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AN ANALYSIS OF A BALTIMORE
TRUSS BRIDGE

Thesis for the Degree of B. S.
MICHIGAN STATE COLLEGE

M. S. Richmond
1943

THESIS

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An Analysis of A
Baltimore Truss Bridge

A Thesis Submitted to

The Faculty of
MICHIGAN STATE COLLEGE
of
AGRICULTURE AND APPLIED SCIENCE

by
M. S. Richmond
M. S. Richmond

Candidate for the Degree of

Bachelor of Science

June 1943

THESIS

1. 1. 1.

In Appreciation

Sincere appreciation is expressed for the kind assistance extended by Mr. George M. Foster, Mr. Wm. J. Baumgras; Registered Civil Engineers of Lansing Michigan; Mr. Wm. Voight, of the Michigan State Highway Department; and Mr. Kenneth Cosens of the Engineering Faculty of the Michigan State College.

The timely advice, information and other assistance extended by these men has been of very great assistance in the preparation of this paper.

BI of I9-7-2I
(General Views of Bridge)



An Analysis of A Baltimore Truss Bridge

In times of peace, as well as in times of war, the question of replacing certain Highway Bridges arises often, either because of the fact that increased traffic conditions have rendered the bridge incapable of meeting traffic requirements, or because the bridge fails to meet present strength requirements either due to deterioration of the various members of the structure, or to increased loading conditions.

In peace times, the usual solution to this problem, when traffic conditions warrant it, is for the responsible authorities to engage Contractors and Engineers to replace the old structure with a new one.

However, in war times, due to critical shortages of both materials and manpower, the replacing of bridges becomes, in most cases, impossible, and the only other solution to the problem of insufficient bridges is to strengthen the existing structures as economically as possible, while being certain that they are either sufficiently strengthened to carry any load that might be placed on them or else posting load limits on the structures that will prevent any overloading that might prove disastrous to the existing structure.

The project undertaken in this thesis is the inspection and analysis of such a structure to determine whether or not the bridge is sufficient to meet existing requirements.

The bridge inspected and analyzed is a single span, high truss of the Baltimore type, crossing the Grand River in Eagle Township, Clinton County, Michigan; between Sec. 29 and Sec. 30. The Michigan State Highway Department's File Number for this bridge is Bl of 19-7-21, the numbers referring to the structure, County, Township and Road numbers as established by the Michigan State Highway Department.

Included in the paper is a diagram of the truss, showing the size and makeup of the various members and the lettering key used for these members and connections as referred to in the summary of stresses, a copy of which is also included in this paper.

The trusses are primarily of seven panels, each of (30'-9") thirty feet and nine inches in length and a total overall length of (215'-3") two hundred fifteen feet and three inches. These panels are each subdivided into panels of (15'-4½") fifteen feet four and one-half inches in length, each with intermediate hangers and floor beams corresponding in size to the floor beams and hangers of the primary panels. The structure was built in 1909 according to the attached plate. The floor consists of three inch oak plank eight to twelve inches in width, laid transversely. There are runner strips

(2)

of two inch plank laid longitudinally for one way traffic. The floor is supported by eight- six inch I beam stringers at approximately twenty three inch spacing. The floor beams are fifteen inch Standard 42.9# I beams suspended from the pin connections of the trusses by one inch square U hangers.

The abutments are of stone masonry in fair condition. At the time of this inspection there was no apparent need of substructure repair except to point up the walls with mortar.

In analyzing this structure for its safe carrying capacity, we have followed the usual practice of using working stresses fifty per cent in excess of ordinary design stresses as representing more definitely the ultimate allowable loading which should be permitted. We have assumed a depreciation of the truss members and floor beams of five per cent, and ten per cent for the stringers and timber floor. The timber floor, while in fair condition at the time of this inspection, is subject to much more rapid deterioration than the steel. Also, the steel stringers showed slightly more deterioration at certain partially hidden points than other members of the structure. We have used the legal loading as now permitted by the statutes of Michigan in making this analysis, except in some cases where it seemed advisable to use an H-15 loading to be definitely on the safe side.

Floor Analysis

In the analysis of the existing floor, we first find the existing bending moment due to the Loading used in the analysis and then find the allowable bending moment which the floor will stand. Finally, we determine whether the existing floor is adequate by comparing the two bending moments.

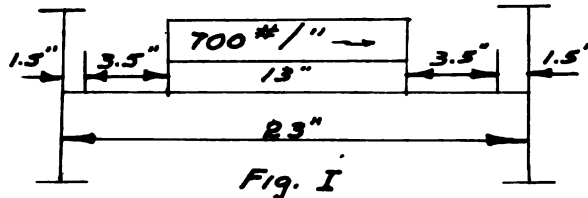


Fig. I

Assuming the wheel load to be uniformly distributed over the three 2"x4" runners, the load would be applied as shown in Fig. I.

The maximum existing bending moment is = $39,800''\#$

$$(700 \times 6.5 \times 1.3 \times 10) - (700 \times 6.5 \times 1.3 \times \frac{6.5}{2}) = 39,800''\#$$

Next, the maximum allowable bending moment for the floor planks is determined by the formula -

$$\text{Moment} = \frac{\text{Mom. of Inertia} \times \text{Allowable Unit Stress}}{\frac{1}{2} \times \text{Thickness of Plate (C)}}$$

The floor is composed of 3"x10" Transverse Planks and 2" longitudinal runners.

Using an allowable unit stress of $1200''\#/in^2$ for these planks and a net moment of inertia of 60.8 ($67.5 - 10\%$) and a $C = 1.5''$ for the 3" Planks, the allowable bending moment is -

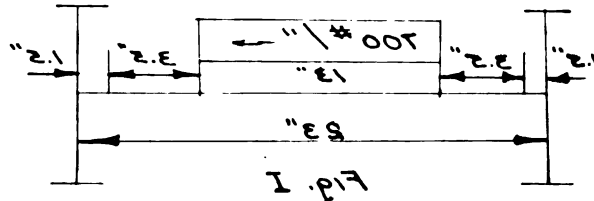
$$M = \frac{I S}{C} = \frac{60.8 \times 1200}{1.5} = 48,500''\#.$$

Since the allowable total moment for the floor is - $48,500''\#$ and there is no dead load existing on the floor, the total existing maximum moment is the live load moment of $39,800''\#$ which shows the floor to be safe as it is, although it will probably wear to an unsafe condition before the other members of the structure do.

stringer Analysis

In the analysis of the stringers we determine the dead load moment existing due to the weight of the floor and the stringers themselves, and then determine the total allowable moment (taking into consideration the assumed depreciation of the members). Subtracting the

Floor Analysis
 In the analysis of the existing floor, we first find the existing bending moment due to the loading used in the analysis and then find the allowable bending moment which the floor will stand. Finally, we determine whether the existing floor is adequate by comparing the two bending moments.



Assuming the wheel load to be uniformly distributed over the three 2"x10" runners, the load would be applied as shown in Fig. I.

The maximum existing bending moment is $32,800$ ft-lb.

$$(700 \times 6.2 \times 1.3 \times 10) - (700 \times 6.2 \times 1.3 \times \frac{6.2}{2}) = 32,800$$

Next, the maximum allowable bending moment for the floor planks is determined by the formula -

$$\text{Moment} = \frac{\text{Mom. of Inertia} \times \text{Allowable Unit Stress}}{\frac{1}{2} \times \text{Thickness of Plank (in)}}$$

The floor is composed of 3"x10" Transverse Planks and 2"

longitudinal runners.

Using an allowable unit stress of 1500 #/sq. in. for these planks and a net moment of inertia of 60.8 (61.2-10%) and $C = 1.2$ for the 3" planks, the allowable bending moment

$$M = \frac{I}{C} = \frac{60.8 \times 1500}{1.2} = 48,200 \text{ ft-lb.}$$

Since the allowable total moment for the floor is $48,200$ ft-lb. and there is no dead load existing on the floor, the total existing maximum moment is the live load moment of $32,800$ ft-lb. which shows the floor to be safe as it is, although it will probably wear to an unsafe condition before the other members of the structure do.

