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22 January 1954

EVALUATION OF THE STANDARD 40-FT BY 100-FT
RIGID FRAME, STRAIGHT SIDED, GABLE ROOFED,
METAL UTILITY BUILDING

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Port Hueneme, California

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SUMMARY

The Standard, Rigid Frame, 40-ft by 100-ft Straight-Sided, Prefabricated Metal Utility Building was evaluated by the Laboratory to determine its adequacy for advanced base use. The evaluation included a study of packaging and crating, ease of erection, and structural adequacy for the specified snow and wind loadings.

It was found by test and observation that the building can be packaged for overseas shipment in 485.7 cu ft with a gross weight of 30,557 lbs; erection of the building was accomplished in 447 manhours, using a six man crew and a crane with operator as an erection aid. The building was found structurally adequate under the structural loadings specified by military specifications¹.

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INTRODUCTION

To facilitate construction of naval activities, a need exists for a standardized, prefabricated, 40-ft by 100-ft, utility building that is easily manufactured, economical in the use of materials, structurally adequate, lightweight, low in shipping cube, rapidly erected by unskilled labor, and suitable for re-erection. As part of a program to develop suitable utility buildings, current standard and commercial designs meeting the requirements are being evaluated by the U. S. Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, California.

This technical memorandum covers the evaluation of the Standard Rigid Frame, 40-ft by 100-ft Utility Building. Studies and tests to determine the ease of erection, structural adequacy, and adequacy of packaging and crating were made by the Laboratory under Project NY 500 002-20 authorized by the Bureau of Yards and Docks².

DESCRIPTION OF BUILDING

The standard rigid frame utility building, as shown in Figure 1, is a rigid frame, prefabricated, steel, straight sided, gabled-roof structure with over-all dimensions of 40-ft 0-in. by 100-ft 6-in., an eave height of 14-ft 0-in., and a ridge height of 20-ft 8-in. The building is designed to be erected on a concrete foundation or slab. Anchor bolts are furnished with the building and are to be preset in the foundation or slab.

The building, as taken from Navy stock for test, consisted of six rigid frame bents which, when erected, form five 20-ft bays. The bents are anchored to the foundation through a base shoe and are joined together with purlins and side wall girts. The purlins and girts fix the spacing of the bents and provide bridging and anchoring points for the exterior sheeting. The frame is held plumb with diagonal face rods in each end bay and the inner face of the bents are held rigid with diagonal brace angles which tie the inner face of the bents to the purlins and side wall girts. Sag rods align the purlins and tie them together. The endwall frame consists of door posts, door header girt, door track girts, and endwall girts with sag rod bracing between them. (See Figure 2 for erected structural frame.) Galvanized 26 gage steel sheeting with deep drawn corrugations 12-in. apart, run transversely across the building and is held in place with 1/4-in. stove bolts and weathertight washers. The same type sheeting is used on the endwalls with specially cut sheets to fit the gable angle. Galvanized steel flashing is used at the gable ends of the building to make this point weathertight.

Interior natural light is provided by two 5-ft by 2-ft 9-in. 6 pane windows located in each endwall. A wiring harness is provided for artificial interior lighting and electrical power. Access

is provided by a 12-ft by 13-ft opening covered by double outside sliding doors in each endwall. Natural ventilation is furnished by a 4-ft by 4-ft louvered ventilator above the door.

In addition to the regular bents having field welded joints, two bents having a bolted connection at all field joints were furnished for testing. The two types of bents were identical in assembled size. The tables in this report show recorded test data for both types. Both types of bents were composed of six I-beam type sections. The portion of the bent from the ridge point of the roof to the inflection point of the roof is made from a rolled I-beam section and the remaining portion of the bent is made from steel plate fabricated into I-sections with the depth of the web member tapered.

The bent that has been normally furnished with this building comes shipped to the site in six parts. It is assembled in the field using field welded joints at the column haunches and at the ridge of the roof, and a bolted joint at the inflection point of the roof beam. A total of five field joints are required to assemble this bent, 3 welded joints and 2 bolted joints.

The new type bent is factory welded at the inflection point leaving only 3 field joints. The 3 bolted field joints occur at the ridge of the frame and at the column haunch, see Figure 3.

The building, as received, was packaged for export shipment in 22 crates weighing 30,557-lbs. and cubing 485.7 cu ft.

TEST FACILITIES

A special facility, see Figure 4, was built for testing 40-ft by 100-ft buildings. The facility consists of two test locations, one for erection and skylighting studies and one for structural tests.

At the first location, the erections are made on a steel foundation consisting of 12-in. by 3-in., 25.3-lb. structural channels welded end-to-end to form a simulated footing. The channels were leveled with blocking and were placed with flanges down to give a 12-in. wide work surface. Openings were provided at the location of the endwall doors to give accessibility. Studs were welded to the channel to simulate anchor bolts. The foundation was located with the longitudinal axis running east and west to expose one side of the roof of a test building to the northern light for skylighting studies.

At the structural test location, wide concrete footings, 40-ft on centers and 105-ft long, provide reactions against uplift caused

by wind loadings. Structural WF beams were embedded transversely 5-ft on centers in the top of these footings to act as tie-downs for 12-in. by 3-in., 25.3-lb. channel foundations for the side walls of buildings under test. These 105-ft channel foundations, placed with the flanges down, were bolted to the WF beams and are adjustable for building width. Studs were welded to the channels to simulate anchor bolts. Simulated wind and snow loads are applied through hydraulic cylinders. For the snow loads, the cylinders are attached to pontoons located on the inside of the building under test. These pontoons are filled with water for added reaction. For supporting and reacting the hydraulic cylinders in the application of wind loads, pontoon walls were placed along the outside of each concrete footing and connected across the top with transverse beams made up of 24-in. by 9-in., 80-lb. WF beams reinforced with 12-in. by 3-in., 25.3-lb. channels welded to the top flange for protection against lateral buckling. A special hydraulic pump and control panel is used to actuate the cylinders. Actual loads are applied through whiffletree systems, see Figure 5.

All strains are measured with SR-4 gages, type A-1, and observed in microinches on a 48-channel Foxboro Scanner Recorder. Deflections are measured in hundredths of inches with deflectometers developed at the Laboratory.

