Systems	7127
Calc. Sub-Type	-
Priority Code	3
Quality Class	S

NUCLEAR GENERATION GROUP

ANALYSIS / CALCULATION

S09-0036
(Calculation #)

Auxiliary Building Overhead Crane (FHCR-5) Supporting Steel Structure - Analysis
(Title including structures, systems, components)

☐ BNP UNIT ________

☒ CR3 ☐ HNP ☐ RNP ☐ NES ☐ ALL

APPROVAL ☒ Electronically Approved

Rev	Prepared By	Reviewed By	Supervisor
0	Signature	Signature	Signature
	Name Mayankant Madhavkant (ENERCON)	Name Gwang Na (ENERCON)	Name Kyong S. Pak (ENERCON)
	Date	Date	Date

(For Vendor Calculations)

Vendor Enercon Services Inc. Vendor Document No. N/A

Owner's Review By ______________________ Date ________

List Of Effective Pages

Page	Rev	Page	Rev	Page	Rev	Page	Rev
i	0	ii	0	iii	0	iv	0
v	0	vi	0	vii	0	viii	0
ix	0	x	0	xi	0	xii	0
xiii	0	xiv	0	xv	0	xvi	0
xvii	0						
1	0	2	0	3	0	4	0
5	0	6	0	7	0	8	0
9	0	10	0	11	0	12	0
13	0	14	0	15	0	16	0
17	0	18	0	19	0	20	0
21	0	22	0	23	0	24	0
25	0	26	0	27	0	28	0
29	0	30	0	31	0	32	0
33	0	34	0	35	0	36	0
37	0	38	0	39	0	40	0
41	0	42	0	43	0	44	0
45	0	46	0	47	0	48	0
49	0	50	0	51	0	52	0
53	0	54	0	55	0	56	0
57	0	58	0	59	0	60	0
61	0	62	0	63	0	64	0
65	0	66	0	67	0	68	0
69	0	70	0	71	0		

Attachments

Attach. Number	Rev	Number of Pages	Attach. Number	Rev	Number of Pages	Attach. Number	Rev	Number of Pages
1	0	50	2	0	78	3	0	9
4	0	9	5	0	25	6	0	101
7	0	292	8	0	3	9	0	3
10	0	5403						

Amendments

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

Table Of Contents

<u>Attachments</u> <u>Total Page(s)</u>

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 per EC 70139

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	This calculation is issued to support the ISFSI project (EC 70139).

Reference Numbers – Reference Systems

Doc Services Action (Enter ADD, DELETE, or —)	**System** (Two letter code for systems affected by results)
ADD	7127

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**
ADD	EC	70139		ISFSI Auxiliary Building Crane Upgrade (FHCR-5)
ADD	AR	431929		Crane drawing requires verification.

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)
ADD	DWG		522-001		1		
ADD	DWG		522-003		6		
ADD	DWG		522-004		4		
ADD	DWG		522-006		3		
ADD	DWG		522-007		1		
ADD	DWG		522-008		1		
ADD	DWG		521-102		6		
ADD	DWG		422-019		8		
ADD	DWG		422-023		11		
ADD	DWG		422-031		4		
ADD	DWG		422-005		7		
ADD	DWG		422-015		15		
ADD	DWG		001-023		26		
ADD	DWG		001-032		31		
ADD	DWG		001-012		41		
ADD	DWG		002-003		5		
ADD	CALC		2:01.16		-		
ADD	CALC		2:01.10		-		
ADD	CALC		2:01.7D		-		
ADD	CALC		2:01.15		-		
ADD	CALC		2:01.14		-		
ADD	CALC		2:01.11		-		
ADD	CALC		2:01.12		-		

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)
ADD	ISFSI
ADD	AUXILIARY BUILDING
ADD	FHCR-5
ADD	OVERHEAD CRANE

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)
ADD	CALC		S10-0063		EC 70139

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)
ADD	FHCR-5, CRN	CRN	Evaluation of supporting structure for new/replacement crane

Record of Lead Review

Document **S09-0036** **Revision** **A**

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.**

Gwang Na	**Civil/Structure**	**4-14-2010**
Lead Reviewer (print/sign)	**Discipline**	**Date**

Item No.	Deficiency	Resolution
1)	NONE	
2)		
3)		
4)		
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 **S09-0036** **Revision** **B**

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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.**

Gwang Na	**Civil/Structure**	**10-3-2010**
Lead Reviewer (print/sign)	**Discipline**	**Date**

Item No.	Deficiency	Resolution
1	Section 3.0: Add following references. NUREG-0554 NUREG-0612 Calculation 2:01:50 Calculation S10-0063	Comment Incorporated
2	Section 6.5: Show load notations defined in DCD (D, L_f, L_r… etc.)	Comment Incorporated
3	Section 6.5.9: Change title of section from "Response Spectra" to "Seismic Load (E, E')"	Comment Incorporated
4	Section 8.0: 4th line, explain Fig 8.8 and Table xx in this Section. For example, add "column base locations and boundary conditions are shown in Figure 8.8 and Table xx, respectively.	Comment Incorporated
5	Section 8.1.7 (f): Reword this paragraph. Explain that eigenvalue analysis is performed instead of just saying mass matrix [M] and stiffness matrix [K] are calculated.	Comment Incorporated
6	Section 8.7.3.2 (a): Change span L=20 ft to 24.25 ft	Comment Incorporated
7	Section 8.7.3.2 (b): Change 'L4x8x3/4' to 'L6x8x7/8'	Comment Incorporated
8	Table of Contents: Add "3.0 References", "4.0 Introduction", "5.0 Assumptions". Update page numbers	Comment Incorporated

9	Change GTSTRUDL version 28 to 30 in Reference.	
10	Add Conclusion section.	Comment Incorporated
11	Section 3.2.2: Change “Specification of Structural Steel Building” to “Steel Construction Manual”	Comment Incorporated
12	Section 5.0: Do we have maintenance requirement and procedure described in this Section? Or, delete these.	Comment Incorporated, statement is deleted
13	Section 6.5.7: Need brief explanation for this load. Paragraph in DCD is also short and you can copy the statements to this Calculation.	Comment Incorporated
14	Section 6.6. Update Table to match with DCD.	Comment Incorporated
15	Divide Section 5.1 to make two Separate sections “Design Drawings”, “Material Properties”	Comment Incorporated
16	Section 5.1: Add Poisson’s Ratio, Mass Density, Modulus of Elasticity.	Comment Incorporated
17	Section 5.3: Change units	Section deleted
18	Section 7.0, Item 8: Add “floor” in front of “live load”. Specify seismic load direction “… for both N-S & E-W directions.”	Comment Incorporated
19	Section 8.6: remove “=” notations in left column of Table. Also, change unit to “kips” in a Table of “Lift Load Condition”.	Comment Incorporated
20	Section 8.5.3.1: For wind pressure calculation at each side of building, specify actual direction. e.g.) change “Windward” to “Windward (west side)”	Comment Incorporated
21	Specify table number to any table referenced in this calculation.	Comment Incorporated
22	Section 8.5.3: Before discussion of wind pressure calculation and actual wind velocity at each elevation, show actual basic design wind velocity of 110 mph used in the following calculation. Also add reference (DBD 1/3).	Comment Incorporated
23	Section 8.5.3: After Table 8.5, for “E-W direction: building height-width ratio”, show actual calculation to show how we got 0.43	Comment Incorporated

Record of Lead Review

Document **S09-0036** **Revision** **C & 0**

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- 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.**

Gwang Na	**Civil/Structure**	**11-01-2010** **2-9-2011**
Lead Reviewer (print/sign)	**Discipline**	**Date**

Item No.	Deficiency	Resolution
1)	NONE	
2)		
3)		
4)		
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 **S09-0036** **Revision** **B**

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- 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.**

Casaba Ranganath	Civil/Structure	10-15-10
Lead Reviewer **(print/sign)**	**Discipline**	**Date**

Item No.	Deficiency	Resolution
1	Page 5, Revise # 0 to B.	Comment Incorporated
2	Calculation number is shown as S10-0036 in all the sheets except the cover sheet. Change this to S09-0036.	Comment Incorporated
3	Page iv, Attachments: Delete "supplied" from Item 4 and the page numbers should be 9 instead of 8.	Comment Incorporated
4	Verify latest revision numbers for drawings listed in Page vi and in reference section. Some of the drawings are not the latest revisions.	Comment Incorporated
5	Page ix, The review comments should be hard copies and not electronic copies. Please include hard copy of the comments.	Comment Incorporated
6	Section 2.0: Add in the last sentence "including column base plates"	Comment Incorporated
7	Section 3, Page 2: In the last sentence 1st paragraph add earthquake loads.	Comment Incorporated
8	Section 4.4, Page 4 Calculation S10-0063 is not final. Need to have an AR to track the completion. Same for DCD in Section 4.5.	AR00427987 for S10-0063 is created. DCD is already issued and the calculation S09-0036 is verified against DCD.

9	Section 7.0, Page 10, Item 2 last sentence change ”to and” to “to verify”	Comment Incorporated
10	Section 8.1.2, Page 16, Column Detail: Last sentence should be 302A-I1 instead of 301A-I1. Why is this mentioned separately, when it is already stated above in that paragraph.	Sentence deleted as information is already provided in the Table
11	Page 18, Table: Change 302-N2 to 302A-N2	Comment Incorporated
12	Section 8.5.2.2, Page 44: Roof Live Load (Lr) – Second line delete ”way”	Comment Incorporated
13	Section 8.4, Page 54, last sentence change “kook” to “hook”.	Comment Incorporated
14	Section 8.7.3.1, Page 61: Delete 8.7.3.1 below 8.7.3.1.	Comment Incorporated
15	Pages 65, 66, &67: In Table under Member IR heading delete “For” from “For Bending stress”.	Comment Incorporated
16	Page 18, Table: Change 302-N2 to 302A-N2.	Comment Incorporated
17	In the STRUDL input in the hook down position, the Y coordinate for CN 450 is shown as -44.2 inches. This would mean that the hook will be below grade Elevation 119’, which is not possible. Need to verify this dimension. This appears to be correct from Page 54 table (rope length of 1056.16 inches) and hook up position Y coordinate 96.16 inches for CN 450. However, this is not feasible. What is the justification for using -44.26 inches Y coordinate in the hook down position for CN 450.	It’s true, that in use hook down position will be less than what is evaluated in the model. Up and down positions for crane hook is provided by crane vendor and needs to be evaluated. Any intermediate position shall be enveloped by these two extreme hook positions.
18	Attachment 3, Page 5. Item 1.0 last sentence change “that” to “than”.	Comment Incorporated
19	Attachment 9 shows the allowable stress as 1.5 times .5 Sy. What is the reference for this allowable, this allowable is not shown in DCD and why 36 ksi is not used as per DBD1/3, which states that the stresses can go up to elastic limit (Sy). Is the modification to eight vertical bracing required if A 490 bolts are used that could reduce the number of bolts and thus may not have reduced section at the bolt location.	Fy /(0.6 Fy) = 1.6 is the multiplier for elastic limit and conservatively 1.5 is used in overall calculation and if some over stress is observed then depending on overstress location and member it is manually checked to see if IR is less than 1.6 or needs modification.

Record of Lead Review

Document **S09-0036** **Revision** **C**

The signature below of the Lead Reviewer records that:

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- 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.**

Casaba Ranganath	**Civil/Structure**	**11-03-10**
Lead Reviewer (print/sign)	**Discipline**	**Date**

Item No.	Deficiency	Resolution
1	Section 4.1, Page 3: Revision number for OP-421C should be 33 instead of 32.	Comment incorporated.
2	Section 4.3, Page 3: Revision numbers for Drawings 001-023, 001-032, and 001-012 are not consistent in Page vi and Page 3. Note: Please verify the latest revision numbers of all the Progress Energy documents referenced in this calculation.	Comment incorporated. Title and revision number of other PE documents are verified.

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 S09-0036 **Revision** 0

The signature below of the Lead Reviewer records that:
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- 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.**

Casaba Ranganath	Civil/Structure	3-12-11
Lead Reviewer (print/sign)	**Discipline**	**Date**

Item No.	Deficiency	Resolution
1	Table on page 24 of calculation shows that the X and Z rotations will be restricted from rotation as per Vendor Stipulation for trolley wheels. Whereas GTSTRUDL input shows that these are free from rotation. The calculation table requires to be revised to reflect the GTSTRUDL input.	Comment incorporated.
2 (3/23/11)	S09-0036 Revision 0 calculation submitted for approval do not have all the attachments that were in Revision B, verify. Also in Revision B attachment the File Folder E1/HD-WL/3 does not have the same format as the rest such as E1/HD-WL/15 etc.	Comment incorporated. All attachments are submitted and computer file folders are updated to have same format.

3 (3/23/11)	Editorial: a) Attachment 8, Page 1: Delete Crane Bracket from Title. b) Attachment 8: Delete from the title on each page from Page 4 onwards "Crane Bracket" c) Attachment 10: Replace "Crane Bracket & Member Force Results for all Load Cases and all Runs" from title from Page 4 onwards with "Support Reactions all Load Cases Excluding 7000 & 8000 series all Runs".	a) This attachment is only for the crane bracket forces, therefore title is not revised. b) This attachment is only for the crane bracket forces, therefore title is not revised. c) Comment Incorporated, the Attachment is renamed "Support Reactions – All runs, All Load Cases Excluding 7000 and 8000 Series"
4 (3/29/11)	Keith's comment regarding the Load Cases LC 13, LC14, and LC15 that are in DCD are not evaluated in Calculation S09-0036, this requires to be addressed.	Load cases LC13, LC14, and LC15 in DCD are evaluated in this calculation. See revised page 10 for clarification.
5	Consider all three direction impact load simultaneously for ASME NOG-1 Load combinations.	Comment incorporated, load combinations in GTSTRUDL input file, calculation and all excel sheets are updated to reflect the same.

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:

1.0 PURPOSE AND SCOPE

The Progress Energy Crystal River Unit 3 (CR3) Auxiliary Building (AB) Overhead Crane support steel structure is being evaluated for overhead crane (FHCR-5) replacement (EC 70139). The purpose of this calculation is to develop a computer models and perform the coupled building/crane analyses. GT STRUDL (Ref. 4.5.1) finite element analysis computer program is used for this purpose. This calculation also addresses the qualification of existing and modified structural members. Evaluation of existing connections and its modification are not addressed in this calculation.

2.0 CONCLUSION

All the structural members excluding crane brackets (qualified in calculation S10-0063, Ref. 4.4.9) and crane members (qualified by crane vendor) are structurally acceptable and meet the necessary code requirements listed in Design Criteria Document (DCD, Attachment 1). As per the evaluation, it is found that total eight vertical bracing members need modifications (Attachment 9). See calculation S10-0063 for evaluation for crane bracket, crane stops, column base connections, crane rails and all member connections.

3.0 INTRODUCTION

Progress Energy Crystal River Unit 3 (CR3) is implementing the Independent Spent Fuel Storage Installation (ISFSI) for Dry Fuel Storage campaign. The Transfer Casks (TC) containing the Dry Shield Canisters (DSCs) are placed into and removed from the Spent Fuel Pool (SFP) using the AB Overhead Crane (FHCR-5). The existing overhead crane capacity (120 tons but has subsequently been derated by 40% to 72 tons, and recently derated further to 25 tons per reference 4.1.1) is inadequate to handle the proposed TC to be used at CR3. In addition, the existing overhead crane does not meet the single-failure-proof criteria of NUREG 0554 (Ref. 4.2.6) and NUREG 0612 (Ref. 4.2.7). Therefore, the overhead crane must be upgraded to increase load capacity to 130 tons/15 tons, main and aux hook capacities. The existing crane is not modified instead complete new crane, including the crane bridge structure as well as the trolley is provided by the crane vendor. Therefore, the Auxiliary Building is evaluated with the new crane loads along with other loads (e.g., dead loads, live loads, earthquake loads and wind loads).

The existing Auxiliary Building is designed to resist Operating Basis Earthquake (OBE) seismic loads and a design wind speed of 110 mph (Refs. 4.1.2, 4.4.2 and 4.4.11). Tornado loads and Maximum Hypothetical Earthquake (MHE) seismic loads were not included in the original design. This calculation and supporting Calculation S10-0063 (Ref. 4.4.9) together demonstrate that the modified crane support structure can accommodate an upgraded single-failure-proof crane under heavy load cask handling to 130 tons capacity in conjunction with the loads defined by the original plant licensing basis and ASME NOG-1 (Ref. 4.2.1). This calculation and the Design Criteria Document (Attachment 1) describe the structural modeling criteria of the coupled crane and crane support structure, as well as the loads, required load combinations, analysis methodology, and acceptance criteria. The intent of this calculation is to identify critical loads for the design/evaluation of the steel frames, connections, and column base connections. The interface point between ENERCON and crane vendor is at the top of the runway rail where crane and supporting structure meet. ENERCON is responsible for the structure below the interface, i.e., the supporting structure and crane vendor is responsible for the above the interface, i.e., the crane bridge.

4.0 REFERENCES

4.1 Site Specifications and Procedures

4.1.1 OP0421C, Operation of the Auxiliary Building Overhead Crane FHCR-5, Rev. 33
4.1.2 Crystal River Nuclear Unit 3 Final Safety Analysis Report, Rev. 32
4.1.3 DBD 1/3, Major Class I Structures, Rev. 6
4.1.4 Specification SP5209, CR3 Seismic Qualification, Rev. 0

4.2 Industrial Codes, Standards, and Manuals

4.2.1 Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder), ASME NOG-1, 2004
4.2.2 Steel Construction Manual, Allowable Stress Design 6th Edition, AISC, 1963
4.2.3 Building Code Requirements for Reinforced Concrete, ACI 318-63
4.2.4 Minimum Design Loads for Buildings and Other Structures, ASCE 7-05
4.2.5 USNRC, Regulatory Guide 1.92, Combining Modal Responses and Spatial Components in Seismic Response Analysis, Rev. 2, July 2006
4.2.6 NUREG-0554, “Single-Failure-Proof Cranes for Nuclear Power Plants”, May 1979
4.2.7 NUREG-0612, “Control of Heavy Loads at Nuclear Power Plants”, July, 1980
4.2.8 Steel Construction Manual, Allowable Stress Design 7th Edition, AISC, 1973

4.3 Drawings and Sketches

4.3.1 U-62238, General Arrangement of a Three Motor Tiger Trolley, Rev. 4
4.3.2 522-001, Auxiliary Buildings – Steel Framing Column Schedule, Rev. 1
4.3.3 522-003, Auxiliary Buildings South Steel Framing Roof at Elev. 167’-6” and 162’-0”, Rev. 6
4.3.4 522-004, Auxiliary Buildings South Steel Framing Roof at Elev. 209’-1” Crane Runway Steel at Elev. 193’-7”, Rev. 4
4.3.5 522-006, Auxiliary Buildings South Steel Framing Column Bracing, Rev. 3
4.3.6 522-007, Auxiliary Buildings Steel Framing East South & West Girt Elevations, Rev. 1
4.3.7 522-008, Auxiliary Buildings Steel Framing West & South Girt Elevations, Rev. 1
4.3.8 521-102, Auxiliary Buildings North Steel Framing Roof Steel Plan-Crane Runway. Roof Elev. 200’-4” & 209’-1”, Rev. 6
4.3.9 422-019, Auxiliary Buildings - South Walls from Elev. 119’-0” to Elev. 143’-0” Plan, Rev. 8
4.3.10 422-023, Auxiliary Buildings - South Floor Elev. 143’-0” Plan Concrete Outline, Rev. 11
4.3.11 422-031, Auxiliary Buildings South Floor Slab Elev. 162’-0” Plan Sections & Details, Rev. 4
4.3.12 422-005, Auxiliary Building South - Foundation Mat Elev. 93’-0” Plan Concrete Outline, Rev. 7
4.3.13 422-015, Auxiliary Building South - Walls from Elev. 93’-0” to Elev. 119’-0” Plan, Rev. 15
4.3.14 001-023, Layout - Plan above Reactor Auxiliary and Intermediate Buildings - Elev. 143'-0”, Rev. 26
4.3.15 001-032, Layout - Plan above Reactor Building Floor Elev. 160’-0” & Auxiliary Building - Elev. 162'-0”, Rev. 31

4.3.16 001-012, Layout - Plan above Reactor Auxiliary and Intermediate Buildings - Basement Floor - Elev. 75'-0" and 95'-0", Rev. 41
4.3.17 002-003, Layout - Longitudinal Section Thru Reactor Bldg. & Spent Fuel Pit, Rev. 5
4.3.18 QR88896, Hook 130 Ton Sister, Rev. 0 (Attachment 4)
4.3.19 R88752, Crane Layout 130 Ton SFP, Sh. 1/3, Rev. 0 (Attachment 4, see Section 5.0)
4.3.20 R88752, Crane Layout 130 Ton SFP, Sh. 2/3, Rev. 0 (Attachment 4, see Section 5.0)
4.3.21 R88752, Crane Layout 130 Ton SFP, Sh. 3/3, Rev. 0 (Attachment 4, see Section 5.0)
4.3.22 R88764, Trolley Layout 130 Ton SFP, Sh. 1/4, Rev. 0 (Attachment 4, see Section 5.0)
4.3.23 R88764, Trolley Layout 130 Ton SFP, Sh. 2/4, Rev. 0 (Attachment 4, see Section 5.0)
4.3.24 R88764, Trolley Layout 130 Ton SFP, Sh. 3/4, Rev. 0 (Attachment 4, see Section 5.0)
4.3.25 R88764, Trolley Layout 130 Ton SFP, Sh. 4/4, Rev. 0 (Attachment 4, see Section 5.0)
4.3.26 NUH-08-8002, NUHOMS - OS200 Onsite Transfer Cask Inner & Outer Shell Assembly, Rev. 1
4.3.27 421-129, Auxiliary Building – North Walls from Elev. 143'-0" to Elev. 162'-0" Plan, Rev. 4
4.3.28 421-130, Auxiliary Building – North Walls from Elev. 143'-0" to Elev. 162'-0" Sections & Details, Rev. 6

4.4 Calculations

4.4.1 Calculation 2:01.16, Seismic Analysis of Steel Frame
4.4.2 Calculation 2:01.10, Steel Frames
4.4.3 Calculation 2:01.7D, Applied Load from Steel Structure
4.4.4 Calculation 2:01.15, Roof Framing, Girts, and Miscellaneous Steel
4.4.5 Calculation 2:01.14, Steel Floor Framing @ 162'-0"
4.4.6 Calculation 2:01.11, Steel Columns
4.4.7 Calculation 2:01.12, Vertical Bracing
4.4.8 Calculation 2:01.50, Structural Steel – Aux. Building
4.4.9 Calculation S10-0063, Auxiliary Building Overhead Crane (FHCR-5) Supporting Steel Structure - Connection Evaluation, Rev. 0
4.4.10 Calculation 2:01.13, Crane Runway Girder
4.4.11 Calculation 2:01.48, Basic Design Requirements

4.5 Other References

4.5.1 GT STRUDL Computer Program, User Manual, Georgia Institute of Technology, Version 30.0 (see Note below)
4.5.2 Wind Forces on Structures, ASCE paper No. 3269, 1961
4.5.3 AISC, Steel Design Guide 7, Industrial buildings Roofs to Anchor Rods, Second edition
4.5.4 FPC118-PR-001, Design Criteria Document for Crystal River Unit 3 Auxiliary Building Evaluation for Crane Upgrades, Rev. 2 (Attachment 1)(Attachment Z23 of EC 70139)
4.5.5 PN036539 Transmittal 04-2: Stick model printout with cover sheet, 8/23/2010 (Attachment 2)

Note: GT STRUDL is commercially available computer software that is procured and maintained under the Enercon Services QA Program.

5.0 ASSUMPTIONS

No degradation of the steel and concrete structures will be considered in the building analysis.

Pending NTM 00431929, crane drawings R88752 (Refs. 4.3.19 to 4.3.21) and R88764 (Refs 4.3.22 to 4.3.25) are not official drawings, and shall be verified to ensure no changes/impact to this calculation once issued.

6.0 DESIGN INPUT

6.1 Design Drawings

The design drawings for CR3 are listed in references 4.3.2 to 4.3.17. In particular, Auxiliary Building Drawings 521-102, 522-001, 522-003, and 522-004 (Refs. 4.3.8, 4.3.2, 4.3.3 and 4.3.4) provide information about steel frame, and Drawings 422-023 (Ref. 4.3.10) provide information about concrete structure serving as the support for steel frame.

6.2 Material Properties

Per drawing 522-001 (Ref. 4.3.2):

Structural steel: ASTM A36 (F_y = 36,000 psi)
Modulus of Elasticity, E = 29,000 psi
Poisson's Ratio, ν = 0.3
Mass Density, ρ = 490 pcf

(Note: Material properties for the crane members are taken from the vendor supplied crane model and are different from structural steel properties mentioned above.)

6.3 Original Design Calculation

The complete evaluation of the Auxiliary Building (concrete and steel) is documented in Gilbert Calculation 2:01, Books I through V. Book II discusses the design of the concrete portion of structure and the interface with the steel supporting structure. Book IV and V provides the evaluation of the steel structure.

6.4 New Crane Information

The geometry and mass distribution of the crane, as provided by the crane vendor, are shown in Attachment 4 and Attachment 2. Additionally, the ANSYS structural model of the crane that incorporates all pertinent structural parameters was provided by the crane vendor and is used as a design input for the evaluation of the Auxiliary Building crane support structure.

a. Major Components Weight

Component	Weights
Trolley Weight	80,000 lbs
Bridge girder Weight	80,000 lbs

b. Lifting Weight Capacity

Hoist	Lifting Weight Capacity
Main Hoist	260,000 lbs (130 Tons)
Auxiliary Hoist	30,000 lbs (15 Tons)

6.5 Design Loads

6.5.1 Dead Load (D)

The dead loads will consist of the self-weight of the structural members including the supporting steel and concrete, girts, siding, purlins, roofing, and miscellaneous equipment.

The dead load of the crane (e.g., trolley, bridge girders, and additional attachments) is provided by the crane vendor and is included in the model.

6.5.2 Floor Live Loads (L_f)

At elevation 162'-0", a 300 psf live load is considered in accordance with DBD 1/3 (Ref. 4.1.3).

6.5.3 Roof Live Loads (L_r)

An area roof live load at EL 209'-1" of 30 psf is used as specified in DBD 1/3 (Ref. 4.1.3).

6.5.4 Crane Live Loads (L_c)

The crane live load will consist of a maximum of 130 tons for the main hook and 15 tons for the auxiliary hook (Attachment 4). The loads of main hook and auxiliary hook are not concurrent. Therefore, only the main hook load is considered in the structural frame analysis.

