	0.000
	4	0.000	0.000	0.000	0.000	0.000	0.000
	5	0.000	0.000	0.000	0.000	0.000	0.000
	55	0.000	0.000	0.000	0.000	0.000	0.000
	6	0.000	0.000	0.000	0.000	0.000	0.000
	66	0.000	0.000	0.000	0.000	0.000	0.000
	7	0.000	0.000	0.000	0.000	0.000	0.000
	77	0.000	0.000	0.000	0.000	0.000	0.000
	8	0.000	0.000	0.000	0.000	0.000	0.000
	88	0.000	0.000	0.000	0.000	0.000	0.000
11	GLOBAL						
	1	0.000	0.000	0.000	0.000	0.000	0.000
	2	0.000	0.000	0.000	0.000	0.000	0.000
	3	0.000	0.000	0.000	0.000	0.000	0.000
	33	0.000	0.000	0.000	0.000	0.000	0.000
	4	0.000	0.000	0.000	0.000	0.000	0.000
	5	0.000	0.000	0.000	0.000	0.000	0.000
	55	0.000	0.000	0.000	0.000	0.000	0.000
	6	0.000	0.000	0.000	0.000	0.000	0.000
	66	0.000	0.000	0.000	0.000	0.000	0.000
	7	0.000	0.000	0.000	0.000	0.000	0.000
	77	0.000	0.000	0.000	0.000	0.000	0.000
	8	0.000	0.000	0.000	0.000	0.000	0.000
	88	0.000	0.000	0.000	0.000	0.000	0.000

RESULTANT JOINT DISPLACEMENTS FREE JOINTS

JOINT	LOADING	/------DISPLACEMENT		------//	------ROTATION		------/
		X DISP.	Y DISP.	Z DISP.	X ROT.	Y ROT.	Z ROT.
2	GLOBAL						
	1	0.000	0.000	0.000	0.000	0.000	0.002
	2	0.000	0.000	0.000	0.000	0.000	0.002
	3	0.000	0.000	0.000	0.000	0.000	-0.003
	33	0.000	0.000	0.000	0.000	0.000	0.000
	4	0.000	0.000	0.000	0.000	0.000	0.002
	5	0.000	0.000	0.000	0.000	0.000	0.001
	55	0.000	0.000	0.000	0.000	0.000	0.004
	6	0.000	0.000	0.000	0.000	0.000	0.001
	66	0.000	0.000	0.000	0.000	0.000	0.004
	7	0.000	0.000	0.000	0.000	0.000	-0.001
	77	0.000	0.000	0.000	0.000	0.000	0.002
	8	0.000	0.000	0.000	0.000	0.000	-0.001
	88	0.000	0.000	0.000	0.000	0.000	0.002
3	GLOBAL						
	1	0.000	0.000	0.000	0.000	0.000	0.002
	2	0.000	0.000	0.000	0.000	0.000	0.001
	3	0.001	0.000	0.000	0.000	0.000	-0.001
	33	0.000	0.000	0.000	0.000	0.000	0.000

		4	0.000	0.000	0.000	0.000	0.000	0.000
		5	0.000	0.000	0.000	0.000	0.000	0.000
		55	-0.001	0.000	0.000	0.000	0.000	0.001
		6	0.000	0.000	0.000	0.000	0.000	0.000
		66	-0.001	0.000	0.000	0.000	0.000	0.001
		7	0.000	0.000	0.000	0.000	0.000	0.000
		77	0.000	0.000	0.000	0.000	0.000	0.001
		8	0.000	0.000	0.000	0.000	0.000	0.000
		88	0.000	0.000	0.000	0.000	0.000	0.001
4	GLOBAL							
		1	0.000	0.000	0.000	0.000	0.000	-0.002
		2	0.000	0.000	0.000	0.000	0.000	-0.001
		3	0.000	0.000	0.000	0.000	0.000	-0.002
		33	0.000	0.000	0.000	0.000	0.000	0.000
		4	0.000	0.000	0.000	0.000	0.000	-0.002
		5	0.000	0.000	0.000	0.000	0.000	-0.001
		55	-0.001	0.000	0.000	0.000	0.000	-0.003
		6	0.000	0.000	0.000	0.000	0.000	0.000
		66	0.000	0.000	0.000	0.000	0.000	-0.003
		7	0.000	0.000	0.000	0.000	0.000	0.001
		77	0.000	0.000	0.000	0.000	0.000	-0.002
		8	0.000	0.000	0.000	0.000	0.000	0.001
		88	0.000	0.000	0.000	0.000	0.000	-0.001
5	GLOBAL							
		1	0.000	0.000	0.000	0.000	0.000	-0.008
		2	0.000	0.000	0.000	0.000	0.000	-0.006
		3	0.000	0.000	0.000	0.000	0.000	0.005
		33	0.000	0.000	0.000	0.000	0.000	0.002
		4	0.000	0.000	0.000	0.000	0.000	0.002
		5	0.000	0.000	0.000	0.000	0.000	-0.001
		55	0.000	0.000	0.000	0.000	0.000	-0.004
		6	0.000	0.000	0.000	0.000	0.000	0.001
		66	0.000	0.000	0.000	0.000	0.000	-0.002
		7	0.000	0.000	0.000	0.000	0.000	-0.004
		77	0.000	0.000	0.000	0.000	0.000	-0.006
		8	0.000	0.000	0.000	0.000	0.000	-0.001
		88	0.000	0.000	0.000	0.000	0.000	-0.004
6	GLOBAL							
		1	0.000	-0.001	0.000	0.000	0.000	-0.010
		2	0.000	-0.001	0.000	0.000	0.000	-0.007
		3	0.000	0.000	0.000	0.000	0.000	0.004
		33	0.000	0.000	0.000	0.000	0.000	0.003
		4	0.000	0.001	0.000	0.000	0.000	0.005
		5	0.000	0.000	0.000	0.000	0.000	-0.001
		55	0.000	0.000	0.000	0.000	0.000	-0.002
		6	0.000	0.000	0.000	0.000	0.000	0.002
		66	0.000	0.000	0.000	0.000	0.000	0.001
		7	0.000	-0.001	0.000	0.000	0.000	-0.006
		77	0.000	-0.001	0.000	0.000	0.000	-0.007
		8	0.000	0.000	0.000	0.000	0.000	-0.003
		88	0.000	0.000	0.000	0.000	0.000	-0.004
7	GLOBAL							
		1	0.000	-0.002	0.000	0.000	0.000	-0.005
		2	0.000	-0.001	0.000	0.000	0.000	-0.004