TEST PROCEDURE

Each package of the building, as received from the manufacturer packaged for overseas shipment, was weighed, cubed, and reviewed for adequacy of crating and compliance with Military storage requirements. Further, the packaging scheme was studied to determine possible combinations of packages and cubage for reducing weight and the suitability of the packaging for convenient distribution around the erection site.

Five erection studies were made to determine the suitability of the building for assembly under advanced base conditions. To simulate these conditions, a team comprised of civilian personnel of varied skills were used for all erections. A crane with operator was used to aid the first three erections, and a Gin-pole was used in the last two erections. The Gin-pole required two additional men in the erection team. The first erection was observed to determine the ease of erection with personnel unfamiliar with the procedure; to establish the most efficient size for the erection team; to check the accuracy of the erection manual; to establish the tool requirements for efficient erection; and to record the manhours required to assemble the frame, exterior sheeting, and endwalls. After the first erection, the building was completely disassembled. The second, third, fourth, and fifth erections and disassemblies were made to determine the suitability of the design for repeated assembly; to record the erection manhours required, when using a crane or Gin-pole as an erection aid, and as the team became more familiar with the building.

Structural tests were made to determine the adequacy of the building under 20-psf snow load, and a 70 mph wind load as stipulated in the Military Specifications¹. The design snow load conditions diagrammed in Figure 6 was applied hydraulically to the roof through whiffletrees, as shown in Figure 7. The design wind load conditions diagrammed in Figure 8 was applied hydraulically to the building through whiffletrees as shown in Figure 9. In each case, loadings scheduled to reach 180 per cent of design load were applied in 10 per cent increments. Location of the strain and deflection gages used in these tests are shown in Figures 10 and 11. Figure 12 shows plotted deflections of the bent with welded joints and the bent with bolted joints.

RESULTS AND OBSERVATIONS

The test results and general observations made during the evaluation of this building are covered in the following paragraphs.

Packaging and Crating

A summary of the packaging and crating study is shown in Table 1. It is seen from this table that the standard rigid frame utility building packaged weight is 30,557-lbs. and has a shipping cube of 485.7 cu ft.

The packaging scheme was found acceptable for handling and site layout. Further, the building parts were properly grouped for minimum weight and cube. In general, the crating was found adequate and complied with the Military Specifications for crating and packaging¹.

Erection

A summary of the manhours required to erect the building in each of the first three erections using a crane as an erection aid and the fourth and fifth erections using a Gin-pole as an erection aid are shown in Table 2. The table gives a breakdown of the third erection and shows that a team using a crane as an erection aid can erect the standard rigid frame utility building in 447 manhours.

The first erection time was very slow because of wrong and illegible markings, shortages, and inaccurate fabrication of the sheeting. (This building was four years old and had been overseas.) Another factor that slowed down all erections was poor control over purlin alignment. The double nut method of attaching sag rods to purlins does not provide a fixed spacing between purlins and to adjust the nuts until the proper spacing is obtained, is very time consuming. It was also found that any bowing in the eave strut caused extreme difficulty in attaching the sheeting as both have pre-punched holes.

During the erection it was found that a six man team, a crane and operators or a Gin-pole, and 2 extra men were required for efficient erections. The tools furnished with the building were adequate and satisfactory.

The method of erection described in the erection manual was adequate and easily followed during erections.

The second and third erections using the crane and the second erection using the Gin-pole became progressively easier as the crew became familiar with the parts and the proper method of handling them.

A considerable number of new holes have to be punched in the exterior sheetings and the old ones patched with each erection if the same sheeting is to be used. The difficulty of aligning the purlins to the same position each time is the chief cause for this condition.

Structural Adequacy

The stresses and deflections recorded in the snow and wind loading tests are summarized in Tables 3 and 4. The tables are divided into two parts, bolted bent and welded bent.

The snow loading was taken to a maximum loading of 180 per cent (36-psf) of design. At design load, a maximum stress, see Table 3, of 10,800 psi tension was recorded in the bolted bent at point 12, and 13,350 psi compression was recorded in the welded bent at point 18 as compared to 18,000 psi allowable. At 180 per cent of design, a maximum stress, see Table 3, of 29,400 psi compression was recorded in the bolted bent at point 4, and 32,400 psi compression was recorded in the welded bent at point 3. The maximum recorded deflection at design load was a vertical movement, see Table 3, of 1.85-in. in the bolted bent at point 8, and a vertical movement of 1.30-in. in the welded bent at point 8. The maximum deflection of 180 per cent of design, see Table 3, was a vertical movement of 4.12-in. in the bolted bent at point 8, and a vertical movement of 3.14-in. in the welded bent at point 8.

The wind loading was taken to 180 per cent (94 mph) of design. At design load, a maximum stress, see Table 4, of 9,300 psi compression was recorded in the bolted bent at point 13, and 10,350 psi tension was recorded in the welded bent at point 1, as compared to the 18,000 psi allowable. At 180 per cent of design, a maximum stress, see Table 4, of 16,800 psi compression was recorded in the bolted bent at point 13, and 21,300 psi tension was recorded in the welded bent at point 1. The maximum deflection at design load, see Table 4, was a horizontal movement of 1.89-in. in the bolted bent at point 2 and a horizontal movement of 1.87-in. in the welded bay at point 2. The maximum deflection at 180 per cent of design,

see Table 4, was a horizontal movement of 3.17-in. in the welded bent at point 2.

CONCLUSIONS

As designed, the building has many desirable features. These include the following:

1. The over-all design makes this building very versatile in its uses, as the bents provide convenient attaching points for equipment, maximum head room and maximum available storage space.
2. The building is adequately crated and the material is properly nested for compactness.
3. The erection manual is adequate and easy to follow.

If the following deficiencies were corrected a more desirable building would be obtained:

1. The present double nut method of attaching the sag rods to the purlins gives poor control over purlin alignment. A sag rod designed so that it would give every purlin the same fixed spacing would correct this condition. The sag rod system should be expanded so that it would include the eave girt and the side wall girts to the foundation. Such a system would make the exterior sheeting easier to apply.
2. A bent with bolted field joints is more desirable than one with welded field joints. The welded joint type requires both welding equipment and a good welder before the building can be erected. This might be a critical item under advanced base conditions. The bent with bolted joints can be assembled using unskilled personnel and it can be disassembled and transported to a new erection site or stored more easily than the bent with welded joints. The structural test shows that, while the bolted joint bent has more deflection than the welded joint bent for the same loadings, there is less stress in the members of the bolted joint bent.

