A STUDY OF THE COST OF MATERIALS AND REAL ESTATE DAMAGE IN THE CONSTRUCTION OF A GRADE SEPARATION ON E. SAGINAW STREET AT THE MICHIGAN CENTRAL RAILROAD CROSSING

THESIS FOR THE DEGREE OF B. S.

Glenn R. Burns   James A. Stone

1930

A Study of the Cost of Materials and Real Estate Damage in the Construction of a Grade Separation on E. Saginaw Street at the Michigan Central Railroad Crossing

A Thesis Submitted to

The Faculty of

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of

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By

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Candidates for the Degree of

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94200

SUPPLEMENTARY MATERIAL IN BACK OF BOOK

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APPRECIATION

We wish to acknowledge our appreciation of the assistance and criticisms of E. A. Finney of the Civil Engineering Department of Michigan State College.

We are indebted to Mr. Jones of the Motor Wheel Corporation, who kindly revealed future plans of the Motor Wheel building program.

We are, also, in debt to Mr. Richard Rey, Bridge Engineer, City of Lansing, for his most helpful data and suggestions.

Glenn R. Burns

James A. Stone

VIEW WEST FROM EAST PARK TERRACE.

VIEW EAST FROM LARCH ST.

VIEW NORTH TOWARD CROSSING.

VIEW WEST FROM SUMMIT ST.

VIEW OF CROSSING AND LOADING DOCK.

THESIS

Saginaw street has developed into a very busy thoroughfare and gives every indication of increasing traffic in the future. The recent extension of Saginaw street to East Lansing carries much of the traffic formerly taken by Michigan and Grand River avenues. A new paved highway, making a direct route from Lansing to Saginaw, Michigan, is now under construction. On completion of this highway Saginaw street will be required to take traffic now carried by M 16 and M 31.

The importance of a grade separation from a point of view of safety cannot be over emphasized. The highway is protected by crossing gates, but the track is blind on both sides. On the south side of Saginaw street and east of the tracks is situated Oak Park, several blocks in size with playground facilities, and on the east side is a grade school. This brings children across the tracks, which are a constant menace to them.

The situation, as viewed from an economical standpoint, necessitates consideration. The crossing is on the main line of the railroad and consists of four tracks and a spur. Passenger trains run almost every hour and sometimes there are two and three within the hour. Freight trains are passing at various times during the day and night. Every time a train passes the crossing delay to traffic on Saginaw street is necessary. It is to be seen that much valuable time and expense in operation of automobiles is lost through these delays. We believe this saving in operating expense of motorists justifies the proposed separation.

Another feature we find is the elimination of operating expense of the crossing gates. While it may seem a minor factor, in years to come quite a saving can be realized.

The essential problem to solve in a grade separation is that of raising the railroad track and depressing the highway, or depressing the tracks and raising the highway. In a city this problem becomes intricate and involves a great deal of study because of high land values and possibilities of high damage costs.

In this particular project this problem has been partially solved by the circumstances of one of the large land owners on Saginaw street alongside the site. This land owner, the Motor Wheel Corporation, with a factory building on the north side of Saginaw

street between the tracks and Summit street, is contemplating and has already negotiated with the City of Lansing to buy and build a loading dock and storage building on the south side of Saginaw street. This building will be built alongside the tracks and to connect the two buildings a viaduct will be built crossing Saginaw street at the level of the second floor of the buildings. This eliminates all consideration of carrying the highway over the tracks.

On further consideration we found the ground sloped ideally for an underpass. A long down grade from Pennsylvania avenue to the tracks is found on the east and continues west of the tracks to Larch street.

To change the grade of the railroad would involve an enormous expense because of building simultaneously other grade separations and also many damage costs by changing the level of loading docks, etc.

We have therefore consulted the city bridge engineer of Lansing, Mr. Richard Rey, and Mr. Jones, the plant engineer of the Motor Wheel Corporation, and designed this separation in accordance with their views. We also consulted the city plan as designed by Mr. Bartholomew of St. Louis, Missouri, which is followed except that the tracks will not be elevated.

