RODER UK

FILE NAME

12 m RODER FRAME

TENT

EVALUATION

THE 12 METER RODER FRAME TENT EVALUATION

F.T.L./ Happold, Incorporated

Submitted to
Mr. Richard Martin, Roder U.S.A.
on July 12, 1996

EVALUATION SUMMARY AND RECOMMENDATIONS

This report, based on the technical background information provided by Roder U.S.A., covers the structural evaluation of their 12 meter Aluminum Frame Tent in accordance with the U.S. Building Code Requirements. The specifications outlined in the American National Standards Institute / American Society of Civil Engineers (ANSI/ASCE) 7-93: "Minimum Design Loads for Buildings and Other Structures" were followed in determining the integrity of the structure. This document was intended to serve as a basis for the acceptability of these "temporary structures" under the standard design wind loads at varying levels of exposure (terrain and wind velocities). Table 0-1 presents the wind pressures (loads) under which the 12 meter frame was tested.

Computer-aided structural frame analyses were involved in the course of the investigation. Different load combinations were considered to find the critical aspects of the design. Member and detail checks were established to derive the conclusions for the entire report.

With such, F.T.L./Happold, Incorporated arrived at the following conclusions and recommendations:

1. The 12 meter Frame Tent and its elements (main flexural) are adequate based on the structural analysis performed in accordance with the nationally recognized wind speeds and exposure classes (as shown in Table 0-1). The 12 meter version was successfully rated up to 80 mph in a Class C exposure.

2. The frames should be anchored securely to the ground to prevent the possibility of uplift in the event of wind suction, especially when the wind hits the structure parallel to its ridge. Considerations should also be given to the resulting horizontal reactions (Part 7.2.3: Base Plates).

Maximum Uplift	:	1.47 K (Class C, 70 mph)
		2.01 K (Class C, 80 mph)
Maximum Shear	:	1.37 K (Class C, 70 mph)
		1.83 K (Class C, 80 mph)

3. The structure should be set on firm and unyielding ground. This ground should sufficiently contain the bearing pressures of the base plates as well as the tractive forces of the rod anchors.

Maximum Pressure	:	0.81 K (Class C, 70 mph)
		0.81 K (Class C, 80 mph)

It is thereby understood that the responsibility of proper installation according to the plans rests upon the contractor. Such includes, but is not limited to, ensuring the following:

1. that the cables are always held taut,
2. that the fabric is stretched tight enough to prevent the development of pockets and to maintain the prescribed roof gradient, and
3. that the purlins are installed securely against the rafters so as to resist the calculated loads.

Finally, reference is made to the condition that the live load allowances (Part 4.2):

left rafter centerspan	:	250 lbs
ridge	:	500 lbs
right rafter centerspan	:	250 lbs

must not be exceeded at any time for the conclusions of this report to remain valid.

12 METER RODER FRAME (15.09 FT MAXIMUM HEIGHT)
WIND PRESSURES, q (psf)

Exposure	60 mph	70 mph	80 mph	90 mph
Class A	1.55	2.11	2.75	3.48
Class B	3.34	4.54	5.93	7.51
Class C	5.77	7.85	10.26	~~12.98~~
Class D	7.54	10.26	~~13.41~~	~~16.97~~

The 12 meter version is suitable for up to a Class C, 80 mph or Class D, 70 mph wind exposure.
Refer to Part 8 of this report.
The stricken values are the unsuitable pressures for the 12 m Roder Frame Tent.

Table 0-1 12 m Roder Frame Tent Allowable Exposure Chart

where, according to ANSI/ASCE 7-93, p. 14:

<u>Exposure A</u>

Large city centers with at least 50% of the buildings having a height in excess of 70 feet. Use of this exposure category shall be limited to those areas for which terrain representative of Exposure A prevails in the upwind direction for a distance of at least one-half mile or 10 times the height of the building or structure, whichever is greater. Possible channeling effects or increased velocity pressures due to the building or structure being located in the wake of adjacent buildings shall be taken into account.

Exposure B

Urban or sub-urban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. Use of this exposure category shall be limited to those areas for which terrain representative of Exposure B prevails in the upwind direction for a distance of at least 1500 feet or 10 times the height of the building or structure, whichever is greater.

Exposure C

Open terrain with scattered obstructions having heights generally less than 30 feet. This category includes flat, open country and grasslands.

Exposure D

Flat, unobstructed areas exposed to wind flowing over large bodies of water. This exposure shall apply only to those buildings and other structures exposed to the wind coming from over the water. Exposure D extends inland from the shoreline a distance of 1500 feet or 10 times the height of the building or structure, whichever is greater.

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Part 1

Introduction

1.1 Nature of the Evaluation

The 12 meter Roder Frame Tent consists of a series of pin-supported, double joint frames spanning the tent hall width. These frames are the main supporting elements and are made up of custom-designed hollow profiles of structural aluminum alloy (Al Mg Si - 1F28). An equivalent American alloy, the 6061-T6, is detailed in the U.S. Aluminum Construction Manual and shall be the basis of material property and allowable stress determinations. The structure is systematically reinforced with steel inserts at the ridge and eaves locations. These moment resisting elements as well as the other connection components of the frame are made of galvanized steel (St 37).

These tents are classified as temporary structures. Their installation and use are restricted to certain seasons and environmental conditions. In lieu of this, snow loads are neglected. If such occurs, acceptable means of snow melting or removal, and interior heating shall be immediately employed. Further, the tent should be maintained closed at all unused times to prevent the possibility of an internal pressure build-up which is not considered in the succeeding stability calculations of this report. It is also assumed that adequate pressure leakage at the side walls is always available.

In general, five (5) load cases and eight (8) load combinations corresponding to a Class C exposure, 80 mph wind velocity are investigated in this evaluation. These are outlined in Table 4-2. Since ANSI/ASCE 7-93 rules out the possibility of windward roof suction for the 20.14 degree rafter inclination, the DL + LL + WSUCTION and DL + WSUCTION load combinations are disregarded. In the course of the structural checks the following frame components are given consideration:

A. Primary Elements

1. Interior Frame Elements: Rafter Sections
2. Interior Frame Elements: Column Sections
3. Gable Frame Elements: Interior Strut Sections

B. Secondary Elements

1. Purlins and Beams
2. Roof and Wall Cables
3. Base Plates

The technical background information, design drawings and material properties were made available to F.T.L./Happold, Incorporated by Mr. Richard Martin of Roder U.S.A. to facilitate the evaluation of the structure according to the more general U.S. wind loading requirements. ANSI/ASCE 7-93 code regulations will be utilized for this purpose in lieu of its more general coverage regarding temporary structures, an advantage it has over the other U.S. codes (Part 4.3 and Appendix B).

1.2 Objectives

The ultimate goal of this analysis is to provide a sound basis for the structural acceptability of the 12 meter Roder Frame Tent in the light of the minimum U.S. Building Code requirements. This evaluation is also aimed at developing a suitability chart for the structure based on the various terrain and wind conditions. In this regard, a stability report on the relevant conditions is presented.

Part 2

Structural Framing Plan

Presented in Figure 2-1 are the typical interior and gable end aluminum frames with their corresponding dimensions. It is understood that the length of the structure may be extended when necessary. As recommended, the minimum hall length would be 32.81 ft (10 m, 2 bays). At hall lengths of over 98.43 ft (30 m), additional wind bracing fields are to be arranged so that there would be 6 bracing-free fields (98.43 ft, 30 m) at the most between the wall bracings. The structure in contention is the extrusion box section tent spanning the full 39.37 ft (12 m) width and the primary structural assemblages are the aluminum frames.

The schematic elevations show the presence of steel inserts at the ridge and eaves and pinned connections at the base support joints. The roof and walls are clad in non-prestressed fabric skin connected to the aluminum frames by edge ropes slid through the aluminum extrusions (Appendix A). Since this fabric is not attached to the purlins, it transmits its forces directly to the supporting frames. Moreover, the structure rests on base plates anchored securely to the ground against uplift. The interior frame has a 39.37 ft span (12 m) and is considered more critical than the intermediately strutted gable end frame.

Finally, for longitudinal stability, high strength cross bracing cables are utilized for the roof and walls. In addition, the purlins, ridge and eaves beams transmit longitudinal forces to the intermediate frames of the structure.

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Figure 2-1 Structural Framing Plan

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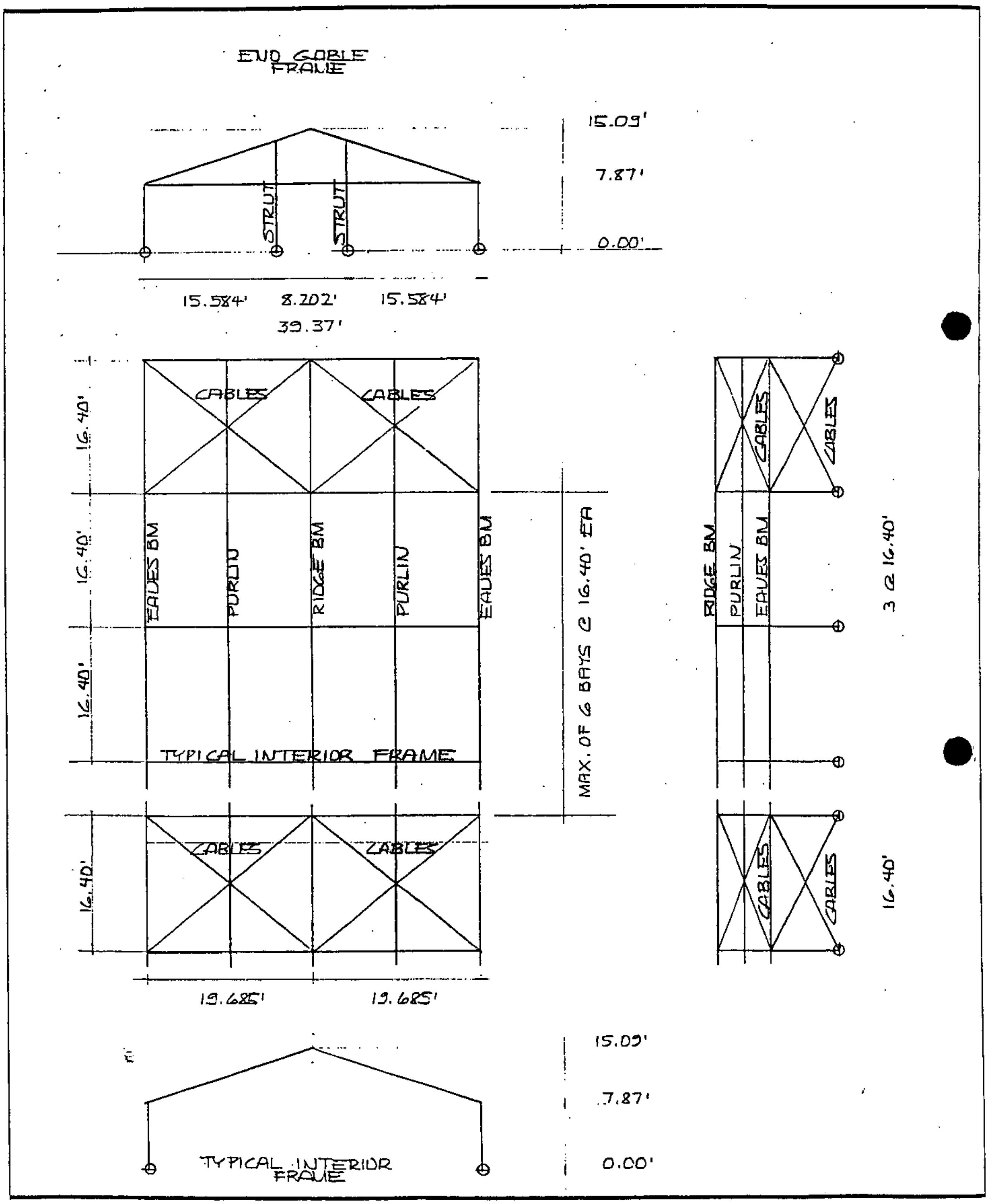

Part 3

Section and Material Properties

3.1 Material Distribution

Figure 3-1 shows the material assignments for 12 meter Roder Frame Tent. The diagram is accompanied by Table 3-1 outlining the section properties relevant to the analysis.

3.2 Section Properties

A tabulation of section properties for the Roder Frame Tent is presented as Table 3-1 in both English and Metric units. More detailed calculations based on component areas, as well as the cross section illustrations of the various profiles, are shown in Appendix A.

3.3 Material Properties and Design Criteria

The frames are assembled using structural aluminum box sections of Al Mg Si - 1F28 alloy conforming to DIN 4113. This is the European aluminum alloy 6082-T6 which has an American equivalent in the form of the 6061-T6. Section 2.2.1.1.2 (b) of the British Standard 8118 states that:

> "An alternative alloy to 6082 is 6061 (Al Mg 1 Si Cu) of durability rating B which has very similar properties with slight improvement in formability and surface finish. It is available in extruded tubular form and is mainly used for structures."

as a reference.

Table 3-2 presents a rough property comparison of equivalent European and U.S. materials for the 12 meter Roder Frame Tent.

3.1 Material Distribution

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Figure 3-1 Material Distribution

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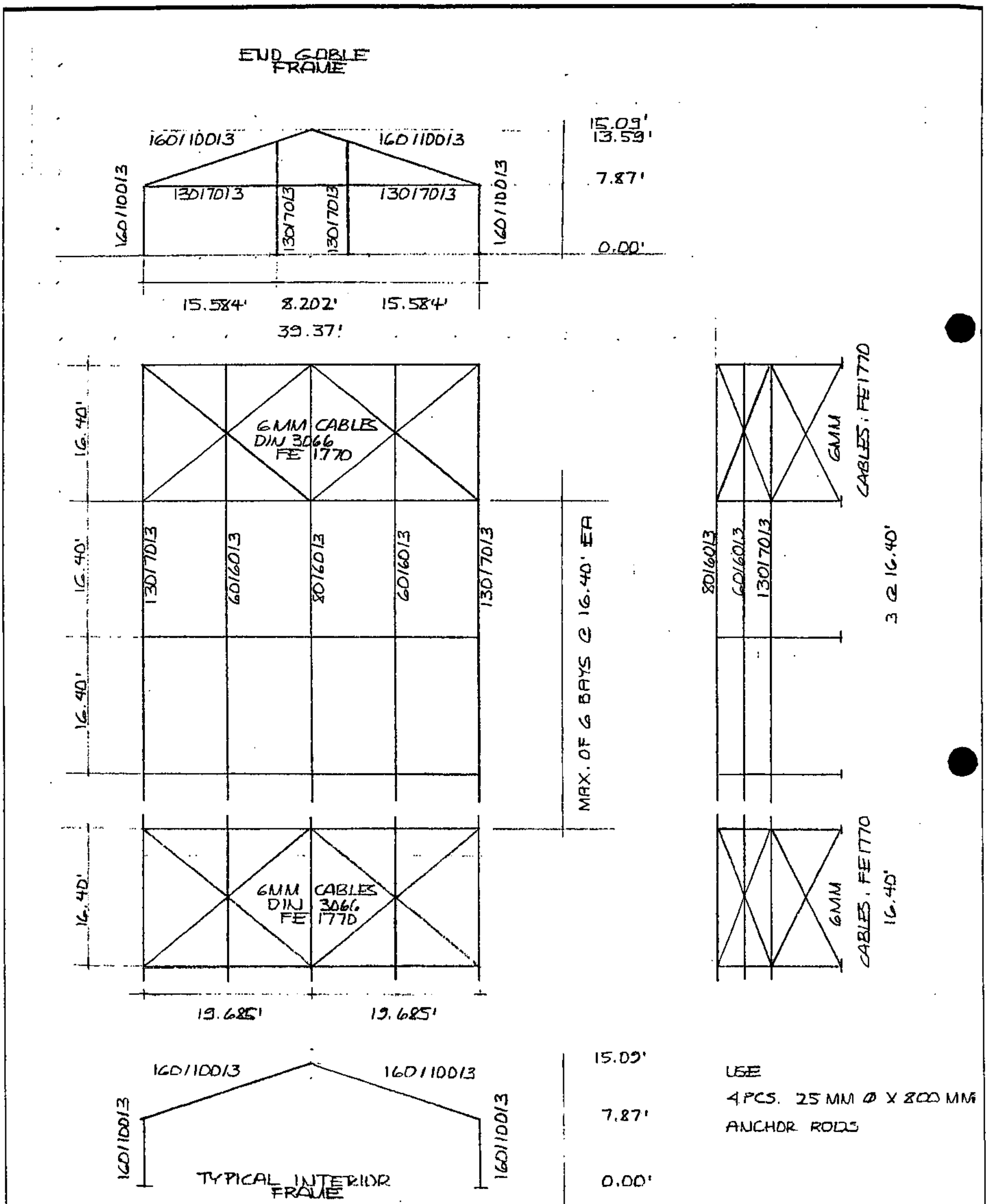

3.2 Section Properties

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Table 3-1 Section Properties (English and Metric Units)

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SECTION PROPERTIES

English System

Section	AlMgSi-1 Type	Axx in^2	Iyy in^4	Syy in^3	ryy in	Izz in^4	Szz in^3	rzz in	Weight plf
60/60/3	F28	1.06	0.89	0.76	0.92	0.89	0.76	0.92	1.25
80/60/3	F28	1.25	1.77	1.12	1.19	1.13	0.95	0.95	1.47
130/70/3	F28	2.36	8.18	3.20	1.86	2.52	1.83	1.03	2.78
160/100/3	F28	2.86	16.04	5.09	2.37	6.92	3.52	1.56	3.36

Metric System

Section	AlMgSi-1 Type	Axx cm^2	Iyy cm^4	Syy cm^3	ryy cm	Izz cm^4	Szz cm^3	rzz cm	Weight kN/m
60/60/3	F28	6.84	37.14	12.38	2.33	37.14	12.38	2.33	0.018
80/60/3	F28	8.04	73.65	18.41	3.03	46.90	15.63	2.42	0.021
130/70/3	F28	15.24	340.58	52.40	4.73	104.75	29.93	2.62	0.041
160/100/3	F28	18.44	667.52	83.44	6.02	288.17	57.63	3.95	0.049

General Notes:

1. Figures are based on the following unit weights:
   a. Aluminum: 169.34 pcf (or 26611.83 N/m^3)
   b. Steel: 490.00 pcf (or 77003.63 N/m^3)
2. Refer to the tabulation of cross sectional properties for the corresponding areas.