Stringer Analysis

In the analysis of the stringers we determine the dead load moment existing due to the weight of the floor and the stringers themselves, and then determine the total allowable moment (taking into consideration the assumed depreciation of the members). Subtracting the

dead-load moment from the allowable total moment, we get the moment allowable due to Live Load plus impact. Then, using an H-15 Loading system, which gives a safer condition than Legal Loading would in this case, we determine the moment due to Live Load plus impact which results from this H-15 Loading, and since this exceeds the allowable moment due to live load plus impact we have to limit the axle load allowable to a proportion of the H-15 loading axle load equal to the allowable live load plus impact moment divided by the H-15 moment.

The stringers are $6" I @ 12.5"$

The stringer computations are-

$$\begin{aligned} C &= 3" & \text{Original Net } I &= +21.8" \\ & & \text{Depreciation } 10\% &= -2.18" \\ & & \text{Available Net } I &= +19.6" \end{aligned}$$

$$\text{Allowable unit stress} = 24,000 \text{ #/sq. in.}$$

$$M = \frac{IS}{C} = \frac{19.6 \times 24,000}{3} = 156,800 \text{ "Lb}$$

The dead Load moment is-

$$\begin{aligned} \text{Dead Load} &= \text{stringer} = 12.5" \\ \text{Floor} &= .25 \times 1.0 \times 11 \times 60 = 20.8" \\ \text{Runner} &= \frac{2 \times 1 \times 6 \times 60}{8} = 7.6" \end{aligned}$$

$$\text{Total} = 48.9 \text{ #/lin. ft.}$$

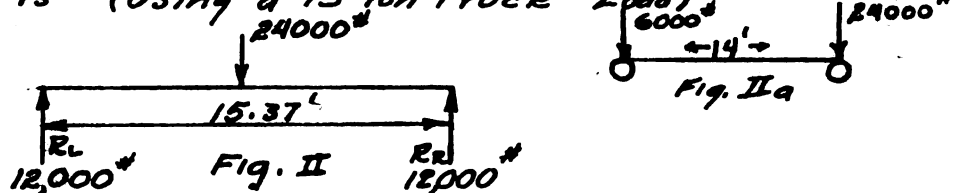
Dead Load Moment =

$$\frac{49 \times 15.37^2 \times 12}{8} = 17,300 \text{ "Lb}$$

The allowable moment due to Live Load plus impact =

$$\begin{aligned} &+156,800 \text{ "Lb} \\ &-17,300 \text{ "Lb} \\ \hline M_{\text{allow LL+I}} &= 139,500 \text{ "Lb} \end{aligned}$$

The Live Load plus impact moment resulting from an H-15 Loading is - (Using a 15 Ton truck Load)



$$LL.M. = 12000 \times \frac{15.37}{2} \times 1.3 \times 12 \times \frac{1.92}{8.5} = 324,000 \text{ "Lb.}$$

dead load moment from the allowable total moment we get the moment allowable due to live load plus impact. Then, using an H-12 loading system, which gives a safer condition than equal loading would in this case, we determine the moment due to live load plus impact which results from this H-12 loading, and since this exceeds the allowable moment due to live load plus impact we have to limit the axle load allowable to a proportion of the H-12 loading axle load equal to the allowable live load plus impact moment divided by the H-12 moment.

The stringers are 6" I @ 15.2

The stringer computations are -

$$\begin{aligned} C &= 3 \\ \text{Original Net I} &= 25.8 \\ \text{Depreciation 10\%} &= -2.58 \\ \text{Available Net I} &= 19.6 \end{aligned}$$

$$\text{Allowable unit stress} = 24,000 \text{ psi}$$

$$M = \frac{S}{C} = \frac{19.6 \times 24,000}{3} = 156,800 \text{ in}^2$$

The dead load moment is -

$$\begin{aligned} \text{Dead Load} &= 2 \text{ stringers} = 15.2 \\ \text{Floor} &= 52 \times 11 \times 10 = 58.8 \\ \text{Runner} &= 5 \times 1 \times 10 = 5 \end{aligned}$$

$$\text{Total} = 48.9 \text{ #/lin ft}$$

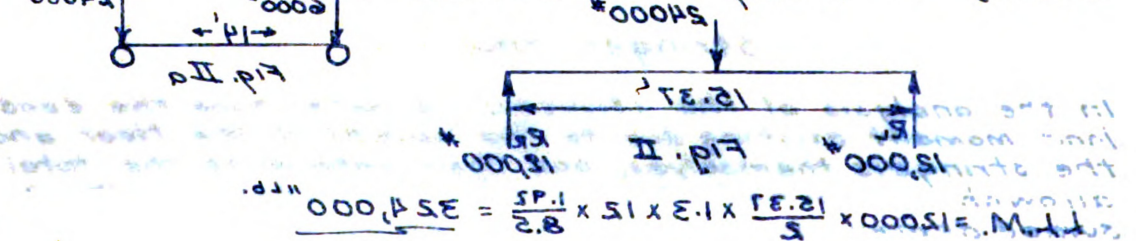
Dead load Moment =

$$M = \frac{wL^2}{8} = \frac{48.9 \times 15.37^2}{8} = 17,300 \text{ in}^2$$

The allowable moment due to live load plus impact =

$$\begin{aligned} M_{\text{allow}} &= 156,800 \\ - M_{\text{dead}} &= -17,300 \\ \hline M_{\text{allow}} &= 139,500 \end{aligned}$$

The live load plus impact moment resulting from an H-12 loading is - (Using a 12 ton truck load)



(Since the moment is a maximum when the load is at the center of the beam) this method gives a safer condition than does Legal Loading and it seems justifiable to use H-15 in this case.

Since the existing moment is above the allowable, the allowable axle load must be limited to -

$$\frac{139.5}{324} \times 24000 = 10,400 \text{ #/Axle}$$

7. The existing moment is above the allowable, the allowable axle load must be limited to -

dead
+ I
+ II
+ III

Floor Beam Analysis

The floor beams are analyzed in a manner similar to that followed in analyzing the stringers.

The Floor beams are 15" I @ 42.9# $C = 7\frac{1}{2}"$

Original Net $I = 441.8 \text{ in}^4$

Depreciation 5% = - 24.1

Available Net $I = 417.7 \text{ in}^4$

Allowable Unit Stress = 24,000 #/in²

Dead Load -

Floor Beam = 21.5#

Floor Stringers $\frac{49}{1.92} \times 15.37 = 392.0$

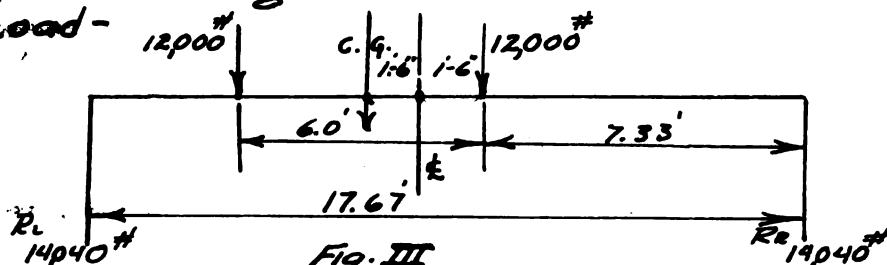
Available Total Net Weight = 413.5#

Dead Load Moment = $\frac{WL^2}{8}$

$$DLM = \frac{413.5 \times 17.67^2 \times 12}{8} = 193,000 \text{ in-lb}$$

Live Load -

floor



In determining the maximum moment due to Live Load on the floor beam, we make use of the theorem for absolute Maximum Bending Moment in a beam. Thus, by placing the loads as shown in Fig. III, the 24,000# axle load of the H-15 Loading system being divided into two wheel loads of 12,000# each, and placed eccentrically as shown, we have the worst possible condition for the bending moment in a beam. The two possible bending moments are shown following, the first being the maximum.

(Since the moment is a maximum when the load is at the center of the beam, this method gives a safer condition than does equal loading and it seems justifiable to use M-12 in this case.

Since the existing moment is above the allowable, the allowable axle load must be limited to -

$$\frac{139.2 \times 54000}{354} = 10,400 \text{ #/Axle}$$

Floor Beam Analysis

The floor beams are analyzed in a manner similar to that followed in analyzing the stringers.

