PRELIMINARY DESIGN AND COST ESTIMATE OF PROPOSED HARRISON STREET BRIDGE AT FLINT, MICHIGAN

Thesis for the Degree of B. S.

F. J. Cook T. C. King

1935

Preliminary Design and Cost Estimate of Proposed Harrison Street Bridge at Flint, Michigan

A Thesis Submitted to

The Faculty of

MICHIGAN STATE COLLEGE

of

Agriculture and Applied Science

By

F. J. Cook T. C. King

Candidates for the Degree of

Bachelor of Science

June, 1935

ACKNOWLEDGMENT

We wish to take this opportunity to thank Professor Allen for his advice, and also the Michigan State Highway Department and the Engineering Department of the City of Flint for the help which we received on this thesis.

T. C. K.

F. J. C.

INTRODUCTION

There comes a time in almost every growing and prosperous city when the discovery is made that, due to lack of foresight and planning, there are inadequate provisions to take care of existing traffic conditions or the growing traffic conditions which are bound to develop in the future. The city of Flint, which is close to if not the center of the automobile industry today, finds itself with this as one of its major problems to solve.

Flint, at the present time has two centrally located bridges, which span the Flint River, and these must take care of all the traffic that passes through the business section of the city. One of these bridges is on Saginaw Street, which is the main street of the city and carries the major burden of the traffic. The other bridge is on Beach Street, which is one block from and parallels Saginaw Street. The Beach Street bridge at present takes some of the burden from the Saginaw Street bridge, but the two bridges together are not sufficient to adequately take care of the traffic which they are supposed to handle. This of course brings up the question of the amount of traffic which crosses these two bridges.

There are, at present, about thirty thousand automobiles in the City of Flint. Genesee County, in which Flint has three-quarters of the population, has in operation more than thirty five thousand automobiles. "It is logical to

assume that most of the thirty thousand cars, which are registered in Flint, pass through the business section almost every day. It is also estimated, and appears, due to traffic jams, that on Saturdays almost all of the thirty-five thousand cars in the county become concentrated around the business section of the city, and cross these two bridges several times during shopping tours". This is a quotation from a local newspaper and while the statements seem to be exaggerated they serve to illustrate the conditions.

We will first discuss this matter from the economic standpoint. When there are a large number of automobiles trying to get from one point to another, and they have to concentrate on two points to do so, there is bound to be congestion, traffic jams, and slow movement of traffic. This slow movement and the constant starting and stopping takes time. Time in many cases means money. Excess starting and stopping means additional gasoline consumption, as well as, extra wear and tear on the automobile. The fact that many people, to get from one place to another, have to go in a round about way to cross these bridges also means additional expense. The loss of time, extra wear and tear on the cars, extra miles, and extra gasoline consumption all mean expense to the motorists which could be substantially eliminated by proper solution of the traffic problem. From the safety standpoint, it must be realized that traffic congestion causes more accidents. These are due to the ruffled tempers of those caught in the traffic jams, and those who endeavor to hurry through the slow moving lines of traffic.

There is a solution to this entire problem. It is the construction of more bridges, across the Flint River, at advantageous points in the business district. The most important of these would be a bridge spanning the river at the foot of Harrison Street. Harrison Street is one block from Saginaw Street in the opposite direction to Beach Street and, outside of Saginaw Street, carries more traffic than any other street in the district. This traffic, at present, as it approaches the river has but one outlet, and that is Saginaw Street; thus it adds to the traffic burden of the street, which is already too heavy.

If a bridge were built across the river at the foot of Harrison Street, it would help the Beach Street and Saginaw Street bridges, in getting the traffic across the river. The traffic approaching or leaving the proposed Harrison Street bridge could do so on Payne Street which parallels Saginaw Street after it crosses the river. Thus a portion of the traffic could be kept on the side streets until it reaches a section outside of the business district where the traffic would naturally be lighter.

We feel sure that the construction of such a bridge, by the City of Flint, would not be a needless expense but would be profitable because of the improvement in the traffic conditions which would result in faster, more economical, and safer driving conditions for its citizens.

SELECTION OF THE GRADE LINE

The selection of the grade is of much less importance on a highway bridge carrying independently propelled vehicles than on a railroad bridge, however we feel that it is of sufficient importance to warrant some consideration. The grade adopted for a bridge and its approaches not only affects the total cost of the structure, but often influences more or less, its economic layout. Inasmuch as there is a difference of but four feet in the elevation of the river banks at this particular site, we feel that the slight increase in cost, incurred by making the bridge at a level grade, will be more than offset by the increase in appearance. Therefore we feel that a level grade is the most appropriate in this case.

Upon investigation of past records we found that high water occurred in the spring of 1910 when the flood waters reached an elevation of 721 feet above mean sea level. This was a very unusual case and has not been approached since, thus it would be a needless expense to have a grade to take care of maximum high water. Investigation of existing bridges showed that if the elevation of the roadway is a 714, which is the elevation of the right-hand bank, the bridge will have ample clearance above the water surface to take care of the usual flood stages.

SELECTION OF TYPE OF STRUCTURE

After the selection of the bridge site the next item in the sequence of events is the selection of the type of structure to be erected. There comes to mind three distinct types of construction, namely, steel, reinforced concrete, and combination steel and reinforced concrete. We will consider the relative merits of each type of construction before making our selection.

