GRADE CROSSING ELIMINATION

M.C.R.R., P.M.R.R., AND MICHIGAN AVENUE

LANSING, MICHIGAN.

A THESIS

Submitted to the Faculty of the

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By

William V. Taylor

Clyde H. Mitchell

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INTRODUCTION.

The subject of grade elimination was first suggested to the writers by H. K. Vedder, Professor of Civil Engineering at the Michigan Agricultural College, and it is to him we are deeply indebted for his valuable advice and guidance of the work.

Altho the subject is not a new one, the available material is small, and the writers have combined what to their knowledge were the best engineering principles applicable to the problem herein.

William V. Taylor.
Clyde H. Mitchell.

HISTORY.

The subject of grade eliminations was first brought into the engineering limelight between 1895 and 1900 and in the next ten years many grades were eliminated in the larger cities, such as Chicago, New York, Philadelphia and Cleveland. The elimination of grades came almost directly as a sequel to the elevated electric lines, and in the larger cities many of the steam roads were brought into the heart of the city on embankments.

In the state of New York laws were passed apportioning the cost of such projects between the city, state and railroad; viz., one-half by the railroad, one-quarter by the city, and one-quarter by the state, but no proceedings can be taken by the commission until the state has appropriated its share.

In 1913 the state of New Jersey passed a law requiring all grade elimination projects to be at the sole expense of the railroad. Other states have provided for some impartial tribunal to arbitrate between the municipality and the railroad company and to proportion the cost. This arrangement has been provided for in New York, Massachusetts, Vermont and Ohio. The newly created Public Utilities Commission of Michigan could easily be assigned this duty.

It has become an accepted fact that whenever possible grade crossing should be eliminated regardless of cost: however, the cost has hitherto been the deciding factor.

If for no other reason, a railroad crossing should be eliminated for the protection of human lives. In the City of New York, with 400 grade crossings, from 1908 to 1911, 90 persons were killed and 136 injured. In many cases a series of serious accidents has awakened the public to the need of elimination of certain grade crossings, but in the case in hand, Providence together with an efficient gate tender, has averted recent serious accidents at this dangerous crossing. The crossing is termed dangerous because of the grade of the street east of the crossing and thus leading over the main lines of the Pere Marquette and Michigan Central railroads together with two sidings. The view of the tracks both north and south is blocked by permanent buildings together with a sharp curve in the main line of the P.M.R.R., to the south, and the station but 600 feet to the north.

This crossing has been recognized as dangerous by city officials and at various times investigations of the feasibility of the project have been started but no accidents have happened to awaken the city to

serious action. Neither have the city officials realized that the municipality as well as the railroad is responsible for accidents at crossings as handed down in a ruling of the Supreme Court of Indiana.

At the time of writing the relaying of the pavement on Michigan Avenue is being agitated and with the new pavement may come serious consideration of eliminating this grade crossing.

FACTORS TO CONSIDER IN GRADE ELIMINATION.

In the design of a grade abolition project the first requirement is a topography of the immediate territory together with a basic understanding of the value of property involved, by these two the economy of design are controlled.

The question of whether the street is to cross over the railroad or vice versa is determined by considerations of economy, but it is not usually economical to depress the railroad since the railroad grades are usually limited to 0.57% while street grades very from 2 to 7%. The railroad, since it pays the greatest portion of the cost, asks as a rule, for a 5 or 6% street gradient. For traffic reasons the city usually objects to anything over 3% which usually results in a compromise, streets on main thorofares being built with not over 3% grades, other streets having as high as 7% grade. In one case, in Fall River, Mass., 12% was allowed on account of the fact that this gradient existed on adjacent streetsq. The question of land damage enters into the question of street grades, and the two should be considered together.

The problem must be given careful study, and estimates of cost made if necessary, to determine which

of the following methods should be used: First, railroad elevation; second, railroad depression; third, street elevation; fourth, street depression; or a combination of railroad elevation with street depression or vice-versa. It must always be borne in mind, that, if railroad depression is adopted, the track must be lowered about 21 ft., 18 ft. for clearance and 3 ft. for bridge floors, while if track elevation is used, there is a change in grade to be made of about 17 ft, 14 for clearance and 3 ft. for bridge floors. Except in the case of sidetracks, which may be made 16 ft, these clearances are required in Mass., unless authorized otherwise by the Public Service Commission.

The points to be observed in an elimination of grade project may be summed up as follows: (1) Cost; (2) Discontinuance of important public ways or continuation of same involving real damage to property without redress at law; (3) drainage, railway and highway; (4) sewage flow, pipe changes, etc.; (5) street junctions; (6) minimum of taxable property to be devoted to new streets and ways; (7) traffic routes, vehicle and street railway, distances, grades and maximum avoidance of curves; (8) railroad grades should be slight at stations; (9) highway grades; (10) accessibility of stations to traffic, vehicular, street railway, and foot; (a) in grades, elevations and

layout, (b) station driveways and carriage yards; (11) industrial sidetracks; (12) bridge headroom; (13) minimum of land damage; (14) maintenance of traffic during construction; (15) bridges and other structures, strength, permanence, waterproofing; (16) apportionment of work; (17) betterments.

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ARCHITECTURAL BEAUTY OF CONSTRUCTION.

From the architects standpoint the proper solution for a grade elimination problem would include a deck girder of unbroken span, together with an ornamental railing, but from the engineers standpoint this is grossly uneconomical.

It must be admitted that a through girder is not as sightly as a deck girder but it must be remembered that the lack of headroom influences the choice of the through girder, and the appearance of the deck girder would be entirely offset by the unsightly grades required by the higher elevation of the tracks.

By the use of column supports at the curb the clear span is broken but the depth of girder is cut and a much neater construction results regardless of the unsightly columns. Again the curb lines in most instances are cluttered with telephone poles and the like, and surely the columns make a better appearance than the other obstructions on the curb.