		3	0.000	0.001	0.000	0.000	0.000	0.002
		33	0.000	0.000	0.000	0.000	0.000	0.001
		4	0.000	0.001	0.000	0.000	0.000	0.003
		5	0.000	0.000	0.000	0.000	0.000	0.000
		55	0.000	0.000	0.000	0.000	0.000	0.000
		6	0.000	0.000	0.000	0.000	0.000	0.001
		66	0.000	0.000	0.000	0.000	0.000	0.001
		7	0.000	-0.001	0.000	0.000	0.000	-0.004
		77	0.000	-0.001	0.000	0.000	0.000	-0.004
		8	0.000	-0.001	0.000	0.000	0.000	-0.002
		88	0.000	-0.001	0.000	0.000	0.000	-0.002
8	GLOBAL							
		1	0.000	-0.002	0.000	0.000	0.000	0.002
		2	0.000	-0.001	0.000	0.000	0.000	0.002
		3	0.000	0.001	0.000	0.000	0.000	-0.001
		33	0.000	0.001	0.000	0.000	0.000	0.000
		4	0.000	0.001	0.000	0.000	0.000	-0.001
		5	0.000	0.000	0.000	0.000	0.000	0.000
		55	0.000	0.000	0.000	0.000	0.000	0.001
		6	0.000	0.000	0.000	0.000	0.000	0.000
		66	0.000	0.000	0.000	0.000	0.000	0.000
		7	0.000	-0.001	0.000	0.000	0.000	0.001
		77	0.000	-0.001	0.000	0.000	0.000	0.002
		8	0.000	-0.001	0.000	0.000	0.000	0.000
		88	0.000	-0.001	0.000	0.000	0.000	0.001
9	GLOBAL							
		1	0.000	-0.001	0.000	0.000	0.000	0.008
		2	0.000	-0.001	0.000	0.000	0.000	0.006
		3	0.000	0.000	0.000	0.000	0.000	-0.003
		33	0.000	0.000	0.000	0.000	0.000	-0.002
		4	0.000	0.001	0.000	0.000	0.000	-0.004
		5	0.000	0.000	0.000	0.000	0.000	0.001
		55	0.000	0.000	0.000	0.000	0.000	0.002
		6	0.000	0.000	0.000	0.000	0.000	-0.002
		66	0.000	0.000	0.000	0.000	0.000	-0.001
		7	0.000	-0.001	0.000	0.000	0.000	0.005
		77	0.000	-0.001	0.000	0.000	0.000	0.006
		8	0.000	0.000	0.000	0.000	0.000	0.003
		88	0.000	-0.001	0.000	0.000	0.000	0.004
10	GLOBAL							
		1	0.000	-0.001	0.000	0.000	0.000	0.009
		2	0.000	0.000	0.000	0.000	0.000	0.006
		3	0.000	0.000	0.000	0.000	0.000	-0.003
		33	0.000	0.000	0.000	0.000	0.000	-0.002
		4	0.000	0.000	0.000	0.000	0.000	-0.005
		5	0.000	0.000	0.000	0.000	0.000	0.001
		55	0.000	0.000	0.000	0.000	0.000	0.001
		6	0.000	0.000	0.000	0.000	0.000	-0.002
		66	0.000	0.000	0.000	0.000	0.000	-0.001
		7	0.000	0.000	0.000	0.000	0.000	0.006
		77	0.000	0.000	0.000	0.000	0.000	0.006
		8	0.000	0.000	0.000	0.000	0.000	0.003
		88	0.000	0.000	0.000	0.000	0.000	0.004

```
(    81) >
(    82) >
(    83) > plot plane
(    84) >
(    85) >
(    86) >
(    87) > $$
(    88) >
(    89) > FINISH
**** STRUDL MESSAGE PL.31 - SCOPE ENVIRONMENT ENDED.
```

ATTACHMENT E LOAD COMBINATION - DESIGN VERIFICATION REVIEW: ALTERNATE CALCULATION METHOD

The load combination used in Calc section 4.1 [C = (1.0 ± 0.05)D + I.0Wt + 1.0Pt] is specifically for containment design and does not apply to "Other Class I Structures". This combination is tabulated in the FSAR Section 5.2.3.2.1 together with other accident load combinations (including accident temperature and pressure) for design of the RB. Note that tornado missile is not included in any of these load combinations. Page 13 of 48 of the Containment DBD states that consideration of tornado missile was not included in the design load combinations (for containment) due to analysis at TMI for aircraft impact. FSAR section 5.4 contains design requirements for "Other Class I Structures and Systems" (other than containment). The following pertinent information can be found in this section:

a. Section 5.4.1.2 states that for tornado loads including missiles refer to Section 5.2.1.2.6. This section identifies the loads but not the load combinations.

b. Section 5.4.3 states that the design is based on ACI 3 18-63 "Ultimate Strength Design" for tornado, earthquake and missile.

c. Section 5.4.3.2.2 states that the AB has been designed to withstand short term tornado loadings, including tornado generated missiles. Structural design is in accordance with ACI 318-63 "Ultimate Strength Design".

d. Section 5.4.5.3 states that the structural design for tornado generated missiles including the wood pole and 2000# auto are per the ultimate strength provisions of ACI 318-63.

Note that ACI 318-63 does not directly address tornado wind loads or tornado generated missiles. This code does apply a load factor of 1.25 when checking wind loads. Also note that G/C generally applied a load factor of 1.25 to both tornado wind and missile loads. However, the SER dated July 5, 1974 Section 3.3 "Wind and Tornado Design Criteria" specifically states that for tornado loads on concrete structures a load factor of 1.0 is to be used. It has also been noted that GIC calculations generally combine tornado missile with tornado wind.

My interpretation/recommendation:

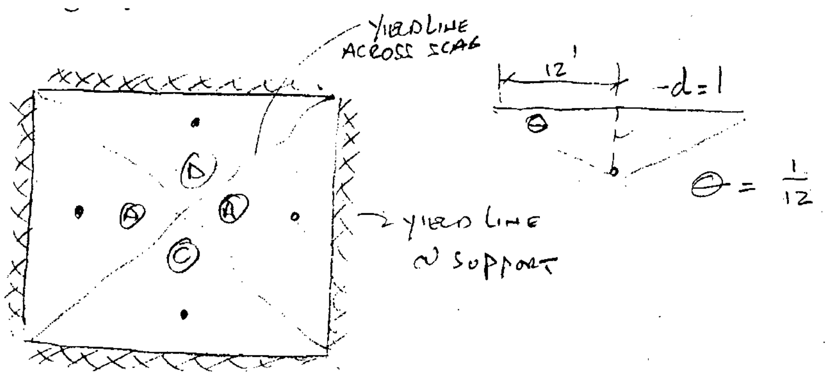
I believe the intent of the FSAR and SER is that missile load is evaluated separately from wind. Also that the LF of 1.25 is not required. Based on this interpretation the following load cases should be valid but must be confirmed.

C = DL + LL + Ww + Wp
C = DL + LL + Ww
C = Wm

Ww = Tornado wind Wp = tornado depressurization Wm = tornado missile

ATTACHMENT F VERIFY ULTIMATE UNIFORM DISTRIBUTED LOAD DERIVES BY YIELD LINE STANDARD EQUATIONS USING WORK ENERGY METHODS

Strain energy is the mechanical energy stored up in stressed material. Stress within the elastic limit is implied; therefore, the strain energy is equal to the work done by the external forces in producing the stress and is recoverable. Ref. Roark 5th Edition, page 11.