The steel bridge usually has a comparatively low first cost. A large part of it can be fabricated in the shops, thus cutting down the field work. Its parts can be swung into place by means of cranes thus permitting easy methods of erection. It is a comparatively light structure and thus adaptable to poor foundation conditions. It is usually quite easily changed. However, the steel type of construction has its drawbacks. It has a high maintenance cost which is quite important as this is an expense that continues year after year until the structure is torn down. The one big argument against the use of the steel bridge in the city is its appearance. Generally speaking, the steel bridge is an ugly looking affair and this point should not be overlooked when choosing a bridge for the city. Many steel bridges become noisy with age but this can be remedied and if it were the only bad feature it would not affect our decision. Steel is quite easily available, at the site in question, so the supply of material should have little or no effect on the type of bridge.

The next type of construction is reinforced concrete. One of the good points of a concrete bridge is its appearance. It can be made very pleasing to the observer. Some of our best looking structures are made of reinforced concrete. Concrete has a very low maintenance cost, if properly constructed as we will assume it will be. This maintenance is so low as to be sometimes neglected. The reinforced concrete bridge is somewhat harder to erect due to the large amount of form work that is necessary. This is especially true if the structure in question is a reinforced concrete arch. The concrete structure needs have better foundation conditions than the steel structure because of its greater weight. The soils bearing power in this case is ample so the foundations will not affect the selection of the type of structure. It is quite generally held that the reinforced concrete arch is the best appearing of the concrete bridges, however it is felt by authorities that for comparatively short spans as is this case, the T-beam type of construction is the most economical so for the case in question that would probably be the type used. If appearance were very important the construction could be masked by making a false arch and thus combining appearance with economy. The materials for reinforced concrete construction are also readily available at this site so this would have little effect.

The third type of construction or the combined type combines not only the steel and the concrete but the advantages of each. This type usually is called I-beam bridges. They are constructed similar to the reinforced concrete Tee-beam bridges except that the concrete Tee-beams are replaced by steel I-beams. This type is used wherever possible by the Michigan State Highway Department on their highway bridges. As stated before, it has many of the advantages of the steel and the concrete types of construction. It is quite easily erected, it has a low maintenance expense, it is a comparatively light construction, and can be made into a very good looking bridge by masking the steel with concrete and faking an arch if needs be. It is usually lower in first cost than the plain reinforced concrete bridge, which is a strong point in its favor.

Another point to be considered is, should a deck span or a through span be used. Quoting, "Suitability of Bridges", by Waddell, "Whenever there is a real choice between a deck structure and a through structure, the deck structure will always be found the more economical. There are two reasons for this: first, the piers for the deck bridge will be lower, shorter, and smaller than those for the through bridge; and second, there is often but by no means always, a saving also in the superstructure". In the same paper Mr. Waddell states that a deck structure lends itself to extension much more readily than does a through structure, which is of importance. Also it is possible to hang such parts as sidewalks on the side of a deck structure by means of cantilever brackets. In view of what has been stated and since head room is of small importance, we feel that the deck structure is the proper type for the case in question.

Upon reviewing the good and bad features of the three types of construction our choice falls with the steel I-beam, masked with concrete, as being the most suitable type. It is a deck structure which is as it should be. It has low first cost, low maintenance cost, and will have a good appearance. Thus our choice falls with this type.

The next consideration will be the number of spans. According to the architects an odd number of spans is preferable from the standpoint of appearance. Two existing bridges of the type selected, across the Flint River and of approximately the same total span consist of three spans. Inasmuch as 132 feet is too long for a single span and in view of the existing structures we feel that three spans of 44 feet each is the appropriate number.

The balustrade shall consist of concrete pilasters with steel railing between. Experiments conducted by the Michigan Highway Department show that this type of construction is more economical, retains its appearance longer, and is, to many, better in appearance than the concrete balustrade.

DESCRIPTION OF STRUCTURE

Having selected the type of bridge as being the combination steel and concrete I-Beam bridge as is used in the Michigan State Highway Department, it is our next purpose to give a description of the various parts as are obtained in the following computations.

The general dimensions which were made necessary by the location, traffic conditions and appearance are:

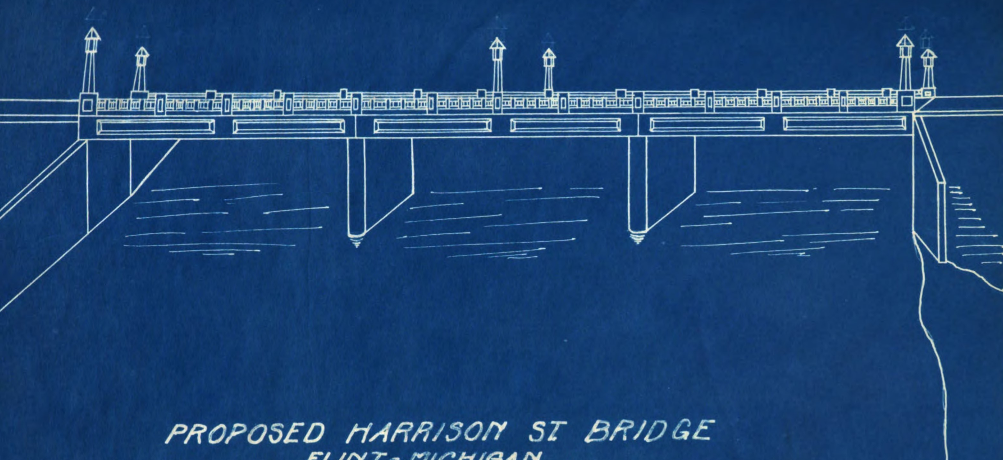
Total length	-	132'
Spans	-	3 at 44'
Width	-	60'
Clearance	-	10'

After usual sample calculations, to determine the most economical design, we decided on a superstructure made up of the following: Thirteen I-Beams, C. B. 301, 30" x 10½", 116 lbs. per foot of length and placed 5 feet center to center. The slab for this spacing of beams is made up of 8 inch thick reinforced concrete and has a crown of 1 inch to allow for drainage, thus making the center 9 inches thick. The sidewalks on each side of the bridge are 10 feet wide and stand 6 inches above the slab. The balustrades consist of concrete pilasters 4 feet high by 1½ feet square, running between which are steel railings 3½ feet high.

