T H E S I S

O N

THE DESIGN OF A ROOF TRUSS FOR THE PROPOSED DRILL SHED

AT THE

OREGON AGRICULTURAL COLLEGE

Submitted to the Faculty

of the

Oregon Agricultural College

June 10,1909.

For the Degree of Civil Engineer

By

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Approved: Redacted for privacy

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Note:

This Thesis was begun jointly by A.P.Tedrow and myself. When the task was approximately sixty per cent completed Mr.Tedrow withdrew from school leaving the remainder of the work to me.

Redacted for privacy

THE DESIGN OF A ROOF TRUSS FOR THE PROPOSED DRILL SHED AT O. A. C.

By an appropriation of the Oregon Legislature of 1909 it becomes possible for the Oregon Agricultural College to build a drill shed, a thing long needed by this institution.

Bennis, Hendricks and Tobey, architects of Portland submitted plans for this drill shed and in designing the truss for this building we have taken the general shape of the truss the same as furnished us by these architects.

We have taken this shape not because it is the same as taken by them but because after an investigation we found it to be as good if not better than any other for this kind of a building. While we have used their shape of a truss we have not used their data in the designing of this truss but designed it after our own ideas. And in the calculation of stresses we used altogether different snow and wind loads, but practically the same dead loads.

In building a shed of this kind it is almost impossible to construct a roof without the aid of trusses because to have pillars within the building would interfere greatly with the purpose for which the shed is to be built.

Before proceeding with any explanation of the truss it might be well to explain what a truss is and what is its purpose. A roof truss as defined by Merriman and Jacoby is a structure whose plane is vertical and is supported at its ends by the side walls of the building, being so arranged that its principal members are subjedted only to tensile or compressive stresses under the influence of the loads which it is designed to carry.

The points where the center lines of the adjacent members meet are the centers of the connection which form the joints. The joints of the truss are supposed to be perfectly flexible, and the external forces consisting of the loads and reactions to be applied only at the joints.

For stability the elementary figures composing a truss must be triangles, since a triangle is the only polygon which cannot change its shape without altering the lengths of its sides when loaded at one or more joints.

The "span" of a truss is the distance between the end joints or the centers of the supports, and the "rise" is the distance from the highest point or peak to the line on which the span is measured.

The "upper chord" consists of the upper line of members extending from one support to the other. The lower line of members is known as the "lower chord."

The truss to be used in the drill shed is what is known as a parabolic bowstring truss. The upper chord being the arc of a parabola and the lower chord two arcs of a parabola joined in the middle by a tangent. All members of the truss are angle irons of mild steel and are used single in some members and double in others. A factor of safety of four is used in all members whether in tension or compression, strength of materials are taken as given by Carnegie Hand Book of Carnegie Steel Company. All work is done by the graphic method with numerous checks by the analytic method. Checks are within 2 %.

PLATE 1.

Plate 1 shows the general outline of the truss with dimensions of all members. It is drawn to a scale of 1 to 60. The truss has a span of 120 feet, that is, the distance between supports. The rise of the upper chord is 22 feet above a horizontal line connecting the supporting points. Its form is the arc of a parabola which is divided into 19 equal parts. Beginning at the middle point and going each way toward the supports every second point on the parabola is connected by a chord, as, points 1 and 3, 3 and 5, 5 and 7, etc., until the last point from each end is reached, the remainder of which is divided into two parts and connedted by chords.

The lower chord has a rise of 10 feet. It is formed by the arcs of two parabolas, which are joined in the middle by a tangent 26 feet 8 inches, in length. The arcs in the lower chord are divided in the same manner as in the upper chord excepting the part between the supporting points and the first points from the supports, which are not divided but are each connected by one chord.

The upper chord is made up of two L bars 4 in. x 6 in. x 7/8 in. with their short legs riveted together. The lower chord is 2 Ls 5 in. x 3 in. x 13/16 in. joined in the same way.

The truss is supported at each end by a latticed column 14 in x 14 in. and 10 feet in height, which rests upon a concrete pier 20 in x 24 in. (See discription elsewhere) The truss is pivoted at one end for expansion.

PLATE 11.

Plate 11 shows the dead load diagram. The dead load includes the weight of the truss itself and the roof covering. The roof covering is taken as twenty pounds per square foot of surface. The scale used is 5 kips (5000 pounds) per inch.

In distributing the dead load it is supposed that all loads are centered at the pannel points on the upper chord, as the purlins rest on these points and take the load off all other parts. Half of the dead load on each side of every pannel point is taken as concentrated at that point.

The construction is begun by laying off the load line aa' equal to the total dead load. Beginning at the left hand side of the truss, the reaction ar is laid off to scale (5 kips to the inch), then the reaction ra' at the right is laid off, next the loads a' b', b'c', c'd', d'e' ------ ba are laid off, closing back to the starting point. Next ak is drawn paralled to AK in the truss (see plate 111) and rk paralled to RK, and where these lines meet it gives the point r. Then from k, kl is drawn paralled to KL to meet a line from b drawn paraliel to BL giving the point l. Next from l a perpendicular is drawn meeting a line from r paralled to RM at m. This method is continued on through the truss, taking each member in regular order until finally it closes back to the starting point.

Now by measuring the length of any line and multiplying it by the scale used the stress in the member corresponding to that line can be determined. And by following through the diagram the nature of the stress, whether it is in tension or compression can be ascertained. If the force is acting toward the joint the member is positive or in tension, and if it is acting away from the joint it is negative or in compression. For example, starting at the point a, it is known that a r is acting up, that is toward the joint, rk is acting away from the joint, therefore it is in tension, and ka is toward the joint or in compression.

The stresses due to snow load are obtained from the same diagram as the dead load, being taken as a per cent of the dead load. The snow load is taken as about 7½ pounds per square foot of surface. That is considered a maximun in this country being more than a foot of well packed snow.

PLATE 111.

Plate 111 shows the diagram for the wind acting on the free side of the truss.

The pressure produced by the wind on a roof surface depends on the direction and velocity of the wind and on the inclination of the roof surface. The wind is supposed to move horizontally, and a hurricane of 100 miles per hour exerts a pressure of probably 50 pounds per square foot of surface normal to its direction.

The wind in this case is taken as 40 pounds per square foot on the vertical projection. This is considered a maximum in this country as it represents a wind of about 80 miles per hour, something unusual if not unknown in the Willamette Valley.