REFERENCES

1. MIL-B-16071(Docks) Military Specifications, "Building, Prefabricated Metal Rigid Frame and Arch Rib Types, 40-ft by 100-ft", 12 February 1951.
2. RDB Project Card NY 500 002 Prefabricated Advanced Base Buildings, 15 May 1949.

Table 1. Summary of Packages, Cubes, and Weights

Item	Units	Standard Rigid Frame
Packages	no.	22
Cubes of crated bldg.		
Maximum crate	cu ft	47.3
Minimum crate	cu ft	5.0
Total cubage	cu ft	485.7
Weight of crated bldg.		
Maximum crate	lb	3,085
Minimum crate	lb	142
Total weight	lb	30,557
Steel weight		
Frame	lb	13,670
Exterior sheeting	lb	9,560
Endwalls	lb	3,870
Miscellaneous	lb	770
Total steel weight	lb	27,870

Table 2. Summary of Erection Time Studies

The first three (3) erections were made with a 6-man erection team, plus crane and operator. Erections numbers 4 and 5 were made with the same 6-man erection team, plus a Gin-pole and two extra men.

Item	Crew Size	Equipment Used	Standard Rigid Frame Manhours
Entire building			
1st erection	6	crane	595
2nd erection	6	crane	487
3rd erection	6	crane	447
4th erection	8	gin-pole	503
5th erection	8	gin-pole	469
Components	6	crane	3rd erection
Frame			107
Sheeting			265
Endwalls			40
Doors and windows			35
Total			447

Table 3. Summary of Structural Tests for Snow Load

The recorded values given in this table represent only liveload values. The structural tests were performed on a 60-ft section of building without end-walls.

Item	Units	Bolted Frame	Welded Frame
Design Loading	as noted	20 psf	20 psf
Maximum Loading	as noted	36 psf	36 psf
Load Increment	% design	10	10
Stress (design load)			
Tension			
Magnitude	psi	10,800	10,800
Location	no.	12	9
Compression			
Magnitude	psi	10,650	13,350
Location	no.	17, 18 & 19	18
Stress (maximum load)			
Tension			
Magnitude	psi	21,000	30,000
Location	no.	12	9
Compression			
Magnitude	psi	29,400	32,400
Location	no.	4	3
Deflection (design load)			
Vertical			
Magnitude	in.	1.85	1.30
Location	no.	8	8
Horizontal			
Magnitude	in.	0.60	0.45
Location	no.	14	14
Deflection (maximum load)			
Vertical			
Magnitude	in.	4.12	3.14
Location	no.	8	8
Horizontal			
Magnitude	in.	1.20	1.08
Location	no.	14	1

Table 4. Summary of Structural Tests for Wind Load

The recorded values given in this table represent only liveload values. The structural tests were performed on a 60-ft section of building without end-walls.

Item	Units	Bolted Frame	Welded Frame
Design Loading	as noted	70 mph	70 mph
Maximum Loading	as noted	94 mph	94 mph
Load Increment	% design	10	10
Stress (design load)			
Tension			
Magnitude	psi	7,200	10,350
Location	no.	1	1
Compression			
Magnitude	psi	9,300	7,050
Location	no.	13	12, 13 & 21
Stress (maximum load)			
Tension			
Magnitude	psi	16,650	21,300
Location	no.	1	1
Compression			
Magnitude	psi	16,800	14,100
Location	no.	13	21
Deflection (design load)			
Vertical			
Magnitude	in.	1.36	1.03
Location	no.	9	9
Horizontal			
Magnitude	in.	1.89	1.87
Location	no.	2	2
Deflection (maximum load)			
Vertical			
Magnitude	in.	2.37	1.95
Location	no.	9	10
Horizontal			
Magnitude	in.	2.63	3.17
Location	no.	1	2

Table 5. Recorded Live-Load Stresses for Simulated Snow Load

Units: psi, + tension, - compression, $E_s = 30 \times 10^6$ psi for converting strain to stress. Allowable unit stress, 18,000 psi. Allowable stress for purlins (points 22 and 23) is 29,500 psi. See Figure 10 for location of strain gages.

Point	SNOW LOAD							
	Per Cent of Design Load							
	50		100		150		180	
	Bolted Frame	Welded Frame	Bolted Frame	Welded Frame	Bolted Frame	Welded Frame	Bolted Frame	Welded Frame
1	- 4,350	- 4,200	- 9,150	- 9,450	-14,400	-15,300	-17,550	-19,500
2	- 4,500	- 4,800	-10,050	-10,350	-16,650	-17,850	-20,550	-23,550
3	- 5,100	- 4,800	-10,050	-12,000	-17,550	-22,200	-23,250	-32,400
4	- 5,100	- 3,150	-10,050	- 4,350	-17,550	- 8,850	-29,400	-16,500
5	- 3,750	- 3,900	- 7,800	- 8,550	-13,350	-13,950	-17,400	-17,850
6	- 2,100	- 1,800	- 4,500	- 3,900	- 7,800	- 7,350	- 9,750	- 9,000
7	+ 750	0	+ 750	+ 750	0	+ 750	0	0
8	+ 3,750	+ 3,450	+ 8,850	+ 8,100	+11,850	+12,150	+14,550	+15,450
9	+ 4,800	+ 4,500	+ 9,150	+10,800	+14,850	+17,850	+20,700	+30,000
10	+ 3,900	+ 3,900	+ 6,600	+ 9,750	+ 9,450	+15,750	+12,000	+21,600
11	+ 3,750	+ 3,900	+ 6,600	+ 9,150	+10,200	+15,450	+13,500	+21,600
12	+ 5,700	+ 4,500	+10,800	+ 9,000	+16,650	+15,450	+21,000	+23,400
13	+ 4,950	+ 3,600	+ 8,100	+ 6,900	+11,550	+11,400	+15,000	+16,040
14	+ 1,200	0	- 300	0	- 1,650	+ 300	- 2,550	+ 1,050
15	+ 1,950	- 2,550	- 4,950	- 5,400	- 8,400	- 8,550	-10,500	-11,700
16	- 3,600	- 4,050	- 9,000	- 8,700	-14,400	-13,800	-18,150	-18,300
17	- 4,350	- 3,600	-10,650	- 3,750	-16,050	-12,150	-21,150	-27,000
18	- 4,500	- 6,000	-10,650	-13,350	-16,200	-26,550	-18,300	-31,500
19	- 4,500	- 6,000	-10,650	-12,000	-16,200	-19,650	-20,250	-26,400
20	- 3,750	- 4,950	- 8,550	-10,200	-13,500	-13,050	-16,500	-21,000
** 21		+ 6,600		+12,600		+19,650		+15,300
* 22	+ 6,300		+16,650		+27,000		+33,900	
* 23	+ 7,350		+16,800		+19,650		+15,300	

* Strain gages located at mid-span of purlins on bottom flange.