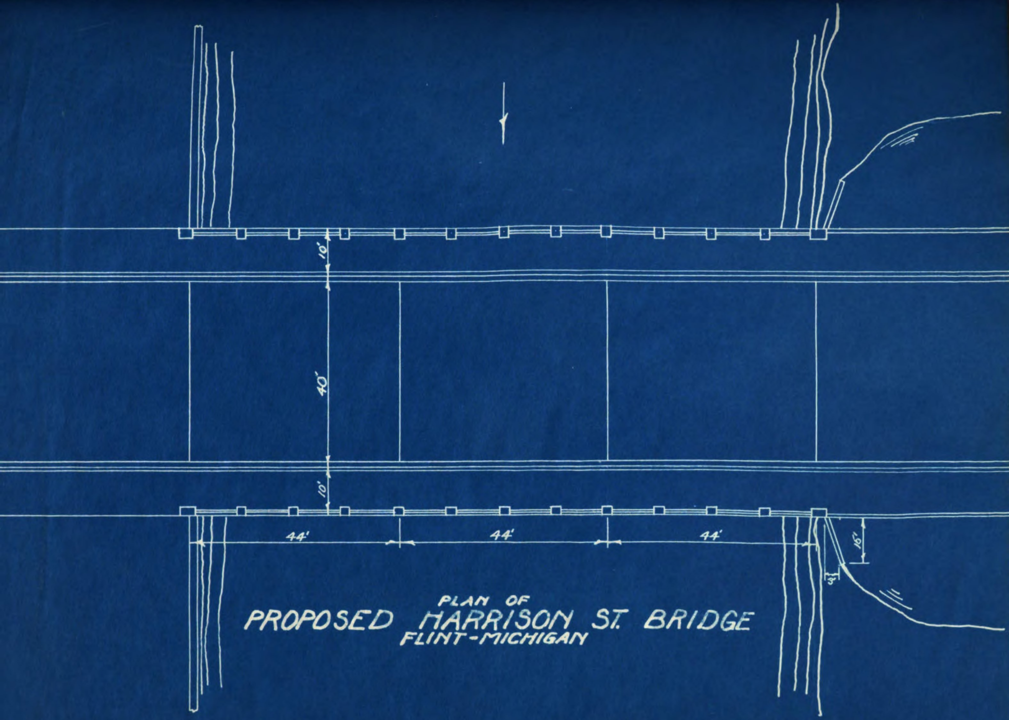
The substructure is made up of 2 piers and two abutments. The piers are made of reinforced concrete, are

27 feet high, and are designed to take the maximum live load, as well as the loads due to the weight of the superstructure and the wind and ice. The base of the piers sets on rock thus making it necessary to have only a 4 foot width. The ends of the piers are built semi-circular to afford a minimum resistance to the flow of water.

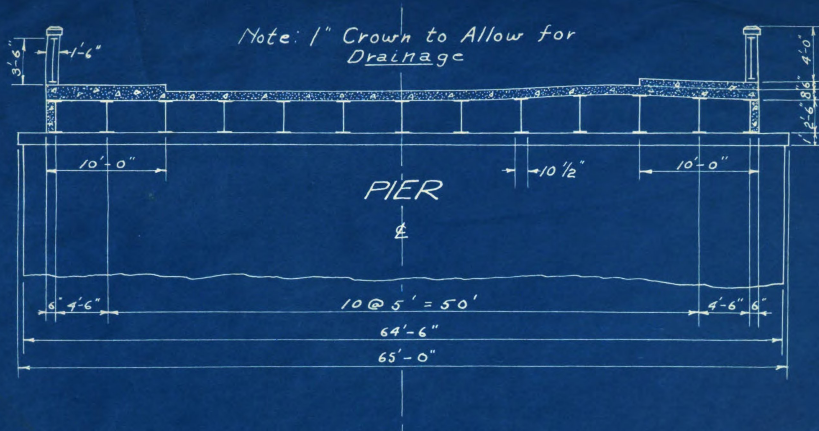
The abutments are also made up of reinforced concrete. In their design it was necessary to make them massive enough to withstand the loads to which they are subjected and also massive enough and high enough to transfer these loads to satisfactory foundation which was sand in this case. Thus the abutment on the right bank is 23 feet and has a 17 foot base, and the abutment on the left bank is 18 feet high and has a 12 foot base.



PROPOSED HARRISON ST. BRIDGE
FLINT - MICHIGAN



10'
40'
10'
44'
44'
44'
16'
3'
PLAN OF
PROPOSED HARRISON ST. BRIDGE
FLINT-MICHIGAN



CROSS SECTION OF PROPOSED BRIDGE
BETWEEN PIERS
Scale 1" = 8'

Computations

I-Beams & Slab

H-20 Loading 3 SP. @ 44' 40' R'dway +

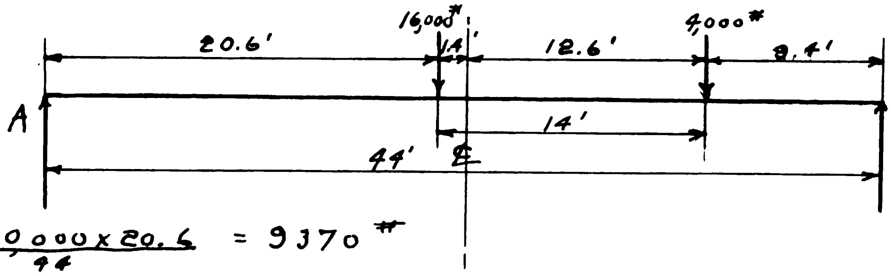
2-10' Side walks = 60' 13 I-Beams @ 5' ℄-℄