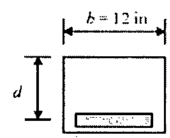
Determine ultimate load w_u that can be carried by the wall.

Concrete compressive strength, f'_c =	3000	psi
Steel yield stress, f_y =	40	ksi
Slab thickness, t =	24	in
Slab width, S_x =	24	ft
Slab height, S_y =	24	ft
Slab unit width, b =	12	in
Re-bar cover, c_c =	2	in

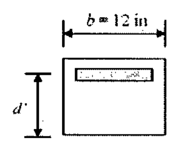
Reinforcement in both directions

Direction	Location	Re-bar #	Spacing	A_s (in^2)	Dia., in
X	Top	6	12	0.44	0.75
	Bottom	6	12	0.44	0.75
Y	Top	6	12	0.44	0.75
	Bottom	6	12	0.44	0.75

Effective depth in x-direction, d_x = t - c_c - Dia / 2
= 24 - 2.000 - 0.750 / 2
= 21.625 in

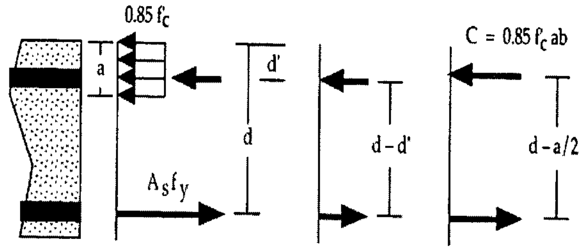


Effective depth in y-direction, d_y = t - c_c - Dia - Dia / 2
= 24 - 2.000 - 0.750 - 0.750 / 2
= 20.875 in



ϕ = 0.9

For X-direction d_x = d_x' = 21.625 in
For X-direction d_y = d_y' = 20.875 in



Calculation of the moments per unit length in both directions

Positive bending moment in X-direction

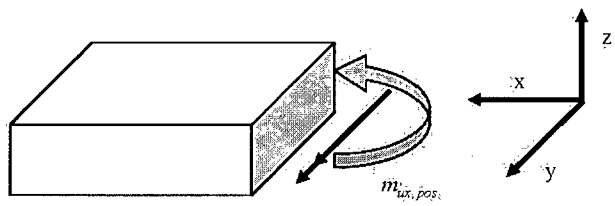


Fig. 2 Positive bending moment in X direction

Top re-bar spacing, s_{xt} =	12	in
Bottom re-bar spacing, s_{xb} =	12	in
Re-bar area, A_{sx} =	0.44	in^2

A_s = (12 / s_{xb}) A_s
= (12 / 12) * 0.4
= 0.44 in^2

a = $f_y A_s$ / (0.85 f'_c b)
= 40000 * 0.44 / (0.85 * 3000 * 12)
= 0.575 in

$m_{ux, pos}$ = $\phi A_s f_y (d_x - a / 2)$
= 0.9 * 0.440 * 40.0 * (21.6 - 0.575 / 2)
= 337.98 in - kip
= 28.17 ft - kip

Negative bending moment in X-direction

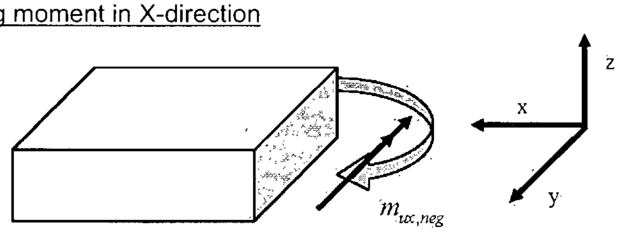


Fig. 3 Negative bending moment in X direction

A_s = (12 / s_{xt}) A_s
= (12 / 12) * 0.4
= 0.44 in^2

a = $f_y A_s$ / (0.85 f'_c b)
= 40000 * 0.44 / (0.85 * 3000 * 12)
= 0.575 in

$m_{ux, neg} = \phi A_s f_y (d_x - a / 2)$
$= 0.9 * 0.44 * 40.0 * (21.6 - 0.575 / 2)$
$= 337.98$ in - kip
$= 28.17$ ft - kip

Positive bending moment in Y-direction

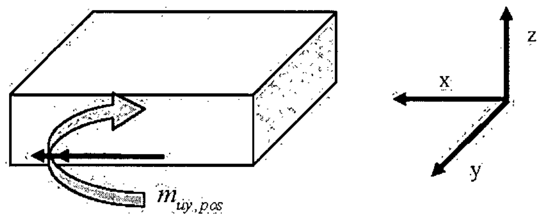


Fig. 4 Positive bending moment in Y direction

Top re-bar spacing, $s_{yt} =$ 12 in
Bottom re-bar spacing, $s_{yb} =$ 12 in
Re-bar area, $A_{sy} =$ 0.44 in^2

$A_s = (12 / s_{xb}) A_s$
$= (12 / 12) * 0.4$
$= 0.44$ in^2

$a = f_y A_s / (0.85 f'_c b)$
$= 40000 * 0.44 / (0.85 * 3000 * 12)$
$= 0.575$ in

$m_{uy, pos} = \phi A_s f_y (d_y - a / 2)$
$= 0.9 * 0.440 * 40.0 * (20.9 - 0.575 / 2)$
$= 326.10$ in - kip
$= 27.18$ ft - kip

Negative bending moment in Y-direction

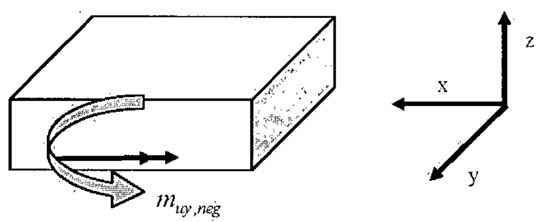


Fig. 5 Negative bending moment in X direction

$A_s = (12 / s_{yt}) A_s$
$= (12 / 12) * 0.4$
$= 0.44$ in^2

$a = f_y A_s / (0.85 f'_c b)$
$= 40000 * 0.44 / (0.85 * 3000 * 12)$
$= 0.575$ in

$m_{uy, neg} = \phi A_s f_y (d_x - a / 2)$
$= 0.9 * 0.44 * 40.0 * (20.9 - 0.575 / 2)$
$= 326.10$ in - kip
$= 27.18$ ft - kip

Segment	Location	$M_u L \Theta$	Value	Remark
A	$+M_u$	28.27 * 24 / 12 =	56.34	(1)
	$-M_u$ (Support)		56.34	
B	$+M_u$	28.27 * 24 / 12 =	56.34	(1)
	$-M_u$ (Support)		56.34	
C	$+M_u$	27.18 * 24 / 12 =	54.36	(1)
	$-M_u$ (Support)		54.36	
D	$+M_u$	27.18 * 24 / 12 =	54.36	(1)
	$-M_u$ (Support)		54.36	
		$\Sigma M_u L \Theta$ =	442.8	

Note: (1) Moment varies along yield lines. Values used are conservative.

