FTL Happold
Consulting Engineers

LOSBERGER FRAME TENT

STRUCTURAL EVALUATION

(15 M H2.84 – 20 M H3.24)

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2/4/99

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20 M LOSBERGER FRAME TENT STRUCTURAL EVALUATION

Prepared for
Losberger U.S. LLC
December 21, 1998

EVALUATION SUMMARY

This report documents the structural evaluation of the 20 meter Losberger Frame Tent (20 meter H3.24 down to 15 meter H2.84) in accordance with applicable U.S. building codes. This study is based on the technical background information provided by Losberger U.S. LLC. The structure is intended for temporary use only and all of the following load assumptions should not be exceeded at any time for the conclusions of this report to remain valid.

F.T.L./Happold, Incorporated compiled this report based on the existing tent system with reference to the applicable building codes in the U.S. This report includes the loading used in the analysis and gives an indication as to what wind exposure the structure is suitable for. Certification of this document only shows that the Professional Engineer of that particular state is in agreement with the report's contents. It does not, however, imply that the structure is generally suitable for use within that state, or that every installation is covered by the report.

WIND SPEED RATING

Wind Speed	:	80 mph (Fastest Mile Wind Speed)
Exposure	:	Class C (Open Country or Terrain)
Return Period	:	2 Years (Accounts for the Temporary Nature of the Structure)

It has been found that for the abovementioned wind speed, exposure class and return period, the structure satisfies the requirements of the American Society of Civil Engineers: Minimum Design Loads for Buildings and Other Structures (ANSI/ASCE 7-93). In addition, for the above wind speed, exposure class and return period, the structure is also in accordance with the following building code standards in the U.S.:

Uniform Building Code (UBC)
Building Officials and Code Administrators (BOCA)
Southern Building Code Congress Int'l: Standard Building Code (SBCCI-SBC)
South Florida Building Code (SFBC)

As for the other wind speeds and exposure classes, refer to Table 0-1 for rating and allowable installation parameters.

BASE REACTIONS

The maximum forces at the foundations / supports due to the rated load and exposure class are as follows:

Maximum Vertical Down Load	:	1.08 K (Class C, 80 mph)
Maximum Vertical Uplift	:	3.35 K (Class C, 80 mph)
Maximum Shear	:	3.13 K (Class C, 80 mph)

The values given are per base plate.

ALLOWABLE HANGING LOADS ON FRAMES

The maximum allowable live load hung from the rafters is 1000 lbs distributed as follows:

Left Rafter Centerspan	:	250 lbs
Ridge	:	500 lbs
Right Rafter Centerspan	:	250 lbs

ALLOWABLE UNIFORM LIVE LOAD

The 20 meter version can sustain an additional 4.0 psf plan projected download in addition to its dead weight.

ADDITIONAL EXPOSURE AND WIND SPEED COMBINATIONS

The 20 meter version is suitable for up to a Class C, 80 mph wind exposure. For other exposures and wind speed combinations refer to the following chart (where the stricken values are the unsuitable pressures for the tent):

20 METER LOSBERGER FRAME TENT (21.33 FT MAXIMUM HEIGHT)
ANSI/ASCE 7-93 WIND PRESSURES, q (psf)

Exposure	60 mph	70 mph	80 mph	90 mph
Class A	1.60	2.18	2.85	3.60
Class B	3.40	4.63	6.04	7.65
Class C	5.84	7.95	10.39	~~13.15~~
Class D	7.61	10.36	~~13.54~~	~~17.13~~

Table 0-1 20 meter Losberger Frame Tent Allowable Exposure Chart

Exposure classes according to ANSI/ASCE 7-93, p. 14 are defined as follows:

Exposure A

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 20 meter Losberger Frame Tent consists of a series of pin-supported interior frames made up of custom-designed hollow profiles of structural aluminum alloy (Al Mg Si 1 - F31) spanning the tent hall width.

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 speed are investigated in this evaluation. The load cases are illustrated in Figure 4-3. 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. End Frame Elements: Interior Strut Sections

B. Secondary Elements

1. Beams and Purlins
2. Roof and Wall Cables
3. Wall Strut

C. Connections

1. Eave Connections
2. Ridge Connections and Rafter Splices
3. Strut Connections
4. Wind Post Connections
5. Base Connections
6. Cable Connections

The technical background information, design drawings and material properties were made available to F.T.L./Happold, Incorporated by Losberger U.S. LLC 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 20 meter Losberger 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 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 65.62 ft (20 m, 4 bays). At hall lengths of over 164.04 ft (50 m), additional wind bracing fields are to be arranged so that there would be 6 bracing-free fields (30 m) at the most between the wall bracings. The structure in contention is the extrusion box section tent spanning the full 65.88 ft (20.08 m) width and the primary structural assemblages are the aluminum frames.

The schematic elevations show the presence of steel inserts at the ridge, plates at the 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 65.88 ft (20.08 m) span and is considered structurally more critical than the strutted end frame.

Finally, for longitudinal stability, wall cables or struts coupled with high strength cross braced cables and aluminum tubes for the roof are provided. In addition, the purlins, ridge and eaves beams transmit longitudinal forces to the interior frames of the structure.

Figure 2-1 Structural Framing Plan, 20 m H 3.24

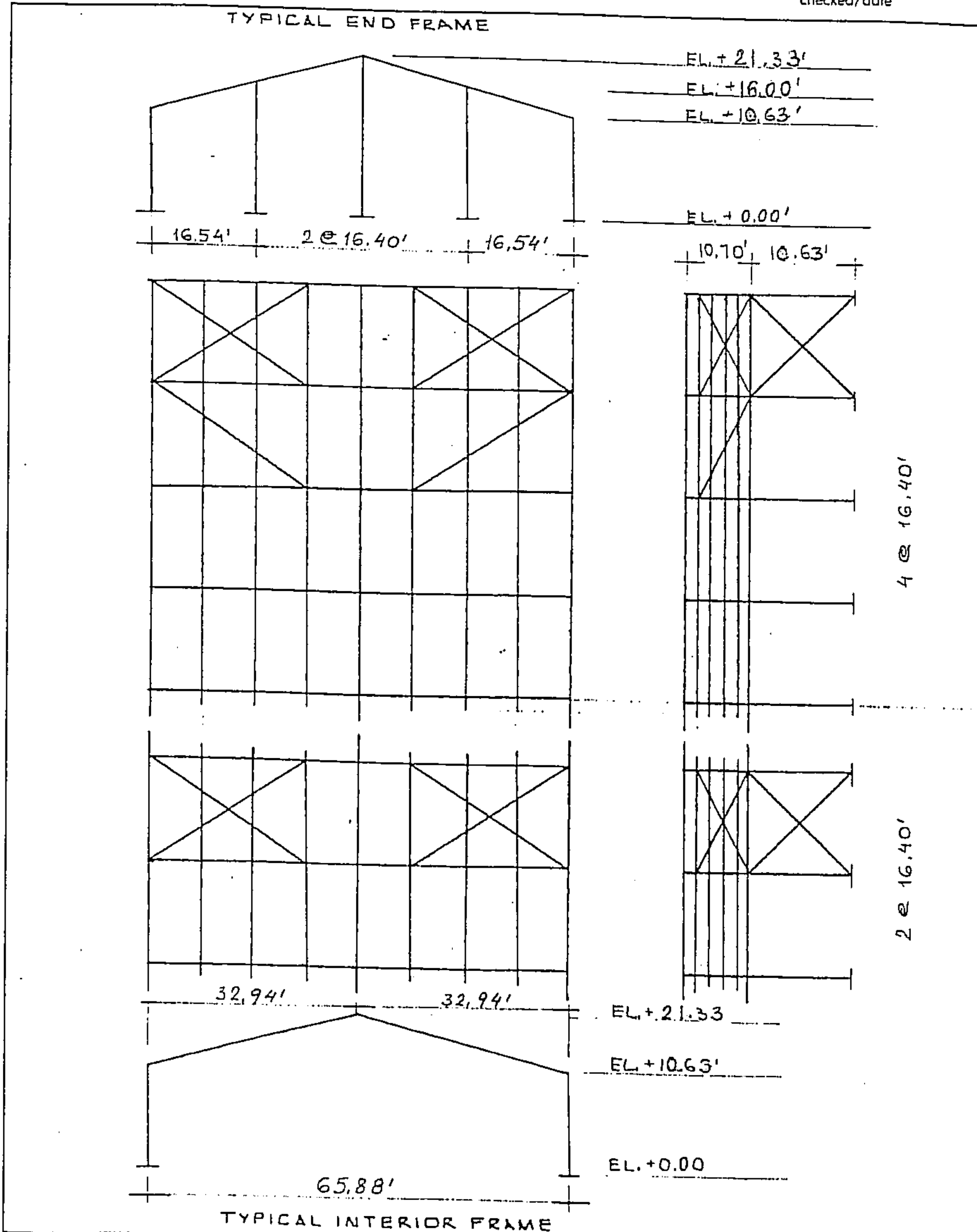

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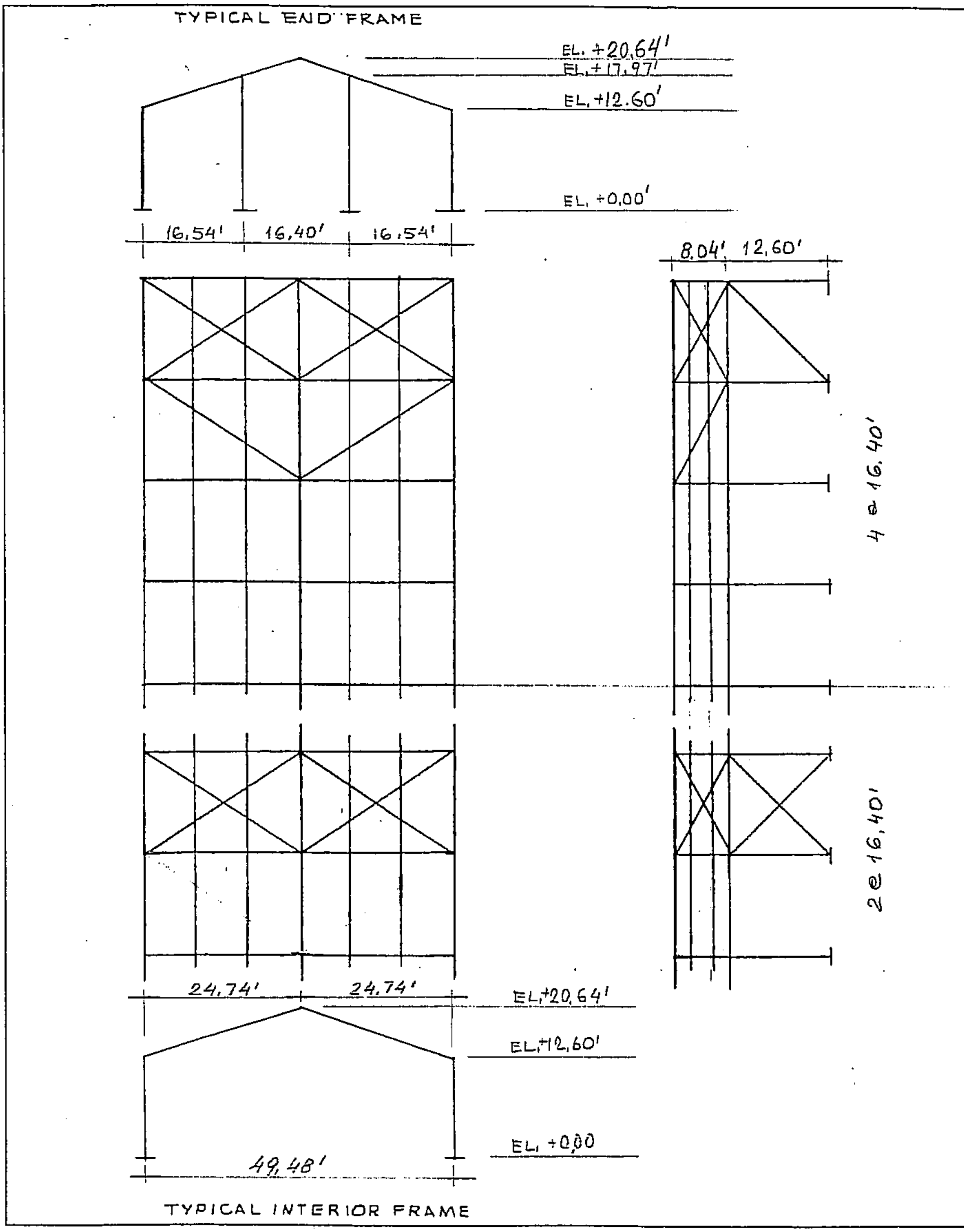
Figure 2-2 Structural Framing Plan, 15 m H 3.84 N. V. Ybañez
checked/date



Part 3

Section and Material Properties

3.1 Section Assignment

Figure 3-1 shows the section assignment for the 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 tent is presented as Table 3-1 in both Imperial and Metric units.

Most aluminum frame tents in the market are made of structural aluminum box sections of Al Mg Si 1 - F28 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.

Fy, yield stress	=	35 Ksi
Fu, ultimate stress	=	38 Ksi

The frames and elements of this tent, however, are made up of F31 aluminum box profiles. This F31 material has a higher yield and ultimate strength than a 6061-T6.

Fy, yield stress	=	38 Ksi
Fu, ultimate stress	=	45 Ksi

Figure 3-1a Section Assignment, 20 m H 3.24 (General)

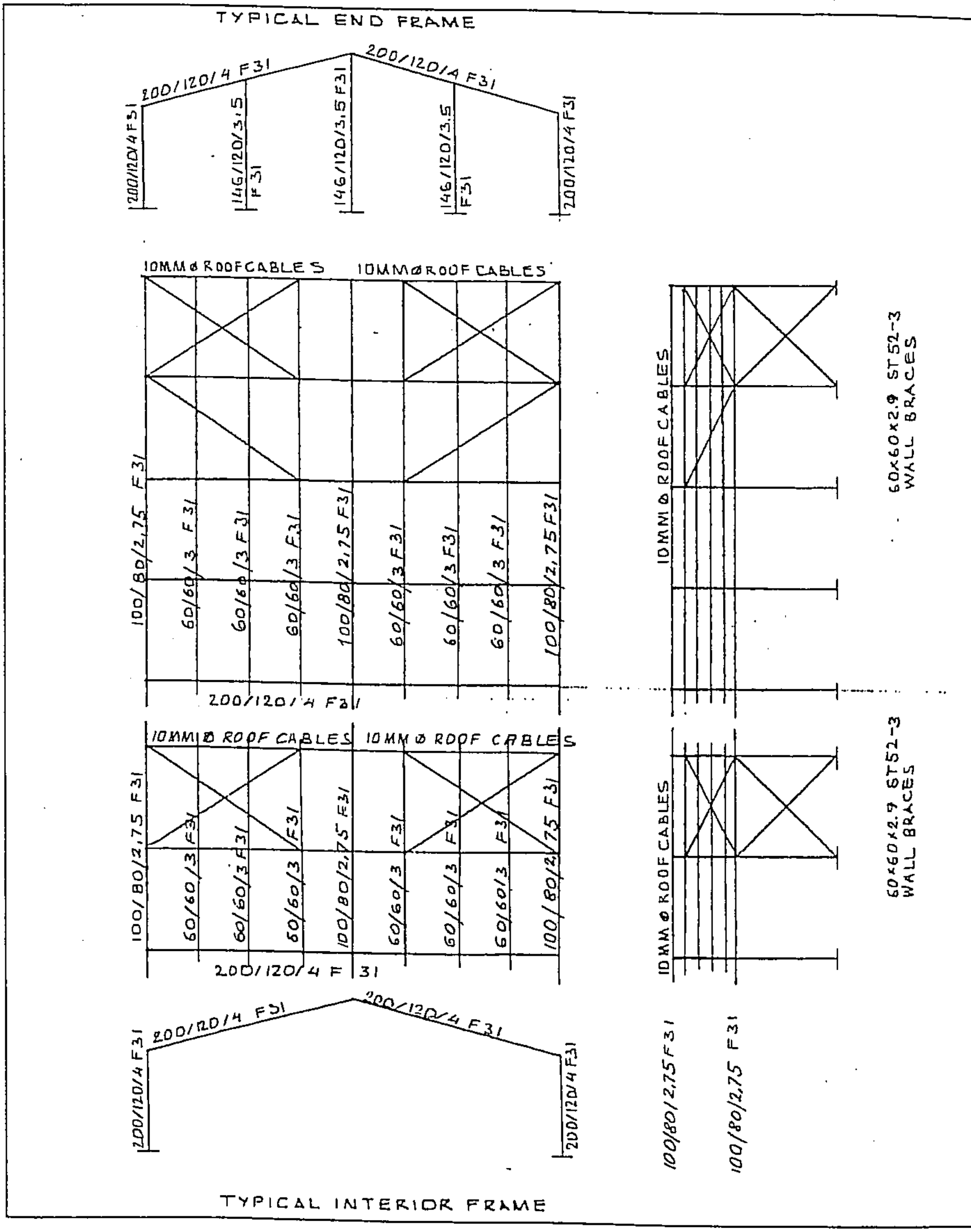


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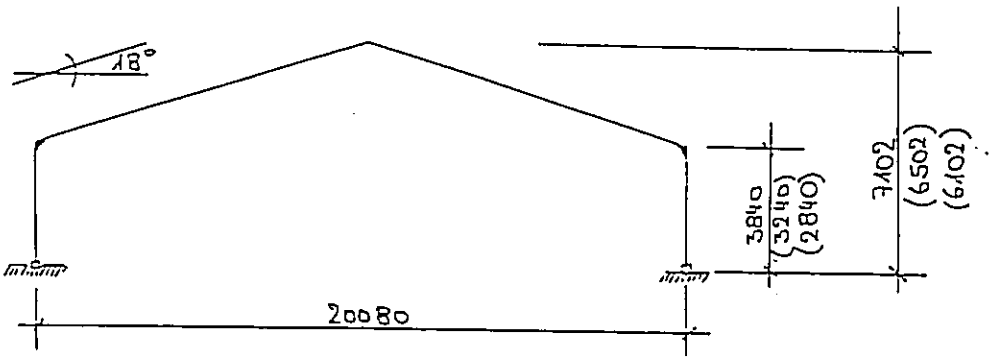
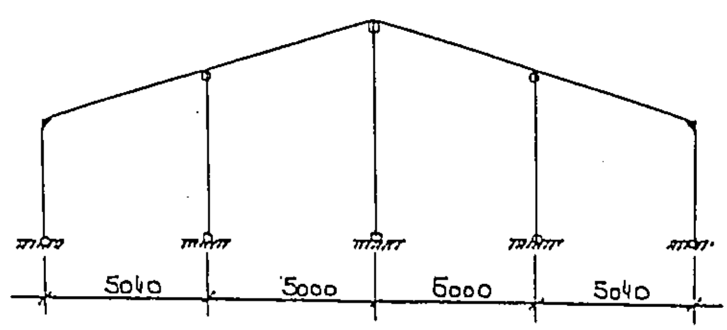
Figure 3-1b Section Assignment, 20 m H 3.24 (Interior and End Wall)