The floor beams are 12" I @ 45.2 # $C = 1\frac{1}{2}"$

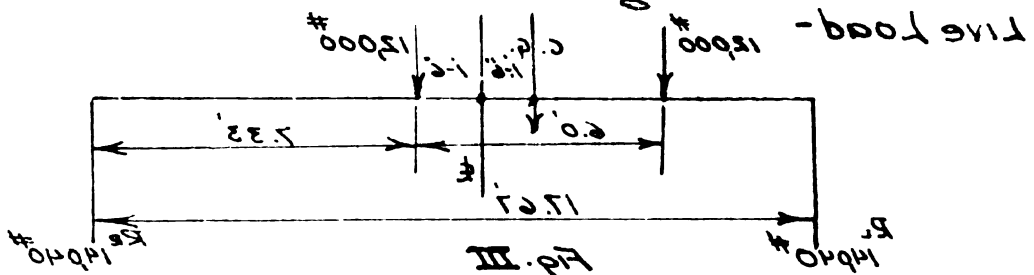
$$\begin{aligned} \text{Available Net I} &= 41.7 \text{ in}^4 \\ \text{Depreciation } 2\% &= -54.1 \text{ in}^4 \\ \text{Original Net I} &= 41.8 \text{ in}^4 \end{aligned}$$

Allowable Unit Stress = 24,000 #/in²

$$\begin{aligned} \text{Total Net Weight} &= 413.2 \text{ #} \\ \text{Available Floor + Stringers} &= \frac{41.7 \times 12.5}{1.25} = 395.0 \text{ #} \\ \text{Floor Beam} &= 51.2 \text{ #} \\ \text{Dead Load} &= 51.2 \text{ #} \end{aligned}$$

$$\text{Dead Load Moment} = \frac{W L^2}{8}$$

$$DL M = \frac{413.2 \times 17.8^2 \times 15}{8} = 193,000 \text{ in}^2$$



In determining the maximum moment due to live load on the floor beam, we make use of the theorem for absolute Maximum Bending Moment in a beam. Thus, by placing the loads as shown in Fig. III, the 5400 # axle load of the H-12 loading system being divided into two wheel loads of 15,000 # each and placed eccentrically as shown, we have the worst possible condition for the bending moment in a beam. The two possible bending moments are shown following, the first being the maximum.

$$L.L.M. = 12000 \times 7.35' \times 1.3 \times 12" = 1,134,000" \text{ (Max.)}$$

$$L.L.M. = 12000 \times 5.83' \times 1.3 \times 12" = 1,090,000" \text{ }$$

The allowable moment for this floor beam is -

$$B.M. = \frac{IS}{C} = \frac{417.7 \times 24000}{7.5} = 1,342,000" \text{ }^{Lb}$$

Thus, the allowable B.M. (1,342,000" ^{Lb}) Minus the dead load B.M. (193,000) = 1,149,000 Allowable for L.L.+I. Therefore, the existing B.M. of 1,134,000" ^{Lb} is safe.

Analysis of Truss Members

In the analysis of the truss members, we find first the dead load stresses due to the weight of the members themselves, the floor beams, stringers and floor. Next, we find the stresses due to live load + impact, (using the legal loading values as stipulated by the Statutes of Michigan at this time), by means of influence lines and finally, we find the total allowable stresses and the allowable Live load plus impact stresses to determine whether or not we must impose load restrictions on the structure or strengthen it.

Dead Load stresses:

For the load of one panel on the intermediate hangers (such as M.L.) we have -

floor - 16'-0" x 15'-4 1/2" x 3' x 60#	= 3690#
Runners - 6'-0" x 15'-4 1/2" x 2' x 60#	= 940#
Stringers - 8 x 12.5" x 15'-4 1/2"	= 1537#
Floor beams - 42.9" x 17'-8"	= 758
	6925 = 3462#
	2
bottom chord 4 x (4 1/2" x 11") x 15.37	= 646#
2 - (3/4" dia) 15' Long	56
	Total = 4580#

The load on each of the main panel points is determined by finding the total load on one truss and subtracting from it the intermediate hanger loads and dividing by the number of main panel points.

The computations used in determining the weight of one truss, the main panel loads and the dead load stresses are shown on the following pages. The method of joint analysis is used to determine the dead load stresses

$$L.T.M. = 15000 \times 2.83 \times 1.3 \times 15 = 1,020,000 \text{ "lb"} \\ L.T.M. = 2460 \times 5.32 \times 1.2 \times 15 = 1,134,000 \text{ "lb (max.)}$$

The allowable moment for this floor beam is -

$$B.M. = \frac{I \cdot S}{C} = \frac{417.7 \times 54000}{1.3 \times 15000} = 1,345,000 \text{ "lb}$$

Thus, the allowable B.M. (1,345,000 "lb) minus the dead load B.M. (1,020,000 "lb) = 1,145,000 Allowable for L.T.I. Therefore, the existing B.M. of 1,340,000 "lb is safe.

Analysis of Truss Members

In the analysis of the truss members, we find first the dead load stresses due to the weight of the members themselves, the floor beams, stringers and floor. Next we find the stresses due to live load + impact, (using the load values as stipulated by the statutes of Michigan at this time), by means of influence lines and finally, we find the total allowable stresses and the allowable live load plus impact stresses to determine whether or not we must impose load restrictions on the structure or strengthen it.

Dead Load Stresses:

For the load of one panel on the intermediate panels (such as M.1), we have -

$$\begin{aligned} & \# 3600 = \\ & \# 400 = \\ & \# 1231 = \\ & \# 528 = \\ & \# 6252 = \frac{3465}{5} \end{aligned}$$

$$\begin{aligned} & \text{floor beam} - 45.9 \times 12 - 8 \\ & \text{stringers} - 8 \times 12.5 \times 12 - 4.5 \\ & \text{members} - 6.0 \times 12 - 4.5 \times 5 \times 60 \\ & \text{floor} - 16.0 \times 12 - 4.5 \times 3 \times 60 \end{aligned}$$

$$\# 22 = \# 646$$

$$\# 4280 = \text{Total}$$

$$\text{bottom chord } 4 \left(\frac{1}{2} \times \frac{1}{16} \right) \times 12.37$$

The load on each of the main panel points is determined by finding the total load on one truss and subtracting from it the intermediate panel loads and dividing by the number of main panel points.

The computations used in determining the weight of one truss, the main panel loads and the dead load stresses are shown on the following pages. The method of joint analysis is used to determine the dead load stresses

Total Weight of One Truss
($\frac{1}{2}$ of Floor)

Floor - 16'-0" x 215'-3" x 3" x 60"	=	51,600
Runners - 6-0 x 215'-3" x 2" x 60	=	13,150
Stringers - 8 x 12.5 x 215'-3"	=	21,500
Floor Beams - 42.9 x 17.8 x 12	=	9,100
		<u>95,350 = 47,675*</u>
		2

(1 Truss)

Top chord = 18 x $\frac{5}{8}$ R x 240	4,600
" " = 2 x (12" L @ 20") 240	9,600
M ₁ L ₁ 4 x (3/4") x 15-0	115
M ₁ L ₂ 4 (5" L @ 6.7") x 21-6	575
U ₂ L ₂ 4 (1") x 30-0	410
U ₂ U ₄ 4 (4 1/2 x 5/8) x 43-0	1,640
U ₂ M ₃ 10 (6.1 x 15-0)	915
M ₃ L ₃ 10 (3/4" x 15-0)	285
M ₃ U ₄ 2 (7/8" x 21-6)	110
U ₄ L ₄ 4 (10" L @ 16" x) 30-0	1,920
U ₄ M ₅ 4 (4 x 9/16) x 21-6"	660
M ₅ L ₆ 4 (1/6 x 3) x 21-6"	600
L ₄ M ₅ 2 (3/4" x 21-6"	90
M ₅ U ₆ 2 (7/8" x 21-6"	110
U ₆ L ₆ 4 (8" L @ 11.5" x 30	1,380
U ₆ M ₇ & M ₇ U ₆ 4 (2" x 3/4) x 21-6"	440
L ₆ M ₇ & M ₇ L ₆ 4 (7/8" x 21-6"	225
L ₆ L ₇ 16 x 4 1/2 x 3/4 x 15-4 1/2"	2,810
L ₄ L ₅ 16 x 4 1/2 x 9/16 x 15-4 1/2"	2,110
L ₆ L ₇ 8 x 4 1/2 x 1/4 x 15-4 1/2"	1,300
	<u>29,885* = 30,000*</u>