$\Sigma P \delta =$ 2 * (w * 24 * 12 * 1 / 2) * 2 * 1 / 3
= 192 w

By conservation of energy the sum of internal and external work must be zero and this will make it possible to calculate the failure load of the construction.

$\Sigma P \delta = \Sigma M_u L \Theta$
192 w = 442.8
w = 442.8 / 192
= 2.306 ksf **CHECKS OK**

```
                     OOOOO
                    OO   OO
                    OO   OO
OOOOOOO    OOOOO   OOOOO  OO       OOOOO  OO    OO   OO  OOOOOOOO   OOOO
OO    OO  OO      OO   OO OO      OO   OO OO    OO   OO OO  OO  OO OO  OO
OO    OO  OO      OOOOOOO OO   OO OO   OO OO    OO   OO OO  OO  OO OO  OO
OOOOOOO   OO      OO   OO OO   OO OO   OO OO    OO   OO OO  OO  OO OO  OO
OO         OOOOO  OO   OO  OOOOO   OOOOO  OOOOO  OOOOO  OO  OO  OO OO  OO (TM)
```

pcaColumn v4.10 (TM)
Computer program for the Strength Design of Reinforced Concrete Sections

General Information:

File Name: D:\PROJECTS\CRYSTAL RIVER\YIELD LINE ANALYSIS\Column_Check\Column.col
Project: CR3 AB East Wall
Column: O1 Engineer: MWM
Code: ACI 318-02 Units: English

Run Option: Investigation Slenderness: Not considered
Run Axis: X-axis Column Type: Structural

Material Properties:

f'c = 3 ksi fy = 40 ksi
Ec = 3320.56 ksi Es = 29000 ksi
Ultimate strain = 0.003 in/in
Beta1 = 0.85

Section:

Rectangular: Width = 36 in Depth = 50.25 in

Gross section area, Ag = 1809 in^2
Ix = 380653 in^4 Iy = 195372 in^4
Xo = 0 in Yo = 0 in

Reinforcement:

Bar Set: ASTM A615

Size	Diam (in)	Area (in^2)	Size	Diam (in)	Area (in^2)	Size	Diam (in)	Area (in^2)
# 3	0.38	0.11	# 4	0.50	0.20	# 5	0.63	0.31
# 6	0.75	0.44	# 7	0.88	0.60	# 8	1.00	0.79
# 9	1.13	1.00	# 10	1.27	1.27	# 11	1.41	1.56
# 14	1.69	2.25	# 18	2.26	4.00			

Confinement: Tied; #3 ties with #10 bars, #4 with larger bars.
phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65

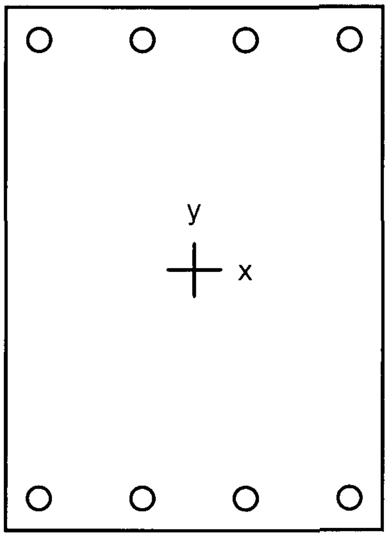
Layout: Rectangular
Pattern: Sides Different (Cover to longitudinal reinforcement)
Total steel area: As = 32.00 in^2 at rho = 1.77%

	Top	Bottom	Left	Right
Bars	4 #18	4 #18	0 #18	0 #18
Cover(in)	2	2	2	2

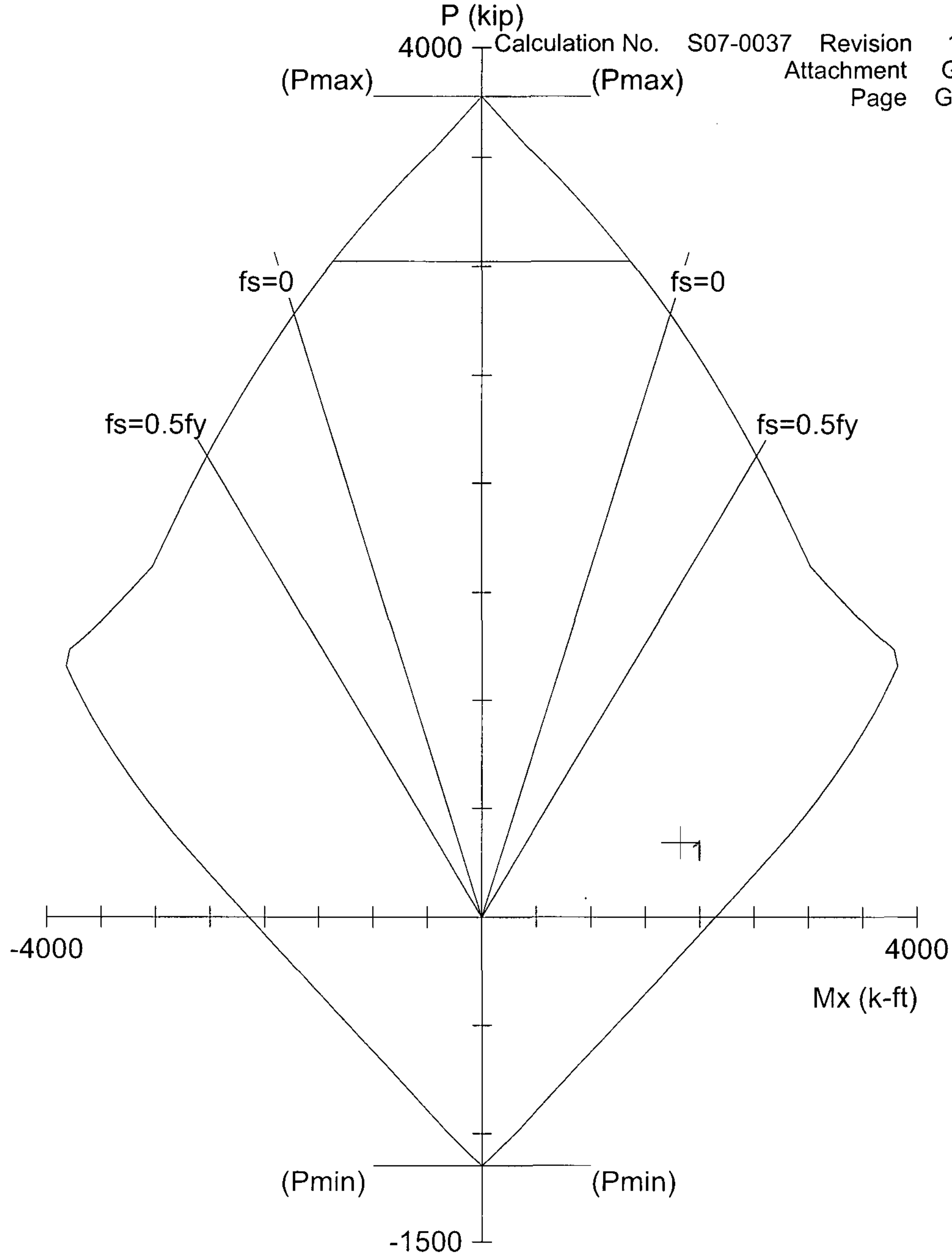
Factored Loads and Moments with Corresponding Capacities:

No.	Pu kip	Mux k-ft	fMnx k-ft	fMn/Mu	N.A. depth in	eps_t	Phi
1	340.60	1822.25	2760.23	1.515	5.64	0.02208	0.900

*** End of output ***



36 x 50.25 in



Code: ACI 318-02

Units: English

Run axis: About X-axis

Run option: Investigation

Slenderness: Not considered

Column type: Structural

Bars: ASTM A615

Date: 04/01/09

Time: 17:12:32

pcaColumn v4.10. Licensed to: Sargent & Lundy Engineers. License ID: 54143-1013717-4-2801B-21AB0

File: D:\PROJECTS\CRYSTAL RIVER\YIELD LINE ANALYSIS\Column_Check\Column.col

Project: CR3 AB East Wall

Column: O1		Engineer: MWM	
f'c = 3 ksi	fy = 40 ksi	Ag = 1809 in^2	8 #18 bars
Ec = 3321 ksi	Es = 29000 ksi	As = 32.00 in^2	rho = 1.77%
fc = 2.55 ksi		Xo = 0.00 in	Ix = 380653 in^4
e_u = 0.003 in/in		Yo = 0.00 in	Iy = 195372 in^4
Beta1 = 0.85		Min clear spacing = 7.66 in	Clear cover = 2.00 in
Confinement: Tied	phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65		

PROGRESS ENERGY FLORIDA, INC.

CRYSTAL RIVER UNIT 3

DOCKET Number 50-302 /License Number DPR-72

LICENSE AMENDMENT REQUEST #303, Revision 1

Revision to Final Safety Analysis Report Sections 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis"

Attachment C

Description of Proposed Change, Background, Technical Analysis, Determination of No Significant Hazards Considerations, and the Environmental Assessment

**Description of Proposed Change,
Background, Technical Analysis, Determination of No Significant
Hazards Consideration, and the Environmental Assessment**

1.0 Description of Proposed Change

The proposed License Amendment Request (LAR) will revise the Crystal River Unit 3 (CR-3) Final Safety Analysis Report (FSAR) Sections 5.4.3 and 5.4.5.3 to include a statement regarding the design of the east wall of the CR-3 Auxiliary Building.

Verbatim

FSAR Section 5.4.3 currently states that the design of Class 1 structures is based on American Concrete Institute (ACI) standard ACI 318-63, "Working Stress Design," for normal operating conditions, and "Ultimate Strength Design" for tornado, earthquake, and missile impact conditions. FSAR Section 5.4.5.3, states that for Class 1 structures, the structural design shall be checked by the ultimate strength provisions of ACI 318-63. These sections are being revised to read:

(5.4.3) This design has been based on ACI 318-63 "Working Stress Design" for normal operating conditions and "Ultimate Stress Design" for tornado, earthquake, and missile impact conditions, *except for the east wall of the Auxiliary Building, which has been based on ACI 349-97, "Code Requirements for Nuclear Safety Related Concrete Structures."*

(5.4.3.1) Same as Section 5.2.3.1 a, b, c, and e, *and ACI 349-97.*

(5.4.3.2.2) The structural design is in accordance with ACI 318-63, "Ultimate Strength Design," *except for the east wall of the Auxiliary building, which has been based on ACI 349-97.*

(5.4.5.3) The orientation of the pole to give the most critical load is end-on. For this condition, standard column formulas indicate that the pole will elastically buckle at a loading of 148 kips, which is considerably smaller than the crushing strength of either the pole or the concrete. The structural design was then checked by the ultimate strength provisions of ACI 318-63 for capacity to withstand this load, *except for the east wall of the Auxiliary Building, which has been based on ACI 349-97.*

The analysis for the automobile is based on the approach used in Reference 40, which has been verified ± 20% in tests conducted by Dr. T. J. Hirsh of the Texas Transportation Institute at Texas A&M University, and by tests indicated in the Reference. This approach was extrapolated for the case of a 2,000 lb automobile traveling at 150 mph. Although the variation of deceleration is sinusoidal, due to the scatter of the test results the analysis was based on maximum deceleration to develop a maximum force applied to the structure. The structural design was then checked by the ultimate strength provisions of ACI 318-63 for capacity to withstand this automobile load, *except for the east wall of the Auxiliary Building, which has been based on ACI 349-97.*

2.0 Background

The CR-3 Auxiliary Building, excluding the steel roof support, is a Class 1 structure. As described in the CR-3 FSAR, a Class 1 structure is a structure whose failure might cause or increase the severity of a Loss of Coolant Accident (LOCA) or result in an uncontrolled release of radioactivity. Class 1 structures are also vital to the safe shutdown and isolation of the reactor. CR-3 Class 1 structures, including the Auxiliary Building, contain and protect safety-related equipment.

The loads used in the design of these Class 1 structures have been determined based on operating and accident requirements, as specified below, in addition to regular loads as required by applicable codes:

Loads During Normal Operation

- Dead load
- Live load
- Wind load
- Equipment loads
- Design Basis Earthquake (DBE)

Abnormal Loads

- Tornado loads
- Main steam turbine missiles
- Tornado missiles
- Maximum Hypothetical Earthquake (MHE)

The tornado loading includes tornado generated missiles. Tornado design requirements are:

a. Tangential wind velocity of 300 miles per hour (mph)
b. An external pressure drop of 3 pounds per square inch gauge (psig)
c. Missile equivalent to a utility pole 35 feet long, 14 inches in diameter, density of 50 pounds per cubic foot, and traveling at 150 mph
d. Missile equivalent to a one ton automobile traveling at 150 mph. (Limiting design basis missile)

The CR-3 FSAR summarizes Class 1 structural design criteria in Section 5.4.3, "...design has been based on ACI 318-63, "Working Stress Design," for normal operating conditions, and "Ultimate Stress Design," for tornado, earthquake, and missile impact conditions."

Upon review of the original design basis structural calculations for the east and south Auxiliary Building walls, it was discovered that calculations were not performed to reflect loading related to tornado driven missiles or tornado wind load combinations as described in the FSAR. An investigation and an assessment of the operability of the east and south walls of the Auxiliary Building were completed. The south wall was qualified using the methods described in the FSAR (ACI 318-63). Calculations indicate the east wall is operable and does not pose a nuclear safety risk.

Calculations to qualify the east wall were performed using the Yield Line Theory methodology. Application of the Yield Line Theory methodology to qualify the east wall is based on meeting the requirements of ACI 349-97, "Code Requirements for Nuclear Safety Related Concrete Structures," and is contrary to the FSAR Section 5.4.3 and 5.4.5 statement that, "The design has been based on ACI 318-63." Therefore, a revision to the FSAR is required.