Impact coeff. $= \frac{50}{44+125} = .296$

Fraction of load on one I-Beam $= \frac{5}{4.5} = 1.11$

Rear wheel = 16,000 x 1.11 = 17,800#

Front " = 4,000 x 1.11 = 4,450#



$R_A = \frac{20000 \times 20.6}{44} = 9370\#$

Max. moment = (9370 x 20.6 x 12) 1.11 = 2,570,000"#

Impact = 2,570,000 x .296 = 760,000"#

Total live moment = 2,570,000 + 760,000 = 3,330,000"#

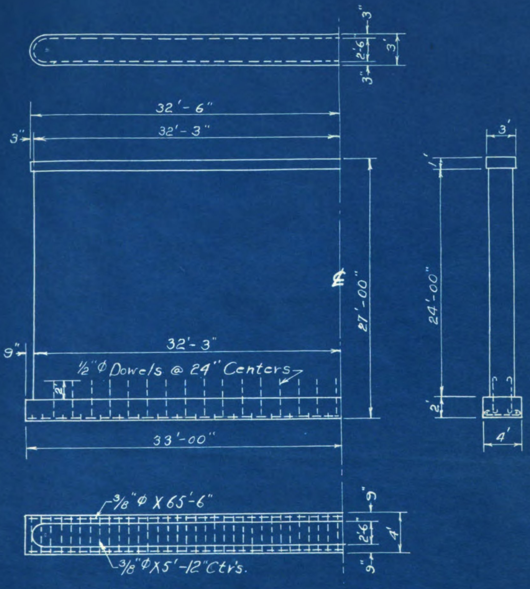
Take thickness of slab for above spacing from "Ketchum's, Design of Highway Bridges" = 8"

Wgt. of slab $= \frac{8}{12} \times 5 \times 150$	=	500#/'
Wgt. of I-Beam (assumed)	=	140#/'
Total	=	640#/'

Dead moment $= \frac{1}{8} \times 640 \times \overline{44}^2 \times 12 = 1,860,000$"#

$\frac{I}{c} = \frac{5,190,000}{16,000} = 324 \text{ in.}^3$

Use I-Beams - C.B. 301 - 30" x 10½" - 116#/' $\frac{I}{c} = 327.9 \text{ in}^3$



PIERS
Showing Location of
REINFORCING STEEL

Piers

Total height = 27'

Wgt. of pier:

Cap = $1 \times 3 \times 65 \times 150$ = 29,200#

Shaft = $24 \times 64.5 \times 2.5 \times 150$ = 580,000#

Base = $2 \times 4 \times 66 \times 150$ = 79,000#

Total = 688,200#

Wgt. due to dead load: (1 span)

Sidewalks & slab = $\left(\frac{6}{12} \times 20 \times 44 + 44 \times 60 \times \frac{8.5}{12}\right)150$ = 346,000#

Reinforcing steel = $\frac{44 \times 12 \times 2}{6.5} \times 60 \times 1.043$ = 10,200#

Structural steel = $116 \times 44 \times 13$ = 66,500#

Railings = 2,300#

Total = 425,000#

Wgt. due to live load: (1 span)

4 Trucks @ max. of 43000# = 172,000#

Total load = 688,000 + 425,000 + 172,000 = 1,285,000#

Uniform pressure on base = $\frac{1,285,000}{66 \times 4}$ = 4,870#/□'

Wind load:

$4 \times 44 \times 1\frac{1}{2} \times 30$ = 7,900# acting at point 30' above base.

200×44 = 8,800# " " " 36' " " .

Ice load:

$P = 200 \times 30 \times 20$ = 120,000# " " " 26' " " .

Taking moments about base:

$$(7,900 \times 30) + (8,800 \times 36) + (120,000 \times 26) = \quad 3,674,000'^{\#}$$

$$I = \frac{1}{12} \times 4 \times \overline{66}^3 = 96,400 \text{ in.}^4$$

$$f_1 = \frac{3,674,000 \times 34}{96,400} = \quad 1,260^{\#}/\square'$$

Traction $= 172,000 \times .10 = 17,200^{\#}$ acting 35' from base.

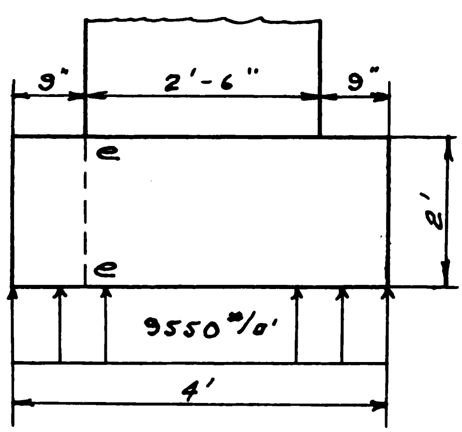
Taking moments: $17,200 \times 35 = \quad 602,000'^{\#}$

$$I = \frac{1}{12} \times 66 \times \overline{4}^3 = 352 \text{ in.}^4$$

$$f_2 = \frac{602,000 \times 2}{352} = \quad 3,420^{\#}/\square'$$

Total max. pressure on base $= 3420 + 1260 + 4,870 = \quad 9,550^{\#}/\square'$

Steel in base:



Taking moments about e-e:

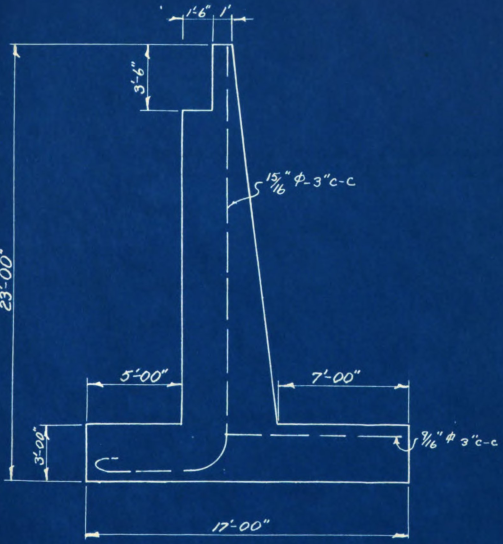
$$12\left[(9,550 \times \tfrac{3}{4})\tfrac{3}{8} - (300 \times \tfrac{3}{4})\tfrac{3}{8}\right] = 31,200''^{\#}$$

Take $d = .21$ ∴ $j = .87$

$$F = \frac{31,200}{.21 \times .87} = 1710^{\#}$$

Steel required in bottom of pier $= \frac{1710}{16,000} = .107 \square''/1$

Use $\frac{3}{8}''\phi$ bars spaced @ 12" ℄-℄ $= .110 \square''/1$



ABUTMENT -R

ABUTMENT-R

Wgt. of Wall:-

$= 17 \times 3 \times 150 + 2.5 \times 16.5 \times 150 + 3.5 \times 1 \times 150 + 2.5 \times .5 \times 20 \times 150$

$= 7660 + 6190 + 525 + 3750$

$= 18{,}115 \ \#/ft.$

Wgt. of Earth:-

$= 2.5 \times .5 \times 20 \times 110 + 7 \times 20 \times 110$

$= 2750 + 15400$

$= 18{,}150 \ \#/ft.$

Pt. App. Vert. Forces:-

$$= \frac{7650 \times 8.5 + 6190 \times 6.25 + 525 \times 7 + 3750 \times 7.8 + 2750 \times 8.1 + 15400 \times 13.5 + 5810 \times 5.75}{18115 + 18150 + 5810}$$

$= 9.45'$

Earth Pressure:-

$= .3 \times \frac{110 \times 26^2}{2}$

$= 11{,}150 \ \#/ft.$

$$x' = \frac{11150 \times 9.45}{42075} = 2.5$$

$d = 9.45 - 2.50 = 6.95$

$e = 8.50 - 6.95 = 1.65'$

Foundation Pressures:-

$$p = \frac{P}{A}\left(1 \pm \frac{6e}{b}\right) = \frac{42075}{17}\left(1 \pm \frac{6 \times 1.65}{17}\right) = 3820 \ \#/\square' \text{ toe}$$

$$1120 \ \#/\square' \text{ heel}$$

Sliding:-

$$f_s = \frac{42075 \times .55}{11150} = 2.07$$

Stem :-

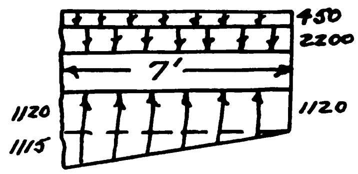
$M = 430 \times 26 \times 23 \times \frac{1}{3} = 85,700$ ft.-lbs.

$d = \sqrt{\frac{85700 \times 12}{107.4 \times 12}} = 28^{+}$ say 29" $\therefore D = 32$"

$A_s = .0077 \times 29 \times 12 = 2.68$ □"/ft.

Use $\frac{15}{16}$"ϕ bars - 3" ctrs. - A = 2.76 □"

Heel Slab :-



change per ft. $= \frac{3820-1120}{17.9} = 159$

$7 \times 159 = 1115$#

$M = 450 \times 7 \times 3.5 + 2200 \times 7 \times 3.5 - 1120 \times 7 \times 3.5 - \frac{1115 \times 7}{2} \times \frac{14}{3}$

$= 19,200$ ft.-lbs.

$d = \sqrt{\frac{19200 \times 12}{107.4 \times 12}} = 13^{+}$ say 14" $\therefore D = 17$"

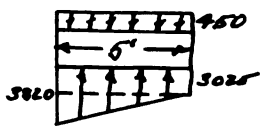
$A_s = 13 \times 12 \times .0077 = 1.20$ □"/ft.

Use $\frac{9}{16}$"ϕ bars - 3" ctrs.

V = 6800#

$v = \frac{6800}{12 \times .874 \times 33} = 20$ #/□"

Toe Slab :-



$159 \times 5 = 795$ #

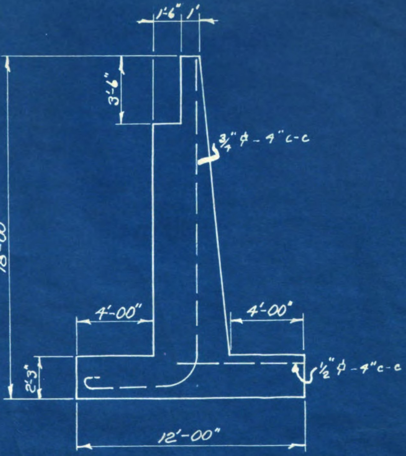
$M = 3025 \times 5 \times 2.5 + \frac{795}{2} \times 5 \times \frac{10}{3} - 450 \times 5 \times 2.5$

$= 39,195$ ft.-lbs.

$d = \sqrt{\frac{39195 \times 12}{107.4 \times 12}} = 19^{+}$ say 20" $\therefore D = 23$"

$A_s = 20 \times 12 \times .0077 = 1.85$ □"/ft. - This will be taken care of by the steel coming from the stem.