Miscellaneous 15%

Wt. 1 Truss	4500*
1/2 Floor	34500
	<u>47700</u>

Load of one Truss = 82,200*

$$\begin{aligned} \text{Int. Panel Load} &= 4.58 \text{ kips} \\ &\times 9 \text{ panels} \\ &= 41.22 \text{ Kips.} \end{aligned}$$

$$\begin{aligned} \text{Truss Load} &= 82.2 \text{ K.} \\ &- 41.22 \end{aligned}$$

= 40.98K for main panel points

$$40.98 \div 5 = 8.2 \text{ Kips each main panel.}$$

Total Weight of One Truss
($\frac{1}{2}$ of Floor)

$$\begin{array}{r}
 \text{Floor Beams} - 45.9 \times 12.8 \times 15 \\
 \text{Stringers} - 8 \times 12.2 \times 512 - 3 \\
 \text{Runners} - 0 - 0 \times 512 - 3 \times 5.1 \times 20 \\
 \text{Floor} - 12 - 0 \times 512 - 3 \times 3 \times 20 \\
 \hline
 22,320 = 45,612
 \end{array}$$

$$\begin{array}{r}
 4,600 \\
 9,600 \\
 1,112 \\
 2,122 \\
 4,110 \\
 1,940 \\
 2,122 \\
 2,882 \\
 1,110 \\
 1,950 \\
 6,620 \\
 6,000 \\
 80 \\
 1,110 \\
 1,380 \\
 4,440 \\
 2,522 \\
 2,810 \\
 5,110 \\
 1,300
 \end{array}$$

$$22,882 = 30,000$$

$$4,200$$

$$3,4200$$

$$4,5200$$

$$\text{Load of one Truss} = 85,500$$

Wt. 1 Truss
1/2 Floor

Miscellaneous 12%

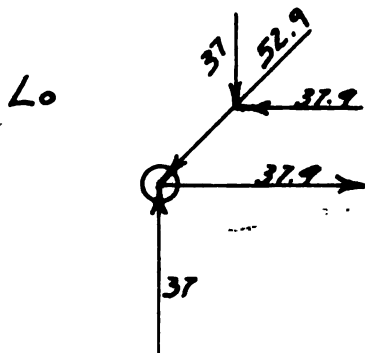
$$\begin{array}{r}
 \text{Wt. Panel Load} = 4,28 \text{ Kips} \\
 \times 9 \text{ Panels} \\
 \hline
 = 41.55 \text{ Kips}
 \end{array}$$

$$\begin{array}{r}
 \text{Truss Load} = 85.5 \text{ K} \\
 - 41.55 \\
 \hline
 \end{array}$$

$$40.95 \text{ K for main panel points}$$

$$40.95 \div 2 = 20.47 \text{ Kips each main panel}$$

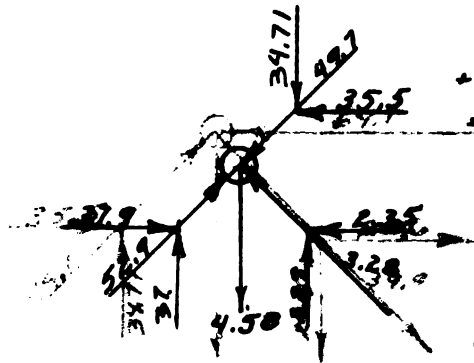
DEAD LOAD STRESSES



$$37 \times 1.432 = 52.9$$

$$37 \times 1.025 = 37.9$$

M_1



$$\begin{array}{r} 37.0 \\ + 2.29 \\ \hline \end{array}$$

$$= 39.29$$

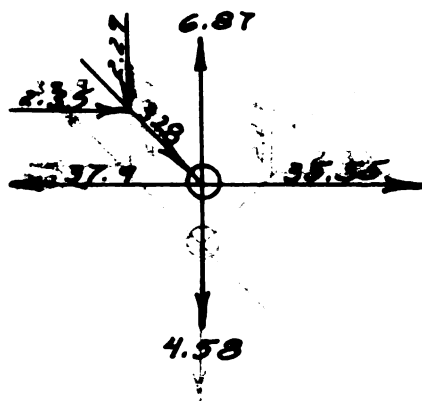
$$- 4.58$$

$$= 34.71$$

$$34.71 \times 1.432 = 49.7$$

$$34.71 \times 1.025 = 35.5$$

L_2



$$37.90$$

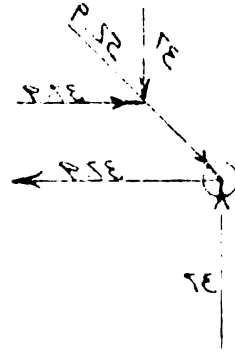
$$- 2.85$$

$$= 35.55$$

DEAD LOAD STRESSES

$$P.S.E = 584.1 \times 7.5$$

$$P.S.E = 4380.75$$

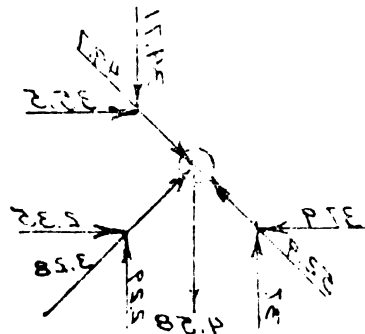


L

$$\begin{array}{r} 0.75 \\ + 5.5 \\ \hline 6.25 \\ - 4.28 \\ \hline 1.97 \end{array}$$

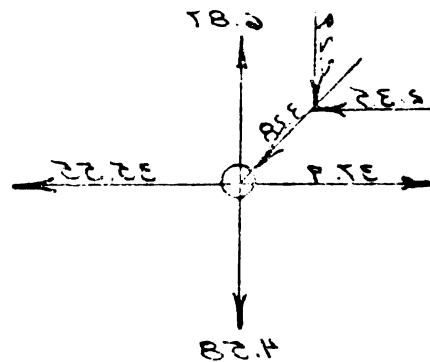
$$7.94 = 584.1 \times 17.4$$

$$22.22 = 250.1 \times 17.4$$



M

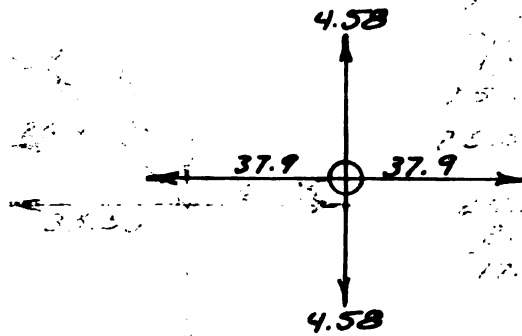
$$\begin{array}{r} 0.75 \\ - 5.32 \\ \hline -4.57 \end{array}$$



L

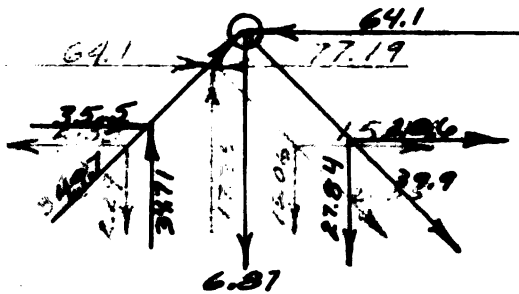
Dead Load Stresses (Cont'd) Dead Load Stresses (Cont'd)

L₁



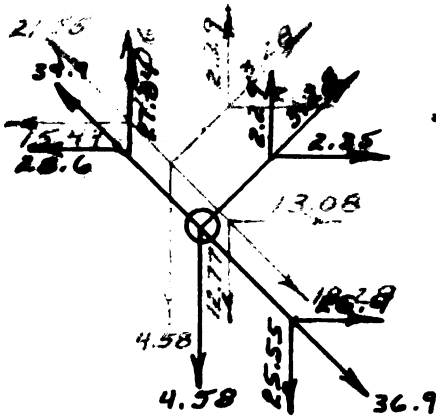
$$\begin{aligned}
 &25.55 \times 1.1412 = 30.9 \\
 &25.55 \times 1.025 = 26.4 \\
 &21.55 \\
 &2.20 \\
 &17.35
 \end{aligned}$$

