A STRUCTURAL ANALYSIS OF THE MICHIGAN STATE COLLEGE LIBRARY BUILDING

THESIS FOR THE DEGREE OF B. S.

W. B. Edwards

1931

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Structures, Theory of
Strains + stresses

Michigan State College library building

A Structural Analysis of
The Michigan State College Library Building

A Thesis Submitted to

The Faculty of

MICHIGAN STATE COLLEGE

of

AGRICULTURE AND APPLIED SCIENCE

By

W. B. Edwards

Candidate for the Degree of

Bachelor of Science

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W. B. E.

BIBLIOGRAPHY

"Roofs & Bridges" - Merriman & Jacoby

"Graphic Statics" - Malcolm

"Structural Theory" - Sutherland & Bowman

"Theory of Structures" - Spofford

"Reinforced Concrete Construction" - Hool, Vol. I & II

Building Code - City of Lansing

A. I. S. C. Handbook

Carnegie Pocket Companion

INTRODUCTION

This thesis, "A Structural Analysis of the Michigan State College Library Building", is presented as a practical problem on one phase of Civil Engineering; namely, Structural Engineering.

The building under consideration is located on the campus of the Michigan State College opposite the Engineering Building. It was erected in 1922 by the State of Michigan; Bowd-Munson & Co. of Lansing, being the architects.

The building is of brick and reinforced concrete construction with a slate roof supported on steel trusses. In general, the buildings may be divided into three parts: the west ell, housing the book stacks; the east ell, housing the Magazine Room, the seminars, and the College Museum; and the main part of the building in which is located the graduate study, the assigned reading room, and the main study hall.

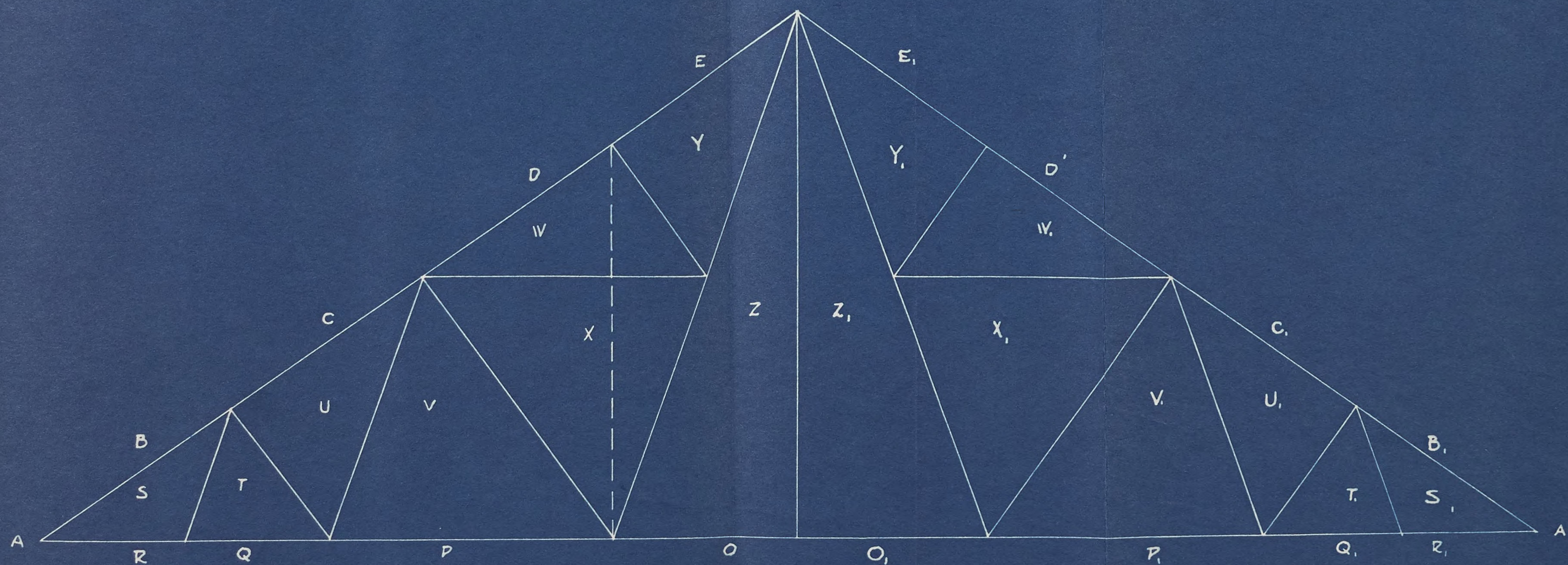
The building may also be classified, for the purpose of analysis, into the roof system, the floor system, the walls and columns, and the footings.

PART I

The roof system is composed of four parts, the truss-supported roofs over the east and west ells and the main section of the building and the reinforced concrete slab roof over the art gallery and main hall.

The first roof to be considered is the roof over the main part of the building. It is composed of slate roofing nailed to wooden sheathing which is supported directly upon the purlins, 8" @ 11.25# channels, which are in turn supported upon the modified Fink roof trusses shown in Fig. 1 at all panel points with the exception of the end panel points just above the reactions, the roof at the end resting directly upon the wall of the building. The size of the members in the roof truss, with other data concerning the trusses is found in table 1 on the following page.

The loads upon the roof trusses may be divided into two classes, the dead and the live. The dead load is composed of the weight of the truss itself supported from the panel points on the upper chord of the truss and the weights of the roof covering and purlins on the upper chord and the weight of the suspended ceiling on the lower chord which is also considered as acting at the panel points. The live load may consist of any of several combinations of loadings acting at the panel points on the upper chord, the combination producing the greatest stress in each member being used in figuring the fiber stress in that particular member. These different combinations of live loads are as follows: (1) snow over the entire roof, (2) wind on one side and snow on the opposite side,



ROOF TRUSS - MAIN ROOF
SCALE - 1/4" = 1'-0"

TABLE 1

MAIN ROOF TRUSS DATA

MEMBER	ANGLES	WT/FT.	LENGTH	AREA (in^2)
BS & B,S,	2-5x3½x5/16	17.4	7' 4¼"	5.12
CU & C,U,	2-5x3½x5/16	17.4	7' 4¼"	5.12
DW & D,W,	2-5x3½x5/16	17.4	7' 4¼"	5.12
EY & E,Y,	2-5x3½x5/16	17.4	7' 4¼"	5.12
SR & S,R,	2-4x3 x5/16	14.4	4' 6-1/16"	4.18
TQ & T,Q,	2-4x3x5/16	14.4	4' 6-1/16"	4.18
VP & V,P,	2-4x3x5/16	14.4	9' 0-1/8"	4.18
ZO & Z,O,	2-4x3x5/16	14.4	5' 11¾"	4.18
ST & S,T,	1-2½x2x¼	3.62	4' 6-1/16"	1.06
TU & T,U,	2-2½x2x¼	7.24	5' 2½"	7.24
UV & U,V,	2-2½x2x¼	7.24	9' 0-1/8"	2.12
VX & V,X,	2-2½x2x¼	7.24	10' 5"	2.12
XW & X,W,	2-2½x2x¼	7.24	9' 0-1/8"	2.12
WY & W,Y,	2-2½x2x¼	7.24	5' 2½"	2.12
XZ & X,Z,	2-2½x2½x¼	8.2	9' 0-1/8"	2.38
YZ & Y,Z,	2-2½x2½x¼	8.2	9' 0-1/8"	2.38
ZZ,	1-2½x2x¼	3.62	17' 0"	1.06

Total weight 2374#

and (3) wind on one side and ice over the whole roof.

The dead load on the main truss is computed as follows: the total weight of the truss itself as taken from table 1 is 2474 pounds, which, when distributed equally over the upper chord, produces a load of 264 pounds at each of the intermediate panel points and 132 pounds at each of the end panel points; the weight of the roof covering is equal to the area of the roof supported by the truss times the weight of a unit area of the roof, the area being 386 square foot per side per truss, and the weight being 11.25 pounds per square foot and the sheathing 4.00. This makes the total weight of the roof covering 4342.5 pounds, which, when divided equally among the panels, produces a load of 960 pounds at each of the intermediate panel points, and a load of 480 pounds acting directly upon the wall at each end. The dead load caused by the purlins at each panel point is obtained by multiplying the distance between trusses (13 feet) by the weight per foot of the purlins (11.5 pounds) and is equal to 150 pounds per panel point. The weight of the suspended ceiling on the lower chord is taken as 10 pounds per square foot producing a load of 130 pounds per foot upon the chord of the truss. This is divided proportionately amoung the various panels as is shown in the load schedule in table 2.

In considering the live load, the snow load is taken as 10 pounds per square foot[1], and the ice load is taken as the same, while the wind load is considered as being 20 pounds

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1. "Theory of Structures" - Spofford

per square foot on vertical surface[2] and the component normal to the surface is figured by the formula $P_N = P_V \frac{\alpha}{45°}$.
These live loads are also shown in tabular form in table 2.