The general plan of the separation is to depress the street from Larch street on the west eastward to the tracks and then rising to meet the present grade between Summit street and East Park Terrace. The roadway is to be built in between retaining walls and is to be forty-eight feet in width. This width allows four lines of traffic and one row of parked cars on the south side of the street which is in accordance with standards of the City of Lansing. On the north side of the street sidewalks will be ended at Summit street and approximately 300 feet from Larch street. The sidewalk on the south side will continue through, passing under the bridge and will be six feet wide.

The pavement is to be a ten inch concrete slab with one and one-half inches of binder and two inches of asphalt for wearing surface.

The bridge carrying the tracks over the street is constructed of rolled thirty-six inch I beams spaced four feet center to center on which is placed a concrete floor slab and ballast with necessary waterproofing, railing and abutments.

The abutments and retaining walls are of the cantilever type of which we made four designs. The

gravity wall was used below eight feet to conserve on expense of steel.

We find little property damage in our problem and so are not taking it into consideration. A possible damage might arise for the owner of a store on the northeast corner of Summit and Saginaw streets. We believe this may be handled by lowering the foundation at a small cost.

In conclusion we wish to recommend our underpass as a method to alleviate traffic conditions at the crossing by providing a continuous passage for traffic and pedestrians.

We hereby submit our preliminary design and estimate.

Glenn R. Burns

James A. Stone

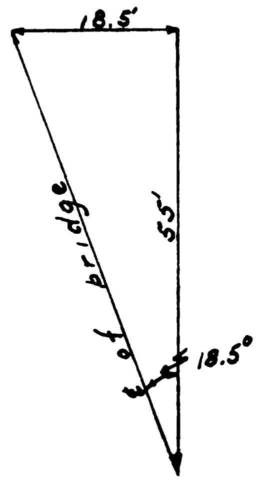
May 31, 1930.

DESIGN SINGLE TRACK BRIDGE

Coopers E_{60} Loading

Right angle clear span - 54'

Right L Center to center of bearing - 55'



Center to center of bearing - 58' 00"

Total length 59' 00"

SHEAR

Load #2 $\frac{8772 + 258X2 - 15X66}{58} = 1448 \text{ K Max.}$

Load #3 $\frac{10062 + 288X3 - (120 + 45X63)}{58} = 137.2 \text{ K}$

$$I = S \frac{300}{300 + \frac{L^2}{100}} = 144.8 \frac{300}{300 + \frac{58^2}{100}} = 130 \text{ K}$$

Total live shear = 274.8 K

Maximum Bending Moment

Load #3 $\frac{(3232.5+174X5)}{2}$ - 345 = 1331 K ft.

Load#4 $\frac{(4276.5+193.5X4)}{2}$ -720 = 1805 K ft. Max.

Load#5 $\frac{(5244+213X4)}{2}$ -1245 = 1803 K ft.

$$I = 1805 \frac{300^2}{300 + \frac{47^2}{100}} = 1680 \text{ K ft.}$$

Total live bending moment = 3485 K ft.

Dead Shear

Rails & fastenings	150#/ft.	
Ballast & ties	2880#/ft.	18"x16'x120#
Slab	1600#/ft.	8"x16'x 150#
Girder	1500#/ft.	300#/ft.x5
Total	6130#/ft.	

6130x29 = 178 K Dead shear

Total shear = 178+275 = 453K

178x14.5 = 2580 K ft. Dead B.M.

Total B.M. = 2580+3485 = 6065 K ft.

$$S = \frac{I}{C} = \frac{M}{s} = \frac{6065000x12}{16000x5} = 910$$

Spacing of girders $\frac{16}{4}$ = 4' 0" center to center

Select 36" rolled I Beam Carnegie CB 362

300#/ft. Area = 88.23 sq. in. Depth of section 36.851

Flange width $=$ 16.189"   Web thickness $=$ .958"

Flange thickness $=$ 1.7155"

Design Slab

Live load	1000#/sq. ft.
Ballast 18"	180#/sq. ft.
Rails 10' section	15#/sq. ft.
Wt. of slab 6"	75#/sq. ft.
Total	1270#/sq. ft.