$v = \frac{12350}{12 \times .874 \times 33} = 36$ #/□"



ABUTMENT - L

ABUTMENT-L

Wgt. of Wall:-

$$= 2.25 \times 12 \times 150 + 1.5 \times 12.25 \times 150 + 1 \times 3.5 \times 150 + \frac{1.5 \times 15.75}{2} \times 150$$

$$= 4050 + 2760 + 525 + 1770$$

$$= 9100\ \#/ft.$$

Wgt. of Earth:-

$$= 4 \times 14.5 \times 110 + \frac{1.5 \times 15.75}{2} \times 110$$

$$= 6380 + 1300$$

$$= 7680\ \#/ft.$$

Pt. App. Vert. Forces:-

$$= \frac{4050 \times 6 + 2760 \times 4.75 + 525 \times 6 + 1770 \times 7 + 6380 \times 10 + 1300 \times 7.5 + 5810 \times 4.75}{9100 + 7680 + 5810}$$

$$= 6.84'$$

Earth Pressure:-

$$= .3 \times \frac{110 \times 19^2}{2}$$

$$= 6000\ \#/ft.$$

$$x' = \frac{6000 \times 6.84}{22590} = 1.82$$

$$d = 6.84 - 1.82 = 5.02$$

$$e = 6.00 - 5.02 = .98'$$

Foundation Pressures:-

$$p = \frac{P}{A}\left(1 \pm \frac{6e}{b}\right) = \frac{22590}{12}\left(1 \pm \frac{6 \times .98}{12}\right) = \begin{array}{l} 3960\ \#/\square'\ \text{toe} \\ 1000\ \#/\square'\ \text{heel} \end{array}$$

Sliding:-

$$f_s = \frac{22590 \times .55}{6000} = 1.87$$

Stem:-

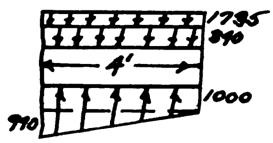
$M = 6000 \times 5.25 = 31{,}500$ ft.-lbs

$d = \sqrt{\frac{31500 \times 12}{102.4 \times 12}} = 17^{+}$ say $18''$ $\therefore D = 21''$

$A_s = .0077 \times 18 \times 12 = 1.67\ \square''/ft$ $V = 6000^{\#}$

Use $\frac{3}{4}''\phi$ bars $-4''$ ctrs. $-A = 1.68\ \square''$ $v = \frac{6000}{18 \times .874 \times 12} = 37^{\#}/\square''$

Heel Slab:-



change per ft. $= \frac{3960-1000}{12} = 247$

$247 \times 4 = 990$

$M = 1735 \times 4 \times 2 + 340 \times 4 \times 2 - 1000 \times 4 \times 2 - \frac{990}{2} \times 4 \times \frac{4}{3}$

$= 5180$ ft.-lbs.

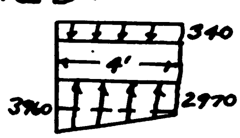
$d = \sqrt{\frac{5180 \times 12}{102.4 \times 12}} = 6^{+}$ say $7''$ $\therefore D = 10''$

$A_s = .0077 \times 7 \times 12 = .65\ \square''/ft$

Use $-\frac{1}{2}''\phi$ bars $-4''$ ctrs. $-A = .75\ \square''$

$V = 2120^{\#}$ $v = \frac{2120}{12 \times .874 \times 7} = 29^{\#}/\square''$

Toe Slab:-



$247 \times 4 = 990$

$M = -340 \times 4 \times 2 + 2970 \times 4 \times 2 + \frac{990}{2} \times 4 \times \frac{8}{3}$

$= 27{,}760$ ft.-lbs.

$d = \sqrt{\frac{27760 \times 12}{102.4 \times 12}} = 16^{+}$ say $17''$ $\therefore D = 20''$

$A_s = 17 \times 12 \times .0077 = 1.58\ \square''/ft$ - This will be taken care of by the steel coming from the stem.

$V = 12{,}890^{\#}$

$v = \frac{12890}{12 \times .874 \times 33} = 33^{\#}/\square''$

Quantities

Concrete:

Sidewalks = $\frac{6 \times 20 \times 44}{12 \times 27}$ = 16.3 cu. yds.

Slab = $\frac{8.5 \times 132 \times 60}{12 \times 27}$ = 208.0 " " .

Total superstructure = 224.3 " " .

Abutment L = $\frac{9100 \times 60}{150 \times 27}$ = 135.0 cu. yds.

Abutment R = $\frac{18,115 \times 60}{150 \times 27}$ = 268.0 " " .

Piers (both the same size) = $\frac{688,200 \times 2}{150 \times 27}$ = 340.0 " " .

Total substructure = 739.0 " " .

Reinforcing steel:

Slab = $\frac{132 \times 12 \times 2 \times 60 \times 1.043}{6.5}$ = 30,500 #

Abutment-L - stem & toe = 180 X 23 X 1.913 = 7,940 #

- heel = 180 X 6 X .85 = 920 #

Abutment-R - stem & toe = 240 X 29 X 2.347 = 16,350 #

- heel = 120 X 10 X 2.044 = 2,460 #

Piers - reinforcing steel = 67 X 5 X .376 = 252 #

- dowels = 32 X 9 X 4 X .668 = 342 #

- erection steel = 65.5 X 4 X .376 = 99 #

Total reinforcing steel = 58,863 #

Structural steel:

I-Beams - 30" X 10½" - 116#/'

116 X 132 X 13 = 199,000 #

Cement:

1-2-4 mix concrete - $1\frac{1}{2}$ bbls. cement per. cu. yd. of concrete.

Total concrete = 224.3 + 739 = 963.3 cu. yds.

Total cement = 963.3 x 1.5 = 1445 bbls.