All stresses in the members of the main truss were found by graphical methods, the stress in the ambiguous members wx and $w_1 x_1$ being found by the method as described in Art. 25 of Part II of "Roofs & Bridges" by Merriman & Jacoby. These stresses are found in table 3, and the graphic solutions are found in Figs. 2, 3, and 4.

The Fink roof truss which is used on the east ell is shown in Fig. 5 and the size of the members is shown in table 4. The method of computing the loads on the truss being the same as that used on the main truss, the distance between trusses being 16.33 feet, and the roof area per truss being 405 square feet. The loads on the east ell trusses are shown in table 5 and the stresses are shown in table 6 with the graphical solutions in Figs. 6, 7, 8, and 9.

The third part of the roof system, the roof over the west ell, is somewhat different than the others in that the truss used to support the roof is statically indeterminate under unsymmetrical loading such as snow or wind on one side. This makes necessary certain assumptions in the computation of the stresses, these assumptions being explained in the discussion of the computation of the stresses produced by the unsymmetrical loading.

The data regarding the members of this truss is found in

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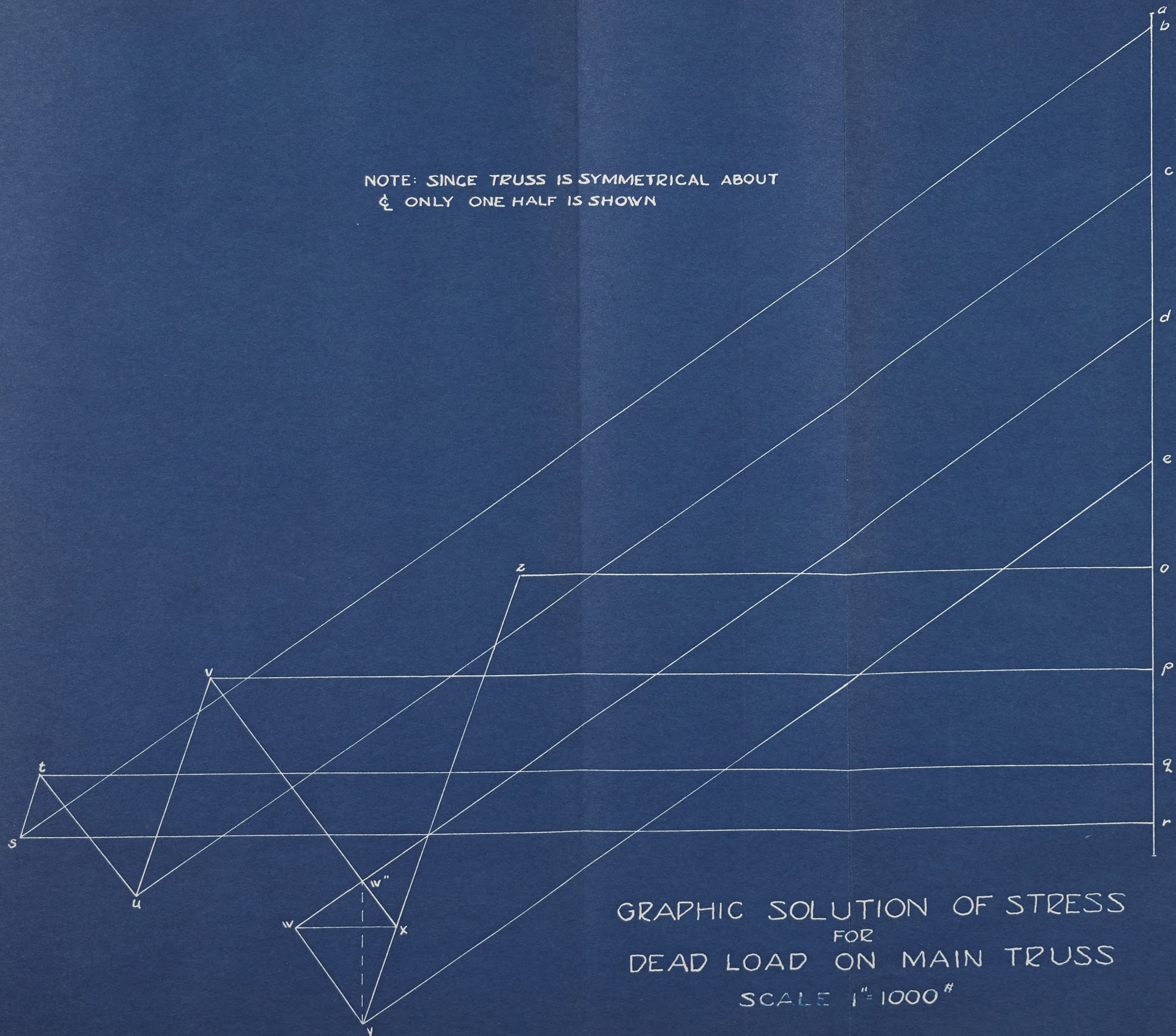
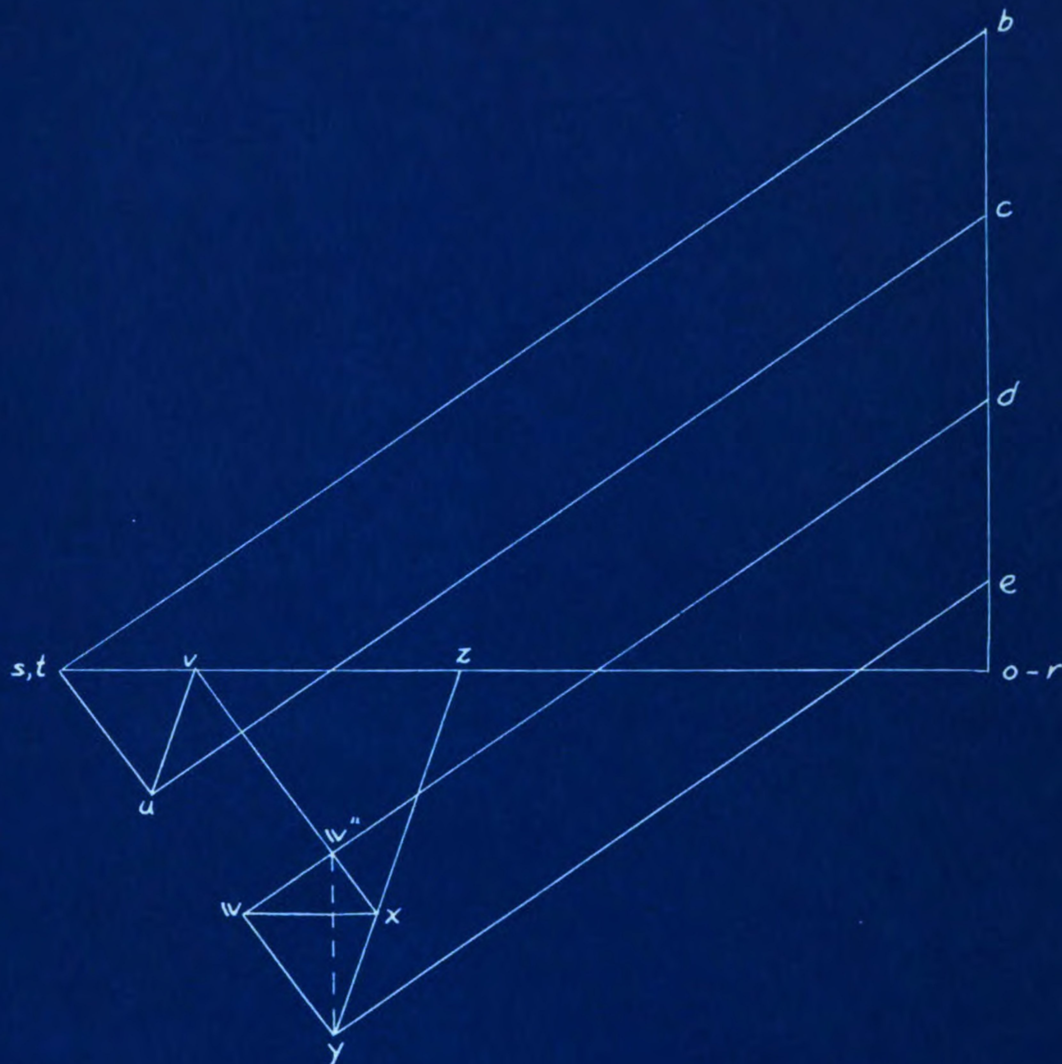
2. Building Code - City of Lansing.