Free span $=$ 4.00' -1.35' $=$ 2.65'

$$M = \frac{wl^2}{12} = \frac{1270 \times 2.65^2 \times 12}{12} = 8925 \text{ in. lbs.}$$

$$d = \left(\frac{8925}{.0077 \times 16000 \times .874 \times 12}\right)^{\frac{1}{2}} = 2.63" \qquad \text{use } 3"$$

$D = 3+2 = 5"$

$$v = \frac{1270 \times 2.65}{2 \times 12 \times .874 \times 3} = 53\#/\text{sq. in.}$$

Try $d = 4"$

$$v = \frac{1270 \times 2.65}{2 \times 12 \times .874 \times 4} = 40\#/\text{sq. in.} \qquad \text{o.k.}$$

$A_s = .0077 \times 12 \times 4 = .37$ sq. in.

Select ½" ϕ bars at 4" cemters

$$u = \frac{1270 \times 2.65}{2 \times .874 \times 4 \times 4.71} = 102\#/\text{sq. in.}$$

use $d = 6"$ $D = 6"+2" = 8"$ slab

Design Four Track Bridge

Clear span 54' 0

Center to center of bearing 55'

Shear

Load#2 $\frac{6948+228x7-15x63}{55} = 138$ K Max.

Load#3 $\frac{8772+258x4-(120+45x60)}{55} = 129$ K

$I = 138 \left(\frac{300}{300+ \frac{55^2}{100}} \right) = 126.5$ K

Total live shear = 264.5 K single track

264.5x4x.75 = 793.5 K

Bending moment

Load#4 $\frac{4276.5+193.5x2.5}{2} - 720 = 1660$ K ft. Max.

Load#5 $\frac{5244+213x2.5}{2} - 1245 = 1643$ K ft.

$I = 1660 \left(\frac{300}{300+ \frac{45.5^2}{100}} \right) = 1550$ K ft.

Total B.M. = 3210 K ft. single track

3210x4x.75 = 9630 K ft.

Dead shear

Rails & fastenings	600#/ft.	
Ballast & ties	10100#/ft.	18"x56'x120#
Slab	5600#/ft.	8"x56'x150#
Girder	4500#/ft.	300#/ft.x15
	20800#/ft.	

20800x27.5 = 572 K dead shear

572x13.75 = 7850 K ft. dead B.M.

Total shear = 572+793 = 1365 K

Total B.M. = 7850+9630 = 17480 K ft.

$$S = \frac{I}{C} = \frac{M}{S} = \frac{1748000 \times 12}{16000 \times 15} = 874$$

Spacing of girders $\frac{56}{14}$ = 4' 0" center to center

Select 36" rolled I beams Carnegie C.B. 362 same as

for single track bridge.

Use same slab as for single track bridge.

Bearing Max. shear = 1,365,000 lbs.

15 I beams bearing surface 15x16.2"x12" = 2908 sq. in.

Bearing pressure = $\frac{1,365,000}{2908}$ = 470#/sq. in.

Allowable pressure = 600#/sq. in.

Single track bridge Max. shear = 453,000#

5 I beams bearing surface = 972 sq. in.

Bearing pressure $\frac{453000}{972} = 467\#/\text{sq. in.}$

Design abutment

This abutment will be designed to withstand two different loadings: A. Full load on bridge and no live load back of abutment; B. Engine load back of abutment and only dead bridge load.

Design A

Bearing load on stem/ft.	28,000#
Weight of stem	4,250#
Weight of footing	2,250#
	34,500#