DESIGN CRITERIA

Criteria	Germany	U.S.	Germany	U.S.	Germany	U.S.
Material	Aluminum	Aluminum	Steel	Steel	Cable	Cable
Type	Al Mg Si -1F28 DIN 4113 Aluminum Alloy	6061-T6 Aluminum Box Sections	ST 37 Hollow Section	A-36 Structural Tubing	FE/1770 DIN 3066	Steel Structural Wire Rope (F.O.S. = 2.5)
Fy	29.0 Ksi @ 0.2%	35.0 Ksi	33.0 Ksi	36.0 Ksi		
Fu	39.9 Ksi	42.0 Ksi	53.1 Ksi	58.0 Ksi		
E	10100 Ksi	10100 Ksi	29000 Ksi	29000 Ksi		16000 Ksi
w	165 pcf	169 pcf	490 pcf	490 pcf		550 pcf
F all	19.1 Ksi (Flexure)	19.0 Ksi (Flexure)		Section 1.5 AISC Specs.	1.32 K (6 mm) Minimum Breaking Load	2.04 K (6 mm) Minimum Breaking Load

General Notes:

1. The German Aluminum (Al Mg Si - 1F28) Alloy conforming to DIN 4113 is also equivalent to the following:
   a. the 6082-T6 European Aluminum Alloy, and
   b. the 6061-T6 American Aluminum Alloy (Fy = 35.0 Ksi and Fu = 42.0 Ksi).
   It has the following properties: Fy = 29.0 Ksi @ 0.2% and Fu = 39.9 Ksi.
2. The German Steel (ST-37) is likewise similar to the American Grade A36 Structural Steel.

Part 4

Load Assumptions

A typical interior frame was considered in determining the loads for analysis. The load calculations for the 12 meter Roder Frame Tent were done with the aid of a spreadsheet program and will mainly consist of a combination of the following: Dead Loads, Live Loads (Snow and Fixtures) and Wind Loads. The output is presented hereafter.

4.1 Dead Loads

The structure dead loads are of two types:

1. a distributed element load, and
2. point loads at the ridge and eaves.

The rafter, purlin, roof fabric and minor component weights account for the former while the ridge and eaves beams, and wall fabric weights make up the latter. The column weight was neglected since it would normally be transmitted directly to the foundations. Nonetheless, it will be incorporated in the analysis of the base plates.

4.2 Live Loads

Due to the temporary nature of the structure and its seasonal installation, snow is neglected in the load considerations. This will be forgone under the condition that measures be provided to ensure snow removal or melting in such an unlikely event. Furthermore, the prescribed gradient of the roof fabric should be maintained to allow for smooth drainage and the prevention of ponding.

Seismic, moving and additional live loads (during the construction stage) are also beyond the scope of the analysis. It is assumed that no onerous stresses will be imposed on the lightweight, fabric-clad frame structure during its installation and subsequent use. Only the electrical and mechanical fixtures (lighting, HVAC, suspended items, etc.) totalling 1000 lbs per frame are accounted for. The total weight is assumed to be distributed accordingly:

1. left rafter centerspan (250 lbs),
2. ridge (500 lbs), and
3. right rafter centerspan (250 lbs).

4.3 Wind Loads

The ANSI/ASCE 7-93 wind loading provisions for various areas around the U.S. shall be used as the guidelines for wind pressure (and load) calculations. ANSI/ASCE 7-93 standards are recognized by all model building codes including the:

1. Building Officials and Code Administrators (BOCA),
2. Standard Building Code (SBC),
3. South Florida Building Code (SFBC), and
3. Uniform Building Code (UBC).

The following ANSI/ASCE 7-93 factors for the wind pressure calculations apply to the 12 meter version of the Roder Frame Tent:

I	=	Importance Factor, which is related to the structure's intended occupancy and use,
Gh	=	Gust Response Factor, which is dependent upon the structure height and exposure class, and
Kz	=	Velocity Pressure Exposure Coefficient, which depends on similar factors as the above mentioned Gh.

The importance factor, I, is set at 0.77 instead of 1.00 since the structures are only temporary and the design winds come with a reduced return period, that is, from 50 years to less than 2 years. It should be noted that the importance factor values of 1.07 and 0.95 are specifically associated with annual probabilities of being exceeded of 0.01 and 0.04 (mean wind recurrence intervals of 100 and 25 years - ANSI/ASCE 7-93 Commentary, p. 60), respectively.

It is considered grossly impractical from an engineering point of view to design for a wind occurrence that has a probability of 0.02 (once in 50 years) especially if the structure has only a short service life. ANSI/ASCE 7-93 gives an allowance for this by reducing the I to 0.77. This is equivalent to a 23% reduction in the design wind speed. This practice is also documented in British codes in the form of S3, the statistical factor for temporary structures [British CP3: "Code of Basic Data for the Design of Buildings", Chapter V, Part 2, Wind Loading].

Refer to the attached calculations for the constant values (Table 4-1). These figures were used in conjunction with varying exposure classes and wind speeds to derive the maximum design wind pressures according to the ANSI/ASCE 7-93 formula. Finally, for a bay width of 16.40 ft (5 m), the uniform wind loads were calculated. These were then subjected to the geometry dependent Cp factors (Table B-1 and Figure B-2) to produce the distributed frame loads utilized in the computer analyses. Figure 4-2 shows the different coefficients for the main wind-force resisting system. An internal pressure coefficient (Cpi) of zero is assumed at this stage.

Furthermore, the structure has been analyzed with the assumption that no dominant windward or leeward openings are present during its exposure to wind. Locally high wind pressures brought about by uncommon topography are also neglected.

Appendix B contains more information on the subject of wind loading.

4.4 General Load Cases and Combinations

The five (5) load cases (the WSUCTION scenario will later be excluded), are graphically illustrated in Figure 4-2 and the eight (8) combinations are summarized in Table 4-2. The frames will be initially analyzed using the C-80 (Class C, 80 mph) wind pressure and will subsequently be tested on the other pressures, if warranted.

DATA FOR THE FRAME LOADS

Structure Geometry	
Bay Width	16.40 ft
Frame Geometry	
Total Frame Width	39.37 ft
Total Frame Height	15.09 ft
Column Height	7.87 ft
Rafter (160/100/3 Aluminum Profile)	
Horizontal Span	19.69 ft
Inclination Angle	20.14 deg
Cosine(Angle)	0.94
Length	20.97 ft
Linear Weight	3.36 plf
Ridge Beam (60/60/3 Aluminum Profile)	
Span	16.40 ft
Linear Weight	1.47 plf
Eaves Beam (130/70/3 Aluminum Profile)	
Span	16.40 ft
Linear Weight	2.78 plf
Purlin (60/60/3 Aluminum Profile)	
Span	16.40 ft
Quantity per Rafter	1.00 pc
Linear Weight	1.25 plf
Fabric	
Tributary Width	16.40 ft
Tributary Height	7.87 ft
Weight	0.208 psf

4.1 Dead Loads
4.2 Live Loads

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Figure 4-1 Dead and Live Loads (Spreadsheet Output)

DEAD LOAD									
Uniform Load Distribution on the Inclined Main Members									
Weight of the Main Member	3.36 plf								
Weight of the Purlins			1.25 plf	*	16.40 ft	*	1.00 pcs	=	20.51 lbs
	0.98 plf	=	20.51 lbs	/	19.69 ft	*	0.94		
Weight of the Fabric	3.41 plf	=	0.208 psf	*	16.40 ft				
Weight of Minor Components, Cables, Bolts, etc.	3.00 plf								
Total	10.75 plf								
Point Load on the Ridge									
Weight of the Ridge Beam	24.11 lbs	=	1.47 plf	*	16.40 ft				
Total	24.11 lbs								
Point Load on the Eaves									
Weight of the Eaves Beam	45.60 lbs	=	2.78 plf	*	16.40 ft				
Weight of the Fabric	26.87 lbs	=	0.208 psf	*	16.40 ft	*	7.87 ft		
Total	72.47 lbs								
LIVE LOAD									
Uniform Load Distribution on the Inclined Main Members									
Weight of Snow	0.00 plf								
Point Loads on the Inclined Main Members									
Weight of the Fixtures									
Left Rafter Midlength	250.00 lbs								
Ridge	500.00 lbs								
Right Rafter Midlength	250.00 lbs								
Total	1000.00 lbs								

WIND LOADS

Mean Structure Height, h 11.48 ft
Tributary Width, b 16.40 ft
Wind Pressure Equation from ANSI/ASCE 7-93
q = 0.00256 (Gh Kz I^2) V^2
where V, the wind velocities are:
60.00 mph = V1
70.00 mph = V2
80.00 mph = V3
90.00 mph = V4

I Factor	0.77			h/L	0.29
Gh Factor	h = z	Exp A	Exp B	Exp C	Exp D
	0.0	2.36	1.65	1.32	1.15
	15.0	2.36	1.65	1.32	1.15
Kz Factor	h = z	Exp A	Exp B	Exp C	Exp D
	0.0	0.12	0.37	0.80	1.20
	15.0	0.12	0.37	0.80	1.20
Roof Cp's	h/L	20.0	30.0	degrees	
	<= 0.3	0.20	0.30	Cp's	

EQUATION CONSTANTS

Exposure	q	Gh	Kz	I
Class A	0.00042985 V^2	2.36	0.12	0.77
Class B	0.00092663 V^2	1.65	0.37	0.77
Class C	0.00160282 V^2	1.32	0.80	0.77
Class D	0.00209460 V^2	1.15	1.20	0.77

WIND PRESSURES, q (psf)

Exposure	60 mph	70 mph	80 mph	90 mph
Class A	1.55	2.11	2.75	3.48
Class B	3.34	4.54	5.93	7.51
Class C	5.77	7.85	10.26	12.98
Class D	7.54	10.26	13.41	16.97

DISTRIBUTED WIND LOADS, P (plf)

Exposure	60 mph	70 mph	80 mph	90 mph
Class A	25.38	34.55	45.13	57.12
Class B	54.72	74.48	97.28	123.13
Class C	94.65	128.84	168.28	212.97
Class D	123.70	168.36	219.91	278.32

WINDWARD ROOF SUCTION / PRESSURE COEFFICIENT, Cp

Cp 0.20

LOAD CASES (C-80 OR D-70 EXPOSURE)

Case	q (psf)	P (plf)	w = Cpw x P	Cpw	w = Cpw x P	Cpr	w = Cpw x P	Cpr	w = Cpw x P	Cpw
WSUCTION (Same as WPRESSURE)	10.26	168.36	134.69	0.80	33.90	0.20	-117.86	-0.70	-84.18	-0.50
WPRESSURE	10.26	168.36	134.69	0.80	33.90	0.20	-117.86	-0.70	-84.18	-0.50
WPARALLEL	10.26	168.36	-117.86	-0.70	-117.86	-0.70	-117.86	-0.70	-117.86	-0.70

4.4 General Load Cases and Combinations

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Figure 4-2 Load Cases (1/2)