Rahmen - Systeme Typ 20,3/280 bis 20,3/400



Innenrahmen

Rahmen: Riegel: Viernutprofil 200/120/4 mm
Stiel : Viernutprofil 200/120/4 mm



Giebelrahmen

Giebelstiele: Viernutprofil 146/120/3,5 mm

Figure 3-1c Section Assignment, 20 m H 3.24 (Roof)

System des Dachverbandes Typ 20/280 bis 20/400

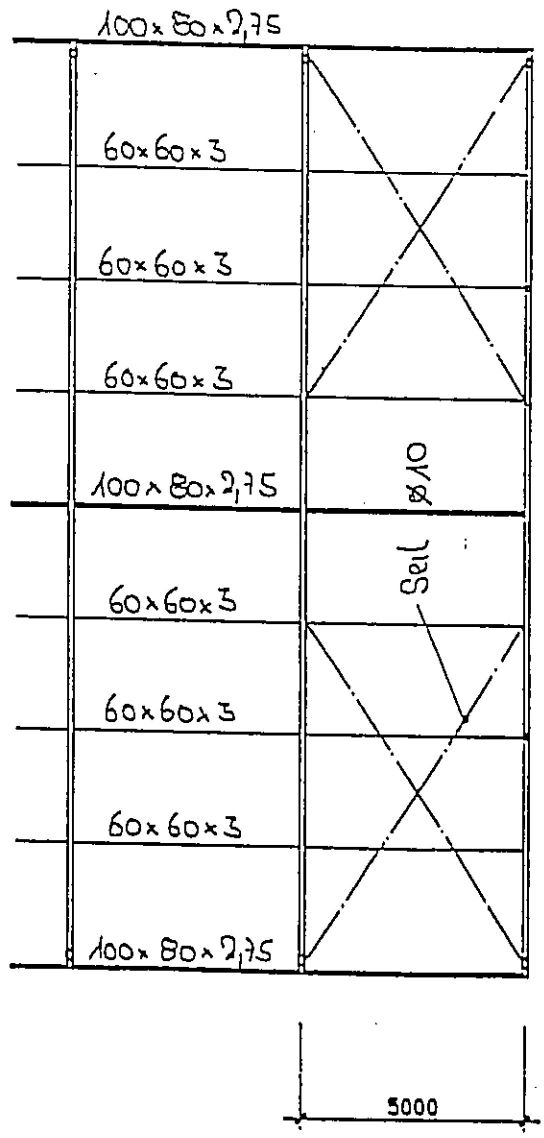
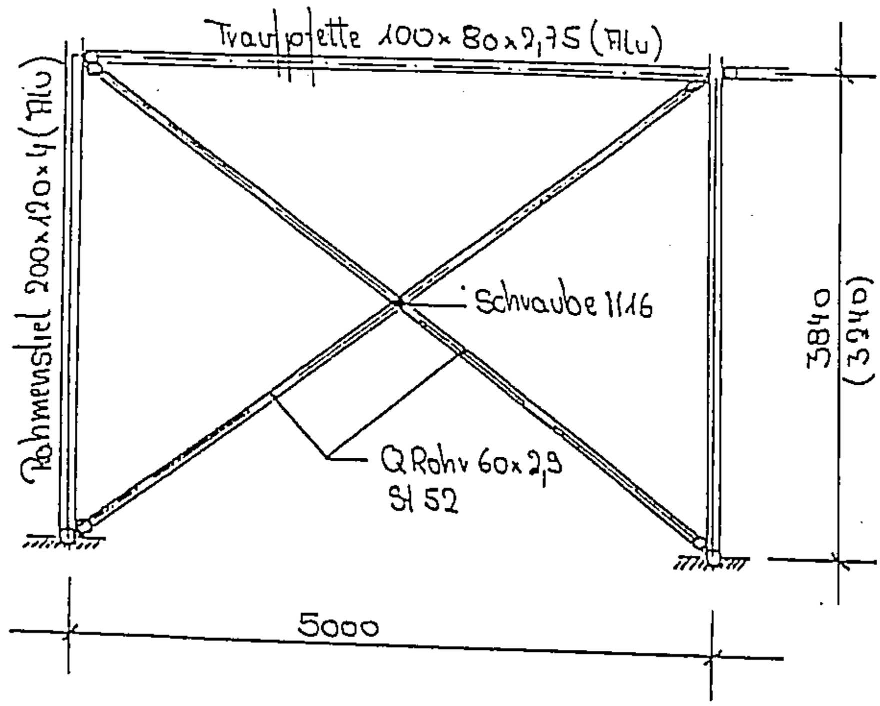


Figure 3-1d Section Assignment, 20 m H 3.24 (Side Wall)

Vertikalverbände der Typen 20/280 bis 25/340 — P O S. 3 a

System M = 1 : 50



Quadratrohr 60*2,9 mm St52

A =	6,55 cm^2		
W =	11,80 cm^3	min i=	2,33 cm

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Figure 3-2a Section Assignment, 15 m H 3.84 (General)

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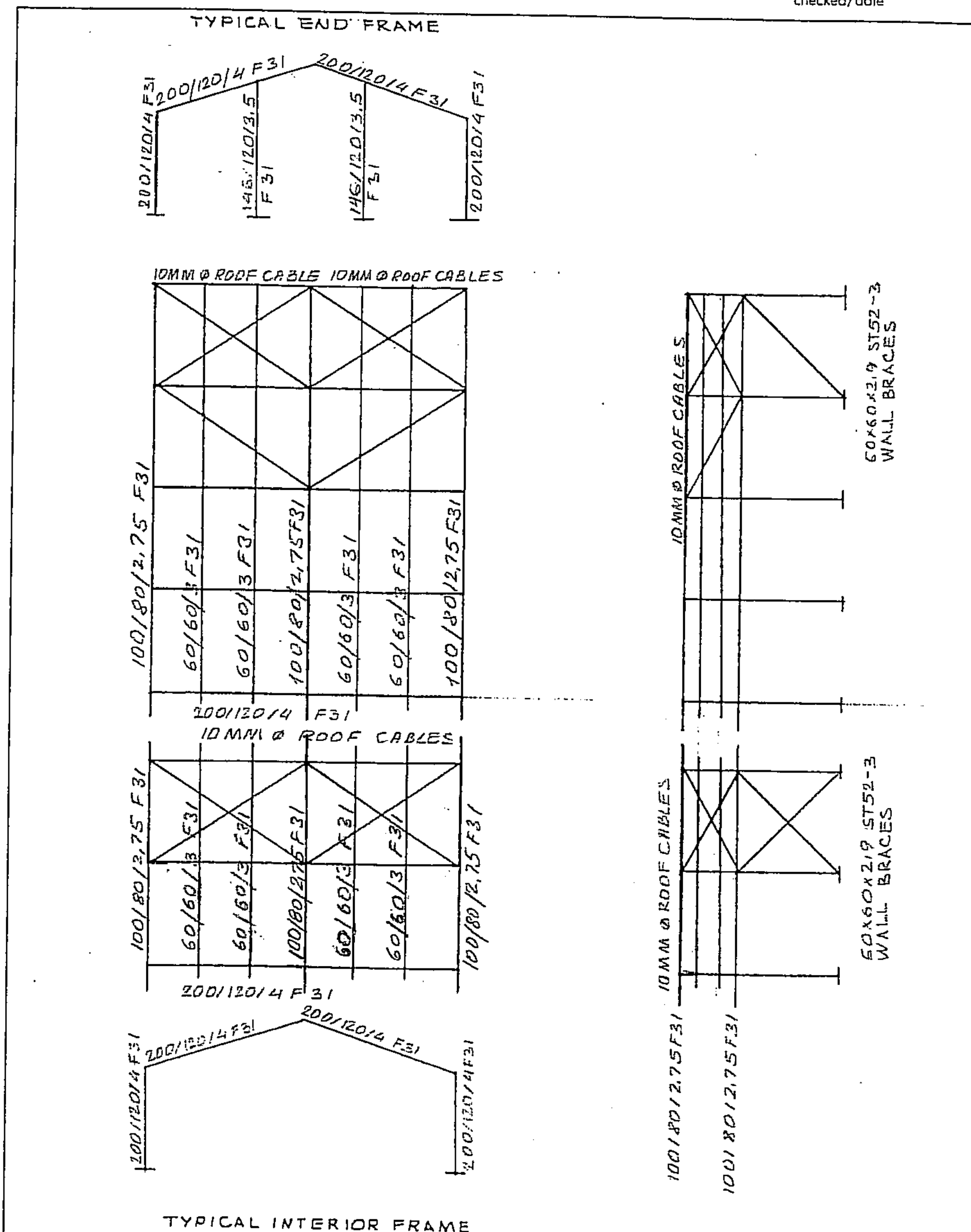

System des Dachverbandes Typ 15/280 bis 15/400

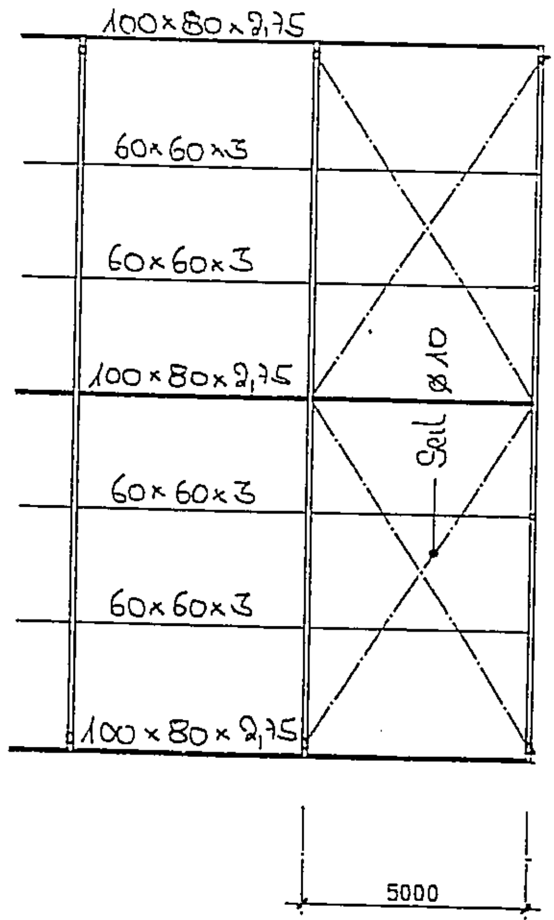

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Figure 3-1c Section Assignment, 15 m H 3.84 (Side Wall)

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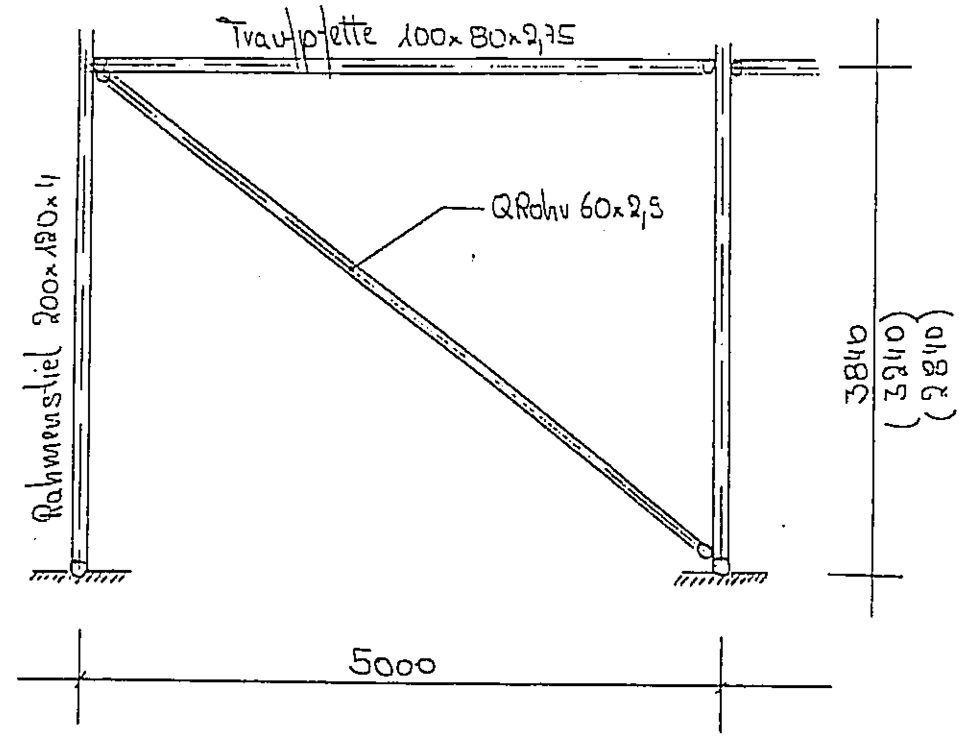
checked/date

Vertikalverbände der Typen 15/280 bis 16/400 P O S. 3 b

System M = 1 : 50



Quadratrohr 60*2,9 mm St52

A =	6,55 cm^2		
W =	11,80 cm^3	min i=	2,33 cm

SECTION PROPERTIES
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Imperial System

Section	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	Al Mg Si 1 - F31	1.06	0.89	0.76	0.92	0.89	0.76	0.92	1.247
100/80/2.75	Al Mg Si 1 - F31	1.97	4.07	2.07	1.44	2.54	1.61	1.13	2.320
146/120/3.5	Al Mg Si 1 - F31	3.38	16.43	5.72	2.21	11.41	4.83	1.84	3.969
189/110	Al Mg Si 1 - F31	6.20	46.09	12.39	2.73	14.27	6.59	1.52	7.291
200/120/4	Al Mg Si 1 - F31	4.61	40.37	10.25	2.96	16.40	6.94	1.89	5.422
Section	Type	Axx (in^2)	Iyy (in^4)	Syy (in^3)	ryy (in)	Izz (in^4)	Szz (in^3)	rzz (in)	Weight (plf)
60/60/2.9	St 52-3	1.03	0.87	0.73	0.92	0.87	0.73	0.92	3.492

SECTION PROPERTIES
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Metric System

Section	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	Al Mg Si 1 - F31	6.84	37.14	12.38	2.33	37.14	12.38	2.33	0.018
100/80/2.75	Al Mg Si 1 - F31	12.73	169.24	33.85	3.65	105.75	26.44	2.88	0.034
146/120/3.5	Al Mg Si 1 - F31	21.78	683.97	93.69	5.60	475.07	79.18	4.67	0.058
189/110	Al Mg Si 1 - F31	40.00	1918.35	203.00	6.93	594.00	108.00	3.85	0.108
200/120/4	Al Mg Si 1 - F31	29.74	1680.47	168.05	7.52	682.53	113.75	4.79	0.079
Section	Type	Axx (cm^2)	Iyy (cm^4)	Syy (cm^3)	ryy (cm)	Izz (cm^4)	Szz (cm^3)	rzz (cm)	Weight (kN/m)
60/60/2.9	St 52-3	6.62	36.09	12.03	2.33	36.09	12.03	2.33	0.051

General Notes:
1. Weights are based on the following densities:
   a. Aluminum: 169.34 pcf (or 26611.83 N/m^3)
   b. Steel: 490.00 pcf (or 77003.83 N/m^3)
2. Refer to the tabulation of cross sectional properties for the corresponding areas.

Part 4

Load Assumptions

A typical interior frame was considered in determining the loads for analysis. The load calculations for the tent were done with the aid of a spreadsheet routine and will mainly consist of a combination of the following: Dead Loads, Live Loads (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 deferred since it would normally be transmitted directly to the foundations.

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 subsequent load calculations. ANSI/ASCE 7-93 standards are recognized by all model building codes including the:

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

4. South Florida Building Code (SFBC).

The following ANSI/ASCE 7-93 factors for the wind pressure calculations apply:

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 used in the evaluation is 0.77. This takes into account the temporary nature of the structure. The basic design wind speeds using I = 1.0 are for a 50 year lifespan. 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.