** Strain gage located on top side of haunch welded bent only.

Table 6. Recorded Live-Load Stresses for Simulated Wind Load

Units: psi, + tension, - compression, $E_s = 30 \times 10^6$ psi for converting strain to stress. Allowable unit stress, 18,000 psi. Allowable stress for purlins (points 22 and 23) is 29,500 psi. See Figure 10 for location of strain gages.

Point	WIND LOAD							
	Per Cent of Design Load							
	50		100		150		180	
	Bolted Frame	Welded Frame	Bolted Frame	Welded Frame	Bolted Frame	Welded Frame	Bolted Frame	Welded Frame
1	+ 2,100	+ 4,650	+ 7,200	+10,350	+ 7,200	+17,550	+16,650	+21,300
2	+ 2,100	+ 4,800	+ 6,450	+ 9,450	+ 6,600	+13,050	+15,600	+14,100
3	+ 1,350	+ 4,500	+ 5,100	+ 9,450	+10,200	+15,000	+13,050	+18,450
4	+ 1,350	+ 3,750	+ 4,500	+ 7,200	+ 8,100	+11,400	+10,200	+13,800
5	0	/	+ 2,550	/	+ 6,150	/	+ 8,400	/
6	0	/	+ 900	/	+ 3,300	/	+ 4,800	/
7	- 2,850	+ 1,950	- 3,000	+ 3,000	- 300	+ 5,850	+ 1,200	+ 7,200
8	- 3,900	- 450	- 5,700	- 1,050	- 5,850	- 1,050	- 5,850	- 1,050
9	- 4,200	- 1,950	- 5,700	- 3,600	- 6,750	- 4,950	- 7,350	- 5,850
10	- 2,400	- 3,000	- 3,600	- 4,800	- 4,800	- 6,000	- 5,250	- 7,200
11	- 2,400	- 3,000	- 4,200	- 4,950	- 5,850	- 6,600	- 7,050	- 8,250
12	- 3,600	- 3,750	- 7,800	- 7,050	-11,250	- 9,900	-13,650	-12,000
13	- 4,350	- 3,750	- 9,300	- 7,050	-13,350	-10,200	-16,800	-12,600
14	- 3,750	- 3,750	- 8,250	- 6,600	-11,700	- 9,300	-14,700	-10,800
15	- 900	- 1,050	- 2,400	- 1,200	- 3,600	- 1,800	- 4,800	- 2,250
16	0	0	- 600	+ 1,050	- 600	+ 1,350	- 600	+ 1,800
17	0	0	- 450	+ 1,800	- 450	+ 2,550	- 450	+ 3,600
18	0	+ 600	+ 600	+ 2,250	+ 1,050	+ 3,300	+ 1,050	+ 4,200
19	0	0	- 450	+ 900	- 450	+ 1,200	- 900	+ 1,500
20	- 600	/	- 1,200	/	- 1,800	/	- 2,550	/
*21		- 4,050		- 7,050		-11,250		-14,100
*22		-4,500		-9,600		-14,250		-17,100
*23		-4,200		-7,050		-10,650		-13,800

/ Gages in-operative.

* Strain gages located at mid-span of purlin on bottom flange.

** Strain gage located on top side of haunch welded bent only.

Table 7. Recorded Live-Load Deflections for Simulated Snow Loadings

Units: inches; see Figure 11 for location and positive direction of deflection gages.

Point	SNOW LOAD							
	Per Cent Design Load							
	50		100		150		180	
	Bolted Frame	Welded Frame	Bolted Frame	Welded Frame	Bolted Frame	Welded Frame	Bolted Frame	Welded Frame
1	-0.20	-0.22	-0.50	-0.43	-0.82	-0.78	-1.10	-1.08
2	-0.11	-0.15	-0.46	-0.38	-0.82	-0.70	-1.19	-1.02
3	+0.02	+0.08	+0.29	+0.20	+0.52	+0.38	+0.68	+0.48
4	+0.22	+0.18	+0.61	+0.43	+1.07	+0.78	+1.38	+0.98
5	+0.40	+0.31	+1.05	+0.74	+1.72	+1.32	+2.24	+1.60
6	+0.52	+0.31	+1.40	+1.00	+2.36	+1.75	+3.07	+2.32
7	+0.60	+0.56	+1.60	+1.26	+2.72	+2.18	+3.60	+2.92
8	+0.70	+0.58	+1.85	+1.30	+3.10	+2.30	+4.12	+3.14
9	+0.68	+0.60	+1.69	+1.27	+2.80	+2.18	+3.65	+3.00
10	+0.58	+0.47	+1.40	+1.02	+2.30	+1.80	+2.98	+2.56
11	+0.96	+0.33	+1.05	+0.71	+1.72	+1.22	+2.20	+1.80
12	+0.21	+0.09	+0.59	+0.23	+0.98	+0.46	+1.22	+0.53
13	+0.10	+0.05	+0.28	+0.19	+0.47	+0.39	+0.62	+0.60
14	+0.18	+0.19	+0.60	+0.45	+0.96	+0.73	+1.20	+0.90
15	+0.20		+0.50		+0.82		+1.03	
16		+0.82		+1.64		+2.82		+3.78
17		+0.91		+1.80		+3.02		+4.06

Table 8. Recorded Live-Load Deflections for Simulated Wind Loadings

Units: inches; see Figure 11 for location and positive direction of deflection gages.