Weight of earth on heel = 10,000#

Earth pressure = 5500# applied 7' from bottom of footing

(1) Overturning moment = 38600 ft. #

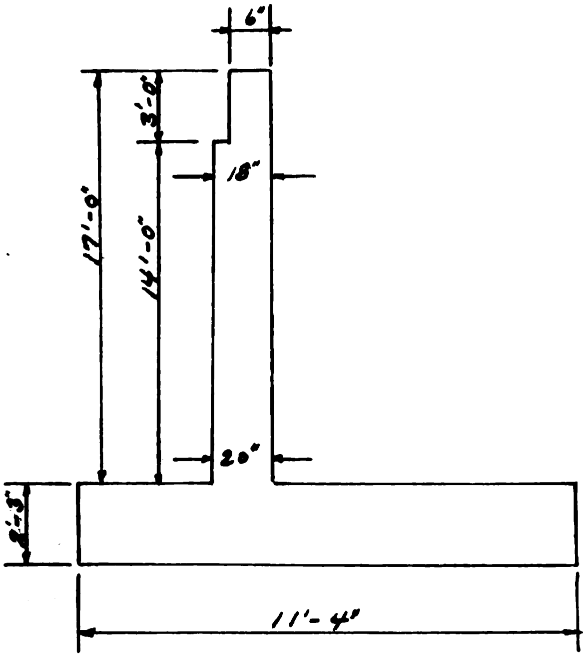
Resisting moment = 205600 ft. #

Factor of safety = 5.3

(2) Sliding force = 5500#

Resisting force = 44500x.4 = 17800#

Factor safety = 3.2



(3) $X = 4.18'$

$e = 5-4.18 = .82'$

$S =$ 6000# compression toe
2200# compression heel o.k.

Design stem

$P = \frac{100 \times 19^2}{2} \times .25 =$ 4520# applied 6.33'

$M =$ 28,600 ft. #

$d = \left(\frac{28600 \times 12}{12 \times 107.7}\right)^{\frac{1}{2}} = 16.3$ say 16.5" $D = 20"$

$v =$ 26#/sq. in. o.k.

$A_s = .0077 \times 12 \times 16.5 = 1.525$ sq. in.

Select 7/8" square bars at 6" = 1.53 sq. in.

$u =$ 44.8#/sq. in.

Design toe

Bending moment $=$ 21150 ft. # acting upward

Shear $=$ 15000#

$d = \left(\frac{21150}{107.7}\right)^{\frac{1}{2}} = 14.1"$ say 14.5" $D = 18"$

$v =$ 98.8#/sq. in. use $d = 24"$ $D = 27"$

Then $v =$ 59.5#/sq. in.

$A_s = .0077 \times 12 \times 24 = 2.22$ sq. in.

Select 7/8" square bars at 6") 2.31 sq. in.
5/8" square bars at 6")

$u =$ 59.7#/sq. in.

Design heel

Bending moment $=$ 14500 ft. # acting upward

Shear $=$ 6000#

$d = \left(\frac{14500}{107.7}\right)^{\frac{1}{2}} = 11.6"$ say 12" $D = 15"$

$v =$ 47.7#/sq. in. use $d = 15"$ $D = 18"$

Then $v =$ 38.1#/sq. in.

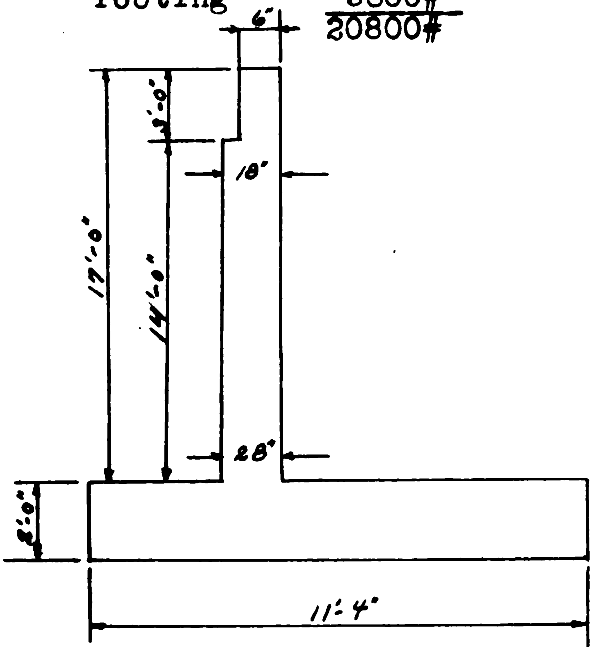
$A_s = .0077 \times 12 \times 15 = 1.385$ sq. in.

Select 7/8" square bars at 6" $=$ 1.53 sq. in.

$u =$ 65.3#/sq. in. o.k.

Design B

Load on stem =	11800#
Weight of stem	5400#
Weight of footing	3600#
	20800#



Surcharge = 800#/sq. ft.