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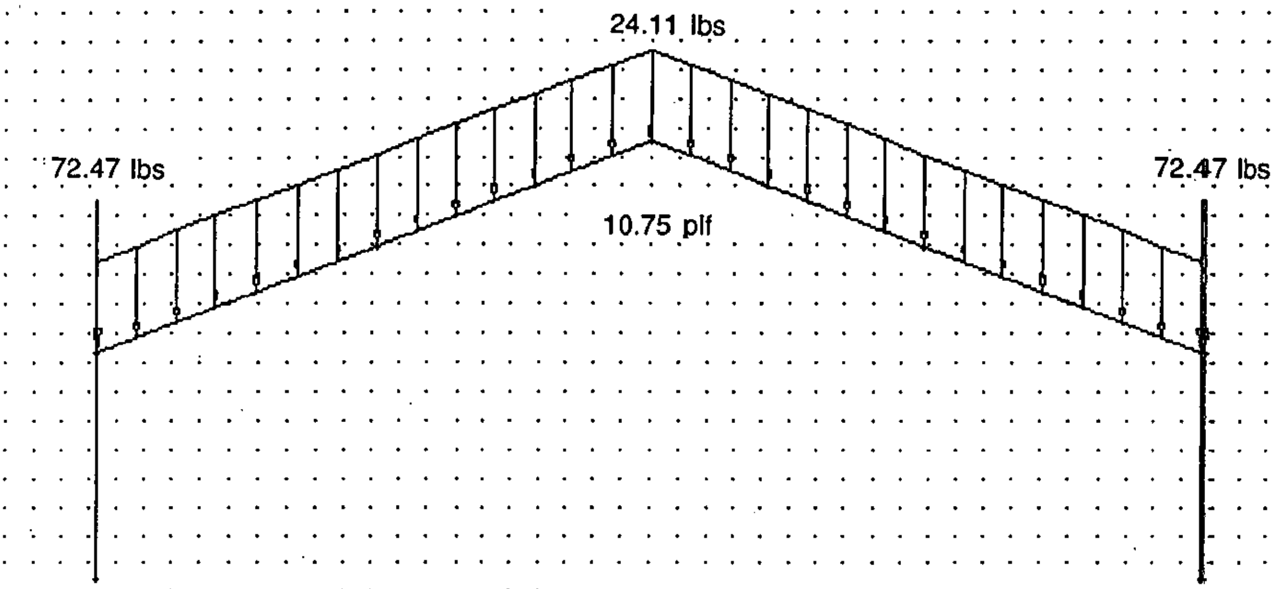
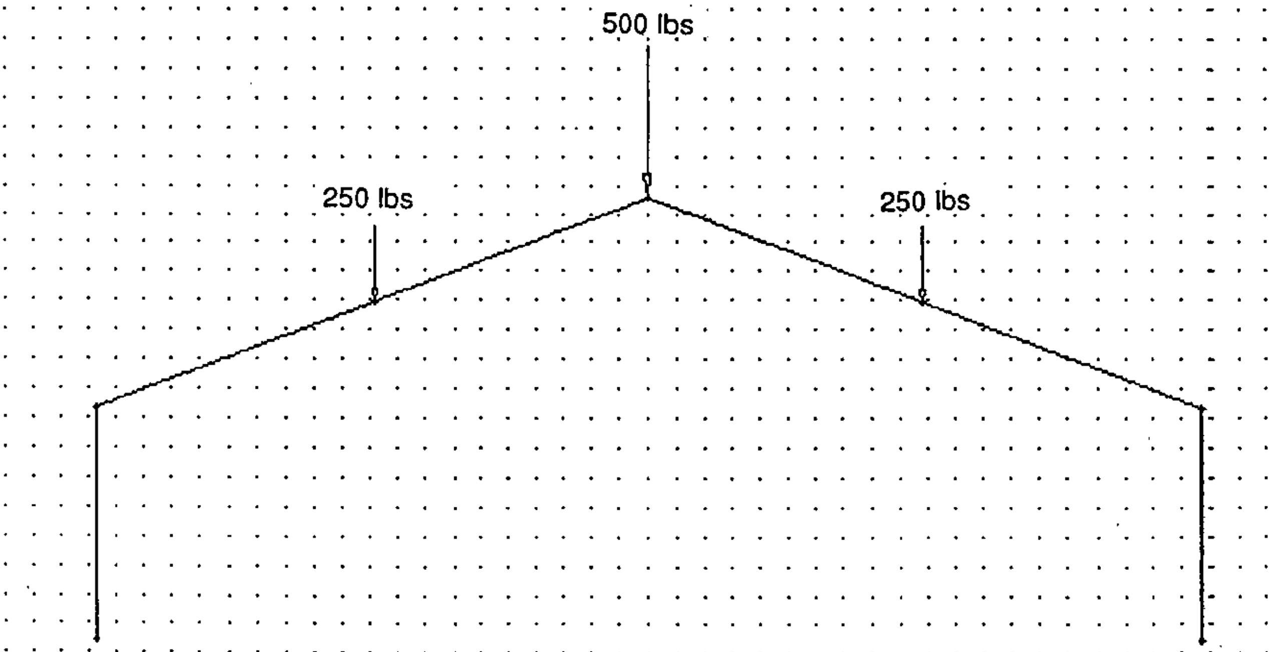
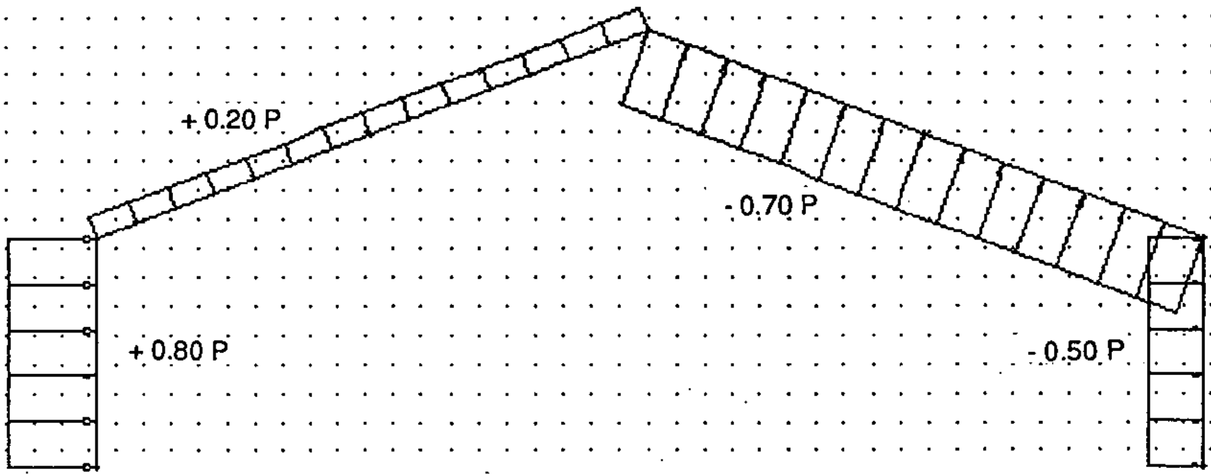


Load Case # 1 : Dead Loads



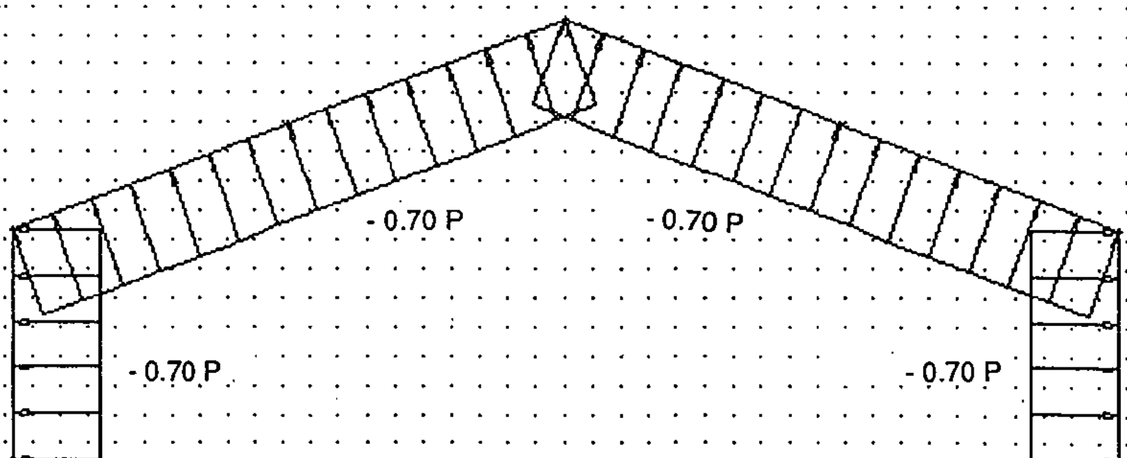
Load Case # 2 : Live Loads

Figure 4-2 Load Cases (2/2)



Load Case # 4 : Wind Perpendicular to the Ridge and Positive Pressure at the Windward Side
0.00 < h/L = 0.29 < 0.30

Y



Load Case # 5 : Wind Perpendicular to the Ridge and Suction at all Sides
0.00 < h/L = 0.29 < 2.50

Y

Table 4.2 Load Case and Combination Summary

LOAD CASE SUMMARY

Case No.	Description
1	Dead Loads
2	Live Loads
3	Wind Load Perpendicular to the Ridge Suction on the Windward Side
4	Wind Load Perpendicular to the Ridge Positive Pressure on the Windward Side
5	Wind Load Parallel to the Ridge Suction on All Sides

LOAD COMBINATION SUMMARY

Case No.	Description
6	DL
7	DL + LL
8	DL + LL + WSUCTION
9	DL + LL + WPRESSURE
10	DL + LL + WPARALLEL
11	DL + WSUCTION
12	DL + WPRESSURE
13	DL + WPARALLEL

Part 5

Structural Analysis and Results

5.1 Computer Model

The Roder Frame is modeled as an assemblage of beam and column segments systematically connected by moment resisting inserts. Releases are set where the components are pinned or bolted to accurately simulate a zero moment condition. These occur at the column bases.

Shown in Figure 5-1 is the typical interior frame with its node and element labels. To facilitate the model set-up, coordinates are assigned to each node (corresponding to its relative point in space) and element connectivity data are introduced. Support or boundary conditions (pinned supports) are then set to finish the system geometry.

This model is then input into ROBOT V6, a graphical user interfaced finite element analysis program, together with the material and cross section properties, load cases and combinations (Figure 5-2). At this stage, the computer model is ready for analysis.

5.2 ROBOT V6 Results

The graphical results involving the frame displacements, moments and internal forces for the resulting six load combinations are shown as Figure 5-3. Also indicated are the extreme values and their relative locations. These should be viewed in conjunction with the listings provided in Appendix C.

5.1 Computer Model

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Figure 5-1 Node and Element Data

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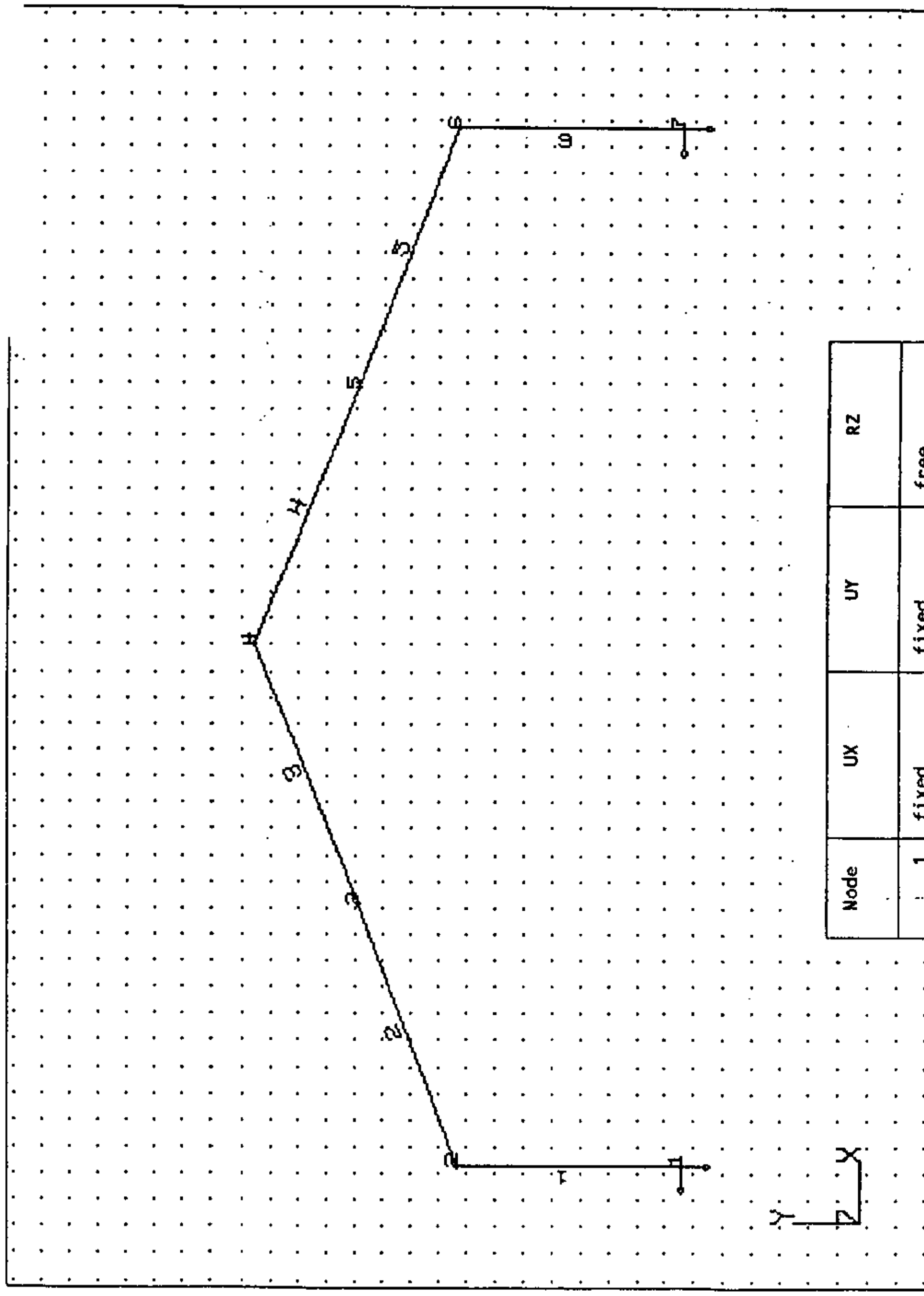
Node	X (ft)	Y (ft)
1	-19.690000	0.0
2	-19.690000	7.870000
3	-9.840000	11.480000
4	0.0	15.090000
5	9.840000	11.480000
6	19.690000	7.870000
7	19.690000	0.0



Node	UX	UY	RZ
1	fixed	fixed	free
7	fixed	fixed	free

Elemen	Node1	Node2	Length (ft)	Materials	Sections
1	1	2	7.870000	ALUM	USER 160x100x3
2	2	3	10.490691	ALUM	USER 160x100x3
3	3	4	10.481302	ALUM	USER 160x100x3
4	4	5	10.481302	ALUM	USER 160x100x3
5	5	6	10.490691	ALUM	USER 160x100x3
6	6	7	7.870000	ALUM	USER 160x100x3

Table 5-1 Coordinate Data

SPREADSHEET GENERATION OF THE FRAME LOADS

96 7 10 13:25 Roder 12m Run Number 1

COORDINATE DATA (METRIC UNITS)

Description	Global X (m)	Global Y (m)
Left Pinned Support	-6.000	0.000
Left Eaves	-6.000	2.400
Left Live Load Application Point	-3.000	3.500
Ridge Point	0.000	4.600
Right Live Load Application Point	3.000	3.500
Right Eaves	6.000	2.400
Right Pinned Support	6.000	0.000

Slope	0.367
Span	12.000 m
Bay Width	5.000 m

COORDINATE DATA (ENGLISH UNITS)

Description	Global X (ft)	Global Y (ft)
Left Pinned Support	-19.69	0.00
Left Eaves	-19.69	7.87
Left Live Load Application Point	-9.84	11.48
Ridge Point	0.00	15.09
Right Live Load Application Point	9.84	11.48
Right Eaves	19.69	7.87
Right Pinned Support	19.69	0.00

Slope	0.37
Span	39.37 ft
Bay Width	16.40 ft

Figure 5-2 ROBOT V6 Input File


```
'This file was generated by r3D on 10.07.1996 at 13:54:43

ROBOT

FRAme PLAne

NODes 7 ELEments 6

UNIts
 LENgth=ft  Force=lbs

NODes
```

N°	X	Y
1	-19.69	0
2	-19.69	7.87
3	-9.84	11.48
4	0	15.09
5	9.84	11.48
6	19.69	7.87
7	19.69	0

```
ELEments
```

N°	ORig	END
1	1	2
2	2	3
3	3	4
4	4	5
5	5	6
6	6	7

```
PROperties
 ALUM
  RO=169.34
  1To6 USER160 x 100 x 3

SUPports
' Label      - free
' No label   - blocked

 1 7 R2

LOAds

CASe # 1 DEAD LOAD
   2 6 FY=-72.47
   4 FY=-24.11
  ELEments
   2To5 PY=-10.75

CASe # 2 LIVE LOAD
   3 5 FY=-250
   4 FY=-500

CASe # 4 WIND PRESSURE
  ELEments
   1 PX=134.62
   2 3 PY=-33.88 LOcal
   4 5 PY=117.79 LOcal
   6 PX=84.14

CASe # 5 WIND PARALLEL
```



```
 ELEments
  1 PX=-117.79
  2 3 PY=117.79 LOcal
  4 5 PY=117.79 LOcal
  6 PX=117.79

COMbination # 6 DL
  1 1

COMbination # 7 DL+LL
  1 1 2 1

COMbination # 9 DL+LL+WPRESSURE
  1 1 2 1 4 1

COMbination # 10 DL+LL+WPARALLEL
  1 1 2 1 5 1

COMbination # 12 DL+WPRESSURE
  1 1 4 1

COMbination # 13 DL+WPARALLEL
  1 1 5 1

END
```

5.2 ROBOT V6 Results

Figure 5-3 Diagrams of Displacements, Moments and Internal Forces
Load Combination No. 6 : DL