In the case of temporary structures which do not have a 50 year service life, it is acceptable to design for a shorter wind return period. Based on an assumption for a typical installation of one month, it is reasonable to select a 2 year return period for evaluating wind pressures. This practice is also documented in the British Code 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 analysis. Figure 4-3 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, are graphically illustrated in Figure 4-3 and the eight (8) combinations are summarized in Table 4-2. The frames will be initially analyzed using the Class C, 80 mph wind pressure and will subsequently be tested with the other pressures, if warranted.

STRUCTURE DATA

Frame Width	65.88 ft	
Bay Width	16.40 ft	
Number of Interior Purlins per Rafter	3.00 pcs	60/60/3 F31
Number of Interior Beams per Rafter	0.00 pc	100/80/2.75 F31
Rafter Slope	0.32	

MATERIAL DATA

Section	Weight	Units	Frame Element
60/60/3 F31 Aluminum Profile	1.247	plf	Purlin
100/80/2.75 F31 Aluminum Profile	2.320	plf	Eaves Beam
100/80/2.75 F31 Aluminum Profile	2.320	plf	Interior Beam
100/80/2.75 F31 Aluminum Profile	2.320	plf	Ridge Beam
146/120/3.5 F31 Aluminum Profile	3.969	plf	Interior Strut (End Frame)
200/120/4 F31 Aluminum Profile	5.422	plf	Rafter and Exterior Column
Fabric	0.208	psf	30 oz per square yard

LOAD DATA

Allowances (Minor Components, Cables, Bolts)	3.50 plf
Snow Load	0.00 psf
Left Rafter Centerspan Load	250.00 lbs
Ridge Load	500.00 lbs
Right Rafter Centerspan Load	250.00 lbs

ELEMENT DATA

Column Post	10.63 ft
Rafter	34.63 ft
Roof Pitch	18.00 deg

DATA FOR THE FRAME LOADS

Structure Geometry	
Bay Width	16.40 ft
Frame Geometry	
Total Frame Width	65.88 ft
Total Frame Height	21.33 ft
Column Height	10.63 ft
Rafter (200/120/4 F31)	
Horizontal Span	32.94 ft
Inclination Angle	18.00 deg
Cosine(Angle)	0.95
Length	34.63 ft
Linear Weight	5.42 plf
Ridge Beam (100/80/2.75 F31)	
Span	16.40 ft
Linear Weight	2.32 plf
Interior Beam (100/80/2.75 F31)	
Span	16.40 ft
Number per Rafter	0.00 pc
Linear Weight	2.32 plf
Purlin (60/60/3 F31)	
Span	16.40 ft
Quantity per Rafter	3.00 pcs
Linear Weight	1.25 plf
Eaves Beam (100/80/2.75 F31)	
Span	16.40 ft
Linear Weight	2.32 plf
Fabric	
Tributary Width	16.40 ft
Tributary Height	10.63 ft
Weight	0.21 psf

Figure 4-2 Dead and Live Loads

DEAD LOADS										
Uniform Load Distribution on the Inclined Main Members										
Weight of the Main Member	5.42 plf									
Weight of the Purlins and Beams			1.25 plf	*	16.40 ft	*	3.00 pcs	=	61.36 lbs
			2.32 plf	*	16.40 ft	*	0.00 pc	=	0.00 lbs
	1.77 plf	=	61.36 lbs	/	32.94 ft	*	0.95		
Weight of the Roof Fabric	3.42 plf	=	0.21 psf	*	16.40 ft				
Weight of Minor Components, Cables, Bolts, etc.	3.50 plf								
Total	14.11 plf								
Point Load on the Ridge									
Weight of the Ridge Beam	38.06 lbs	=	2.32 plf	*	16.40 ft				
Total	38.06 lbs								
Point Load on the Eaves									
Weight of the Eaves Beam	38.06 lbs	=	2.32 plf	*	16.40 ft				
Weight of the Wall Fabric	36.33 lbs	=	0.21 psf	*	16.40 ft	*	10.63 ft		
Total	74.39 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 15.98 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:

V1 = 60.00 mph
V2 = 70.00 mph
V3 = 80.00 mph
V4 = 90.00 mph

I Factor	0.77			h/L	0.24	
Gh Factor	h = z	Exp A	Exp B	Exp C	Exp D	
	15.0	2.36	1.65	1.32	1.15	
	20.0	2.20	1.59	1.29	1.14	
Kz Factor	h = z	Exp A	Exp B	Exp C	Exp D	
	15.0	0.12	0.37	0.80	1.20	
	20.0	0.15	0.42	0.87	1.27	
Roof Cp's	h/L	15.0	20.0	degrees		
<=	0.3	0.20	0.20	Cp's		
<=	0.3	-0.90	0.20	Cp's		

EQUATION CONSTANTS

Exposure	q	Gh	Kz	I
Class A	0.00044494 V^2	2.33	0.13	0.77
Class B	0.00094442 V^2	1.64	0.38	0.77
Class C	0.00162307 V^2	1.31	0.81	0.77
Class D	0.00211496 V^2	1.15	1.21	0.77

WIND PRESSURES, q (psf)

Exposure	60 mph	70 mph	80 mph	90 mph
Class A	1.60	2.18	2.85	3.60
Class B	3.40	4.63	6.04	7.65
Class C	5.84	7.95	10.39	13.15
Class D	7.61	10.36	13.54	17.13

DISTRIBUTED WIND LOADS, P (plf)

Exposure	60 mph	70 mph	80 mph	90 mph
Class A	26.28	35.76	46.71	59.12
Class B	55.77	75.91	99.15	125.49
Class C	95.85	130.46	170.40	215.66
Class D	124.90	170.00	222.04	281.02

WINDWARD ROOF PRESSURE COEFFICIENT, Cp (+)

Cp (+) 0.20

WINDWARD ROOF SUCTION COEFFICIENT, Cp (-)

Cp (-) -0.24

LOAD CASES (C-80 EXPOSURE)

Case	q (psf)	P (plf)	Windward Wall: w = Cpw x P	Windward Wall: Cpw	Windward Roof: w = Cpw x P	Windward Roof: Cpr	Leeward Roof: w = Cpw x P	Leeward Roof: Cpr	Leeward Wall: w = Cpw x P	Leeward Wall: Cpw
WSUCTION	10.39	170.40	136.32	0.80	-40.90	-0.24	-119.28	-0.70	-85.20	-0.50
WPRESSURE	10.39	170.40	136.32	0.80	34.08	0.20	-119.28	-0.70	-85.20	-0.50
WPARALLEL	10.39	170.40	-119.28	-0.70	-119.28	-0.70	-119.28	-0.70	-119.28	-0.70

4.4 General Load Cases and Combinations

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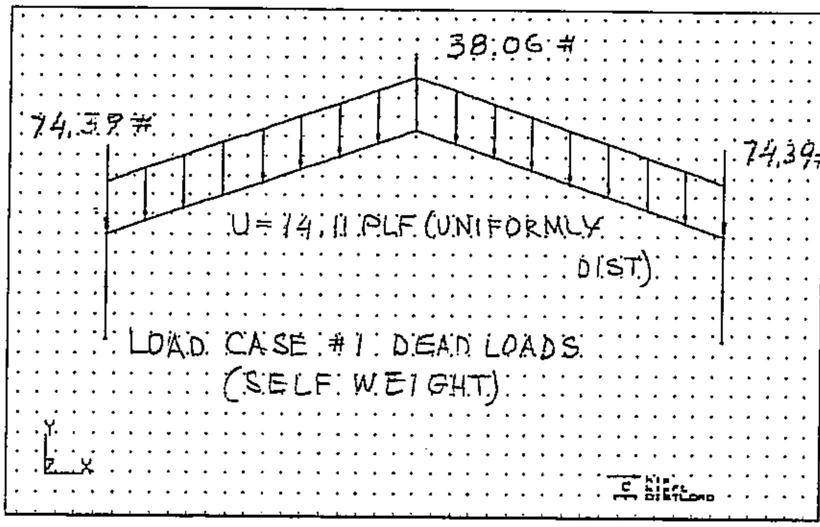
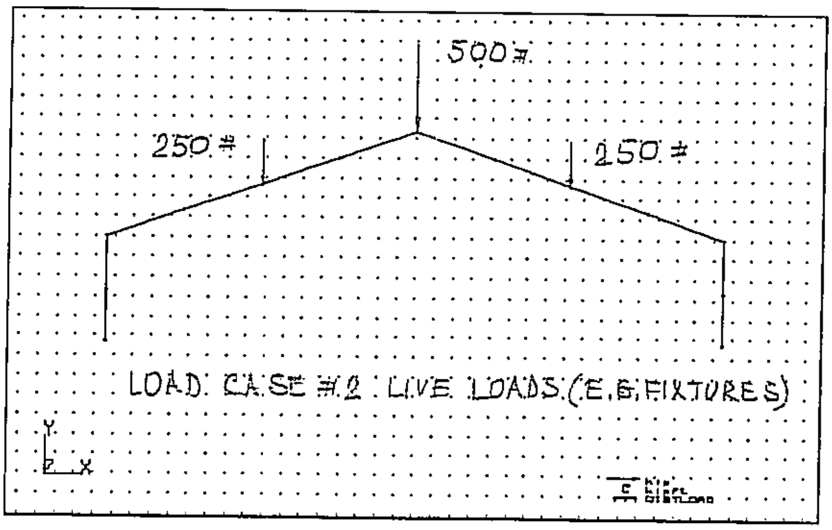
Figure 4-3 Load Case # 1 : Dead Loads
Load Case # 2 : Live Loads
Load Case # 3 : Wind Perpendicular to the Ridge and Suction at the Windward Side of the Roof





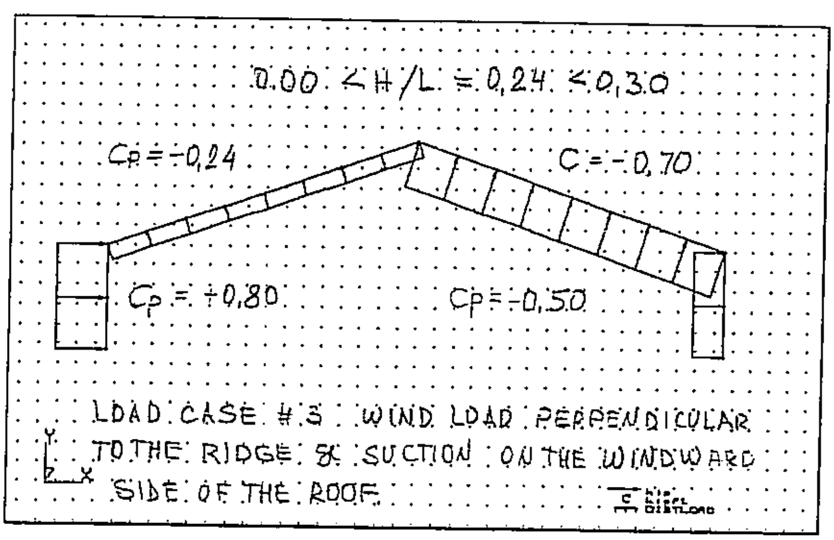
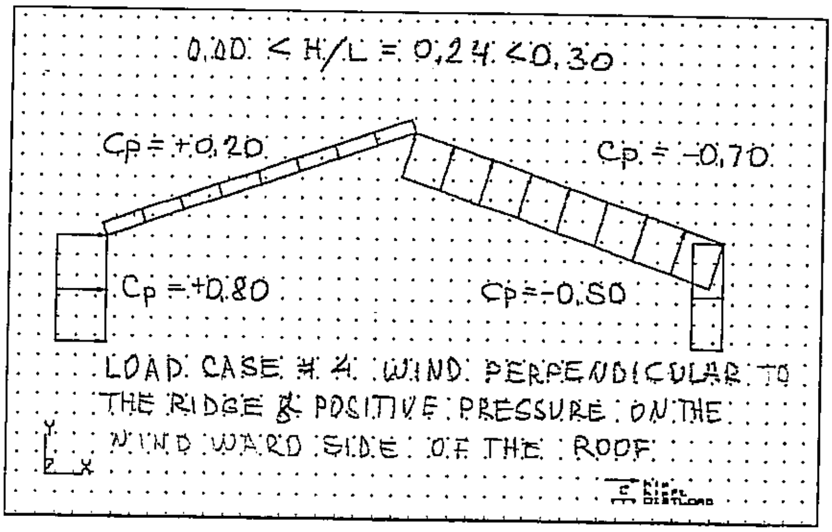


Figure 4-3 Load Case # 4 : Wind Perpendicular to the Ridge and Pressure at the Windward Side of the Roof
Load Case # 5 : Wind Parallel to the Ridge and Suction at All Sides

made by/date
N. V. Ybañez
checked/date



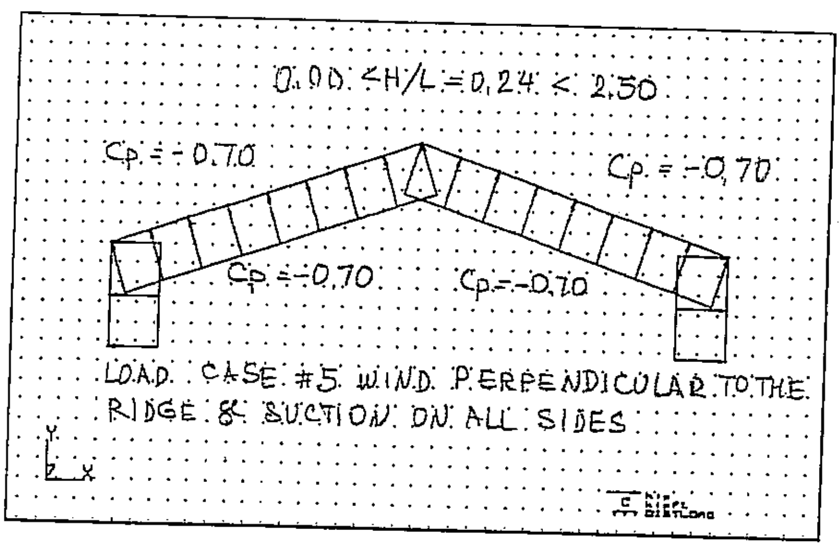


Table 4-2 Load Case and Combination Summary

LOAD CASE SUMMARY

Case No.	Description
1	Dead Loads
2	Live Loads
3	Wind Load Perpendicular to the Ridge Suction on the Windward Side of the Roof
4	Wind Load Perpendicular to the Ridge Positive Pressure on the Windward Side of the Roof
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 Losberger frame is modeled as an assemblage of beam and column segments systematically connected with struts and moment resisting inserts or plates. Releases are set where the components are pinned or bolted to accurately simulate a zero moment condition. These occur at the strut connections and column bases.

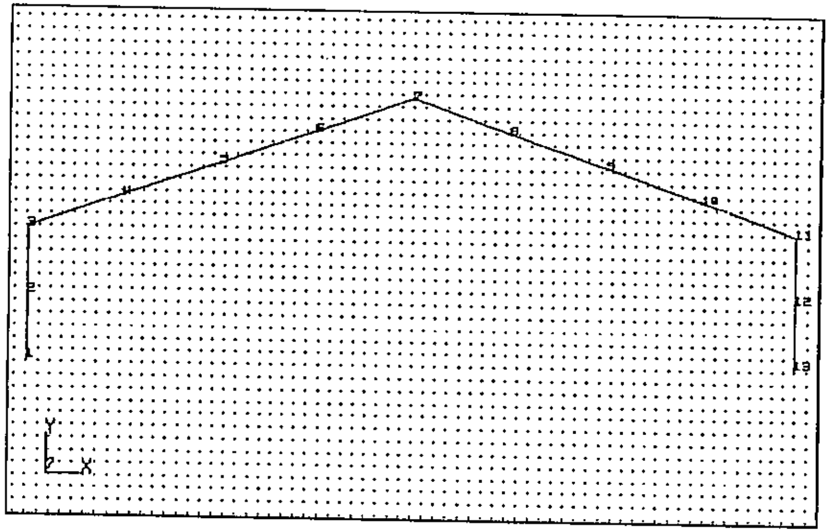
Shown in Figure 5-1 is the typical interior frame with its node labels. To facilitate the model set-up, coordinates are assigned to each node (corresponding to its relative point in space) and element connectivity data are introduced. Support or boundary conditions (pinned supports) are then set to finish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

Figure 5-1 ROBOT V6 Computer Model



Listing of support definitions

Node 1 13
1To13

Node	UX	UY	RZ
1	fixed	fixed	free
13	fixed	fixed	free

Listing of nodes

Node all
1To13

Node	X (ft)	Y (ft)
1	-32.9400000	0.0
2	-32.9400000	5.3150000
3	-32.9400000	10.6300000
4	-24.7050000	13.3060000
5	-16.4700000	15.9810000
6	-8.2350000	18.6570000
7	0.0	21.3330000
8	8.2350000	18.6570000
9	16.4700000	15.9810000
10	24.7050000	13.3060000
11	32.9400000	10.6300000
12	32.9400000	5.3150000
13	32.9400000	0.0

Listing of elements

Element all
1To12

Elem.	Node1	Node2	Length (ft)	Materials	Sections
1	1	2	5.3150000	ALUM	NS_01 .002
2	2	3	5.3150000	ALUM	NS_01 .002
3	3	4	8.6588799	ALUM	NS_01 .002
4	4	5	8.6585709	ALUM	NS_01 .002
5	5	6	8.6588799	ALUM	NS_01 .002
6	6	7	8.6588799	ALUM	NS_01 .002
7	7	8	8.6588799	ALUM	NS_01 .002
8	8	9	8.6588799	ALUM	NS_01 .002
9	9	10	8.6585709	ALUM	NS_01 .002
10	10	11	8.6588799	ALUM	NS_01 .002
11	11	12	5.3150000	ALUM	NS_01 .002
12	12	13	5.3150000	ALUM	NS_01 .002