U₁
U₂



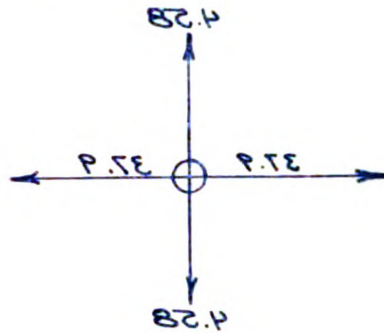
$$\begin{aligned}
 &34.71 \\
 &12.67 \\
 &22.04 \\
 &27.84 \times 1.4028 = 39.455 \\
 &27.84 \times 0.25 = 20.64 \\
 &+ 35.5 \\
 &+ 25.10 \\
 &124.7 \\
 &79.74 \\
 &1.65 \\
 &77.19
 \end{aligned}$$

M₅
M₃

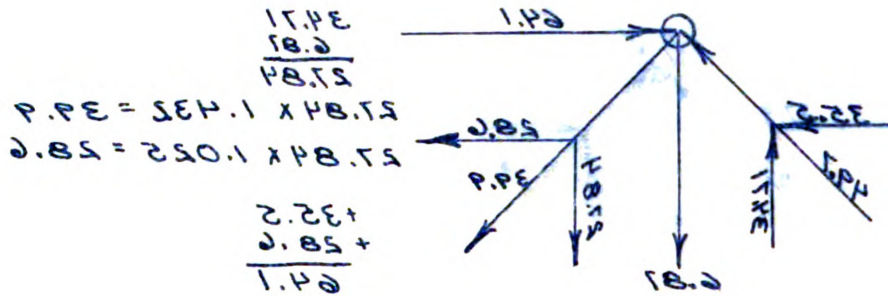


$$\begin{aligned}
 &27.84 \times 1.5125 = 42.29 \\
 &+ 2.29 \\
 &= 30.13 \\
 &- 4.58 \\
 &25.55 \times 1.025 = 26.4 \\
 &25.55 \times 1.432 = 36.9 \\
 &25.55 \times 1.025 = 26.4
 \end{aligned}$$

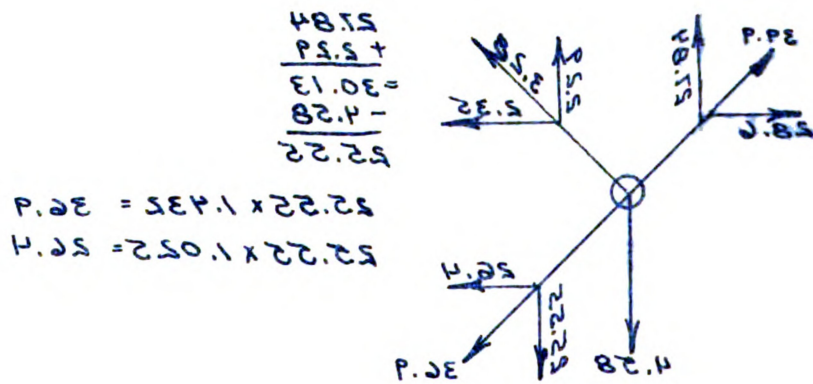
Dead Load Stress
(Cont'd)



1

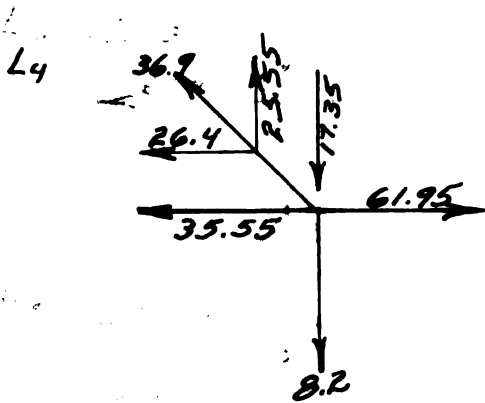


2



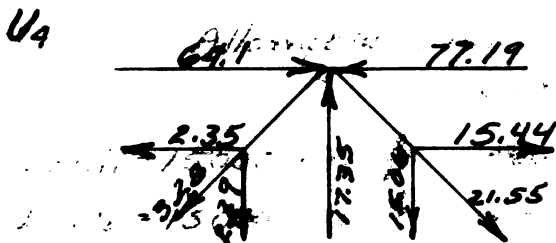
3

Dead Load Stresses (Cont'd)



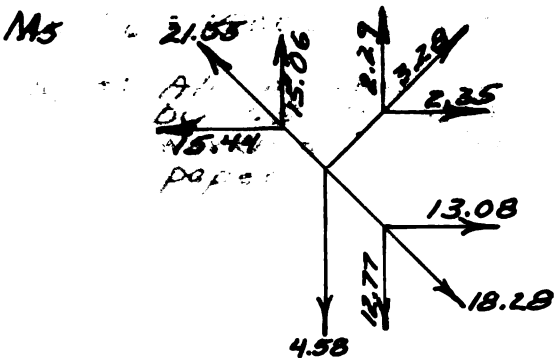
$$\begin{array}{r}
 27.84 \\
 2.29 \\
 \hline
 30.13 \\
 4.58 \\
 \hline
 25.55 \times 1.432 = 36.9 \\
 25.55 \times 1.025 = 26.4
 \end{array}$$

$$\begin{array}{r}
 25.55 \\
 8.20 \\
 \hline
 17.35
 \end{array}$$



$$\begin{array}{r}
 17.35 \\
 2.29 \\
 \hline
 15.06 \times 1.432 = 21.55 \\
 15.06 \times 1.025 = 15.44
 \end{array}$$

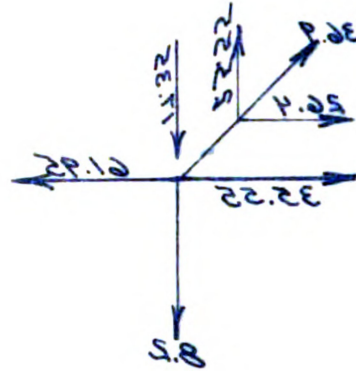
$$\begin{array}{r}
 64.10 \\
 15.44 \\
 \hline
 79.54 \\
 2.35 \\
 \hline
 77.19
 \end{array}$$



$$\begin{array}{r}
 15.06 \\
 2.29 \\
 \hline
 17.35 \\
 4.58 \\
 \hline
 12.77 \times 1.432 = 18.28 \\
 12.77 \times 1.025 = 13.08
 \end{array}$$

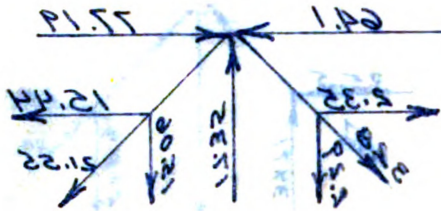
Dead Load Stresses (Cont'd)

$$\begin{array}{r}
 52.22 \times 1.052 = 54.9 \\
 52.22 \times 1.435 = 74.9 \\
 \hline
 127.12
 \end{array}$$



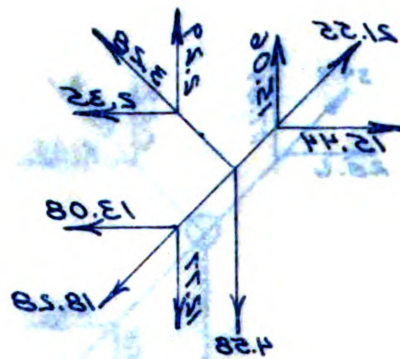
14

$$\begin{array}{r}
 12.00 \times 1.052 = 12.62 \\
 12.00 \times 1.435 = 17.22 \\
 \hline
 30.13
 \end{array}$$



14

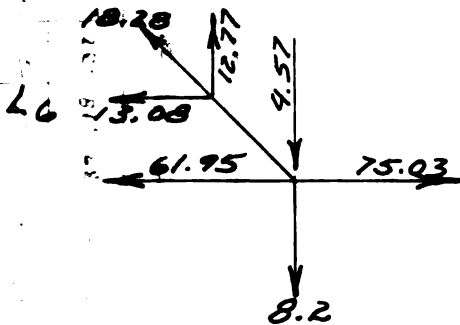
$$\begin{array}{r}
 12.62 \\
 17.22 \\
 \hline
 30.13
 \end{array}$$