The Yield Line Theory methodology has been used as an acceptable methodology for internal missiles inside the Reactor Building at CR-3. FSAR Section 5.2.4.1.3 documents the application of this methodology. Additionally, a letter from the NRC to Florida Power Corporation, dated September 1, 1973, discusses the use of the Yield Line Theory methodology as an acceptable technique for determining the failure capacity of concrete structures for a High Energy Line Break in Category 1 structures outside containment.

3.0 Technical Analysis

The proposed amendment will revise FSAR described methodology for determining ultimate yield strength of the east wall of the CR-3 Auxiliary Building. The design basis structural design criteria described in the FSAR for Class 1 structures is that of ACI 318-63. Upon review of the original design basis calculations for the Auxiliary Building, it was discovered that calculations were not performed on the east or south wall that reflect loading related to tornado driven missiles or tornado wind load combinations as described in the FSAR.

The east wall of the Auxiliary Building is approximately 2 feet thick, constructed of reinforced concrete. FSAR Section 5.2.1.2.6, "Tornado Load," has determined that a minimum of two feet of concrete provides sufficient resistance to the postulated missile spectrum and no additional penetration calculations are required.

Calculation S07-0037, Revision 1, (Attachment B) was performed to confirm that the east wall of the Auxiliary Building is OPERABLE. The calculation also qualifies the wall to the FSAR described postulated tornado driven missile and wind loads using standard structural analysis techniques.

Calculations were performed to qualify the east wall using methods of ACI 318-63 as described in the FSAR. These calculations were not successful. The stresses on the wall due to tornado wind pressure and missiles are not within the allowable limits of ACI 318-63. However, the east wall can be qualified utilizing the Yield Line Theory methodology. The Yield Line Theory methodology is one of the methods discussed in ACI 349-97.

The guidelines of Standard Review Plan (NUREG-0800, Revision 2 – March 2007) Section 3.8.4, "Other Seismic Category 1 Structures," provide direction that the design and analysis of Category 1 buildings be in accordance with ACI 349-97. A review of the requirements of ACI 349-97 was performed to verify that the east wall of the Auxiliary Building would satisfy the applicable design requirements due to the amount of reinforcement in the wall.

Appendix C of ACI 349-97 does not specify any requirements for minimum reinforcement so Section 10.5.3 is applied for minimum reinforcement of flexural members which refers to Section 7.12 for structural slabs of uniform thickness. Section 7.12.5 requires that the ratio of reinforcement area provided at the tension face to gross area of concrete not be less than 0.0018 unless the area of reinforcement provided is at least one-third greater than that required by analysis. The ratio provided in the CR-3 Auxiliary Building east wall is 0.0015. In order to satisfy Section 7.12.5 for a lower ratio of reinforcement, the requirements of Appendix C have been checked for a wall with a reduced area of reinforcement which is three-quarters of the actual reinforcement area in the east wall. The result satisfies the requirement of ACI 349-97, Section 7.12.5, in that the area of reinforcement provided on the tension face is at least one third greater than required by analysis. The shear capacity of the east wall has been reviewed to ensure that the wall meets the requirements of Section C.3.6 for flexure to control the design.

The collapse load due to tornado missiles used to calculate ductility demand was determined by using a circular fan yield pattern based on the Yield Line Theory methodology. This analysis assumes fixed boundary conditions at the ends of the wall panel. The two-foot thick wall is bounded by three-foot thick slabs on the top and bottom, and three-foot wide by four-foot deep columns on each side. These members provide enough rigidity to assume fixed boundary conditions. The columns have also been checked to withstand the missile impact loads.

The governing loads for the Auxiliary Building east wall are the tornado wind plus depressurization and the tornado missile. The tornado wind plus depressurization load is qualified against the ultimate moment strength of the wall with reduced reinforcement area. The tornado missile loading is governed by the one ton automobile. The resulting missile load is a rectangular force pulse with duration of 0.081 seconds.

Structural Calculation S07-0037, Revision 1, (Attachment B) was performed using the Yield Line Theory methodology and concludes that the ultimate strength of the Auxiliary Building east wall exceeds the applied tornado and pressure drop loads and no overall failure for the walls will occur due to missile impact.

4.0 No Significant Hazard Consideration Determination

The proposed License Amendment Request (LAR) #303, Revision 1, will revise the Crystal River Unit 3 (CR-3) Final Safety Analysis Report (FSAR) Sections 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis." The proposed amendment will revise the analysis utilized to qualify specific portions of Class 1 structures.

1. *Does not involve a significant increase in the probability or consequences of an accident previously evaluated.*

The proposed LAR will revise the methodology used to qualify the east wall of the CR-3 Auxiliary Building for all expected and postulated loads including tornado wind and missile loading. The Yield Line Theory methodology is an industry standard that is used for the design and analysis of concrete slabs and is applied to CR-3 in accordance with American Concrete Institute (ACI) 349-97, "Code Requirements for Nuclear Safety Related Concrete Structures." A change in the methodology of an analysis used to verify qualification of an existing structure will not have any impact on the probability of accidents previously evaluated.

The analysis performed demonstrates that the CR-3 Auxiliary Building east wall will remain structurally intact following the worst case loadings assumed in the calculation. Therefore, this proposed change does not involve a significant increase in the probability or consequences previously evaluated.

2. *Does not create the probability of a new or different type of accident from any accident previously evaluated.*

The function of the CR-3 Auxiliary Building wall is to house and protect the equipment that is important to safety from damage during normal operation, transients, and design basis accidents. The use of ACI 349-97 for qualifying the east wall of the CR-3 Auxiliary Building has no impact on the capability of the structure. A calculation that uses the Yield Line Theory methodology demonstrated that the structure meets required design criteria. This ensures that the wall is capable of performing its design basis function without alteration or compensatory actions of any kind. No changes to any plant system, structure, or component (SSC) are proposed. No changes to any plant operating practices, procedures, computer firmware/software will occur.

Therefore, the proposed change will not create the possibility of new or different type of accident from any previously evaluated.

3. *Does not involve a significant reduction in the margin of safety.*

The design basis of the plant requires structures to be capable of withstanding normal and accident loads including those from a design basis tornado. The requirements of ACI 349-97, as applied in an approved plant calculation, demonstrated that the east wall of the CR-3 Auxiliary Building is capable of performing its design function. There is a slight reduction in conservatism between the method used for the remaining Class 1 structures, ACI 318-63 and ACI 349-97, but the calculation performed validates the requirement that the east wall of the Auxiliary Building will protect the important to safety systems, structures, and components located in proximity to the wall from damage.

Therefore, the proposed change does not involve a significant reduction in the margin of safety.

Based on the above, Florida Power Corporation concludes that the proposed amendment presents no significant hazards consideration under the standards set forth in 10 CFR 50.92(c) and, accordingly, a finding of "no significant hazards consideration" is justified.