The wind loads are concentrated at the pannel points by taking one half the wind load on each side of every pannel point. Where there are two chords having different slopes meeting at a pannel point the resultant of the loads on each side is taken. As all of the chords have different slopes the vertical projection of the entire half roof is not taken and the loads divided propertionally, but the vertical projection for ecah chord is taken.

The load line ϵ a, a b, bc ----------jϵ' is first laid off with each load paralled to the corresponding load on the truss, to a scale of 4 kips per inch. Next an equilibrum polygon is drawn (shown by the dotted diagram under the truss). Through the pole o in the force polygon a line is drawn paralled to the closing side of the equilibrum polygon and from ξ a perpendicular is dropped meeting this line. This gives the reaction r ξ' at the fixed end of the truss, the reaction at the free end being vertical.

Then beginning at the left hand end of the truss the forces are laid off in the same manner as in the dead load, diagram. First ak is laid off from a, paralled to the member AK in the truss and meets the line r k drawn from r parallel to RK. Next from the point k just found kl is drawn parallel to KL meeting a line from b parallel to BL at the point b. Then from b a perpendicular is dropped to the point m where it intersects m r, parallel to M R in the truss representing the member L M. This process is continued on through the truss taking each member in regular order.

The stresses in each member may be obtained by measuring its length and multiplying by 4 kips. It will be noticed that the stresses in the members on the fixed side are very small as compared to those of the free side, when the wind is acting on the free side.

PLATE IV.

Plate 4 is the wind diagram for the wind blowing on the fixed side of the truss. The wind is taken the same as on the free side, that is 40 pounds per square foot of vertical projection. The loads are also distributed in the same way.

The load line ξ' a', a'b', b'c' -----------j ξ is first laid off with each load parallel to the corresponding load on the truss. Then the reactions are determined by the force and equilibrum polygons. It is known that the reaction at the free end will be perpendicular but at the fixed end it will not be. Therefore from the ξ end of the load line a perpendicular is erected representing the direction of the reaction at that end of the truss. Then, if from the point where a line drawn from the pole o of the force polygon parallel to the closing side of the equilibrum polygon cuts this perpendicular, a line is drawn to ξ' end of the load line, it represents the reaction for the fixed end of the truss.

The diagram is then drawn in the usual manner, that is in the same manner as in the dead and wind on the free side diagram, except that we begin with the forces acting at the right support and passing to joints alternately on the upper and lower chords. The scale used is 4 kips to the inch. It will be noticed as in the wind on the free side diagram that the stresses in the members on the opposite side to which the wind is blowing on are very much smaller than on the windward side.

PLATE V.

Plate 5 shows the upper and lower lateral bracing and the diagram working out the stresses in the lower lateral bracing system for a wind of 80 miles per hour.

The lateral system of bracing consists of bracing which unites the corresponding chords of the trusses and together with the chords form horizontal trusses which can resist any forces that may act on the foof. The purlins form a part of the bracing in one of these systems.

The wind is to be regarded as blowing horizontally at right angles to the line of the truss and exerting a pressure of 40 pounds per square foot of surface. The wind pressure against the members of the trusses is transferred by them to the upper and lower pannel points or the upper and lower bracing systems.

The lower lateral bracing is made up of tie rods with counters. They are fastened every 13 feet 4 in. or at every other pannel point on the lower chord and also at the first two points at each end of the truss.

The upper bracing is made up of the purlins with sag rods. The purlins are 9 inch steel channels spaced 6 feet 8 inches apart or at every pannel point on the upper chord excepting the first one from each end of the truss. The sag rods are steel rods 7/8 in. in diameter running at right angles to the purlins and spaced 5 feet apart.

In constructing the stress diagram for the lower lateral bracing a scale of 4 kips to the inch is used. The wind can only blow in one direction at a time, therefore the stresses are figured as loads concentrated at the pannel points on one side of the bracing system, without any loads on the other side. First the load line aa' is laid off to scale with the loads a'b', b'c', c'd' -------ba acting downward and the reaction ar and ra' acting upward. Then the remainder of the stress diagram is constructed in the same manner as in the dead load diagram. The table on Plate 5 gives the results obtained.

It will be noticed that the stresses in the upper and lower chords are almost the same, only, the side on which the wind is blowing is in compression and the opposite side is in tension. Half of the verticals are in tension and half in compression and likewise with the diagonals. When the wind changes to the opposite side, all members change the nature of their stresses, that is, those in tension change to compression, and those in compression change to tension.

PLATE Vl.

Plate 6 is a tabulation of all the stresses found by the stress diagrams on plates 2, 3 and 4. This table besides giving the dead loads, snow loads, and both wind loads, also gives the maximum and minimum stresses for all members.

In order to design a member for the range of stress, it is necessary to know both the maximum and minimum stress to which it is subjected by the combined loads. As the dead load always acts, its effect must be included in finding both the maximum and minimum stresses. Snow load always produces stresses of the same kind as the dead load when the rafters are straight, and hence is used only in obtaining the maximum. As the wind cannot blow on more than one side of the roof at the same time, only one of the wind stresses is to be combined with the dead, or with the dead and snow load stresses. If in any member a stress produced by the wind is of a different kind from that due to dead load, the minimum stress equals the algebraic sum of the two, but when, all the stresses in any member are either tensile or compressive, the minimum equals the dead load stress and the maximum equals the sum of the dead, snow, and larger wind load stresses.

For an example of the maximum stress, take the member AK, the dead load is -76.90 kips, the snow load is -25.63 kips, the wind on the free side -28.52 kips, and the wind on the fixed side -8.40 kips. Now the wind can only blow from one direction at a time, therefore for the maximum the greatest wind load is taken, which is when the wind is on the free side. Hence the maximum stress for the member AK is (-76.90 kips) + (- 25.63 kips) + (- 28. 52 kips) = -131.05 kips.

Again, take the diagonal member OP, the dead and snow loads enter into the maximum. But of the wind loads the load on the free side produces compression and the wind on the fixed produces tension. As both the other stresses are tension the wind load producing tension must be used in computing the maximum for this member. Therefore the maximum for OP is + 3.30 kips + 1.10 kips + 2.48 kips = + 6.88 kips.

For an example of the minimum take the member R'K' the dead load is + 51.80 kips, the snow load is + 17.27 kips, the wind load on the free side is - 12.16 kips and the wind load on the fixed side is + 35.88 kips. The dead load will always be acting under all conditions but the snow and wind loads will not be. When the wind blows on the free side it produces a stress opposite in sign to that of the dead load and when on the fixed side one of the same sign. Therefore for the minimum stress in R'K' the dead load and the wind load on the free side is taken, which gives (+51.80 kips)+(-12.16 kips) = + 39.64 kips.