NOTE: SINCE TRUSS IS SYMMETRICAL ABOUT ℄ ONLY ONE HALF IS SHOWN



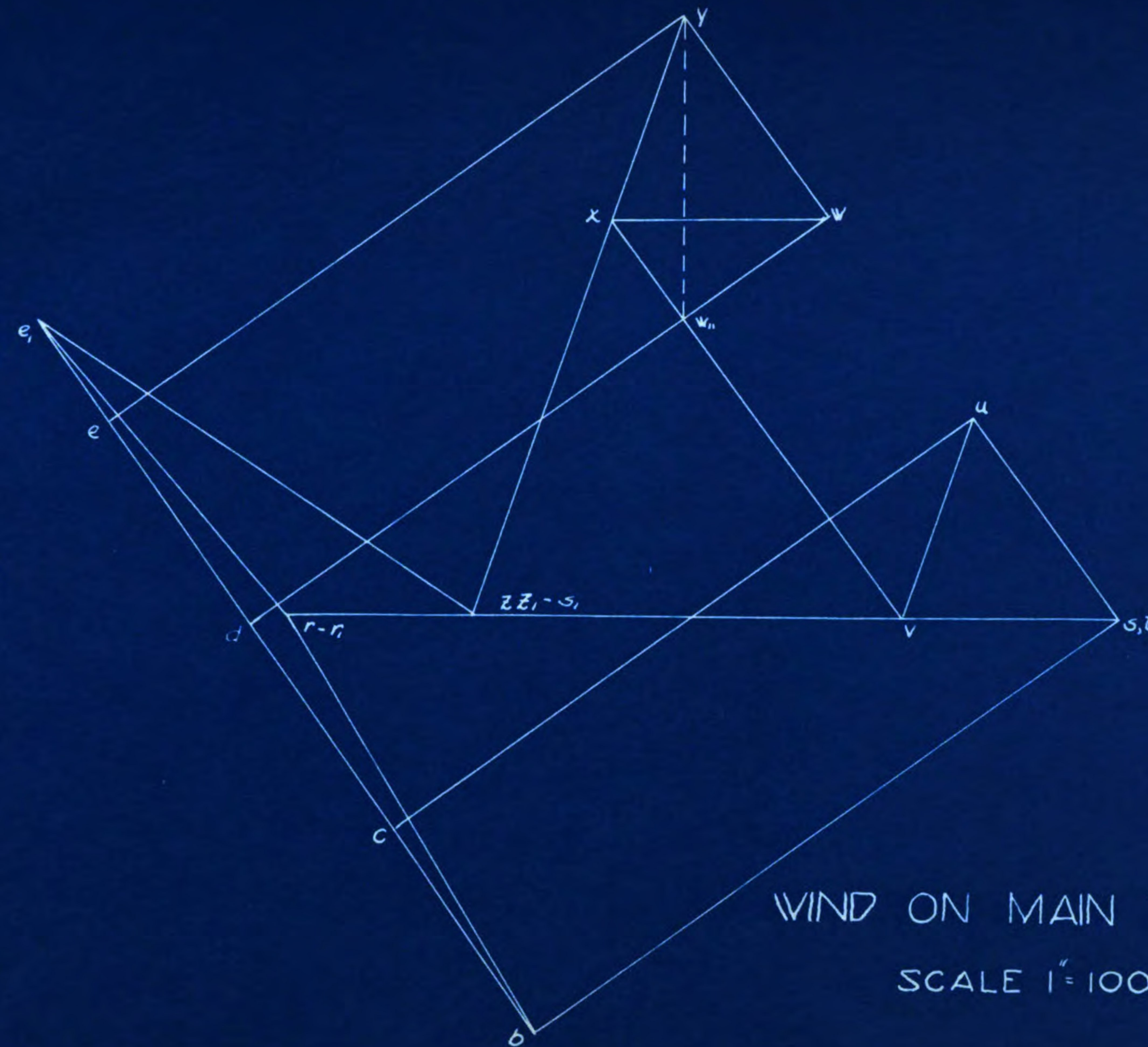
GRAPHIC SOLUTION OF STRESS FOR DEAD LOAD ON MAIN TRUSS

SCALE 1" = 1000#



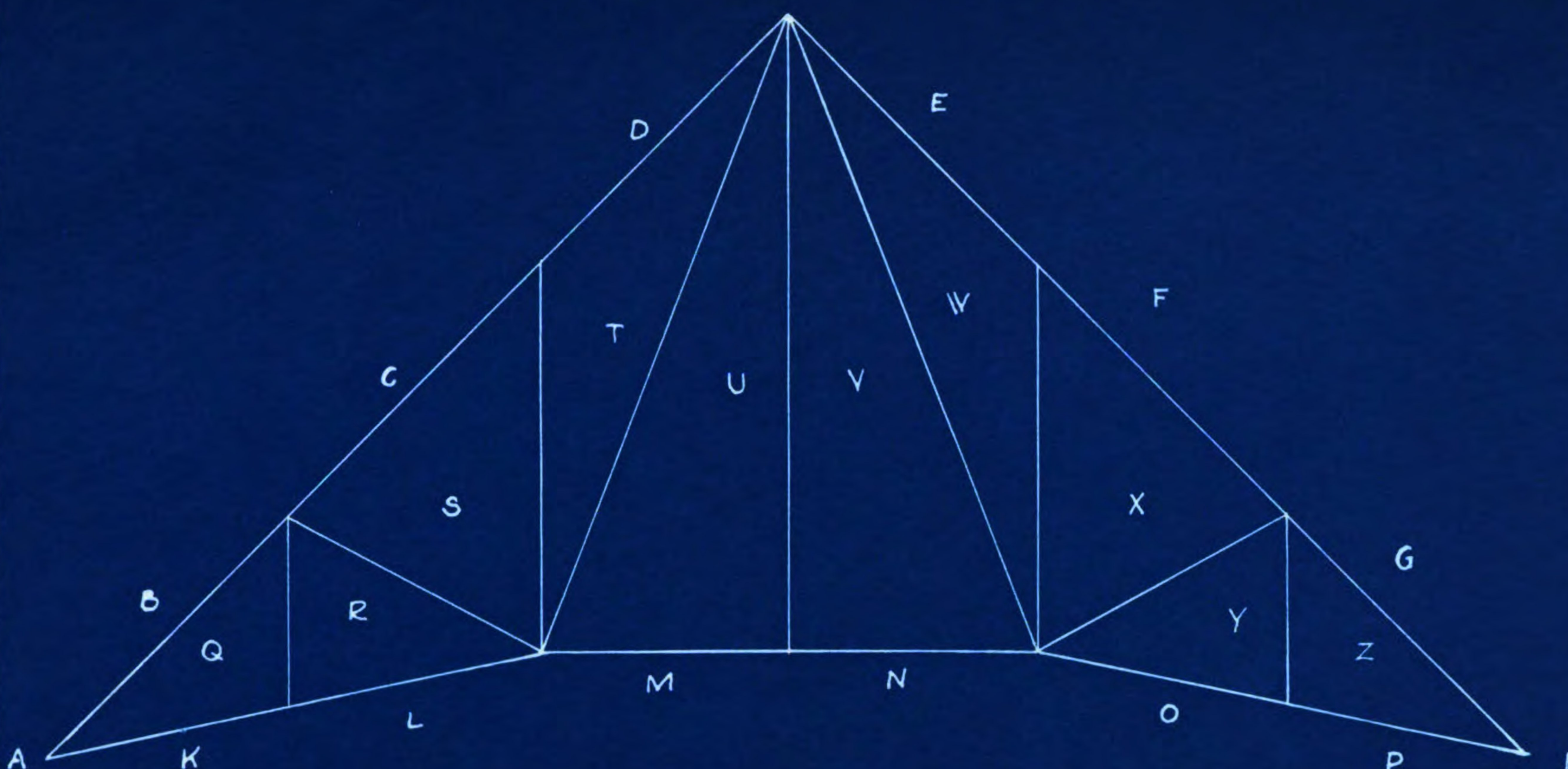