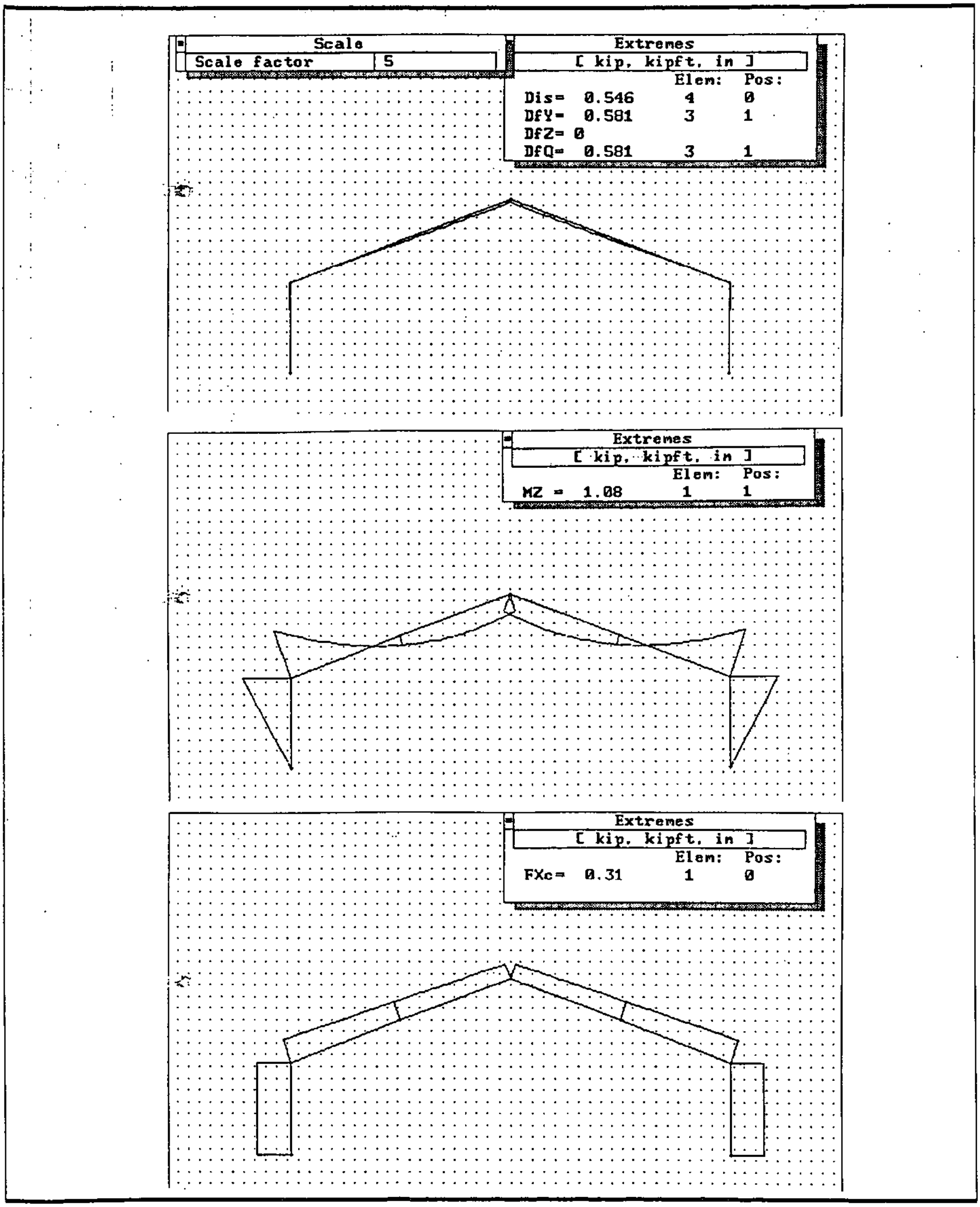
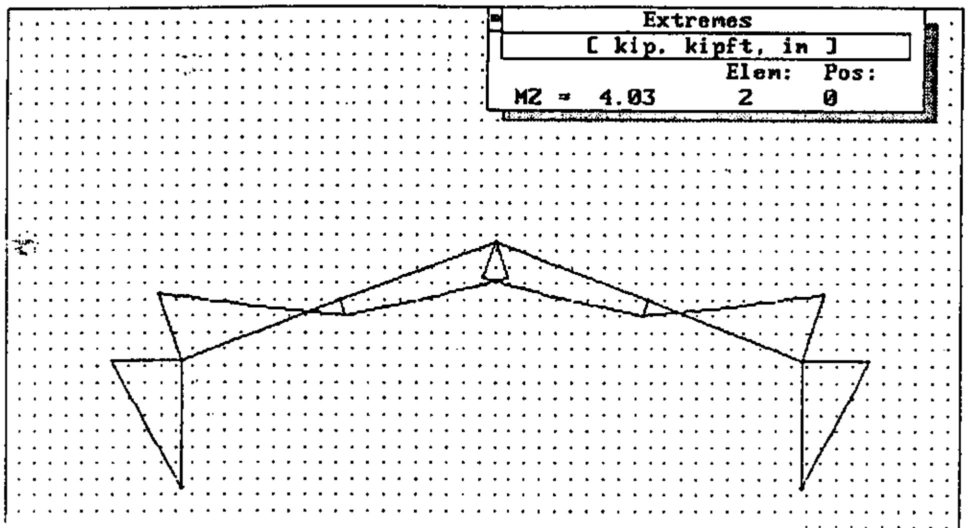
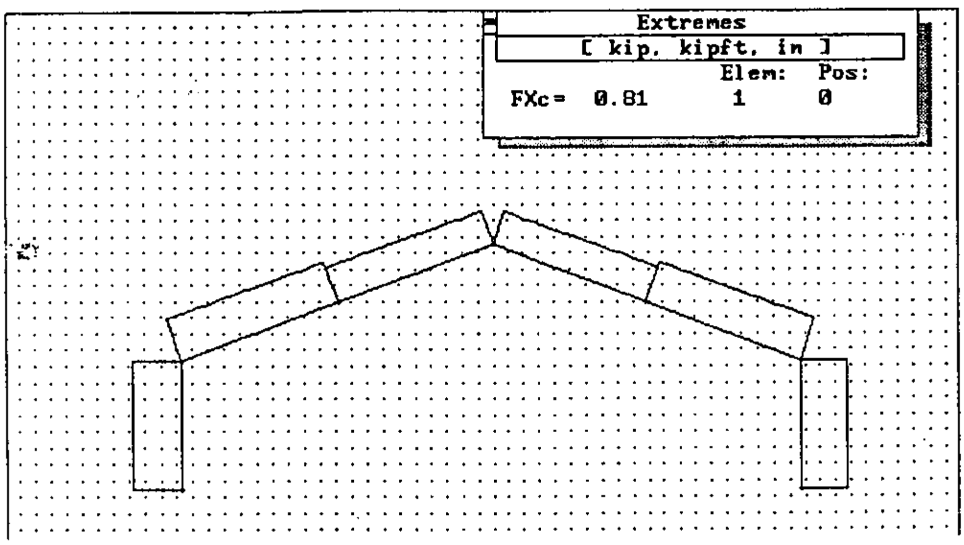


Figure 5-3 Diagrams of Displacements, Moments and Internal Forces
Load Combination No. 7 : DL + LL





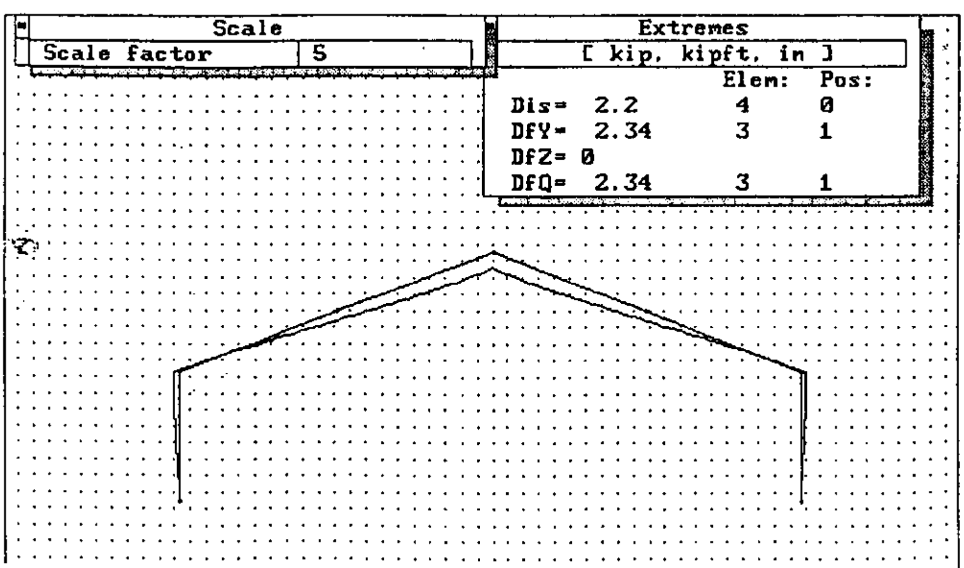
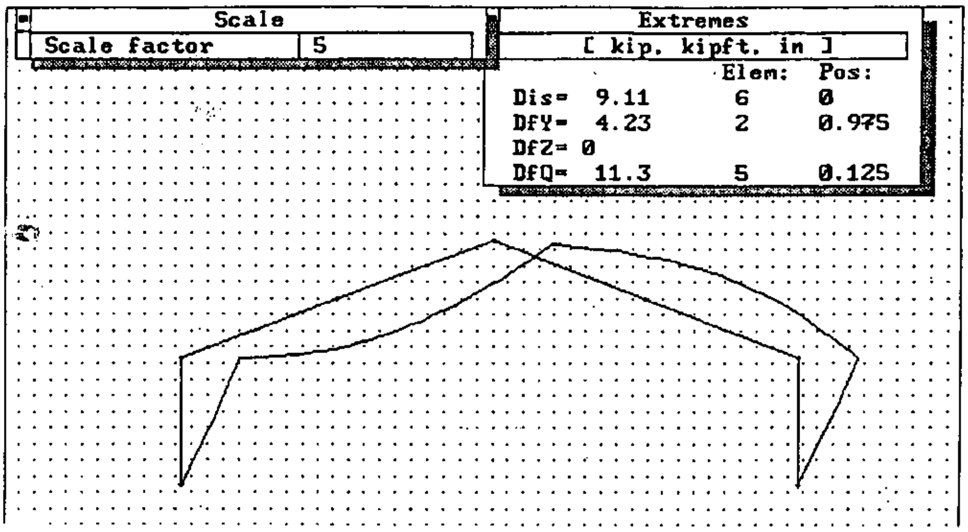
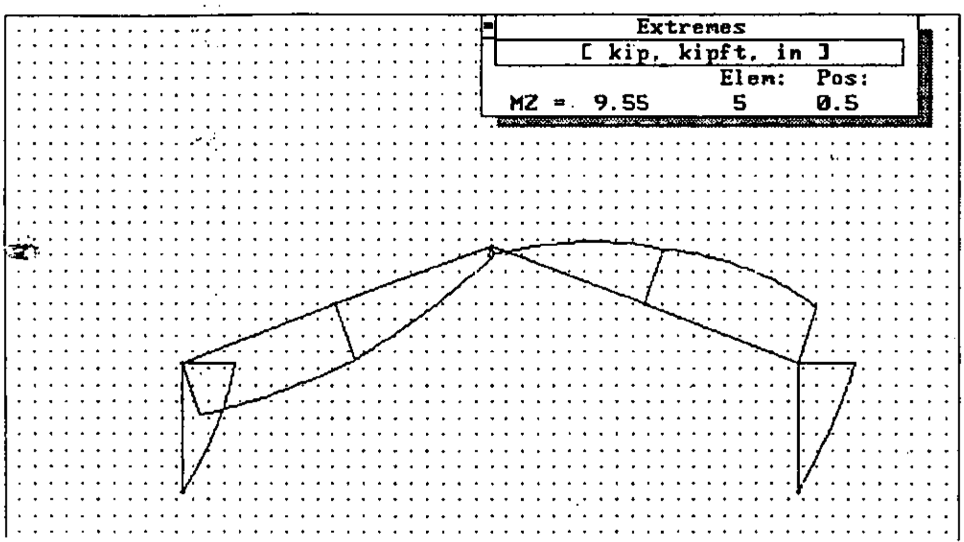


Figure 5-3 Diagrams of Displacements, Moments and Internal Forces
Load Combination No. 9 : DL + LL + WPRESSURE





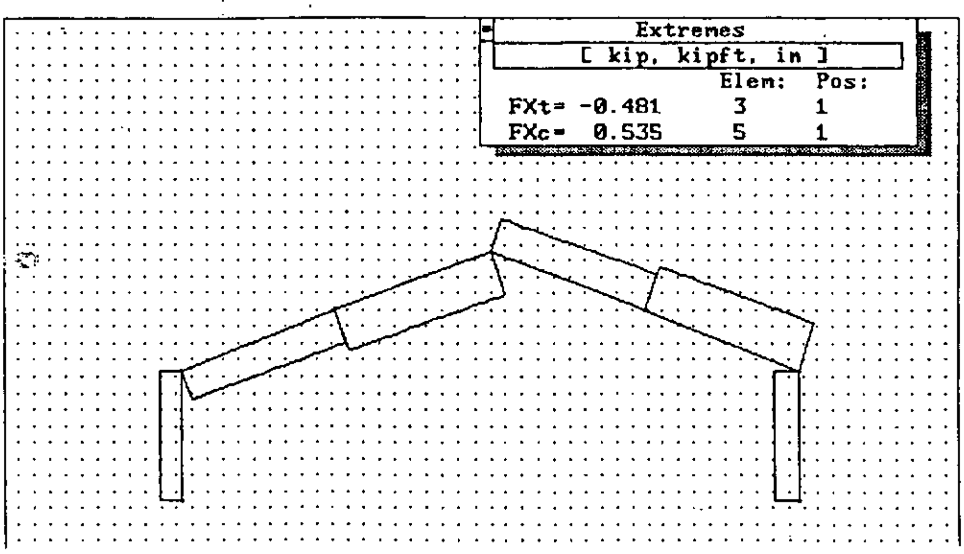
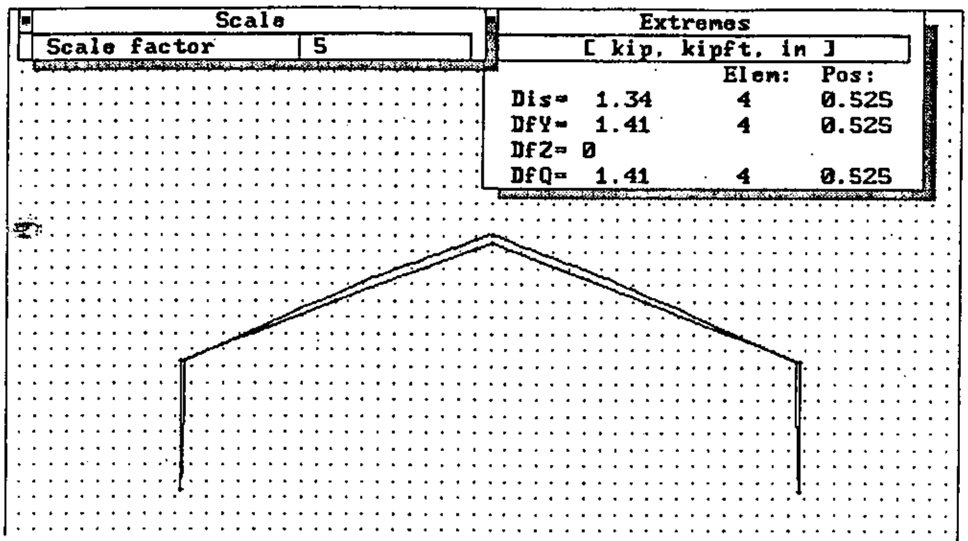
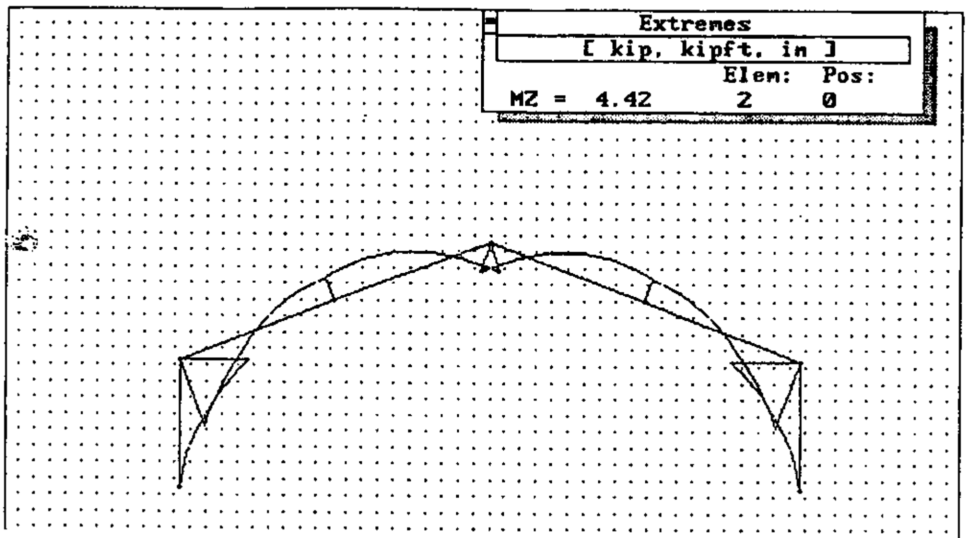