By referring to this table it is possible to find the maximum for any member and compute the deminsions of the steel beam required for that member.

PLATE VII.

Plate 7 shows the expansion bearings for the truss. Roof trusses of short span and particularly wooden trusses, have generally both ends firmly fixed in the supporting walks or columns. But iron or steel trusses, and usually all trusses of long span have only one end fixed, while the other is left free to move or is merely supported, so that it may move horizontally in the direction of the plane of the truss. This construction is adopted in order that the truss may expand and contract under changes of temperature and thus stresses due to this cause be eliminated.

The coeficient of liniar expansion for steel is .0000074. Then a steel truss of the length of this one with a difference of temperature of 100° Fahrenheit which is the greatest range of temperature known in this country, will not expand nearly one inch.

There are many different devices used to provide for the expansion. The free end may rest upon a smooth iron plate upon which it slides, but this arrangement requires too much friction to be overcome in the case of a heavy roof like this one, and especially so in this country where the plate is likely to become rusty. A rocker may be used but it also has its disadvantages. The kind most generally used and probably the most satisfactory is some form of the roller bearing. This is the kind we have adopted.

This expansion bearing is made up of eight steel rollers 1½ inches in diameter resting between two cast iron bed plates. The rollers are kept at the proper clearence by two side bars which are fastened to the rollers by tap bolts in the ends of the rollers. The rollers are of hard steel and pollished. The rollers rest upon a cast iron bed plate made perfectly smooth. This bed plate fits over the top of the latticed column supporting the truss, and is riveted to the top of this column, by eight ~~and~~ $\frac{3}{4}$ inch steel rivets. Under the end of the truss and resting on the rollers is another cast plate similar to the one underneath. This is riveted to the pin plate that forms the joint with the upper and lower chords with 8 $\frac{3}{4}$ inch rivets. The rollers are kept in place by flanges cast along the edges of the bed plates. These also partially prevent the collection of dust on the roller bearings.

The joint connecting the upper and lower chords with the expansion bearing is a pin plate joint with a pin. The pin is a three inch steel pin and the plates are 1 inch steel plates securely riveted to the upper and lower chords and the upper bad plate.

At the fixed end a cast iron base is used on top of the column whose height equals that of the rollers and bed combined so as to make the height of the column the same at both ends. This base is riveted to the top of the column in the same manner as at the free end.

This plate also shows a cross section of the upper and lower chords of the truss. The upper chord is made up of two L bars 6 x 4 x 7/8 inches with their short legs riveted together. The lower chord is made up the same way with the L bars having deminsions of 5 x 3 x 13/16 inches.

PLATE V111.

Plate 8 is a drawing showing the latticed column that supports the ends of the truss. This column is 10 feet in height and 14 inches square. It is made up of 4 L bars $2\frac{1}{2}$ in. x $2\frac{1}{2}$ in. x $\frac{1}{4}$ in. and the lattice bars are $1\frac{1}{2}$ in. by $\frac{1}{4}$ in. The lattice bars are put on at right angles to each other with their ends overlapping. The ends are fastened to the L bars by 3/8 in, rivets, with one rivet at each end. The column rests on a concrete base 20 in. x 24 in. sunk into the ground five feet. Into this concrete base are set 8 steel bars $2\frac{1}{2}$ in x $\frac{1}{2}$ in. x 3 ft. projecting 1 ft. above the surface of the concrete. To these steel bars the column is riveted by 7, $\frac{3}{4}$ in. rivets for each bar. This column is designed to meet the maximum load on the truss. The scale used in this plate is 10 to 1.

The advantage of this column is that it has greater strength for the amount of material in it than a solid steel column would have. It is lighter than a solid column. And being set on a concrete foundation there will be no settling of the roof, which would tend to put a much greater stress upon the truss and thus weaken it.

PLATE lX.

Plate 9 shows a pin joint with pin plates. The pin system of connections is the one which has been most used and which is most favorable regarded by engineers in this country. At each pannel point a pin or round bar passes through holes in the chords or web members and serves to transfer the longitudenal stresses from one member to another by means of the shearing and bending stresses generated by it. One advantage of the pin joint it that less material is needed in it than in the riveted system. It is also cheaper and better workmanship is usually secured in it.

In a pin joint there is danger of crushing the material which presses against the pin. In order to prevent this a strip of metal called a pin plate or reinforcing plate is riveted to the member giving a sufficient bearing surface for the pin.

The pin is a three inch steel pin and designed to resist bending and shearing stresses from the members through which it passes. The pin plates vary in thickness for various members, also vary in width with the width of the L bars.

Size of member.	Size of pin plate	Diam. of rivet.
2 Ls $2\frac{1}{2}$" x $2\frac{1}{2}$" x $\frac{1}{2}$"	$4\frac{1}{2}$" x $\frac{1}{2}$"	$\frac{3}{4}$"
2 Ls $2\frac{1}{2}$ x $2\frac{1}{2}$ x 3/8"	$4\frac{1}{2}$" x 3/8"	$\frac{3}{4}$"
1 L $2\frac{1}{2}$" x $2\frac{1}{2}$" x $\frac{1}{4}$"	$2\frac{1}{4}$" x $\frac{1}{4}$"	$\frac{1}{2}$"
2 Ls 4" x 6" x 7/8"	11" x 7/8"	1"
2 Ls 3 " x 5" x 13/16"	9" x $\frac{3}{4}$"	