Losberger 20 m Run No. 1

COORDINATE DATA (METRIC UNITS)

Description	Global X (m)	Global Y (m)
Left Pinned Support	-10.040	0.000
Mid-Column	-10.040	1.620
Left Eaves	-10.040	3.240
Left Rafter, 1/4 L	-7.530	4.056
Left Rafter Live Load Application Point, 1/2 L	-5.020	4.871
Left Rafter, 3/4 L	-2.510	5.687
Ridge	0.000	6.502
Right Rafter, 3/4 L	2.510	5.687
Right Rafter Live Load Application Point, 1/2 L	5.020	4.871
Right Rafter, 1/4 L	7.530	4.056
Right Eaves	10.040	3.240
Mid-Column	10.040	1.620
Right Pinned Support	10.040	0.000

Slope	0.325
Span	20.080 m
Bay Width	5.000 m

COORDINATE DATA (IMPERIAL UNITS)

Description	Global X (ft)	Global Y (ft)
Left Pinned Support	-32.940	0.000
Mid-Column	-32.940	5.315
Left Eaves	-32.940	10.630
Left Rafter, 1/4 L	-24.705	13.306
Left Rafter Live Load Application Point, 1/2 L	-16.470	15.981
Left Rafter, 3/4 L	-8.235	18.657
Ridge	0.000	21.333
Right Rafter, 3/4 L	8.235	18.657
Right Rafter Live Load Application Point, 1/2 L	16.470	15.981
Right Rafter, 1/4 L	24.705	13.306
Right Eaves	32.940	10.630
Mid-Column	32.940	5.315
Right Pinned Support	32.940	0.000

Slope	0.325
Span	65.879 ft
Bay Width	16.404 ft

Figure 5-2 ROBOT V6 Input File (1/2)

```
'The file was used to analyze the 20 m Losberger Frame Tent (3.24 m eaves
'height) using an ANSI/ASCE 7-93 Class C, 80 mph wind load. This analysis
'envelopes those of similar but smaller versions.
'                              q = 10.39 psf

ROBOT

FRAme PLAne

NODes 13 ELEments 12

UNIts
 LENgth=ft  Force=lbs

NODes
```

Nº	X	Y
1	-32.940	0.000
2	-32.940	5.315
3	-32.940	10.630
4	-24.705	13.306
5	-16.470	15.981
6	-8.235	18.657
7	0.000	21.333
8	8.235	18.657
9	16.470	15.981
10	24.705	13.306
11	32.940	10.630
12	32.940	5.315
13	32.940	0.000

```
ELEments
```

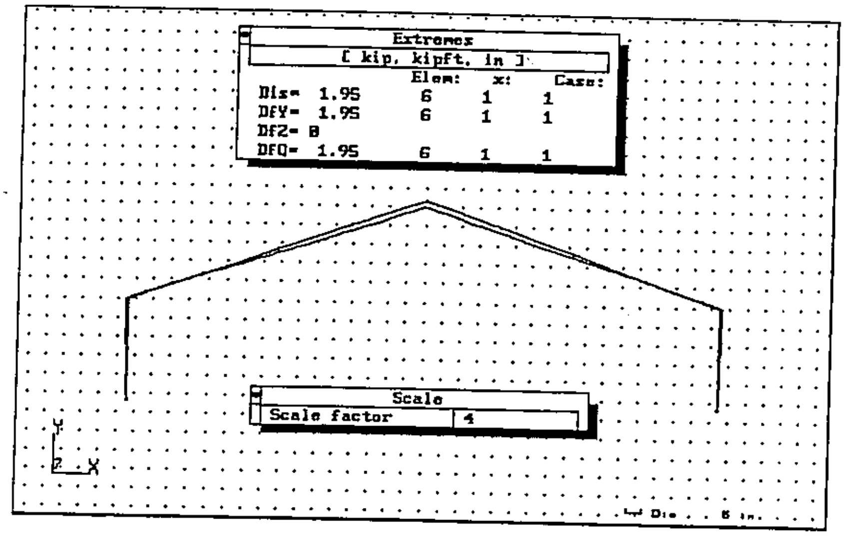
Nº	ORig	END
1	1	2
2	2	3
3	3	4
4	4	5
5	5	6
6	6	7
7	7	8
8	8	9
9	9	10
10	10	11
11	11	12
12	12	13

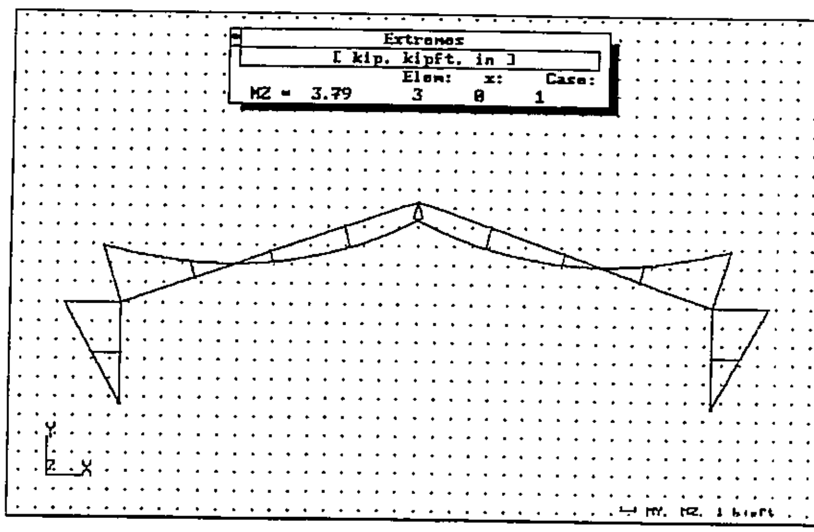
```
PROperties
 ALUM
  RO=169.34
  '200/120/4 F31, AX = 29.74 cm^2 IZ = 1680.47 cm^4
  1To12 AX=0.032012 IZ=0.001947

SUPports
' Label      - free
' No label   - blocked

 1 13 RZ

RELeases
' Label      - free
' No label   - blocked

LOAds
```

Figure 5-2 ROBOT V6 Input File (2/2).

```
CASe # 1 DEAD LOAD
   3 11  FY=-74.39
   7     FY=-38.06
  ELEments
   3To10 PY=-14.11

CASe # 2 LIVE LOAD
   5 9   FY=-250
   7     FY=-500

CASe # 3 WIND SUCTION
  ELEments
   1 2   PX=136.32
   3To6  PY=40.90  LOcal
   7To10 PY=119.28 LOcal
   11 12 PX=85.20

CASe # 4 WIND PRESSURE
  ELEments
   1 2   PX=136.32
   3To6  PY=-34.08 LOcal
   7To10 PY=119.28 LOcal
   11 12 PX=85.20

CASe # 5 WIND PARALLEL
  ELEments
   1 2   PX=-119.28
   3To6  PY=119.28 LOcal
   7To10 PY=119.28 LOcal
   11 12 PX=119.28

COMbination # 6 DL
  1 1

COMbination # 7 DL+LL
  1 1 2 1

COMbination # 8 DL+LL+WSUCTION
  1 1 2 1 3 1

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

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

COMbination # 11 DL+WSUCTION
  1 1 3 1

COMbination # 12 DL+WPRESSURE
  1 1 4 1

COMbination # 13 DL+WPARALLEL
  1 1 5 1

END
```

Figure 5-3 Load Combination #.6 : DL





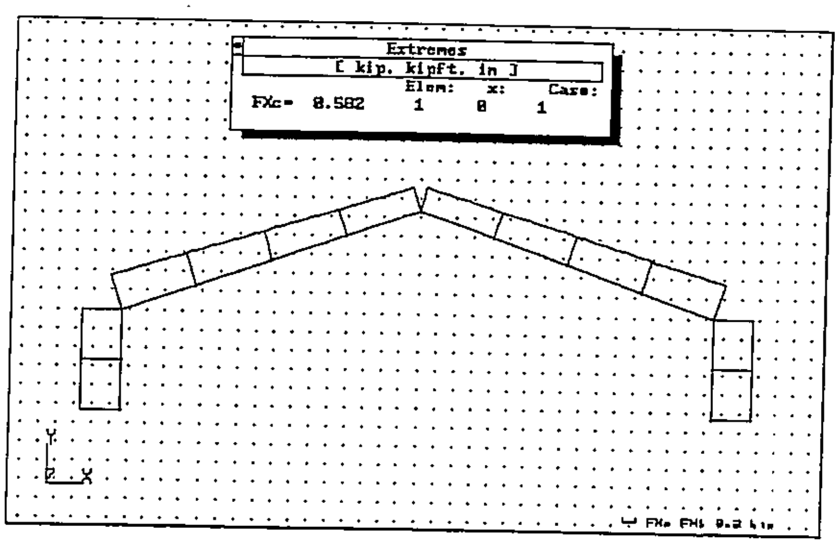
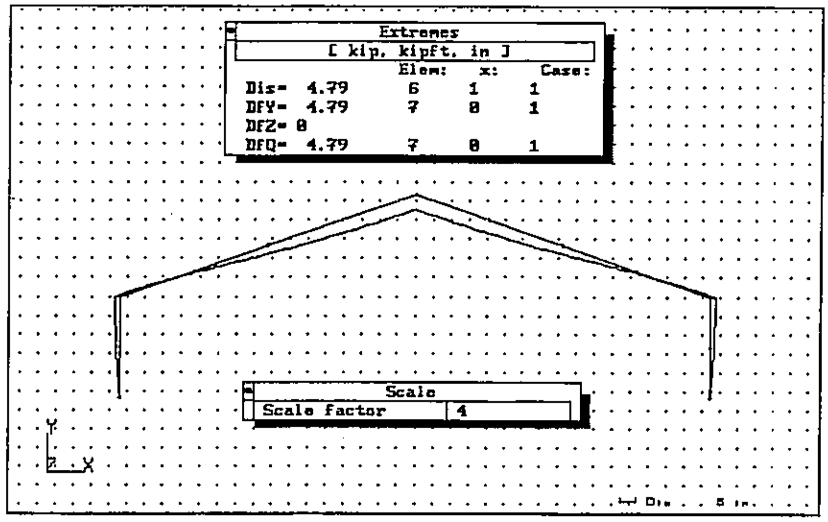
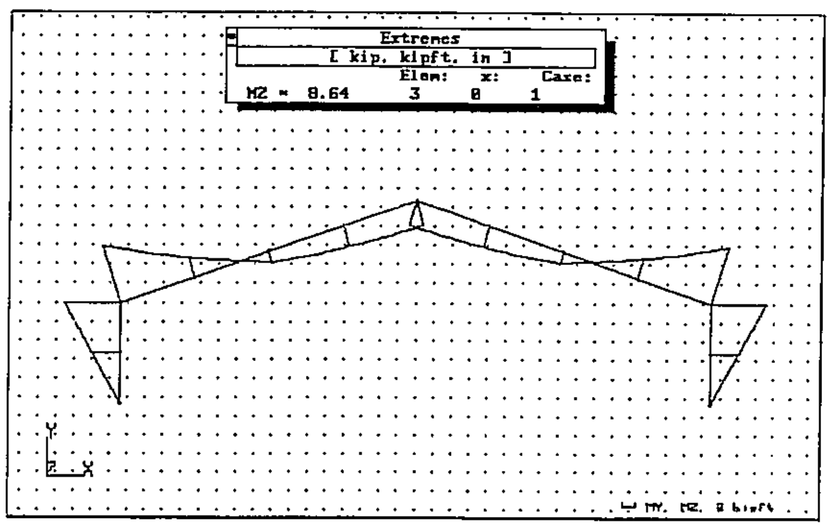


Figure 5-3 Load Combination # 7 : DL + LL





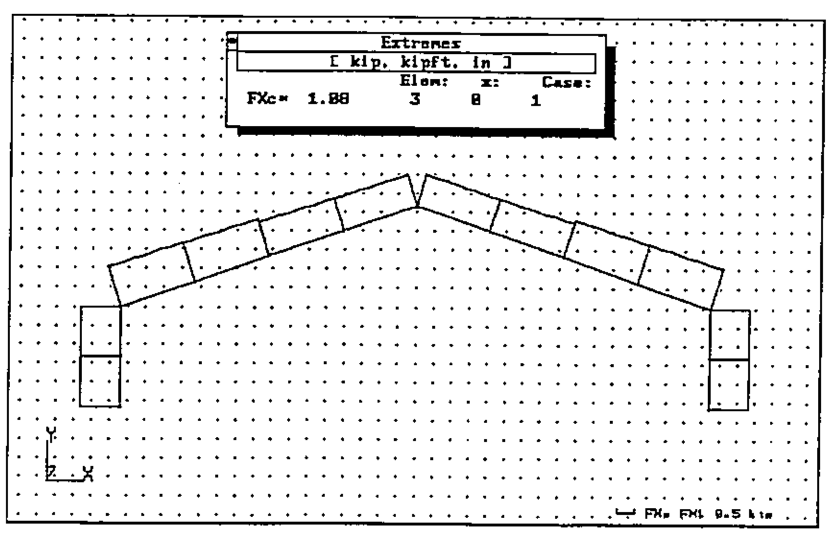
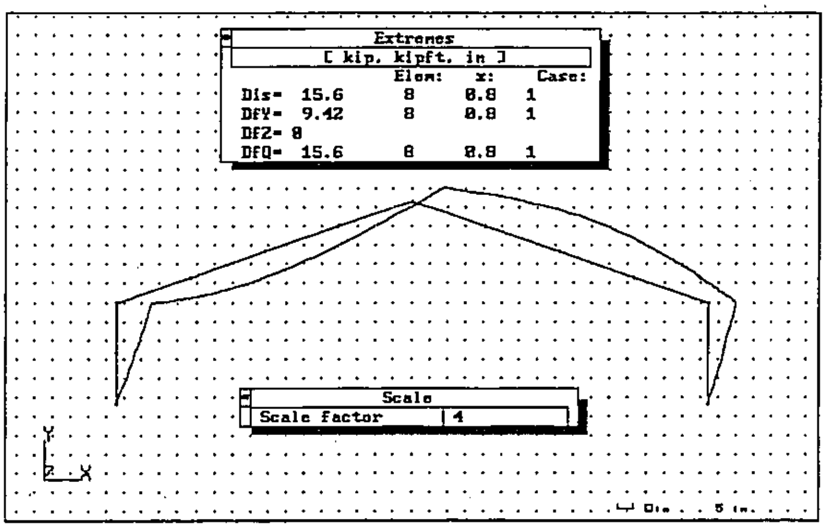
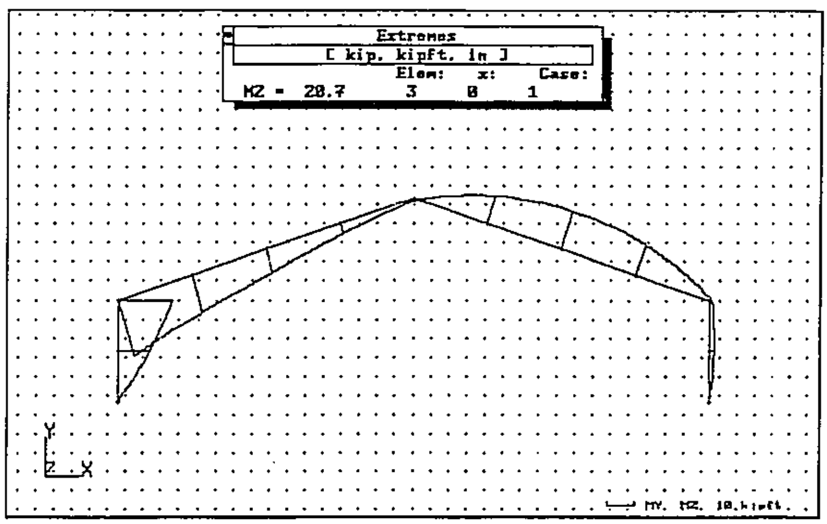