In some instances it has been attempted to cover the girders with ornamental castings as well as other means of disguise, but it has resulted in failure as far as artistic beauty is concerned.

It has become an accepted practice, that where headroom is limited, a through girder with the end panels rounded off in an arc shall be used.

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PROPERTY DAMAGE AND IMPROVEMENT.

When the street grades are changed in a settled district, it necessarily follows that property damage must occur, and the law provides that such property shall be compensated for to the amount of the damage.

In many of the first grade eliminations property damage was paid for in cash, and many property owners made claim for such, claiming the need of retaining walls, but after receiving the cash no walls or grade slopes were made. The law gives the city no power to enter upon private lands in order to build retaining walls or grade slopes, but the method now used is to make this work one of the conditions of the damage settlements.

It is obvious that in cases where the street is depressed there will be some property standing so high above the street as to be unsightly. In some cases this property will not be of sufficient value to warrant the expenditure of any great sum for improvements. In our case there are four frame residences on the south side of Michigan Avenue between the tracks and Hosmer street which we recommend for condemnation, as they now stand approximately eight feet above the present grade of the street and would not warrant any great

expenditure, since with the growth of Lansing the business district would soon extend over this property and the land could then be excavated. As to the other property on Michigan Avenue the city when laying the new pavement should be required to put in the slope grades where necessary. Going west on Michigan Avenue from the tracks there are no commercial buildings that will be affected; all merchandise being brought in and delivered from the alley at the rear. A driveway would be necessary for vehicular traffic to and from the depot as well as a driveway to the Michigan Central freight house.

In considering the damage done by raising the bed of the railroad little will be done as the tracks are not flanked on each side by higher land. The Union Station having been built at the present grade must be augmented by a loading platform built at the new grade. Although this will cause a slight inconvenience to traffic, the present depot will soon be outgrown and the new station can be built at the proper grade.

As compared with grade elimination problems of the past, the project in hand presents little difficulty from the standpoint of property damage.

PRELIMINARY SURVEY

In considering a problem of grade elimination one of the most important features of the work is the preliminary surveying.

On the preliminary survey is based the feasibility of the project. That is, it determines whether or not economical grades can be used and the character of both surface of land and of the soil in the immediate vicinity.

The operations for the survey are as follows:

First - Determining the line.
Second - Getting the levels for profiles.
Third - Determining the topography of the land.
Fourth - Fixing the grades.
Fifth - Estimating the excavation.
Sixth - Taking a survey of the traffic.

We first laid the lines. The first line was run for 14 stations north and south on the P.M.R.R. The starting point was taken on a manhole 9 feet east of the east rail of the P.M.R.R., 23 feet east of the east rail of the M.C.R.R., and 38'8" north from the center line of the city electric railway line and fifty feet from the south west corner of the railway freight depot. This manhole was used as the starting point for

all the transit work and as a bench mark for the leveling. The line run on Michigan Avenue was run on the north curb line. Both lines were stationed every 100 ft. The transit work on this survey was very simple and took very little time of the total survey.

The next operation that was undertaken was that of running levels for obtaining the profiles in order to set the grades. The first levels were taken at every station to fix the grade and cross sections were taken. This was practically all that was done in straight level work.

The biggest job we had was taking the topography of the land in the vicinity. The territory covered in this survey is bounded on the north by Shiawassee St., the east by Pennsylvania Avenue, the south by Kalamazoo St., and the west by Larch St. This comprises an area of about one square mile. Two separate surveys were made, the plot being divided into two parts, one east of the railway and the other on the west side.

On the east side there were no problems that presented very great difficulties. On the south side of Michigan Avenue, beginning at the track is a terrace about ten feet high. This terrace gradually decreases until it comes to grade on Kerr,St.

The situation on this side of this is shown very well in picture number one.

On the north side at the corner of Michigan Avenue and Hosmer St., there is an excavation of about ten feet. East of this excavation there is a low terrace which will not interfere with this project. Picture number two shows a view of Michigan Avenue east of the railroad. It also shows how the street railway service is impeded as the conductor has to leave the car and close the derailer every time before crossing the railroad tracks.

Michigan Avenue, west of the tracks is shown in picture number three. The grade of the street drops about five feet in 1200. There are no buildings of any value on the south side in the first block which is the only one that will be affected. This side of the street is occupied by a lumber company which can get their entrance from the rear. On the opposite side of the street there are some business structures but they are of little importance and can have their entrance from the rear. The land rises gradually on both sides of the street going from Michigan Avenue.

Next taking the railroad going north which is shown in picture number four, the grade of the railroad drops slightly for about 3000 feet and then begins to rise

again. The grade is five tenths of one percent. On the east side there is a slight rise in the land and on the west the land is nearly level. There will be no difficulty in raising the tracks on this side of Michigan Avenue.

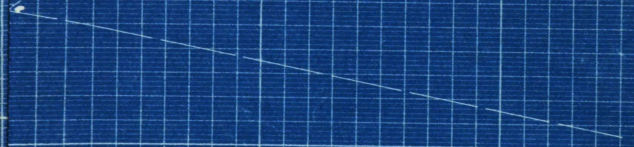
The railroad on the south is level for about 700 feet. The P.M.R.R., and M.C.R.R. separate here, the M.C.R.R. going straight ahead, while the P.M.R.R. turns and goes southeast. The M.C.R.R. has a grade that is level for 900 feet more and then drops slightly. The P.M.R.R. rises about six feet in the next 900 feet. On both sides there are banks running up to about 12 feet. This is perfectly adapted for a rise in the tracks. Picture number five shows the railroad looking south from Michigan Avenue.

Picture number six is a view of the union station. This view shows that when the railroad is raised the station must be raised or a loading platform installed. In order to keep the cost down as low as possible we have decided on installing the loading platform.

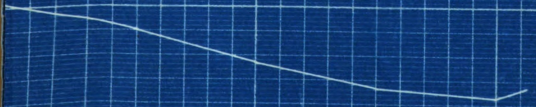
The survey showed that the most economical construction was to raise the tracks slightly and lower the street to get the required head room.