14

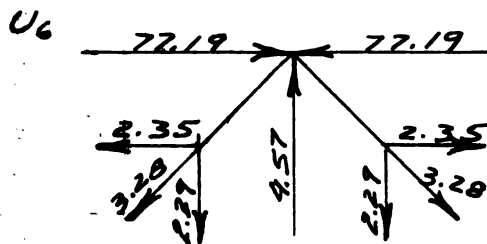
$$\begin{array}{r}
 15.11 \times 1.052 = 15.88 \\
 15.11 \times 1.435 = 21.68 \\
 \hline
 37.56
 \end{array}$$

Dead Load Stresses (Cont'd)



$$\begin{array}{r} 12.77 \\ 8.20 \\ \hline 4.57 \end{array}$$

$$\begin{array}{r} 61.95 \\ 13.08 \\ \hline 75.03 \end{array}$$



$$\begin{array}{r} 2.29 \\ 2.29 \\ \hline 4.58 \end{array}$$

$$\begin{array}{r} 8.67 \\ 4.58 \\ \hline 4.09 \end{array}$$

Allowable Unit Stresses in Compression Members

$$L_0 M_1 = 15000 - 70 \frac{L}{r} = 15000 - 70 \frac{358}{4.76} = 16,800 \text{ #/sq"}$$

$$L_0 U_2 = 15000 - 70 \frac{L}{r} = 15000 - 70 \frac{516}{6} = 13,500 \text{ #/sq"}$$

$$U_2 U_4 = 15000 - 70 \frac{L}{r} = 15000 - 70 \frac{370}{6.0} = 16,050 \text{ #/sq"}$$

$$M_1 L_2 = 15000 - 70 \frac{L}{r} = 15000 - 70 \frac{258}{1.95} = 8,600 \text{ #/sq"}$$

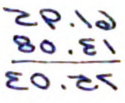
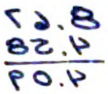
$$U_4 L_9 = 15000 - 70 \frac{L}{r} = 15000 - 70 \frac{360}{3.63} = 12,105 \text{ #/sq"}$$

$$U_6 L_6 = 15000 - 70 \frac{L}{r} = 15000 - 70 \frac{360}{3.1} = 10,305 \text{ #/sq"}$$

Note: All of above results have been multiplied by 1.5 to obtain the maximum allowable working stresses as explained earlier in the paper.

$$\begin{aligned} 10W_1 &= 12000 - 50 \cdot \frac{1}{4} = 12000 - 12.5 = 11987.5 \\ 10U_2 &= 12000 - 50 \cdot \frac{1}{4} = 12000 - 12.5 = 11987.5 \\ U_2 W_1 &= 12000 - 50 \cdot \frac{1}{4} = 12000 - 12.5 = 11987.5 \\ W_1 U_2 &= 12000 - 50 \cdot \frac{1}{4} = 12000 - 12.5 = 11987.5 \\ U_1 W_4 &= 12000 - 50 \cdot \frac{1}{4} = 12000 - 12.5 = 11987.5 \\ U_1 U_2 &= 12000 - 50 \cdot \frac{1}{4} = 12000 - 12.5 = 11987.5 \end{aligned}$$

Allowable Unit Stress in

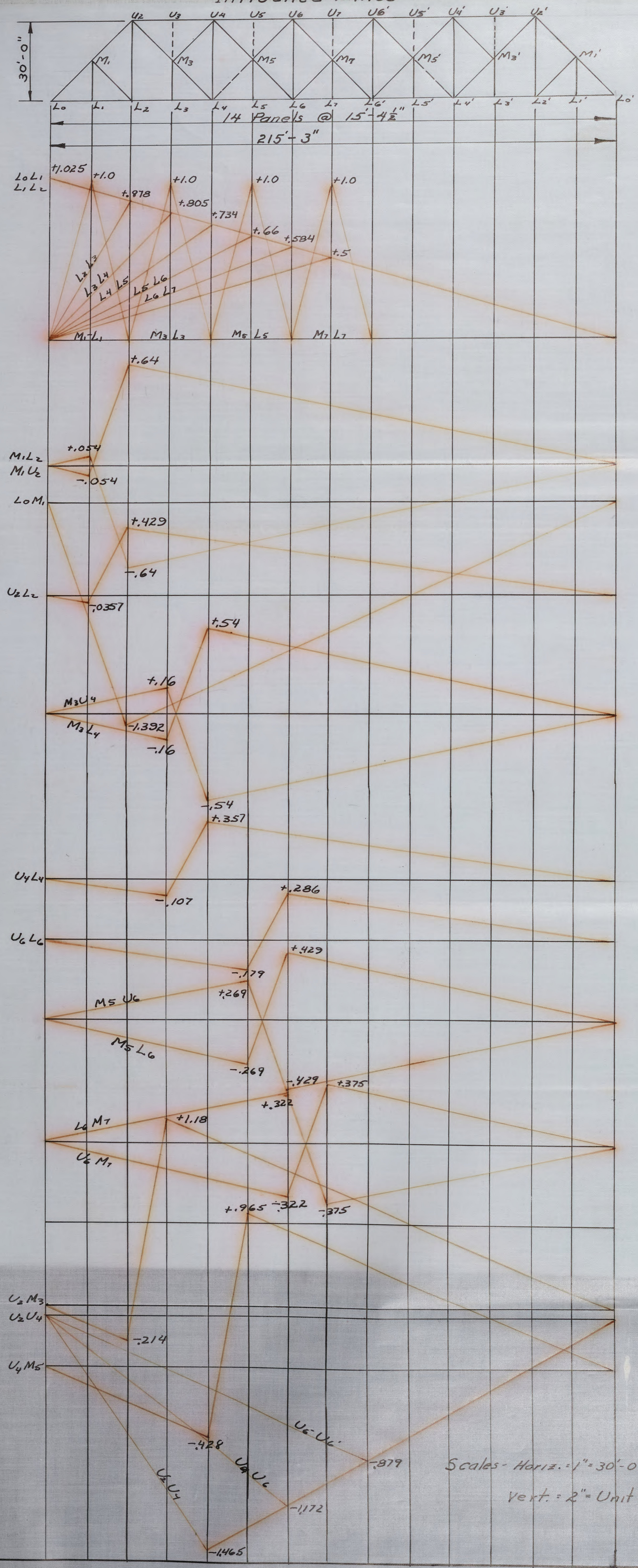

$$\begin{array}{r} 29.10 \\ 80.81 \\ \hline 109.91 \end{array}$$

Load	M ₁₋₂ M ₂₋₃ M ₃₋₄	L ₁₋₂	L ₂₋₃	L ₃₋₄	L ₄₋₅	L ₅₋₆	L ₆₋₇	U ₁₋₂	U ₂₋₃	U ₃₋₄	U ₄₋₅	U ₅₋₆	U ₆₋₇	U ₇₋₈	U ₈₋₉	U ₉₋₁₀	U ₁₀₋₁₁	U ₁₁₋₁₂	U ₁₂₋₁₃	U ₁₃₋₁₄	U ₁₄₋₁₅	U ₁₅₋₁₆	U ₁₆₋₁₇	U ₁₇₋₁₈	U ₁₈₋₁₉	U ₁₉₋₂₀	
1	-						1.465	1.172	1.10	1.39					.04	.42		.38	.22	.39	.18	.32	.38				
2	+	.67	1.03	.88	.81	.73	.66	.584		.64	.38	.95	.42	.04	.29	.39	.22	.29	.38	.32							
3	-								1.32	1.10	1.00	1.33		.61		.07	.52										
4	+	.09	.99	.83	.76	.69	.62	.542		.61	.41	1.14	.52	.07	.34	.90	.35	.19	.27	.34	.29						
5	-								1.29	1.015	.93	1.25		.58		.10	.48		.26	.17	.33	.15	.26	.31			
6	+	.13	.94	.80	.73	.65	.58	.50		.58	.39	1.07	.48	.10	.32	.85	.33	.17	.25	.31	.26						
7	-								1.20	.93	1.85	1.19		.55		.14	.45		.20	.14	.29	.13	.24	.28			
8	+	.72	.90	.75	.67	.61	.53	.455		.55	.37	1.00	.45	.14	.30	.78	.29	.14	.22	.28	.24						
9	-								1.12	.845	.77	1.12		.52		.16	.42		.43	.27	.43	.11	.20	.24			
10	+	0	.85	.66	.64	.57	.48	.415		.52	.35	.95	.42	.16	.28	.72	.43	.27	.20	.24	.20						
Total Index	-								6.40	5.06	4.65	6.28		2.9		.51	2.29		.160	.99	1.79	.74	1.31	1.55			
Stress	+	.161	.471	.392	.361	.325	.287	.250		2.9	1.90	5.11	2.29	.51	.453	4.22	.99	.99	1.23	1.55	1.31						
Total Stress-Tens. KIPS		14.44	42.35	37.27	32.47	27.24	25.88	22.26		26.1	17.10	45.71	20.61	4.57	13.77	37.98	16.11	8.91	11.07	13.35	11.79						
Total Stress-Comp. KIPS									57.56	45.88	41.85	56.54		26.1		4.59	20.61		14.4	8.91	16.11	6.66	11.79	13.35			
															</												