Point	WIND LOAD							
	Per Cent Design Load							
	50		100		150		180	
	Bolted Frame	Welded Frame	Bolted Frame	Welded Frame	Bolted Frame	Welded Frame	Bolted Frame	Welded Frame
1	+0.72	+0.70	+1.52	+1.34	+2.16	+1.88	+2.63	+2.22
2	+1.00	+0.90	+1.89	+1.87	+2.03	+2.63	+2.12	+3.17
3	-0.10	+0.04	-0.21	+0.11	-0.39	+0.08	-0.50	0
4	-0.23	+0.11	-0.41	+0.28	-0.61	+0.23	-0.77	+0.18
5	-0.40	+0.15	-0.70	+0.42	-0.97	+0.37	-1.13	+0.30
6	-0.55	0	-1.00	0	-1.36	-0.18	-1.61	-0.29
7	-0.60	-0.15	-1.18	-0.31	-1.65	-0.58	-1.99	-0.74
8	-0.63	-0.31	-1.34	-0.70	-1.95	-1.02	-2.36	-1.30
9	-0.67	-0.49	-1.36	-1.03	-1.93	-1.48	-2.37	-1.78
10	-0.56	-0.50	-1.20	-1.12	-1.72	-1.62	-2.12	-1.95
11	-0.41	-0.50	-0.94	-1.13	-1.37	-1.60	-1.70	-1.91
12	-0.30	-0.31	-0.66	-0.78	-0.97	-1.10	-1.20	-1.32
13	-0.11	-0.19	-0.30	-0.39	-0.44	-0.53	-0.56	-0.65
14	+0.58	+0.65	+1.29	+1.43	+1.78	+1.99	+2.11	+2.30
15	+0.43	+0.39	+0.91	+0.92	+1.26	+1.29	+1.47	+1.52
16		-0.40		-0.90		-1.49		-2.20
17		-0.65		-1.46		-2.14		-2.65



Figure 1. Standard Navy Rigid Frame, 40-Ft by 100-Ft, Utility Type Building.



Figure 2. Assembled frame.

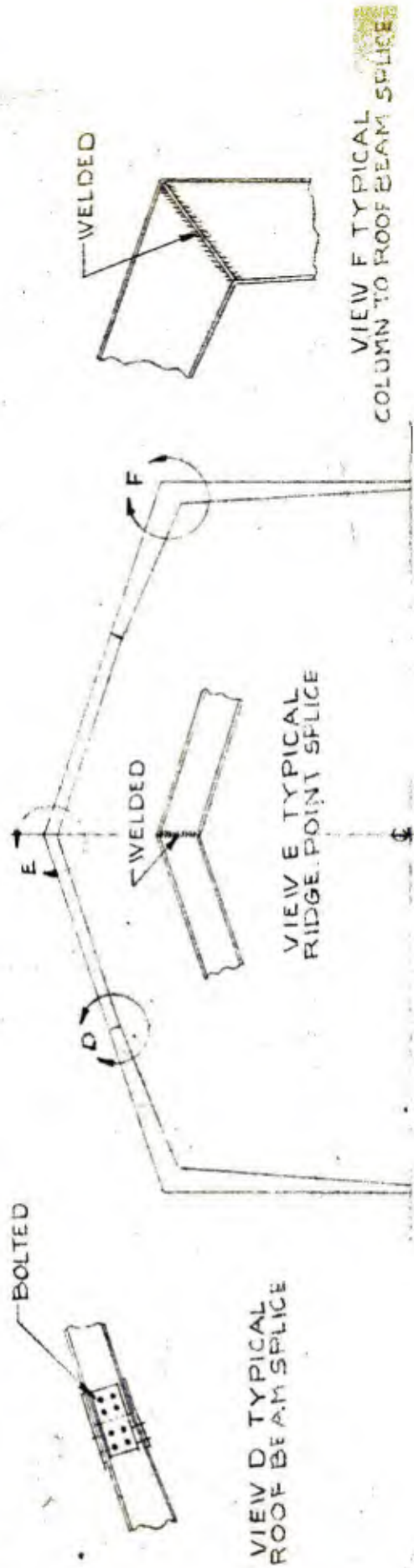
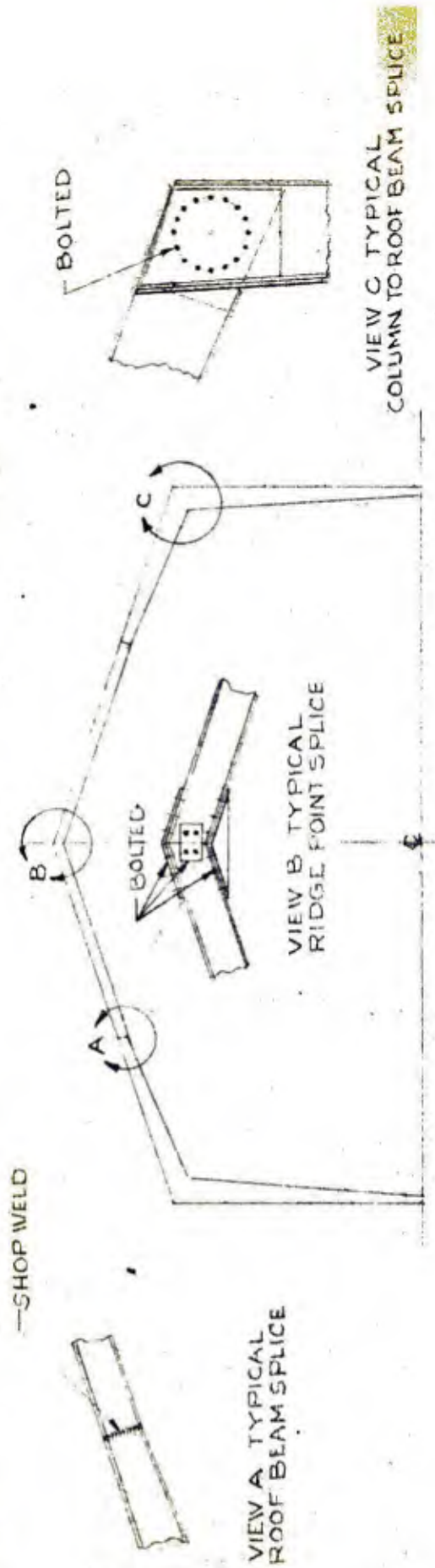


Figure 3. Details of field joints for welded and bolted bents.



Figure 4. Test facility for 40-ft by 100-ft building.