5.0 <u>Applicable Regulatory Requirements/Criteria</u>

The proposed amendment is not a risk-informed change. The operation of the system will be the same as is currently considered in the CR-3 Probabilistic Risk Analysis. Requirements in 10 CFR 50, Appendix A, "General Design Criteria," do not directly apply to CR-3 since CR-3 was licensed prior to the General Design Criteria. However, there is a similarity to some of the criteria that CR-3 was licensed to, and of these, Criteria, 1, 2, and 40 are applicable as referenced in the CR-3 FSAR.

Criterion 1, "Quality Standards," requires systems, structures and components used in the prevention of accidents or mitigating the effects of an accident to be constructed according to quality standards. The Yield Line Theory methodology is an industry standard used in verifying that the design of the east wall of the Auxiliary Building assures its design function is satisfied. The calculation performed to demonstrate adequacy of the Auxiliary Building east wall is performed using this methodology, and is applicable for use in this application under ACI 349-97, "Code Requirements for Nuclear Safety Related Concrete Structures."

Criterion 2, "Performance Standards," requires systems, structures, and components to be designed, fabricated, and erected in accordance to performance standards that will enable the facility to withstand, without loss of the capability to protect the public, additional forces that may be imposed by natural forces such as earthquakes, tornados, flooding, etc. ACI 318-63 is one such performance standard. ACI 349-97 is another performance standard that provides for similar design and construction techniques and methodologies that will assure protection to the public from failures of structures that could allow the release of radioactive materials. The Yield Line Theory methodology is applicable for use at CR-3 under the provisions of ACI 349-97.

Criterion 40, "Missile Protection," requires protection of engineered safeguard equipment from the effects of internal and externally generated missiles. Inherent in this requirement is the protection afforded by the external walls of the building that houses the equipment. The calculation performed on the east wall of the Auxiliary Building, satisfying the requirements of ACI 349-97, demonstrates that the Auxiliary Building east wall will successfully perform this function against all required loading combinations.

6.0 Environmental Impact Evaluation

10 CFR 51.22 (c)(9) provides criteria for identification of licensing and regulatory actions eligible for categorical exclusion from performing an environmental assessment. A proposed amendment to an operating license for a facility requires no environmental assessment if operation of the facility in accordance with the proposed amendment would not:

- (i) Involve a significant hazards consideration,
- (ii) Result in a significant change in the types or significant increase in the amounts of any effluents that may be released offsite, and
- (iii) Result in a significant increase in individual or cumulative occupational radiation exposure.

FPC has reviewed proposed License Amendment Request #303, Revision 1, and concludes it meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(c), no environmental impact statement or environmental assessment needs be prepared in connection with this request.

PROGRESS ENERGY FLORIDA, INC.

CRYSTAL RIVER UNIT 3

DOCKET Number 50-302 /License Number DPR-72

LICENSE AMENDMENT REQUEST #303, Revision 1

Revision to Final Safety Analysis Report Sections 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis"

Attachment D

Proposed Revised Final Safety Analysis Report Pages Strikeout and Shadowed Text Format

5.4 OTHER CLASS I STRUCTURES AND SYSTEMS

Other Class I structures are listed in Section 5.1.1.1. With the exception of the Dedicated Emergency Feedwater Tank Enclosure and the Diesel Driven Emergency Feedwater Pump Enclosure, other Class I structures are designed as discussed in Sections 5.4.1 through 5.4.3. Design of the Dedicated Emergency Feedwater Tank Enclosure is discussed in Section 5.4.6. Design of the Diesel Driven Emergency Feedwater Pump Enclosure is discussed in section 5.4.7.

5.4.1 STRUCTURAL DESIGN PARAMETERS

The loads used in design of these other Class I structures have been determined based on operating and accident requirements, as specified below, in addition to regular loads as required by applicable codes.

5.4.1.1 Loads During Normal Operation

The loads due to normal operating conditions are:

a. Dead load
b. Live load
c. Wind load
d. Equipment loads
e. Design Basis Earthquake (DBE), see Section 5.2.1.2.9a

5.4.1.2 Abnormal Loads (Protection of Safeguards)

These Class I structures which protect Class I Systems and equipment have been designed for such incidents as:

a. Tornado loads, see Section 5.2.1.2.6.
b. Main steam turbine missiles.
c. Tornado missiles, see Section 5.2.1.2.6.
d. Maximum Hypothetical Earthquake (MHE), see Section 5.1.2.1.

5.4.2 MATERIALS AND SPECIFICATIONS

The material and specifications for these other Class I structures are similar to those detailed in Section 5.2.2, except for the concrete which has a minimum compressive strength of 3,000 psi in 28 days (see Section 5.2.2.1).

5.4.3 STRUCTURAL DESIGN CRITERIA

This design has been based on ACI 318-63 "Working Stress Design" for normal operating conditions, and "Ultimate Strength Design" for tornado, earthquake, and missile impact conditions, except for the east wall of the Auxiliary Building, which has been based on ACI 349-97, "Code Requirements for Nuclear Safety Related Concrete Structures."

5.4.3.1 Codes

Same as Section 5.2.3.1 a, b, c, and e, and ACI 349-97.

5.4.3.2 Loads

The design has been based upon normal operating loads, earthquake loads, and accident loads as described in Sections 5.4.1.1 and 5.4.1.2.

5.4.3.2.1 At Normal Operating Conditions

The stresses in the concrete and reinforcing steel resulting from combinations of those loads listed in Section 5.4.1.1 are in accordance with ACI 318-63, "Working Stress Design."

5.4.3.2.2 Abnormal Loads

The other Class I structures have been designed to withstand short term tornado loadings, including tornado generated missiles where such structures house systems and components whose failure would result in an inability to safely shutdown and isolate the reactor. Structures that are so designed include the following:

a. Control building.

b. Auxiliary building, excluding the steel roof support structure.

   The concrete portion of the auxiliary building which houses Class I items is designed for tornado generated missiles. The spent fuel pool and new fuel vault have been evaluated for tornado generated missiles by calculation S06-0010.

   The roof was designed considering seismic loads but the roof will not act as a barrier against a tornado missile.

c. Diesel generator building, including the radiator exhaust air deflector wall and its support structure (EGX-2).

   The deflector wall is missile resistant, not missile proof. Structural failure (collapse) of the wall will not occur, but it is not designed to prevent local deformation of the structure or puncture of the wall (Ref 68).

d. NSSS intake pump structure.

e. Intermediate building.

f. Exterior safety related piping and component missile shields.

The tornado design requirements are described in Section 5.2.1.2.6.

The structural design is in accordance with ACI 318-63, "Ultimate Strength Design," except for the east wall of the Auxiliary Building, which has been based on ACI 349-97, "Code Requirements for Nuclear Safety Related Concrete Structures."

5.4.3.2.3 Turbine Report

A vulnerability analysis of the plant design was made to determine what changes would have to be made in the event a turbine-missile could be produced. The basic criteria for this analysis was that plant shutdown and security could not be jeopardized by a turbine-missile strike. Moreover, the consequences of a strike could not cause or result in an uncontrolled release of excessive amounts of radioactivity. On this basis, those systems, structures, and

A detailed stress analysis of the internals under accident conditions is discussed in Babcock & Wilcox Topical Report BAW-10008.