Railings:

132 x 2 = 264 ft.

Wet excavation:

Piers = $\frac{16.5 \times 4 \times 66}{27}$ = 161 cu. yds.

Abutment-L = $\frac{51.8 \times 60}{27}$ = 115 " " .

Total = 276 " " .

Dry excavation:

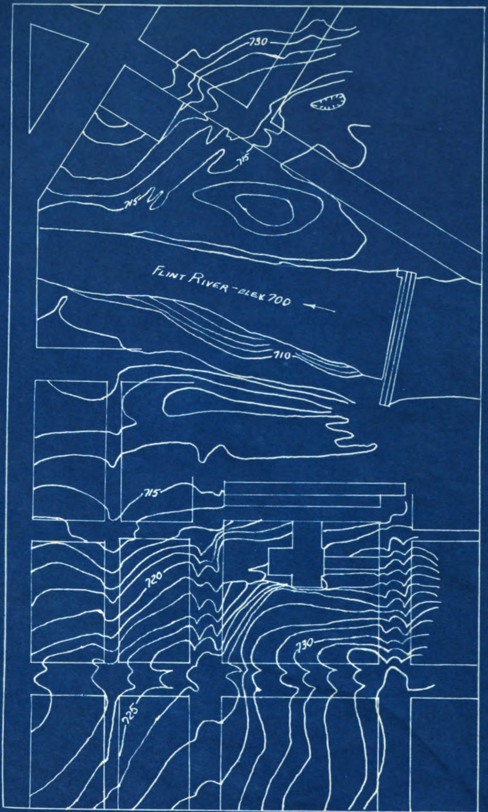
Abutment-R = $\frac{17 \times 23 \times 60}{27}$ = 870 cu. yds.

Fill:

As computed from profile = $\frac{42,400}{27}$ = 1570 cu. yds.

COST OF STRUCTURE

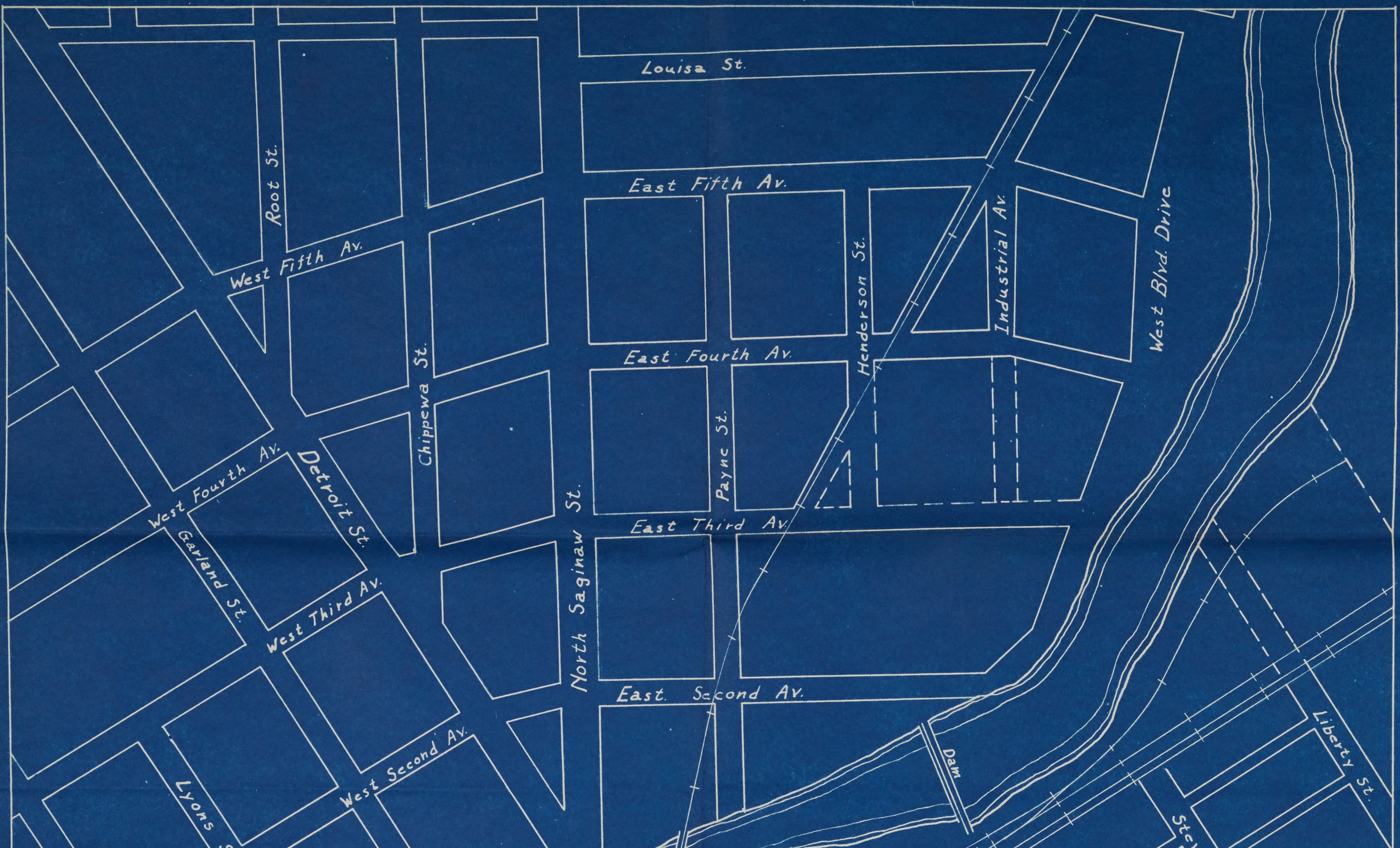
Item	Quantity	Unit	Unit Price	Amount
Grade AA Concrete Superstructure	224.3	cu. yds.	$10.00	$ 2,243
Grade AA Concrete Substructure	739.0	" "	15.00	11,085
Reinforcing Steel	58,863.0	lbs.	.04	2,355
Structural Steel	199,000.0	"	.035	6,965
Cement	1,445.0	bbls.	2.25	3,251
Railings	264.0	ft.	5.00	1,320
Wet Excavation	276.0	cu. yds.	2.00	552
Dry Excavation	870.0	" "	1.00	870
Fill	3,140.0	yd.miles	.20	628
Cofferdams	Lump sum			2,000
				$31,369
Plus 10% for Engineering				3,137
Total				$34,506