The level and stadia notes are in the pocket in the back of the book.

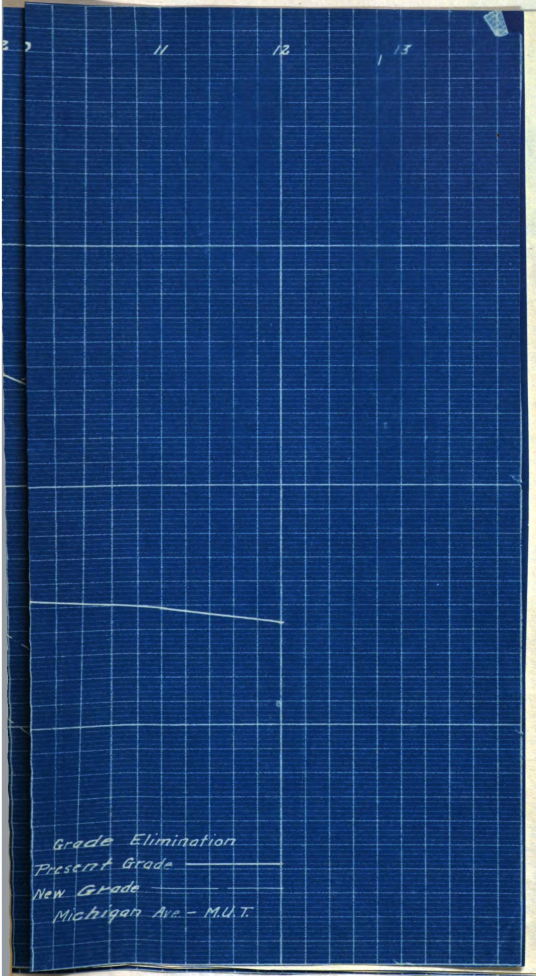
10 11 12 13 14



Note:-
The new grade will come
to the present grade of
the R.R at Sta. 64.



Grade Elimination
Showing R.R. Grades.
Present Grade ——————
New Grade


11
12
13
Grade Elimination
Present Grade
New Grade
Michigan Ave. – M.U.T.

TRAFFIC SURVEY.

On April 3rd, we took a traffic survey between the hours of 5:00 and 6:00 P.M. We decided to take the survey at this time as it is the busy hour for traffic. The results of this survey are tabulated below:

KIND OF VEHCILE	NUMBER
Pleasure cars	536
Trucks 1/2 ton	56
Trucks 1 ton	24
Trucks over 1 ton	4
Horse drawn vehciles	14
Street Cars	26
Interurbans	6
TOTAL	666

These results show that the elimination of this crossing will be necessary with constant increase in the growth of the population in Lansing.


YOUNG BROS
1


2


5


4


5


6

DESIGN OF ABUTMENTS AND RETAINING WALLS.

An abutment in its simplest form is a retaining wall terminating the approach embankment to a bridge and provided with a bridge seat for the end of the first span to rest upon.

There are several classes of abutments and they are classified below according to the general forms as follows:

1. Pier abutments,
2. Wing abutments,
3. Cellular abutments,
4. U - Abutments,
5. T - abutments,
6. Buried pier abutments,
7. Skeleton and arch abutments.

After studying the various forms of abutments we finally decided on the U - abutment. We did this because of the limited space we had on each side of the track. On the west side it was necessary to put in a retaining to keep the fill from spreading to the Station and parking space.

The U - abutment gets its name from its shape. The wing walls are placed at right angles to the face wall and are usually 1-1/2 times as long as it is high. In this case however the wing walls are considerably

longer. The batter is usually 2 inches in 12 to provide for frost expansion.

Abutments may fail in three ways:

1. By sliding forward,
2. By overturning,
3. By crushing.

There is very little chance of the abutments failing by the first two causes mentioned above, so failure by crushing was investigated.

The mathematical theory of the pressure of the earth being uncertain it is not customary to compute the stabelity of the abutment. The thickness of the wall at the top of the footing is generally taken as 0.4 of the height of the abutment. The thickness of the wing walls is generally taken as 0.3 of height. Trantwine recommends that for a backing of gravel the thickness be increased 1/8 to 1/6 part, which was done in our case.

The footing area depends upon the bearing power of the soil and is determined by any one of various empirial formulas that have been discovered. The soil at the location of our project is well packed sand and clay. The formulas follow on another page.

All of the data and formulas for computing the abutment will be found on the page following:

RETAINING WALLS.

The retaining walls are designed as for the abutment. However the retaining wall designed for this problem is reinforced, therefore it has been made considerably thinner. The height of the wall is only seven feet with a back fill of five feet leaving a rail of two feet to prevent trucks and automobiles from plunging over into the car tracks.

The formulas and data follow:-

Angles of Repose and Weights per Cu.Ft. for Various Earths.

Material	Slope	Angle of Repose Degrees.	Weight in lbs. per cu. ft.
Sand, dry	2.8:1 to 1.4:1	20 - 35	90 - 110
Sand, moist	1.75:1 to 1:1	30 - 45	100 - 110
Sand, wet	2.8:1 to 1.2:1	20 - 40	110 - 120
Ordinary earth dry	2.8:1 to 1:1	20 - 45	80 - 100
Ordinary earth, wet	2.1:1 to 1.75:1	25 - 30	100 - 120
Gravel, round to angular	1.75:1 to 0.9:1	30 - 48	100 - 135
Gravel, sand and clay	2.8:1 to 1.3:1	20 - 37	100 - 115

From Cain's "Earth Pressure, Walls and Bins", page 9.

Coefficients and Angles of Friction Between Earth and Other Materials.

Materials	f = ton	φ
Masonry on masonry	0.65	33°
Masonry on wood, with grain	0.60	31°
Masonry on wood, across grain	0.50	26°40'
Masonry on dry clay	0.50	26°40'
Masonry on wet clay	0.33	18°20'
Masonry on sand	0.40	21°50'
Masonry on gravel	0.60	31°

From Haul and Johnson, page 582.