MAIN TRUSS - ICE ON WHOLE ROOF

SCALE 1" = 1000#

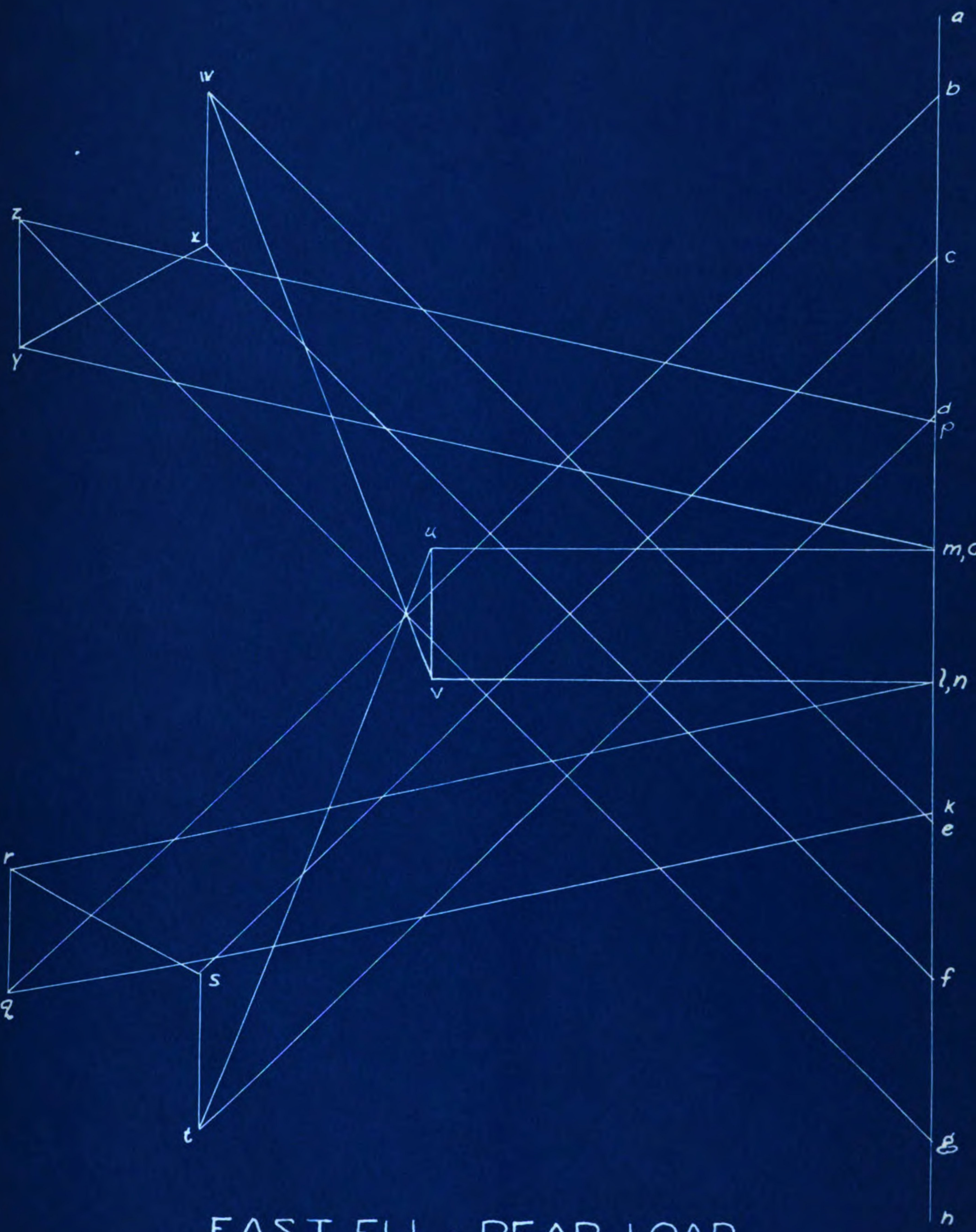


WIND ON MAIN TRUSS

SCALE 1" = 1000#

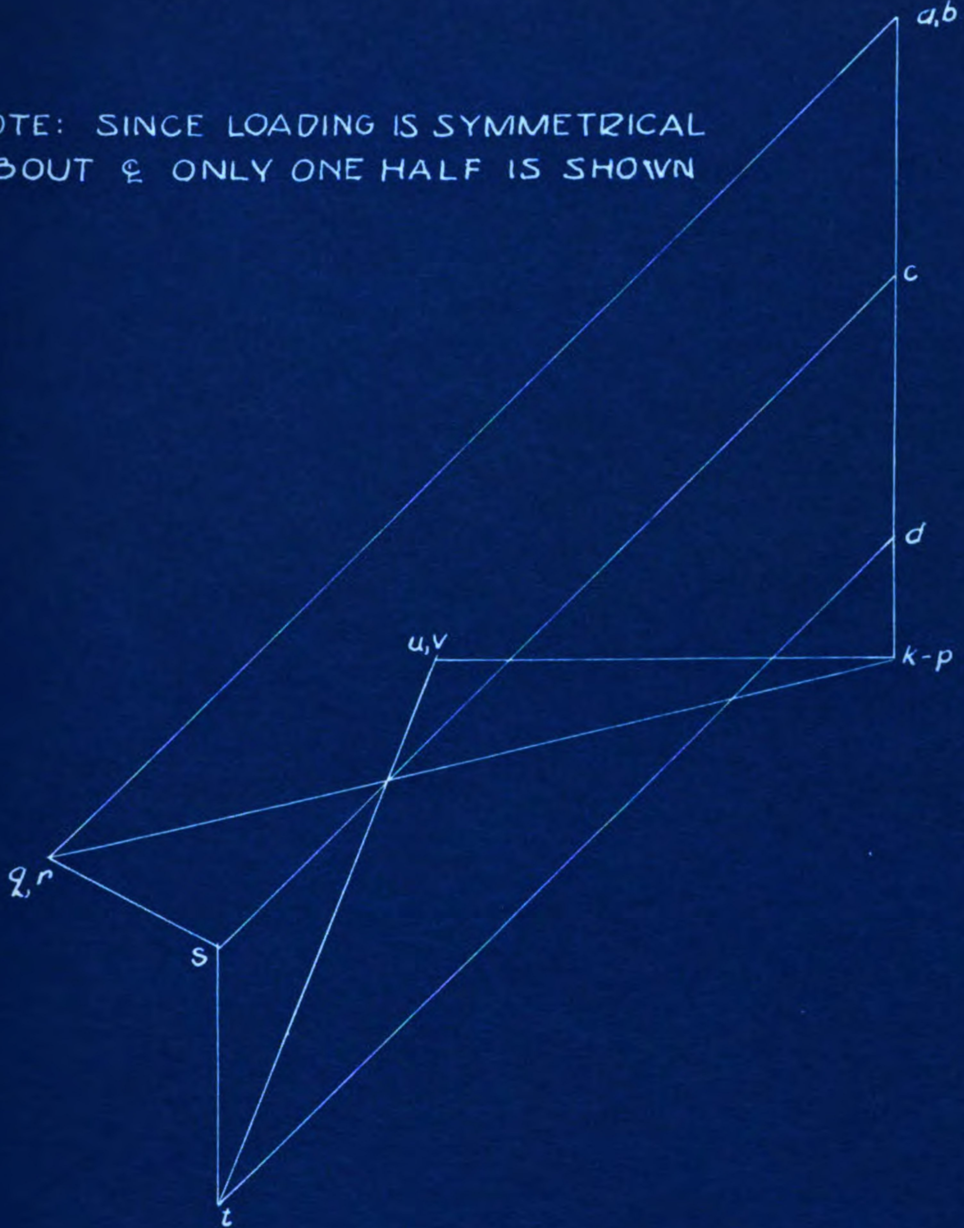


ROOF TRUSS — EAST ELL
SCALE 1/4" = 1'-0"