Figure 5-3 Diagrams of Displacements, Moments and Internal Forces
Load Combination No. 10 : DL + LL + WPARALLEL





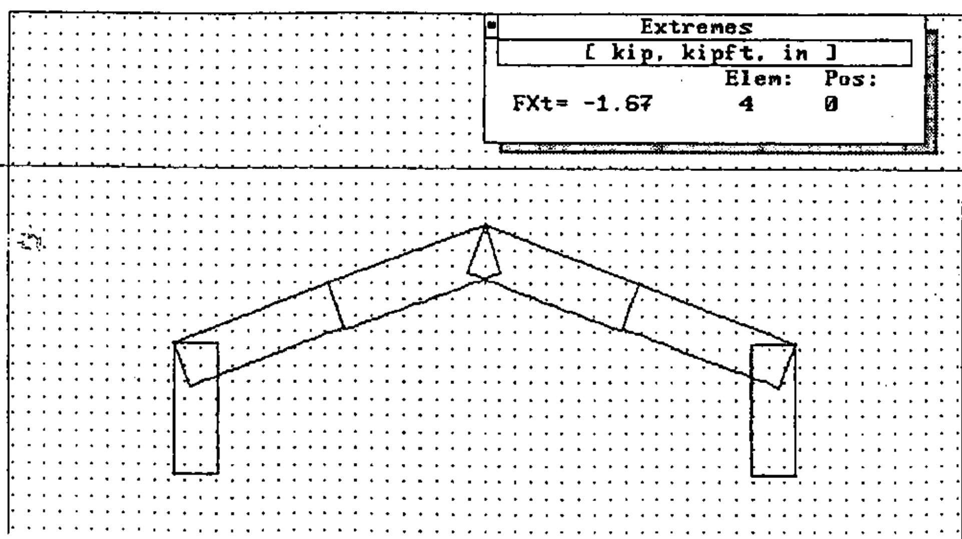


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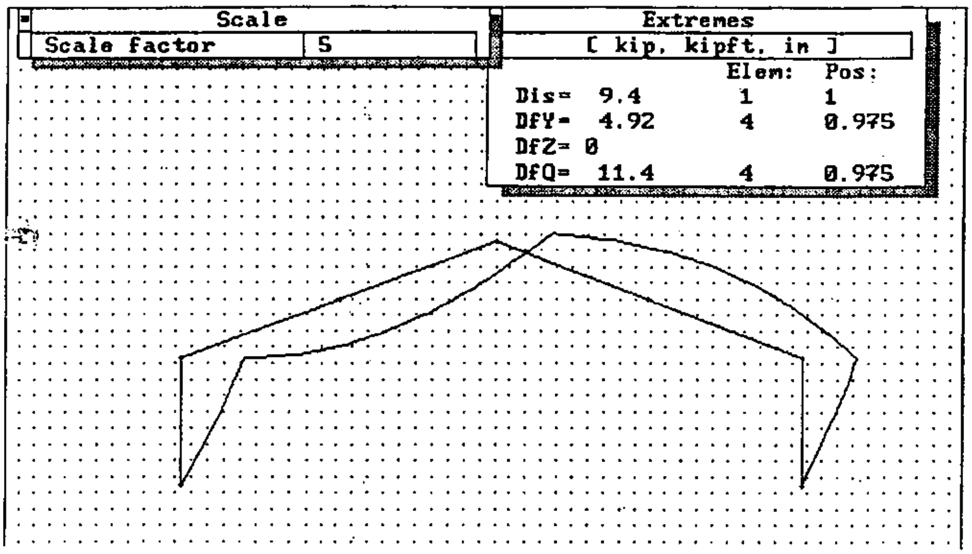
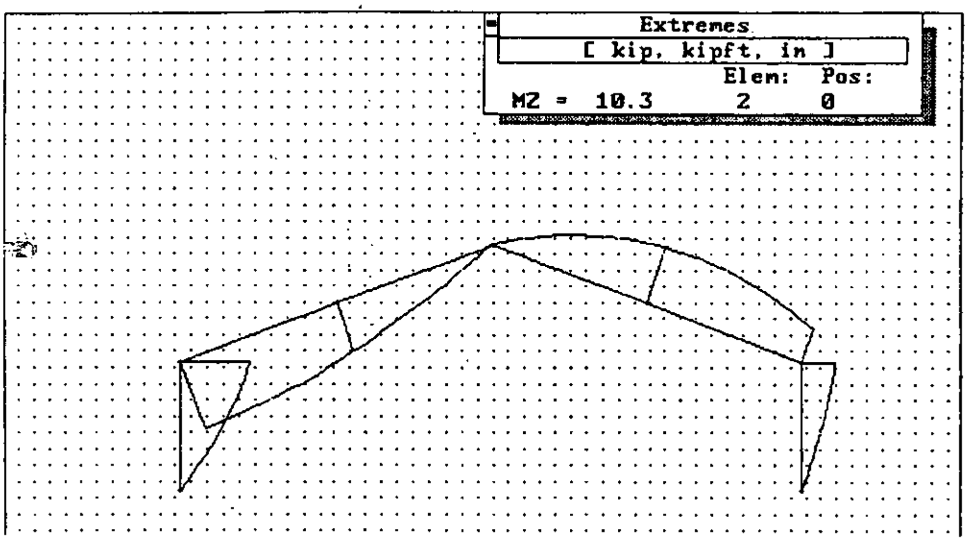
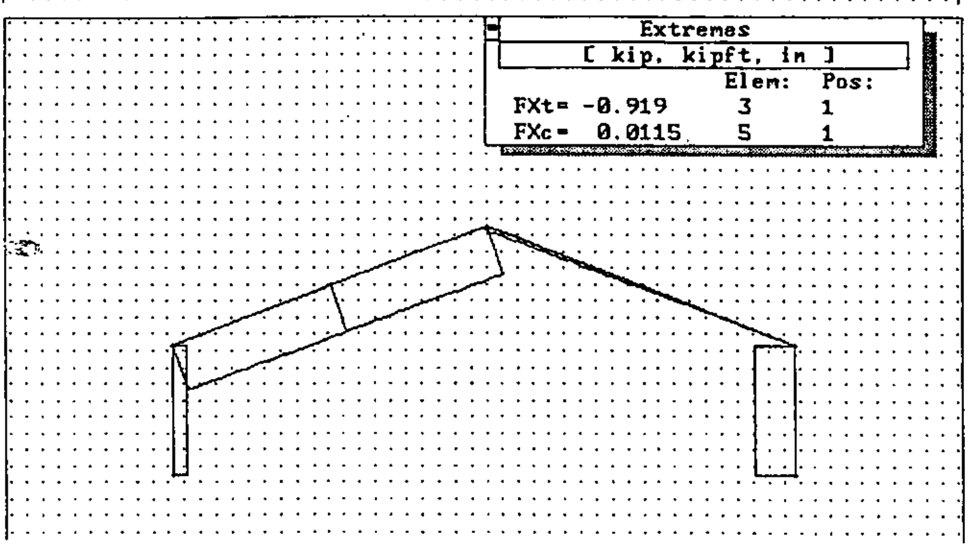
Figure 5-3 Diagrams of Displacements, Moments and Internal Forces
Load Combination No. 12 : DL + WPRESSURE

checked/date







Part 6

Critical Loads

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Table 6-1 Critical Applied Loads

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CRITICAL APPLIED LOADS

FRAME ELEMENT	LOAD COMBINATION	MEMBER	MAX P (Kips)	MAX V (Kips)	MAX M (Kip-ft)
Flexural Members (Rafters)	DL + WPRESSURE	2	0.84	-0.05	-10.26
Frame Column Segments	DL + WPRESSURE	1	0.26	0.77	-10.26
Supports or Foundations	DL + LL	1,6	0.81	(+/-) 0.51	0.00
	DL + WPRESSURE	1	-0.26	-1.83	0.00
	DL + WPARALLEL	1,6	-2.01	(-/+) 0.47	0.00

Note:

The other elements will be tested using q = 10.26 psf corresponding to a Class C, 80 mph or Class D, 70 mph wind exposure.

Part 7

Structural Investigations

This section covers the evaluation of key structural elements, connections and details that may prove critical to the frame stability under the applied wind loads. In the course of the analyses, constant reference is made to the following:

1. Section properties (Part 3 or Appendix A),
2. Failure criteria established for the frame version, and
3. The Aluminum and Steel Construction Manuals (U.S.).

Frame Loading Provisions

On the subject of external loading and allowable stresses, the following important provisions are lifted from the Aluminum Construction Manual:

> Section 2.3.1: Dead Load
>
> The dead load to be used in the design of the structure includes its self-weight and the weight of all materials permanently attached to and supported by it.
>
> Section 2.3.2: Live Load
>
> Static and dynamic live loads, as well as snow, ice, ponding, and wind loads shall be based on the appropriate building codes. Where building codes do not apply, requirements shall be established from performance specifications of the structure.
>
> In computing allowable stresses, the values provided in these specifications may be increased by one-third (1/3) when stresses are produced by wind or seismic loading, acting alone or in combination with the design dead and live loads.
>
> However, these sections shall not be less than that required for the dead and other live loads acting alone. In the case of wind or ice loads, the form of the structure and any of its exposed components (e.g. increased area exposed to wind due to icing) shall be considered.

Likewise, from the manual of the American Institute of Steel Construction:

> Section 1.5.6: Wind and Seismic Stresses
>
> Allowable stresses may be increased 1/3 above the values otherwise provided when produced by wind or seismic loading, acting alone or in combination with the design dead and live loads, provided that the required section computed on this basis is not less than that required for the design dead and live load and impact (if any), computed without the 1/3 stress increase, and further provided that the stresses

are not otherwise required to be calculated on the basis of reduction factors applied to design loads in combinations.

12 Meter Roder Frame Tent Version

The 12 meter version of the Roder Frame Tent, with an external column height of 7.87 ft, was analyzed with design loads corresponding to a C-80 (Class C exposure, 80 mph) wind. The following were calculated in Part 4.3:

$$q = 10.26 \text{ psf}$$
$$P = 168.28 \text{ plf}$$

according to the ANSI/ASCE 7-93 guidelines for wind loading.

The analyses using the other wind pressures will be deferred until Part 8: Acceptability Under Variable Exposure and Wind Conditions. This section will only investigate the effects of the C-80 forces to facilitate the determination of the most critical frame element.

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Figure 7-1 Eave Joint

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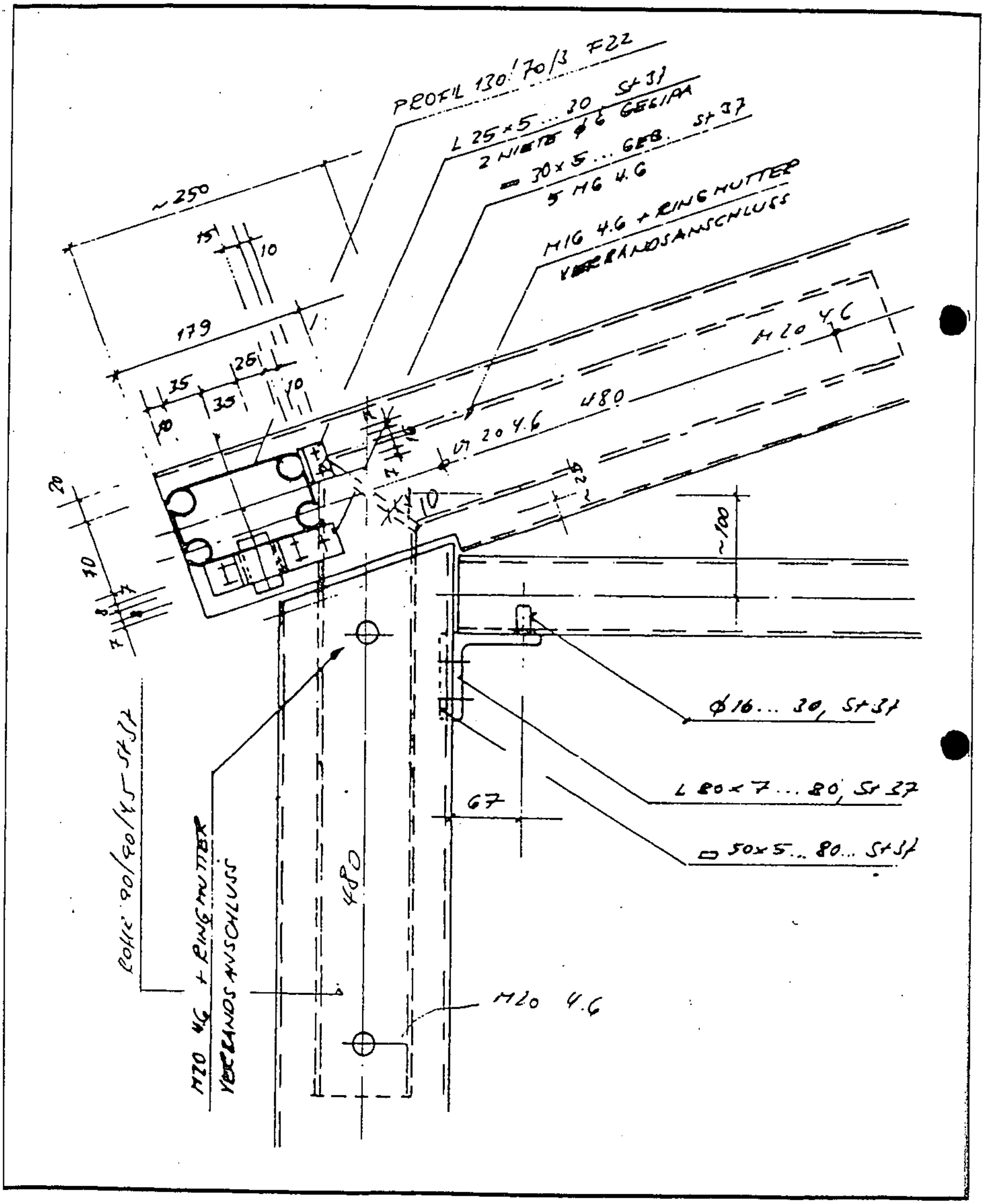

12 M RODER FRAME TENT — project

0858 H — no.

032 — page no.