Weight of earth and surcharge = 18000#

Earth pressure = 9100# applied 9' above bottom of footing

(1) Overturning moment = 82000 ft. #

Resisting moment = 241,000 ft. #

Factor of safety = 2.94

(2) Sliding force = 9100#

Resisting force = 38800x.4 = 15500#

Factor of safety = 1.7

(3) $X = 4.10'$

$e = 6.00 - 4.10 = 1.9'$

$s =$ 6700# compression toe
170# compression heel

Design stem

$P = 7820\#$ applied 8.33'

B.M. = 65000 ft. #

$d = \left(\frac{65000}{107.7}\right)^{\frac{1}{2}} = 24.55''$ say 25" $D = 28''$

$v = 29.8\#/\text{sq. in.}$

$A_s = .0077 \times 12 \times 25 = 2.31$ sq. in.

Select 1" ϕ bars at 4" = 2.35 sq. in.

$u = 79\#/\text{sq. in.}$ o.k.

Design toe

Bending moment = 11,250 ft. # Shear = 8750#

$d = \left(\frac{11250}{107.7}\right)^{\frac{1}{2}} = 10.25''$ say 10.5"

$d = \frac{8750}{.874 \times 12 \times 40} = 20.8''$ say 21" $D = 24''$

$A_s = .0077 \times 12 \times 21 = 1.94$ sq. in.

Select 1" ϕ bars at 4" = 2.35 sq. in.

$u = 53\#/\text{sq. in.}$

Design heel

Bending moment = 23380 ft. #   Shear = 4680#

$d = \left(\frac{23380}{107.7}\right)^{\frac{1}{2}} = 14.75"$ say 15"   D = 18"

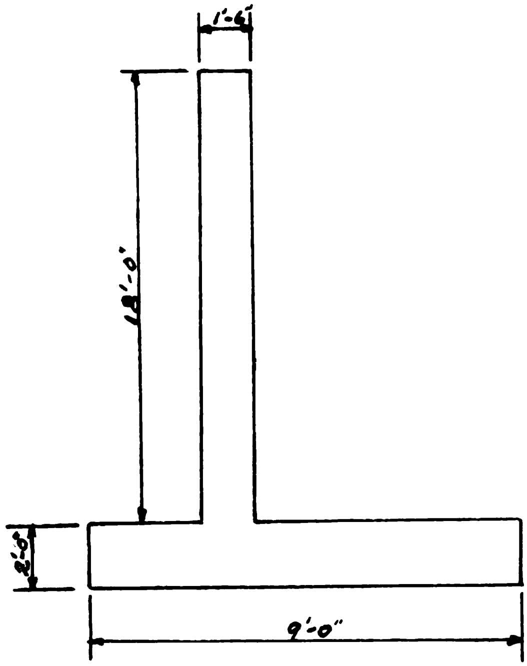
$d = \frac{4680}{.874x12x40} = 11.15"$

$A_s = .0077x12x15 = 1.385$ sq. in.

Select 7/8" square bars at 6" = 1.53 sq. in.

u = 63.8#/sq. in.

DESIGN OF RETAINING WALLS



f_c = 650# f_s = 16000#

t = .41x20 = 8.2'   say 9'

Assume thickness of base 2'

Design stem

Total pressure $\frac{1}{2}$x25x(18)^2 = 4050#

applied 6' above top footing

SM_B = 292000# ft.

$d = \left(\frac{292000}{107.7x12}\right)^{\frac{1}{2}} = 15"$

Total thickness of stem = (15-3) = 18"

A_s = .0077x12x15 = 1.39 sq. in.

Use 7/8"ϕbars spaced 5" c-c = 1.44 sq. in.

$v = \frac{4050}{12x15x(7/8)} = 25.7$#/sq. in. o.k.

$u = \frac{4050}{(12/5)x2.75x.875x15} = 46.7$#/sq. in. o.k.

Horizontal bars use ½" ϕ

(12x18).0025 = .54 sq. in.

.196x2-196 = 59 sq. in./ft of height o.k.

Design of footing

$P = \frac{1}{2}(25)(20)^2 = 5000$#

Total weight = 16200#

Moment arm = 5.22

X = 2.03

(1) F.S. against sliding

$16200x.4 = \frac{6480}{5000} = 1.30$ o.k.

(2) Overturning

$\frac{5.22}{2.03} = 2.57$ o.k.