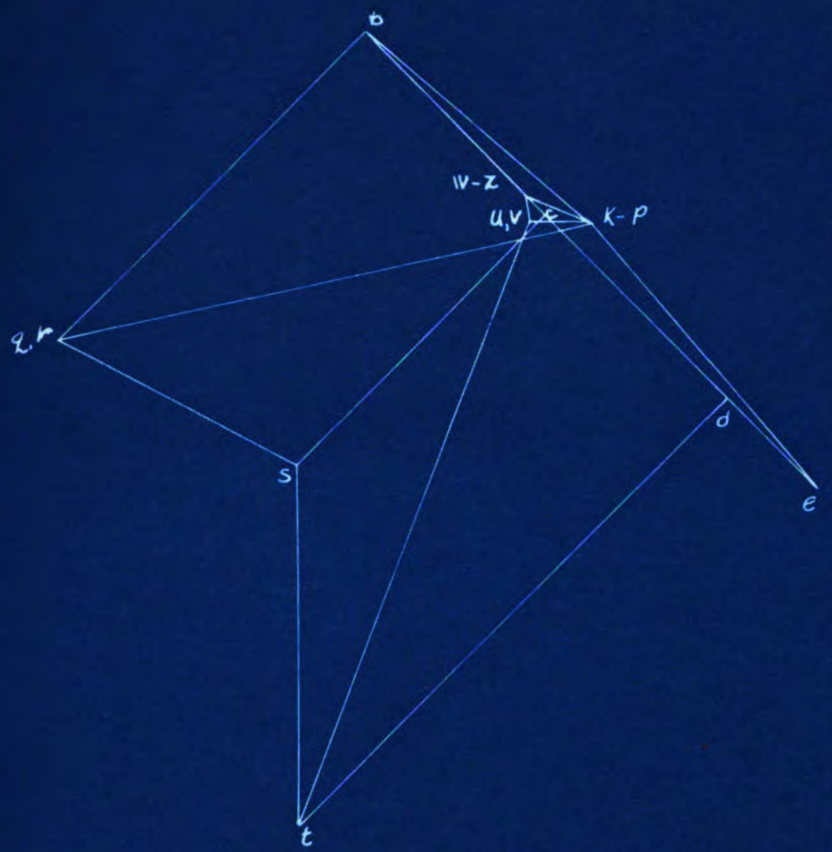
EAST ELL - DEAD LOAD
SCALE 1"=1000#

NOTE: SINCE LOADING IS SYMMETRICAL ABOUT ℄ ONLY ONE HALF IS SHOWN

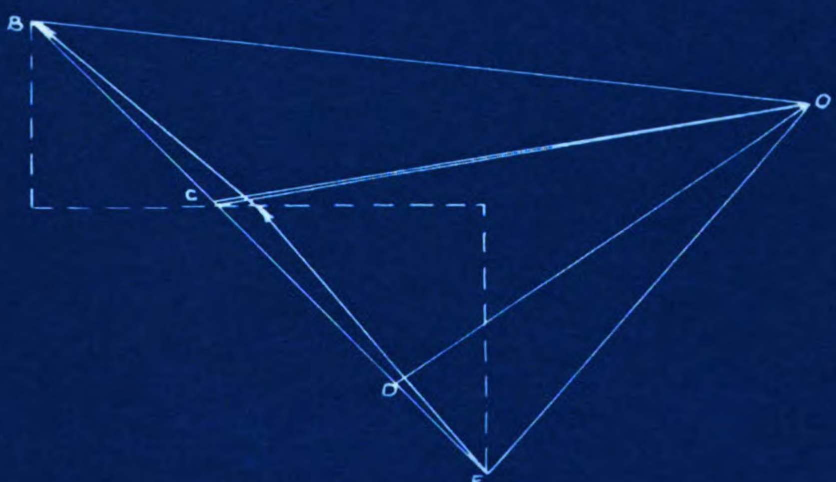


EAST ELL - ICE ON WHOLE ROOF

SCALE 1" = 500#



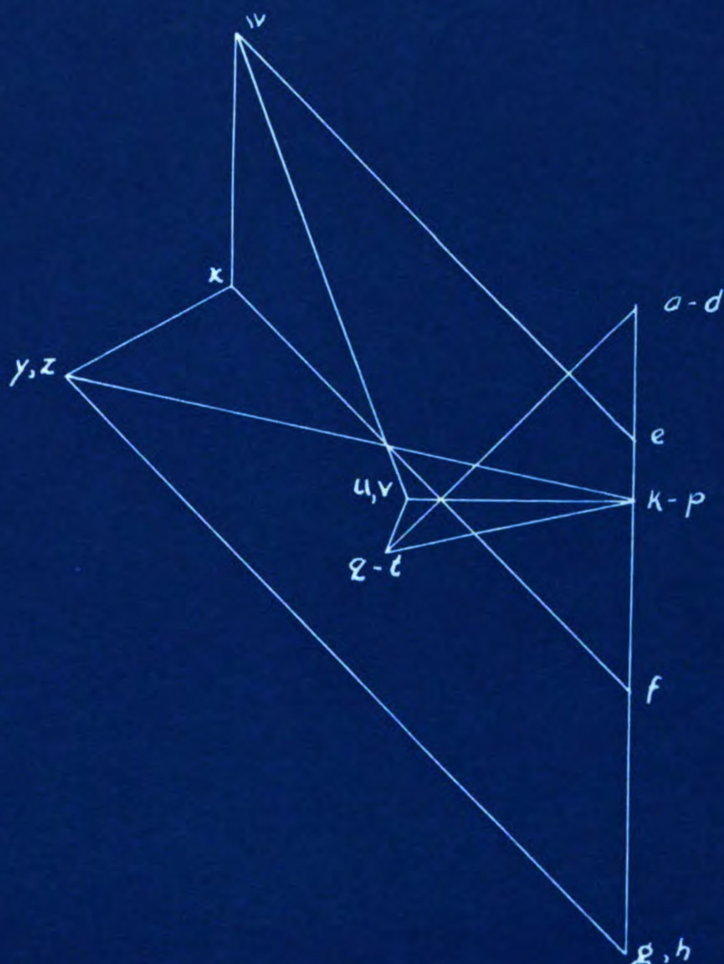
STRESS DIAGRAM



REACTIONS

EAST ELL- WIND ON LEFT

SCALE 1"=1000#



EAST ELL - SNOW ON RIGHT
SCALE - 1" = 500#

TABLE 2

LOADS ON MAIN TRUSS

LOAD	DEAD	SNOW OR ICE	WIND
AB	130		
BC	1380	970	1550
CD	1380	970	1550
DE	1380	970	1550
EE'	1380	970	775
E'D'	1380	970	
D'C'	1380	970	
C'B'	1380	970	
B'A'	130		
AR	300		
RQ	600		
QP	900		
PO	990		
OO'	780		
O'P'	990		
P'Q'	900		
Q'R'	600		
R'A'	300		
Left Reaction	8140	3395	3050
Right Reaction	8140	3395	2400

Note:- All loads vertical except wind which is normal to the roof surface

TABLE 3

STRESSES IN MAIN TRUSS MEMBERS

MEMBER	DEAD STRESS	ICE ON WHOLE ROOF	WIND	MAX.
BS	13330 C	5900 C	4460 C	23690 C
CU	11940 C	5330 C	4460 C	21730 C
DW	10120 C	4750 C	4460 C	19330 C
EY	9330 C	4160 C	4460 C	17950 C
RS	10820 T	4850 T	5200 T	20870 T
QT	10640 T	4850 T	5200 T	20690 T
PV	9050 T	4140 T	3850 T	17040 T
OZ	6120 T	2750 T	1170 T	10040 T
ST	640 T	0	0	640 T
TU	1470 C	810 C	1550 C	3830 C
UV	2210 T	700 T	1320 T	4230 T
VX	2970 C	1590 C	1550 C	6110 C
XW	960 T	710 T	1320 T	2990 T
WY	1150 C	810 C	1550 C	3510 C
YZ	4580 T	2030 T	3950 T	10560 T
XZ	3580 T	1340 T	2590 T	7510 T
ZZ'	780 T	0	0	780 T
X'Z'	3580 T	1340 T	0	4920 T
Y'Z'	4580 T	2030 T	0	6610 T
W'Y'	1150 C	810 C	0	1960 C
X'W'	960 T	710 T	0	1670 T
V'X'	2970 C	1590 C	0	4560 C

(cont)

TABLE 3 (cont)

MEMBER	DEAD STRESS	ICE ON WHOLE ROOF	WIND	MAX.
U'V'	2210 T	700 T	0	2910 T
T'U'	1470 C	810 C	0	2280 C
S'T'	640 T	0	0	640 T
O'Z'	6120 T	2750 T	1170 T	10040 T
P'V'	9050 T	4140 T	1170 T	14360 T
Q'T'	10640 T	4850 T	1170 T	16660 T
R'S'	10820 T	4850 T	1170 T	16840 T
E'Y'	9330 C	4160 C	3300 C	16790 C
D'W'	10120 C	4750 C	3300 C	18170 C
C'U'	11940 C	5330 C	3300 C	20570 C
B'S'	13330 C	5900 C	3300 C	22530 C

Maximum Compressive Stress is 4640 pounds per square inch

Maximum Tensile Stress is 5000 pounds per square inch

TABLE 4

EAST ELL TRUSS DATA

MEMBER	ANGLES	WT/FT	LENGTH	AREA (in^2)
BQ & GZ	2-4x3x5/16	14.4	7' 11¼"	4.18
CS & FX	2-4x3x5/16	14.4	7' 11¼"	4.18
DT & EW	2-4x3x5/16	14.4	7' 11¼"	4.18
QK & ZP	2-3x3x5/8	23.0	5' 8¾"	6.72
RL & YO	2-3x3x5/8	23.0	5' 8¾"	6.72
UM & YN	2-3x3x5/8	23.0	5' 7-5/16"	6.72
QR & YZ	2-2½x2x¼	3.62	4' 5-5/16"	1.06
RS & YX	2-2½x2x¼	7.24	6' 6"	2.12
ST & XW	2-2½x2x¼	7.24	8' 10-5/8"	2.12
TU & WV	2-2½x2½x¼	8.2	15' 6-9/16"	2.38
UV	1-2½x2x¼	7.24	14' 6"	1.06
	Total weight	1200#		

TABLE 5

LOADS ON EAST ELL

LOAD	DEAD	SNOW OR ICE	SNOW ON RIGHT	WIND
AB	100			
BC	1150	675		1350
CD	1150	675		1350
DE	1150	675	338	675
EF	1150	675	675	
FG	1150	675	675	
GH	100			
AK	470			
KL	940			
LM	940			
MN	940			
NO	940			
OP	940			
PH	470			
Left React.	5795	1688	506.5	1540
Right React.	5795	1688	1181.5	1850