The safe bearing power of gravel and sand well packed in short tons per square foot is 8 as a minimum and 10 as a maximum.

Computations for Retaining Walls. Conlombs Formula for Earth Pressure.

$E = 1/2\ wh^2 \tan^2 (45° - 1/2\varphi)$

Where w = weight of cubic unit of earth

h = vertical height of wall

φ = angle of repose.

$E = 1/2\ 115 \times 5^2 \times \tan^2 (45° - 30°/2)$

$= 57.5 \times 25 \times \tan^2 30°$

$= 57.5 \times 25 \times \overline{0.57735^2}$

$= 478.2$

The thickness of the wall was taken as 1/3 of the height of wall making it about 1 foot 6 inches.

Computations for the Abutment.

Height of wall from footing to bridge seat is 12 ft. There are no set formulas that are followed in designing the abutment, but constants of recognized value are used.

12 x 4/10 = 4.8' wide.

Using a factor of safety of 1/2 we have 7'0" as the thickness used.

The abutment has 3/4" weep holes and the backing is of cinder to facilitate the drainage.

Footings

The bearing power of the soil is from 16,000 to 20,000 pounds per square foot. From constants obtained in various handbooks on concrete construction we have the depth equal to five feet and the width equal to eight feet.

2000 x 8 x 8 = 128000# which is weight footing will hold.

$M_{mom} = C_2 d\ P$

Where

d = length of longest side,

P = applied force,

a = depth of column

b = breath of footing

$C_2 = 1/24\ (2 + a/b)\ (1 - a/d)^2$

$= 1/24\ (2 + \frac{1.25}{8.00})\ (1 - \frac{1.25}{8.00})^2$

$= 1/24\ (2 + .156)\ (1 - .156)^2$

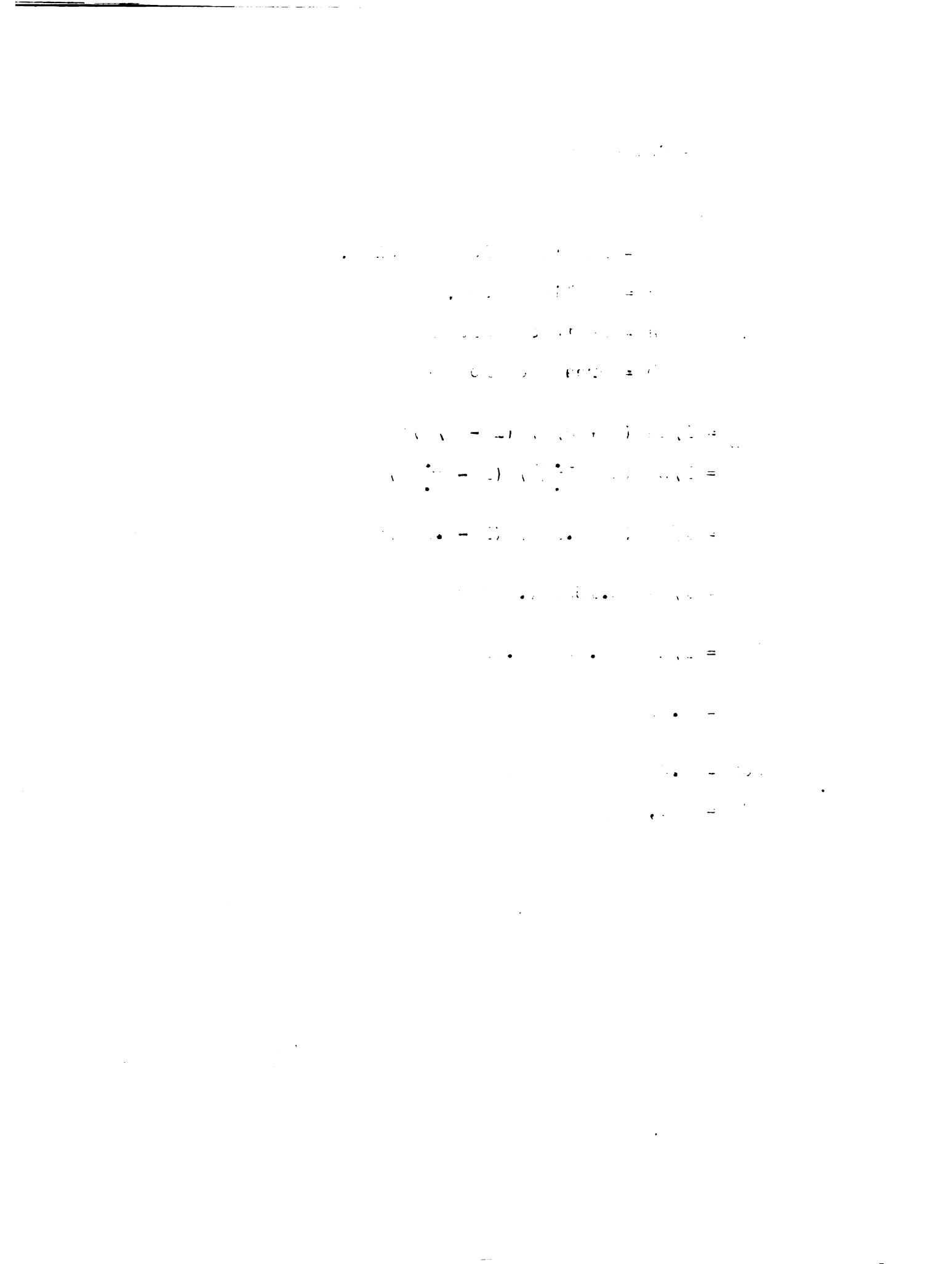
$= 1/24\ (2.156)\ (.844)^2$

$= 1/24 \times 2.156 \times .71$

$= 0.63$

Mom = $0.63 \times 8 \times 60000$

" = 300,000#



DESIGN OF THE RAILROAD BRIDGE.