6.5.5 Crane Impact Loads (I)

Impact loads resulting from the operation of the crane are applied to the structural model in accordance with DBD 1/3 (Ref. 4.1.3) and ASME NOG-1 (Ref. 4.2.1). Gilbert Calculation 2.01.13 (Ref. 4.4.10) uses the impact loads listed in DBD 1/3 for analysis. The impact loads utilized in this calculation are shown on the next page and are further discussed in the section 7.5 of Design Criteria Document (Attachment 1).

Table 1: Crane Impact Factor

Crane Impact Loads	ASME NOG-1 (Ref. 4.2.1)	DBD 1/3 (Ref. 4.1.3)	Factors Used in Analysis
Vertical Impact Load	15 (Percent of max lift load)	25 (Percent of max lift load)	DBD 1/3
Transverse Impact Load	10 (Percent of trolley and lift load – which is the longitudinal horizontal load on the crane bridge girders)	20 (Percent of trolley and lift load – 10% applied to each crane runway girder)	DBD 1/3
Longitudinal Impact Load	5 (Percent of gantry bridge, trolley load and lifted load – which is the transverse horizontal load on the crane bridge girders)	10 (Percent of max wheel load)	DBD 1/3

6.5.6 Wind Loads

The design wind speeds used for the original plant licensing basis are shown below. In accordance with ASME NOG-1 (Ref. 4.2.1), the new upgraded crane support structure will consider an operating wind speed as shown below.

Table 2: Wind Coefficients applied to the Auxiliary Building

Wind Load		Speed (mph)
Tornado	Original	None
	New	None
Design Wind (W)	Original	110
	New	110
Operating Wind (W_O)	Original	None
	New	50

The design wind pressure for 110 mph wind speed is calculated in accordance with ASCE Paper No. 3269 (Ref. 4.5.2). The operating wind pressure is based on ASCE 7-05 (Ref. 4.2.4). For further discussion, see Sections 7.7, 7.8 and 7.11 of the Design Criteria Document (Attachment 1).

6.5.7 Thermal Loads (T)

The building structure is thermally constrained only at the column attachments to the concrete structure. The building structure experiences a temperature range of 55^0F to 95^0F. Thermal expansion, considering an ambient temperature of 70^0F will be small and the structural configuration provides adequate flexibility. Consequently thermal expansion loads on the structure will be negligible. Therefore, thermal loads will not be considered in the analysis of the Auxiliary Building.

6.5.8 Pendulum Effect

As required by NUREG-0554 Section 2.5 (Ref. 4.2.6), pendulum effect of the lifted load on the crane hoist during a seismic event are considered in the analysis of the Auxiliary Building. The lifted load is modeled in both the hook-up and hook-down positions of the main hoist of the crane such that the worst-case dynamic effects of the swinging mass are captured during the seismic analysis.

6.5.9 Seismic Load (E, E')

Enveloped response spectra curve is generated for the Auxiliary Building evaluation. See Appendix 2 of DCD (Attachment 1) for derivation of response curve. Table shown below provides the brief summary.

Seismic Analysis for Aux. Building Steel Structure
Enveloped [1] Response Spectra

	Current Licensing Basis [2]	ASME NOG-1-2004	Revised Aux. Building Qualification
Operating Basis Earthquake (OBE)	**FSAR:** OBE Ground Response Spectra (GRS) with damping value of 1% for welded and 2.5% for bolted structure (Ref. FSAR Section 5.2.4.1.2) **Analysis:** OBE Ground Response Spectra (GRS) with 1% damping (Ref. Gilbert Calculations 2:01)	Applicable OBE Response Spectra for the CR-3 site at appropriate level with 4% damping (Ref. ASME NOG-1-2004, Section 4152 & 4153.8)	**OBE** Spectra envelopes: • Current Licensing Basis • OBE Floor Response Spectra (FRS) at EL. 162' with 4% damping [3] NOTE: The enveloped response spectra conservatively envelopes both the current licensing basis & ASME NOG-1 requirement.
Maximum Hypothetical Earthquake (MHE)	**FSAR:** MHE Ground Response Spectra (GRS) with damping value of 1% for welded and 2.5% for bolted structure (Ref. FSAR Section 5.2.4.1.2) **Analysis:** MHE not included	Applicable MHE Response Spectra for the CR-3 site at appropriate level with 7% damping (Ref. ASME NOG-1-2004, Section 4152 & 4153.8)	MHE Spectra envelopes: • Current Licensing Basis • MHE Floor Response Spectra (FRS) at EL. 162' with 7% damping [3] NOTE: The enveloped response spectra conservatively envelopes both the current licensing basis & ASME NOG-1 requirement.

1) Enveloped spectra refers to a composite response spectra comprised of the maximum responses from each of the contributing response spectra.

2) GRS curves from FSAR, Fig. 2-35 for OBE (to a ground acceleration of 0.05 g acting horizontally and 0.033 g acting vertically) and Fig. 2-36 for MHE (to a ground acceleration of 0.1 g acting horizontally and 0.067 g acting vertically): Weston Geophysical Research, Inc., Seismicity Analysis and Response Spectra for Crystal River Nuclear Power Plant, June 27, **1967**.
NOTE: GRS curve for 2.5% damping is obtained using linear interpolation of the GRS curves for 2% and 5%, **2010**.

3) - OBE FRS curves for Aux. Building elevation up to 162' for damping values of 0.5% and 1% were developed in calculation S73-0001, Revision 0, "Response Spectrum Analysis", by M.P.H., **1973**.
- FRS curves for Aux. Building elevation for damping values of 2%, 3%, and 5% were developed in S92-0171, Revision 0, "Floor Response Spectrum Generation", by S.J. Serhan, **1992**.
OBE: FRS curve @ EL. 162' for 4% damping is obtained using linear interpolation of the OBE FRS curves for 3% and 5% damping, **2010**.
MHE: FRS curve @ EL. 162' for 7% damping is obtained using Lin and Chang method using MHE FRS curve for 5% damping, **2010**.
(NOTE: Lin & Chang method bounds Power, Newmark and Hall, and General Implementation Procedure (GIP) methods.)

6.6 Load Combinations and Allowable Stresses

The load combinations used in the building analysis envelope the original calculations, and the applicable load combinations per ASME NOG-1, as shown in the Design Criteria Document (Attachment 1). Table 3 presents the load combinations and corresponding allowable stresses used in the evaluation of the Auxiliary Building. The structural analysis shall analyze the structure with different crane configurations and the applicable load cases shall be applied, as required.

Table 3: Load Combinations used to qualify the structural members of the Auxiliary Building.

Load Combination	Allowable Stress Increase	GT STRUDL Load Cases (LC)	Total LCs (Cumulative)
$D + L + L_c$	None	2000	1
$D + L + L_c + I$	None	2010 to 2030 by 10	4
$D + L + L_c + W$	1.33	3000 to 3030 by 10	8
$D + L + L_c + E$	1.33	7000 to 7050 by 10	14
$D + L + L_c + E'$	Elastic Limit	4000 to 4050 by 10	20
$D + L + L_c + I_A + W_o$	1.33	5000 to 5030 by 10	24
$D + L + L_c + E + W_o$	1.33	8000 to 8230 by 10	48
$D + L + L_c + E' + W_o$	Elastic Limit	6000 to 6230 by 10	72

$L = L_f + L_r$
$I = I_V$ or I_L or I_T
$I_A = I_V + I_L + I_T$
L_C = 130 Ton for loaded crane hook condition OR
= 0 Ton for unloaded crane hook condition

Independent Loads

D	=	Dead Load Including Crane Members
L_f	=	Floor Live Load
L_r	=	Roof Live Load
L_C	=	Crane Live Load
W	=	Wind Load (Hurricane)
W_O	=	Operating Wind Load
E	=	Earthquake Load (OBE)
E'	=	Earthquake Load (MHE) (Note: This is same as SSE)
I_V	=	Crane Impact Load (Vertical)
I_T	=	Crane Impact Load (Transverse)
I_L	=	Crane Impact Load (Longitudinal)

Note: LC13, LC14 and LC15 of DCD (Attachment 1) are considered in the GT STRUDL analyses when crane is in unloaded hook up configuration, where Lc = 0 Ton.

7.0 METHODOLOGY

In order to analyze the Auxiliary Building with new crane upgrade, a computer structural model of the crane and supporting steel structure is prepared using GT STRUDL software (Ref. 4.5.1). The structural model consists of the overhead crane bridges, trolley, cable, lifted load, crane runway girders and steel supporting frame with appropriate boundary conditions. This steel frame and crane/trolley are modeled using space frame members. The crane pendulum is modeled using non-linear springs. The steel column base plates are modeled using appropriate releases and the concrete shear walls are modeled using springs with appropriate spring stiffness.

The specific steps in the analysis of the Auxiliary Building are as follows:

1. A structural model of the existing Auxiliary Building is prepared that consists of the steel members supporting the crane. Data used in the representation of the Auxiliary Building in the model is obtained from the applicable plant drawings and calculations.
2. The Auxiliary Building is modeled to an extent appropriate to represent the actual structural behavior and boundary conditions. Some discrepancies were observed between the structural drawing and fabrication drawings. Field walk down was performed to verify as-built condition.
3. The crane including trolley and bridge girders is modeled in GT STRUDL. Vendor crane model is used to generate GT STRUDL crane model. The boundary conditions for the crane wheels interfacing with runway girder are modeled in accordance with ASME NOG-1 (Ref. 4.2.1), where as trolley wheel boundary conditions are modeled as suggested by vendor crane model.
4. The model is analyzed for the crane bridge located at various different positions chosen to maximize the structural response in the steel structure.
5. For each crane bridge position, up to four trolley positions (i.e. each end, mid-span, and the quarter point from the east side) are analyzed.
6. At each trolley location, analyses is performed for the loaded hook up, unloaded hook up and loaded hook down condition.
7. The model is subjected to the independent/primary loads as listed in Section 6.6.
8. The lateral load cases (e.g., seismic loads, wind loads) with directionalities are taken into account in the load combinations by using plus or minus sign conventions for both North-South and East-West direction. Ten percent (10%) of the floor live load in the building model will be considered as excitable mass in the dynamic analysis.
9. The dynamic input to the analysis shall be determined from the response spectra curves discussed in Section 6.5.9. The resulting structural responses in the horizontal and vertical directions will be obtained separately.
10. The modal frequencies and shapes are extracted from the model up to zero period accelerations (ZPA) frequency of 33 Hz, so that most of the modal mass is included in the seismic analysis. The modal responses of the structure is combined using Complete

Quadratic Combination (CQC) method in compliance with Regulatory Guide 1.92 (Ref. 4.2.5).

11. In accordance with Regulatory Guide 1.92 (Ref. 4.2.5), the missing-mass method is used to account for residual rigid response of the structure. The missing-mass method creates independent static load cases based on the acceleration associated with the ZPA frequency. These static load cases generated from the missing mass method are then combined with the pseudo-static loading from the dynamic responses the Square Root Sum of the Squares (SRSS) methodology to create seismic loads in each direction and that account for the dynamic structural responses due total mass of the model.

12. In accordance with FSAR (Ref. 4.1.2), the current plant licensing basis requires that the combination of the seismic directional responses be the envelope of the absolute sum of the responses in the vertical direction and one horizontal direction (north-south or east-west). ASME NOG-1 requires that the directional responses in the three orthogonal directions be combined using the SRSS combination method. Since a coupled analysis of the building and crane is to be performed, a conservative and bounding approach is used that envelops the results from the two methodologies required by the current plant licensing basis and ASME NOG-1.

13. The resulting stresses in the structural members are computed using the load combinations specified in Section 6.6 and compared to the acceptance criteria for steel and concrete structures in accordance with the DCD (Attachment 1) and the AISC Code provisions (Ref. 4.2.2).

14. The members of the developed analysis models will be evaluated by GT STRUDL code checking function or by manual hand calculations. The steel connections and column base plates will be evaluated by manual hand calculations per applicable site specifications and building standards in Calculation S10-0063 (Ref. 4.4.9).

8.0 CALCULATIONS

8.1 Auxiliary Building Steel Structure

The model is constructed in GT STRUDL. The overall geometry is shown in Fig. 8.1 and the member identifications are shown beside the members in Figs. 8.2 to 8.9. The Auxiliary Building is modeled using GT STRUDL version 30 (Ref. 4.5.1). The steel members are modeled with space frame which may experience six force actions (i.e., axial and two shear forces, and torsion and two bending moments). The members are rigidly connected to the joints unless member releases are specified. Column base locations and boundary conditions are shown in Section 8.1.2.

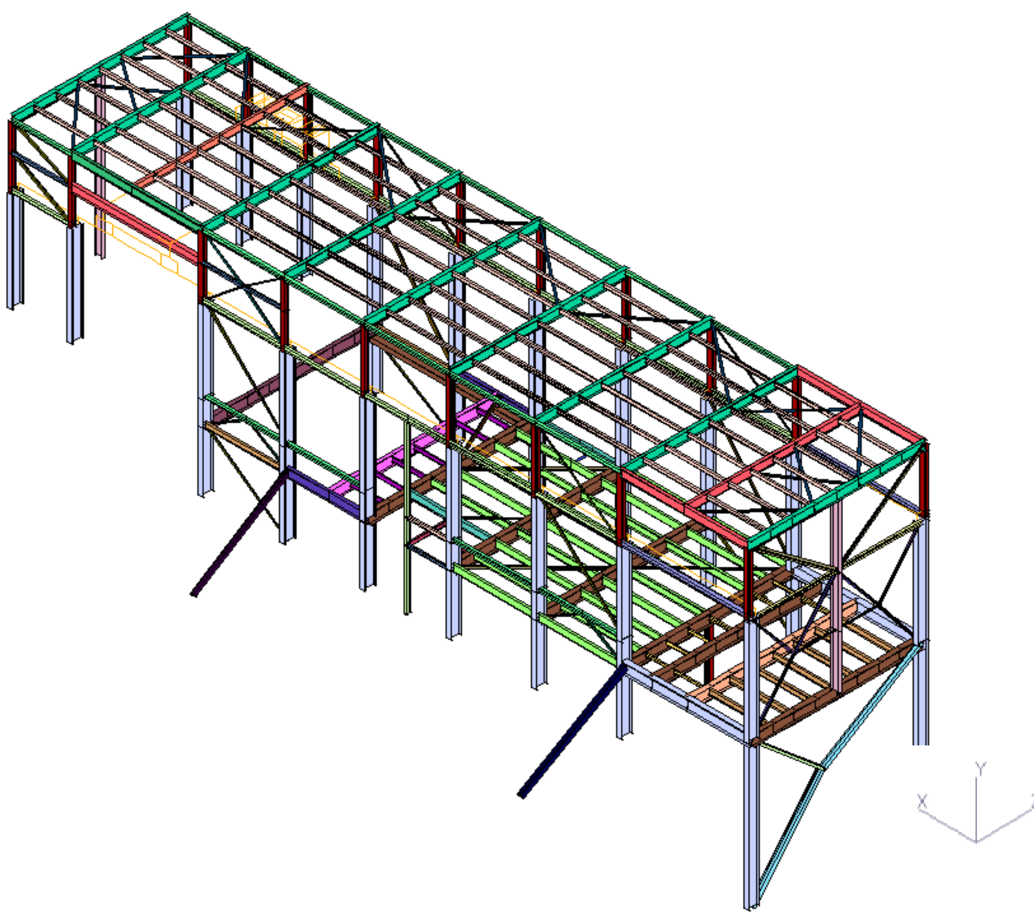


Figure 8.1 3D View of Auxiliary Building with One Crane Location Case

8.1.1 GT STRUDL Model Geometry

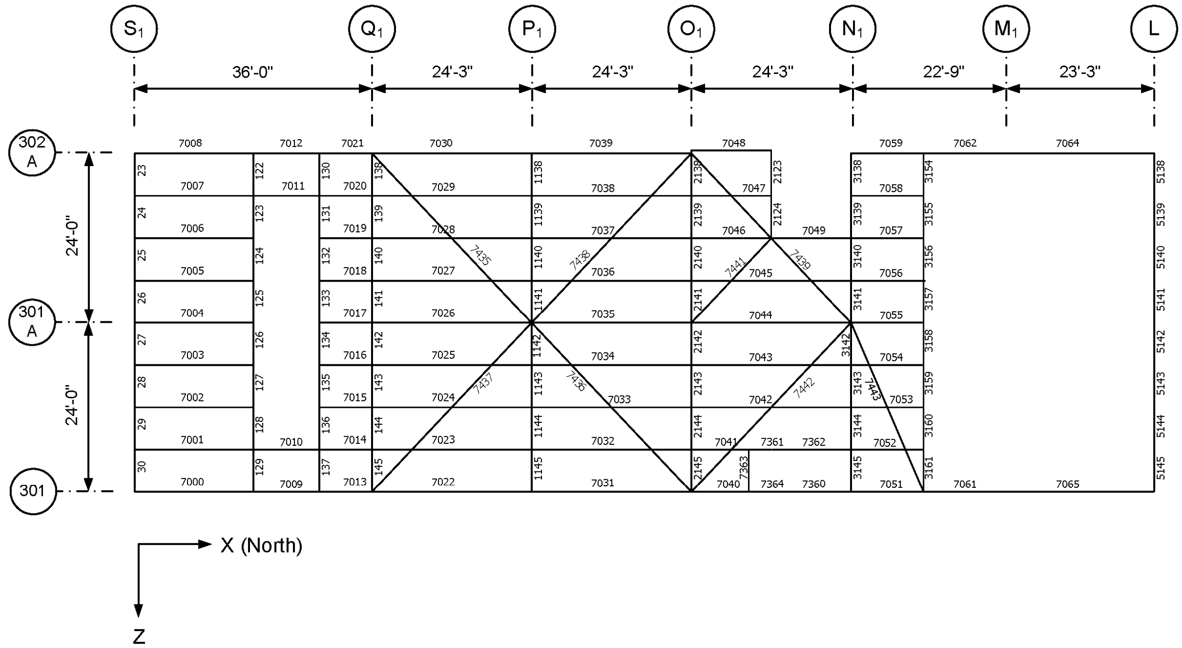


Figure 8.2 PLAN VIEW - Floor at EL. 162'-0" (Member IDs)

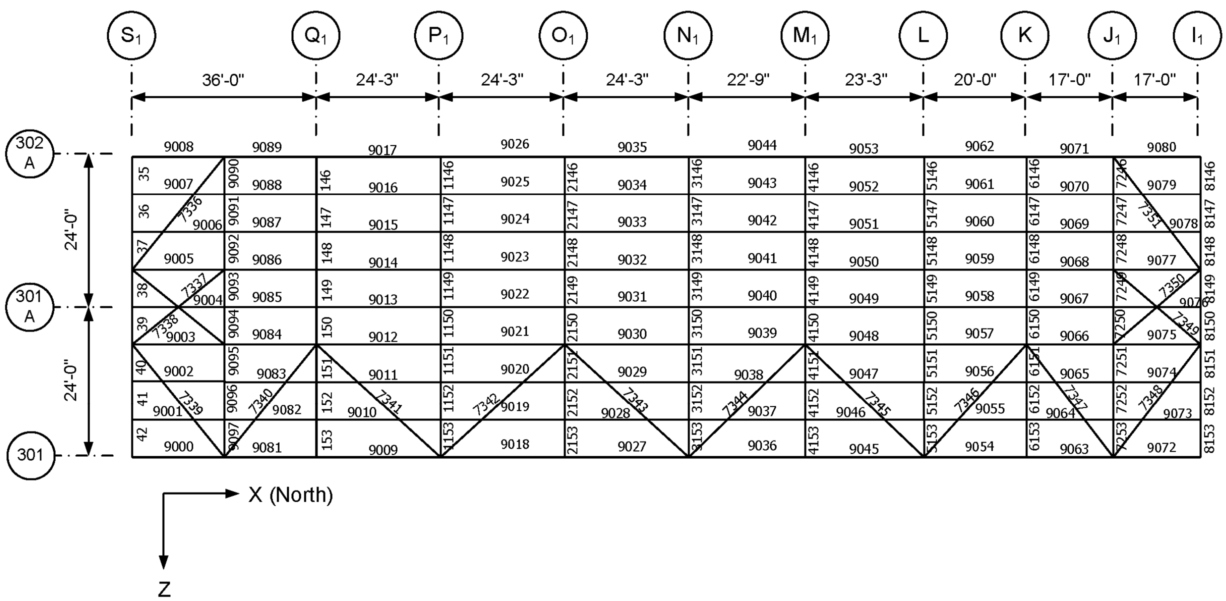


Figure 8.3 PLAN VIEW - TOS at Roof EL. 209'-1" (Member IDs)

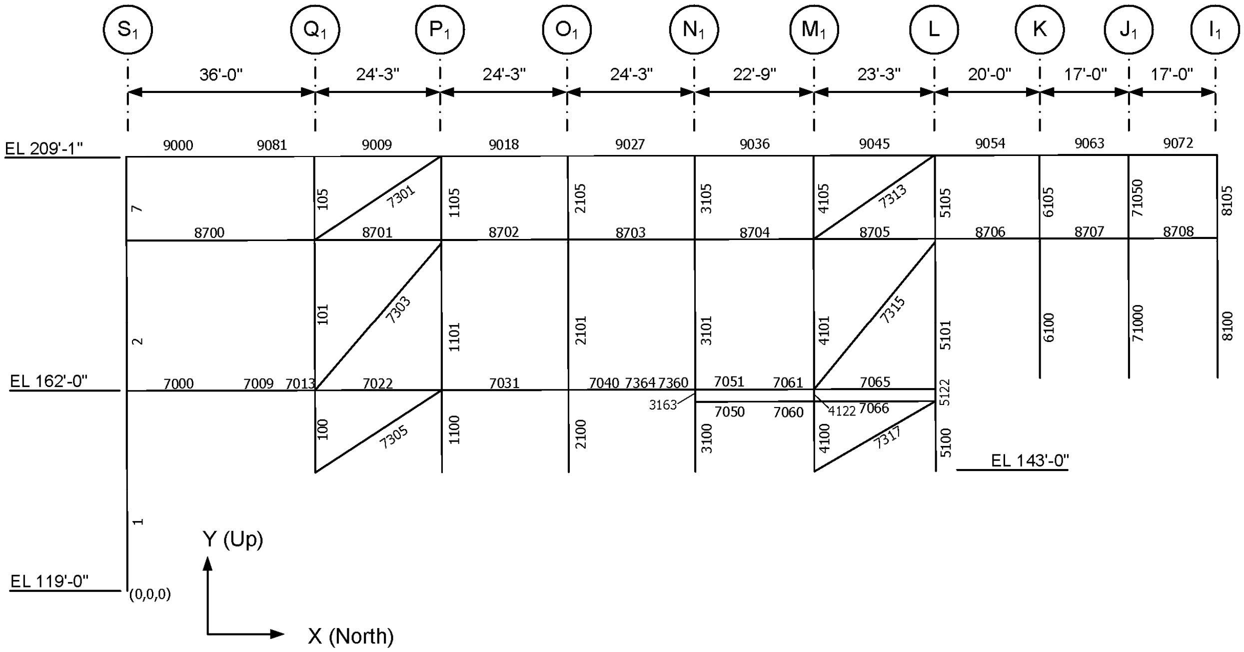


Figure 8.4 ELEVATION VIEW - Column Line 301 (Member IDs)

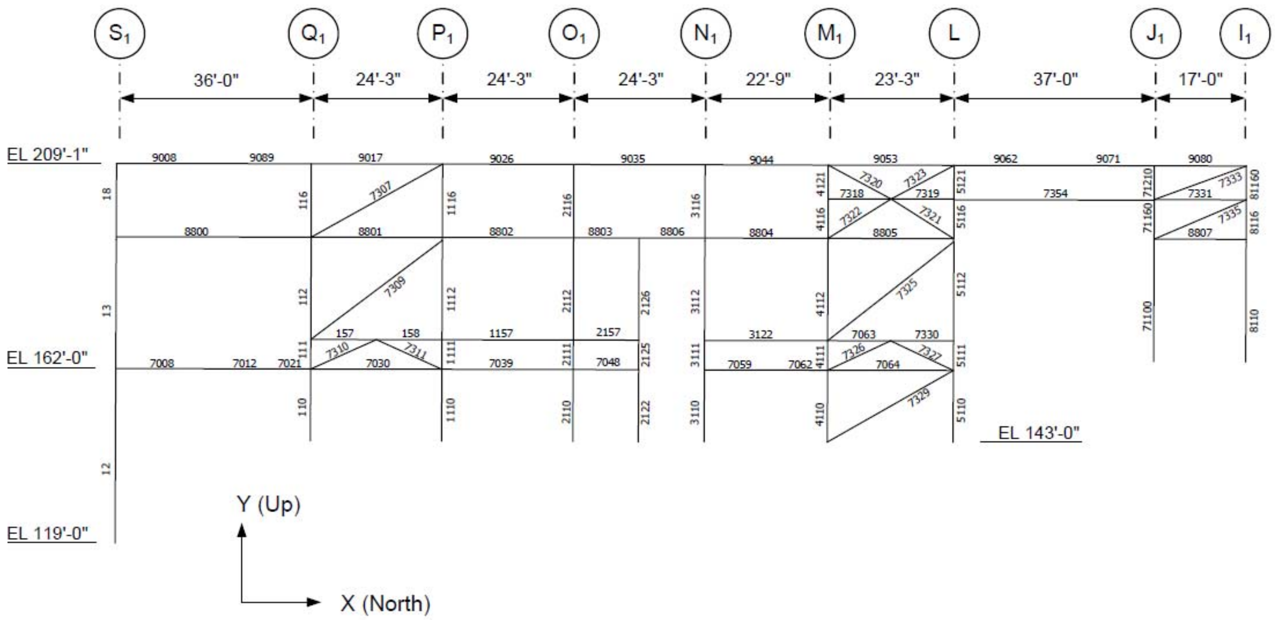


Figure 8.5 ELEVATION VIEW - Column Line 302A (Member IDs)