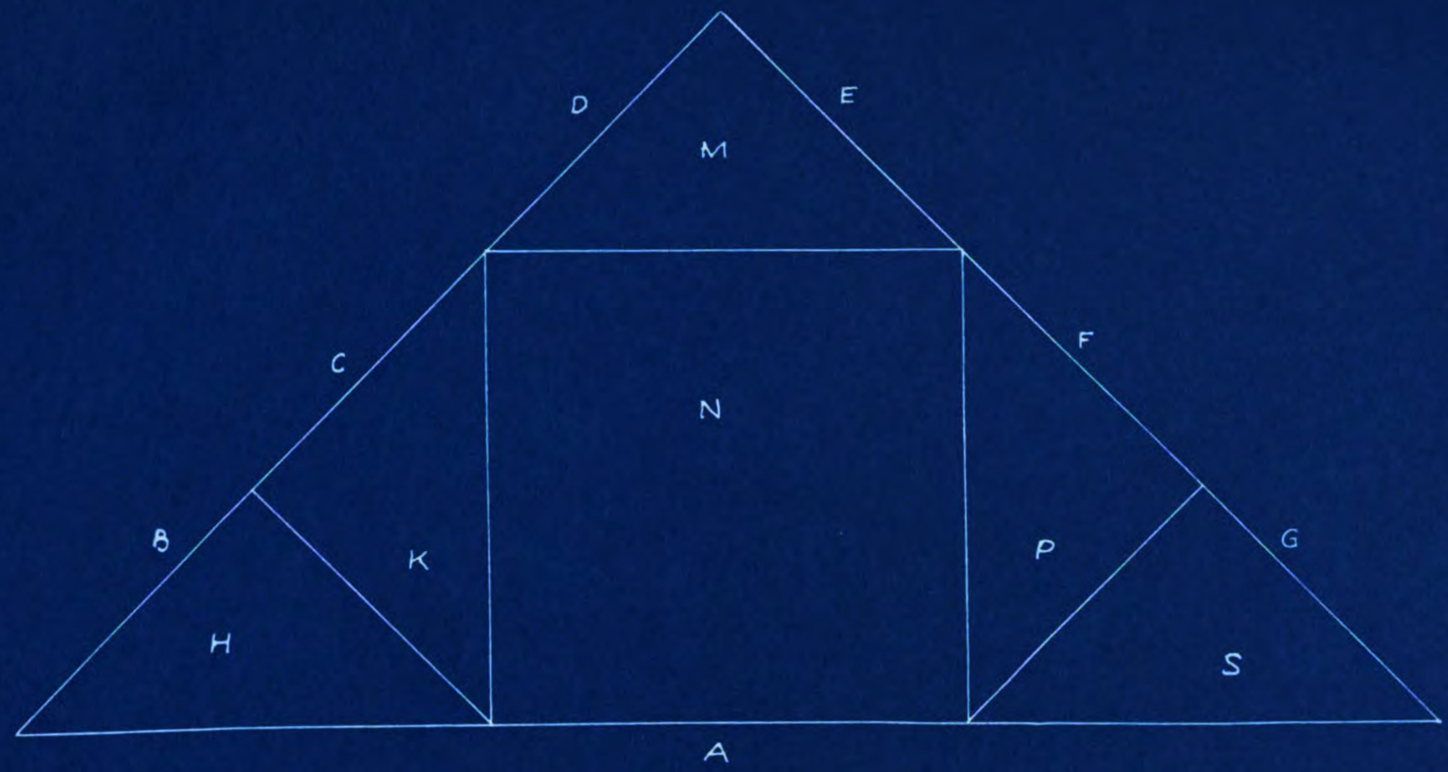
Note: - All loads vertical except wind which is normal to the roof surface.

TABLE 6

STRESSES IN EAST ELL TRUSS MEMBERS

MEMBER	DEAD STRESS	SNOW ON RT.	ICE ON WHOLE	WIND ON LEFT	MAX.
BH	9390 C	925 C	3110 C	2250 C	14750 C
CS	7450 C	925 C	2490 C	1830 C	11770 C
DT	7450 C	925 C	2490 C	3150 C	13090 C
KQ	6700 T	670 T	2260 T	2840 T	11800 T
LR	6700 T	670 T	2260 T	2840 T	11800 T
MU	3630 T	585 T	1200 T	300 T	4130 T
QR	940 T	0	0	0	940 T
RS	1550 C	0	500 C	1400 C	3450 C
ST	1150 C	0	675 C	1900 C	3725 C
TU	4560 T	150 T	1550 T	3390 T	9500 T
UV	940 T	0	0	0	940 T
VW	4560 T	1300 T	1550 T	200 T	6310 T
WX	1150 C	675 C	675 C	0	1825 C
XY	1550 C	500 C	500 C	0	2050 C
YZ	940 T	0	0	0	940 T
NV	3630 T	585 T	1200 T	300 T	5130 T
OY	6700 T	1525 T	2260 T	380 T	9340 T
PZ	6700 T	1525 T	2260 T	380 T	9340 T
EW	7450 C	1500 C	2490 C	2190 C	12130 C
FX	7450 C	1500 C	2490 C	2190 C	12130 C
GZ	9390 C	2125 C	3110 C	2190 C	14690 C

Maximum compressive stress is 3530 pounds/sq. inch
Maximum tensile stress is 1750 pounds/sq. inch

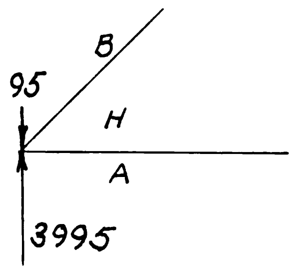


ROOF TRUSS - WEST ELL

SCALE - 1/4" = 1'-0"

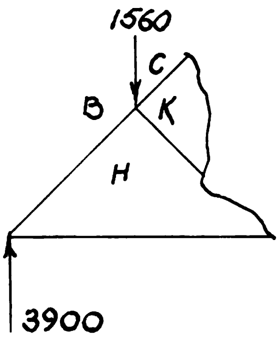
table 7 and the loads on the truss are found in table 8.

The dead stress in the members of the truss have been computed by the method of joints, these computations being shown in the following paragraphs.



$$\text{Stress}_{(BH)} = \frac{3898.5}{.707} = 5520\# \text{ C}$$

$$\text{Stress}_{(AH)} = 3898.5^{\#} \text{ T}$$



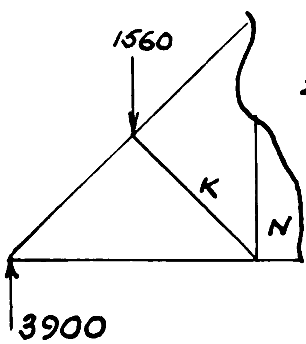
$$\Sigma M = 0$$

$$3898.5(9.91) - 1559.4\ (4.95) - 7.01\ S_{(CK)} = 0$$

$$S_{(CK)} = 4400^{\#} \text{ C}$$

$$1559.4\ (4.95) - 7.01\ S_{(HK)} = 0$$

$$S_{(HK)} = 1100^{\#} \text{ C}$$



$$\Sigma M = 0$$

$$1559.4\ (4.95) = 9.91\ S_{(KN)}$$

$$S_{(KN)} = 779.7^{\#} \text{ T}$$

TABLE 7

WEST ELL TRUSS DATA

MEMBER	ANGLES	WT./FT.	LENGTH	AREA (in^2)
BH & GS	2 - 4x3x5/16	14.4	7'- 1/8"	4.18
CK & FP	2 - 4x3x5/16	14.4	7'- 1/8"	4.18
DM & EM	2 - 4x3x5/16	14.4	7'- 1/8"	4.18
HK & PS	2 - 3x3x5/16	12.2	7'- 1/8"	3.56
KN & NP	2 - 3x3x5/16	12.2	9'- 11"	3.56
MN	2 - 3x3x5/16	12.2	9'- 11"	3.56
HNS-A	18" - 20" G	*	29'- 9"	
	Total weight	1139.41#		

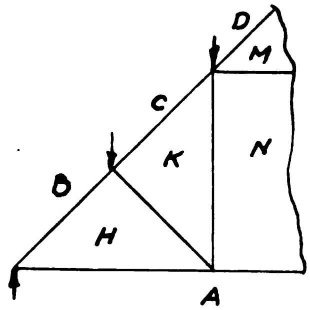
* Weight of Girder beam considered elsewhere

TABLE 8

LOADS ON WEST ELL

LOAD	DEAD	SNOW OR ICE	SNOW ON RT.		WIND
BC	1560	1080			2160
CD	1560	1080			2160
DE	1560	1080	540		1080
EF	1560	1080	1080		
FG	1560	1080	1080		
GA	95				
AB	95				
Left Reaction	3995	2700	810	V	1530
				H	1913
Right Reaction	3995	2700	1890	V	3825
				H	1913

Note:- All loads vertical except wind which is normal to the roof surface.