Because of limited head room it was decided to use a through plate girder bridge with columns just inside the curb lines, making a span of 80 ft. between centers of supports. And taking Waddel as an authority but two girders are to be used for the double track bridge. The two sidings also at the crossing being changed.

The live load was taken as two consolidation locomotives and train per track, or an alternative load of 120,000 pounds equally distributed on two pair of driving wheels, spaced 6 feet center to center. This loading is known as Cooper's Standard Class E50. The allowance for impact due to live load was taken from Waddell's formula:

$$I = 400\ L\ (L + 500) \text{ or } 80\ \%.$$

As the economic depth of plate girders varies, and the average being the reciprocal of 10.5, 90 inches was taken as the depth of the girder.

The girders were spaced 28 ft. 9 in. on centers with 12 ft. between the tracks.

No attempt shall be made in this thesis to make a final design but proposal drawings and computations are included herein as an aid to cost computation.

(See pocket on rear cover.)

BRIDGE COMPUTATIONS.

LOADING

Cooper's Class E50.

WEB

Max. live load shear - - - - - - 310,200

Impact 80 % - - - - - - - - - - - 248,160

Wt. 1 girder + 1/2 floor 55000.

Wt. 1/2 track - - - - - 37600

1/2 Dead load = 92600 #

Dead load shear -- - - - - - - - 46,300

Total vertical shear - - - - - - 604,660 #

Unit shear stress = 12,000.

Area web = 50.4 sq. in.

Depth of girder = 90 inches.

Thickness web = .55 in.

Use 5/8 x 90" plate.

FLANGE

Max. moment l.l. - - - - - - - - 5,406,000.

Impact - - - - - - - - - - - - - 4,324,800.

Dead load moment - - - - - - - - 926,000.

Total bending mom- - - - - - - 10,656,800. ft. lbs.

Total bending mom- - - - - - 127,881,600. in. lbs.

Effective depth of girder = 90 + .25 - 1.5 = 88.75 in.

Unit tensile strength = 17,000 lbs. per sq. in.

Assume 12 % gross web section as effective flange area.

$$A = \frac{10,656,800 \times 12}{17,000 \times 88.75} - (0.12 \times 5/8 \times 90) = 85.2 - 6.75$$

Net area of lower flange = 78.45 sq. in.

USE 2 - 8 x 8 x 1 1/8" LS 2 - 1" holes = 31.21

3 - 20 x 7/8" plates 2 - 1" holes = 47.25

78.46 sq. in.

STIFFENERS.

Max. floor load - - - - - - - - - - 60,000.lbs.

Impact- - - - - - - - - - - - - - 48,000.

108,000. lbs.

Unit fiber stress - - - - - - - - - 16,000. lbs.

Sectional area- - - - - - - - - - - 6.75 sq. in.

USE 8 x 3 1/2 x 1/2" LS

END STIFFENERS.

Vertical shear- - - - - - - - - - - 600,000. lbs.

$$\frac{600,000}{15,000} = 40 \text{ sq. in.}$$

USE 4 - 8 x 3 1/2 x 1/2" LS

LATERAL BEAMS.

WEB

Live load shear- - - - - - - - - -	120,000.
Impact 80 %- - - - - - - - - - - -	96,000.
Dead load shear- - - - - - - - - -	4,000.
Total shear- - - - - - - -	220,000. lbs.
Unit shear stress- - - - - - - - -	12,000. lbs.
Area web - - - - - - - - - - - - - -	18.33 sq. in.
Depth girder - - - - - - - - - - -	30 in.
Thickness web- - - - - - - - - - -	.61 in.

USE 30 x 5/8" plate.

FLANGE $M = \frac{wa}{2} = 120{,}000 \times 8/2 = 480{,}000.$

Max. mom. l.l. - - - - - - - - - -	480,000.
Impact - - - - - - - - - - - - - - -	384,000.
Dead load mom. - - - - - - - - - -	100,000.
Total bend. mom- - - - - - - - - -	964,000. ft. lbs.
Unit tensile strength- - - - - -	17,000. lbs/sq.in.

Assume 12 % gross web section as flange area.

$$A = \frac{964{,}000 \times 12}{17{,}000 \times 29} - (0.12 \times 5/8 \times 30) = 23.5 - 2.25$$

Net area lower flange = 21.25 sq. in.

USE (2 - 6 x 6 x 3/4" LS
(
(1 - 12 x 3/4" plates

Reinforced Concrete Stringers.

$$M = \frac{wl}{4} + \frac{100{,}000 \times 10}{4} = 250{,}000.$$

$$M_c = p\ f\ s\ j\ b\ d^2$$

$$250{,}000 = .0077 \times 16{,}000 \times 7/8 \times 10 \times d^2$$

d = 15.5" depth of girder

2.5" ; steel protection.

USE 10 x 18 inch concrete beam.

$a_s = p\ b\ d = .0077 \times 10 \times 15.5 = 1.2$ sq. in.

USE Trough formed of

3 x 3 x 1/4" LS

1/4 x 18" plate

1/4 x 10" plate.

1/2 bridge. Wt. of Steel.

WEB PLATE 1 5/8" x 90" - 80'lg at 191.3 =	15,304.
FLANGE	
4 - 8 x 8 x 1 1/8" LS - 88' - 10" lg at 56.9 =	19,730.
1 - 20" x 7/8" Pl - 32' - 6" lg at 59.2=	1,935.
1 - 20" x 7/8" Pl - 47' - 6" lg at 59.5=	2,775.
1 - 20" x 7/8" Pl - 86' - 10"lg at 59.5=	5,160.
	29,600.
STIFNERS	
14 - 8 x 3 1/2 x 1/2" LS - 7' - 4" lg at 18.7) 16 - 8 x 3 1/2 x 1/2" LS - 7' - 4" lg at 18.7)	4,110.
LATERAL BEAMS	
1 - 5/8" x 30" Pl - 28' - 8 3/8" lg at 63.75 =	1,835.
4 - 6 x 6 x 3/4" LS - 28'-8" lg at 28.7 =	3,300.
2 - 13 x 3" Pl - 28' - 8" lg at 33.2 =	1,900.
	7,035.
COLUMNS	
16 - 15" - 45# [s - 12' - 0" lg at 40 =	7,680.
16 - 16" x 1" Pl - 12' - 0" lg at 54.4 =	10,445.
	18,125.
BRACES	
4 - 6 x 6 x 3/4" LS LS - 30' - 7" lg at 28.7=	3,550.