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Figure 7-2 Ridge Joint

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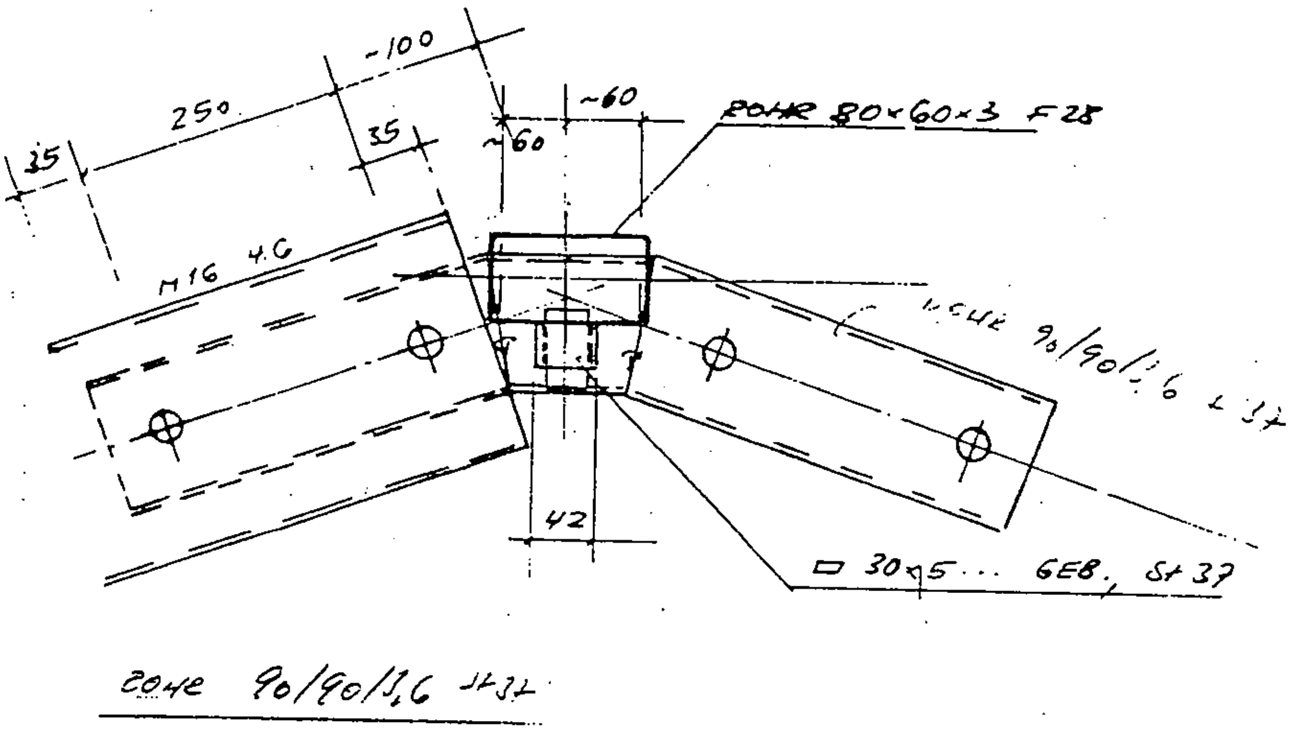

7.1 Primary Elements

7.1.1 Interior Frame Elements: Rafter Sections

MAIN FLEXURAL FRAMING MEMBERS, 160/100/3 RAFTER SECTIONS

A. MAXIMUM APPLIED LOADS

COMBINATION	DESCRIPTION	EL #	ND #	P(K)	M(K')	LENGTH (FT)
#12	DL + WPRESSURE	2	2	+0.84	−10.26	20.97

B. FAILURE CRITERION

UNITY CHECK FOR COMBINED AXIAL & BENDING STRESSES

C. ALLOWABLE STRESSES

TENSION

ON THE AXIAL NET SECTION OF ANY TENSION MEMBER

$F_t = 19$ KSI

BENDING

ON THE EXTREME TENSION FIBER OF BEAMS

$F_t = 10$ KSI

ON THE EXTREME COMPRESSION FIBER OF BEAMS

$$\frac{L_b S_c}{I_y} = \frac{(0.5 \times 20.97 \times 12)(5.02)}{6.22} = 92.55$$

THE RESULT IS LESS THAN 146, THEREFORE,

$F_c = 21$ KSI

THE LOWER F GOVERNS, IE.,

$F_b = 12$ KSI

D. WORKING STRESSES

TENSION

$$f_t = \frac{P}{A} = \frac{0.84}{2.86} = 0.29 \text{ KSI}$$

BENDING

$$\text{SLEEVE LENGTH} = \frac{460 + 250 - 172}{304.8} = 1.81'$$

$$M \text{ (ASSUMING A SIMPLIFIED LINEAR DISTRIBUTION)} = \left(\frac{20.27 - 1.81}{20.27}\right) \times -10.26 = -9.37k'$$

$$f_b = \frac{9.37 \times 12}{5.02} = 22.10 \text{ KSI}$$

E. UNITY CHECK

$$\frac{f_t}{1.33 F_t} + \frac{f_b}{1.33 F_b} = \frac{0.29}{1.33(19)} + \frac{22.10}{1.33(19)} = 0.88 < 1.00 \quad \text{GOOD!}$$

SINCE THE RESULT IS LESS THAN UNITY,

THE 160/100/3 RAFTER SECTION IS ACCEPTABLE.

IN ADDITION, FOR THIS ANALYSIS TO BE VALID, THE SECTION CUT AT THE EAVE SPLICE SHOULD BE AT LEAST AS STRONG AS THE ORIGINAL RAFTER, THIS MEANS THAT THE 90/50/4.5 & 160/100/3 SECTIONS SHOULD ACT COMPOSITELY.

12 M RODER FRAME TENT — project

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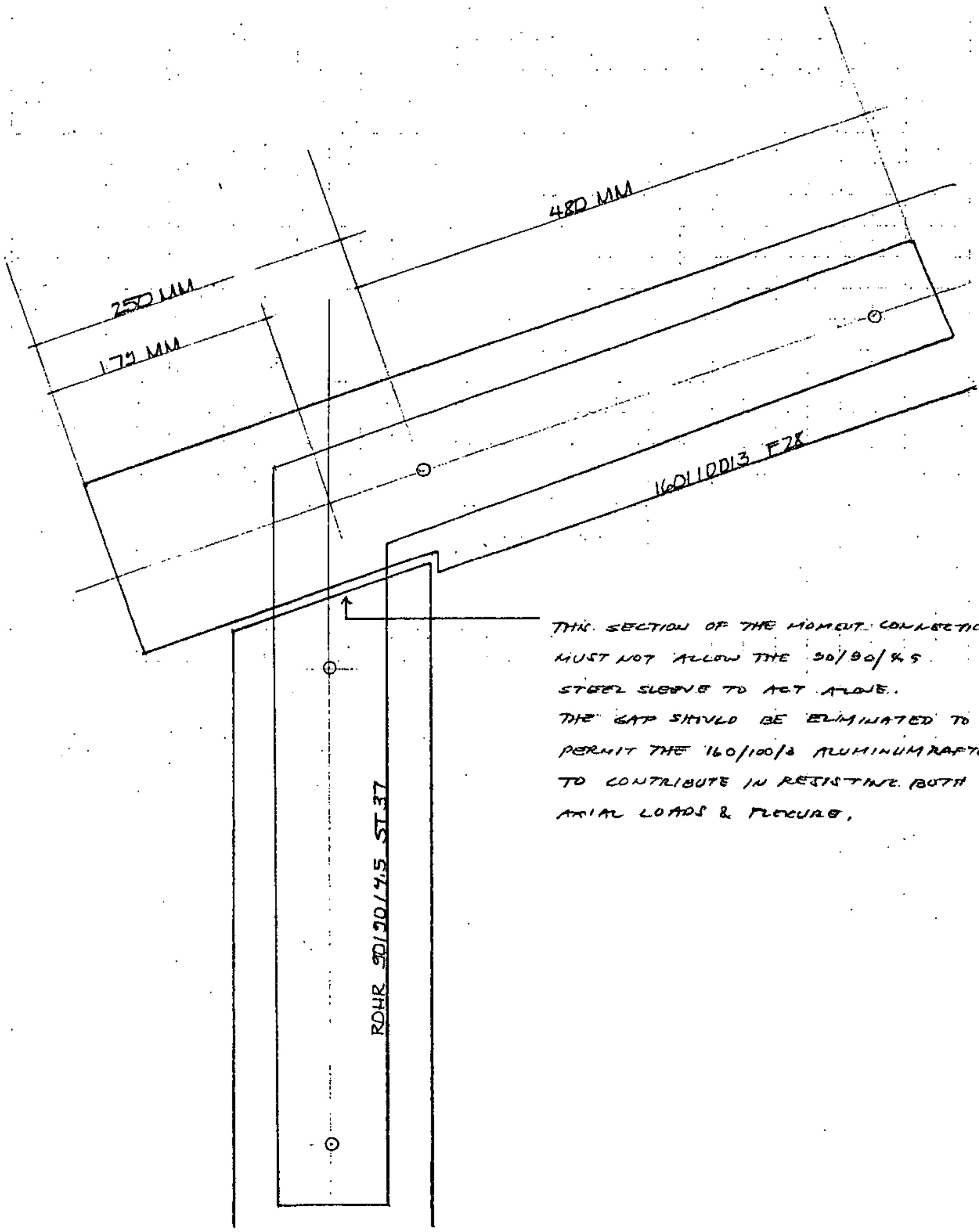

THIS SECTION OF THE MOMENT CONNECTION MUST NOT ALLOW THE 90/90/4.5 STEEL SLEEVE TO ACT ALONE.
THE GAP SHOULD BE ELIMINATED TO PERMIT THE 160/100/3 ALUMINUM RAFTER TO CONTRIBUTE IN RESISTING BOTH AXIAL LOADS & FLEXURE.

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7.1.2 Interior Frame Elements: Column Sections

checked/date

MAIN FLEXURAL FRAMING MEMBERS : 160/100/3 COLUMN SECTIONS

A. MAXIMUM APPLIED LOADS

COMBINATION	DESCRIPTION	EL #	ND #	P(K)	M(K')	LENGTH (FT.)
#12	DL + UPRESSURE	1	2	+0.26	-10.26	7.87

B. FAILURE CRITERION

UNITY CHECK FOR COMBINED AXIAL & BENDING STRESSES

C. ALLOWABLE STRESSES

TENSION

ON THE AXIAL NET SECTION OF ANY TENSION MEMBER

$F_t = 19$ KSI

BENDING

ON THE EXTREME TENSION FIBER OF BEAMS

$F_b = 19$ KSI

ON THE EXTREME COMPRESSION FIBER OF BEAMS

$\frac{L_b S_c}{I_y} = \frac{(7.87 \times 12) / 5.03)}{6.92} = 69.47$

THE RESULT IS LESS THAN 146. THEREFORE,

$F_b = 21$ KSI

THE LOWER F GOVERNS, IE,

$F_b = 19$ KSI

D. WORKING STRESSES

TENSION

$f_t = \frac{P}{A} = \frac{0.26}{2.86} = 0.09$ KSI

BENDING

SLEEVE LENGTH $= \frac{480 + 65 + 100}{304.8} = 2.12'$

M (ASSUMING A SIMPLIFIED LINEAR DISTRIBUTION) $= \frac{(7.87 - 2.12)}{7.87} \times 10.26 = 7.50$ K'

$f_b = \frac{7.50 \times 12}{5.03} = 17.68$ KSI

E. UNITY CHECK

$\frac{f_t}{1.33 F_t} + \frac{f_b}{1.33 F_b} = \frac{0.09}{1.33(19)} + \frac{17.68}{1.33(19)} = 0.70 < 1.00$ GOOD!

SINCE THE RESULT IS LESS THAN UNITY,

THE 160/100/3 RAFTER SECTION IS ACCEPTABLE.

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Figure 7-3 Gable Wall Strut

checked/date

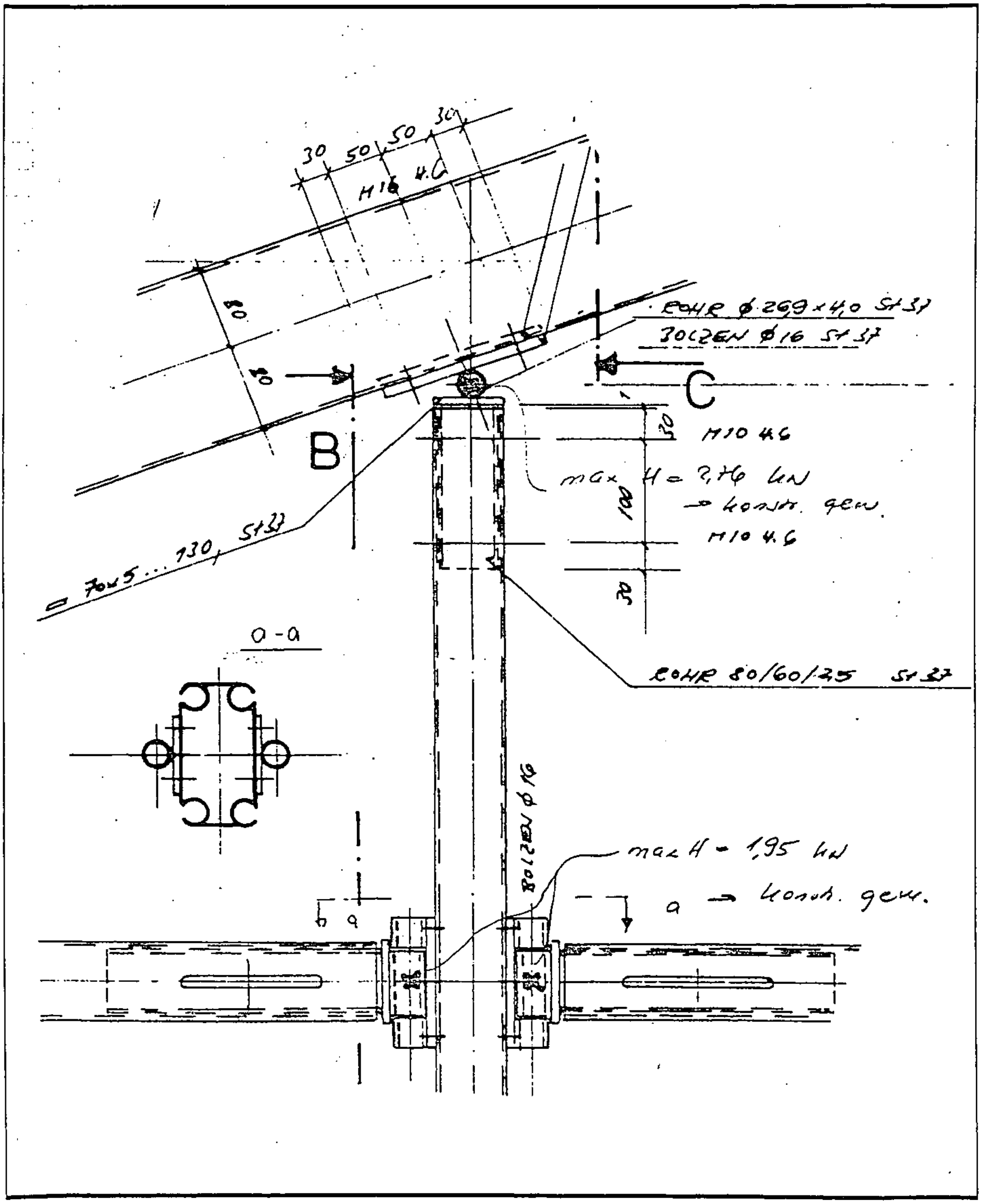

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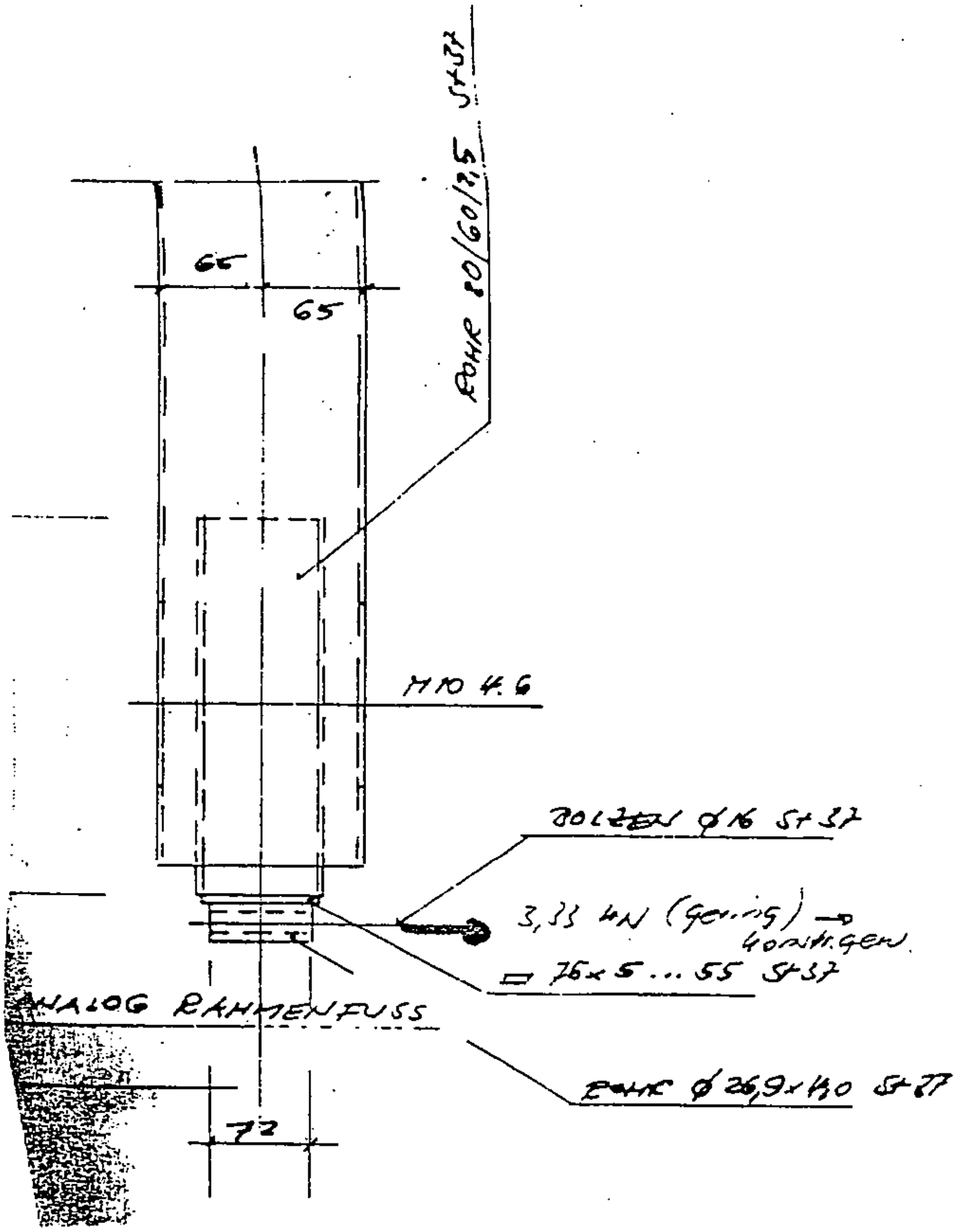
Figure 7-3 Gable Wall Strut