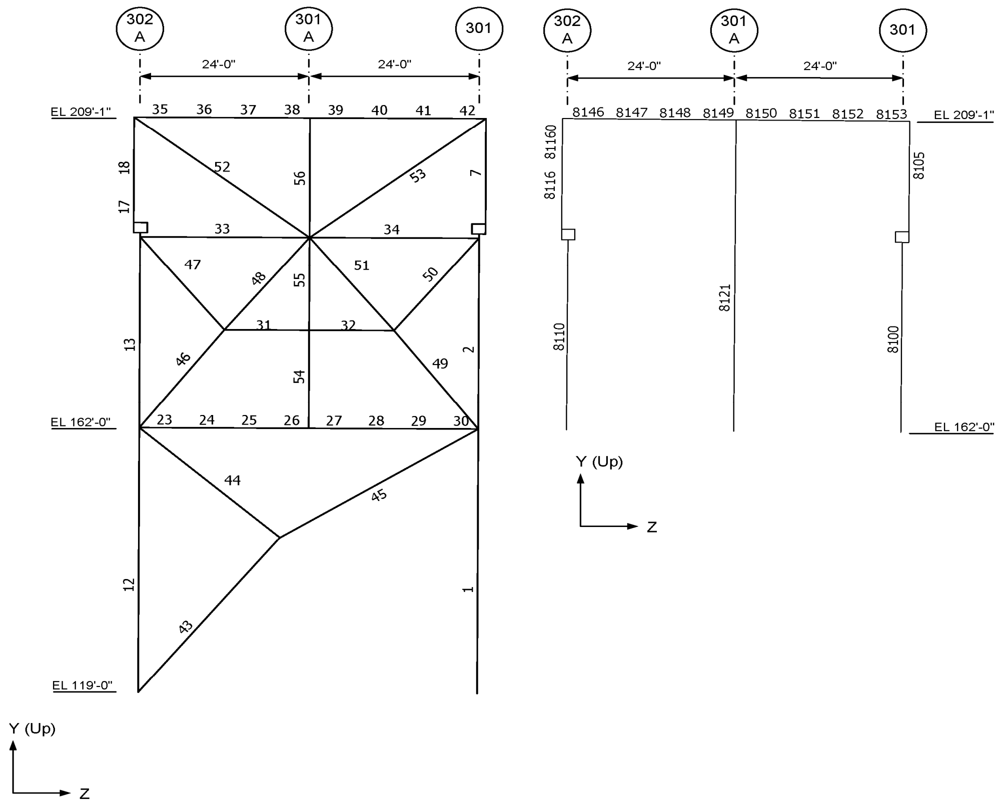


Figure 8.6 ELEVATION VIEW - Column Lines S_1 and I_1 (Member IDs)

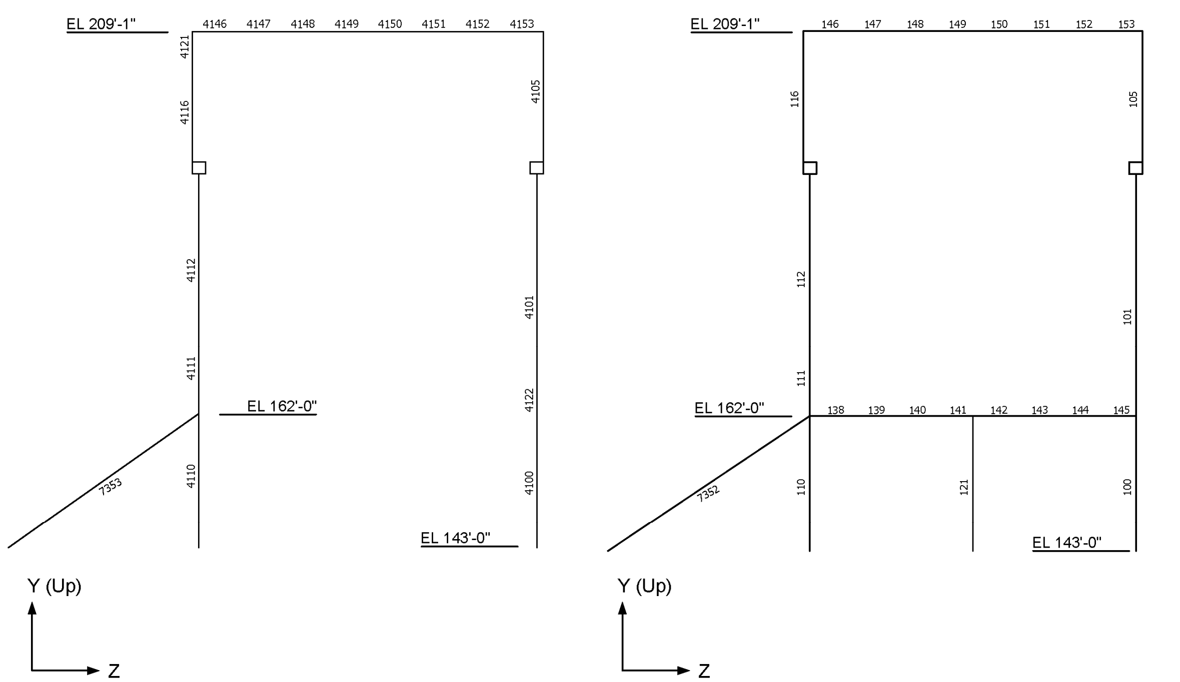


Figure 8.7 ELEVATION VIEW - Column Lines M1 and Q1 (Member IDs)

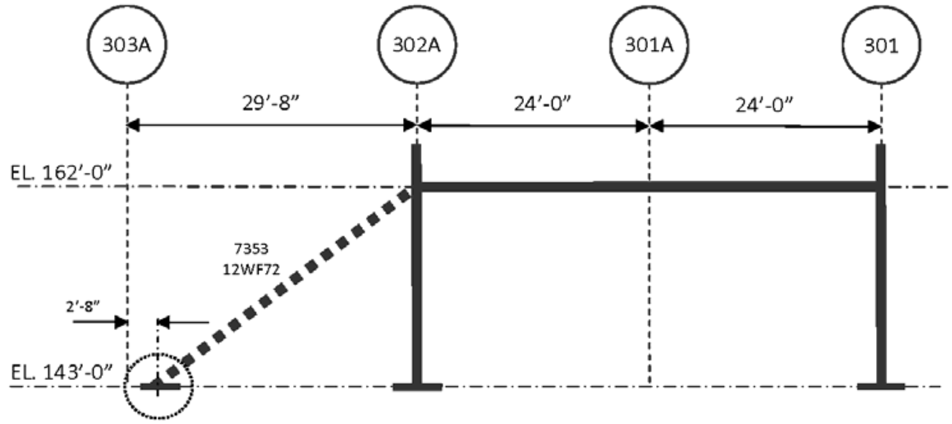


Figure 8.8 <u>Kicker at Column line M1 (Member IDs)</u>

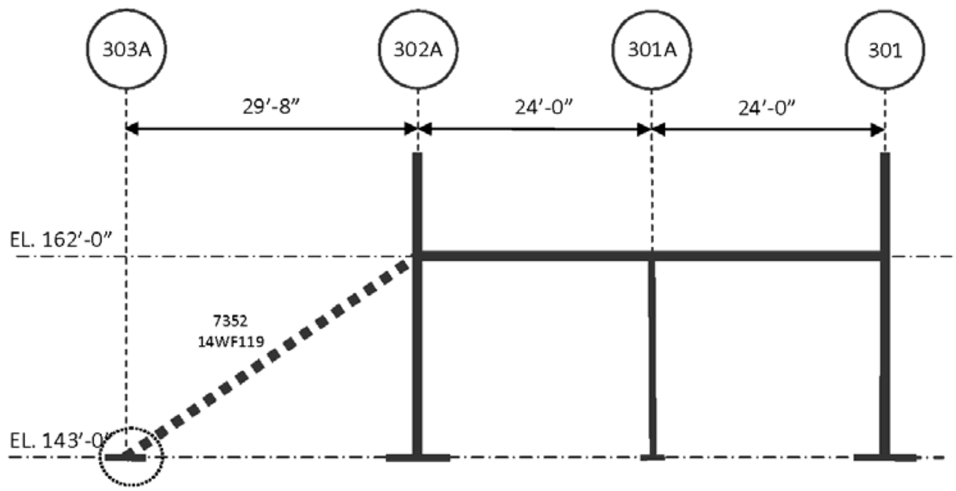


Figure 8.9 <u>Kicker at Column line Q1 (Member IDs)</u>

8.1.2 Columns Detail

Figure 8.10 shows the column bases layout. The base plates to concrete structure are modeled as fixed connections about strong axis and pin connections about weak axis for columns 302A-I1, 302A-J1, 302A-L, 302A-M1, 302A-N1, 302A-N2, 302A-O1, 302A-P1, 302A-Q1, 302A-S1, 301-I1, 301-J1, 301-L, 301-M1, 301-N1, 301-N2, 301-O1, 301-P1, 301-Q1, 301-S1.

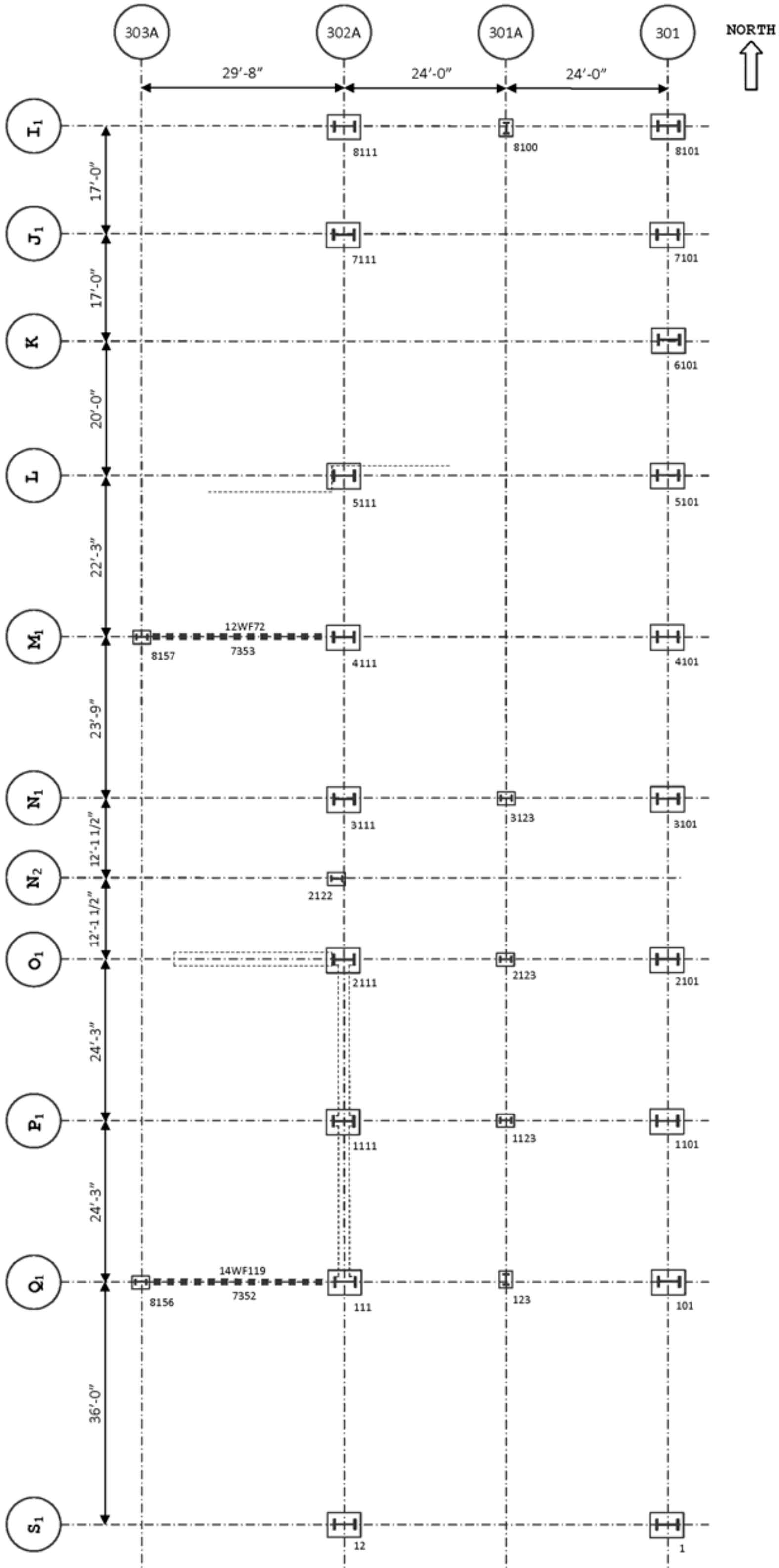


Figure 8.10 PLAN VIEW - Column Base Layout

Table 4: Summary of column base boundary condition for all steel bent

Support Elevation	Joint No.	Column Location	Translational Restrain *			Rotational Restrain *		
			X	Y	Z	X	Y	Z
162'-0"	8101	301-I1	-	-	-	-	-	R
	8111	302A-I1	-	-	-	-	-	R
	7101	301-J1	-	-	-	-	-	R
	7111	302A-J1	-	-	-	-	-	R
162'-0"	6101	301-K	-	-	-	R	-	R
143'-0"	5101	301-L	-	-	-	-	-	R
	5111	302A-L	-	-	-	-	-	R
	4101	301-M1	-	-	-	-	-	R
	4111	302A-M1	-	-	-	-	-	R
	3101	301-N1	-	-	-	-	-	R
	3111	302A-N1	-	-	-	-	-	R
	2101	301-O1	-	-	-	-	-	R
	2111	302A-O1	-	-	-	-	-	R
	1101	301-P1	-	-	-	-	-	R
	1111	302A-P1	-	-	-	-	-	R
	101	301-Q1	-	-	-	-	-	R
	111	302A-Q1	-	-	-	-	-	R
119'-0"	1	301-S1	-	-	-	-	-	R
	12	302A-S1	-	-	-	-	-	R
162'-0"	8100	301A-I1	-	-	-	R	-	R
143'-0"	2112	302A-N2	-	-	-	R	-	R
143'-0"	3123	301A-N1	-	-	-	R	-	R
	2123	301A-O1	-	-	-	R	-	R
	1123	301A-P1	-	-	-	R	-	R
	123	301A-Q1	-	-	-	R	-	R

* 'R' denotes that rotation/translation is released

8.1.3 Discrepancies

Various discrepancies were observed between the Gilbert Calculation, structural drawings and As-built condition. These differences are listed below.

1. Member connections at the ends of (4) 36WF230 beams spanning between column lines 301 and 302A (Total 8 connections) below EL. 162'-0" floor are simple shear connections per structural drawing S-522-003 (Ref. 4.3.3). This is consistent with existing Gilbert Calculation 2:01.10 (page 40 & onward, Ref. 4.4.2), which evaluated the frame with simple shear connection at these points. However, the erection plan for the same drawing shows moment connection details for the ends of the beams mentioned above. Also, the details shown on shop drawings agree with the Erection plan (i.e. the beams are detailed with Moment Connections and not Simple Shear Connections). In the present model these beams have moment restraints at the ends to characterize the true behavior of structure.
2. The existing Gilbert Calculation (2:01.50, page 26, Ref. 4.4.8) considers a fictitious support in the qualification of the frame at column line "K". Elimination of the fictitious support in the ongoing structural analysis shows very high loads on the anchorage connection at column line 301 and K. A modification to the connection (fixed to pinned) is required to eliminate the excessive loading. The elimination of the fictitious support in model and modification of the anchorage connection type is expected to result in a general redistribution of stresses in the structure. The present model at jt. 6101 has a pin condition to address this issue, see Section 8.1.2.
3. As per existing Gilbert Calculation 2:01.14 (page 18 & onwards, Ref. 4.4.5), the wind/seismic forces at EL. 162'-0" floor are designed to be resisted by the truss system, which consists of braces and only one N-S beam at column line 301A between O and P. No axial force transfer is considered for the remaining beams in the N-S direction. Structural drawing S-522-003 (Ref. 4.3.3), Plan at EL. 162'-0", does not show any axial force being carried by the N-S beams except one member mentioned above. Based on review of shop drawings and limited visual inspection from walkdown, the secondary beams running N-S direction at EL. 162'-0" are configured to take axial force. Also, connection details do not indicate any slotted/oversized holes at bolt locations or other suitable mechanism to release axial force on the beams. Hence all the secondary beams (North –South direction) are modeled to transfer the axial forces.
4. As per existing Gilbert Calculation 2:01.15 (page 6 & onwards, Ref. 4.4.4), the wind/seismic forces on roof are designed to be resisted by the truss system, which consists of roof braces and three N-S roof beams centered along the length of the E-W beams. The calculated axial force on these beams is as high as 42.4 kips. No axial force transfer is considered for the remaining beams in the N-S direction in Gilbert Calculation. Structural drawing S-522-004, Roof Plan at EL. 209'-1", does not show any axial force being carried by any of the roof beams (N-S direction). Based on review of shop drawings and limited visual inspection from walkdown, all of the roof beams running N-S direction are configured to take axial force. Also, connection details do not indicate any

slotted/oversized holes at bolt locations or other suitable mechanism to release axial force on the beams. Hence all the secondary beams (North –South direction) are modeled to transfer the axial forces.

8.1.4 Concrete Shear Wall (East – West)

As per reference 4.4.7, calculation 2:01.12, the reinforced concrete shear wall in east–west direction will provide lateral stiffness to Column 302A-O1. The wall has a thickness of 2 feet, length of approximately 24'-8", and height of approximately 19 feet.

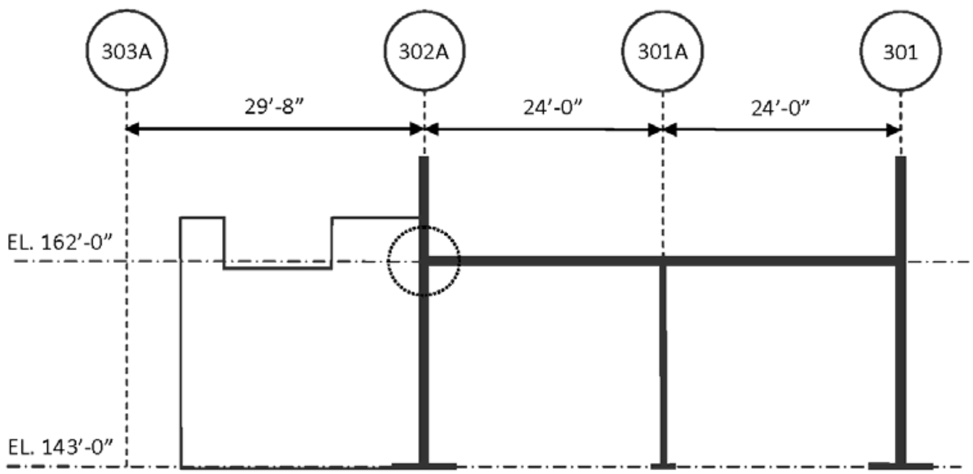


Figure 8.11 **Concrete Shear Wall (East – West) at Column Line O1 (Joint 2112)**

The stiffness of the shear wall can be calculated as follow:

$$k = \frac{1}{\frac{H^3}{3EI} + \frac{1.2H}{GA}}$$

where, k = Lateral stiffness of the wall

H = height of wall = 228 inches

Concrete Elastic Modulus = $E = 57000\sqrt{f'_C} = 57000\sqrt{3000\,psi} = 3122\ ksi$

Shear Modulus = $G = \frac{E}{2(1+\upsilon)} = \frac{3122}{2(1+0.25)} = 1249\ ksi$

Moment of Inertia = $I = \frac{1}{12}(24in)(296in)^3 = 5.187 \times 10^7\ in^4$

Area = $A = (24in)(296in) = 7104\ in^2$

Therefore, the stiffness can be obtained from as follows:

$$k = \frac{1}{\frac{H^3}{3EI} + \frac{1.2H}{GA}} = \frac{1}{\frac{228^3}{3 \times 3122 \times 5.187 \times 10^7} + \frac{1.2 \times 228}{1249 \times 7104}} = 18105\, kip / in$$

This stiffness value is for a spring constant (KFZ) in GT STRUDL at joint 2112 on for Column 302A-O1 to account for the stiffness provided by the shear wall.

8.1.5 Concrete Shear Wall (North –South)

As per reference 4.4.7, calculation 2:01.12, the reinforced concrete shear wall in North-South direction will provide lateral stiffness to Column 302A at location O1, P1 and Q1.

Wall thickness = 2’ (Ref. 4.3.27)

Height of wall = H = 16’ = 192 in (Ref. 4.3.28)

Length = 24’-3” = 291 in (Between two columns) (Ref. 4.3.28)

Moment of Inertia = $I = \frac{1}{12}(24in)(291in)^3 = 4.93 \times 10^7 in^4$

Area = $A = (24in)(291in) = 6984\ in^2$

Therefore, the stiffness can be obtained from as follows:

$$k = \frac{1}{\frac{H^3}{3EI} + \frac{1.2H}{GA}} = \frac{1}{\frac{192^3}{3 \times 3122 \times 4.93 \times 10^7} + \frac{1.2 \times 192}{1249 \times 6984}} = 23956\, kip / in$$

There is no positive connection between shear wall and column to transfer tension force to the shear wall. Thus shear wall is considered to resist only compressive force through shear. At any given instance only two of the three columns will be actively involved in transferring the forces. As Column 302A-P1 is in between 302A-O1 and 302A-Q1, the stiffness value of 23956 kip/in is provided as spring constant (KFX) at joint 1112 and half of it (23956 / 2 = 11978 kips/inch) is provided to remaining columns at GT STRUDL joint 2112 and 112.

8.1.6 Crane Support Structure Interface with Adjacent Auxiliary Building frame

The Crane Support structure frame at floor EL. 162’-0” is connected to the adjacent Auxiliary Building. Lateral supports are provided at 302A-P1 and 302A-N1 column line to reflect the boundary condition.

At Column line L, Spent Fuel Pool wall interact with the Column 302A-L and provide lateral support in east west direction at joint 5112. A support is defined at joint 5112 to take axial force in east west direction.

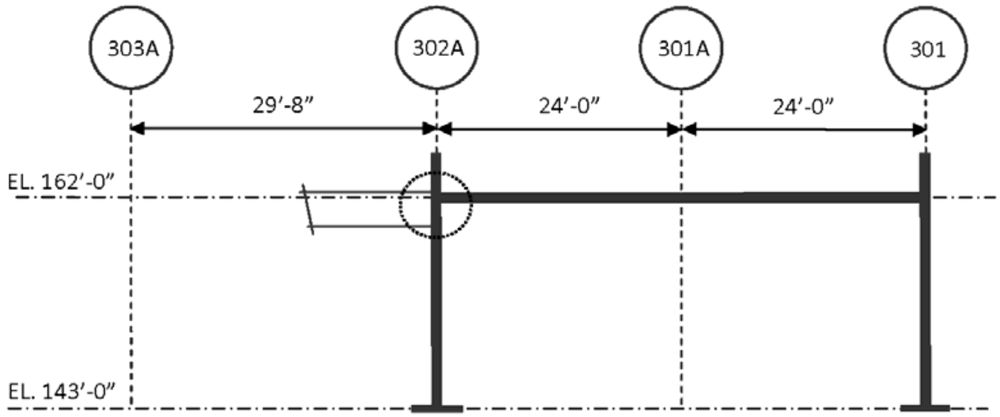


Figure 8.12 **Connection to Concrete Slab/Beam Column Line L (Joint 5112)**

8.1.7 General Model Input Procedures

(a) Defined geometry including joint coordinates and member incidences.

(b) Defined member and element properties for steel and rigid link members.

(c) Defined support conditions and member end releases.

(d) Defined response spectra with acceleration versus frequency data under available damping ratios for OBE and MHE case.

(e) Defined loads including dead loads and live loads of building structure and crane, wind, and seismic loads.

(f) Eigenvalue analysis is performed using up to approximately the first 250 modes. The numbers of mode are chosen to make sure that ZPA frequency is achieved.

(g) Applied response spectrum loads in three directions, for OBE and MHE.

(h) Used Complete Quadratic Combination (CQC) method to combine structural modal responses associated with different modal frequencies.

(i) Computed a new independent static loading condition (i.e., missing loads) consisting of joint load components that reflect the mass associated with all modes ignored in a prior response spectrum analysis.

(j) Transformed response spectrum analysis results into static loading conditions (pseudostatic loads in GT STRUDL terminology) for loading combinations.

(k) Combined missing mass loads and pseudostatic loads for X, Y and Z-directions. The results from the vertical and horizontal directions are then combined using the absolute sum methodology for directional combinations. Also use SRSS combination to combine all three direction results. This produces seismic load cases in two horizontal directions which can be used in load combinations.

(l) Performed static analyses of the other defined load conditions (dead, live, and wind), and these results along with the seismic results are combined using appropriate load combinations. Wind and seismic loads are considered for north, south, east and west directions.

(m) Performed AISC code check for major crane support steels. Members that are determined to be overstressed will be modified.

8.2 Crane Model

The properties of the crane model in the structural analysis model (e.g. geometry, mass distribution, dynamic characteristics, etc.) are based on information provided by the crane vendor (Attachments 2 & 4). The crane vendor provided an ANSYS crane model with the crane hoist in the fully retracted position and another ANSYS model with the crane hoist in the fully extended position. As the structural analysis model of the Auxiliary Building is built in GT STRUDL, it is necessary to convert the ANSYS crane models to GT STRUDL while retaining the pertinent structural properties.

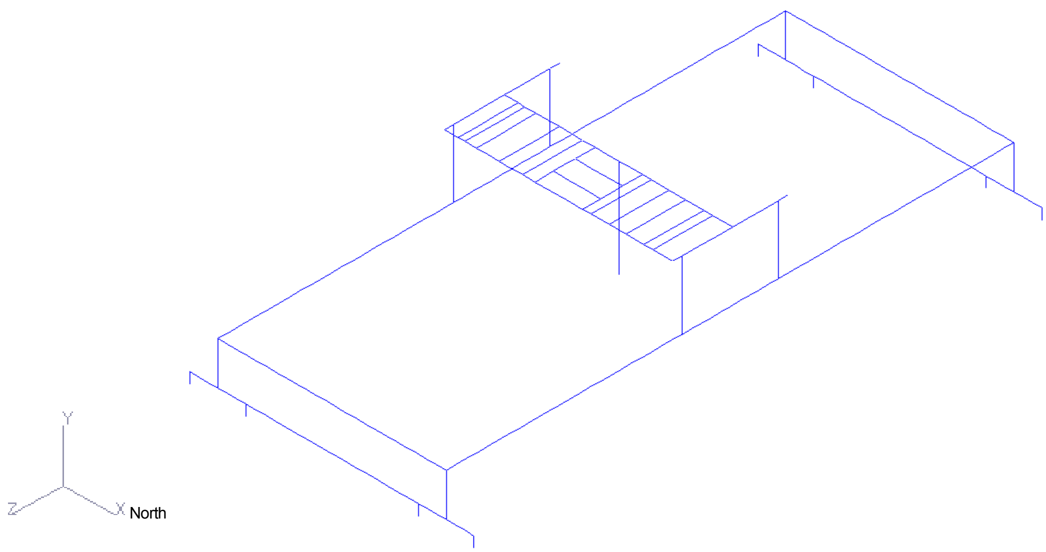


Figure 8.13 Isometric View of GT STRUDL Crane Model (Hook Up)

The boundaries at the crane wheel and rail interface are modeled in accordance with NOG-1 (Ref. 4.2.1) and consistent with the boundary conditions in the crane vendor ANSYS model.