TOPOGRAPHIC MAP
OF
PROPOSED HARRISON BRIDGE SITE
SCALE - 1" = 200'
MAY - 1935

BIBLIOGRAPHY

Harger & Bonney	"Highway Engineers Handbook".
Ketchum	"Design of Highway Bridges".
Kirkham	"Highway Bridges".
Sutherland & Clifford	"Reinforced Concrete Design".
Spalding, Hyde & Robinson	"Masonry Structures".
Waddell	"Economics of Bridges".
	"Suitability of Various Types of Bridges".

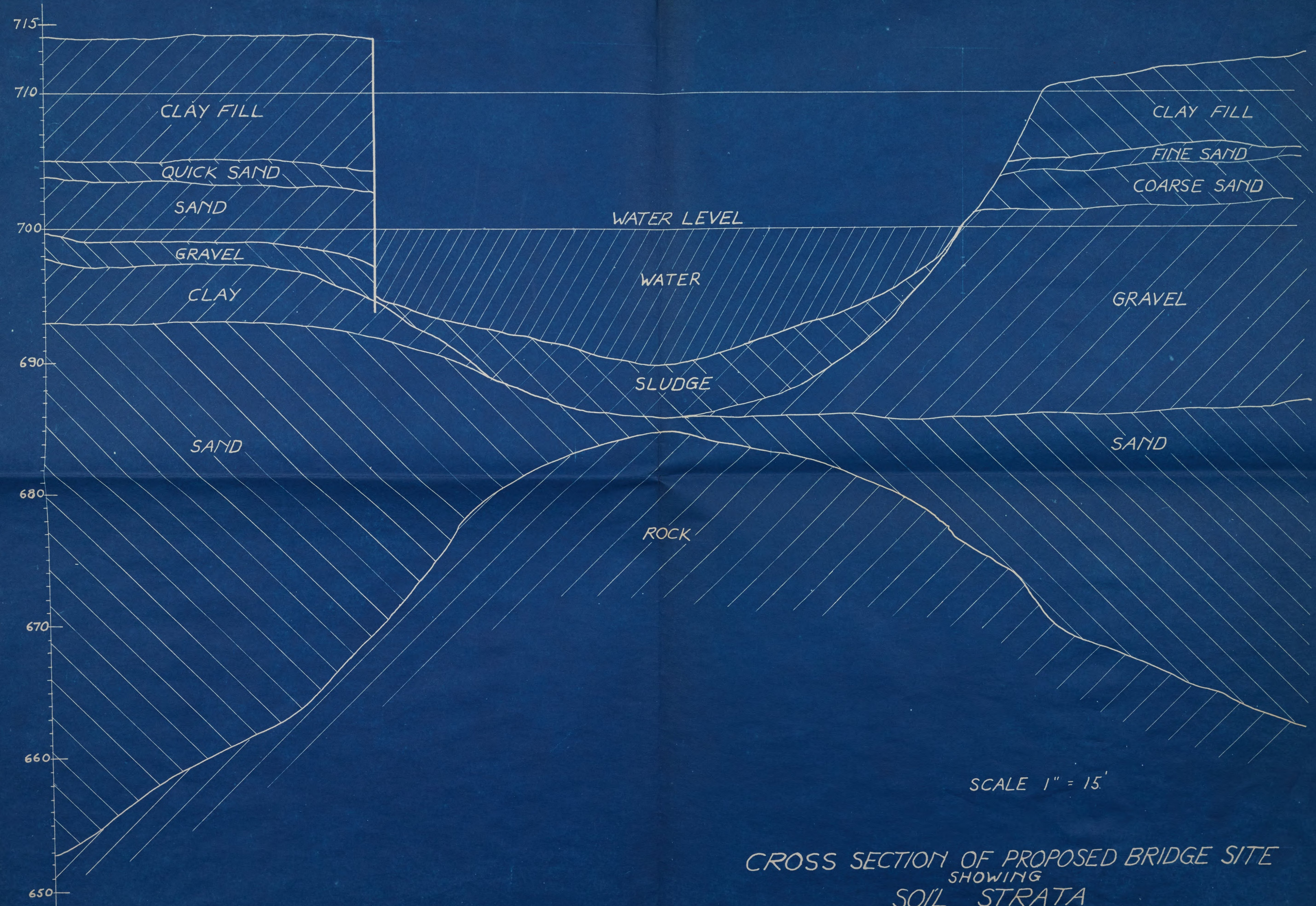


MAP SHOWING
PORTION OF BUSINESS SECTION OF FLINT
AND
PROPOSED BRIDGE SITE

T. C. KING
F. J. COOK

MAP OF
PROPOSED HARRISON ST. BRIDGE
SITE AND PROFILE
FLINT, MICHIGAN
APRIL-1935
SCALE-1"=50'

F.J. COOK
T.C. KING



CROSS SECTION OF PROPOSED BRIDGE SITE
SHOWING
SOIL STRATA

T. C. KING
F. J. COOK