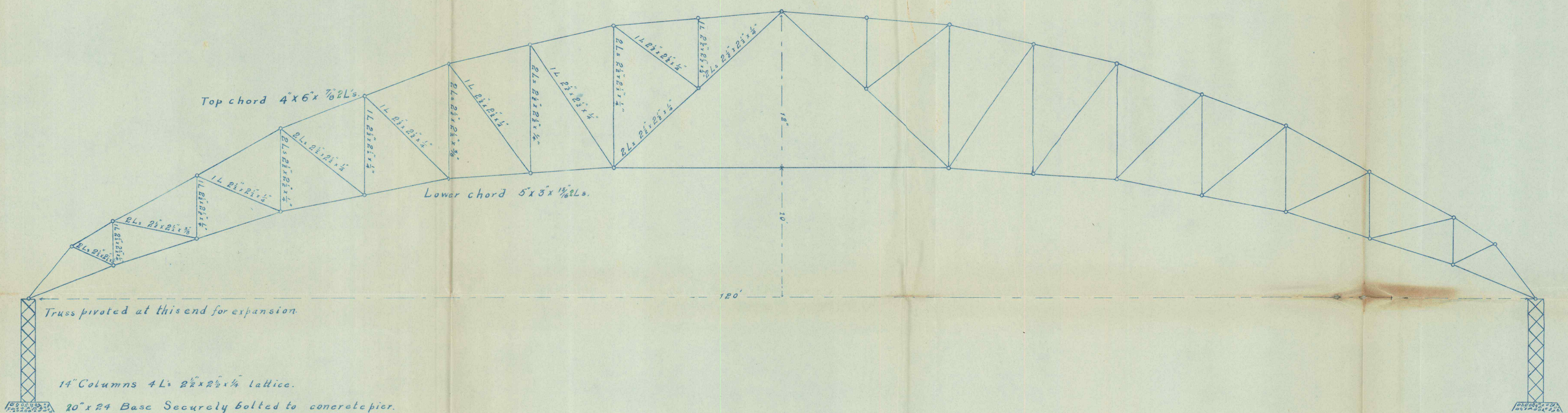
Length of rivet	# Pitch.
$1\frac{3}{4}$"	1 7/8"
$1\frac{1}{4}$"	1 7/8"
7/8"	$1\frac{1}{4}$"
2 7/8"	$2\frac{1}{2}$"
$2\frac{1}{2}$"	$2\frac{1}{4}$"

The pitch is the distance from center to center of rivets in horizontal rows.

Rivets are spaced not less than 1 5/8 times their diameter from center to center. And not less than