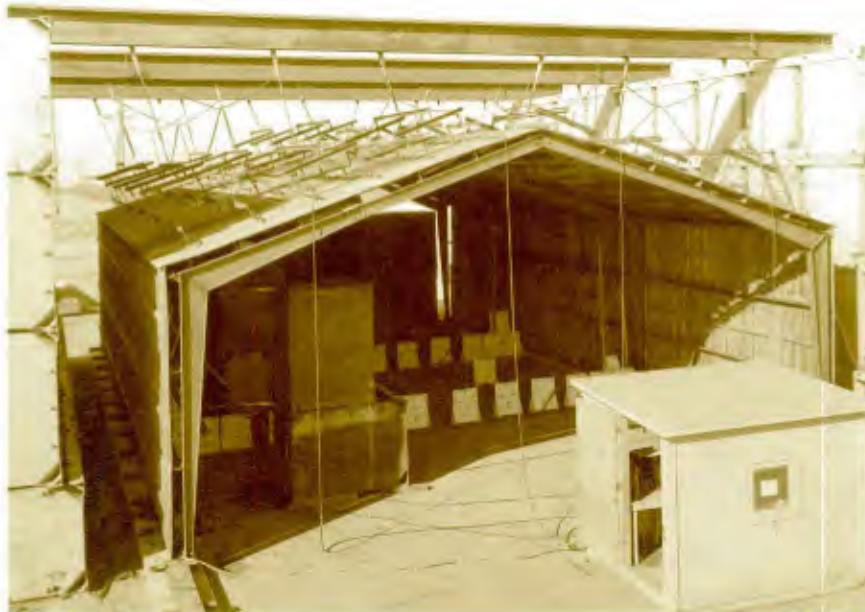


Figure 5. Test gear for applying simulated wind loadings.