Figure 5-3 Load Combination # 8 : DL + LL + WSUCTION





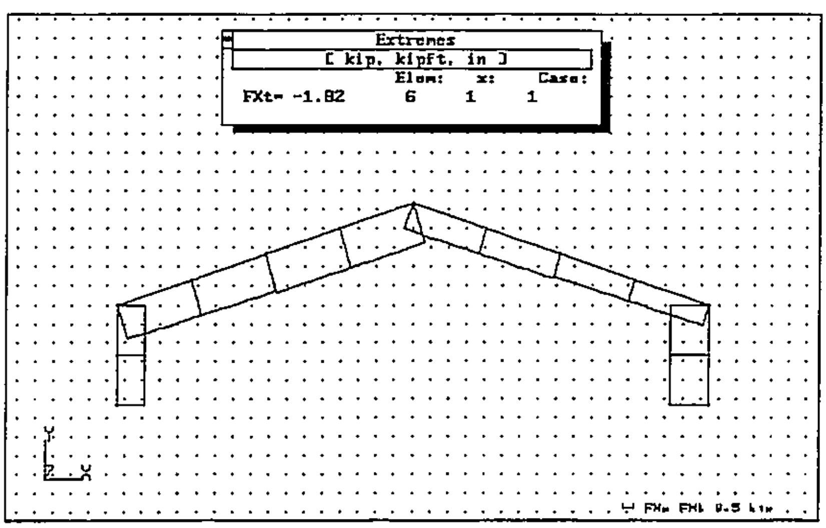


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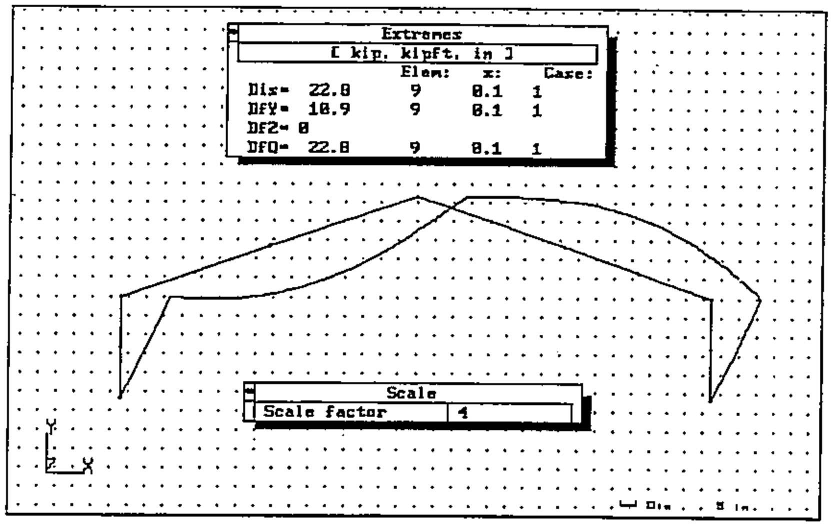
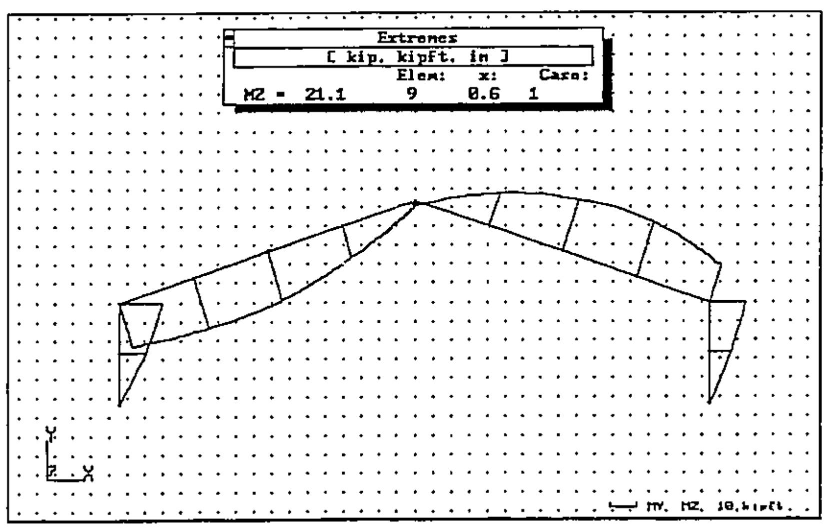
Figure 5-3 Load Combination # 9 : DL + LL + WPRESSURE





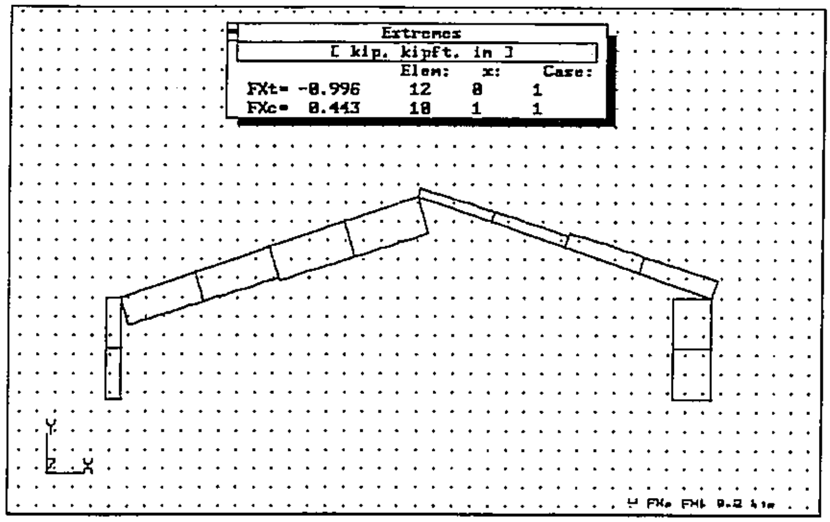
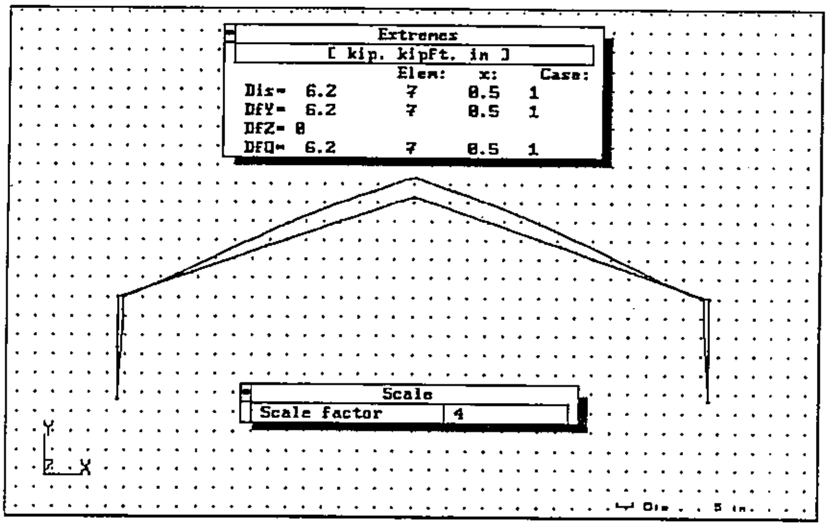
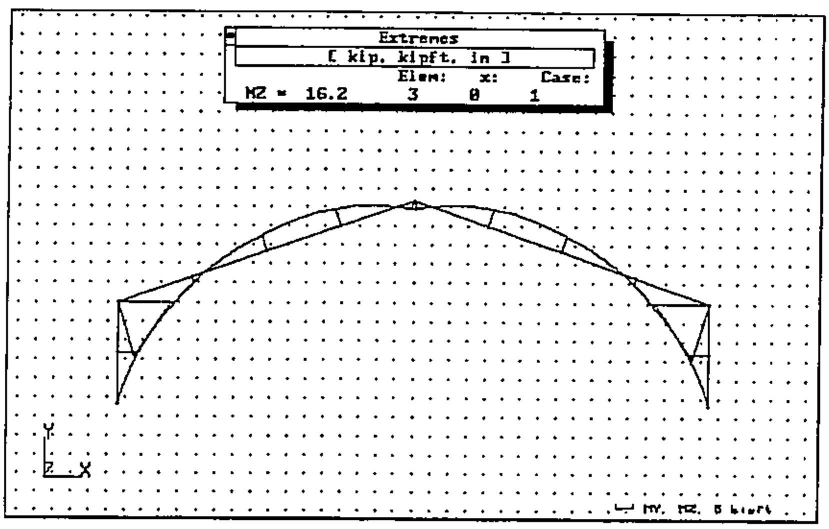


Figure 5-3 Load Combination # 10 : DL + LL + WPARALLEL





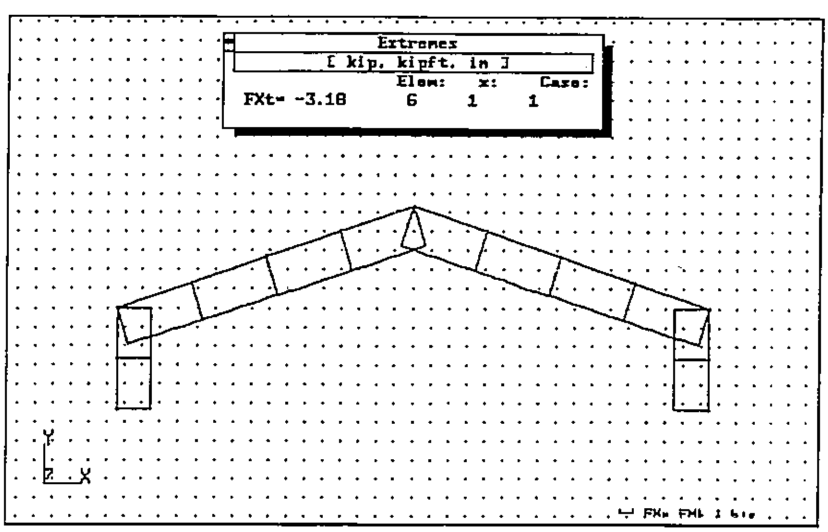


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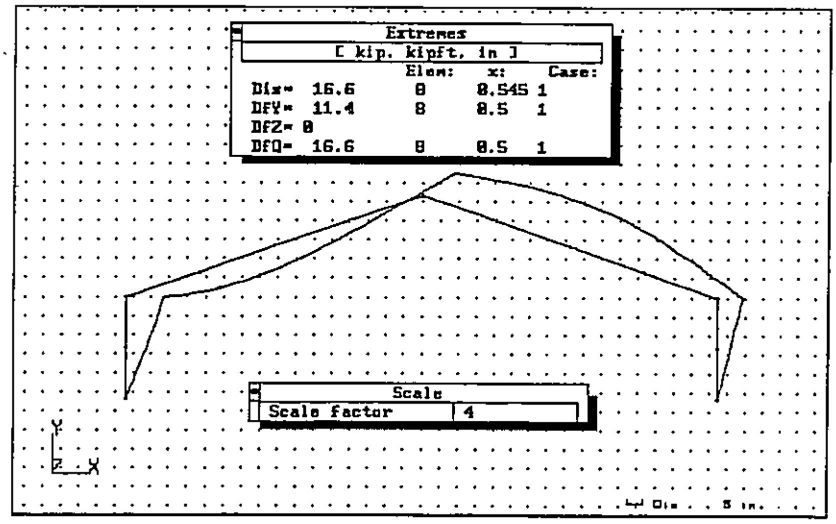
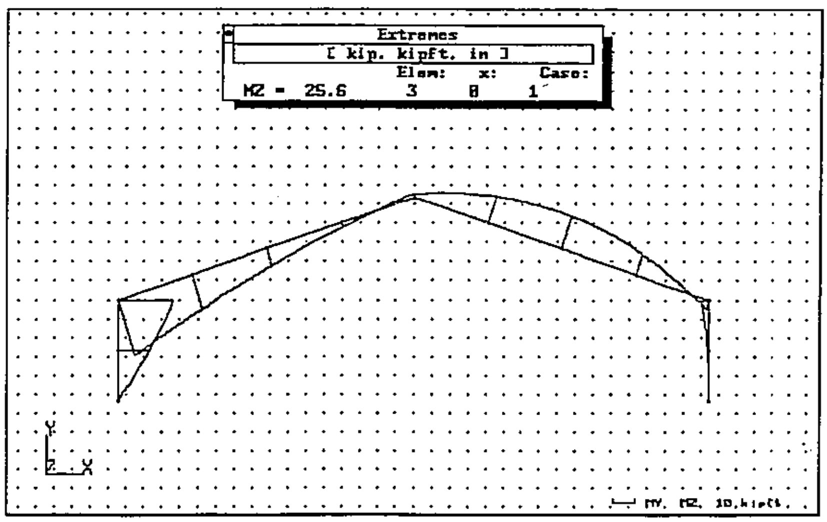
Figure 5-3 Load Combination # 11 : DL + WSUCTION





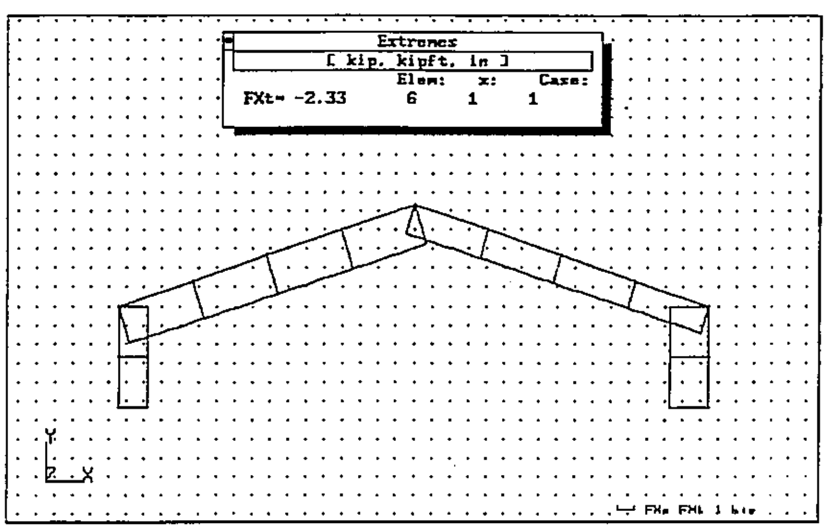


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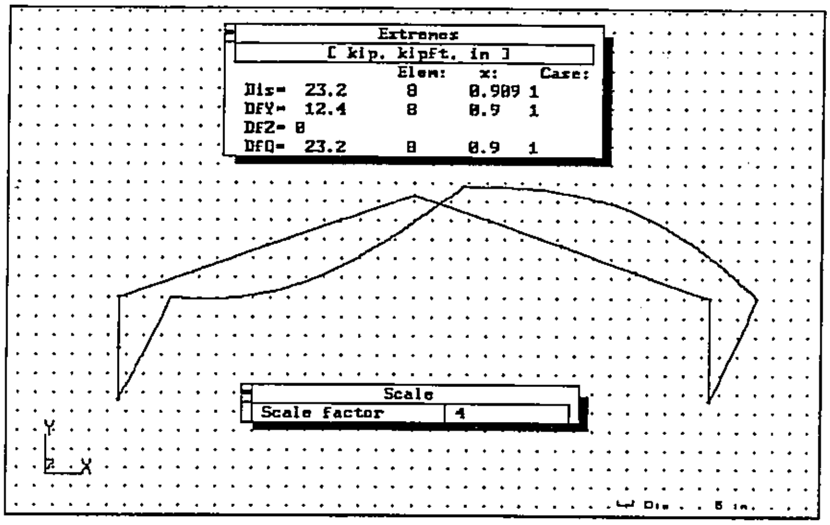
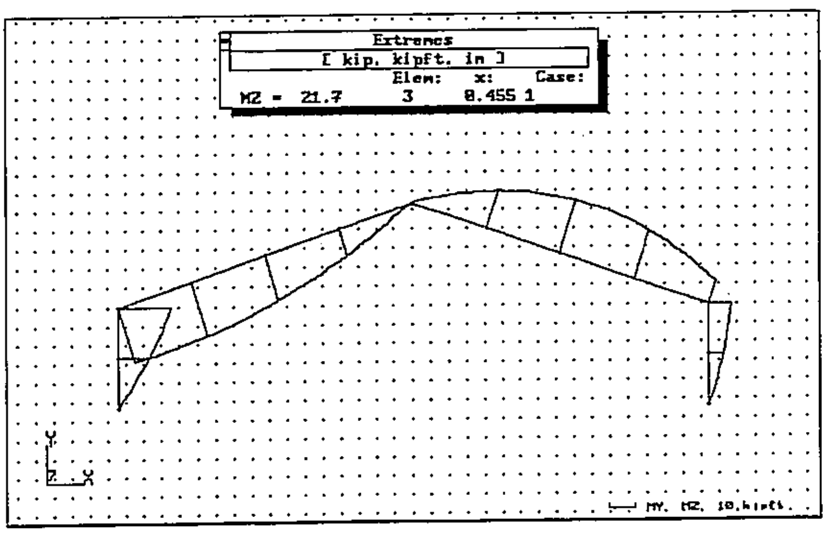
Figure 5-3 Load Combination # 12 : DL + WPRESSURE