Table 5: Restraint conditions at the crane nodes for the sign convention defined in Figure 8.14.

	Translation			Rotation		
Node	**X**	**Y**	**Z**	**θx**	**θy**	**θz**
A	Fixed	Fixed	Fixed	All Free		
B	Fixed	Free	Fixed			
C	Free	Fixed	Fixed			
D	Free	Free	Fixed			
E	Fixed	Fixed	Fixed			
F	Fixed	Fixed	Fixed			
G	Free	Fixed	Fixed			
H	Free	Fixed	Fixed			

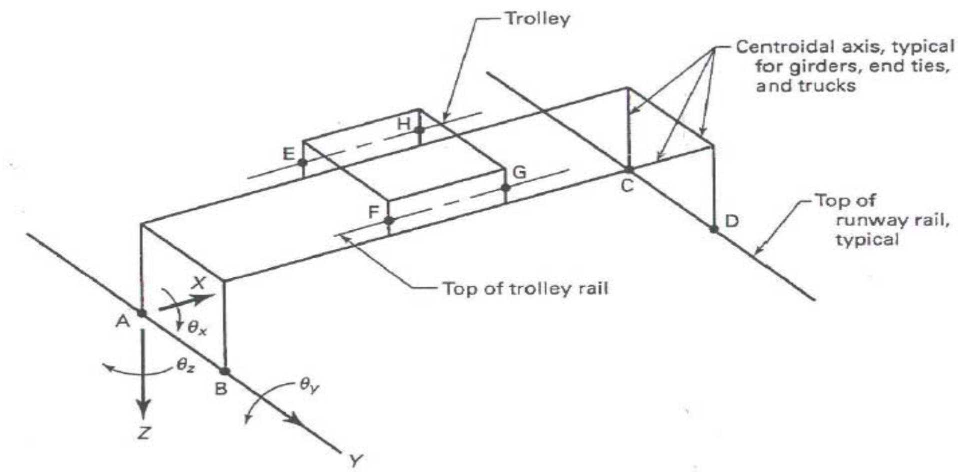


Figure 8.14 Crane Boundary Conditions in Accordance with ASME NOG-1

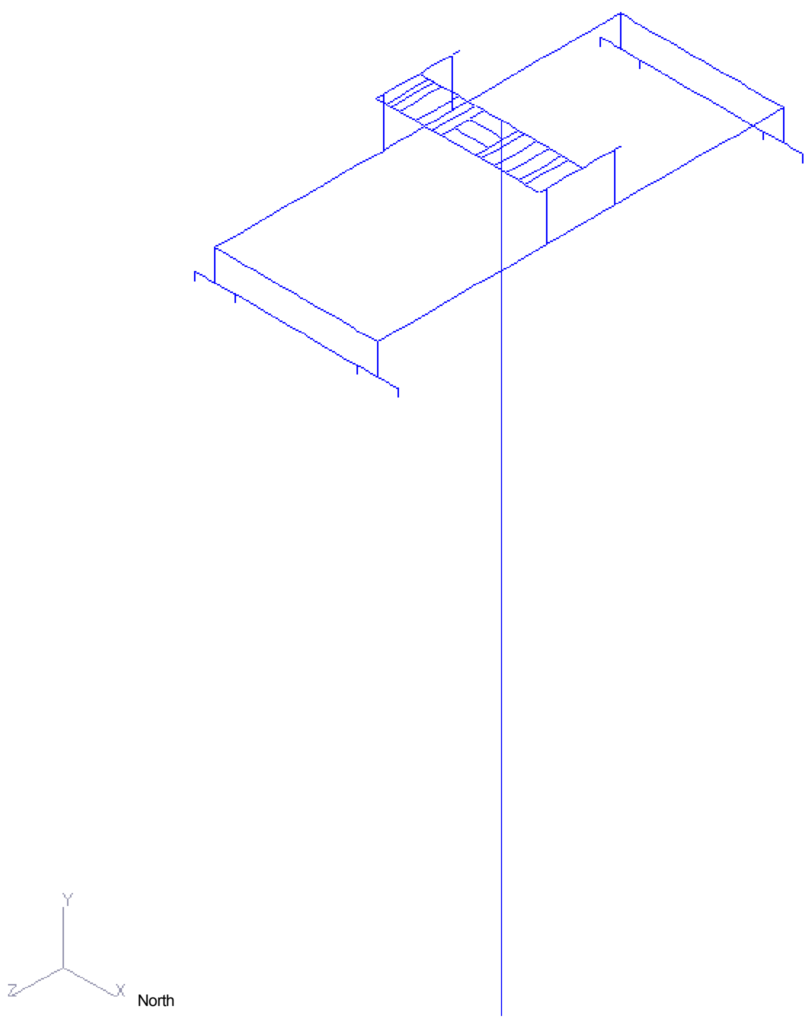


Figure 8.15 Isometric View of GT STRUDL Crane Model (Hook Down)

8.3 Trolley Position

In accordance with ASME NOG-1 (Ref. 4.2.1), consideration is given to five different trolley positions defined relative to the main hook position in the evaluation of the crane support structure. These five trolley positions are at (1) the extreme end positions on the bridge span, (2) at the quarter points of the span positions, and (3) at mid span. As per ASME NOG-1 (Ref. 4.2.1), the analyses are performed with the trolley at its extreme end positions on the bridge span, the trolley at the 1/4 points of the span positions, and trolley at mid span.

However, as a result of the crane configuration (as shown in Figure 8.16), the western quarter point location of the trolley (located 11’-0” from gridline 301) is almost identical to the western extreme end position of the trolley (located 10’-7 3/8” from gridline 301) and therefore the two positions will be considered together in the analysis of the Auxiliary Building. The resulting four positions of the crane trolley are shown in Figures 8.17(a) to 8.17(d)

Consider various positions of trolley from E1 to E4 as trolley moves from east to west.

Total Span of Crane bridge (rail to rail) = 46’-0”

(E1) East end position for hook (301) = 5’-0”

(E2) ¼ Span distance = 11’-6” (from east end)

(E3) Mid Span distance = 23’-0” (from either ends)

(E4) ¼ Span distance = 11’-6” (from west end)

(E4) West end position (302A) = 10’-7 3/8”

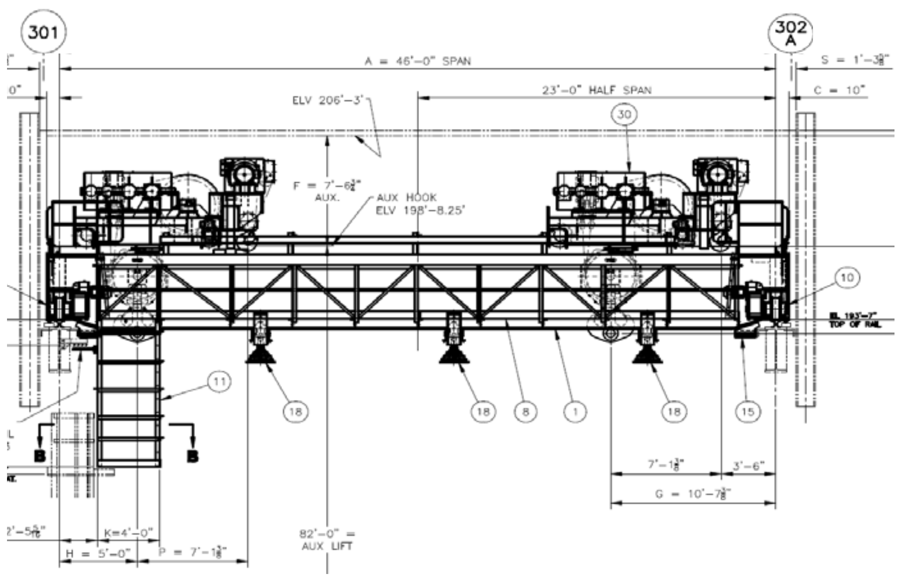


Figure 8.16 Trolley Movement Detail (Attachment 4)
(Elevation View of Crane along with Trolley)

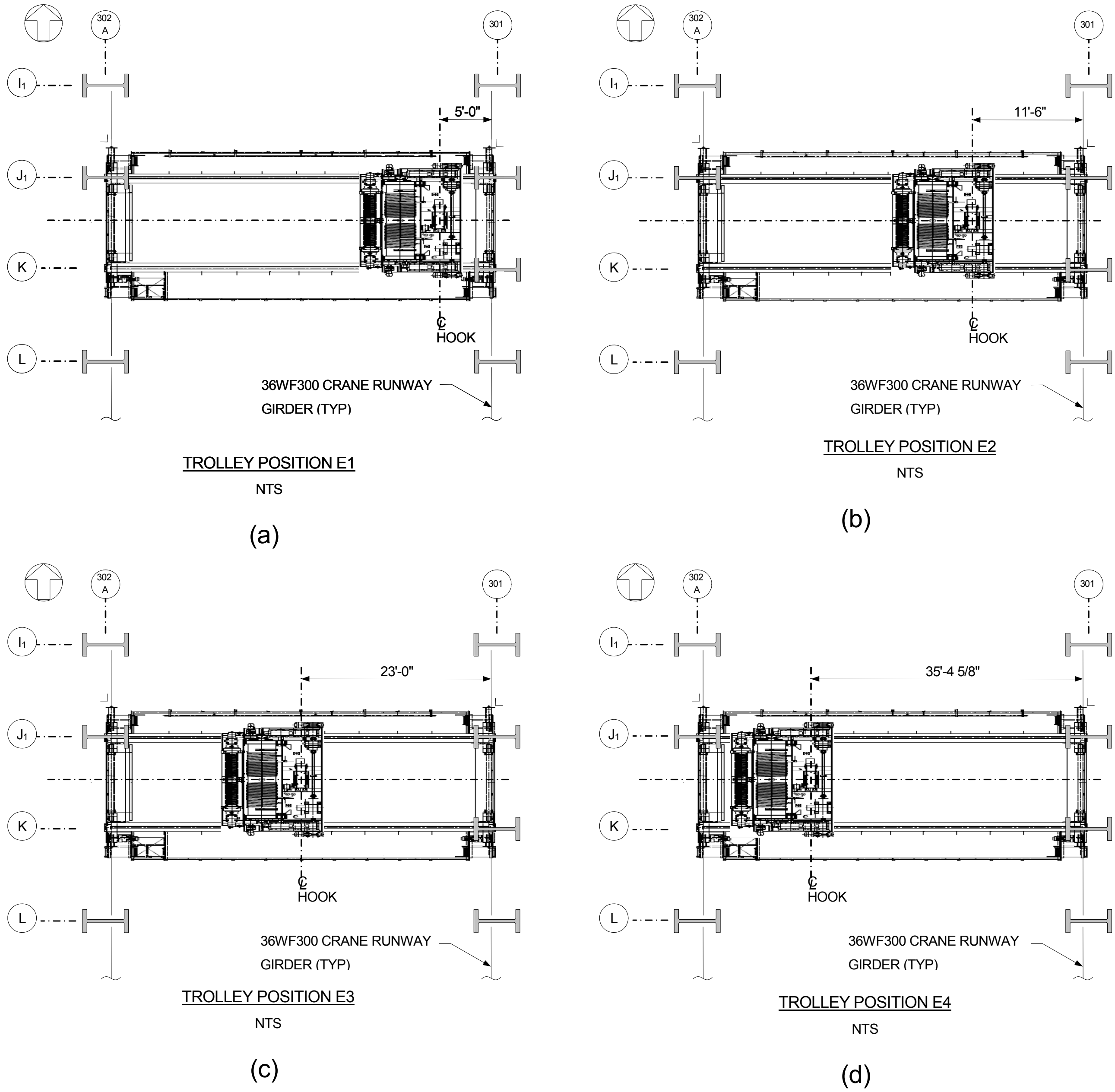


Figure 8.17 Modeled Trolley Positions

In accordance with ASME NOG-1 (Ref. 4.2.1), analyses are performed with the main hoist in both the loaded and unloaded hook-up position and the loaded hook-down position for a total of twelve cases at every crane bridge location. Table 6 summarizes the various trolley and hook positions and loading conditions at a representative crane bridge location. All of the trolley and hook locations are considered.

Table 6: Crane Hook Loading Conditions

Loading Condition	Trolley Position on Bridge			
	East End (N1E1)	1/4 Span (N1E2)	Mid-span (N1E3)	West End (N1E4)
Hook-up – Loaded	SR1	SR2	SR3	SR4
Hook-up – Unloaded	SR5	SR6	SR7	SR8
Hook-down – Loaded	SR9	SR10	SR11	SR12

Note: SR denotes maximum structural responses obtained from load combinations.

8.4 <u>Crane Bridge Positions for Structural Analysis</u>

The crane bridge girders travel along the Auxiliary Building runway girders in the N-S direction along gridlines 301 and 302A and the crane trolley moves along the crane bridge girders in E-W direction. The crane bridge girders are positioned on the runway girder to produce the highest stress conditions on the runway girders and the steel supporting structure. Each crane bridge position is combined with the various trolley and hook positions discussed in Section 8.3.

Based on the Auxiliary Building structural layout, nine bridge positions are evaluated that produce maximum structural responses in the Auxiliary Building and provide sufficient information to evaluate the structural components of the building. For any given crane rail span, the crane bridge will be positioned at:

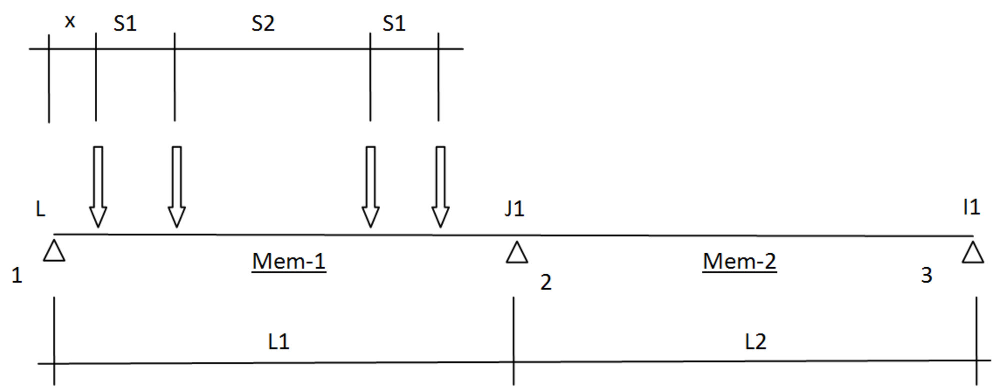
- The critical bridge position that produces the maximum positive bending moment in runway girders. This occurs when the pair of crane wheel is located near mid span of the runway girder.
- The critical bridge position that produces the maximum shear in the runway girders. This occurs when the crane is placed near a column.
- The position of a pair of crane wheels that produces maximum column loadings. The crane wheel loads can induce the maximum responses of columns and this generally happens when the pair of two crane wheel is directly above the column or near the column.

A unit wheel load (1.0 Kips) is applied to determine the critical bridge position. The GT STRUDL input and output files can be found in Attachment 6. Based on the runway girder locations in the structure it can be divided into three categories.

1 North end 37 ft span (two span continuous crane runway girder. 37′-0″ & 17′-0″)

Two-span continuous runway beam along 302A between column lines L and I1 is modeled in GT STRUDL. 'x' represents distance from column line L to the south most wheel of the crane.

Crane parameters: S1 = 4.5 ft, S2 = 14 ft
Runway parameters: L1 = 37 ft, L2 = 17 ft



Excerpt from GT STRUDL Output

Load no. shown below is equal to the distance of first crane wheel (X) from support 1 as shown in diagram (i.e. load 10 means x = 10' and similarly 25_5 means x = 25.5')

Mem 1

Max/min Section Forces for member 1 , locations are fractional.

	Value	Load	Location		Value	Load	Location
Max FX:	0.0000000E+00	25_5	0.9800	Min FX:	0.0000000E+00	25_5	0.9800
Max FY:	2.675668	10	0.9800	Min FY:	-1.865886	5	0.1200
Max MZ:	14.68257	9	0.3600	Min MZ:	-11.55412	7	0.9800

Mem 2

Max/min Section Forces for member 2 , locations are fractional.

	Value	Load	Location		Value	Load	Location
Max FX:	0.0000000E+00	25_5	0.9800	Min FX:	0.0000000E+00	25_5	0.9800
Max FY:	0.5334905	25_5	0.9800	Min FY:	-1.519795	16	0.1000
Max MZ:	2.902187	25_5	0.6800	Min MZ:	-13.31330	8	0.0000

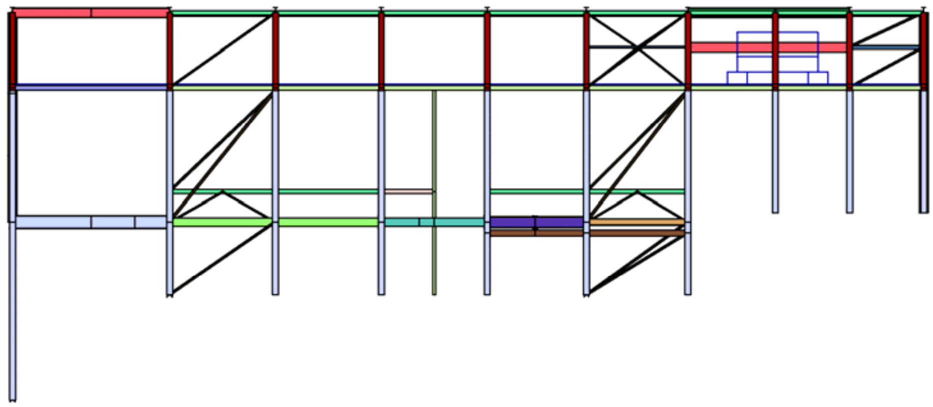
Table 7: Vertical Reaction at Joint 2

x (ft)	R2y (kips)	x (ft)	R2y (kips)
5	2.90	16	3.73
6	3.02	16.25	3.73
7	3.14	17	3.73
8	3.25	18	3.72
9	3.35	18.5	3.71
10	3.44	25.5	3.22

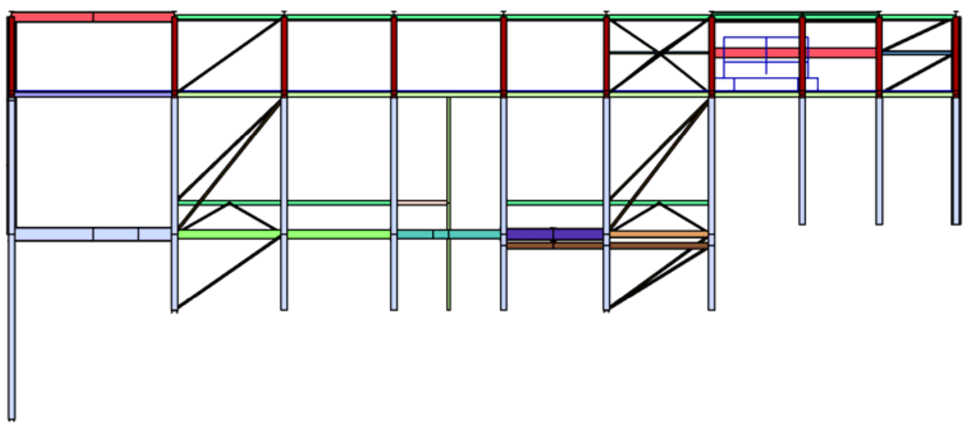
Based on the GT STRUDL results:

N1: Maximize runway girder moment x = 9 ft
N2: Maximize shear force at end of beam x = 0.5 ft (approx. end of beam at the longest span)
N3*: Maximize column axial force x = 16 ~ 17 ft. (Use x = – 2'-3")

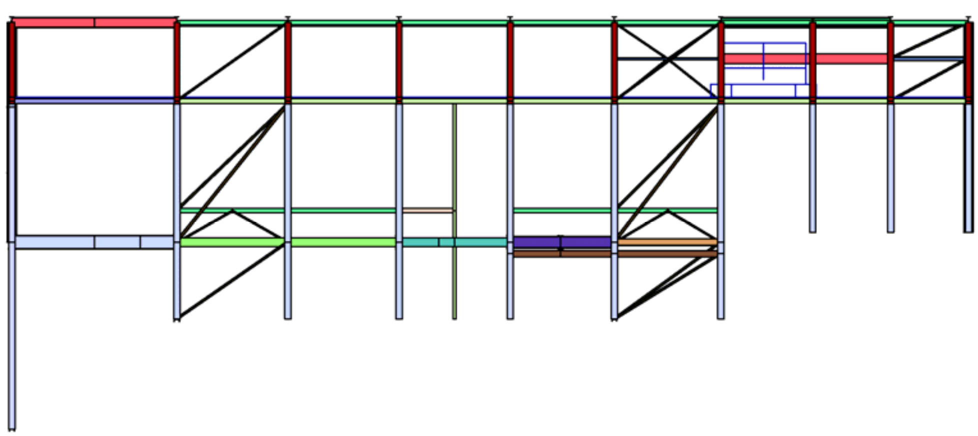
* South span of column line L is 24.25 ft, which is greater than the span 17 ft between I1 and J1. This means that the axial force of column L due to the building itself will be greater than that of column J1. Therefore, this wheel pattern is applied to the column line L to maximize the column axial force. Thus new x = – 2'-3", i.e. pair of wheel is exactly above the column L instead of column J_1



(a) Crane Bridge Position N1



(b) Crane Bridge Position N2



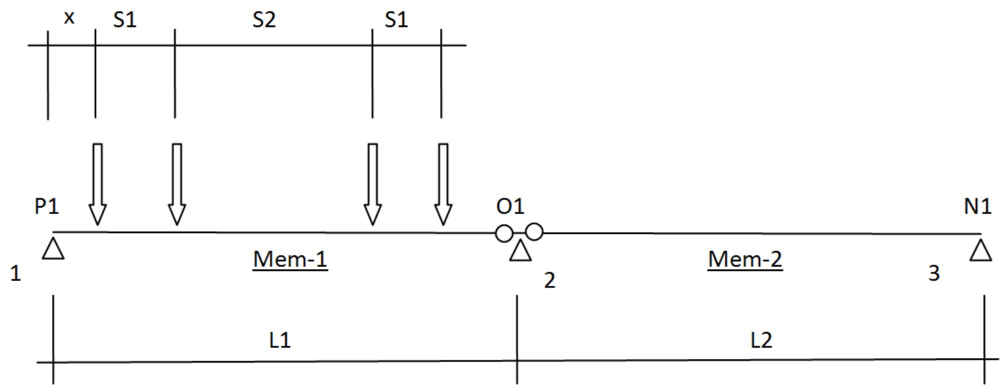
(c) Crane Bridge Position N3

Figure 8.18 **Crane Bridge Position for North end 37' span runway girder**

2 Typical Intermediate span (two span crane runway girder. 24′-3″ & 24′-3″)

Typical intermediate span is 24’-3″ long simple beam. Two spans between column lines P1 and L1 are modeled in GT STRUDL. ‘x’ represents distance from column line P1 to the south most wheel of the crane.