checked/date



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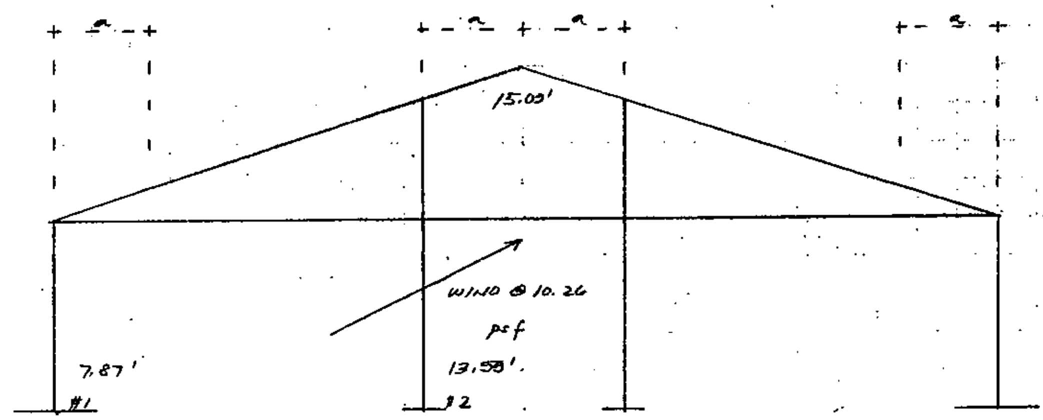
Load Assumptions : Gable Frame Elements

checked/date

LOAD DISTRIBUTION FOR A CASE # 5 WIND (PARALLEL TO THE RIDGE)

GABLE END FRAME



TOTAL WIND FORCE, F, ON THE GABLE FRAME

$$A = 39.37 \times \frac{(7.87 + 15.03)}{2} = 452.08\ ft^2$$

$$F = \pm GC_p\, q_h\, A = \pm GC_p \frac{(10.26)}{1.32} A = 7.77 \pm GC_p A$$

ASSUME THAT THE STRUTS SHARE THIS LOAD ACCORDING TO THEIR TRIBUTARY AREAS.

REFER TO THE TABULATION OF STRUT LOADS BASED ON FIGURE 3-a OF ANSI/ASCE 7-93.

ALSO ASSUME THAT F IS DIVIDED AMONG THE CORRESPONDING RESISTING MEMBERS.

REFER TO THE TABULATION OF BEAM & PURLIN LOADS WHERE THE +P'S ARE THE TENSION FORCES DUE TO NEGATIVE PRESSURES.

FOR THE UPLIFT FORCES PER LINEAR FOOT OF THE RAFTER,

REFER TO THE TABULATION OF UPLIFT LOADS FOR AREAS WITHIN & BEYOND a.

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checked/date

Table 7-1 Wind Load Distribution, Struts
Table 7-2 Wind Load Distribution, Beams and Purlins
Table 7-3 Uplift Forces, Rafter

WIND LOAD DISTRIBUTION, STRUTS

Strut No.	Strut Height (ft)	Tributary Area (sq ft)	+GCp	-GCp	q (psf)	Lateral Load (+) (lbs)	Strut Shear (lbs)	Lateral Load (-) (lbs)	Strut Shear (lbs)
1	7.87	72.49	1.20	-1.54	7.77	674.66	337.33	-870.07	-435.04
2	13.59	153.56	1.12	-1.22	7.77	1337.63	668.81	-1456.98	-728.49
		452.08	sq ft			4024.58	2012.29	-4654.11	-2327.05

Note : For A < 10 sq ft, GCp = Cl
For A > 500 sq ft, GCp = Cf
ANSI/ASCE 7-93 Figure 3 (a)
(Figure B-2 in Appendix B)

WIND LOAD DISTRIBUTION, BEAMS AND PURLINS

Component	Corresponding Strut No.	Cross Section Area (sq in)	Compressive Capacity (K)	Tensile Capacity (K)	Compression (K)	Tension (K)	Remarks
Eaves Beam	1	2.36	3.43	44.84	-0.97	1.14	ok
Purlin	na	1.06	1.23	20.14	-0.49	0.57	ok
Ridge Beam	na	1.25	1.55	23.75	-1.08	1.19	ok

Note : Fa, the allowable compressive stress, was derived according to slenderness restrictions.
Ft, the allowable tensile stress for the aluminum profiles, is 19 Ksi.

UPLIFT FORCES, RAFTER

Region	-GCp	Ws (plf)
Ridge & Eaves	-2.00	-127.51
Beyond "a"	-1.10	-70.13

where a < 3.94 ft
4.59 ft
but > 1.57 ft
3.00 ft

A = 171.97 sq ft
171.97 sq ft

Note : For A < 10 sq ft, GCp = Cl
For A > 100 sq ft, GCp = Cf
ANSI/ASCE 7-93 Figure 3 (b)
(Figure B-2 in Appendix B)

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7.1.3 Gable Frame Elements: Interior Strut Sections

checked/date

END GABLE FRAME INTERIOR STRUTS: 130/70/3 STRUT SECTIONS

A. MAXIMUM APPLIED LOADS

COMBINATION	DESCRIPTION	STRUT	P(K)	V(K)	LENGTH (FT)
#5	WIND/ALLOW	#2	REFER TO "D"	-0.73	13.50

B. FAILURE CRITERION

UNITY CHECK FOR COMBINED AXIAL & BENDING STRESSES

C. ALLOWABLE STRESSES

TENSION

ON THE AXIAL NET SECTION OF ANY TENSION MEMBER

$F_t = 19$ KSI

BENDING

ON THE EXTREME TENSION FIBER OF BEAMS

$F_t = 19$ KSI

ON THE EXTREME COMPRESSION FIBER OF BEAMS

$$\frac{L_b S_c}{I_y} = \frac{(13.50 - 7.87) \times 12 \times 3.20}{2.52} = 87.16$$

THIS RESULT IS LESS THAN 146. THEREFORE,

$F_c = 21$ KSI

THE LOWER F GOVERNS, IE,

$F_b = 19$ KSI

D. WORKING STRESSES

TENSION

$$f_t = \frac{P}{A} = \frac{127.51(3.94) + 70.13(9.84 - 3.94)}{1000(2.36)} = \frac{0.92}{2.36} = 0.39 \text{ KSI}$$

BENDING

$$M = \frac{VL}{4} = \frac{0.73(13.50)}{4} = 2.48 \text{ K}'$$

$$f_b = \frac{M}{S} = \frac{2.48 \times 12}{3.20} = 9.30 \text{ KSI}$$

E. UNITY CHECK & CONCLUSION

$$\frac{f_t}{1.33 F_t} + \frac{f_b}{1.33 F_b} = \frac{0.39}{1.33(19)} + \frac{9.30}{1.33(19)} = 0.38 < 1.00 \text{ GOOD!}$$

SINCE THE RESULT IS LESS THAN UNITY,

THE 130/70/3 STRUT SECTION IS ACCEPTABLE.

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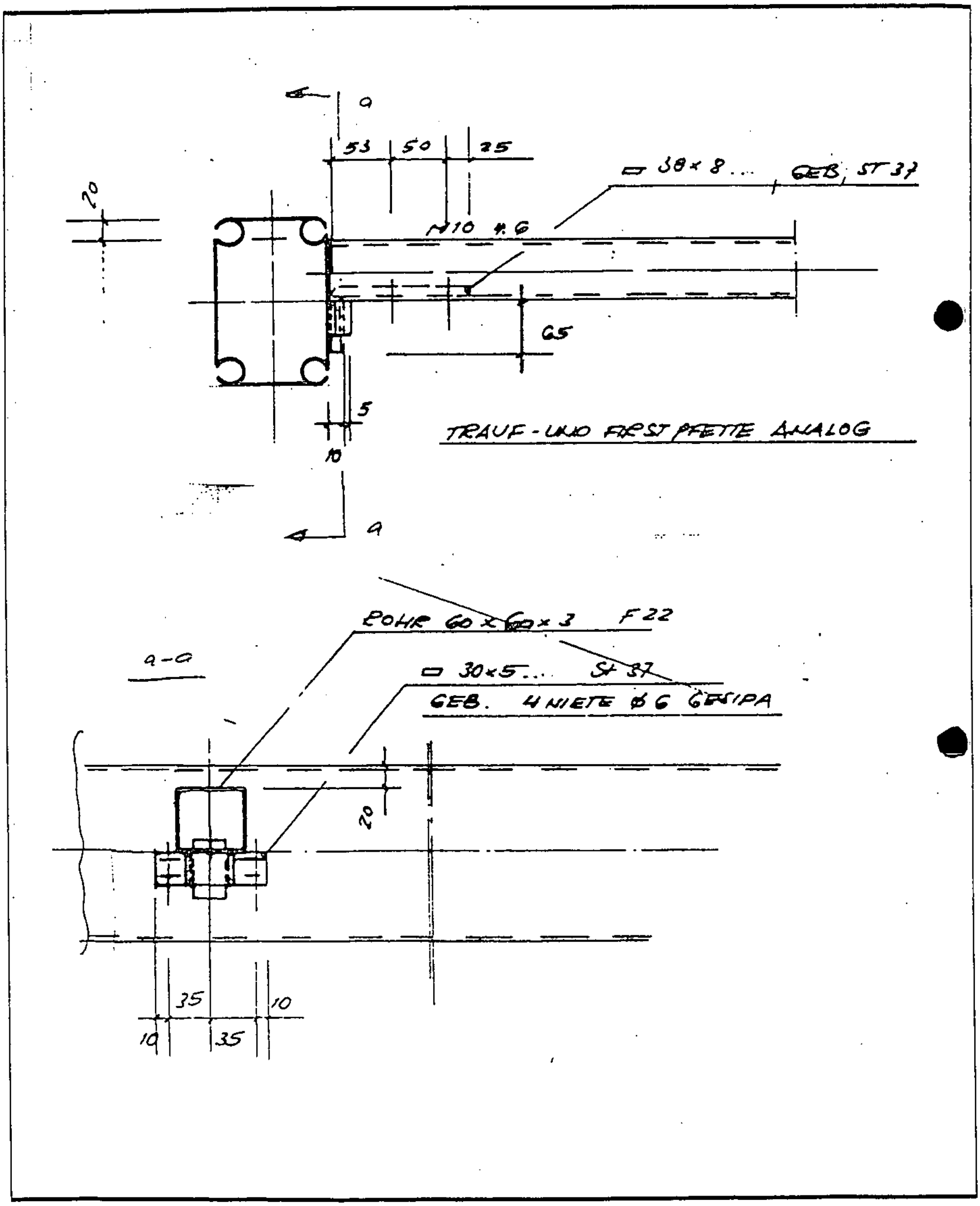
Figure 7-4 Purlin

checked/date



TOTAL COMPRESSIVE CAPACITY OF THE LONGITUDINAL FORCE-RESISTING MEMBERS

Criteria		Units	Purlins	Eaves Beams	Ridge Beam	Remarks
Section			60/60/3	130/70/3	80/60/3	F28 Aluminum
Quantity		(pcs)	2.00	2.00	1.00	
Length		(ft)	16.08	16.08	16.08	Net Length
Ax		(sq in)	1.06	2.36	1.25	
r min		(in)	0.92	1.03	0.95	
Slenderness	KL / r min, K = 1		209.69	187.29	203.07	> 66
Fa	51E3 / (KL/r)^2	(Ksi)	1.16	1.45	1.24	Compression
P	Ax Fa	(K)	1.23	3.43	1.55	
Sum P	P x Quantity	(K)	2.46	6.86	1.55	
Total		(K)				10.87

7.2 Secondary Elements

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7.2.1 Purlins and Beams

checked/date

PURLINS & BEAMS, 60/60/3, 80/60/3 & 130/70/3 ALUMINUM PROFILES

A. MAXIMUM APPLIED LOADS

COMBINATION	DESCRIPTION	TOTAL P(K)	REMARKS
#5	WPARALLEL	2.01	DUE TO NORMAL WIND LOAD

REFER TO TABLE 7-1 FOR THE TOTAL MAXIMUM COMPRESSIVE LOAD ON THE ROOF.

B. FAILURE CRITERION

TOTAL CAPACITY OF THE AXIALLY LOADED ELEMENTS

C. ALLOWABLE CAPACITY

FROM THE LOAD ASSUMPTIONS

$\Sigma P_c = 10.87$ K

D. WORKING LOAD

FROM PREVIOUS CALCULATIONS

$P = 2.01$ K

E. LOAD CHECK & CONCLUSION

THERE IS ENOUGH CAPACITY IN THE SYSTEM TO RESIST THE CALCULATED WIND LOADS.
SINCE THE TOTAL CAPACITY IS NOT EXCEEDED, IE

$P = 2.01\ K < 10.87\ K = \Sigma P_c$

THEN THE ASSEMBLAGE OF AXIAL ELEMENTS IS ACCEPTABLE.

F. ADDITIONAL CHECKS

REFER TO TABLE 7.2 FOR THE ACTUAL LOAD VS. CAPACITY CHECKS FOR A CASE #5 WIND LOAD DISTRIBUTION.