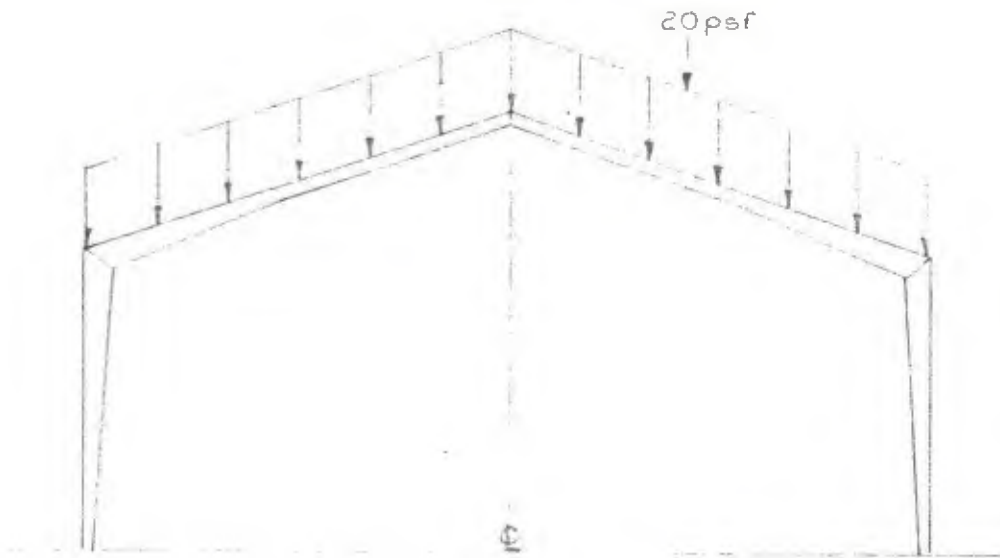


FIGURE 6. DESIGN SNOW LOADING CONDITION

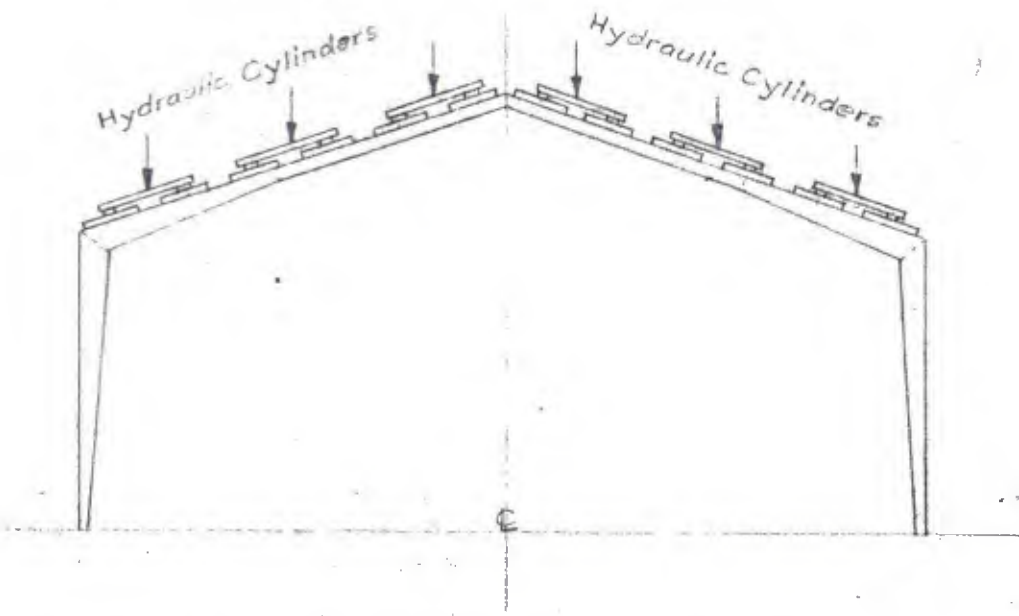


FIGURE 7. METHOD OF APPLYING SIMULATED SNOW LOADING HYDRAULICALLY USING PADS

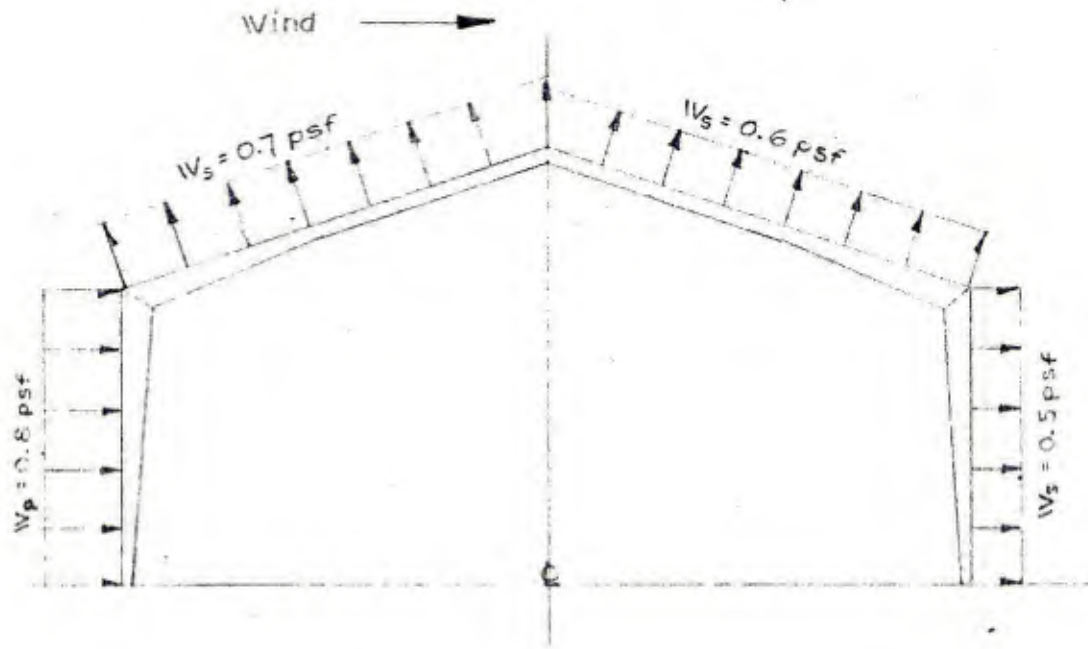


FIGURE 8. DESIGN WIND LOADING CONDITION FOR 70 MPH WIND

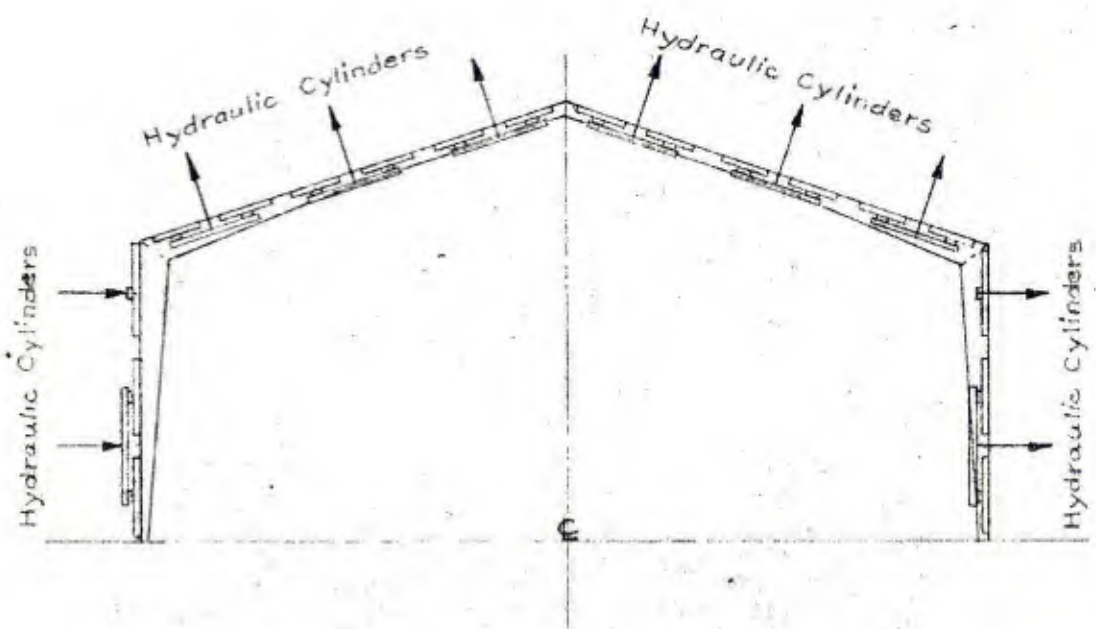


FIGURE 9. METHOD OF APPLYING SIMULATED WIND LOADING HYDRAULICALLY USING PADS

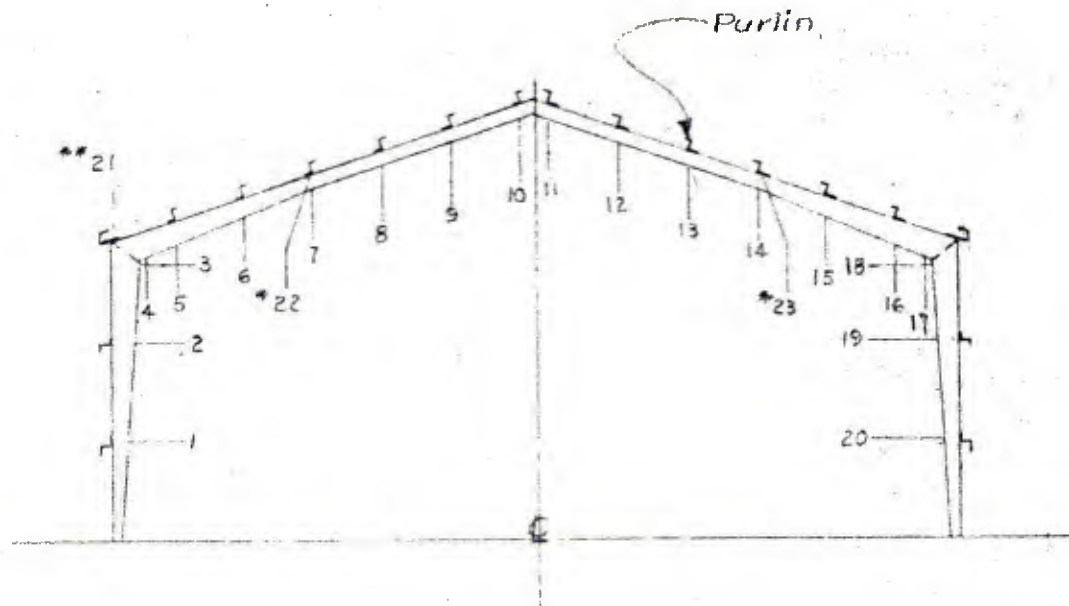


FIGURE 10 LOCATION OF STRAIN GAGES
TYPICAL FOR BOTH BOLTED & WELDED BENTS

NOTE:

- * STRAIN AND DEFLECTION GAGES ARE LOCATED AT THE MID-SPAN OF THE PURLIN BETWEEN THE BOLTED AND WELDED BENTS. STRAIN GAGES ARE ON THE BOTTOM FLANGE.
- ** STRAIN GAGE ON TOP SIDE OF HAUNCH, WELDED BENT ONLY