1 5/8 times their diameters from the edges.

ROOF TRUSS


Top chord 4"x 6"x 7/8 2L's.
Lower chord 5"x 3"x 11/16 2Ls.
18'
10'
120'
Truss pivoted at this end for expansion.
14" Columns 4 L's 2½"x 2½"x ¼" lattice.
20"x 24 Base Securely bolted to concrete pier.

DEAD LOAD

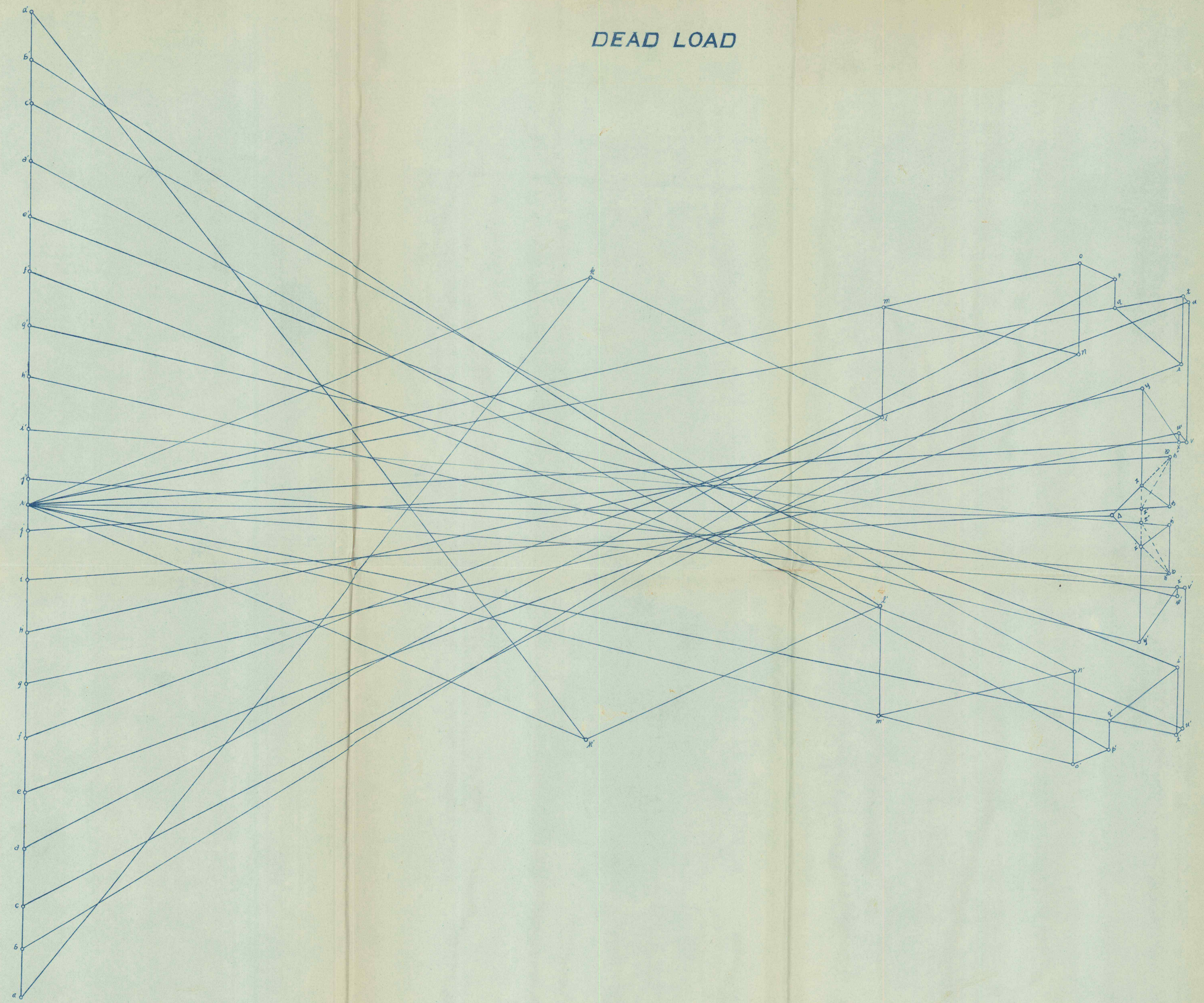
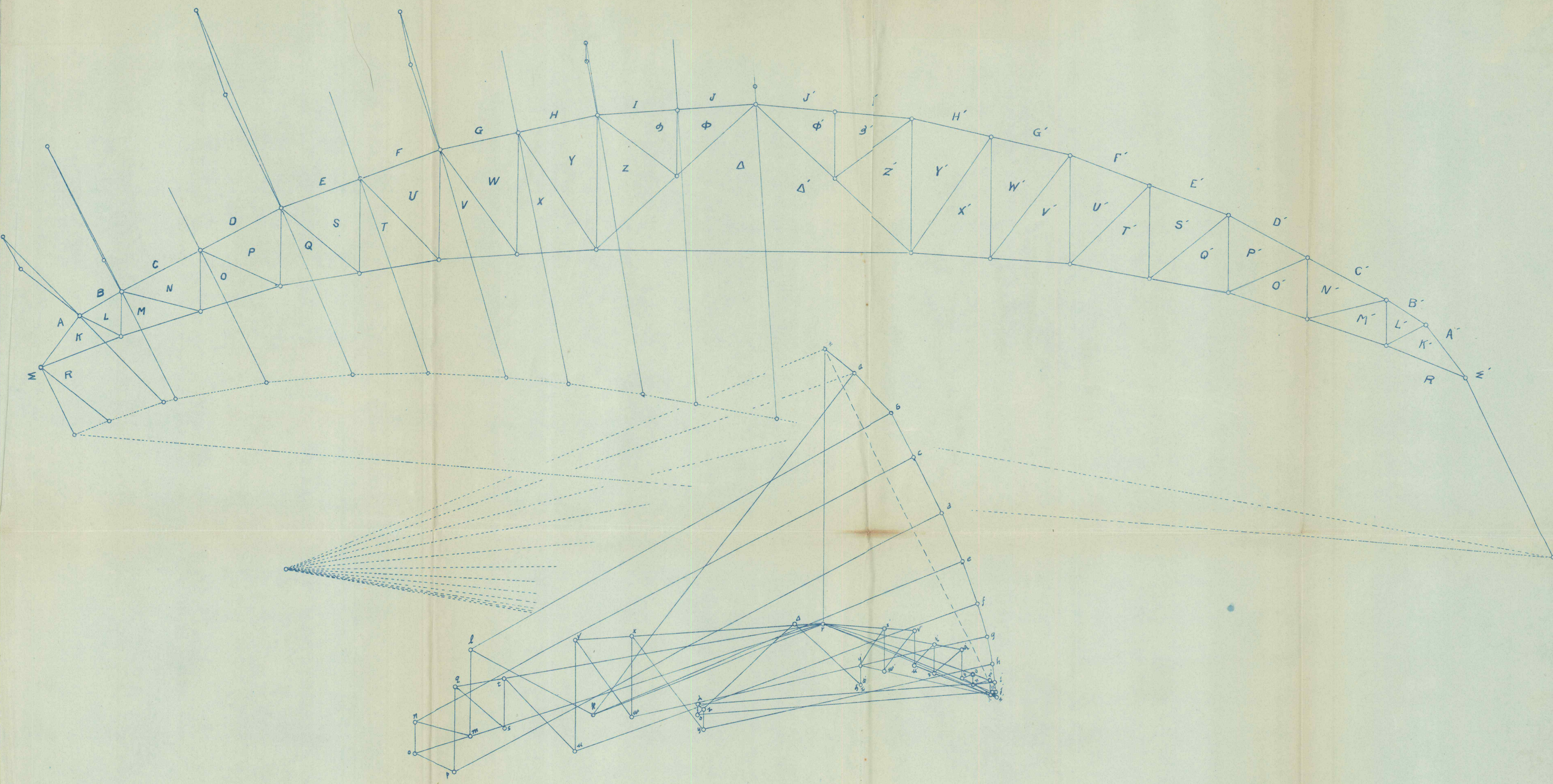