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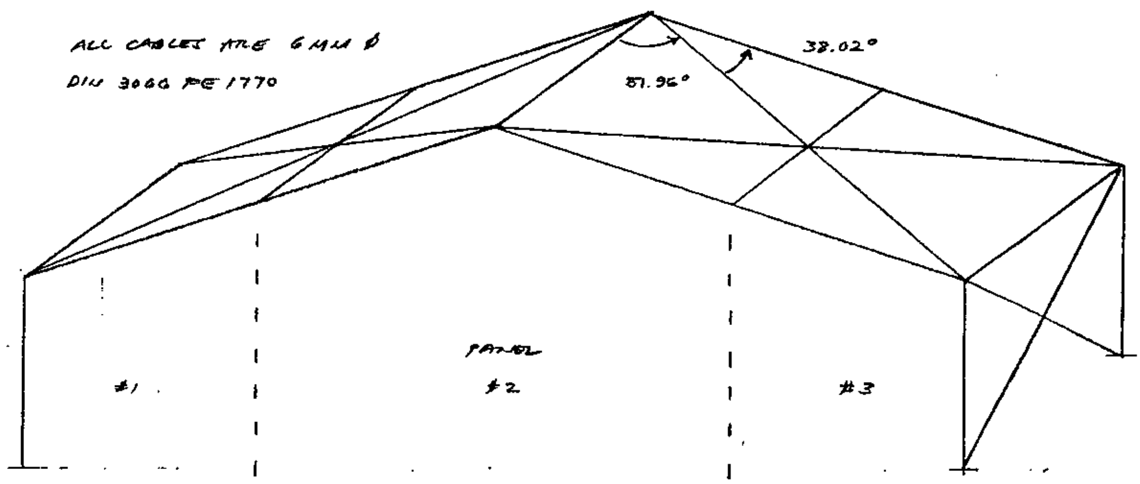
Load Assumptions : Roof and Wall Cables

checked/date

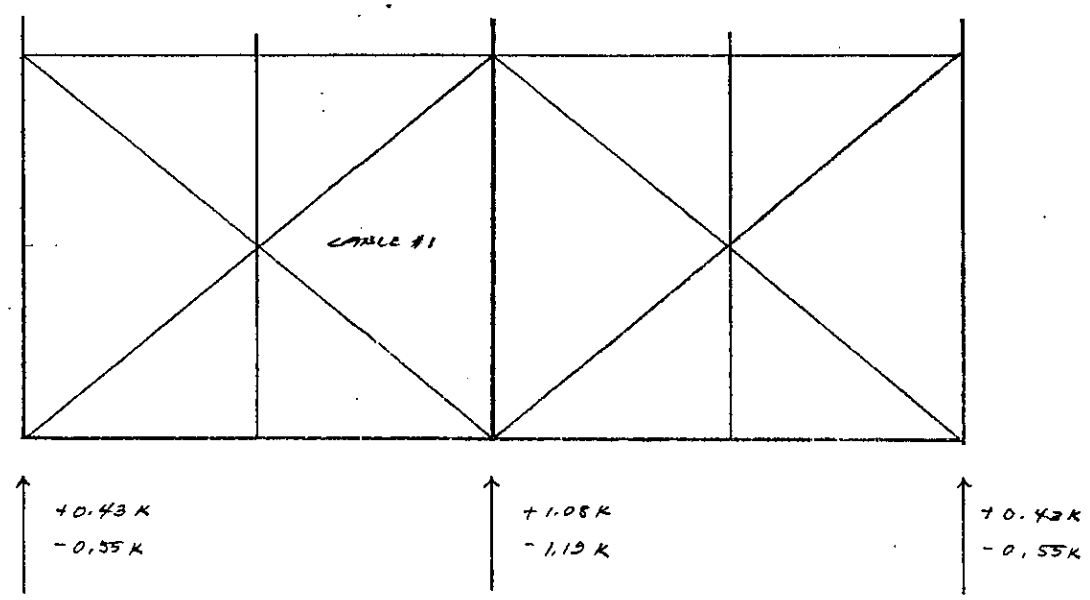
LOAD DISTRIBUTION FOR A CASE #5 WIND (WIND PARALLEL TO THE RIDGE)

BEAMS & CABLES

ISOMETRIC



PLAN



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ELEVATION

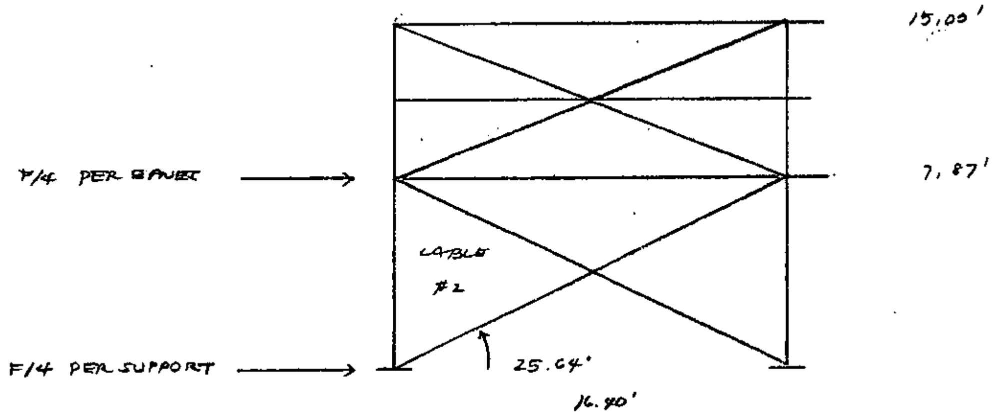

Table 7-5 Cable Loads

CABLE FORCES

Panel No.	Mean Panel Ht. (ft)	Tributary Area (sq ft)	+GCp	-GCp	q (psf)	Lateral Load (+) (lbs)	Lateral Load (-) (lbs)	P (+) (lbs)	P (-) (lbs)
1	9.68	95.26	1.17	-1.48	7.77	865.96	-1096.91	432.98	-548.45
2	13.29	261.56	1.07	-1.17	7.77	2167.75	-2371.05	1083.87	-1185.53
3	9.68	95.26	1.17	-1.48	7.77	865.96	-1096.91	432.98	-548.45
		452.08				3899.67	-4564.87	1949.83	-2282.44

Note : For A < 10 sq ft, GCp = Cl
For A > 500 sq ft, GCp = Cf
ANSI/ASCE 7-93 Figure 3 (a)
(Figure B-2 in Appendix B)

7.2.2 Roof and Wall Cables

ROOF AND WALL CABLE TENSIONS

Pressure Loads

Cable No.	No. of Bays	Diameter (mm)	Capacity F.O.S = 2.5 (k)	Cable Inclination (deg)	Wind Load (Pressure) (K)	Beam / Purlin Compression (K)	Aggregate Cable Tension (K)	Relative Stress (%)
1: Roof	1	6.00	2.04	51.96	1.08	1.08	0.88	43.15
2: Wall	1	6.00	2.04	25.64	0.43	0.97	1.08	53.01

F / 4 = 0.97
F = 3.90

Suction Loads

Cable No.	No. of Bays	Diameter (mm)	Capacity F.O.S = 2.5 (k)	Cable Inclination (deg)	Wind Load (Suction) (K)	Beam / Purlin Tension (K)	Aggregate Cable Tension (K)	Relative Stress (%)
1: Roof	1	6.00	2.04	51.96	-1.19	1.19	0.96	47.19
3: Wall	1	6.00	2.04	25.64	-0.55	1.14	1.27	62.05

F / 4 = -1.14
F = -4.56

Note:
1. The aggregate cable tension needed to resist the applied wind load is distributed among the bays with cables.
2. The cable inclination is taken from the beams or purlins.
3. The relative stress is the ratio of the actual load per bay to the cable capacity.

![FTL Happold logo]

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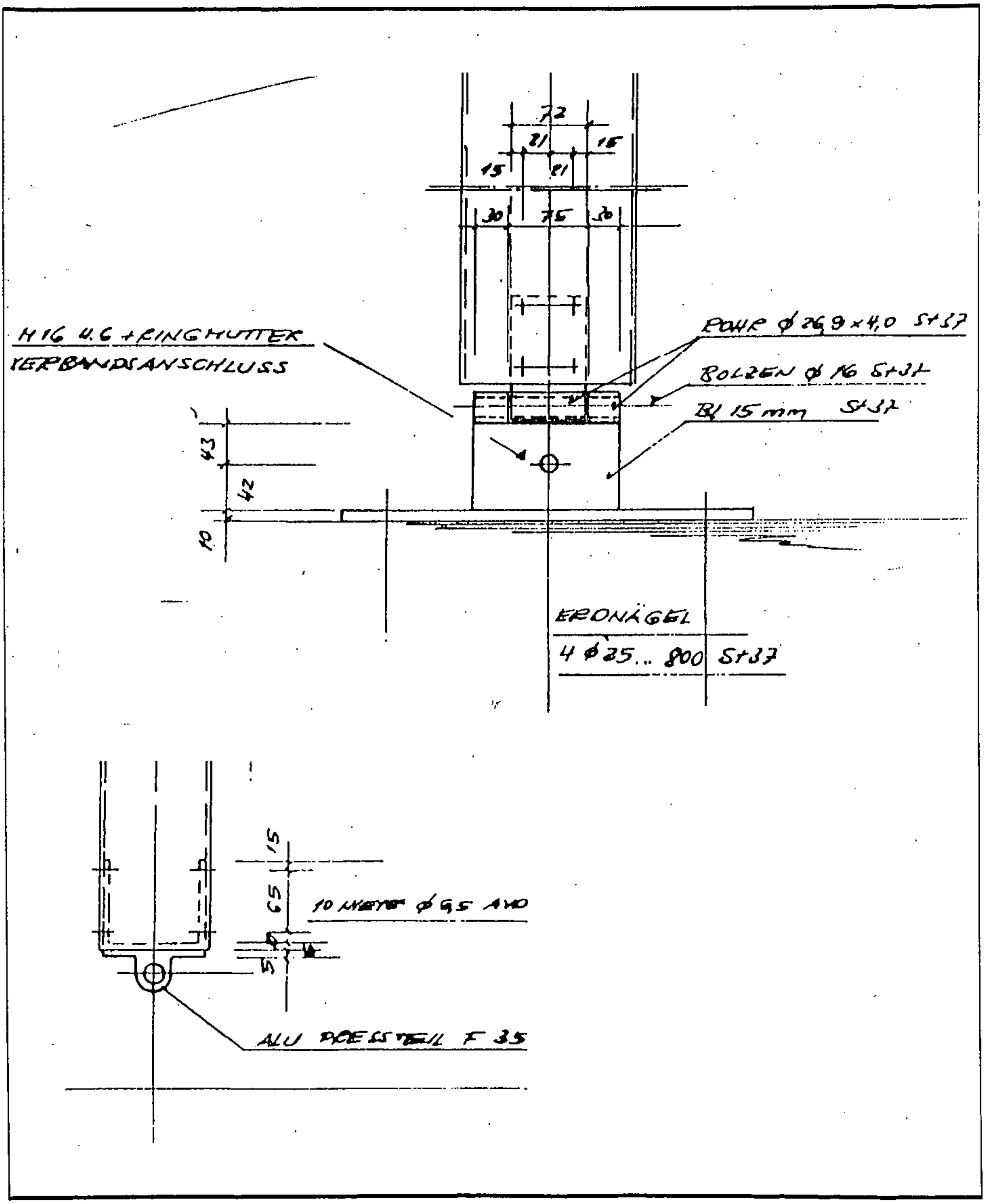
Figure 7-5 Base Connection



7.2.3 Base Plates

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EXTERIOR BASE PLATES 400 X 350 X 10 ST 37

A. MAXIMUM APPLIED LOADS

COMBINATION	DESCRIPTION	P (K)	V (K)	REMARKS
#7	DL + LL	± 0.81	± 0.51	MAXIMUM PRESSURE
#12	DL + W PRESSURE	− 0.26	± 1.83	MAXIMUM SHEAR
#13	DL + W [illegible]	− 2.01	∓ 0.47	MAXIMUM UPLIFT

B. FAILURE CRITERIA

A_{req}, THE MINIMUM REQUIRED BASE PLATE AREA

F_V, ON THE GROUND AREA (ST 37)

THE EFFECTS OF UPLIFT SHALL BE COUNTERACTED BY OTHER ACCEPTABLE MEANS.

C. REQUIRED BASE PLATE AREA & ALLOWABLE SHEAR STRESS

$$A_{req} = \frac{0.81 + (7.87 \times 3.36)10^{-3}}{3\,ksf} = 0.28\ ft^2$$

F_V = 10 KSI AISC MANUAL

D. ACTUAL BASE PLATE AREA & SHEAR STRESS

BEARING AREA

$$A_{prov} = 400(350)(304.8)^{-2} = 1.57\ ft^2$$

SHEAR STRESS ON EACH OF THE 4 ∅ 25 mm RODS

$$A_{25} = 0.25\pi\left(\frac{25}{25.4}\right)^2 = 0.76\ in^2$$

$$f_{v\,25} = \frac{1.83}{4(0.76)} = 0.60\ ksi$$

E. CHECKS & CONCLUSION

SINCE

$A_{prov} = 1.57\ ft^2 > 0.28\ ft^2 = A_{req}$

$f_{v\,25} = 0.60\ ksi < 10\ ksi = F_V$

THEN THE 400 X 350 X 10 EXTERIOR BASE PLATE IS ACCEPTABLE.

IN IMPLEMENTING THE FOUNDATION AND/OR ANCHORAGE SCHEMES, CONSIDERATIONS SHOULD BE GIVEN TO THE MAXIMUM UPLIFT & SHEAR LOAD COMBINATIONS.

Part 8

Acceptability Under Variable Conditions

8.1 Relative Stress Levels

Table 8-1 shows the frame components' loading condition under the standard C-80 wind. It is from this tabulation that the most stressed element is discovered and consequently tested against additional, higher loadings.

8.2 Allowable Exposure Chart

Since it was already proven that the frame can sufficiently withstand C-80 wind pressures, minor calculations can be performed to determine its adequacy for a slightly more severe exposure. This is made valid and possible by the principle of superposition. Reference is made to Appendix C: ROBOT V6 Listings for internal force and moment values at the same node of the critical element or segment for both the static (DL or DL+LL) and the dynamic loading conditions.

Table 8-1 Relative Stress Levels

RELATIVE STRESS LEVELS (AS PERCENTAGES OF THE ALLOWABLE STRESSES)
MAIN AND SECONDARY MEMBERS

ELEMENT	AXIAL (%)	BENDING (%)	SHEAR (%)	BEARING (%)
Rafters	1.14	87.24		
Columns	0.36	69.79		
Gable Struts	1.54	36.71		
Purlins and Beams	13.87			
Roof Cables	47.19			
Wall Cables	62.05			
Base Plates				
Bearing Plate				18.54
Ground Pegs			6.00	

ACCEPTABILITY UNDER VARIABLE WIND PRESSURES (EXPOSURE CLASSES & WIND SPEEDS)

FROM THE TABLE OF RELATIVE STRESS LEVELS & BY INSPECTION, THE CRITICAL FRAME ELEMENT IS EL #2 (RAFTER SECTION). THIS IS TRUE FOR A DESIGNATED C-80 WIND DELIVERING A PRESSURE OF 10.26 psf.

ELEMENT #2 WITH A MAXIMUM MOMENT AT NODE #2

COMBINATION	DESCRIPTION	EL #	ND #	P(K)	M(K')	LENGTH (FT)	MAX @
#12	DL + W PRESSURE	2	2	+0.84	−10.26	20.97	0 L
#6	DL	2	2	−0.21	+1.08	20.97	0 L

MAXIMUM MOMENT @ $q = 12.98$ psf (CLASS C, 90 MPH)

$$MAX\ M = (-10.26 - 1.08)\frac{12.98}{10.26} + 1.08 = -13.27\ k'$$

MAXIMUM AXIAL FORCE @ $q = 12.98$ psf (CLASS C, 90 MPH)

$$MAX\ P = (+0.84 - -0.21)\frac{12.98}{10.26} + -0.21 = +1.12\ k$$

AXIAL & BENDING STRESSES

$$f_t = \frac{P}{A} = \frac{1.12}{2.86} = 0.39\ ksi$$

$$M\ (\text{ASSUMING A SIMPLIFIED LINEAR DISTRIBUTION}) = \frac{20.97 - 1.81}{20.97} \times -13.27 = -12.12\ k'$$

$$f_b = \frac{M}{S} = \frac{12.12 \times 12}{5.09} = 28.58\ ksi$$

UNITY CHECKS WHERE F_t & F_b ARE LIFTED FROM PREVIOUS (7.1.1) CALCULATIONS

$$\frac{f_t}{1.33F_t} + \frac{f_b}{1.33F_b} = \frac{0.39}{1.33(19)} + \frac{28.58}{1.33(19)} = 1.14 > 1.00 \quad \text{NOT GOOD!}$$

THE RESULT IS GREATER THAN UNITY.

THEREFORE, THE MEMBER WILL FAIL AT A CLASS C, 90 MPH OR WORSE EXPOSURE.

SHOWN HEREAFTER IS A WIND PRESSURE CHART FOR THE 12M RODER FRAME TENT. ELIMINATED ARE THE PRESSURES AT WHICH THE STRUCTURE IS NOT ADEQUATELY DESIGNED FOR.

Table 8-2 Allowable Exposure Chart

12 METER RODER FRAME (15.09 FT MAXIMUM HEIGHT)
WIND PRESSURES, q (psf)

Exposure	60 mph	70 mph	80 mph	90 mph
Class A	1.55	2.11	2.75	3.48
Class B	3.34	4.54	5.93	7.51
Class C	5.77	7.85	10.26	~~12.98~~
Class D	7.54	10.26	~~13.41~~	~~16.97~~

The 12 meter version is suitable for up to a Class C, 80 mph or Class D, 70 mph wind exp. The stricken values are the unsuitable pressures for the 12 m Roder Frame Tent.