Crane parameters: S1 = 4.5 ft, S2 = 14 ft
Runway parameters: L1 = 24.25 ft, L2 = 24.25 ft



Excerpt from GT STRUDL Output:

Load no. shown below is equal to the distance of first crane wheel (X) from support 1 as shown in diagram (i.e. load 23 means x = 23’)

Mem 1

```
-----------------------------------------------------------------------------------------------
Max/min Section Forces for member 1        , locations are fractional.
             Value           Load       Location              Value            Load      Location
             -------------   --------   --------              -------------    --------  --------
    Max FX:  0.0000000E+00   23          0.9800     Min FX:   0.0000000E+00    23          0.9800
    Max FY:   2.000000       0.625       0.9800     Min FY:   -2.020619        0.5         0.0200
    Max MZ:   9.965001       11          0.4600     Min MZ: -0.1212660E-14     16          0.0000
-----------------------------------------------------------------------------------------------
```

Mem 2

```
-----------------------------------------------------------------------------------------------
Max/min Section Forces for member 2        , locations are fractional.
             Value           Load       Location              Value            Load      Location
             -------------   --------   --------              -------------    --------  --------
    Max FX:  0.0000000E+00   23          0.9800     Min FX:   0.0000000E+00    23          0.9800
    Max FY:   1.742268       23          0.9800     Min FY:   -1.793815        6           0.0000
    Max MZ:   9.950001       15          0.5600     Min MZ: -0.2425319E-14     14          0.0000
-----------------------------------------------------------------------------------------------
```

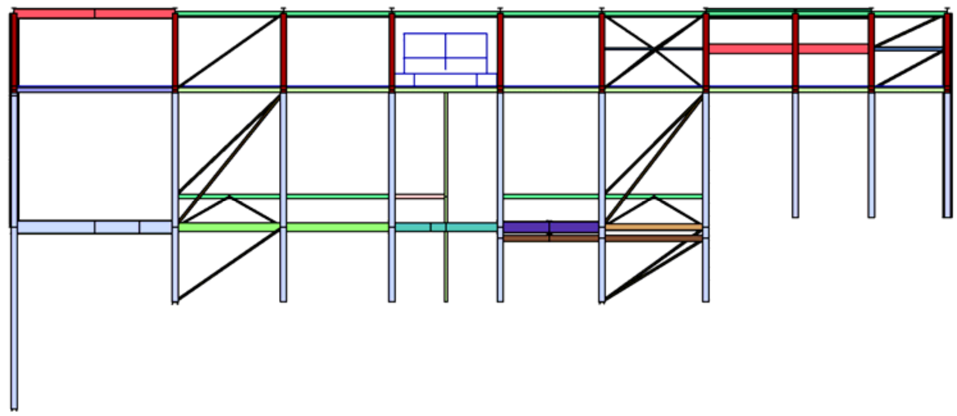
Table 8: Vertical Reaction at Joint 2

x (ft)	R2y (kips)	x (ft)	R2y (kips)	x (ft)	R2y (kips)	x (ft)	R2y (kips)
0.5	1.98	5	2.41	11	2.47	21	2.37
0.625	2	6	2.47	12	2.47	22	2.29
1	2.06	7	2.47	13	2.47	23	2.21
2	2.16	8	2.47	14	2.47		
3	2.25	9	2.47	15	2.47		
4	2.33	10	2.47	16	2.47		

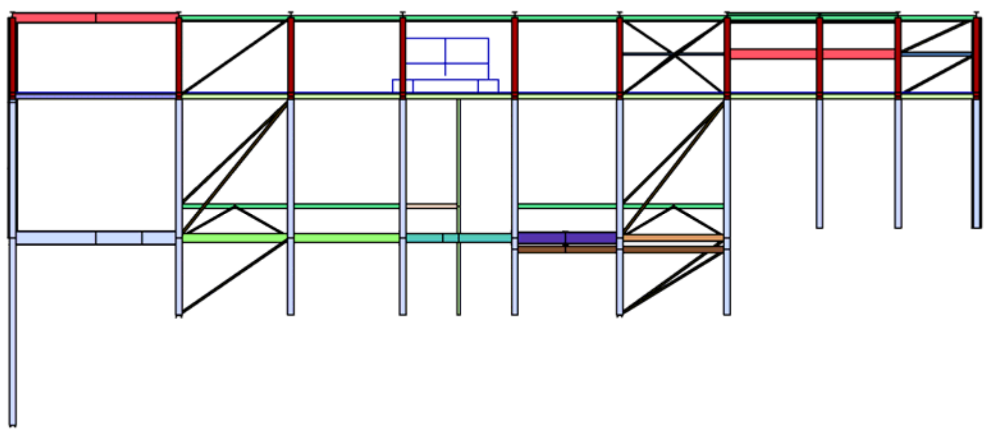
Based on the GT STRUDL results:

N4: Maximize shear force at end of beam x = 0.5 ft (approximately end of beam)
N5*: Maximize column axial force x = 6 ft ~ 16 ft (Use x = – 2'-3")
N6: Maximize runway girder moment x = 11 ft

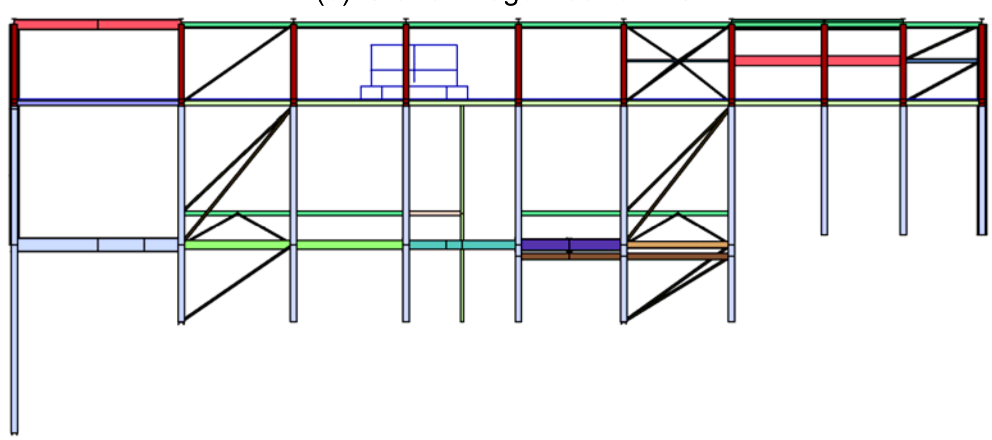
* N6 condition for runway girder moment x = 11 ft also envelopes the X value range shown above for N5 condition. Thus in present evaluation x = – 2'-3" is used, which is different than obtained from 2 span runway analysis.



(a) Crane Bridge Position N4



(b) Crane Bridge Position N5



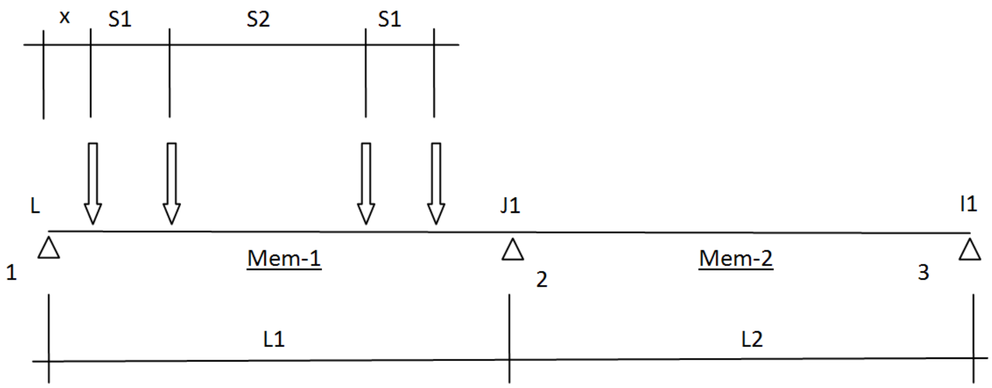
(c) Crane Bridge Position N6

Figure 8.19 **Crane Bridge Position for Typical span runway girder.**

3 South end 36 ft span (two span continuous crane runway girder. 36′-0″ & 24′-3″)

Two-span continuous runway beams between column lines S1 and P1 are modeled in GT STRUDL. ‘x’ represents distance from column line S1 to the south most wheel of the crane.

Crane parameters: S1 = 4.5 ft, S2 = 14 ft
Runway parameters: L1 = 36 ft, L2 = 24.25 ft



Excerpt from GT STRUDL Output:

Load no. shown below is equal to the distance of first crane wheel (X) from support 1 as shown in diagram (i.e. load 20 means x = 20’)

Mem 1

```
--------------------------------------------------------------------------------------------
Max/min Section Forces for member 1         , locations are fractional.
             Value          Load       Location              Value          Load       Location
             -------------  --------   --------              -------------  --------   --------
    Max FX:  0.0000000E+00  20           1.0000   Min FX:  0.0000000E+00  20           1.0000
    Max FY:    2.978778     13           1.0000   Min FY:  -2.188561      2.25         0.0500
    Max MZ:    14.49173     8            0.3500   Min MZ:  -11.21909      7            1.0000
--------------------------------------------------------------------------------------------
```

Mem 2

```
--------------------------------------------------------------------------------------------
Max/min Section Forces for member 2         , locations are fractional.
             Value          Load       Location              Value          Load       Location
             -------------  --------   --------              -------------  --------   --------
    Max FX:  0.0000000E+00  20           1.0000   Min FX:  0.0000000E+00  20           1.0000
    Max FY: -0.3109314E-01  20           1.0000   Min FY:  -2.161282      18           0.0000
    Max MZ:  0.2726237E-05  18           1.0000   Min MZ:  -11.21908      7            0.0000
--------------------------------------------------------------------------------------------
```

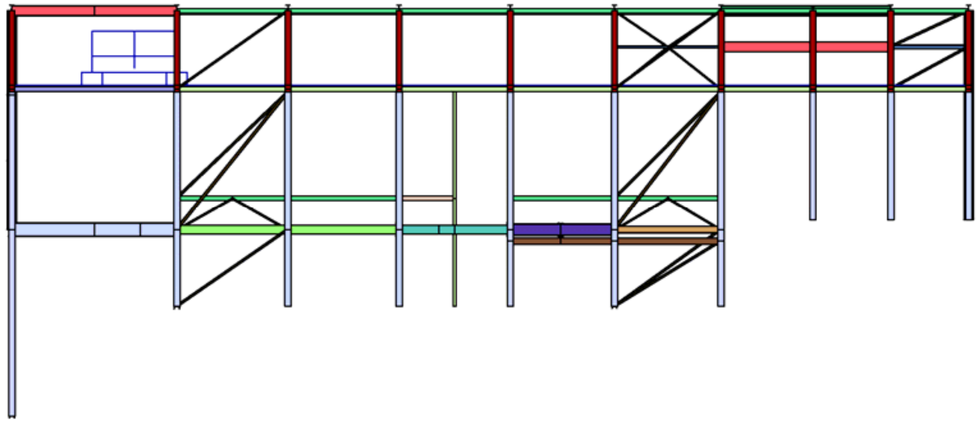
Table 9: Vertical Reaction at Joint 2

x (ft)	R2y (kips)	x (ft)	R2y (kips)	x (ft)	R2y (kips)	x (ft)	R2y (kips)
2.25	2.23	8.5	2.99	15	3.46	18	3.55
6	2.72	9	3.04	15.25	3.47	19	3.55
7	2.83	13	3.36	16	3.50	20	3.55
8	2.94	14	3.42	17	3.53		

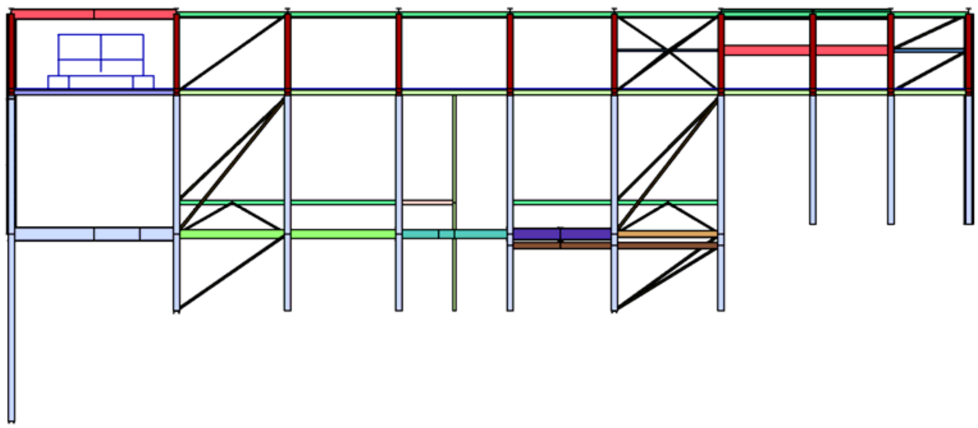
Based on the GT STRUDL results:

N7*: Maximize column axial force x = 18 ft (max at column line Q1)
N8: Maximize runway girder moment x = 8 ft
N9:** Maximize shear force at end of beam x = 2.25 ft (max shear at south end of beam S1-Q1)

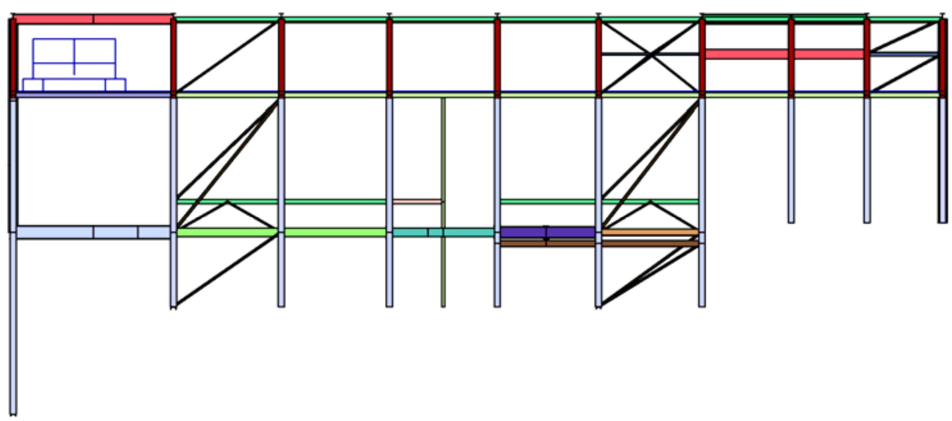
* N7 condition for column axial load is similar to N3 condition and N3 envelopes this condition. In present evaluation x = 15.25 ft different then obtained from 2 span runway girder analysis.
** based on the maximum crane travel limit to the south end of the runway girder per 522-004 (Ref. 4.3.4).



(a) Crane Bridge Position N7



(b) Crane Bridge Position N8



(c) Crane Bridge Position N9

Figure 8.20 <u>Crane Bridge Position for South end 36’ span runway girder</u>

Hook Centerline coordinate for 9 Bridge positions

X = 0 is located at Jt. 1, along column lines S_1 and 301 (i.e. south end bent near to hatch)

S_1 = Distance between outer and inner wheels of crane = 4'-6"

S_2 = Distance between two inner wheels of crane = 14'-0"

A = Distance in X direction from X = 0 coordinate along S_1 column line to Column Line L
= 36'-0" + 24'-3" x 3 + 22'-9" + 23'-3 = 154'-9"

B = Distance in X direction from X = 0 coordinate along S_1 column line to Column Line O_1
= 36'-0" + 24'-3" x 2 = 84'-6"

C = Distance in X direction from X = 0 coordinate along S_1 column line to Column Line N_1
= 36'-0" + 24'-3" x 3 = 108'-9"

Crane Bridge Position 1 (N1)

X = A + (S_1 + S_2/2) + (9'-0") = 154'-9" + 4'-6" + 7'-0" + 9'-0" = 175'-3" = 2103 inch

Crane Bridge Position 2 (N2)

X = A + (S_1 +S_2/2) + (0'-6") = 154'-9" + 4'-6" + 7'-0" + 0'-6"= 166'-9" = 2001 inch

Crane Bridge Position 3 (N3)

X = A + (S_1 +S_2/2) – (2'-3") = 154'-9" + 4'-6" + 7'-0" - (2'-3") = 164'-0" = 1968 inch

Crane Bridge Position 4 (N4)

X = B + (S_1 +S_2/2) + (0'-6") = 84'-6" + 4'-6" + 7'-0" + 0'-6"= 96'-6" = 1158 inch

Crane Bridge Position 5 (N5)

X = B + (S_1 +S_2/2) - (2'-3") = 84'-6" + 4'-6" + 7'-0" – (2'-3") = 93'-9" = 1125 inch

Crane Bridge Position 6 (N6)

X = C – (S_1 +S_2/2) – (11'-0") = 108'-9" – (4'-6") – (7'-0") – (11'-0") = 86'-3" = 1035 inch

Crane Bridge Position 7 (N7)

X = (S_1 +S_2/2) + (15'-3") = 4'-6" + 7'-0" + 15'-3"= 26'-9" = 321 inch

Crane Bridge Position 8 (N8)

X = (S_1 +S_2/2) + (8'-0") = 4'-6" + 7'-0" + 8'-0"= 19'-6" = 234 inch

Crane Bridge Position 9 (N9)

X = (S_1 +S_2/2) + (2'-3") = 4'-6" + 7'-0" + 2'-3"= 13'-9" = 165 inch

<u>Wheel Coordinates</u>

The x coordinates and node numbers of the 8 crane wheels at each bridge positions are calculated based on the hook positions and the relative distance between wheel and the hook.

Table 10: Wheel Coordinates

Crane Bridge Position	Hook X- Coordinate (inch)	X - coordinates of Wheel (inch)	Node Number West Wheels	Node Number East Wheels
N1	2103	2241	CNR1011'	CNR1131'
		2187	CNR1021'	CNR1141'
		2019	CNR1031'	CNR1151'
		1965	CNR1041'	CNR1161'
N2	2001	2139	CNR2011'	CNR2131'
		2085	CNR2021'	CNR2141'
		1917	CNR2031'	CNR2151'
		1863	CNR2041'	CNR2161'
N3	1968	2106	CNR3011'	CNR3131'
		2052	CNR3021'	CNR3141'
		1884	CNR3031'	CNR3151'
		1830	CNR3041'	CNR3161'
N4	1158	1296	CNR4011'	CNR4131'
		1242	CNR4021'	CNR4141'
		1074	CNR4031'	CNR4151'
		1020	CNR4041'	CNR4161'
N5	1125	1263	CNR5011'	CNR5131'
		1209	CNR5021'	CNR5141'
		1041	CNR5031'	CNR5151'
		987	CNR5041'	CNR5161'
N6	1035	1173	CNR6011'	CNR6131'
		1119	CNR6021'	CNR6141'
		951	CNR6031'	CNR6151'
		897	CNR6041'	CNR6161'
N7	321	459	CNR7011'	CNR7131'
		405	CNR7021'	CNR7141'
		237	CNR7031'	CNR7151'
		183	CNR7041'	CNR7161'
N8	234	372	CNR8011'	CNR8131'
		318	CNR8021'	CNR8141'
		150	CNR8031'	CNR8151'
		96	CNR8041'	CNR8161'
N9	165	303	CNR9011'	CNR9131'
		249	CNR9021'	CNR9141'
		81	CNR9031'	CNR9151'
		27	CNR9041'	CNR9161'

8.5 Loads

8.5.1 Dead Load (D)

8.5.1.1. Structural Selfweight

The selfweight of structural steel members is automatically calculated by GT STRUDL based on cross-section area and material weight density.

8.5.1.2. Floor Dead Load at Elevation 162'-0"

Uniform member load due to concrete floor is applied to N-S direction beams at floor.
Floor Thickness = 8" (Ref. 4.3.11)
Floor dead loads are applied to beams as uniform member load on N-S direction beams, based on tributary width.

Floor Load: $= 150\frac{lbf}{ft^3} \times (\frac{8}{12} ft) = 100 psf$

Width = 6 ft (Intermediate Beams) $D_c = 100 psf \times 6 ft = 600\frac{lbf}{ft}$

Width = 3 ft (Periphery Beams) $D_c = 100 psf \times 3 ft = 300\frac{lbf}{ft}$

Near Decontamination pit (see details in GT STRUDL input files):

Width = 2.75 ft $D_c = 100 psf \times 2.75 ft = 275\frac{lbf}{ft}$

Width = 2.25 ft $D_c = 100 psf \times 2.25 ft = 225\frac{lbf}{ft}$

Width = 2.0 ft $D_c = 100 psf \times 2 ft = 200\frac{lbf}{ft}$

Width = 1.0 ft $D_c = 100 psf \times 1 ft = 100\frac{lbf}{ft}$

8.5.1.3. Roof Dead Load at Elevation 209'-0"

20 psf (Calc No. 2.01.16, Ref. 4.4.1) of load is applied at the roof beams as roof dead load.

Width = 6.25 ft (Intermediate Beams) $D_c = 20 psf \times 6.25 ft = 125\frac{lbf}{ft}$

Width = 3.125 ft (Periphery Beams) $D_c = 20 psf \times 6.25 ft = 62.5\frac{lbf}{ft}$

8.5.1.4. Dead Load from Adjacent Frame Along Column Line 302A

The columns along 302A are shared by adjacent frame and Auxiliary Building. Therefore, part of the dead load of the adjacent frame shall be taken by the 302A column line. The tributary areas for the columns are shown in Figures 8.21 and 8.22. The dead loads at EL. 167'-6" and EL. 200'-4" for each tributary area are summarized in Table 11. The calculated total weights are applied at each column as joint loads.

The beam end force of each roof beam of the adjacent frame shown on drawing 522-003 (Ref. 4.3.3) is 4.3 kip. The applied uniform loads are estimated of 20 psf floor dead load and 40 psf floor live load is calculated to achieve the 4.3 kip beam end force. Likewise, the beam end force of each roof beam of the adjacent Auxiliary Building shown on drawing 521-102 (Ref. 4.3.8) is 3.1 kip. The applied uniform loads are estimated 20 psf dead load, and 40 psf live load is calculated to achieve the 3.1 kip beam end force. The joint loads applied at the columns are summarized in Tables 11 & 12.

Table 11: Roof Dead Load from adjacent Auxiliary Building frame (20 psf)

Column ID	Tributary Area (ft^2)	Applied Joint Load (kip)
302A-Q_1	180	3.6
302A-P_1	360	7.2
302A-O_1	360	7.2
302A-N_1	349	7.0
302A-M_1	342	6.9
302A-L (EL 167'-6")	173	3.5
302A-L (EL 200'-4")	275	5.5
302A-J_1	401	8.1
302A-I_1	127	2.6

Table 12: Structural Selfweight from adjacent frame.

Column ID	Member Section	Member Length within Tributary Area (ft)	Weight (kip)
302A-Q_1	W12x27	36.38	0.982
	W16x36	14.84	0.534
	WT4x12	19.16	0.230
		Total Weight (kip)	1.746
302A-P_1	W12x27	73.50	1.985
	W18x50	14.84	0.742
		Total Weight (kip)	2.727
302A-O_1	W12x27	67.00	1.809
	W18x50	14.84	0.742
	WT4x12	38.32	0.460
		Total Weight (kip)	3.011
302A-N_1	W12x27	59.13	1.597
	W18x50	14.83	0.742
		Total Weight (kip)	2.339
302A-M_1	W12x27	67.50	1.823
	W18x50	14.83	0.742
	WT4x12	37.54	0.451
		Total Weight (kip)	3.016
302A-L	W12x27	34.80	0.942
EL 167'-6"	W16x36	14.83	0.534
		Total Weight (kip)	1.476
302A-L	W14x30	14.83	0.445
EL 200'-4"	W10x21	37.00	0.777
	W18x45	14.83	0.668
	WT4x12	26.00	0.312
	12I40.8	19.74	0.806
		Total Weight (kip)	3.008
302A-J_1	W10x21	54.00	1.134
	W27x84	18.50	1.554
	W18x45	28.75	1.294
	W10x33	8.50	0.281
		Total Weight (kip)	4.263
302A-I_1	W10x21	17.00	0.147
	W14x30	14.38	0.432
	W10x33	8.50	0.281
		Total Weight (kip)	0.860

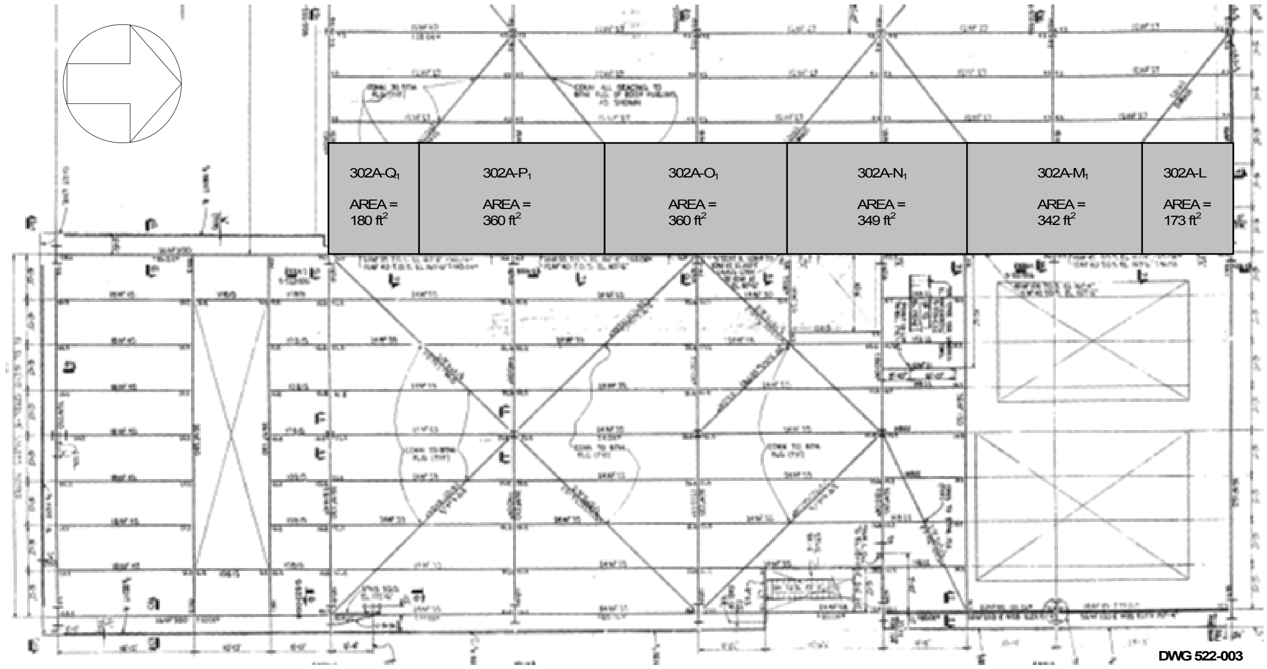


Figure 8.21 <u>**Crane Roof at EL. 167'-6" (between Column Lines Q1 and L per Ref. 4.3.3)**</u>

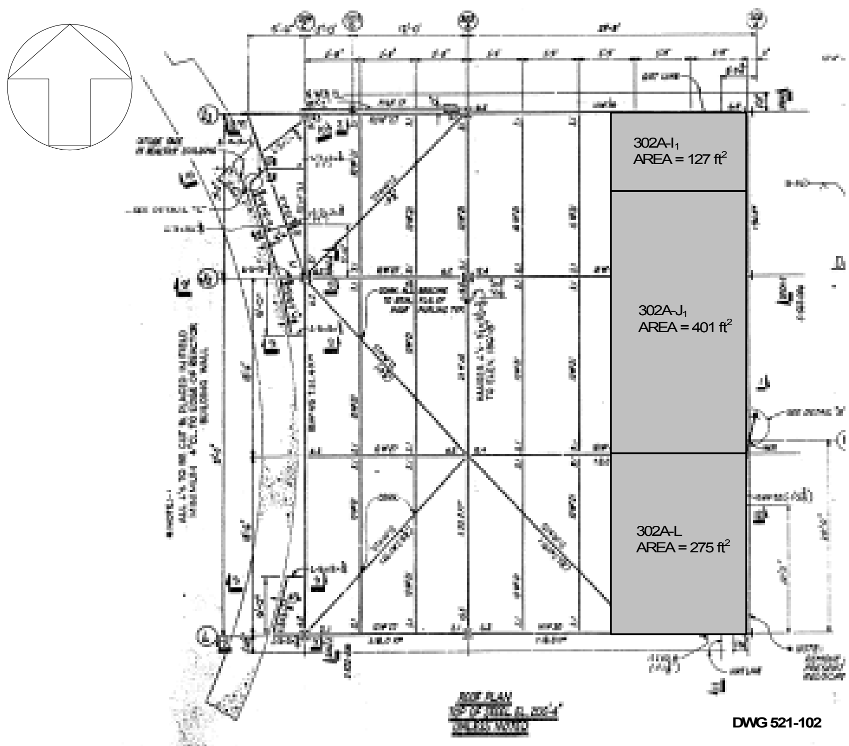


Figure 8.22 <u>**Roof at EL. 200'-4" (between Column Lines L and I1 per Ref. 4.3.8)**</u>

8.5.1.5. Siding and Girts Dead Load

Girts consists of channel section C15x33.9 and W14x22 and are used to support the siding panels.
Siding Panels: Weight = 1.5 psf (Ref. 4.4.4)
Height of building (above EL 162'-0") = 47 ft

Siding panels across the building height is supported using nine channels (C15x33.9) and two beams (W14x22), typically.