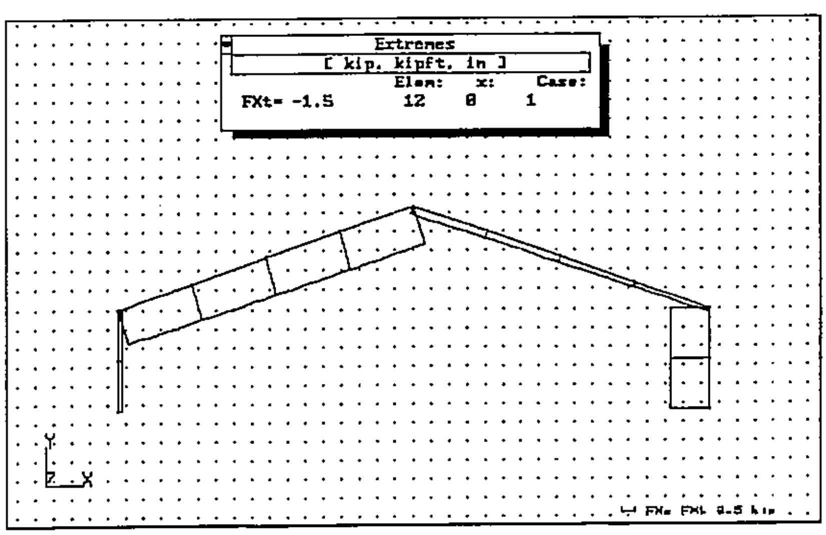


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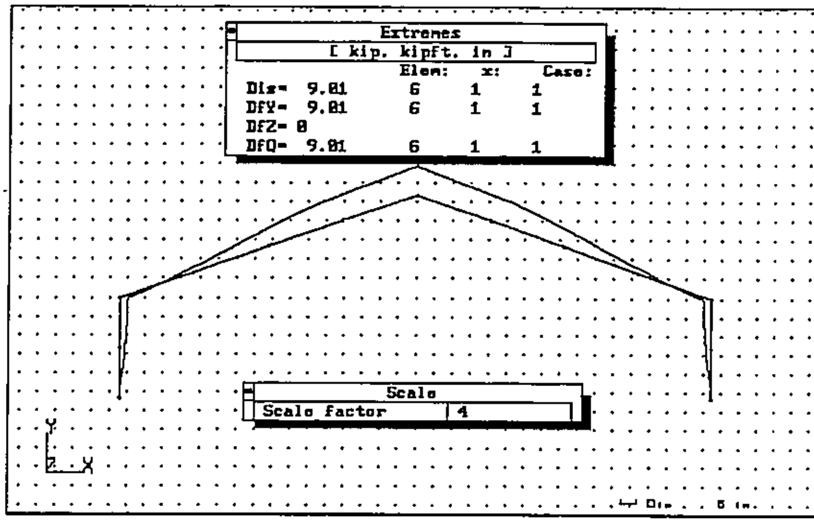
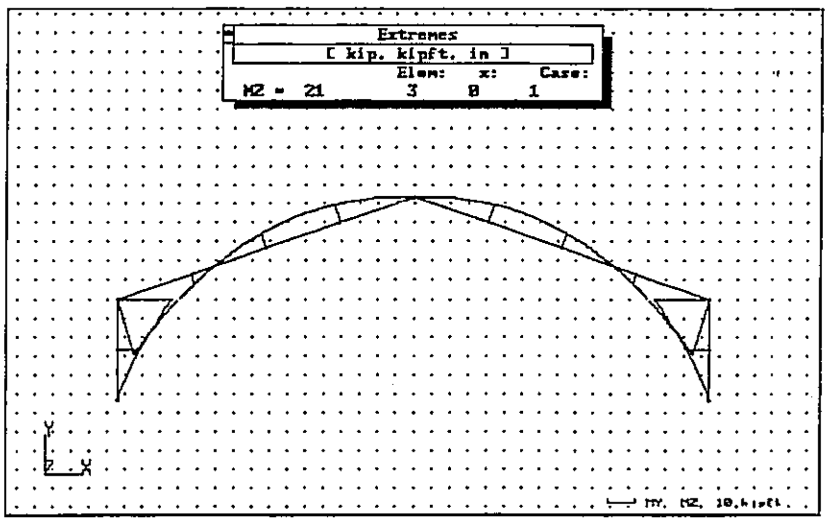
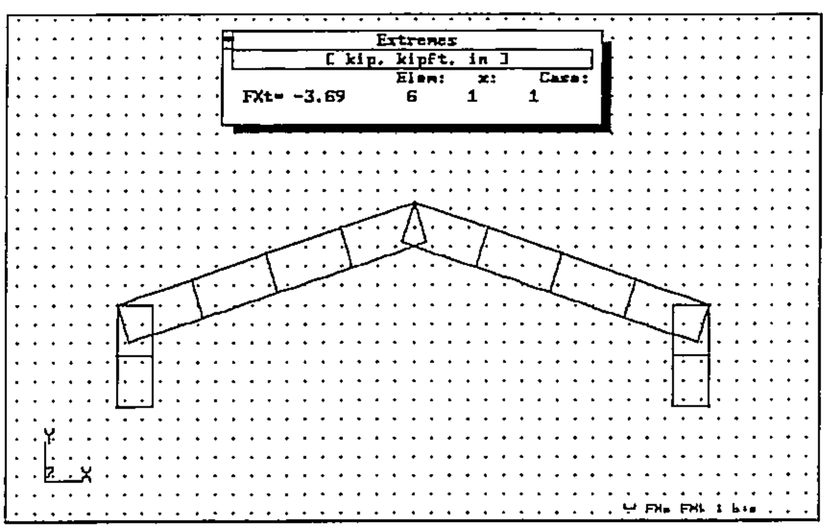
Figure 5-3 Load Combination # 13 : DL + WPARALLEL







5.2.2 Maximum Applied Loads

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Table 5-2 ASCE 7-93 Critical Loads: Rafter

20 M LOSBERGER FRAME TENT
21-Dec-98

RAFTER LOADS

Load Combination (#)	C (K)	T (K)	M (Kft)	Nature	Segment	Length (ft)	Unity Check (%)
6	-0.496		3.786	End Moment	Eave	34.635	
7	-1.084		8.635	End Moment	Eave	34.635	53
8		1.593	-20.747	End Moment	Eave	34.635	
9	-0.390		21.100	Center Moment and Compression	Middle	34.635	86
10		2.955	-16.200	End Moment	Eave	34.635	
11		2.182	-25.597	End Moment	Eave	34.635	100
12		1.308	-21.700	End Moment	Eave	34.635	
13		3.544	-21.049	End Moment	Eave	34.635	83

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Table 5-2 ASCE 7-93 Critical Loads: Column

20 M LOSBERGER FRAME TENT
21-Dec-98

COLUMN LOADS

Load Combination (#)	C (K)	T (K)	M (Kft)	Nature	Segment	Length (ft)	Unity Check (%)
6	-0.582		3.786	End Moment	Eave	10.630	
7	-1.082		8.635	End Moment	Eave	10.630	48
8		1.304	-20.747	End Moment	Eave	10.630	
9	-0.354		-16.501	End Moment	Eave	10.630	64
		0.996	13.463	End Moment	Eave	10.630	
10		2.847	-16.200	End Moment	Eave	10.630	
11		1.804	-25.597	End Moment	Eave	10.630	100
12		0.146	-21.350	End Moment	Eave	10.630	
13		3.347	-21.049	End Moment	Eave	10.630	83

Table 5-2 ASCE 7-93 Critical Loads: Joint Moments

JOINT MOMENTS

Load Combination (#)	Left Eaves (Kft)	Ridge (Kft)	Right Eaves (Kft)
6	3.786	-1.078	3.786
7	8.635	-3.699	8.635
8	-20.747	-0.842	0.686
9	-16.501	-1.951	13.463
10	-16.200	-2.445	-16.200
11	-25.597	1.779	-4.164
12	-21.350	0.670	8.614
13	-21.049	0.176	-21.049

20 M LOSBERGER FRAME TENT
18-Dec-98

MAXIMUM BASE REACTIONS

Criteria	ANSI/ASCE 7-93 Load Combination	Fx (K)	Fy (K)
Maximum Vertical Download	LC # 7: DL + 1000 lbs LL		1.082
Maximum Vertical Uplift	LC # 13: DL + WPARALLEL		-3.347
Maximum Horizontal Shear	LC # 11: DL + WSUCTION	-3.133	

Part 6

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 American Institute of Steel Construction Manual:

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.

20 Meter Losberger Frame Tent

The 20 meter Losberger Frame Tent, with an eaves height of 10.63 ft, was analyzed with design loads corresponding to a Class C exposure, 80 mph wind. The following were calculated in Part 4.3:

$$q = 10.39 \text{ psf}$$
$$P = 170.40 \text{ plf}$$

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

The analyses using the other wind pressures will be deferred until Part 7: Acceptability Under Variable Exposure and Wind Conditions. This section will only investigate the effects of the Class C, 80 mph wind forces to facilitate the determination of the most critical frame element.

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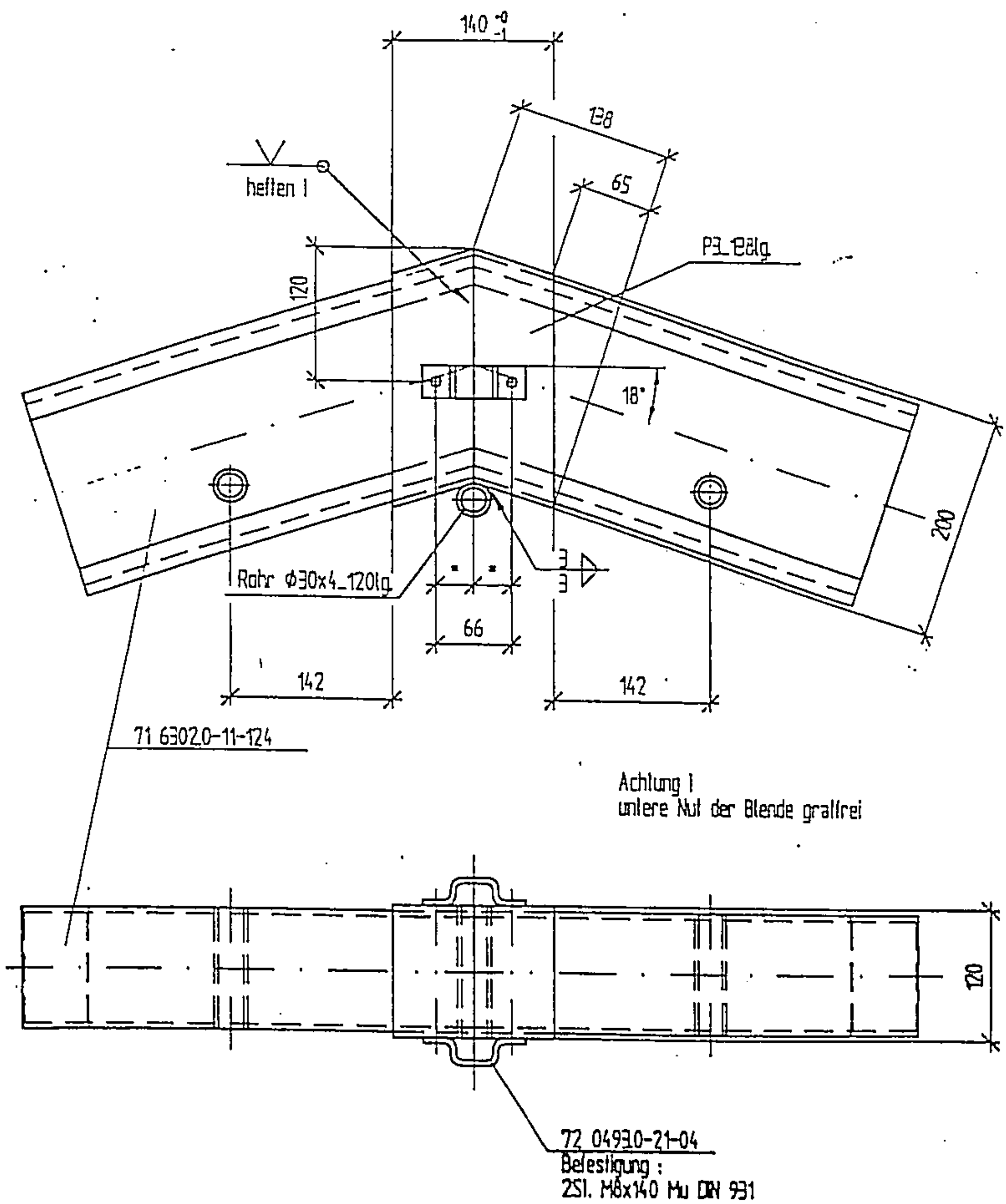
N. V. Ybañez
checked/date

Figure 6-1 Ridge Joint



Main Flexural Framing Members, 200/120/4 F31 Rafter Section (Case 1)

A. Maximum Applied Loads

Combination (#)	Description	Element (#)	Node (#)	Tension (K)	Moment (Kft)	Length (ft)
11	DL + WSUCTION	3 to 6	3 and 7	2.182	-25.597	34.635
13	DL + WPARALLEL	3 to 6	3 and 7	3.544	-21.049	34.635

B. Failure Criterion

Unity check for combined axial and flexural stresses.

C. Allowable Stresses

For an Al Mg Si 1 - F31 Aluminum alloy:

Fty = Fcy = 37.7 Ksi
Ftu = 45.0 Ksi

Tension on the net axial section of any tension member

Ft = Fty / Ny = $\frac{37.7}{1.65}$ = 22.9 Ksi or

Ft = Ftu / Kt Nu = $\frac{45.0}{1.95}$ = 23.1 Ksi (Kt = 1.0)

Ft = min(Ft) = 22.9 Ksi (allowable tensile stress)

Flexure on the extreme fibers in beams

For the extreme tension fiber:

Fbt = Fty / Ny = $\frac{37.7}{1.65}$ = 22.9 Ksi or

Fbt = Ftu / Kt Nu = $\frac{45.0}{1.95}$ = 23.1 Ksi (Kt = 1.0)

Fbt = min(Fbt) = 22.9 Ksi

For the extreme compression fiber:

Fbc = Fcy / Ny = $\frac{37.7}{1.65}$ = 22.9 Ksi if Lb Sc / ly < 122

Lb = 8.69 ft max = 104.32 in

Lb Sc / ly = 104.32 x $\frac{10.25}{16.40}$ = 65.24 < 122 Good!

Fbc = 22.9 Ksi

In general, use the minimum Fb.

Fb = 22.9 Ksi (allowable flexural stress)

Analyze Case 1.1

D1.1. Working Stresses

Tension

ft = T / A = $\frac{2.18}{4.61}$ = 0.47 Ksi

Flexure

fb = 12 M / S = $\frac{25.60}{10.25}$ x 12 = 29.95 Ksi

E1.1. Unity Check and Conclusions

$\frac{ft}{1.33\ Ft} + \frac{fb}{1.33\ Fb} < 1.00$

$\frac{0.47}{30.47} + \frac{29.95}{30.47} = 1.00 < 1.00$ Good!

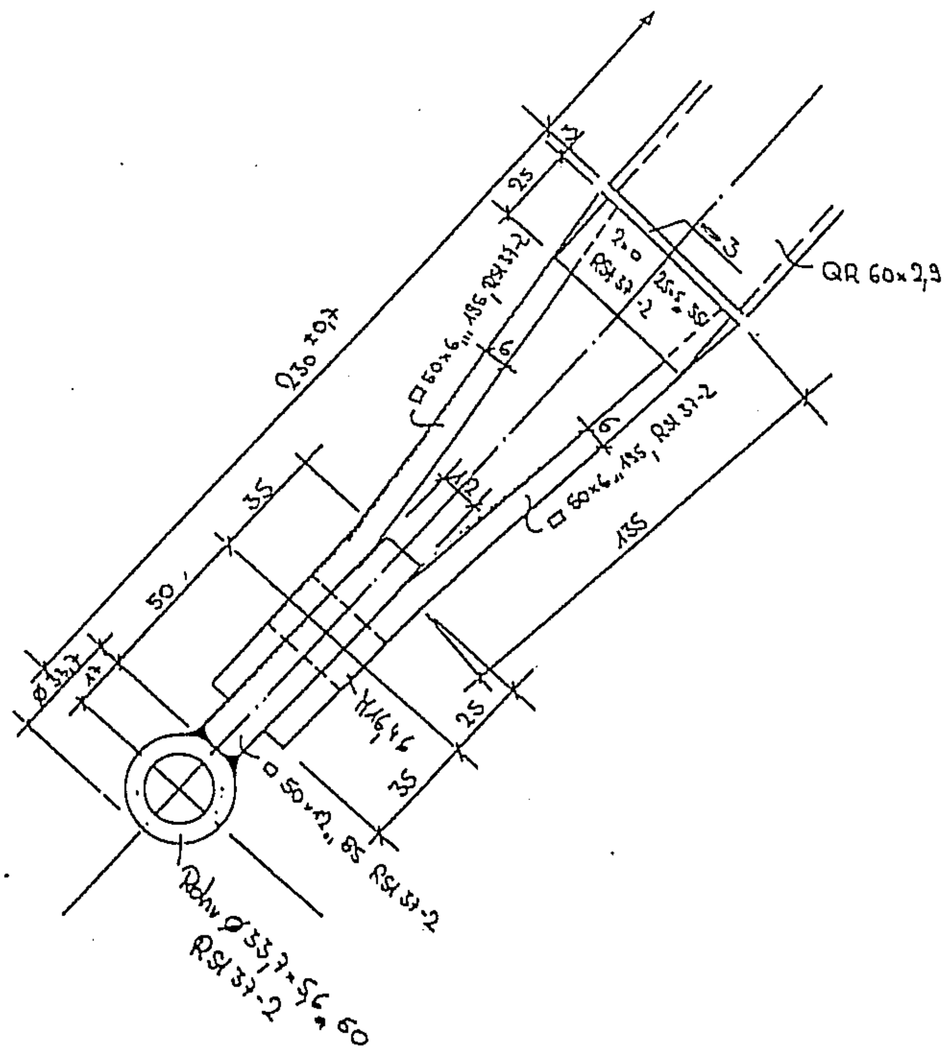
The result is unity. Therefore, the 200/120/4 F31 rafter section is acceptable.

Figure 6-9b Side Wall Strut, End Connection

A N S C H L U S S T E I L
====================================
für die Streben des Vertikalverbandes an die Bodenplatten

Maßstab 1 : 2

Material: St37 verzinkt



Secondary Bracing Members. 60/60/2.9 St 52-3 Wall Strut Section

A. Maximum Applied Loads

Combination (#)	Description	Tension (K)	Length (ft)
5	WPARALLEL	2.990	19.547

B. Failure Criterion

Unity check for axial stresses.

C. Allowable Stress

For an St 52-3 steel:

Fty = Fcy = 50.0 Ksi
Ftu = 65.0 Ksi

Tension on the net axial section of a pin connected member

$L = 19.55 \times 12 = 234.57$ in

$KL/r_{min} = 1.0 \times \frac{234.57}{0.92} = 255.71 < 300$ Good!

$F_t = 0.45\,F_y$
$= 0.45 \times 50.0$
$F_t = 22.5$ Ksi

D. Working Stress

Tension

$f_t = T/A = \frac{2.99}{1.03} = 2.91$ Ksi

E. Unity Check and Conclusions

$\frac{f_t}{1.33\,F_t} < 1.00$

$\frac{2.91}{30.00} = 0.10 < 1.00$ Good!

The result is less than unity. Therefore, the 60/60/2.9 St 52-3 wall strut section is acceptable.
The wall struts are assumed to only sustain tension loads.