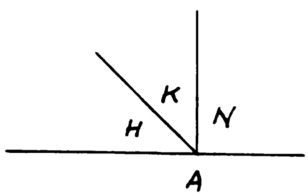
$\Sigma M = 0$

$$1559.4\ (9.91 + 4.95) = 9.915\ S_{(MN)}$$

$$S_{(MN)} = 2339.1^{\#}\ C$$

$\Sigma F_V = 0$

$$S_{(DM)} = 3898.5 - 2(1559.4) \div .707 = 1100^{\#}\ C$$

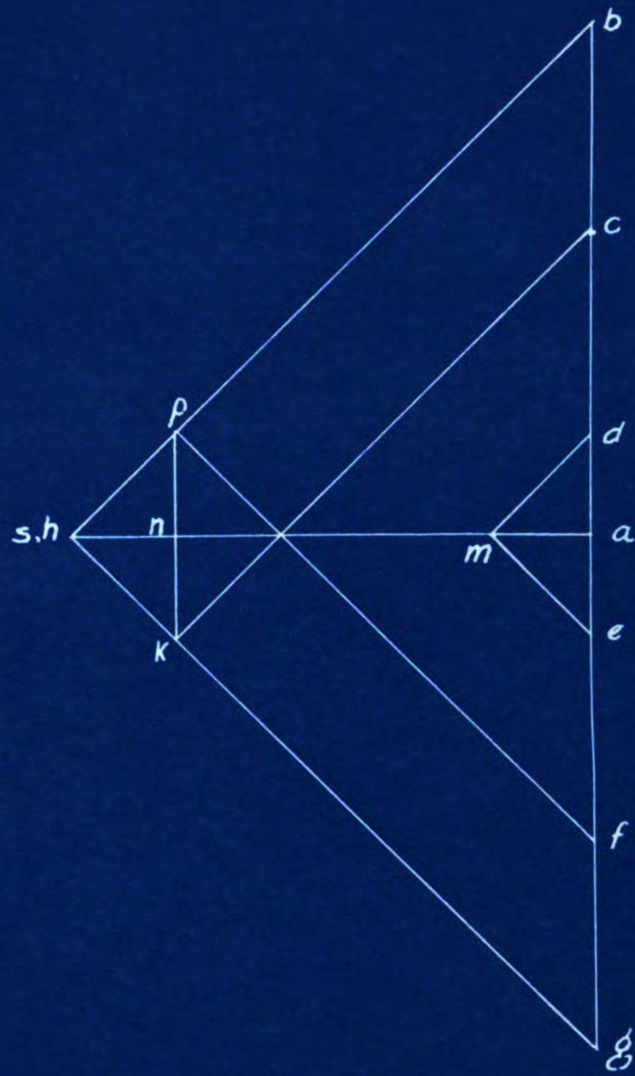


$$S_{(AN)} = 3898.5 - .707(1100) = 3119^{\#}\ T$$

The stresses in the members on the opposite side of the truss are the same as those already computed.

The stresses for ice or snow over the entire roof are shown in Fig. 11 and are included in the table on stresses in West ell members, Table 9.

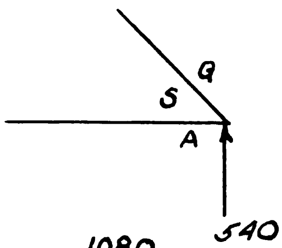
From this point on the truss becomes statically indeterminate if the entire truss is considered as a unit with reactions at each end of the supporting girder beam, but if the upper portion of the truss is considered as being supported by the girder beam with reactions at the four points where the truss is fastened to the girder H, N, S, A, the stresses for conditions of unsymmetrical loading may be readily computed. Following is the solution for snow on the right side of the truss. The loads as given in Table 8 are DE = 540$^{\#}$, EF & FG = 1080$^{\#}$. These loads are considered as being transmitted to



WEST ELL - ICE ON WHOLE ROOF
SCALE - 1" = 1000#

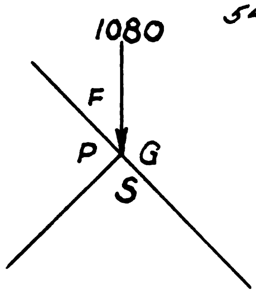
the beam along the most direct route causing reactions on the beam, reading from left to right, of 0, 270, 1890, and 540 pounds, respectively. With this assumption the stresses may be readily figured by the method of joints.

Since the left reaction is zero, it is apparent that the stress in members BH, HA, HK, and CK must also be zero.



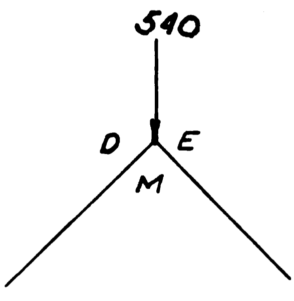
$$S_{(SG)} = 540 \div .707 = 760^{\#} \text{ C}$$

$$S_{(SA)} = 760 \times .707 = 540^{\#} \text{ T}$$



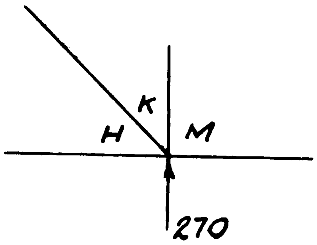
$$S_{(PS)} = .707 \times 1080 = 760^{\#} \text{ C}$$

$$S_{(FP)} = 760 - .707 \times 1080 = 0$$

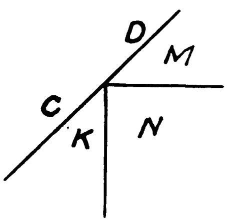


$$S_{(DM)} = \frac{540}{2(,707)} = 380^{\#} \text{ C}$$

$$S_{(ME)} = \frac{540}{2(.707)} = 380^{\#} \text{ C}$$

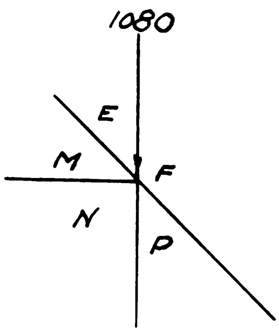


$S_{(KM)} = 270^{\#}$ C



$S_{(MN)} = 380 \times .707 = 270^{\#}$ T

$S_{(CK)} = 0$



$S_{(NP)} = 1080 + .707 \times 380 = 1350^{\#}$ C

Considering the reactions as concentrated loads upon the beam, the reactions upon the walls may be determined by the equation $\Sigma M = 0$.

$$(270)1 + (1890)2 + (540)3 = 3\, R_{(right)}$$

$$R_{(right)} = 1890^{\#}$$

$$R_{(left)} = 810^{\#}$$

The other condition of unsymmetrical loading is that of the wind on the left side of the roof. The wind load as computed by the formula in the discussion of the main truss is 20 pounds per square foot normal to the surface which is at an angle of 45° with the horizontal. The panel loads as given in table 8 are 2160# at the top panel point. The reactions here are considered in the same manner as were the reactions for the unbalanced snow load, that is, there are assumed to be four reactions instead of the customary two end reactions. Since the loads are normal to the surface there will be both horizontal and vertical components to the reactions on the beam, the horizontal components being considered as producing shear in the rivets which fasten the truss to the girder beam, there being fourteen rivets at each end joint and twelve at each intermediate joint. The reactions on the girder beam are taken as follows: left - zero, second - vertical 3060#, horizontal 1530#; third - vertical negative 1530# (acting down) horizontal zero; right - vertical 2295#, horizontal 2295#. With these assumptions it is very easy to compute the stresses in the members using the method of joints. The stresses computed in this manner are shown with the other stresses in west ell members in table 9.

One further assumption is made in the computation on this truss, that is that the horizontal components of the reactions on the girder are transmitted equally to the supporting walls causing a horizontal component of 1913# on each wall. The vertical components of the reactions are:

TABLE 9

STRESSES IN WEST ELL TRUSS MEMBERS

MEMBER	DEAD STRESS	SNOW ON RT.	ICE ON WHOLE	WIND ON LEFT	MAX.
BH	5520 C	0	3810 C	0	9330 C
CK	4400 C	0	3050 C	0	7450 C
DM	1100 C	380 C	750 C	0	1850 C
HA	3900 T	0	2730 T	0	6630 T
NA	3120 T	0	2180 T	0	5300 T
HK	1100 C	0	750 C	2160 C	4010 C
KN	780 T	270 C	540 T	1530 C	1320 T 1020 C*
MN	2340 C	270 C	1650 C	1530 C	5520 C
ND	780 T	1350 C	540 T	1530 T	2850 T 570 C*
PS	1100 C	760 C	750 C	0	1860 C*
SA	3900 T	540 T	2730 T	0	6630 T
ME	1100 C	380 C	750 C	1080 C	2930 C
PF	4400 C	0	3050 C	3240 C	10690 C
SG	5520 C	760 C	3810 C	3240 C	12570 C

* Maximum produced with snow on one side

Maximum compressive stress is 3000 pounds/square inch

Maximum tensile stress is 800 pounds/square inch left - 1530# and right - 2295#.