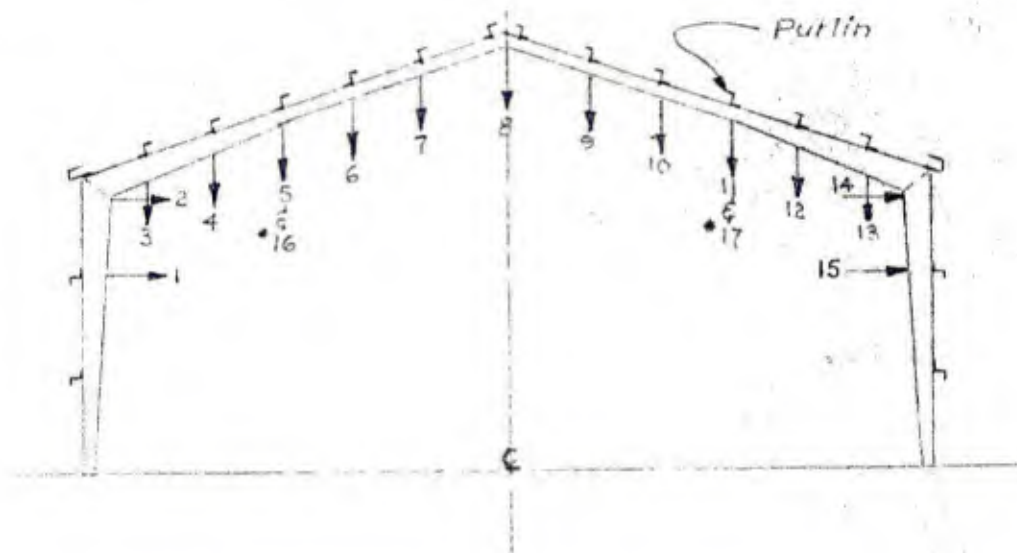


FIGURE 11 LOCATION OF DEFLECTION GAGES
TYPICAL FOR BOTH BOLTED & WELDED BENTS

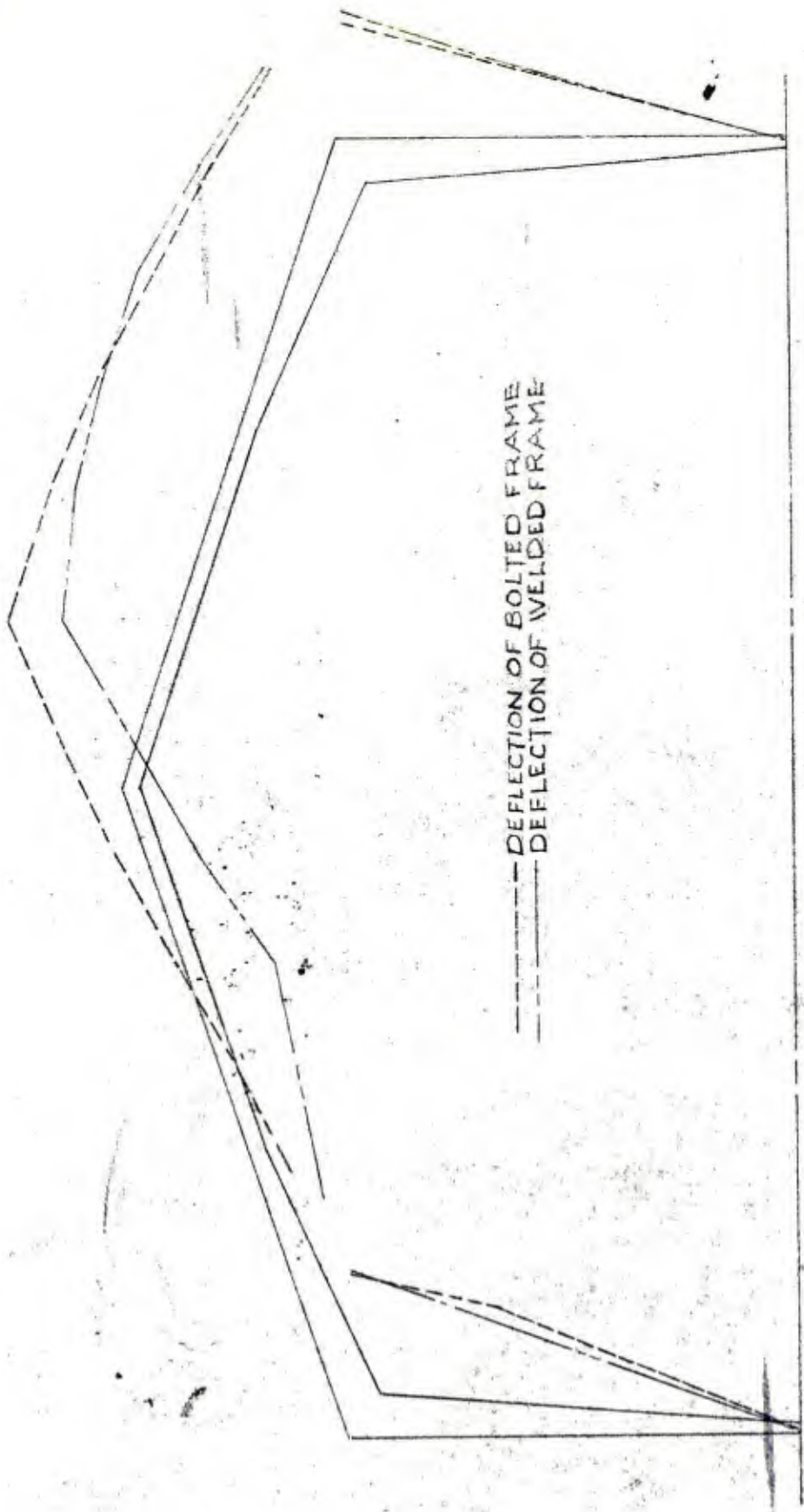


FIGURE 12. GRAPHIC ILLUSTRATION OF RECORDED DEFLECTIONS FOR BOLTED AND WELDED FRAMES AT 100 PER CENT OF DESIGN WIND LOAD. EXPANDED SCALE WAS USED TO SHOW THE DEFLECTIONS.