FLOOR

(136 - 1/4 x 18" Pl - 10' - 0" lg)	at 15.3 =	10,400
(272 - 1/4 x 10" Pl - 10' - 0" lg)	at 8.5 =	11,550
(544 - 3 x 3 x 1/4" LS - 10'-0"lg)	at 4.9 =	13,350
		35,300.
Rivets, clips, splices, etc. 7 % =		113,024
		7.912
Total wt. =		120,936

SIDEWALKS GIRDER

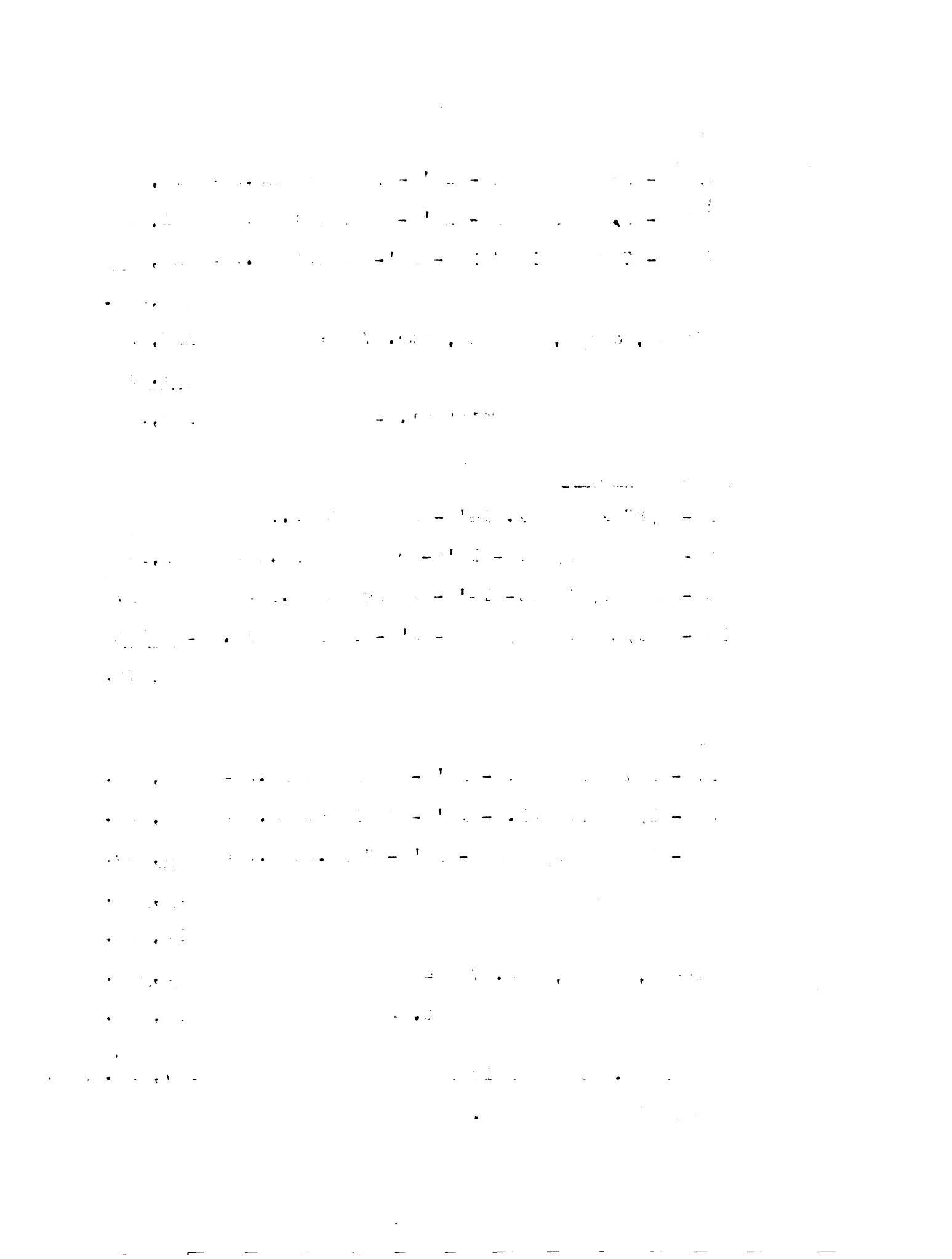
1 - 3/8" x 36" Pl. 14' - 0" lg at 45.9 =	643
4 - 6 x 6 x 1/2"L - 14' - 0" lg at 19.6 =	1,100
2 - 13 x 1/2" Pl.- 14' - 0" lg at 22.1 =	617
10 - 3 1/2 x 5 x 3/8"LS - 3' - 0" lg at 10.4 =	312
	2,672.

FLOOR

17 - 1/4 x 18" Pl. - 14' - 0" lg at 15.3 =	3,640.
34 - 1/4 x 10" Pl. - 14' - 0" lg at 8.5 =	4,050.
68 - 3 x 3 x 1/4" LS - 14' -0" lg.at 4.9 =	4,670.
	12,360.
	15,032.
Rivets, clips, etc. 7 % =	1,050.
Total Wt. =	16,082.

Total wt. of steel in 1/2 bridge = 137,018. lbs.

Approximate 140 tons.



Estimate of Concrete.