6.3.1 Eave Connection
6.3.2 Ridge Connection and Rafter Splice
6.3.3 Wall Strut Connection
6.3.4 Wind Post Connection
6.3.5 Column Base Connection
6.3.6 Cable Connection

THESE CHECKS ARE COVERED BY THE 25 M REPORT.

Figure 6-10a Eave Connection

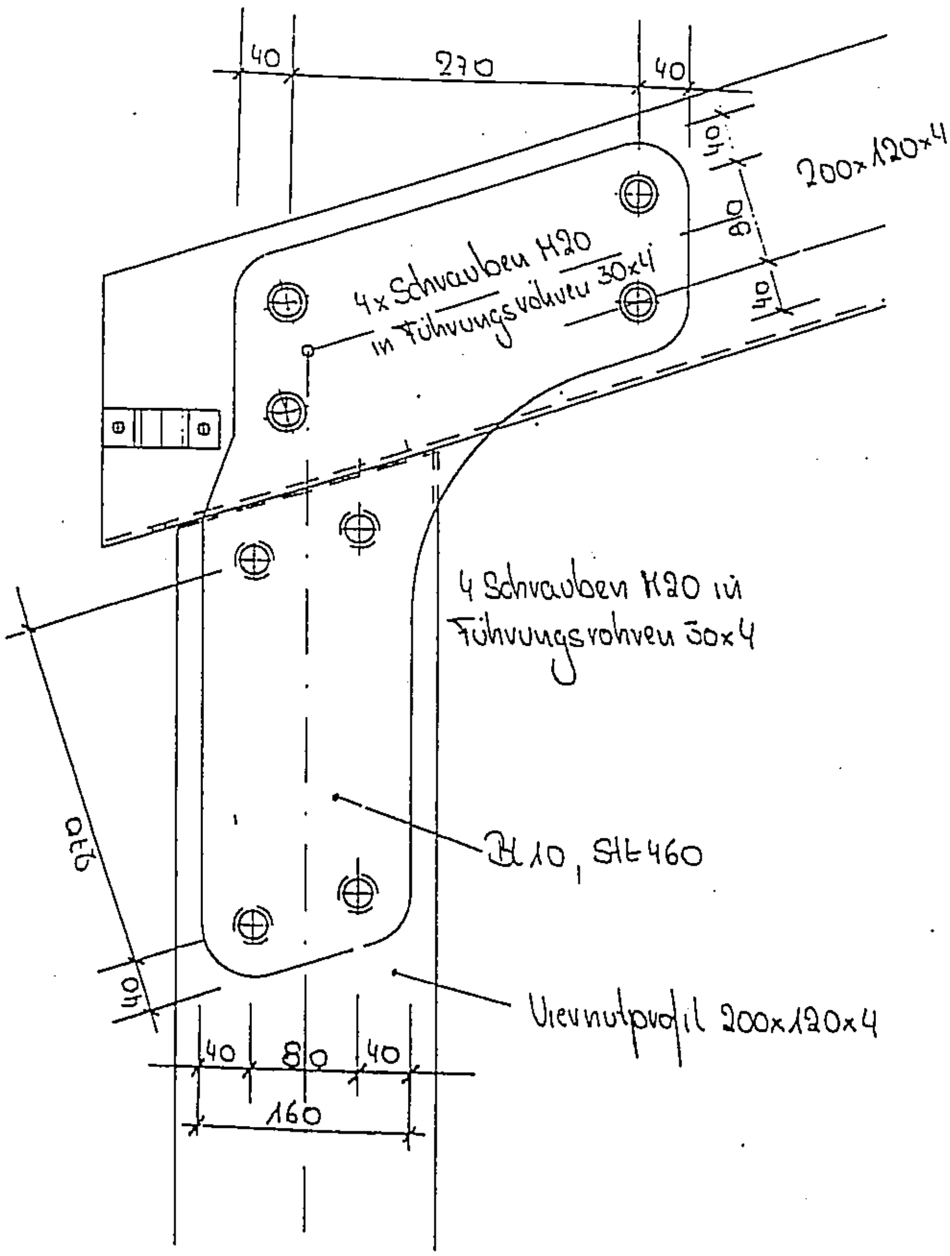


Figure 6-10b Eave Connection

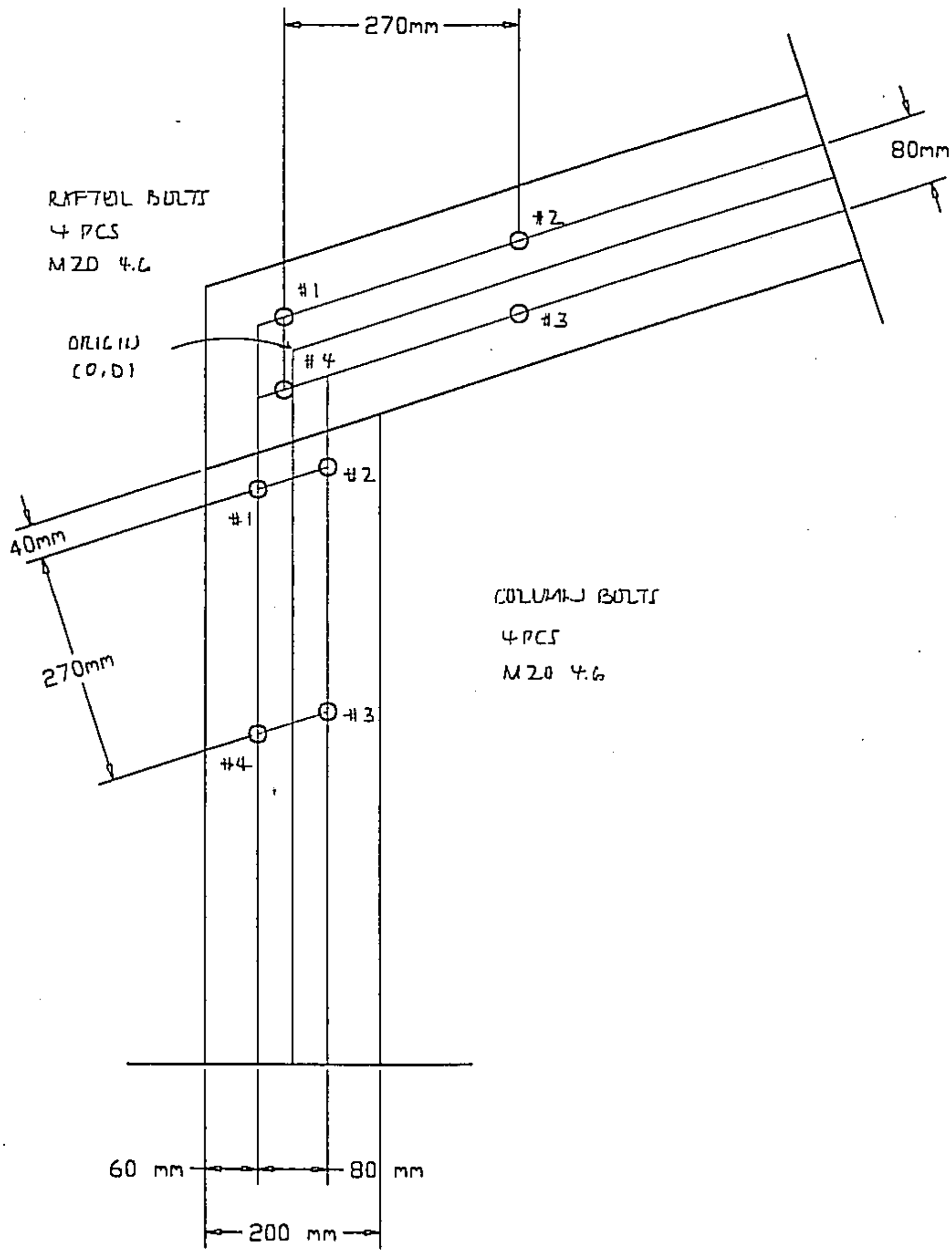


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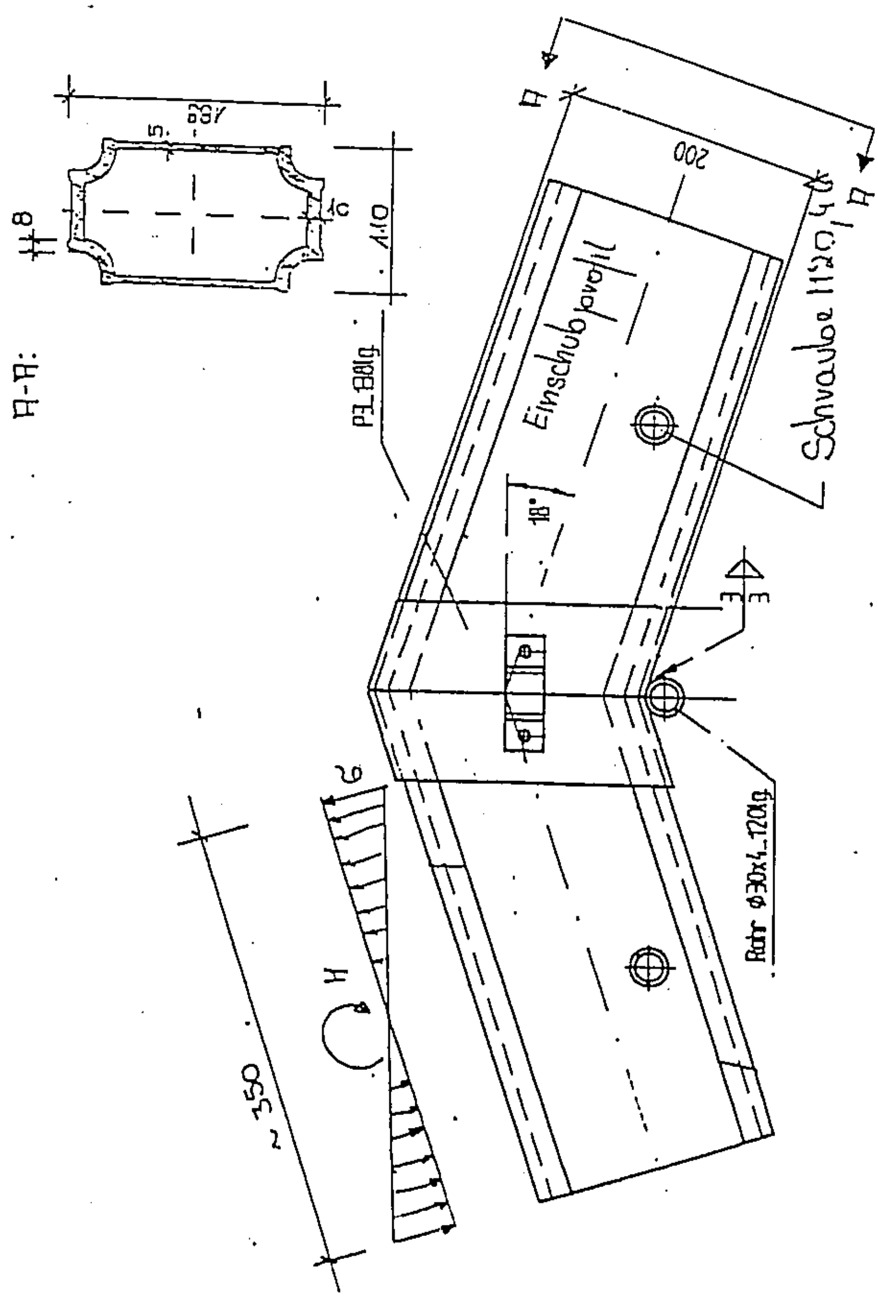
Figure 6-11 Ridge Connection

made by/date
N. V. Ybañez
checked/date

Firstpunkt M. 1 :

Einschubprofil: Al Mg Si1 F31

Wx = 203,00 cm^4 A = 40,00 cm^2
Wy = 108,00 cm^4



Part 7

Acceptability Under Variable Conditions

7.1 Allowable Exposure Chart

Since it was already proven that the 20 meter frame can marginally withstand Class C, 80 mph wind pressures, no further calculations are necessary to determine its adequacy for a slightly more severe exposure. A chart is hereby presented to delineate the suitable from the unsuitable wind loading conditions.

20 METER LOSBERGER FRAME TENT (21.33 FT MAXIMUM HEIGHT)
ANSI/ASCE 7-93 WIND PRESSURES, q (psf)

Exposure	60 mph	70 mph	80 mph	90 mph
Class A	1.60	2.18	2.85	3.60
Class B	3.40	4.63	6.04	7.65
Class C	5.84	7.95	10.39	~~13.15~~
Class D	7.61	10.36	~~13.54~~	~~17.13~~

Table 0-1 20 meter Losberger Frame Tent Allowable Exposure Chart

Appendix A

Profiles

SECTION PROPERTIES
9/12/98 6:41

Imperial System

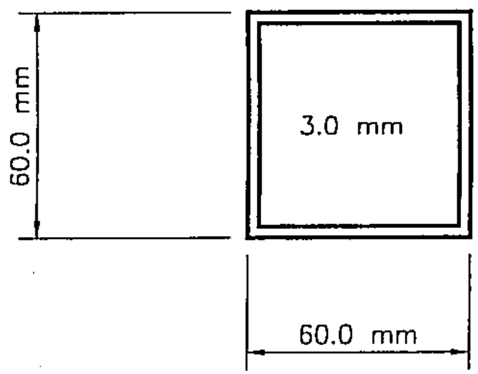
Section	Type	Axx (in^2)	Iyy (in^4)	Syy (in^3)	ryy (in)	Izz (in^4)	Szz (in^3)	rzz (in)	Weight (plf)
60/60/3	Al Mg Si 1 - F31	1.06	0.89	0.76	0.92	0.89	0.76	0.92	1.247
100/80/2.75	Al Mg Si 1 - F31	1.97	4.07	2.07	1.44	2.54	1.61	1.13	2.320
146/120/3.5	Al Mg Si 1 - F31	3.38	16.43	5.72	2.21	11.41	4.83	1.84	3.969
189/110	Al Mg Si 1 - F31	6.20	46.09	12.39	2.73	14.27	6.59	1.52	7.291
200/120/4	Al Mg Si 1 - F31	4.61	40.37	10.25	2.96	16.40	6.94	1.89	5.422
Section	Type	Axx (in^2)	Iyy (in^4)	Syy (in^3)	ryy (in)	Izz (in^4)	Szz (in^3)	rzz (in)	Weight (plf)
60/60/2.9	St 52-3	1.03	0.87	0.73	0.92	0.87	0.73	0.92	3.492

SECTION PROPERTIES
9/12/98 6:41

Metric System

Section	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	Al Mg Si 1 - F31	6.84	37.14	12.38	2.33	37.14	12.38	2.33	0.018
100/80/2.75	Al Mg Si 1 - F31	12.73	169.24	33.85	3.65	105.75	26.44	2.88	0.034
146/120/3.5	Al Mg Si 1 - F31	21.78	683.97	93.69	5.60	475.07	79.18	4.67	0.058
189/110	Al Mg Si 1 - F31	40.00	1918.35	203.00	6.93	594.00	108.00	3.85	0.106
200/120/4	Al Mg Si 1 - F31	29.74	1680.47	168.05	7.52	682.53	113.75	4.79	0.079
Section	Type	Axx (cm^2)	Iyy (cm^4)	Syy (cm^3)	ryy (cm)	Izz (cm^4)	Szz (cm^3)	rzz (cm)	Weight (kN/m)
60/60/2.9	St 52-3	6.62	36.09	12.03	2.33	36.09	12.03	2.33	0.051

General Notes:
1. Weights are based on the following densities:
   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.



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25 m Losberger Frame Tent

drawing title: 60/60/3 F31			
job no.: 980097H	drawn: NVY	reviewed:	date: 12/9/98
scale: 1:2	dwg. no.: A-60A		revision:

60/60/3 F31 Aluminum Profile

Dimensions

Depth	=	6.00 cm	=	2.36 in		
Width	=	6.00 cm	=	2.36 in		
Wall Thickness	=	0.30 cm	=	0.12 in		
Inside Depth	=	5.40 cm				
Inside Width	=	5.40 cm				

Section Properties

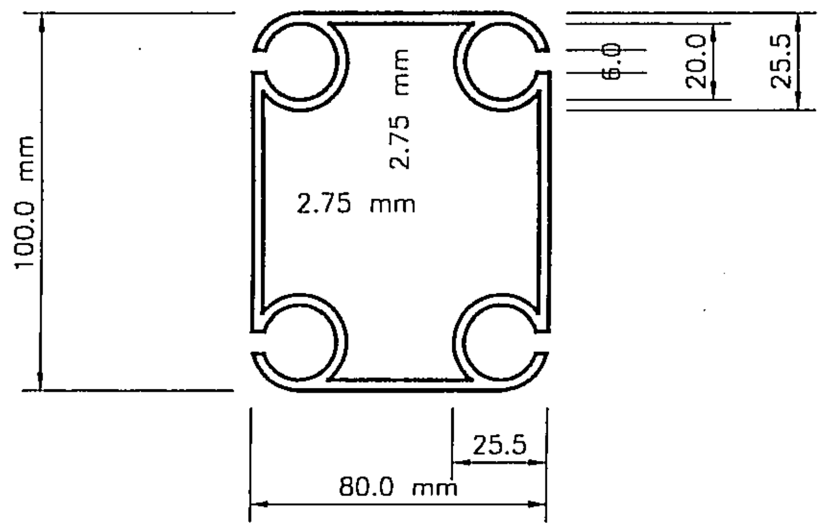
Ax	=	6.84 cm^2	=	1.06 in^2	=	0.007363 ft^2

Major Axis

Iy	=	37.14 cm^4	=	0.89 in^4	=	0.000043 ft^4
Sy	=	12.38 cm^3	=	0.76 in^3		
ry	=	2.33 cm	=	0.92 in		

Minor Axis

Iz	=	37.14 cm^4	=	0.89 in^4	=	0.000043 ft^4
Sz	=	12.38 cm^3	=	0.76 in^3		
rz	=	2.33 cm	=	0.92 in		



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25 m Losberger Frame Tent

drawing title: 100/80/2.75 F31

job no:	drawn:	reviewed:	date:
980097H	NVY		12/9/98
scale: 1:2	dwg no: A-100		revision:

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made by/date
Figure A-1 Aluminum Profile (100/80/2.75, Al Mg Si - 1F31), Calculations N. V. Ybañez
checked/date

100/80/2.75 F31 Aluminum Profile

d = 10.000 cm
b = 8.000 cm
t = 0.275 cm

Consider a quarter of the section to get 0.25Iyy and 0.25Izz of the entire profile.