Conservatively use following weight.
C15x33.9: W = 35 lbs/ft
W14x22: W = 25 lbs/ft
Total Load of Girts per unit length = 35x9 + 25x2 = 365 lbs/ft (use 400 lbs/ft)
Load per unit height across the building = 400/47 = 8.5 psf

Total load = Sidings + Girts = 1.5 + 8.5 = 10 psf.

This load is applied across the height of column based on the tributary distance between the columns.

8.5.1.6. Concrete Blocks (Hatch Cover)

The weight of eight-inch thick concrete hatch covers at EL. 162'-0" at south end of the building between GT STRUDL members 123 to 128 131 to 136 are considered.
Load = 150 pcf x (8/12) ft x 5 ft = 0.5 kip/ft

8.5.1.7. Crane Dead Load

The crane dead loads are obtained from manufacture's crane ANSYS model (Attachment 4). The material properties and member sections in the model provide the weight of the members. Below is the summary showing the GT STRUDL Joint where load is applied and magnitude of the load

Table 13: Crane Components Dead Load

GT STRUDL Joint	Joint Load (Kips)
CN450	1.130
CN6	0.444
CN7	0.440
CN285	0.880
CN270	1.415
CN278	1.415
CN3	0.250
CN27	0.250
CN541	0.250

8.5.2 Live Loads (L)

8.5.2.1. Floor Live Loads (Lf)

Floor live load at EL 162'-0" is 300 psf as specified in DBD 1/3 (Ref. 4.1.3). This load is applied in the similar manner and location as load from concrete floor, see Section 8.5.1.2 for methodology.

Table 14: Floor Live Load

Width (ft)	Uniform Load (lbs/ft)
6	1800
3	900
2.75	825
2.25	675
2	600
1	300

8.5.2.2. Roof Live Load (Lr)

The roof live load specified in DBD 1/3 (Ref. 4.1.3) is 30 psf. The member load applied at the roof beams is similar in the manner roof dead load is applied, see Section 8.5.1.3 for methodology.

Table 15: Roof Live Load

Width (ft)	Uniform Load (lbs/ft)
6.25	187.5
3 .125	93.75

8.5.2.3. Roof Live Load from Adjacent Frame Along Column Line 302A

The roof live load of the adjacent frame is estimated as 40 psf uniform loads per Sec. 8.5.1.4 in this calculation. The joint loads applied at the columns are summarized in Table 16.

Table 16: Roof Live Load from adjacent frame (40 psf)

Column ID	Tributary Area (ft^2)	Applied Joint Load (kip)
302A-Q_1	180	7.2
302A-P_1	360	14.4
302A-O_1	360	14.4
302A-N_1	349	14.0
302A-M_1	342	13.7
302A-L (EL 167'-6")	173	7.0
302A-L (EL 200'-4")	275	11.0
302A-J_1	401	16.1
302A-I_1	127	5.1

8.5.3 Design Wind Loads (W)

The wind loads shall be based on a basic design wind speed of 110 mph as established in Gilbert calculations (Refs. 4.4.2 & 4.4.11). The wind pressures, as a function of height and pressure coefficients, have been established per ASCE Paper No. 3269 (Ref. 4.5.2). The design wind velocities (V) for EL. 98'-0" to EL. 148'-0" and EL. 148'-0" to EL. 248'-0" are determined as 121 mph and 149 mph, respectively, per calculation 2:01.10 (Ref. 4.4.2). The pressure coefficients, summarized in Table 17, in different directions depend on the dimensions of the building and require interpolations per ASCE Paper No. 3269 (Ref. 4.5.2).

Table 17: Pressure Coefficients (Ref. 4.5.2)

Height-width Ratio	Windward	Leeward	Side	Roof
0.25	0.9	0.3	0.8	0.5
1	0.9	0.5	0.8	-
≥ 2.5	0.9	0.6	0.8	0.8

The pressure coefficients are directly obtained from Table 17 or calculated as:

E-W direction: building height-width ratio = height / width = 90.1' / 208.75' = 0.43

Windward: 0.9

Leeward: $0.3 \times \frac{(1-0.43)}{(1-0.25)} + 0.5 \times \frac{(0.43-0.25)}{(1-0.25)} = 0.35$

Sideward: 0.8

Roof: $0.5 \times \frac{(2.5-0.43)}{(2.5-0.25)} + 0.8 \times \frac{(0.43-0.25)}{(2.5-0.25)} = 0.52$

N-S direction: building height-width ratio = height / width = 90.1′ / 48′ = 1.9

Windward: 0.9

Leeward: $0.5 \times \frac{(2.5-1.9)}{(2.5-1)} + 0.6 \times \frac{(1.9-1)}{(2.5-1)} = 0.56$

Sideward: 0.8

Roof: $0.5 \times \frac{(2.5-1.9)}{(2.5-0.25)} + 0.8 \times \frac{(1.9-0.25)}{(2.5-0.25)} = 0.72$

The calculated pressure coefficients are multiplied to the following wind pressure

Wind pressure, $q = 0.002558\ V^2$ (Ref. 4.5.2, Eq. 8)

8.5.3.1. Wind Loads in +Z-direction (wind blow from west to east)

The wind pressures for windward, leeward, and side walls are applied at the columns and wind pressure at roof is applied at roof beams as member loads in GT STRUDL. Figures 8.23, 8.24, and 8.25 shows the column spacing on west, east, south, and north sides of the building, respectively. The member loads are calculated based on the various tributary areas based on column spacing. Tables 18, 19, 20, and 21 show the member loads applied at columns for windward, leeward, and side walls respectively.

Wind pressures at each side of building:

EL 98'-0" to EL 148'-0":

Windward (west side): $q = 0.002558 \times 121^2 \times 0.9 = 33.7\ psf$

Leeward (east side): $q = 0.002558 \times 121^2 \times 0.35 = 13.1\ psf$

Side (north and south sides): $q = 0.002558 \times 121^2 \times 0.8 = 30.0\ psf$

EL 148'-0" to EL 248'-0":

Windward (west side): $q = 0.002558 \times 149^2 \times 0.9 = 51.1\ psf$

Leeward (east side): $q = 0.002558 \times 149^2 \times 0.35 = 19.9\ psf$

Side (north and south sides): $q = 0.002558 \times 149^2 \times 0.8 = 45.4\ psf$

Roof: $q = 0.002558 \times 149^2 \times 0.52 = 29.5\ psf$

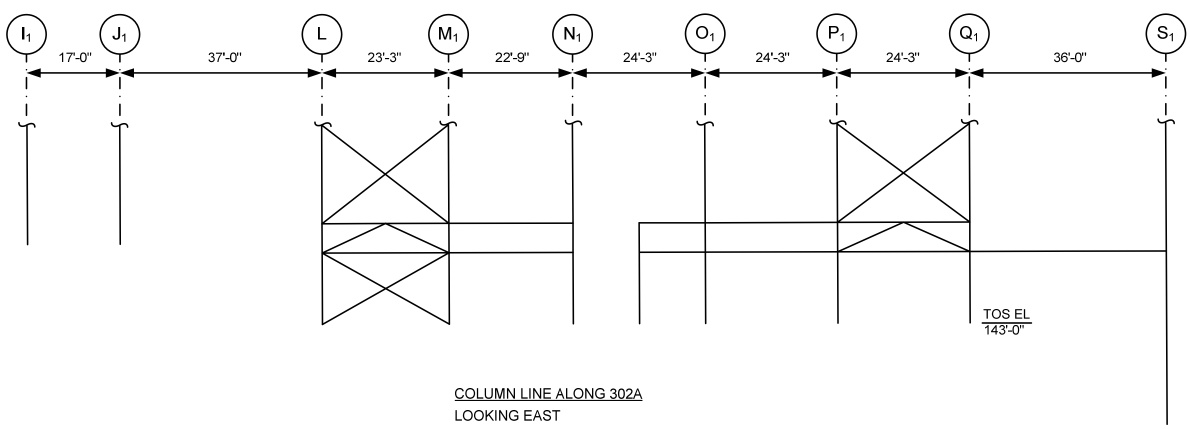


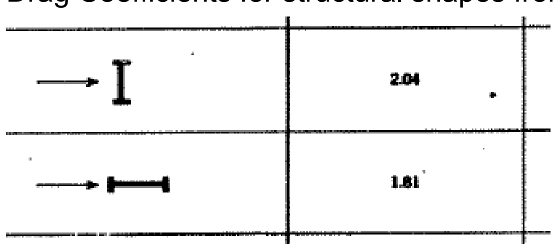
Figure 8.23 Column Line along 302A Looking East

Table 18: Windward Pressure (West Side) due to Wind +Z-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
I_1	10.5'	-	537
J_1	27'	-	1380
L(above 162')	30.1'	-	1538
L (EL 162')	23.25'/2	392	594
M_1	23'	775	1175
N_1	23.5'	792	1201
O_1	24.3'	819	1242
P_1	24.3'	819	1242
Q_1 (above 162')	30.1'	-	1538
Q_1 (EL 162')	14.0'	472	715
S_1	20'	674	1022

Member 12 and 1 are located at column line S_1. These columns are directly exposed to wind and wind load is applied on theses member based on their size and Drag coefficients obtained from paper ASCE 3629 (Ref. 4.5.2).

Drag Coefficients for structural shapes from Table 2 of ASCE 3269 (Ref. 4.5.2)



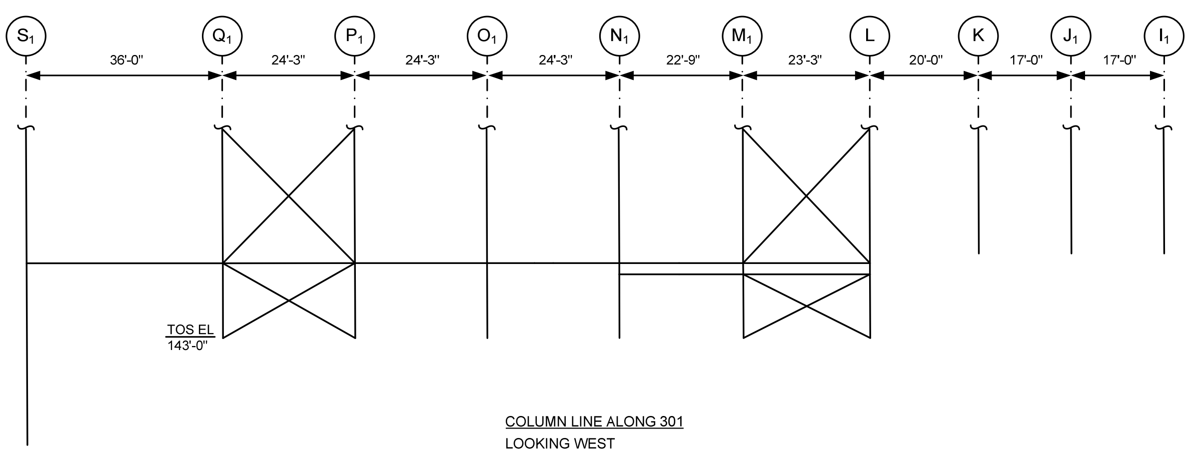


Figure 8.24 Column Line along 301 Looking West

Table 19: Leeward Pressure (East Side) due to Wind +Z-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
I1	10.5'	-	209
J1	17'	-	338
K	18.5'	-	368
L (above 162')	21.6'	-	430
L (EL 162')	23.25'/2	152	231
M1	23'	301	458
N1	23.5'	308	468
O1	24.3'	318	484
P1	24.3'	318	484
Q1 (above 162')	30.1'	-	599
Q1 (EL 162')	14.0'	184	279
S1	20'	262	398

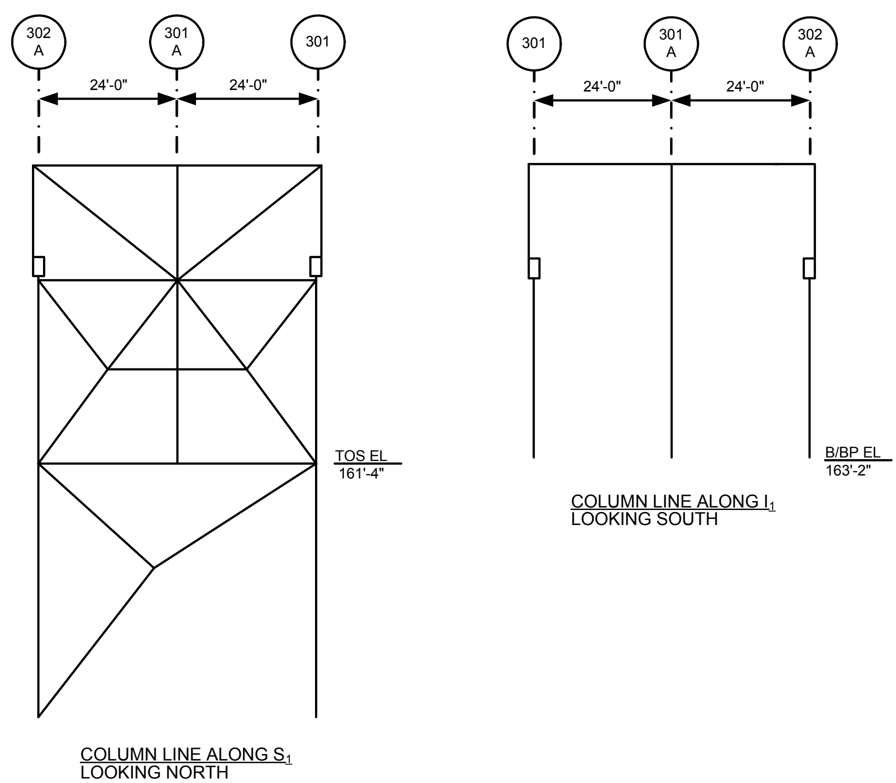


Figure 8.25 Column Lines along S_1 and I_1 Looking North and South, respectively

Table 20: Side Wall Pressure (South Side) due to Wind in +Z-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
301	14'	-	-636
301A	24'	-	-1090
302A	14'	-	-636

Table 21: Side Wall Pressure (North Side) due to Wind in +Z-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
301	14'	-	636
301A	24'	-	1090
302A	14'	-	636

The wind suction applied at the roof beams due to the wind in +Z-direction is calculated as:

$$29.5\frac{lbf}{ft^2} \times 6.25\,ft = 184\frac{lbf}{ft}$$

8.5.3.2. Wind Loads in -Z-direction (wind blow from east to west)

The wind pressures for windward, leeward, and side walls are applied at the columns and wind pressure at roof is applied at roof beams as member loads in GT STRUDL. Figures 8.23 to 8.25 show the column spacing on west, east, south, and north sides of the building, respectively. Tables 22, 23, 24, and 25 list the member loads applied at columns for windward, leeward, and side walls, respectively.

Table 22: Windward Pressure (East Side) due to Wind in -Z-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
I1	10.5'	-	-567
J1	17'	-	-869
K	18.5'	-	-945
L(above 162')	21.6'	-	-1104
L (EL 162')	23.25'/2	-392	-594
M1	23'	-775	-1175
N1	23.5'	-792	-1201
O1	24.3'	-819	-1242
P1	24.3'	-819	-1242
Q1(above 162')	30.1'	-	-1538
Q1 (EL 162')	14.0'	-1014	-1538
S1	20'	-674	1022

Table 23: Leeward Pressure (West Side) due to Wind in -Z-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
I1	10.5'	-	-209
J1	27'	-	-537
L (above 162')	30.1'	-	-599
L (EL 162')	23.25'/2	-152	-231
M1	23'	-301	-458
N1	23.5'	-308	-468
O1	24.3'	-318	-484
P1	24.3'	-318	-484
Q1 (above 162')	30.1'	-	-599
Q1 (EL 162')	14.0'	-394	-599
S1	20'	-262	-398

Table 24: Side Wall Pressure (South Side) due to Wind in -Z-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
301	14'	-	-636
301A	24'	-	-1090
302A	14'	-	-636

Table 25: Side Wall Pressure (North Side) due to Wind in -Z-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
301	14'	-	636
301A	24'	-	1090
302A	14'	-	636

The wind suction applied at the roof beams due to the wind in -Z-direction is calculated as:

$$29.5\frac{lbf}{ft^2} \times 6.25\,ft = 184\frac{lbf}{ft}$$

8.5.3.3. Wind Loads in +X-direction (wind blow from south to north)

The wind pressure for windward, leeward, and side walls are applied at the columns and wind pressures at roof is applied at roof beams as member loads in GT STRUDL. Figures 8.23 to 8.25 show the column spacing on west, east, south, and north sides of the building, respectively. Tables 26 to 29 list the member loads applied at columns for windward, leeward, and both side walls, respectively.

Wind pressures at each side of building:

EL 98'-0" to EL 148'-0":

Windward (south side): $q = 0.002558 \times 121^2 \times 0.9 = 33.7 \text{ psf}$

Leeward (north side): $q = 0.002558 \times 121^2 \times 0.56 = 21.0 \text{ psf}$

Side (east and west sides): $q = 0.002558 \times 121^2 \times 0.8 = 30.0 \text{ psf}$

EL 148'-0" to EL 248'-0":

Windward (south side): $q = 0.002558 \times 149^2 \times 0.9 = 51.1 \text{ psf}$

Leeward (north side): $q = 0.002558 \times 149^2 \times 0.56 = 31.8 \text{ psf}$

Side (east and west sides): $q = 0.002558 \times 149^2 \times 0.8 = 45.4 \text{ psf}$

Roof: $q = 0.002558 \times 149^2 \times 0.72 = 40.9 \text{ psf}$

Table 26: Windward Pressure (South Side) due to Wind in +X-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
301	14'	-	715
301A	24'	-	1226
302A	14'	-	715

Table 27: Leeward Pressure (North Side) due to Wind in +X-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
301	14'	-	445
301A	24'	-	763
302A	14'	-	445

Table 28: Side Wall Pressure (East Side) due to Wind in +X-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
I1	10.5'	-	447
J1	17'	-	772
K	18.5'	-	840
L (above 162')	21.6'	-	981
L (El 162')	23.25'/2	349	528
M1	23'	690	1044
N1	23.5'	705	1067
O1	24.3'	729	1103
P1	24.3'	729	1103
Q1 (above 162')	30.1'	-	1367
Q1 (EL 162')	14.0'	420	636
S1	20'	600	908

Table 29: Side Wall Pressure (West Side) due to Wind in +X-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
I1	10.5'	-	-477
J1	27'	-	-1226
L (above 162')	30.1'	-	-1367
L (El 162')	23.25'/2	-349	-528
M1	23'	-690	-1044
N1	23.5'	-705	-1067
O1	24.3'	-729	-1103
P1	24.3'	-729	-1103
Q1 (above 162')	30.1'	-	-1367
Q1 (El 162')	14.0'	-420	-636
S1	20'	-600	-908

The wind suction applied at the roof beams due to the wind in -Z-direction is calculated as:

$$40.9 \frac{lbf}{ft^2} \times 6.25\,ft = 256 \frac{lbf}{ft}$$

8.5.3.4. Wind Loads in -X-direction (wind blow from north to south)

The wind pressures for windward, leeward, and both side walls are applied at the columns and win pressures at roof is applied at roof beams as member loads in GT STRUDL. Figures 8.23 to 8.25 show the column spacing on west, east, south, and north sides of the building, respectively. Tables 30 to 33 list the member loads applied at columns for windward, leeward, and both side walls, respectively.

Table 30: Windward Pressure (North Side) due to Wind in -X-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
301	14'	-	-613
301A	24'	-	-1226
302A	14'	-	-613

Table 31: Leeward Pressure (South Side) due to Wind in -X-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
301	14'	-	-382
301A	24'	-	-763
302A	14'	-	-382

Table 32: Side Wall Pressure (East Side) due to Wind in -X-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
I1	10.5'	-	477
J1	17'	-	772
K	18.5'	-	840
L (above 162')	21.6'	-	981
L (El 162')	21.6'	349	528
M1	23'	690	1044
N1	23.5'	705	1067
O1	24.3'	729	1103
P1	24.3'	729	1103
Q1 (above 162')	30.1'	-	1367
Q1 (El 162')	30.1'	420	636
S1	20'	600	908

Table 33: Side Wall Pressure (West Side) due to Wind in -X-direction

Column ID	Spacing for Tributary Area (ft)	Member Load @ EL 98' to 148' (lb/ft)	Member Load @ EL 148' to 248' (lb/ft)
I1	10.5'	-	-477
J1	27'	-	-1226
L (above 162')	30.1'	-	-1367
L (El 162')	30.1'	-349	-528
M1	23'	-690	-1044
N1	23.5'	-705	-1067
O1	24.3'	-729	-1103
P1	24.3'	-729	-1103
Q1 (above 162')	30.1'	-	-1367
Q1 (El 162')	30.1'	-420	-636
S1	20'	-600	-908

The wind suction applied at the roof beams due to the wind in -Z-direction is calculated as:

$$40.9\frac{lbf}{ft^2}\times 6.25\,ft = 256\frac{lbf}{ft}$$

8.5.4 Operating Wind Loads (W_o)

The operating wind loads shall be based wind speed of 50 mph, and wind pressure is calculated as per ASCE 7-05 (Ref. 4.2.4). See Attachment 5 for operating wind load calculation.

8.5.5 Crane Impact Loads (I_V or I_L or I_T)

Crane impact load is applied at the crane bridge and trolley wheels.

No. of Crane bridge wheels = 8

No. of Trolley wheels = 4

Trolley weight = 80 Kips (Section 6.4)

Crane Bridge Girder weight = 80 Kips (Section 6.4)

Hook - Loaded

Lifted Load = 260 Kips (Section 6.5.4)

Maximum Wheel Load = 88.5 Kips (Ref. 4.3.20)

Vertical Impact = 25% of Lift Load (Section 6.5.5)
= 0.25 x 260
= 65 Kips

Longitudinal Impact Load
= 10 % of maximum wheel load (Section 6.5.5)
= 0.1 x 88.5
= 8.85 Kips applied at each crane bridge wheel location.

Transverse Impact Load
= 10 % of trolley weight and lift load on each girder (Section 6.5.5)
= 0.1 x (266 + 80)
= 34.6 Kips

This load is applied at trolley wheel locations.

Load on each wheel = 34.6 / 4 = 8.65 Lips

Hook - Unloaded

Lifted Load = 0 Kips

Maximum Wheel Load = [(Crane bridge girder weight / 2) + (Trolley weigh)] / 4
= (80/2 + 80) / 4 = 20 Kips (Use conservatively 30 Kips)

Vertical Impact = 25% of Lift Load (Section 6.5.5)
= 0.25 x 0
= 0 Kips

Longitudinal Impact Load
= 10 % of maximum wheel load (Section 6.5.5)
= 0.1 x 30
= 3 Kips applied at each crane bridge wheel location.

Transverse Impact Load
= 10 % of trolley weight and lift load on each girder (Section 6.5.5)
= 0.1 x (0 + 80)
= 8 Kips

This load is applied at trolley wheel locations.

Load on each wheel = 8 / 4 = 2 Kips

8.6 Analysis Scheme and File Name Designation

This section explains the naming convention used for the input files, its location on DVD (electronic transmittal) and explanation for various output files generated during the analyses.