Equipment such as safety features valves, tanks, and heat exchangers were stress analyzed using the equivalent static load method. The analysis includes evaluation of the equipment for normal and abnormal conditions. Seismic shock and vibration tests have been conducted on a valve operator which is typical of the valves used in the Engineered Safeguards (ES) Systems. The valve operator was tested at a 5.3g shock level at 35 cps with no discrepancies observed. A scan from 5 cps to 35 cps was made and no critical resonant frequencies were noted. The valve operator was shock and vibration tested in each of three different axes in a 2 minute "on" - 1 minute "off" cycle for a total of 3 times per axis. The unit was then electrically operated to the full-open and full-closed position, and all torque switches and limit switches functioned properly. All electrical and mechanical devices on the operator functioned properly.

The RCP motors have been dynamically tested by the supplier under operational conditions in a test loop. The tests demonstrated that the pump motor would operate satisfactorily under the worst anticipated vibratory loadings resulting from full flow conditions for Crystal River Unit 3. The natural frequency of the RCP and motor (above 25 cps) is appreciably above the fundamental seismic response spectra (10 cps) of the reactor coolant loop. The pump motors are capable of withstanding the calculated design earthquake loading with unaffected operational capability.

5.4.5.3 Missile Analysis

The missile loading requirements for Class I structures are as in Section 5.4.3.2.3 for main steam turbine missiles, and as in Section 5.2.1.2.6 for tornado missiles.

The orientation of the pole to give the most critical load is end-on. For this condition, standard column formulas indicate that the pole will elastically buckle at a loading of 148 kips, which is considerably smaller than the crushing strength of either the pole or the concrete. The structural design was then checked by the ultimate strength provisions of ACI 318-63 for capacity to withstand this pole load, except for the east wall of the Auxiliary Building, which has been based on ACI 349-97.

The analysis for the automobile is based on the approach used in Reference 40, which has been verified ±20% in tests conducted by Dr. T. J. Hirsh of the Texas Transportation Institute at Texas A&M University, and by tests indicated in the Reference. This approach was extrapolated for the case of a 2,000 lb automobile traveling at 150 mph. Although the variation of deceleration is sinusoidal, due to the scatter of the test results the analysis was based on maximum deceleration to develop a maximum force applied to the structure. The structural design was then checked by the ultimate strength provisions of ACI 318-63 for capacity to withstand this automobile load, except for the east wall of the Auxiliary Building, which has been based on ACI 349-97.

Missile analysis based on Standard Review Plan 3.5.1.4 (Ref 49) guidelines was used for the Emergency Feedwater Tank Enclosure and the Diesel Driven Emergency Feedwater Pump Enclosure. See sections 5.4.6 and 5.4.7 for more information.

5.4.5.4 Seismic Design and Review of Class I (Seismic) Components and Equipment

The seismic input, including any necessary feedback from structural and system dynamic analyses, were specified to the vendors of purchased Class I (seismic) components and equipment. Independent engineering review was made within the respective departments by persons other than the original Design Engineer.

PROGRESS ENERGY FLORIDA, INC.

CRYSTAL RIVER UNIT 3

DOCKET Number 50-302 /License Number DPR-72

LICENSE AMENDMENT REQUEST #303, Revision 1

Revision to Final Safety Analysis Report Sections 5.4.3, "Structural Design Criteria," and 5.4.5.3, "Missile Analysis"

Attachment E

**Proposed Revised Final Safety Analysis Report Pages
Revision Bar Format**

5.4 OTHER CLASS I STRUCTURES AND SYSTEMS

Other Class I structures are listed in Section 5.1.1.1. With the exception of the Dedicated Emergency Feedwater Tank Enclosure and the Diesel Driven Emergency Feedwater Pump Enclosure, other Class I structures are designed as discussed in Sections 5.4.1 through 5.4.3. Design of the Dedicated Emergency Feedwater Tank Enclosure is discussed in Section 5.4.6. Design of the Diesel Driven Emergency Feedwater Pump Enclosure is discussed in section 5.4.7.

5.4.1 STRUCTURAL DESIGN PARAMETERS

The loads used in design of these other Class I structures have been determined based on operating and accident requirements, as specified below, in addition to regular loads as required by applicable codes.

5.4.1.1 Loads During Normal Operation

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These Class I structures which protect Class I Systems and equipment have been designed for such incidents as:

a. Tornado loads, see Section 5.2.1.2.6.
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5.4.2 MATERIALS AND SPECIFICATIONS

The material and specifications for these other Class I structures are similar to those detailed in Section 5.2.2, except for the concrete which has a minimum compressive strength of 3,000 psi in 28 days (see Section 5.2.2.1).

5.4.3 STRUCTURAL DESIGN CRITERIA

This design has been based on ACI 318-63 "Working Stress Design" for normal operating conditions, and "Ultimate Strength Design" for tornado, earthquake, and missile impact conditions, except for the east wall of the Auxiliary Building, which has been based on ACI 349-97, "Code Requirements for Nuclear Safety Related Concrete Structures."

5.4.3.1 Codes

Same as Section 5.2.3.1 a, b, c, and e, and ACI 349-97.

5.4.3.2 Loads

The design has been based upon normal operating loads, earthquake loads, and accident loads as described in Sections 5.4.1.1 and 5.4.1.2.

5.4.3.2.1 At Normal Operating Conditions

The stresses in the concrete and reinforcing steel resulting from combinations of those loads listed in Section 5.4.1.1 are in accordance with ACI 318-63, "Working Stress Design."

5.4.3.2.2 Abnormal Loads

The other Class I structures have been designed to withstand short term tornado loadings, including tornado generated missiles where such structures house systems and components whose failure would result in an inability to safely shutdown and isolate the reactor. Structures that are so designed include the following:

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   The concrete portion of the auxiliary building which houses Class I items is designed for tornado generated missiles. The spent fuel pool and new fuel vault have been evaluated for tornado generated missiles by calculation S06-0010.

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d. NSSS intake pump structure.

e. Intermediate building.

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The tornado design requirements are described in Section 5.2.1.2.6.

The structural design is in accordance with ACI 318-63, "Ultimate Strength Design," except for the east wall of the Auxiliary Building, which has been based on ACI 349-97, "Code Requirements for Nuclear Safety Related Concrete Structures."

5.4.3.2.3 Turbine Report

A vulnerability analysis of the plant design was made to determine what changes would have to be made in the event a turbine-missile could be produced. The basic criteria for this analysis was that plant shutdown and security could not be jeopardized by a turbine-missile strike. Moreover, the consequences of a strike could not cause or result in an uncontrolled release of excessive amounts of radioactivity. On this basis, those systems, structures, and

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5.4.5.4 Seismic Design and Review of Class I (Seismic) Components and Equipment

The seismic input, including any necessary feedback from structural and system dynamic analyses, were specified to the vendors of purchased Class I (seismic) components and equipment. Independent engineering review was made within the respective departments by persons other than the original Design Engineer.