Plate II.

WIND ON FREE SIDE



WIND ON FIXED SIDE

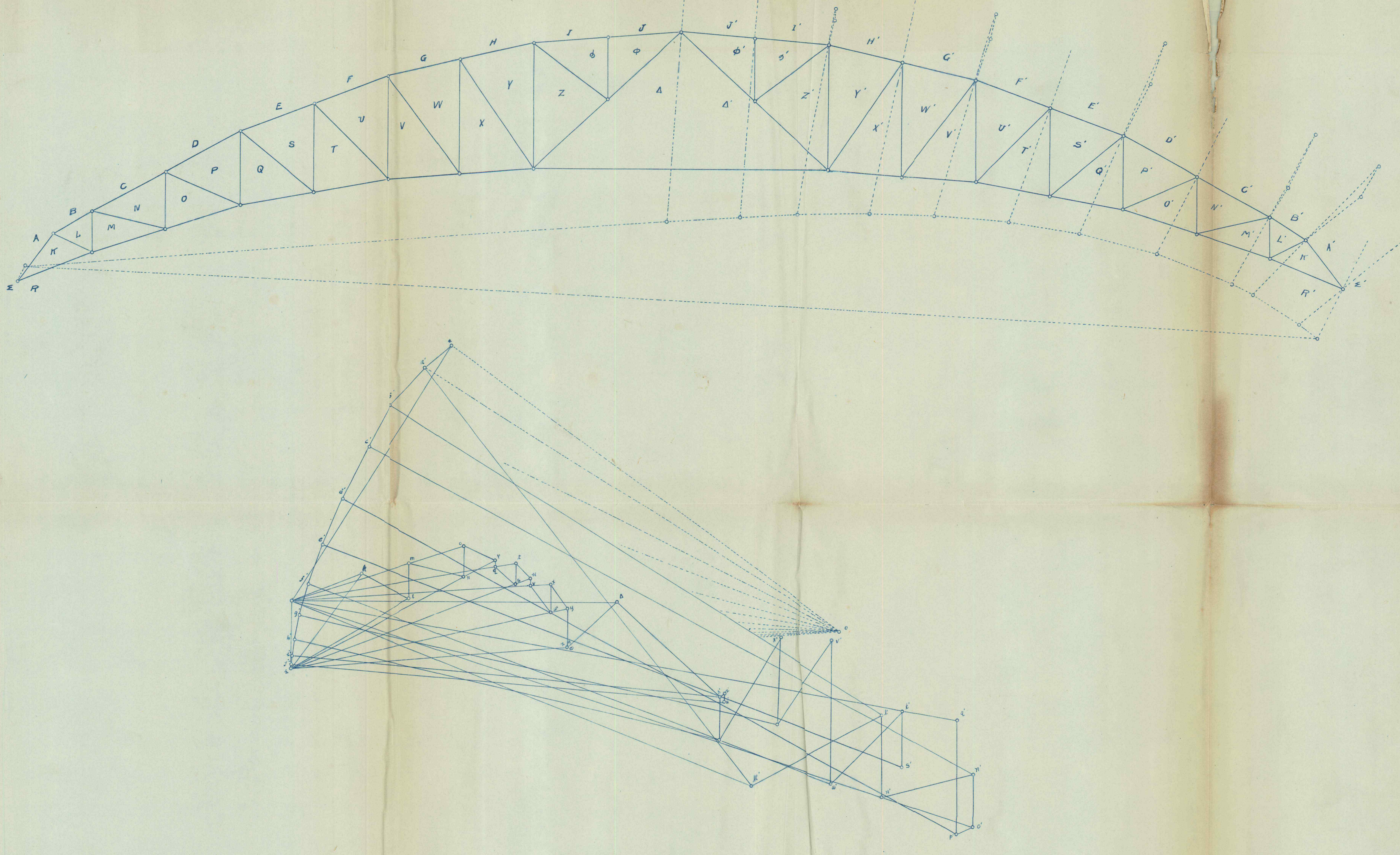
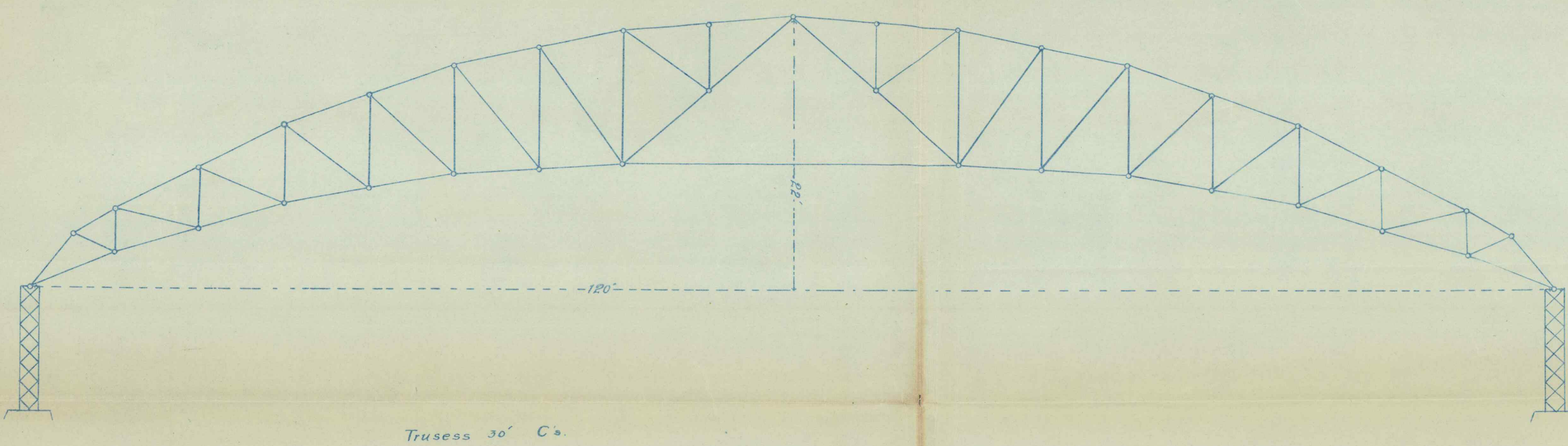
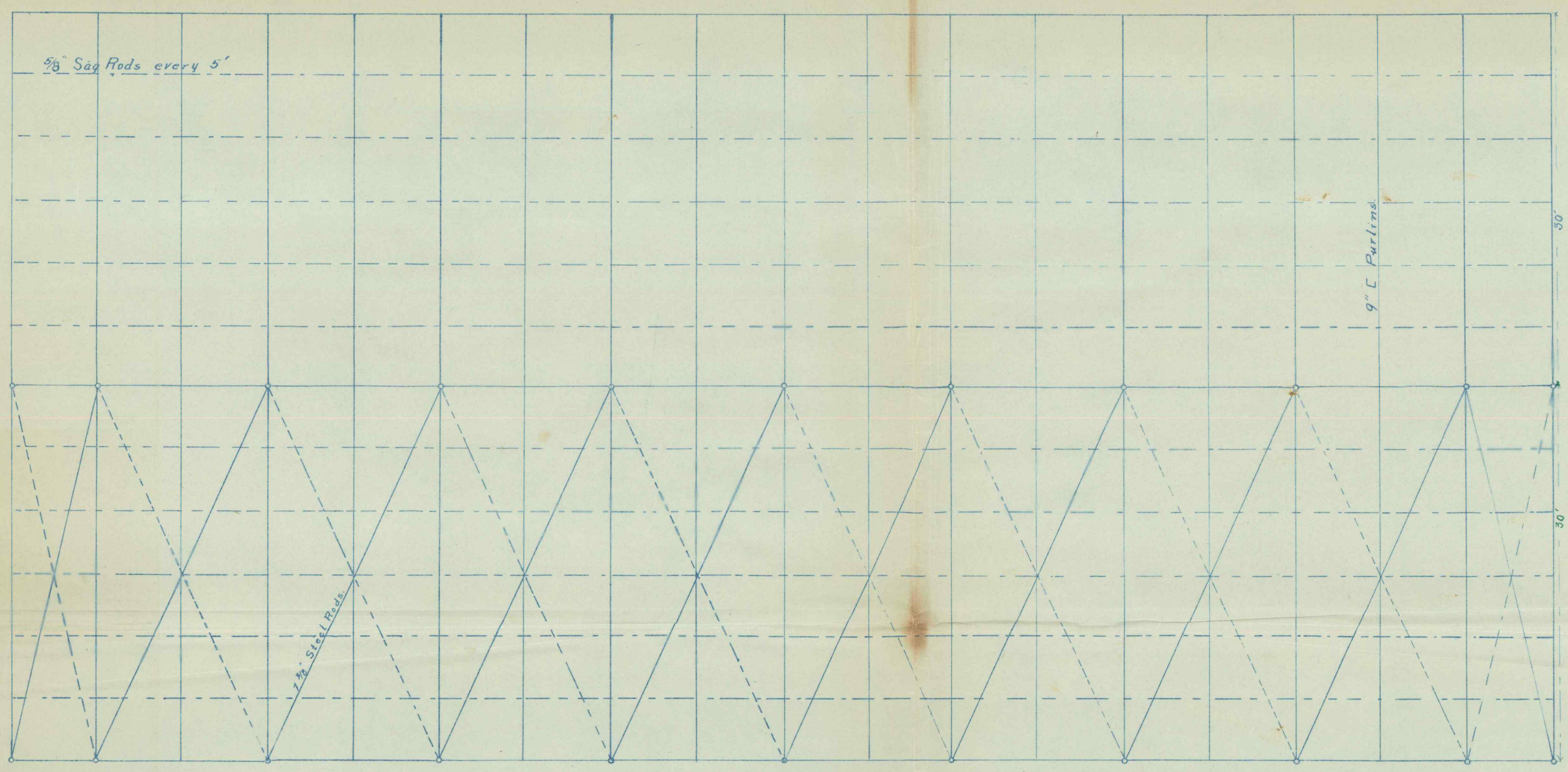