The fourth and last section of the roof system is the flat slab roof over the art gallery and main stairway. Since data concerning the placing of steel in this slab was not available, the only computations made were the values of the reactions upon the wall. The slab is a 4" slab covered with cinders and roofing material. It is 28' wide and is supported on eight 9" -21# I-beams spaced 13 feet apart. The total weight of the roof including a dead load of 55 pounds and a snow load of 10 pounds, is 65 pounds per square foot. Considering a section of the slab one foot wide as a continuous beam over the eight supports the loads per foot upon the supporting I-beams are as follows:

Supports No. 1 & 8	333 pounds per foot
Supports No. 2 & 7	960 pounds per foot
Supports No. 3 & 6	786 pounds per foot
Supports No. 4 & 5	853 pounds per foot

The above loads, together with the weight of the I-beams produce the following reactions upon the supports:

On each end of the 1 st & 8 th beams	4,950 pounds
2 nd & 7 th beams	13,750 pounds
3 rd & 6 th beams	11,300 pounds
4 th & 5 th beams	12,250 pounds

PART II

After considering the roof system, the next part of the building to be considered will be the floors. All of the floors in the building, with the exception of those of patented construction used in the book stacks, are of reinforced concrete. The important slabs are of the steel pan type of construction, the slabs being 2" thick and the joists varying from 8" to 14".

The first slab to be considered will be the one in the attic of the west ell. This slab is of type "X" and has a span of 14' from girder to girder. It is 6" thick and is reinforced with 5/8" round bars 8" c.c. The dead load per square foot is 1 x 1 x $\frac{1}{2}$ x 150, or 75 pounds. The live load as taken from the Lansing Building Code is 20 pounds per square foot, making a total load of 95 pounds per square foot.

$$M = 1/8\ wl^2 = 1/8 \times 95 \times (14)^2 = 2330'\# = 27{,}960''\#$$

$$A_s = .3068 \times 12/8 = .4602 \quad ; \quad p = \frac{.4602}{12 \times 6} = .0064$$

$$j = .884 \quad ; \quad k = .355$$

$$f_s = \frac{27960}{.4602 \times 6 \times .884} = 11{,}400 \text{ pounds per square inch}$$

$$f_c = \frac{2(11{,}400) \times .0064}{.355} = 412 \text{ pounds per square inch}$$

The reactions on the walls, exclusive of the weights of the girders are $\frac{1}{2}$ x 95 x 14 x 34 22,600#, acting at each end of each girder, and an equal weight uniformly distributed over each of the end walls. Each of the two southermost girders weighs 3920 pounds, 1960 pounds being carried by each support, while the remaining girders weigh 3220 pounds, 1610 pounds acting at each support.

The only other slabs at the same elevation as the above are two small slabs in alcoves off of the attic. These slabs are 6' long and 10' wide and 4" thick, having 3/8" round bars 6" c.c. The dead load is 50 pounds per square foot and the live load is 20 pounds per square foot, making a total load of 70 pounds per square foot.

$$M = 1/8 \times 70 \times 36 = 315'\# = 3780''\#$$

$$A_s = 2 \times .1104 = .2208 \quad ; \quad p = .2208/48 = .0045$$

$$j = .897 \qquad k = .305$$

$$f_s = \frac{3780}{.2208 \times 4 \times .897} = 4770 \text{ pounds per square inch}$$

$$f_c = \frac{2 \times 4770 \times .0045}{.305} = 141 \text{ pounds per square inch}$$

The total weight distributed over each of the supporting walls is 70 x 3 x 10, or 2100 pounds.

The remaining floors slabs have been checked by finding the safe load as given in tables taken from the Concrete Designer's Manual by Hool and Whitney. These results are found in table 10 on the following page.

The last point for consideration under the general classification of floors will be a typical stair slab used in the main stairs. The slab considered is the one leading from the first floor to the landing. This is a 7" slab, 17' long, having ½" square bars, 5½" c.c. and 1/4" round bars, 12" c.c., making a steel area of .594 square inches. The live load to

TABLE 10

FLOOR SLABS

SLAB	LOCATION	SAFE LOAD #/sq. ft.	AREA sq ft.	TOTAL LOAD PER SLAB
m	Middle 3 Seminars and Conference Rooms	112 (64)	496	55,600
u	N & S Seminars	93 (48)	496	46,100
t	E ½ of Delivery Room	101 (40)	312	31,600
v	N 1/3 of W ½; S 1/3 of W ½ of Delivery Room	95 (56)	96	9,130
w	Middle 1/3 of W ½ of Delivery Room	162 (123)	144	23,300
s	SW & SE corner of Main Reading Room	164 (103)	496	81,500
l	NW & NE corner of Main Reading Room	153 (78)	1008	154,000
q	S center section of Main Reading Room	130 (75)	527	58,500
r	N center section of Main Reading Room	150 (100)	182	27,300
t	Art Gallery	101 (40)	1162	117,500
w	East end of hall	162 (123)	70	11,340
s	Coat Rooms (1st. floor)	164 (103)	496	81,500
l	Assigned Readings and Graduate Study	153 (78)	1008	154,000
q	Hall	130 (75)	527	58,500
r	N. Vestibule	150 (100)	182	27,300
g	Library Offices - Catalogue Room	101 (40)	884	89,200
f	Corridor	241 (186)	153	36,900

(cont)

TABLE 10 (cont)

SLAB	LOCATION	SAFE LOAD #/sq. ft.	AREA sq ft.	TOTAL LOAD PER SLAB
o	N & S Assigned Reading Periodicals (e. ell)	93 (48)	496	46,100
n	Periodicals(other than s)	93 (48)	496	46,100
h	Supplies (Basement)	105 (57)	527	55,300
p	Closet	204 (104)	169	34,200
f	Corridor	241 (186)	153	36,900
g	Staff Room and Receiving Room	101 (40)	884	89,200
k	Storage - south part	164 (103)	496	81,500
l	Storage - north part	153 (78)	1008	154,000
n	Bindery - Janitors room Rest room (mid)	93 (48)	496	46,100
O	Bindery - Rest room N & S sections	93 (48)	496	46,100
a	Fan Room S. Section Basement	188 (112)	512	96,400
b	Fan Room Cent. Section	188 (112)	512	96,400
c	Fan Room - N. Section	378 (302)	256	96,800
d	Air Chamber	178 (126)	810	144,400

Safe Live Load in Parenthesis

be used is taken as 100 pounds per square foot.

$M = 1/10\ wl^2 = 1/10 \times 137.5 \times (17)^2 = 5420'\# = 65040''\#$

$J = .883$; $k = .351$

$$f_s = \frac{65040}{.594 \times .883 \times 7} = 17{,}750 \text{ pounds per square inch}$$

(18,000 allowable)

$$f_c = \frac{2 \times 17750 \times .594}{.351 \times 94} = 642 \text{ pounds per square inch}$$

(650 allowable)

PART III

The last parts of the building to be analyzed in this thesis are the columns, the bearing walls and footings. Since a number of the columns, walls and footings are of the same type, only one of each will be considered here.

The column to be considered is one of the columns supporting the roof of the west ell and the attic floor in the west ell. This column is 45'-4" long and has a cross-sectional area of 720 square inches. As the column is a portion of the west wall of the building, there is ample support to prevent buckling, thus compressive area will be the limiting factor in the design of the column; and since a steel plate is used to spread the load over the top of the column the allowable stress will be somewhat above the 500 pounds per square inch as recommended by the Joint Committee for plain concrete columns made of 2000 pound concrete.

The maximum load upon the column is somewhat under 36,000 pounds, (35,080), but to allow for the weight of the parapet wall and the end reactions of the roof, this value will be taken, giving a unit stress of 36000/720, or 50 pounds per square inch.

It would seem that the size of the column was determined by artistic considerations rather than by the stress in the member.

The wall to be considered is the east wall of the west ell. This wall is 17" thick, and the maximum load per foot of wall is the reaction of the roof truss and floor girder in the attic; the load being 36,000 pounds plus 8500 pounds which is the weight of one foot of the wall itself. The load is transmitted to the wall by means of a plate 12" x 14", therefore the effective area considered will be 168 square inches. The unit stress will be 44500/168, or 265 pounds per square inch.

The first footing checked will be one of the footings under the book stacks. One cubic foot of books weigh approximately 64 pounds. In computing the weight supported by the footings under the stacks, a value of 70 pounds will be taken to allow for the weight of the stacks and other loads supported by them.

The total load upon each book-stack footing is 12 x 2 x 42 x 70, or 70560 pounds.

The area of the base of the footing is 28 square feet, making the total load equal to 2520 pounds per square foot, this being less than the allowable under the most adverse conditions.

The other footing checked is the footing under the wall column discussed previously. The externally applied load is 36000 pounds, which with the load of 30000 pounds exerted by the column itself, applies a total load of 66000 pounds. The area of the footing is 9.72 square feet, making the load per square foot equal to 6800 pounds, this load being allowable under good conditions.

While there are other parts of the construction which might be included in this problem, those presented are typical examples and are all that could be done in the time allotted with the data available.

F I N I S