Key variable Definitions

Table 34: Crane Bridge Position

N1	Between column lines L and J1 - Maximum Moment
N2	Between column lines L and J1 - Maximum Shear
N3	Between column lines L and J1 - Maximum Column Load
N4	Between column lines Q1 and L- Maximum Shear
N5	Between column lines Q1 and L – Maximum Column Load
N6	Between column lines Q1 and L - Maximum Moment
N7	Between column lines S1 and Q1 – Maximum Column Load
N8	Between column lines S1 and Q1 - Maximum Moment
N9	Between column lines S1 and Q1- Maximum Shear

Table 35: Trolley Position

E1	Trolley in the extreme East Position
E2	Trolley East 1/4 Point Position
E3	Trolley in Middle Position
E4	Trolley in extreme West Position

Table 36: Hook Position

HU	Hook is in extreme UP position (Rope Length = 96.16 inch)
HD	Hook is in extreme DOWN position (Rope Length = 1056.16 inch)

Table 37: Lift Load Condition

WL	With Lift Load (Lift Load = 260 kips)
WO	Without Lift Load (Lift Load = 0 kips)

Per ASME NOG-1 (Ref. 4.2.1), three conditions of HU_WL, HU_WO, and HD_WL are considered for the hook position and hook lift load condition.
Total number of model configurations
= Crane Bridge Position x Trolley Position x (combinations of hook position and lift load condition) = 9 x 4 x 3 = 108
Input files are named in such a manner that it includes all the variables explained above, which helps in determining the exact configuration of each model.
The Table Below lists all 108 model configurations for the combinations of bridge/trolley/hook positions and load conditions. It also list the designated Model number, folder name and Input file name for each model configurations

Table 38: Model Configuration

Model No. / Folder Name	GT STRUDL input File name	Crane Bridge Position	Trolley Position	Hook Position	Loading Condition
1	N1E1_HU_WL.gti	**N1**	E1	**HU**	WL
2	N1E1_HU_WO.gti	**N1**	E1	**HU**	WO
3	N1E1_HD_WL.gti	**N1**	E1	**HD**	WL
4	N1E2_HU_WL.gti	**N1**	E2	**HU**	WL
5	N1E2_HU_WO.gti	**N1**	E2	**HU**	WO
6	N1E2_HD_WL.gti	**N1**	E2	**HD**	WL
7	N1E3_HU_WL.gti	**N1**	E3	**HU**	WL
8	N1E3_HU_WO.gti	**N1**	E3	**HU**	WO
9	N1E3_HD_WL.gti	**N1**	E3	**HD**	WL
10	N1E4_HU_WL.gti	**N1**	E4	**HU**	WL
11	N1E4_HU_WO.gti	**N1**	E4	**HU**	WO
12	N1E4_HD_WL.gti	**N1**	E4	**HD**	WL
13	N2E1_HU_WL.gti	**N2**	E1	**HU**	WL
14	N2E1_HU_WO.gti	**N2**	E1	**HU**	WO
15	N2E1_HD_WL.gti	**N2**	E1	**HD**	WL
16	N2E2_HU_WL.gti	**N2**	E2	**HU**	WL
17	N2E2_HU_WO.gti	**N2**	E2	**HU**	WO
18	N2E2_HD_WL.gti	**N2**	E2	**HD**	WL
19	N2E3_HU_WL.gti	**N2**	E3	**HU**	WL
20	N2E3_HU_WO.gti	**N2**	E3	**HU**	WO
21	N2E3_HD_WL.gti	**N2**	E3	**HD**	WL
22	N2E4_HU_WL.gti	**N2**	E4	**HU**	WL
23	N2E4_HU_WO.gti	**N2**	E4	**HU**	WO
24	N2E4_HD_WL.gti	**N2**	E4	**HD**	WL
25	N3E1_HU_WL.gti	**N3**	E1	**HU**	WL
26	N3E1_HU_WO.gti	**N3**	E1	**HU**	WO
27	N3E1_HD_WL.gti	**N3**	E1	**HD**	WL
28	N3E2_HU_WL.gti	**N3**	E2	**HU**	WL
29	N3E2_HU_WO.gti	**N3**	E2	**HU**	WO
30	N3E2_HD_WL.gti	**N3**	E2	**HD**	WL
31	N3E3_HU_WL.gti	**N3**	E3	**HU**	WL
32	N3E3_HU_WO.gti	**N3**	E3	**HU**	WO
33	N3E3_HD_WL.gti	**N3**	E3	**HD**	WL
34	N3E4_HU_WL.gti	**N3**	E4	**HU**	WL
35	N3E4_HU_WO.gti	**N3**	E4	**HU**	WO
36	N3E4_HD_WL.gti	**N3**	E4	**HD**	WL

Model No. / Folder Name	GT STRUDL input File name	Crane Bridge Position	Trolley Position	Hook Position	Loading Condition
37	N4E1_HU_WL.gti	**N4**	E1	**HU**	WL
38	N4E1_HU_WO.gti	**N4**	E1	**HU**	WO
39	N4E1_HD_WL.gti	**N4**	E1	**HD**	WL
40	N4E2_HU_WL.gti	**N4**	E2	**HU**	WL
41	N4E2_HU_WO.gti	**N4**	E2	**HU**	WO
42	N4E2_HD_WL.gti	**N4**	E2	**HD**	WL
43	N4E3_HU_WL.gti	**N4**	E3	**HU**	WL
44	N4E3_HU_WO.gti	**N4**	E3	**HU**	WO
45	N4E3_HD_WL.gti	**N4**	E3	**HD**	WL
46	N4E4_HU_WL.gti	**N4**	E4	**HU**	WL
47	N4E4_HU_WO.gti	**N4**	E4	**HU**	WO
48	N4E4_HD_WL.gti	**N4**	E4	**HD**	WL
49	N5E1_HU_WL.gti	**N5**	E1	**HU**	WL
50	N5E1_HU_WO.gti	**N5**	E1	**HU**	WO
51	N5E1_HD_WL.gti`	**N5**	E1	**HD**	WL
52	N5E2_HU_WL.gti	**N5**	E2	**HU**	WL
53	N5E2_HU_WO.gti	**N5**	E2	**HU**	WO
54	N5E2_HD_WL.gti	**N5**	E2	**HD**	WL
55	N5E3_HU_WL.gti	**N5**	E3	**HU**	WL
56	N5E3_HU_WO.gti	**N5**	E3	**HU**	WO
57	N5E3_HD_WL.gti	**N5**	E3	**HD**	WL
58	N5E4_HU_WL.gti	**N5**	E4	**HU**	WL
59	N5E4_HU_WO.gti	**N5**	E4	**HU**	WO
60	N5E4_HD_WL.gti	**N5**	E4	**HD**	WL
61	N6E1_HU_WL.gti	**N6**	E1	**HU**	WL
62	N6E1_HU_WO.gti	**N6**	E1	**HU**	WO
63	N6E1_HD_WL.gti	**N6**	E1	**HD**	WL
64	N6E2_HU_WL.gti	**N6**	E2	**HU**	WL
65	N6E2_HU_WO.gti	**N6**	E2	**HU**	WO
66	N6E2_HD_WL.gti	**N6**	E2	**HD**	WL
67	N6E3_HU_WL.gti	**N6**	E3	**HU**	WL
68	N6E3_HU_WO.gti	**N6**	E3	**HU**	WO
69	N6E3_HD_WL.gti	**N6**	E3	**HD**	WL
70	N6E4_HU_WL.gti	**N6**	E4	**HU**	WL
71	N6E4_HU_WO.gti	**N6**	E4	**HU**	WO
72	N6E4_HD_WL.gti	**N6**	E4	**HD**	WL
73	N7E1_HU_WL.gti	**N7**	E1	**HU**	WL
74	N7E1_HU_WO.gti	**N7**	E1	**HU**	WO
75	N7E1_HD_WL.gti	**N7**	E1	**HD**	WL
76	N7E2_HU_WL.gti	**N7**	E2	**HU**	WL
77	N7E2_HU_WO.gti	**N7**	E2	**HU**	WO
78	N7E2_HD_WL.gti	**N7**	E2	**HD**	WL
79	N7E3_HU_WL.gti	**N7**	E3	**HU**	WL

Model No. / Folder Name	GT STRUDL input File name	Crane Bridge Position	Trolley Position	Hook Position	Loading Condition
80	N7E3_HU_WO.gti	**N7**	E3	**HU**	WO
81	N7E3_HD_WL.gti	**N7**	E3	**HD**	WL
82	N7E4_HU_WL.gti	**N7**	E4	**HU**	WL
83	N7E4_HU_WO.gti	**N7**	E4	**HU**	WO
84	N7E4_HD_WL.gti	**N7**	E4	**HD**	WL
85	N8E1_HU_WL.gti	**N8**	E1	**HU**	WL
86	N8E1_HU_WO.gti	**N8**	E1	**HU**	WO
87	N8E1_HD_WL.gti	**N8**	E1	**HD**	WL
88	N8E2_HU_WL.gti	**N8**	E2	**HU**	WL
89	N8E2_HU_WO.gti	**N8**	E2	**HU**	WO
90	N8E2_HD_WL.gti	**N8**	E2	**HD**	WL
91	N8E3_HU_WL.gti	**N8**	E3	**HU**	WL
92	N8E3_HU_WO.gti	**N8**	E3	**HU**	WO
93	N8E3_HD_WL.gti	**N8**	E3	**HD**	WL
94	N8E4_HU_WL.gti	**N8**	E4	**HU**	WL
95	N8E4_HU_WO.gti	**N8**	E4	**HU**	WO
96	N8E4_HD_WL.gti	**N8**	E4	**HD**	WL
97	N9E1_HU_WL.gti	**N9**	E1	**HU**	WL
98	N9E1_HU_WO.gti	**N9**	E1	**HU**	WO
99	N9E1_HD_WL.gti	**N9**	E1	**HD**	WL
100	N9E2_HU_WL.gti	**N9**	E2	**HU**	WL
101	N9E2_HU_WO.gti	**N9**	E2	**HU**	WO
102	N9E2_HD_WL.gti	**N9**	E2	**HD**	WL
103	N9E3_HU_WL.gti	**N9**	E3	**HU**	WL
104	N9E3_HU_WO.gti	**N9**	E3	**HU**	WO
105	N9E3_HD_WL.gti	**N9**	E3	**HD**	WL
106	N9E4_HU_WL.gti	**N9**	E4	**HU**	WL
107	N9E4_HU_WO.gti	**N9**	E4	**HU**	WO
108	N9E4_HD_WL.gti	**N9**	E4	**HD**	WL

Output Files

Mainly two types of files are generated after running the input files.

1. Output file (*.gto), the name of this file is same input file name but with file type changed from '.gti' to '.gto'. This file contains all the input information and results for Eigenvalue solution, modal analysis, generation of seismic load, deflection summary and member code checks.
2. Text Files which contain member and joint results are generated. The naming format for text file is **(X)File_Y.txt** is as follows:
   where, X = Model no. and Y = A or B or C or S (see table 39 for explanation)

Table 39: Output file 'X' Description

Suffix	Description	GT STRUDL Load Cases
A	Envelope member force results for Load Cases with Normal allowable stresses.	2000 to 2030 by 10
B	Envelope member force results for Load Cases with one third increase in allowable stresses.	3000 to 3030 by 10 7000 to 7050 by 10 5000 to 5030 by 10 8000 to 8230 by 10
C	Envelope member force results for Load Cases with Elastic Limit allowable stresses.	4000 to 4050 by 10 6000 to 6230 by 10
S	Member force results for all load cases	All

File = Member component name for which results are being extracted. (See below for complete list of all member components)

Table 40: Output file 'File' description

	Member Components
1	CRANE BRACKET
2	CRANE GIRDER (Runway Girders)
3	FLOOR BRACING
4	FLOOR E-W BEAM CONNECTIONS
5	FLOOR N-S BEAM CONNECTIONS
6	MISC BEAMS
7	ROOF BRACING
8	ROOF E-W BEAM CONNECTIONS
9	ROOF N-S BEAMS CONNECTIONS
10	STEP UP COLUMN BTM CON
11	VERTICAL BRACING

Three additional files are generated with following names.

'RESPONSE SPECTRA ACC.TXT' contains response spectra acceleration values at crane wheels and hook location.

'RUNWAY MEM_L8X4.TXT' and 'RUNWAY MEM_L8X6.TXT' contains member results (all load cases) for the runway girders
Total number of output files generated per configuration = 1 + (4x11) + 3 = 48 files
Each configuration of model is placed under unique folder designated with its model no. and all the 108 folders are placed in main folder with name "GT STRUDL RUNS" and then this folder is placed under the main folder named "CR3 AUX BLDG ANALYSES" folder.

8.7 Member Evaluations

Both existing and new steel members are evaluated based on AISC 6th edition (Ref. 4.2.2)

8.7.1 Member Code Check

Member code check for all members (excluding vertical bracings, runway girders, crane brackets and crane members) was carried out using GT STRUDL. GT STRUDL doesn't have a code check feature for AISC 6th edition (Ref. 4.2.2), hence a code check was carried out using the AISC 7th edition (Ref. 4.2.8) feature available in GT STRUDL. A code comparison between AISC 6th edition and AISC 7th edition is documented in Appendix 3 and shows that AISC 6th edition is generally equal or more conservative than that based on AISC 7th edition. Only difference observed is in the allowable for minor axis bending stress in compact I and H Section, where the section has higher allowable compared to 6^{th} edition.

For all models the code check is carried out on the basis of allowable mentioned in Section 6.6 and review of the results show that all the members meet the required stress requirements.

8.7.2 Vertical Bracing

In Calculation No. 2:01.12 (Ref. 4.4.7), some of the vertical braces are designed for tension only. In order to simulate the tension-only members, the braces in the X-bracing configuration are modeled as one diagonal bracing to take tensile forces only. The failure in compression in GT STRUDL warnings are ignored, and the separate hand calculations are performed to check the vertical bracing for tension force. See, Attachment 9 for vertical bracing evaluation.

Member 7301, 7303, 7313 and 7315 were overstressed using the original section sizes, these members needs to be replaced and GT STRUDL runs documents the new section properties for these members. See Attachment 9 for these member evaluations.

8.7.3 Crane Runway Girder Evaluation

The crane runway girders are built-up members with a W36x300 and two angles welded on the top flanges. Since the current GT STRUDL version (Ref. 4.5.1) does not provide the function to code check the built-up members, the built-up runway girders are code checked manually in this Section. Figure 8.26 shows the runway girder section. Two L4x8x3/8 angles or L6x8x7/8 are welded on the top flanges for simple and continuous spans, respectively.

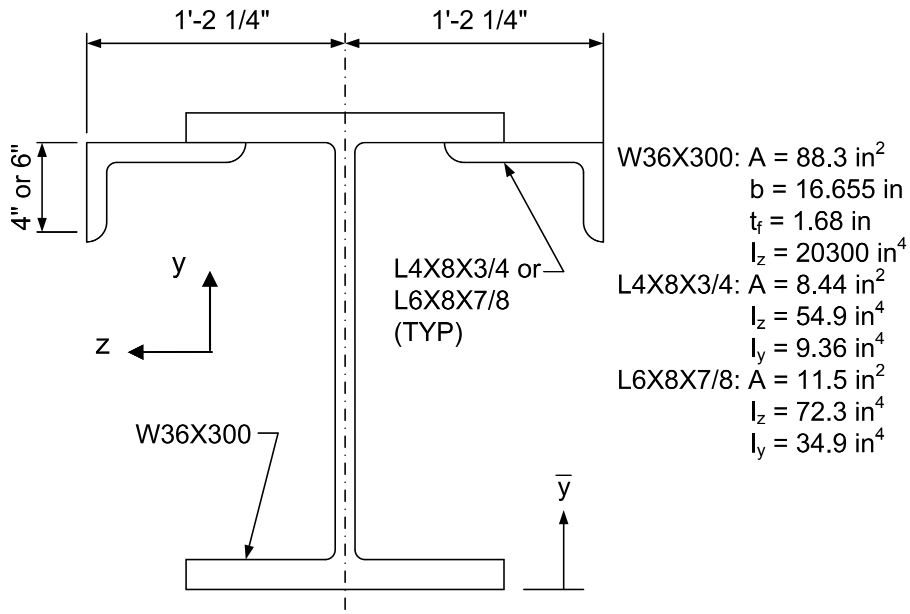


Figure 8.26 Runway Girder Section (Section 1-1 in Ref. 4.3.3)

8.7.3.1. Sectional Properties

(1) Section 1 (W36x300 with two L4x8x3/4)

Area, $A = 88.3 + 2 \times 8.44 = 105.18\ in^2$

Centroid location, $\bar{y} = \dfrac{88.3 \times 36.74/2 + 2 \times 8.44 \times (36.74 - 1.68 - 1.05)}{105.18} = 20.88\ in$

Moment of inertia,

$$I_z = 20300 + 88.3(36.74/2 - 20.88)^2 + 2 \times 9.36 + 2 \times 8.44(36.74 - 20.88 - 1.68 - 1.05)^2 = 23785\ in^4$$

AISC Design Guide 7 (Ref. 4.5.3) recommends using the Sectional Modulus of the section composed of top flange of W-section and added members (angles) for minor axis bending to account for torsion due to eccentrically applied lateral load.

Moment of inertia about y-axis of top portion of runway girder,

$$I_y = 646.8 + 54.9 \times 2 + 2 \times 8.44(14.25 - 2.95)^2 = 2912\ in^4$$

Sectional modulus about z-axis, $S_z = \dfrac{I_z}{d - \bar{y}} = \dfrac{23785}{36.74 - 20.88} = 1500\ in^3$

Sectional modulus about y-axis, $S_y = \dfrac{2912}{14.25} = 204\ in^3$

(2) Section 2 (W36x300 with two L6x8x7/8)

Area of runway girder, $A = 88.3 + 2 \times 11.5 = 111.3\ in^2$

Centroid location, $\bar{y} = \dfrac{88.3 \times 36.74/2 + 2 \times 11.5 \times (36.74 - 1.68 - 1.61)}{111.3} = 21.49\ in$

Moment of inertia about z-axis,

$I_z = 20300 + 88.3(36.74/2 - 21.49)^2 + 2 \times 34.9 + 2 \times 11.5(36.74 - 21.49 - 1.68 - 1.61)^2 = 24519\ in^4$

Moment of inertia about y-axis of top portion of the runway girder,

$I_y = 646.8 + 72.3 \times 2 + 2 \times 11.5(14.25 - 2.61)^2 = 3908\ in^4$

Sectional modulus about z-axis, $S_z = \dfrac{I_z}{d - \bar{y}} = \dfrac{24519}{36.74 - 21.49} = 1608\ in^3$

Sectional modulus about y-axis, $S_y = \dfrac{3908}{14.25} = 274\ in^3$

8.7.3.2. Allowable Stresses

(1) Allowable axial stress:

(a) Section 1 (W36x300 with two L4x8x3/4)

Maximum span, L = 24'-3" use $L = 25\ feet = 300\ in$, conservatively.

Radius of gyration, $r = \sqrt{\dfrac{I_y}{A}} = \sqrt{\dfrac{2912}{105.18}} = 5.26\ in$

Slenderness ratio, $\dfrac{\mathrm{kL}}{\mathrm{r}} = \dfrac{1 \cdot 300}{5.26} = 57 \Rightarrow \mathrm{F_a} = 17.71\ \mathrm{ksi}$

(b) Section 2 (W36x300 with two L6x8x7/8)

Maximum span, $L = 37\ feet = 444\ in$

Radius of gyration, $r = \sqrt{\dfrac{I_y}{A}} = \sqrt{\dfrac{3908}{111.3}} = 5.9\ in$

Slenderness ratio, $\dfrac{kL}{r} = \dfrac{1 \cdot 444}{5.9} = 75 \Rightarrow F_a = 15.9\ ksi$

(2) Allowable bending stress about major-axis:

Conservatively, only consider W36x300 section for bending stress.

Tension extreme fiber: $F_{bz} = 0.6F_y = 21.6\ ksi$

Compressive extreme fiber:

$$F_{bz.1} = \left[1.0 - \frac{(L/r_z)^2}{2{C_c}^2 C_b}\right]0.6F_y = \left[1.0 - \frac{(444/15.17)^2}{2(126.1)^2(1)}\right]0.6(36) = 21.6\ ksi$$

$$F_{bz.2} = \frac{12{,}000}{\left[L \cdot (d/A_f)\right]} = \frac{12{,}000}{\left[444 \cdot (1.31)\right]} = 20.6\ ksi$$

$$F_{bz} = \min\lfloor \max(F_{bz.1}, F_{bz.2}), 0.6F_y \rfloor = 21.6\ ksi$$

Therefore, use $F_{bz} = 21.6\ ksi$

(3) Allowable bending stress about minor-axis $F_{by} = 0.75F_y = 27\ ksi$

8.7.3.3. Runway Stress Criteria (longitudinal stress)

$$f_a = \frac{F_x}{A} \qquad f_{bz} = \frac{M_z}{S_z} \qquad f_{by} = \frac{M_y}{S_y}$$

Check $\frac{f_a}{F_a} + \frac{f_{bz}}{F_{bz}} + \frac{f_{by}}{F_{by}} \leq 1.0$

8.7.3.4. Check Shear Stress

Present condition of runway girders do not have any stiffeners and as per Section 1.10.5 of AISC 6th edition (Ref. 4.2.2) when intermediate stiffeners are omitted.

Allowable shear stress $F_v = \frac{F_y}{2.89}(C_v)$ but not more than 0.4 F_y

a = Clear distance between transverse stiffeners = 37' = 444 in

h = Clear distance between flanges = Depth of section – 2 x flange thickness = 36.75 – 2 x 1.6875 = 33.375 in

t = Thickness of web = 15/16 = 0.9375 in

a / h = 444 / 33.375 = 13.30

h / t = 33.375 / 0.9375 = 35.6

$$k = 5.34 + \frac{4.00}{(a/h)^2} = 5.34 + \frac{4.00}{13.30} = 5.64$$

$$C_v = \frac{6000}{h/t}\sqrt{\frac{k}{F_y}} = \frac{6000}{35.6}\sqrt{\frac{5.64}{36000}} = 2.1$$

$F_v = \frac{36000}{2.89}(2.1) = 26.15 ksi$ > 14.4 ksi Use F_v = 14.4 ksi

A_w = Area of web = 33.375 x 0.9375 = 31.2 in^2

f_v = Shear Stress = Shear Force / A_w

Check $\frac{f_v}{F_v} \leq 1.0$

8.7.3.5. Code Check

Envelope Load from all models and Load combinations are used for the runway girder qualification. 'L8x4' represents the runway girder composed of W36x300 and two L8x4x3/4 and 'L8x6' represents the runway girder composed of W36x300 and two L8x6x7/8 in the following table.

Table 41: Runway Girder Code Check

	MEMBER	END	FORCE			MOMENT			Member Interaction Ratio			
			FX	FY	FZ	MX	MY	MZ	Bending Stresses		Shear Stresses	
L8 X 4	RG1	0	1.574	3.039	0.000	0.485	0.000	0.000	0.00	< 1.0 OK	0.01	< 1.0 OK
L8 X 4	RG1	1	1.574	3.039	0.000	0.485	0.000	0.000	0.00	< 1.0 OK	0.01	< 1.0 OK
L8 X 4	RG10	0	101.273	31.393	0.475	0.827	11.045	611.899	0.31	< 1.0 OK	0.07	< 1.0 OK
L8 X 4	RG10	1	101.273	29.784	0.475	0.827	13.135	735.658	0.36	< 1.0 OK	0.07	< 1.0 OK
L8 X 4	RG11	0	44.511	103.666	0.877	0.827	13.135	948.204	0.40	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG11	1	44.511	105.096	0.877	0.827	9.660	530.686	0.24	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG12	0	63.667	105.220	1.801	0.836	9.660	530.686	0.25	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG12	1	63.667	106.203	1.801	0.836	4.720	269.547	0.14	< 1.0 OK	0.24	< 1.0 OK
L8 X 4	RG13	0	75.865	106.253	2.080	0.836	4.720	239.981	0.14	< 1.0 OK	0.24	< 1.0 OK
L8 X 4	RG13	1	75.865	106.879	2.080	0.836	1.082	53.491	0.06	< 1.0 OK	0.24	< 1.0 OK
L8 X 4	RG14	0	76.005	199.873	2.165	0.797	1.082	99.981	0.08	< 1.0 OK	0.44	< 1.0 OK
L8 X 4	RG14	1	76.005	200.051	2.165	0.797	0.000	0.000	0.04	< 1.0 OK	0.45	< 1.0 OK
L8 X 4	RG15	0	44.509	127.443	2.059	0.715	0.000	0.000	0.02	< 1.0 OK	0.28	< 1.0 OK
L8 X 4	RG15	1	44.509	126.638	2.059	0.715	4.632	285.841	0.14	< 1.0 OK	0.28	< 1.0 OK
L8 X 4	RG16	0	31.716	8.167	0.221	0.715	4.632	250.342	0.12	< 1.0 OK	0.02	< 1.0 OK
L8 X 4	RG16	1	31.716	15.676	0.221	0.715	0.000	0.000	0.02	< 1.0 OK	0.03	< 1.0 OK
L8 X 4	RG17	0	30.543	4.067	0.000	0.630	0.000	0.000	0.02	< 1.0 OK	0.01	< 1.0 OK
L8 X 4	RG17	1	30.543	4.067	0.000	0.630	0.000	0.000	0.02	< 1.0 OK	0.01	< 1.0 OK
L8 X 4	RG18	0	29.965	225.815	2.588	0.407	0.000	0.000	0.02	< 1.0 OK	0.50	< 1.0 OK
L8 X 4	RG18	1	29.965	225.546	2.588	0.407	1.941	169.260	0.08	< 1.0 OK	0.50	< 1.0 OK
L8 X 4	RG19	0	29.873	183.663	2.159	0.392	1.941	169.191	0.08	< 1.0 OK	0.41	< 1.0 OK
L8 X 4	RG19	1	29.873	182.680	2.159	0.392	7.873	641.618	0.27	< 1.0 OK	0.41	< 1.0 OK
L8 X 4	RG2	0	3.596	129.006	0.809	0.924	0.000	0.000	0.00	< 1.0 OK	0.29	< 1.0 OK
L8 X 4	RG2	1	3.596	127.218	0.809	0.924	4.046	640.561	0.25	< 1.0 OK	0.28	< 1.0 OK
L8 X 4	RG20	0	29.873	104.994	1.689	0.392	7.873	641.552	0.27	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG20	1	29.873	104.368	1.689	0.392	10.818	682.016	0.29	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG21	0	29.873	104.174	1.192	0.431	10.818	682.016	0.29	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG21	1	29.873	103.191	1.192	0.431	13.894	838.525	0.36	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG22	0	29.873	102.860	0.647	0.431	13.894	838.525	0.36	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG22	1	29.873	101.788	0.647	0.431	15.366	1145.485	0.47	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG23	0	29.873	43.084	0.394	0.431	15.366	1145.409	0.47	< 1.0 OK	0.10	< 1.0 OK
L8 X 4	RG23	1	29.873	44.693	0.394	0.431	13.926	1089.475	0.45	< 1.0 OK	0.10	< 1.0 OK
L8 X 4	RG24	0	29.873	122.713	1.183	0.431	13.926	1089.465	0.45	< 1.0 OK	0.27	< 1.0 OK
L8 X 4	RG24	1	29.873	124.054	1.183	0.431	9.664	626.782	0.27	< 1.0 OK	0.28	< 1.0 OK
L8 X 4	RG25	0	53.042	124.389	1.765	0.470	9.664	626.782	0.28	< 1.0 OK	0.28	< 1.0 OK
L8 X 4	RG25	1	53.042	125.372	1.765	0.470	4.824	283.363	0.14	< 1.0 OK	0.28	< 1.0 OK