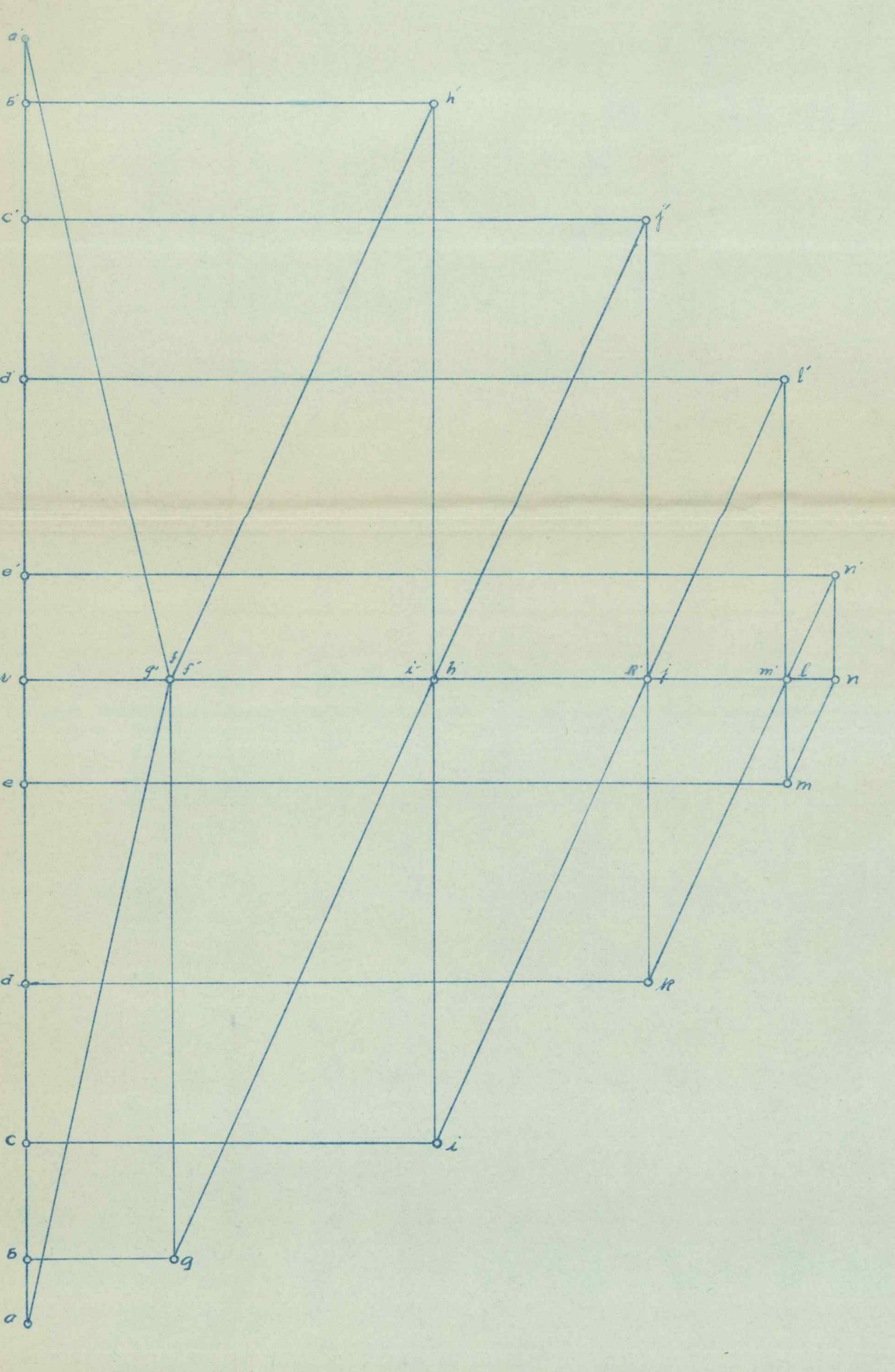
Plate IV.

WIND LOAD ON LOWER LATERAL BRACING



Trusess 30' C's.





Upper Chord.									
Members	BG	CI	DK	EM	E'N'	D'L'	C'J'	B'H'		
Stresses	-4.20	-11.80	-17.96	-22.00	-23.40	-22.00	-17.96	-11.80		

Lower Chord.										
Members	RF	RH	RJ	RL	RN	RM'	RK'	RI'	RG'	RF'
Stresses	+4.28	+11.88	+17.92	+22.00	+23.40	+22.00	+17.92	+11.88	+4.28	+4.28

Verticals.										
Members	FG	HI	JK	LM	NN'	M'L'	K'J'	I'H'	G'F'	
Stresses	+17.12	+13.76	+9.00	+3.08	-3.08	-9.00	-13.76	-17.12	0.0	

Diagonals.										
Members.	AF	GH	IJ	KL	MN	N'M'	L'K'	J'I'	H'G'	F'A'
Stresses.	-19.52	-18.80	-15.04	-9.92	-3.36	+3.36	+9.92	+15.04	+18.80	-19.52

Plate V.