Live Load Influence Table

[illegible]

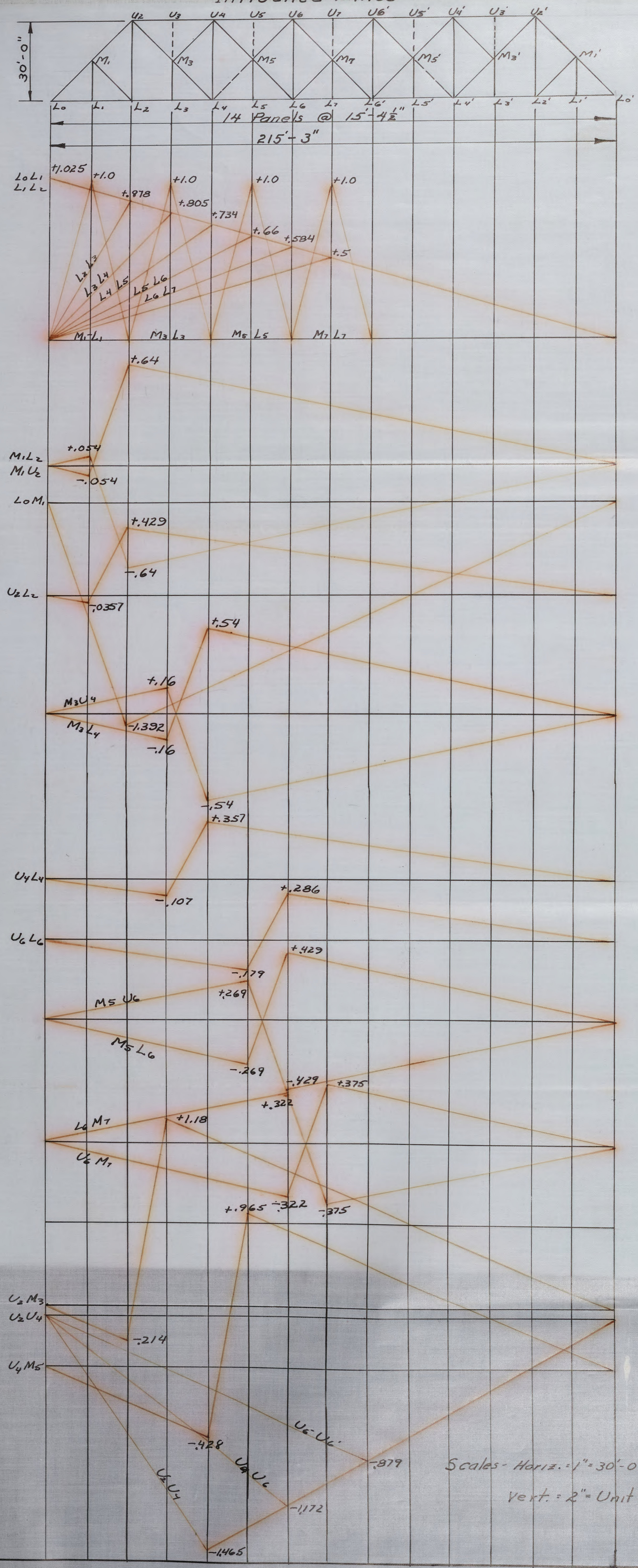
Influence Lines



Scales - Horiz. = 1" = 30'-0"
 Vert. = 2" = Unit Load

[illegible]

Influence Lines



Scales - Horiz. = 1" = 30'-0"
 Vert. = 2" = Unit Load

STRESS SUMMARY

Member	Section	Length - IN.	Radius of Gyration - IN.	Original Net Area - IN ²	Assumed % Depreciation	Available Net Area - IN ²	Allowable Unit Stress lb/in ²	Allowable Total Stress - (1000) lb	Dead Load Stress - 1000 lb	Allowable Stress for LL + I - 1000 lb	Max. LL Stress	* Due to Legal Load	" " H-15 1000 lb Load	Allowable Axle Load - 1000 lb.
Member	Section	Length - IN.	Radius of Gyration - IN.	Original Net Area - IN ²	Assumed % Depreciation	Available Net Area - IN ²	Allowable Unit Stress lb/in ²	Allowable Total Stress - (1000) lb	Dead Load Stress - 1000 lb	Allowable Stress for LL + I - 1000 lb	Max. LL Stress	* Due to Legal Load	" " H-15 1000 lb Load	Allowable Axle Load - 1000 lb.
U2 U4	Do	185	4.76	17.62	5	16.74	16.74	16050	269	204.9	14.9	173.1	13.6	
U4 U6	Do	185	4.76	17.62	5	16.74	16.74	16050	269	191.8	59.4	191.8	59.4	
U6 U8	Do	185	4.76	17.62	5	16.74	16.74	16050	269	153.7	54.5	153.7	54.5	
L6 L8	4-4 1/2" x 9"	—	—	10.12	5	9.62	9.62	24000	2307	61.95	38.1	61.95	38.1	
L6 L8	4-4 1/2" x 11"	—	—	12.38	5	11.76	11.76	24000	282	15.03	28.9	205.7	28.9	
M.L. M.L.	2-3" x 3"	—	—	1.12	5	1.07	1.07	24000	25.7	4.58	18.00	21.12	18.00	
M.L. M.L.	2-5" x 7"	258	1.95	3.70	5	3.71	3.71	8600	31.9	38.62	34	38.62	34	14.6
U.L. L2	2-1" x 1"	—	—	2.0	5	2.0	1.90	24000	45.6	38.73	22.2	38.73	22.2	
U2 M3	2-4 1/2" x 5"	—	—	5.62	5	5.34	5.34	24000	1282	88.3	59.8	88.3	59.8	
M3 L4	2-4 1/2" x 5"	—	—	5.62	5	5.34	5.34	24000	1282	91.3	26.8	91.3	26.8	
M3 U4	1-3" x 3"	—	—	6.1	5	5.72	5.72	24000	17.3	3.28	26.8	14.02	26.8	9.5
U4 L4	2-10" x 16"	360	3.63	9.6	5	9.12	9.12	12100	110.3	17.35	17.9	92.95	17.9	
Laced M3 U6 M3 U7	2-10" x 16"	—	—	—	—	—	—	—	—	—	—	—	—	—
U4 M5	2-4" x 9"	—	—	5.7	5	5.24	5.24	24000	102.7	21.53	49.4	81.15	49.4	
M3 U6	1-3" x 3"	—	—	6.1	5	5.72	5.72	24000	17.3	3.28	14.4	14.02	14.4	17.5
L4 M5	1-3" x 3"	—	—	5.6	5	5.3	5.3	24000	12.7	0	22.4	12.7	22.4	10.4
M5 L6	2-1 1/2" x 3"	—	—	4.12	5	3.92	3.92	24000	94.1	18.28	20.9	15.82	20.9	
U6 L6	2-8" x 5 1/2"	360	3.1	9.12	5	6.38	6.38	10,300	65.7	4.57	14.4	61.13	14.4	
U6 M1	2-2" x 3"	—	—	3.0	5	2.85	2.85	24000	68.4	3.28	18.2	65.12	18.2	
L6 M1	2-2" x 3"	—	—	3.0	5	2.85	2.85	24000	68.4	3.28	18.2	65.12	18.2	
M2 U6	2-8" x 3"	—	—	1.53	5	1.45	1.45	24000	34.8	0	18.2	34.8	18.2	

* included is impact factor = 1.3

14

101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279	1280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Stress Summary