	MEMBER	END	FORCE			MOMENT			Member IR			
			FX	FY	FZ	MX	MY	MZ	Bending Stresses		Shear Stresses	
L8 X 4	RG26	0	89.083	133.834	2.099	0.470	4.824	302.054	0.17	< 1.0 OK	0.30	< 1.0 OK
L8 X 4	RG26	1	89.083	134.460	2.099	0.470	1.153	67.297	0.08	< 1.0 OK	0.30	< 1.0 OK
L8 X 4	RG27	0	89.018	228.299	2.305	0.528	1.153	114.194	0.09	< 1.0 OK	0.51	< 1.0 OK
L8 X 4	RG27	1	89.018	228.478	2.305	0.528	0.000	0.000	0.05	< 1.0 OK	0.51	< 1.0 OK
L8 X 4	RG28	0	89.345	157.453	2.664	0.550	0.000	0.000	0.05	< 1.0 OK	0.35	< 1.0 OK
L8 X 4	RG28	1	89.345	156.649	2.664	0.550	5.994	353.365	0.19	< 1.0 OK	0.35	< 1.0 OK
L8 X 4	RG29	0	29.538	156.504	2.228	0.550	5.994	353.365	0.16	< 1.0 OK	0.35	< 1.0 OK
L8 X 4	RG29	1	29.538	155.431	2.228	0.550	12.662	821.267	0.35	< 1.0 OK	0.35	< 1.0 OK
L8 X 4	RG3	0	4.436	27.016	0.168	0.924	4.046	640.483	0.25	< 1.0 OK	0.06	< 1.0 OK
L8 X 4	RG3	1	4.436	25.407	0.168	0.924	4.329	678.264	0.26	< 1.0 OK	0.06	< 1.0 OK
L8 X 4	RG30	0	100.482	44.277	1.417	0.550	12.662	644.233	0.32	< 1.0 OK	0.10	< 1.0 OK
L8 X 4	RG30	1	100.482	42.668	1.417	0.550	18.970	838.258	0.41	< 1.0 OK	0.09	< 1.0 OK
L8 X 4	RG31	0	29.538	70.523	1.308	0.550	18.970	1060.168	0.45	< 1.0 OK	0.16	< 1.0 OK
L8 X 4	RG31	1	29.538	75.707	1.308	0.550	0.000	0.000	0.02	< 1.0 OK	0.17	< 1.0 OK
L8 X 4	RG32	0	62.921	33.808	2.355	0.430	0.000	0.000	0.03	< 1.0 OK	0.08	< 1.0 OK
L8 X 4	RG32	1	62.921	41.674	2.355	0.430	51.808	830.305	0.45	< 1.0 OK	0.09	< 1.0 OK
L8 X 4	RG33	0	61.819	164.963	3.208	0.461	51.808	830.305	0.45	< 1.0 OK	0.37	< 1.0 OK
L8 X 4	RG33	1	61.819	165.768	3.208	0.461	56.030	924.973	0.50	< 1.0 OK	0.37	< 1.0 OK
L8 X 6	RG34	0	47.332	272.153	4.357	0.514	85.810	1131.415	0.56	< 1.0 OK	0.61	< 1.0 OK
L8 X 6	RG34	1	47.332	271.302	4.357	0.514	80.216	666.829	0.39	< 1.0 OK	0.60	< 1.0 OK
L8 X 6	RG35	0	47.034	271.216	4.200	0.514	80.216	666.829	0.39	< 1.0 OK	0.60	< 1.0 OK
L8 X 6	RG35	1	47.034	270.175	4.200	0.514	74.060	421.725	0.29	< 1.0 OK	0.60	< 1.0 OK
L8 X 6	RG36	0	46.648	205.200	3.845	0.514	74.060	421.799	0.29	< 1.0 OK	0.46	< 1.0 OK
L8 X 6	RG36	1	46.648	203.498	3.845	0.514	65.540	917.158	0.45	< 1.0 OK	0.45	< 1.0 OK
L8 X 6	RG37	0	46.342	203.254	3.357	0.514	65.540	917.158	0.45	< 1.0 OK	0.45	< 1.0 OK
L8 X 6	RG37	1	46.342	202.781	3.357	0.514	63.427	1152.877	0.53	< 1.0 OK	0.45	< 1.0 OK
L8 X 6	RG38	0	46.037	120.879	2.902	0.514	63.427	1152.918	0.53	< 1.0 OK	0.27	< 1.0 OK
L8 X 6	RG38	1	46.037	119.177	2.902	0.514	56.129	1132.974	0.51	< 1.0 OK	0.27	< 1.0 OK
L8 X 6	RG39	0	45.745	118.963	2.620	0.514	56.129	1132.974	0.51	< 1.0 OK	0.26	< 1.0 OK
L8 X 6	RG39	1	45.745	118.584	2.620	0.514	54.448	1245.287	0.54	< 1.0 OK	0.26	< 1.0 OK
L8 X 4	RG4	0	5.179	89.044	0.444	0.924	4.329	678.254	0.26	< 1.0 OK	0.20	< 1.0 OK
L8 X 4	RG4	1	5.179	90.474	0.444	0.924	2.712	356.343	0.14	< 1.0 OK	0.20	< 1.0 OK
L8 X 6	RG40	0	155.399	68.838	2.468	0.514	54.448	1088.971	0.55	< 1.0 OK	0.15	< 1.0 OK
L8 X 6	RG40	1	155.399	67.136	2.468	0.514	45.967	1297.826	0.61	< 1.0 OK	0.15	< 1.0 OK
L8 X 6	RG41	0	43.493	101.821	2.515	0.533	45.967	1602.832	0.65	< 1.0 OK	0.23	< 1.0 OK
L8 X 6	RG41	1	43.493	102.861	2.515	0.533	39.894	1321.438	0.55	< 1.0 OK	0.23	< 1.0 OK
L8 X 6	RG42	0	150.638	103.134	2.827	0.533	39.894	1321.438	0.61	< 1.0 OK	0.23	< 1.0 OK
L8 X 6	RG42	1	150.638	104.837	2.827	0.533	28.139	1173.808	0.54	< 1.0 OK	0.23	< 1.0 OK
L8 X 6	RG43	0	42.674	181.945	3.134	0.584	28.139	1469.850	0.58	< 1.0 OK	0.40	< 1.0 OK
L8 X 6	RG43	1	42.674	182.418	3.134	0.584	24.425	1242.126	0.49	< 1.0 OK	0.41	< 1.0 OK

	MEMBER	END	FORCE			MOMENT			Member IR			
			FX	FY	FZ	MX	MY	MZ	Bending Stresses		Shear Stresses	
L8 X 6	RG44	0	87.399	182.689	3.507	0.584	24.425	1242.126	0.52	< 1.0 OK	0.41	< 1.0 OK
L8 X 6	RG44	1	87.399	184.391	3.507	0.584	8.670	416.199	0.21	< 1.0 OK	0.41	< 1.0 OK
L8 X 6	RG45	0	3.923	249.001	3.853	0.610	8.670	561.209	0.21	< 1.0 OK	0.55	< 1.0 OK
L8 X 6	RG45	1	3.923	249.852	3.853	0.610	0.000	0.000	0.00	< 1.0 OK	0.56	< 1.0 OK
L8 X 4	RG5	0	5.771	101.165	0.741	0.924	2.712	356.288	0.14	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG5	1	5.771	102.148	0.741	0.924	0.679	103.388	0.04	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG50	0	1.117	52.167	10.878	0.646	0.000	0.000	0.00	< 1.0 OK	0.12	< 1.0 OK
L8 X 4	RG50	1	1.117	58.246	10.878	0.646	184.928	938.508	0.75	< 1.0 OK	0.13	< 1.0 OK
L8 X 6	RG51	0	28.513	243.878	39.758	74.467	200.097	1051.410	0.70	< 1.0 OK	0.54	< 1.0 OK
L8 X 6	RG51	1	28.513	241.986	39.758	74.467	151.852	272.240	0.36	< 1.0 OK	0.54	< 1.0 OK
L8 X 6	RG52	0	28.882	157.131	19.674	28.310	151.852	272.240	0.36	< 1.0 OK	0.35	< 1.0 OK
L8 X 6	RG52	1	28.882	155.428	19.674	28.310	155.269	509.432	0.44	< 1.0 OK	0.35	< 1.0 OK
L8 X 6	RG53	0	29.216	155.281	19.410	28.310	155.269	509.432	0.44	< 1.0 OK	0.35	< 1.0 OK
L8 X 6	RG53	1	29.216	153.768	19.410	28.310	164.498	1115.160	0.67	< 1.0 OK	0.34	< 1.0 OK
L8 X 6	RG54	0	29.508	121.783	17.002	23.894	164.498	1115.144	0.67	< 1.0 OK	0.27	< 1.0 OK
L8 X 6	RG54	1	29.508	120.742	17.002	23.894	170.493	1122.578	0.68	< 1.0 OK	0.27	< 1.0 OK
L8 X 6	RG55	0	29.687	48.872	3.596	13.339	170.493	1122.553	0.68	< 1.0 OK	0.11	< 1.0 OK
L8 X 6	RG55	1	29.687	48.210	3.596	13.339	174.137	1088.228	0.68	< 1.0 OK	0.11	< 1.0 OK
L8 X 6	RG56	0	29.893	48.097	3.540	14.616	174.137	1088.228	0.68	< 1.0 OK	0.11	< 1.0 OK
L8 X 6	RG56	1	29.893	47.057	3.540	14.616	179.580	1032.053	0.66	< 1.0 OK	0.10	< 1.0 OK
L8 X 6	RG57	0	30.115	69.513	3.688	14.926	179.580	1032.030	0.66	< 1.0 OK	0.15	< 1.0 OK
L8 X 6	RG57	1	30.115	70.554	3.688	14.926	184.675	1137.506	0.71	< 1.0 OK	0.16	< 1.0 OK
L8 X 6	RG58	0	150.249	70.699	3.998	14.926	184.675	891.833	0.69	< 1.0 OK	0.16	< 1.0 OK
L8 X 6	RG58	1	150.249	72.402	3.998	14.926	194.725	1055.553	0.77	< 1.0 OK	0.16	< 1.0 OK
L8 X 6	RG59	0	55.726	145.131	21.549	45.134	194.725	1322.013	0.80	< 1.0 OK	0.32	< 1.0 OK
L8 X 6	RG59	1	55.726	146.644	21.549	45.134	108.540	738.466	0.46	< 1.0 OK	0.33	< 1.0 OK
L8 X 4	RG6	0	6.079	137.609	0.906	0.892	0.679	103.308	0.04	< 1.0 OK	0.31	< 1.0 OK
L8 X 4	RG6	1	6.079	137.878	0.906	0.892	0.000	0.000	0.00	< 1.0 OK	0.31	< 1.0 OK
L8 X 6	RG60	0	79.122	146.733	21.673	45.134	108.540	738.466	0.48	< 1.0 OK	0.33	< 1.0 OK
L8 X 6	RG60	1	79.122	147.773	21.673	45.134	50.671	333.522	0.24	< 1.0 OK	0.33	< 1.0 OK
L8 X 6	RG61	0	187.331	147.805	22.504	51.207	50.671	333.522	0.30	< 1.0 OK	0.33	< 1.0 OK
L8 X 6	RG61	1	187.331	148.467	22.504	51.207	23.461	74.284	0.17	< 1.0 OK	0.33	< 1.0 OK
L8 X 6	RG62	0	187.426	232.718	46.922	99.754	23.461	116.406	0.18	< 1.0 OK	0.52	< 1.0 OK
L8 X 6	RG62	1	187.426	232.907	46.922	99.754	0.000	0.000	0.11	< 1.0 OK	0.52	< 1.0 OK
L8 X 4	RG63	0	167.763	131.178	24.545	47.204	0.000	0.000	0.09	< 1.0 OK	0.29	< 1.0 OK
L8 X 4	RG63	1	167.763	130.374	24.545	47.204	55.226	294.246	0.32	< 1.0 OK	0.29	< 1.0 OK
L8 X 4	RG64	0	40.728	7.588	2.630	5.796	55.226	80.496	0.17	< 1.0 OK	0.02	< 1.0 OK
L8 X 4	RG64	1	40.728	6.174	2.630	5.796	0.000	0.000	0.02	< 1.0 OK	0.01	< 1.0 OK
L8 X 4	RG65	0	40.808	4.067	0.000	0.781	0.000	0.000	0.02	< 1.0 OK	0.01	< 1.0 OK
L8 X 4	RG65	1	40.808	4.067	0.000	0.781	0.000	0.000	0.02	< 1.0 OK	0.01	< 1.0 OK

	MEMBER	END	FORCE			MOMENT			Member IR			
			FX	FY	FZ	MX	MY	MZ	Bending Stresses		Shear Stresses	
L8 X 4	RG66	0	40.715	194.044	32.480	62.828	0.000	0.000	0.02	< 1.0 OK	0.43	< 1.0 OK
L8 X 4	RG66	1	40.715	193.776	32.480	62.828	24.360	145.432	0.13	< 1.0 OK	0.43	< 1.0 OK
L8 X 4	RG67	0	40.856	156.603	23.920	46.486	24.360	145.403	0.13	< 1.0 OK	0.35	< 1.0 OK
L8 X 4	RG67	1	40.856	155.620	23.920	46.486	83.808	546.872	0.41	< 1.0 OK	0.35	< 1.0 OK
L8 X 4	RG68	0	41.035	87.892	14.540	28.317	83.808	546.844	0.41	< 1.0 OK	0.20	< 1.0 OK
L8 X 4	RG68	1	41.035	87.266	14.540	28.317	84.883	581.716	0.42	< 1.0 OK	0.19	< 1.0 OK
L8 X 4	RG69	0	41.213	87.220	14.387	28.317	84.883	581.716	0.42	< 1.0 OK	0.19	< 1.0 OK
L8 X 4	RG69	1	41.213	86.236	14.387	28.317	116.387	701.700	0.54	< 1.0 OK	0.19	< 1.0 OK
L8 X 4	RG7	0	6.382	123.696	1.979	0.862	0.000	0.000	0.00	< 1.0 OK	0.28	< 1.0 OK
L8 X 4	RG7	1	6.382	123.338	1.979	0.862	1.979	123.517	0.05	< 1.0 OK	0.27	< 1.0 OK
L8 X 4	RG70	0	41.440	86.158	14.205	28.317	116.387	701.700	0.54	< 1.0 OK	0.19	< 1.0 OK
L8 X 4	RG70	1	41.440	85.085	14.205	28.317	158.755	958.551	0.72	< 1.0 OK	0.19	< 1.0 OK
L8 X 4	RG71	0	41.735	36.440	2.974	5.913	158.755	958.522	0.72	< 1.0 OK	0.08	< 1.0 OK
L8 X 4	RG71	1	41.735	38.049	2.974	5.913	152.197	910.208	0.69	< 1.0 OK	0.08	< 1.0 OK
L8 X 4	RG72	0	42.057	102.399	17.226	33.673	152.197	910.207	0.69	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG72	1	42.057	103.740	17.226	33.673	87.677	523.705	0.41	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG73	0	57.396	103.828	17.465	33.673	87.677	523.705	0.42	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG73	1	57.396	104.812	17.465	33.673	49.641	236.826	0.23	< 1.0 OK	0.23	< 1.0 OK
L8 X 4	RG74	0	78.229	115.380	22.055	43.195	49.641	260.517	0.25	< 1.0 OK	0.26	< 1.0 OK
L8 X 4	RG74	1	78.229	116.005	22.055	43.195	21.212	58.055	0.11	< 1.0 OK	0.26	< 1.0 OK
L8 X 4	RG75	0	78.314	193.856	42.424	82.570	21.212	96.973	0.12	< 1.0 OK	0.43	< 1.0 OK
L8 X 4	RG75	1	78.314	194.035	42.424	82.570	0.000	0.000	0.04	< 1.0 OK	0.43	< 1.0 OK
L8 X 4	RG76	0	76.206	134.721	26.774	51.922	0.000	0.000	0.04	< 1.0 OK	0.30	< 1.0 OK
L8 X 4	RG76	1	76.206	133.916	26.774	51.922	60.240	302.216	0.28	< 1.0 OK	0.30	< 1.0 OK
L8 X 4	RG77	0	40.795	133.874	26.619	51.922	60.240	302.216	0.26	< 1.0 OK	0.30	< 1.0 OK
L8 X 4	RG77	1	40.795	132.802	26.619	51.922	140.087	702.229	0.59	< 1.0 OK	0.30	< 1.0 OK
L8 X 4	RG78	0	91.755	35.485	3.611	6.687	140.087	554.513	0.56	< 1.0 OK	0.08	< 1.0 OK
L8 X 4	RG78	1	91.755	33.876	3.611	6.687	151.756	709.094	0.64	< 1.0 OK	0.08	< 1.0 OK
L8 X 4	RG79	0	41.925	59.267	10.466	20.406	151.756	896.962	0.68	< 1.0 OK	0.13	< 1.0 OK
L8 X 4	RG79	1	41.925	64.452	10.466	20.406	0.000	0.000	0.02	< 1.0 OK	0.14	< 1.0 OK
L8 X 4	RG8	0	6.707	122.090	1.880	0.843	1.979	123.517	0.05	< 1.0 OK	0.27	< 1.0 OK
L8 X 4	RG8	1	6.707	121.107	1.880	0.843	7.143	456.664	0.19	< 1.0 OK	0.27	< 1.0 OK
L8 X 4	RG80	0	27.747	29.464	5.201	5.575	0.000	0.000	0.01	< 1.0 OK	0.07	< 1.0 OK
L8 X 4	RG80	1	27.747	37.331	5.201	5.575	114.426	734.750	0.54	< 1.0 OK	0.08	< 1.0 OK
L8 X 4	RG81	0	27.747	142.992	24.847	51.096	114.426	734.750	0.54	< 1.0 OK	0.32	< 1.0 OK
L8 X 4	RG81	1	27.747	143.797	24.847	51.096	73.493	819.662	0.48	< 1.0 OK	0.32	< 1.0 OK
L8 X 6	RG82	0	38.955	236.925	35.802	68.014	77.149	967.002	0.48	< 1.0 OK	0.53	< 1.0 OK
L8 X 6	RG82	1	38.955	236.074	35.802	68.014	114.123	564.231	0.40	< 1.0 OK	0.53	< 1.0 OK
L8 X 6	RG83	0	38.955	236.039	35.692	68.014	114.123	564.231	0.40	< 1.0 OK	0.53	< 1.0 OK
L8 X 6	RG83	1	38.955	234.998	35.692	68.014	161.784	346.363	0.40	< 1.0 OK	0.52	< 1.0 OK

	MEMBER	END	FORCE			MOMENT			Member IR			
			FX	FY	FZ	MX	MY	MZ	Bending Stresses		Shear Stresses	
L8 X 6	RG84	0	38.955	178.370	18.201	32.098	161.784	346.413	0.40	< 1.0 OK	0.40	< 1.0 OK
L8 X 6	RG84	1	38.955	176.668	18.201	32.098	167.477	785.660	0.56	< 1.0 OK	0.39	< 1.0 OK
L8 X 6	RG85	0	38.955	176.559	18.036	32.098	167.477	785.660	0.56	< 1.0 OK	0.39	< 1.0 OK
L8 X 6	RG85	1	38.955	176.086	18.036	32.098	170.346	993.130	0.64	< 1.0 OK	0.39	< 1.0 OK
L8 X 6	RG86	0	38.955	104.958	6.222	12.547	170.346	993.154	0.64	< 1.0 OK	0.23	< 1.0 OK
L8 X 6	RG86	1	38.955	103.256	6.222	12.547	181.925	968.463	0.65	< 1.0 OK	0.23	< 1.0 OK
L8 X 6	RG87	0	38.955	103.131	5.744	12.547	181.925	968.463	0.65	< 1.0 OK	0.23	< 1.0 OK
L8 X 6	RG87	1	38.955	102.753	5.744	12.547	186.914	1066.271	0.69	< 1.0 OK	0.23	< 1.0 OK
L8 X 6	RG88	0	131.475	57.544	5.525	12.734	186.914	944.093	0.70	< 1.0 OK	0.13	< 1.0 OK
L8 X 6	RG88	1	131.475	55.842	5.525	12.734	206.317	1111.596	0.79	< 1.0 OK	0.12	< 1.0 OK
L8 X 6	RG89	0	38.955	86.801	13.225	23.942	206.317	1371.084	0.83	< 1.0 OK	0.19	< 1.0 OK
L8 X 6	RG89	1	38.955	87.841	13.225	23.942	196.790	1130.990	0.73	< 1.0 OK	0.20	< 1.0 OK
L8 X 4	RG9	0	7.184	121.107	1.423	0.827	7.143	456.664	0.19	< 1.0 OK	0.27	< 1.0 OK
L8 X 4	RG9	1	7.184	120.123	1.423	0.827	11.045	788.355	0.32	< 1.0 OK	0.27	< 1.0 OK
L8 X 6	RG90	0	128.455	87.996	13.428	23.942	196.790	1130.990	0.78	< 1.0 OK	0.20	< 1.0 OK
L8 X 6	RG90	1	128.455	89.699	13.428	23.942	211.197	1004.779	0.76	< 1.0 OK	0.20	< 1.0 OK
L8 X 6	RG91	0	38.955	155.731	26.285	52.317	211.197	1258.917	0.80	< 1.0 OK	0.35	< 1.0 OK
L8 X 6	RG91	1	38.955	156.204	26.285	52.317	178.348	1063.960	0.68	< 1.0 OK	0.35	< 1.0 OK
L8 X 6	RG92	0	75.096	156.322	26.397	52.317	178.348	1063.960	0.70	< 1.0 OK	0.35	< 1.0 OK
L8 X 6	RG92	1	75.096	158.025	26.397	52.317	101.651	356.682	0.33	< 1.0 OK	0.35	< 1.0 OK
L8 X 6	RG93	0	3.929	215.367	45.178	90.390	101.651	485.532	0.33	< 1.0 OK	0.48	< 1.0 OK
L8 X 6	RG93	1	3.929	216.218	45.178	90.390	0.000	0.000	0.00	< 1.0 OK	0.48	< 1.0 OK

Therefore, the runway girders are structurally acceptable.

8.7.4 Slack Rope Condition

During operation of crane under normal condition, the lifted load always generates a tension force in the rope and this force is equivalent to the lifted mass. But during earthquake, when the total mass of structure gets excited, the lifted load also gets excited. Excitation of the mass in vertical upward direction may cause the slack rope condition. If the upward excitation is high enough that the lifted mass overcomes the downward force due to its self weight, then the lifted mass will move in upward direction and produce a slack rope condition. The slack rope condition is evaluated for the seismic loading in this Section. After the complete of modal analysis, spectral accelerations at the hook joint 'CN450' for all the three directions due to the response spectra loading were extracted. The three directional components of each direction loading were combined using SRSS respectively to get the acceleration in three directions. This evaluation shows that the maximum vertical accelerations (Y) obtained for all the configurations (with hook loaded) have acceleration less than 1.0g. Thus the lifted mass at the hook will always have the governing downward force acting on it, which in turn will keep the rope in tension and slack rope condition will not be observed. See below for the acceleration values

Hook Up with load model Cases

Table 42: Spectral Accelerations at Jt. CN450

Model No.	Combined directional response spectrum accelerations (g)					
	MHE			OBE		
	X	Y	Z	X	Y	Z
Model 1	0.08	0.22	0.06	0.03	0.11	0.03
Model 13	0.08	0.21	0.07	0.03	0.11	0.03
Model 25	0.08	0.21	0.07	0.03	0.11	0.03
Model 37	0.08	0.22	0.07	0.03	0.11	0.03
Model 49	0.08	0.22	0.07	0.03	0.11	0.03
Model 61	0.08	0.23	0.07	0.03	0.12	0.03
Model 73	0.08	0.23	0.07	0.03	0.12	0.03
Model 85	0.08	0.24	0.06	0.03	0.12	0.03
Model 97	0.08	0.24	0.06	0.03	0.12	0.03
Model 4	0.08	0.23	0.06	0.03	0.11	0.03
Model 16	0.08	0.22	0.07	0.03	0.11	0.03
Model 28	0.08	0.22	0.07	0.03	0.11	0.03
Model 40	0.08	0.22	0.07	0.03	0.11	0.03
Model 52	0.08	0.23	0.07	0.03	0.12	0.03
Model 64	0.08	0.23	0.07	0.03	0.12	0.03
Model 76	0.08	0.23	0.07	0.03	0.12	0.03
Model 88	0.08	0.24	0.06	0.03	0.12	0.03
Model 100	0.08	0.24	0.06	0.03	0.12	0.03
Model 7	0.08	0.23	0.06	0.03	0.12	0.03
Model 19	0.08	0.23	0.07	0.03	0.12	0.03
Model 31	0.08	0.23	0.07	0.03	0.12	0.03
Model 43	0.08	0.22	0.07	0.03	0.11	0.03
Model 55	0.08	0.23	0.07	0.03	0.12	0.03
Model 67	0.08	0.23	0.07	0.03	0.12	0.03
Model 79	0.08	0.23	0.07	0.03	0.12	0.03
Model 91	0.08	0.24	0.06	0.03	0.12	0.03
Model 103	0.08	0.24	0.06	0.03	0.12	0.03
Model 10	0.07	0.23	0.06	0.03	0.12	0.03
Model 22	0.07	0.23	0.07	0.03	0.11	0.03
Model 34	0.07	0.22	0.07	0.03	0.11	0.03
Model 46	0.07	0.22	0.07	0.03	0.11	0.03
Model 58	0.07	0.23	0.07	0.03	0.12	0.03
Model 70	0.07	0.23	0.07	0.03	0.12	0.03
Model 82	0.07	0.23	0.07	0.03	0.12	0.03
Model 94	0.07	0.24	0.06	0.03	0.12	0.03
Model 106	0.07	0.24	0.06	0.03	0.12	0.03

Hook Down with load Cases

Table 43: Spectral Accelerations at Jt. CN450

Model No.	Combined directional response spectrum accelerations (g)					
	MHE			OBE		
	X	Y	Z	X	Y	Z
Model 3	0.00	0.21	0.01	0.00	0.11	0.00
Model 15	0.00	0.21	0.01	0.00	0.10	0.00
Model 27	0.00	0.21	0.01	0.00	0.10	0.00
Model 39	0.00	0.21	0.01	0.00	0.11	0.00
Model 51	0.00	0.21	0.01	0.00	0.11	0.00
Model 63	0.00	0.22	0.01	0.00	0.11	0.00
Model 75	0.00	0.22	0.01	0.00	0.11	0.00
Model 87	0.00	0.22	0.01	0.00	0.11	0.00
Model 99	0.00	0.22	0.01	0.00	0.11	0.00
Model 6	0.00	0.22	0.01	0.00	0.11	0.00
Model 18	0.00	0.22	0.01	0.00	0.11	0.00
Model 30	0.00	0.22	0.01	0.00	0.11	0.00
Model 42	0.00	0.22	0.01	0.00	0.11	0.00
Model 54	0.00	0.22	0.01	0.00	0.11	0.00
Model 66	0.00	0.22	0.01	0.00	0.11	0.00
Model 78	0.00	0.22	0.01	0.00	0.11	0.00
Model 90	0.00	0.22	0.01	0.00	0.11	0.00
Model 102	0.00	0.22	0.01	0.00	0.11	0.00
Model 9	0.00	0.22	0.01	0.00	0.11	0.00
Model 21	0.00	0.22	0.01	0.00	0.11	0.00
Model 33	0.00	0.22	0.01	0.00	0.11	0.00
Model 45	0.00	0.22	0.01	0.00	0.11	0.00
Model 57	0.00	0.22	0.01	0.00	0.11	0.00
Model 69	0.00	0.22	0.01	0.00	0.11	0.00
Model 81	0.00	0.22	0.01	0.00	0.11	0.00
Model 93	0.00	0.23	0.01	0.00	0.11	0.00
Model 105	0.00	0.23	0.01	0.00	0.11	0.00
Model 12	0.00	0.22	0.01	0.00	0.11	0.00
Model 24	0.00	0.22	0.01	0.00	0.11	0.00
Model 36	0.00	0.22	0.01	0.00	0.11	0.00
Model 48	0.00	0.22	0.01	0.00	0.11	0.00
Model 60	0.00	0.22	0.01	0.00	0.11	0.00
Model 72	0.00	0.22	0.01	0.00	0.11	0.00
Model 84	0.00	0.22	0.01	0.00	0.11	0.00
Model 96	0.00	0.22	0.01	0.00	0.11	0.00
Model 108	0.00	0.22	0.01	0.00	0.11	0.00