	Upper Chord									
Member	AK	BL	CN	DP	ES	FU	GW	HY	Iϑ	JΦ
Dead Load	-76.90	-85.75	-101.25	-104.60	-105.15	-105.80	-100.85	-97.45	-98.00	-97.90
Snow Load	-25.63	-28.58	-33.75	-34.87	-35.03	-35.27	-33.62	-32.48	-32.67	-32.63
Wind on Free Side	-28.52	-32.44	-37.92	-37.00	-32.82	-28.72	-24.44	-19.88	-20.08	-20.12
Wind on Fixed Side	-8.40	-9.96	-14.20	-19.60	-17.48	-18.60	-19.36	-20.60	-20.16	-20.16
Maximum	-131.05	-134.77	-172.92	-176.47	-173.00	-169.79	-158.91	-150.53	-150.83	-150.69
Minimum	-76.90	-85.75	-101.25	-104.60	-105.15	-105.80	-100.85	-97.45	-98.00	-97.90

	Lower Chord							
Member	RK	RM	RO	RQ	RT	RV	RX	RΔ
Dead Load	+51.80	+75.00	+92.10	+94.35	+100.30	+99.25	+98.65	+92.90
Snow Load	+17.27	+25.00	+30.70	+31.45	+33.43	+33.08	+32.88	+30.96
Wind on Free Side	+16.52	+24.48	+28.80	+25.12	+21.80	+16.64	+12.88	+7.92
Wind on Fixed Side	+5.44	+9.04	+13.20	+15.12	+16.64	+17.52	+19.00	+23.76
Maximum	+84.59	+124.48	+151.60	+150.92	+155.53	+149.85	+150.53	+147.62
Minimum	+51.80	+75.00	+92.10	+94.35	+100.30	+99.25	+98.65	+92.90

	Verticals							
Member	LM	NO	PQ	ST	UV	WX	YZ	ϑΦ
Dead Load	-9.10	-7.55	+2.35	-5.60	+11.65	+0.80	+8.00	-4.10
Snow Load	-3.03	-2.51	+0.78	-1.87	+3.88	+0.27	+2.67	-1.37
Wind on Free Side	-5.52	-2.08	+5.44	+3.24	+7.12	+5.20	-1.32	-0.68
Wind on Fixed Side	-2.48	-2.16	+0.44	-1.48	+0.52	-1.96	+2.72	0.00
Maximum	-17.65	-12.22	+8.57	-8.85	+23.15	+6.27	+14.39	-6.15
Minimum	-9.10	-7.55	+2.35	-2.36	+11.65	+0.80	+8.00	-4.10

	Diagonals									
Member	KL	MN	OP	QS	TU	VW	XY	Zϑ	ZΔ	ΦΔ
Dead Load	+27.40	+17.10	+3.30	+7.35	+0.65	-1.00	-5.95	+2.95	+3.60	+6.90
Snow Load	+9.13	+5.70	+1.10	+2.45	+0.22	-0.33	-1.98	+0.98	+1.20	+2.30
Wind on Free Side	+9.24	+3.84	-3.00	-4.28	-6.72	-6.20	-7.68	+0.56	+8.12	+8.68
Wind on Fixed Side	+4.00	+4.08	+2.48	+1.88	+1.52	+2.32	+2.08	0.00	-4.80	-4.80
Maximum	+45.77	+26.88	+6.88	+11.68	-6.07	-7.53	-15.61	+4.49	+12.92	+17.88
Minimum	+27.40	+17.10	+0.30	+3.07	+0.65	-1.00	-3.87	+2.95	-1.20	+2.10

	Upper Chord									
Member	A'K'	B'L'	C'N'	D'P'	E'S'	F'U'	G'W'	H'Y'	I'ϑ'	J'Φ'
Dead Load	-76.90	-85.75	-101.25	-104.60	-105.15	-105.80	-100.85	-97.45	-98.00	-97.90
Snow Load	-25.63	-28.58	-33.75	-34.87	-35.03	-35.27	-33.62	-32.48	-32.67	-32.63
Wind on Free Side	-0.48	-0.48	-1.76	-2.60	-4.40	-5.80	-7.64	-9.32	-9.16	-9.16
Wind on Fixed Side	-37.72	-41.92	-49.68	-50.44	-45.00	-40.60	-35.52	-31.68	-31.52	-31.52
Maximum	-136.25	-156.25	-184.68	-189.90	-185.20	-180.66	-169.99	-161.61	-162.19	-162.05
Minimum	-76.90	-85.75	-101.25	-104.60	-105.15	-105.80	-100.85	-97.45	-98.00	-97.90

	Lower Chord							
Member	R'K'	R'M'	R'O'	R'Q'	R'T'	R'V'	R'X'	R'Δ'
Dead Load	+51.80	+75.00	+92.10	+94.35	+100.30	+99.25	+98.65	+92.90
Snow Load	+17.27	+25.00	+30.70	+31.45	+33.43	+33.08	+32.88	+30.96
Wind on Free Side	-12.16	-11.80	-10.56	-9.52	-7.64	-6.20	-4.16	+1.92
Wind on Fixed Side	+35.88	+45.16	+52.08	+49.12	+45.16	+39.52	+35.64	+23.76
Maximum	+104.94	+145.16	+174.88	+174.92	+178.89	+171.85	+167.17	+147.62
Minimum	+39.64	+63.20	+81.54	+84.83	+92.66	+93.05	+94.49	+92.90

	Verticals							
Member	L'M'	N'O'	P'Q'	S'T'	U'V'	W'X'	Y'Z'	ϑ'Φ
Dead Load	-9.10	-7.55	+2.35	-5.60	+11.65	+0.80	+8.00	-4.10
Snow Load	-3.03	-2.51	+0.78	-1.87	+3.88	+0.27	+2.67	-1.37
Wind on Free Side	-0.80	-0.64	-1.76	-1.76	-2.24	-2.72	+1.20	0.00
Wind on Fixed Side	-5.72	-3.64	+7.92	+3.88	+10.12	+6.28	+3.04	-0.76
Maximum	-17.85	-13.71	+11.05	-9.22	+25.65	+7.35	+13.71	-6.22
Minimum	-9.10	-7.55	+0.59	-1.72	+7.88	+3.56	+8.00	-4.10

	Diagonals									
Member	K'L'	M'N'	O'P'	Q'S'	T'U'	V'W'	X'Y'	Z'ϑ'	Z'Δ'	Φ'Δ'
Dead Load	+27.40	+17.10	+3.30	+7.35	+0.65	-1.00	-5.95	+2.95	+3.60	+6.90
Snow Load	+9.13	+5.70	+1.10	+2.45	+0.22	-0.33	-1.98	+0.98	+1.20	+2.30
Wind on Free Side	+0.12	+1.20	+0.80	+2.36	+1.92	+3.24	+2.84	0.00	-5.92	-5.92
Wind on Fixed Side	+10.80	+6.80	-1.32	-5.12	-7.20	-7.32	-8.52	+0.48	+10.00	+10.56
Maximum	+47.33	+29.60	-5.72	-14.92	-8.07	-8.65	-16.35	+4.41	+14.80	+19.76
Minimum	+27.40	+17.10	-2.50	-4.99	-0.65	-1.00	-3.11	+2.95	-2.35	+0.98

Plate VI.