1.- ABUTMENT

$42.5 \times 8 \times 5\frac{13}{}$ =	1,700.
42. x 10.67 x 7 =	3,135.
6.3 x 39.6 x 1.5 =	374.
2.2 x 36. x 2 =	159.
	5,368. cu.ft.
x 2 =	400 cu. yds.

1.- RETAINING WALLS. (Road Bed)

North side	(3.42 x 5 x 400 =	6,840.
	(2.2 x 6 x 400 =	5,280.
South side	(3.42 x 5 x 20 =	342.
	(2x2 x 6 x 20 =	264.
		12,726. cu.ft.
		470 cu. yds.

RETAINING WALLS. (Protection Property)= 6,000 cu.ft.
225 cu.yds.

RETAINING WALLS. (Street railway)

East	[(1 x 4.0) + (1.5 x 6)] 900 =	11,700 cu. ft.
West	[(1 x 4.0) + (1.5 x 4)] 400 =	4,000 cu. ft.
		15,700 cu. ft.
	x 2 =	1,165 cu. yds.

COLUMN FOOTINGS

8 x 5 x 32 x 2 =	2,560 cu. ft.
	95 cu. yds.

BRIDGE FLOOR

BRIDGE BEAMS

108. x 30. x .3 =	972.
17 x 8 x 1.5 x .83 x 10 =	1,690.
17 x 2 x 1.5 x .83 x 14 =	593.
	3,255 cu. ft.
	120 cu. yds.
Total Concrete =	2,475. cu. yds.

DRAINAGE

The drainage of the bridge floor will be well taken care of by sloping the three inch concrete floor to the center line of the bridge, and laying in a 4 inch tile longitudinally, with a stand pipe at the north end of the bridge.

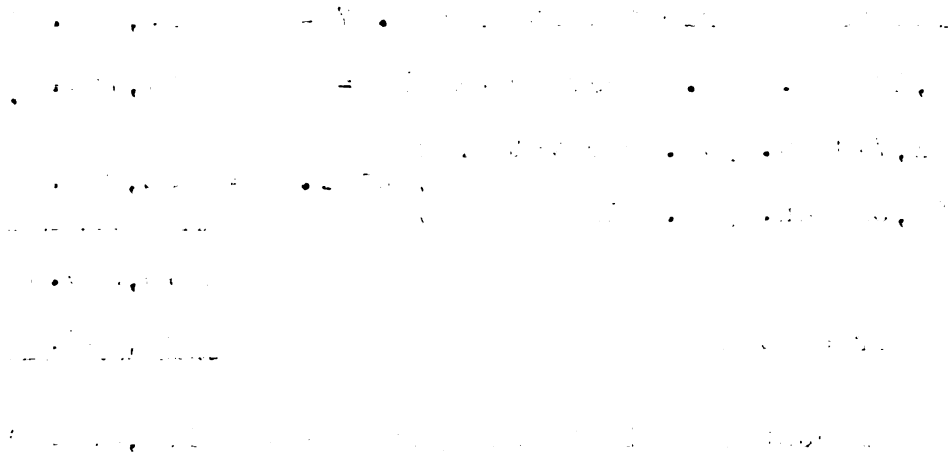
The present drainage of the street will be useless with the new grade, and another sewer must be constructed. At the present time there is a 20" x 33" egg-shaped sewer laying 7 foot 8 inches beneath grade which drains this section of Michigan Avenue. This sewer is not properly constructed and has never given efficient service so the loss will not be deeply felt by the municipality.

The writers recommend that a 30 inch tile drain be put in sufficiently below the frost line, and to run from the center of the crossing west to Larch Avenue and thence down Larch to Shiawassee and from there to the river.

Other changes to be made below grade will include the conduits of the Michigan State Telephone Company, the gas mains, and the water mains. However, these changes involve no direct cost to the project in hand as the lines are under pressure and do not depend on grade for their flow.

ESTIMATE OF COST.

140 tons fabricated steel at .07 =		$ 19,600.00
2,475 cu. yds. concrete at $10 =		24,750.00
31,740 cu. yds. excavation 28,520 cu. yds. fill	at 1.00 =	32,000.00
		$ 76,350.00
Labor = 40 %		30,540.00
Total cost (not including pavement)=		$106,890.00



FEASIBILITY OF PROJECT.

After conducting the thorough investigation herein contained, the writers agree that the project is, entirely feasible, for the following reasons:

1. The grades used in this problem have not exceeded the limiting grades as established in other projects of this nature. It has been stated elsewhere in this thesis that the recognized maximum grade of paved street approaches is 3 1/2 % and so this was used as the maximum. In changing the grade of railroads the limiting grade is taken as the maximum grade on that line. In this case a 1 % grade was found, which is greater than the usual maximum of .57 %, but the conditions as stated will allow the 1 % maximum grade which was used.

2. The damage of property caused by the change of grades, is very low as compared with that done in similar work in other cities. Only four frame dwellings must be condemned and the slope grades along the other part of the street are not extreme.

3. The changes required by the construction outlined are not prohibitive. The loading plat-

form at the station, altho a slight inconvenience to traffic, can be used until a new station is required which with the present growth of Lansing is not far distant.

The change of industrial sidings which will be required, will cause cars to be switched in from either side of Michigan Avenue at the present grade, leaving only the two main lines to cross the street.

The Hosmer street paving will have to be torn up for about 200 feet south of Michigan and brought down to the new grade of Michigan Avenue. The same will apply to Larch Avenue on both the north and south sides. Shiawassee Street must be torn up for about 200 feet east and west of the tracks and brought to the new grade of the tracks.