Area	Axx (cm^2)	Iyy (cg) (cm^4)	z (cm)	Iyy (cm^4)	Izz (cg) (cm^4)	y (cm)	Izz (cm^4)
A1	0.399	0.003	4.863	9.431	0.070	0.725	0.279
A2	1.965	1.290	3.725	28.562	1.290	2.725	15.885
A3	-0.165	-0.005	3.725	-2.294	-0.001	3.863	-2.463
A4	0.134	0.007	2.775	1.039	0.001	3.908	2.048
A5	0.175	0.001	4.908	4.224	0.016	1.875	0.632
A6	0.674	0.337	1.225	1.348	0.004	3.863	10.056
	3.182			42.310			26.438

Metric Units : r (cm), A (cm^2), S (cm^3), I (cm^4)

Axx = 12.729

Iyy = 169.240
Syy = 33.848
ryy = 3.646

Izz = 105.752
Szz = 26.438
rzz = 2.882

Imperial Units : r (in), A (in^2), S (in^3), I (in^4)

Axx = 1.973

Iyy = 4.066
Syy = 2.066
ryy = 1.436

Izz = 2.541
Szz = 1.613
rzz = 1.135

Component Areas

A1. Flange
bf 1.450 cm
tf 0.275 cm

A2. Cylinder
od 2.550 cm
id 2.000 cm

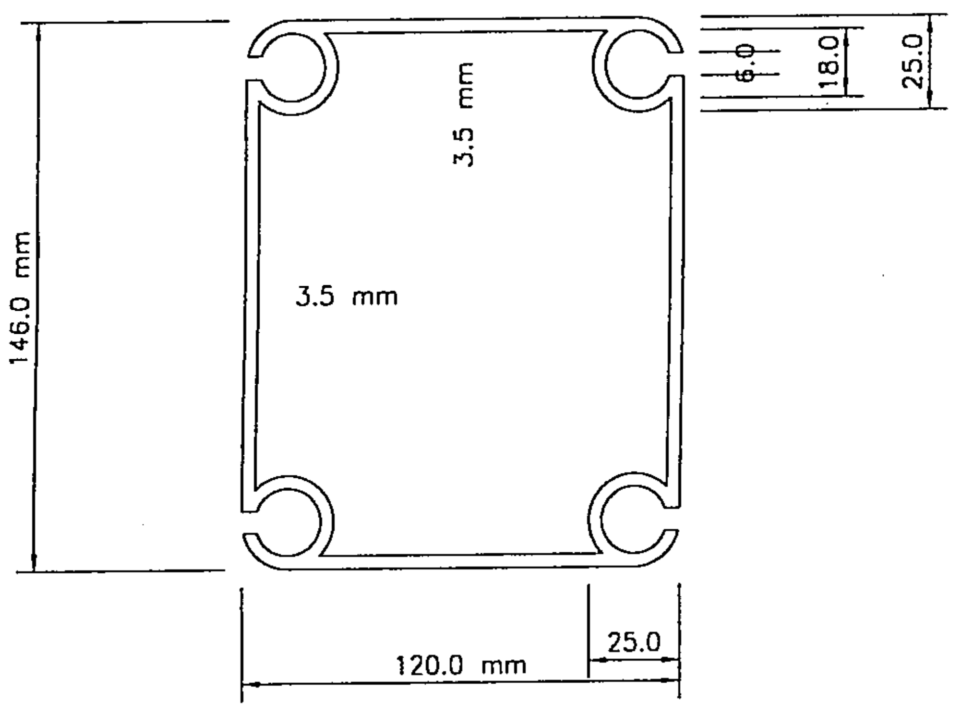
A3. Cylinder Cut-Out
hco 0.600 cm
tco 0.275 cm

A4. Triangle at Web
btw 0.275 cm
htw 0.975 cm

A5. Triangle at Flange
btf 1.275 cm
htf 0.275 cm

A6. Web
dw 2.450 cm
tw 0.275 cm

Dimension Checks:
b 8.000 cm
d 10.000 cm



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40 m Losberger
Frame Tent

drawing title: 146/120/3.5 F31

job no.	drawn:	reviewed:	date:
980097H	NVY		11/3/98
scale: 1:2	dwg. no.: A-146		revision:

060

146/120/3.5 F31 Aluminum Profile

d = 14.60 cm
b = 12.00 cm
t = 0.35 cm

Consider a quarter of the section to get 0.25Iyy and 0.25Izz of the entire profile.

Area	Axx (cm^2)	Iyy (cg) (cm^4)	z (cm)	Iyy (cm^4)	Izz (cg) (cm^4)	y (cm)	Izz (cm^4)
A1	1.225	0.013	7.125	62.200	1.251	1.750	5.002
A2	2.364	1.402	6.050	87.932	1.402	4.750	54.741
A3	-0.210	-0.006	6.050	-7.693	-0.002	5.825	-7.128
A4	0.166	0.008	5.117	4.361	0.001	5.883	5.756
A5	0.219	0.001	7.183	11.289	0.019	3.917	3.375
A6	1.680	3.226	2.400	12.902	0.017	5.825	57.021
	5.444			170.992			118.766

Metric Units : r (cm), A (cm^2), S (cm^3), I (cm^4)

Axx = 21.776

Iyy = 683.968
Syy = 93.694
ryy = 5.604

Izz = 475.066
Szz = 79.178
rzz = 4.671

Imperial Units : r (in), A (in^2), S (in^3), I (in^4)

Axx = 3.375

Iyy = 16.432
Syy = 5.718
ryy = 2.206

Izz = 11.414
Szz = 4.832
rzz = 1.839

Component Areas

A1. Flange
bf 3.50 cm
tf 0.35 cm

A2. Cylinder
od 2.50 cm
id 1.80 cm

A3. Cylinder Cut-Out
hco 0.60 cm
tco 0.35 cm

A4. Triangle at Web
btw 0.35 cm
htw 0.95 cm

A5. Triangle at Flange
btf 1.25 cm
htf 0.35 cm

A6. Web
dw 4.80 cm
tw 0.35 cm

Dimension Checks:
b 12.00 cm
d 14.60 cm

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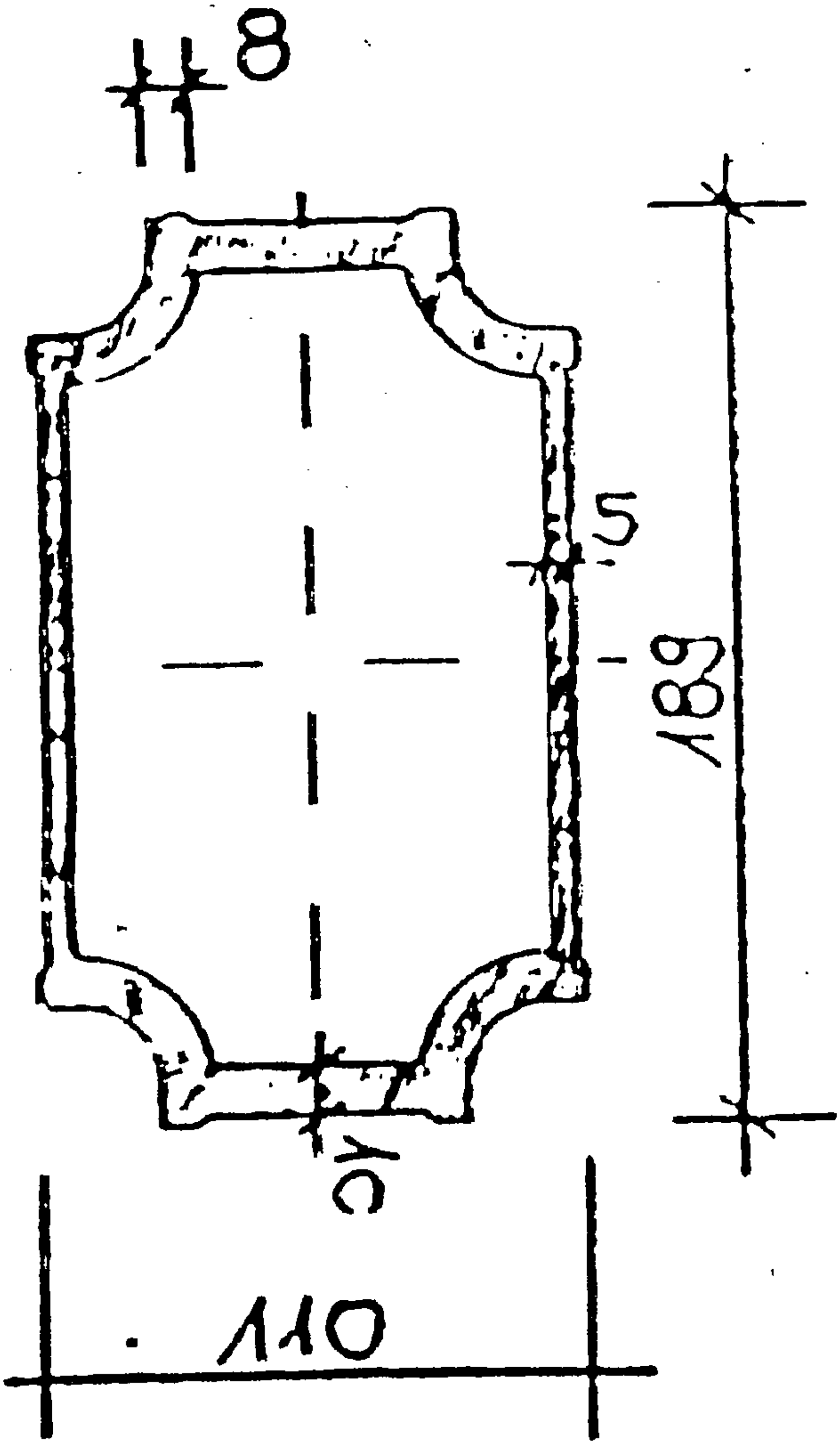
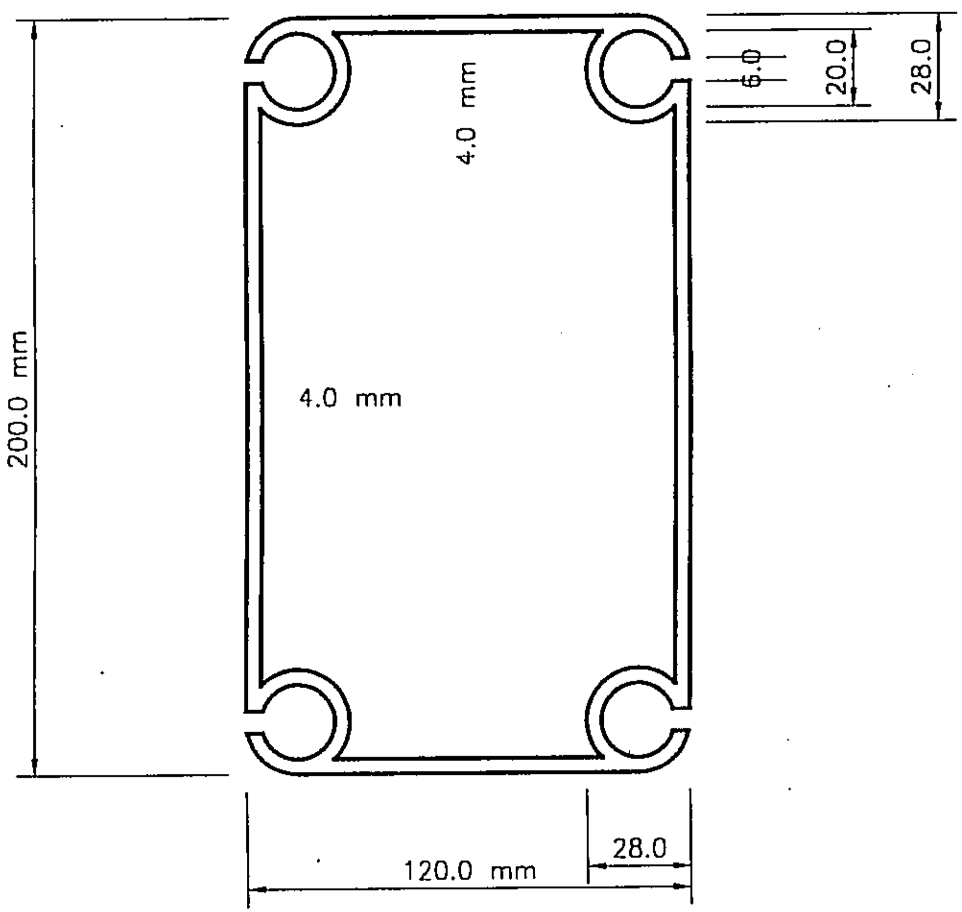
N. V. Ybañez
checked/date

Figure A-1 Aluminum Insert (189/110, Al Mg Si - 1F31)





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25 m Losberger Frame Tent

drawing title: 200/120/4 F31

job no:	drawn:	reviewed:	date:
980097H	NVY		12/9/98
scale: 1:2	dwg no: A-200C		revision:

093

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checked/date

Figure A-1 Aluminum Profile (200/120/4, Al Mg Si - 1F31), Calculations

200/120/4 F31 Aluminum Profile

d = 20.00 cm
b = 12.00 cm
t = 0.40 cm

Consider a quarter of the section to get 0.25Iyy and 0.25Izz of the entire profile.

Area	Axx (cm^2)	Iyy (cg) (cm^4)	z (cm)	Iyy (cm^4)	Izz (cg) (cm^4)	y (cm)	Izz (cm^4)
A1	1.280	0.017	9.800	122.948	1.092	1.600	4.369
A2	3.016	2.232	8.600	225.290	2.232	4.600	66.049
A3	-0.240	-0.007	8.600	-17.758	-0.003	5.800	-8.077
A4	0.220	0.015	7.567	12.611	0.002	5.867	7.574
A5	0.280	0.002	9.867	27.261	0.030	3.667	3.795
A6	2.880	12.442	3.600	49.766	0.038	5.800	96.922
	7.436			420.119			170.632

Metric Units : r (cm), A (cm^2), S (cm^3), I (cm^4)

Axx =	29.744	Iyy =	1680.474	Izz =	682.526
		Syy =	168.047	Szz =	113.754
		ryy =	7.517	rzz =	4.790

Imperial Units : r (in), A (in^2), S (in^3), I (in^4)

Axx =	4.610	Iyy =	40.374	Izz =	16.398
		Syy =	10.255	Szz =	6.942
		ryy =	2.959	rzz =	1.886

Component Areas

A1. Flange
bf 3.20 cm
tf 0.40 cm

A2. Cylinder
od 2.80 cm
id 2.00 cm

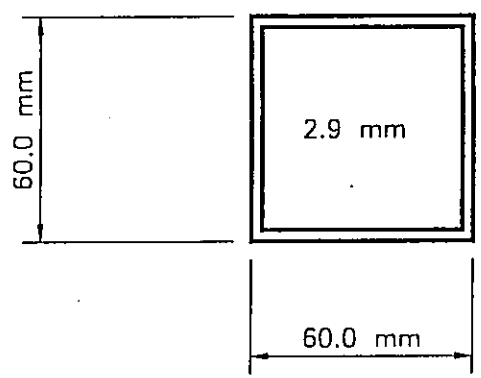
A3. Cylinder Cut-Out
hco 0.60 cm
tco 0.40 cm

A4. Triangle at Web
btw 0.40 cm
htw 1.10 cm

A5. Triangle at Flange
btf 1.40 cm
htf 0.40 cm

A6. Web
dw 7.20 cm
tw 0.40 cm

Dimension Checks:
b 12.00 cm
d 20.00 cm



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25 m Losberger
Frame Tent

drawing title
60/60/2.9 ST 52-3

job no:	drawn:	reviewed:	date:
980097H	NVY		12/9/98
scale: 1:2	dwg. no: A-608		revision:

F T L Happold

Steel Strut, St 52-3
60 mm x 60 mm x 2.9 mm Tube

Dimensions

Depth	=	6.00 cm	=	2.36 in
Width	=	6.00 cm	=	2.36 in
Wall Thickness	=	0.29 cm	=	0.11 in
Inside Depth	=	5.42 cm		
Inside Width	=	5.42 cm		

Section Properties

Ax	=	6.62 cm^2	=	1.03 in^2	=	0.007130 ft^2

Major Axis

Iy	=	36.09 cm^4	=	0.87 in^4	=	0.000042 ft^4
Sy	=	12.03 cm^3	=	0.73 in^3		
ry	=	2.33 cm	=	0.92 in		

Minor Axis

Iz	=	36.09 cm^4	=	0.87 in^4	=	0.000042 ft^4
Sz	=	12.03 cm^3	=	0.73 in^3		
rz	=	2.33 cm	=	0.92 in		