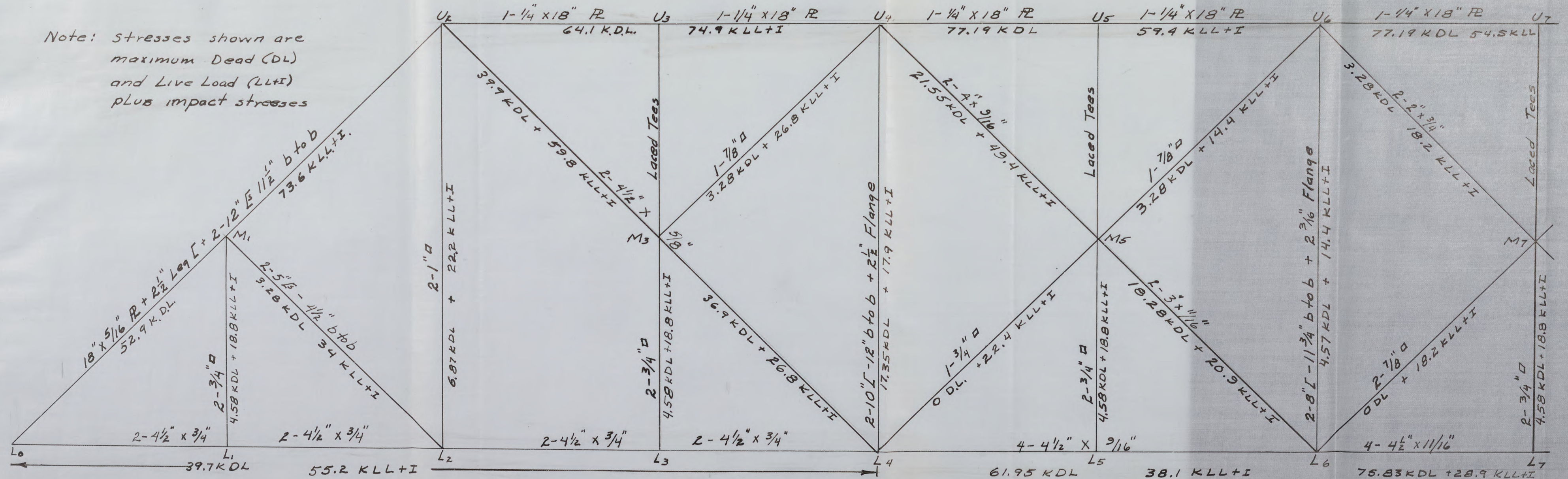
Member	Floor	Stringers	Floor Beams
Section	3x10" oak Transv. 2" Long. Runners	6"I @ 12.5*	15"I @ 42.9*
C - IN.	1.5	3	7½
Original Net I	67.5	21.8	441.8
Assumed Depreciation	10 %	10%	5%
Available Net I	60.8	19.6	417.7
Allowable #/in" Unit Stress	1200	24000	24,000
Allowable Total Mom. "Lb	48,500	156,800	1,342
D.L. Moment "Lb	0	17.3	193
Allowable Mom. for LL + I "Lb	48,500	139,500	1,149,000
Max. LL + I "Lb Mom Due to Legal Load	39,800		
H-15 Load		324,000	1,134,000
Allowable Axle Load	✓	10,400	✓

Member	Section	C - 14	Original Net I	Assumed Depreciation	Available Net I	Allowable #/ft	Unit Stress	Allowable Total Mom. "ft"	D.L. Moment "ft"	Allowable Mom. for LL + I "ft"	Max. LL + I Mom Due to Dead Load	H-12 Load	Allowable Axle Load
Floor	3x10" Oak Transv. 5" Lead. Runners	1.2	65.2	10%	60.8	1500	1500	48,200	0	48,200	32,800		✓
2x10" I @ 15.2"		3	51.8	10%	46.6	54000	54000	126,800	15.3	138,200		354,000	10,400
Floor Beams	12" I @ 45.4"	2 1/2	441.8	2%	417.7	24,000	24,000	1,345	183	1,441,000		1,134,000	✓

Stress Summary

DIAGRAM SHOWING MAKEUP AND STRESSES OF MEMBERS

Note: Stresses shown are maximum Dead (DL) and Live Load (LL+I) plus impact stresses



One-Half Span - 7 Panels @ 15'-4 1/2" = 107'-7 1/2"
Rise = 30'-0"

With the preceeding assumptions and calculations, we find first that the floor and floor stringers limit the capacity to axle loads not exceeding 10400 lbs per axle. Further, all intermediate floor beams' hangers are limited to a capacity of 13400 lbs per axle. The end hangers are limited to a capacity of 16400 lbs per axle. The upper counter diagonals M3U4 and M5U6 are limited to 9500 lbs per axle and 17500 lbs per axle respectively. These are the upper diagonal members in panels two and three, sloping toward the center of the top chord. They consist of one $7/8$ " square bar each. Likewise, the lower diagonal L4M5 is limited to 10400 lbs per axle. This is the lower diagonal in the third panel sloping toward the center of the top chord. It consists of one $3/4$ " square bar. Otherwise, the trusses figure safe for legal loading.

In view of the above, it is recommended that the structure be posted for loads not to exceed 9500 lbs per axle.

It is further recommended that this structure be reinforced at an early date to safely carry legal loading and remove the necessity of any posting for limiting loadings. This would be done first at such time as the present floor begins to show need of repair and we make the following recommendations for this work.

1. Replace the present 6" I beam stringers with nine lines of 8"-19# wide flange beams. These should be welded to the present floor beams for rigidity.
2. Place a new timber floor consisting of 2"x4" treated timber of structural grade yellow pine or Douglas fir. These should be placed on edge and properly spiked together and fastened to the floor stringers with suitable steel clips.
3. Provide protection to the treated timber as well as traffic markers for one way traffic by the placing of 30"x $1\frac{1}{4}$ " multigrip runner plates for the full length of the structure. These plates should be bolted to the timber floor with bolts at not more than 1 ft. spacing. A bituminous seal could be used for this purpose in place of the plates but is rather more difficult to seal to the treated timber and does not have the extra provision of providing a traffic marker which the writer has noticed does help materially to keep traffic in the center of the roadway, thus lessening the possibility of sideswiping the trusses by traffic and providing a more equal distribution of traffic to both trusses of the structure.
4. The present structure has only a $1\frac{1}{2}$ " pipe railing which is not a protection to the trusses against collision. It is therefore recommended that a substantial hubguard be

placed consisting of a 10" channel, smooth face out attached rigidly to the truss members and at a height of about 16" from the top of the floor to the center of the channels.

5. Strengthen the weak truss members by the addition of a third member of proper size in each of the weak sections to properly carry the stress in these members from the loading above mentioned.

6. Clean and paint the entire structure another coat of paint at the time the floor is removed at which time the most thorough job can be best accomplished.

7. Remove, clean, cover well with a fiber grease, and replace the rollers in the bridge shoes on the north end of the bridge.

With the above conditioning, this structure should be suitable and safe for legal loading for many years to come. It is very evident from the size of this structure and the relatively light volume of traffic which it gets, that its life should be prolonged as long as it is possible to do so with proper safety.

Below is attached a photograph of the bridge shoe mentioned above.



[REDACTED]

16'-2" clear Rdwg
15'-4 1/2" Panels x 14 = 215'-3"
30'-0" Hght Truss ctoc pins
Bottom 2 1/4 x 2 1/4 x 1/4 E 12" b-b Ls } Trans
Top 3 x 3 x 5/16 Ls } sway
Stone masonry abut's, } braces
Top chord

Top chord
2-12" Ls & 18 x 1/4" cover PL
4 12" b-b Ls

hangers 1" D L
Floor Bms 15" I
floor 3" oak plank 8"-12"
2" Runner strips
1 1/2" pipe railing
8 Lines 6" I @ 23" stringers
16'-3" clear opening
built 1898

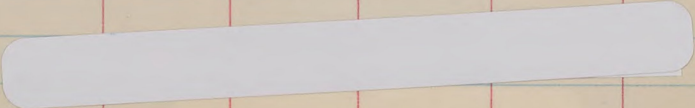
123
290
THS
Suppl 2

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Pocket
has 2 Suppls.

1

1

1

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1

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7115
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