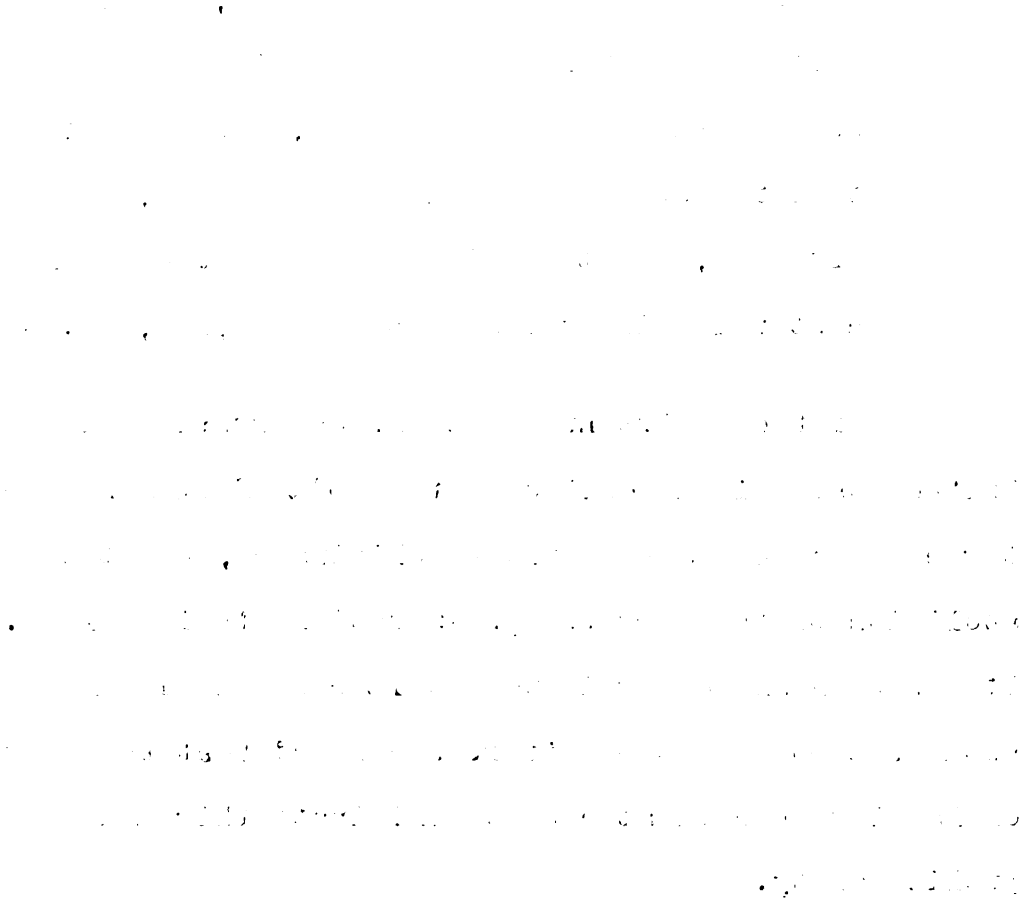
Traffic on Michigan Avenue can be diverted during construction either down Kalamazoo street or Shiawassee street. Railroad traffic can be continued over a temporary trestle as has been done in similar cases.

4. The cost of this project must be considered reasonable as the much needed relaying of Michigan Avenue cannot be directly applied to the project.

The division of cost would have to be

settled by a board of arbitration, and the writers do not favor the apportionment as used in the State of New York, but suggest that the state be required to pay 20%, the city 40%, and the railroad 40% of the total cost which is estimated at about $125,000.00.

Of the entire number of grade crossings in the United States it is estimated that 30% of them may be termed dangerous and should be eliminated, and the abolition of these crossings is rapidly taking place. It has been shown herein that this crossing is classed among the 30% and the writers recommend that the City of Lansing proceed at once to eliminate this menace to public safety.



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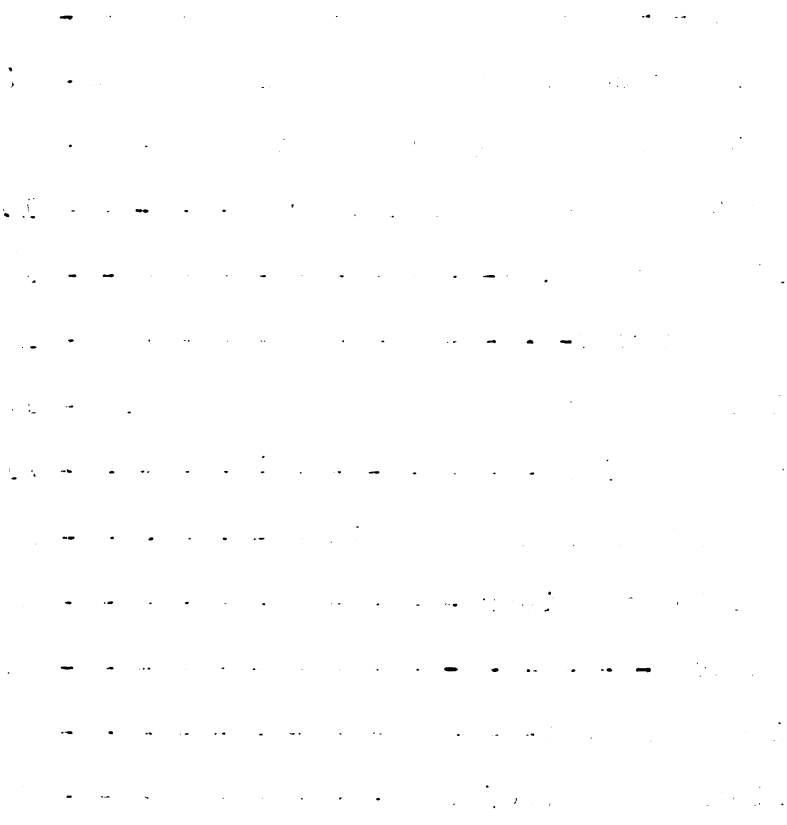

CONTENTS OF POCKET.

"A" Elevation and Plan of Project. (Blue Print and Tracing)

"B" Details of Bridge and Abutment. (Blue Print and Tracing)

"C" Topography of Location. (Blue Print and Tracing)

"D" Profile Sheets.

"E" Field Notes.