Inner cantilever

Shear at D = 6615#

Momemt at D = 233000#ft.

use 7/8" bars spaced 7"

5"x1½" = 7½" say 7"

d for shear = $\frac{6615}{(12/7)2.75x20x.90} = 20$"

d for moment = $\left(\frac{233000}{12x107.7}\right)^{\frac{1}{2}} = 13.5$

$u = 77.5\#$ o.k.

$v = 30.5\#$ o.k.

Outer cantilever

Downward weight = 675#

$M_E = -9100\# - 101{,}000\# = 91{,}900$ in #

$$d = \left(\frac{91.900}{12x107.7}\right)^{\frac{1}{2}} = 8.45''$$

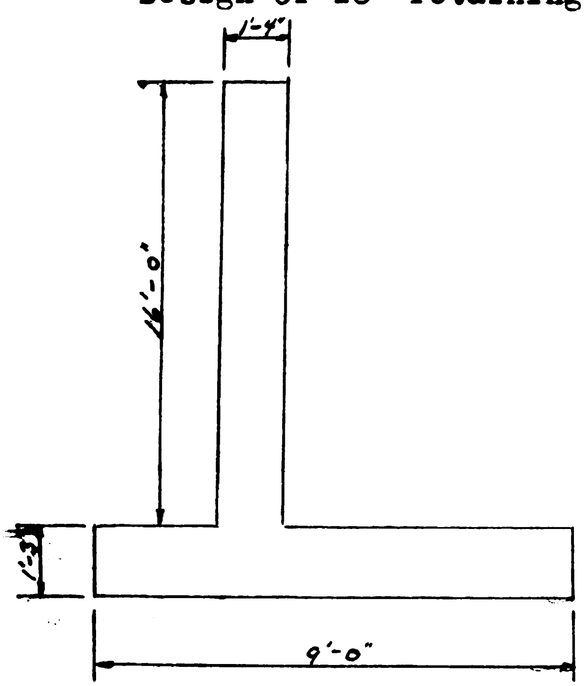
$$V = \left(\frac{3600-2700}{2}\right) 2.25-675 = 6425^{\#}$$

$$d = \frac{6425}{(12/7)2.75x80(7/8)} = 19.6''$$ use 7" spacing

$u = 77.5\#$ o.k.

$v = 30.4\#$ o.k.

Design of 16' retaining wall



Design stem

$P = \frac{100(16)^2}{2} x.25 = 3200\#$ applied 5.33'

$M = 17050$ ft.#

$d = \left(\frac{17050}{107.7}\right)^{\frac{1}{2}} = 12.6"$ say 13" $D = 16"$

$d = \frac{3200}{.874x12x40} = 7.63$

$A_s = .0077x12x13 = 1.20$ sq. in.

Use 7/8" ø bars spaced 6"

$u = 55.5\#$ sq. in. o.k.

weight of stem	3200#
weight of footing	2020#
	5220#

weight of earth 8550#

Earth pressure 4050 applied at 6'

(1) Overturning M. = 24,300 ft.#

Resisting M. = 72,900 ft.#

F.S. $= \frac{72900}{24300} = 3.00$ o.k.

(2) Sliding F. = 4050#

Resisting F. = 5520#

F.S. $= \frac{5520}{4050} = 1.36$ o.k.

(3) $X = 3.53$

$c = 4.5-3.53 = .97$

$$s = \frac{13770}{9}\left(1 - \frac{6x.97}{9}\right) = \begin{matrix}2520\# \\ 540\#\end{matrix}$$ Comp. toe / " heel

Design toe

Ordinate

$$2520 - \left(\frac{2520-540}{9}\right)2.33 = 2010$$

B.M. = 5900 ft.#

Shear = 4840#

$$d = \left(\frac{5900}{107.7}\right)^{\frac{1}{2}} = 7.4"$$

$$d = \frac{4890}{.874x12x40} = 11.5" \quad \text{say } 12" \quad D = 15"$$

A_s = .0077x12x12 = 1.11 sq. in. Use 7/8" ϕ bars spaced 6"

u = 83#/sq. in. o.k.

Design heel

B.M. = 14,800 ft.#

Shear = 3730#

$$d = \left(\frac{14800}{107.7}\right)^{\frac{1}{2}} = 11.7" \quad \text{say } 12"$$

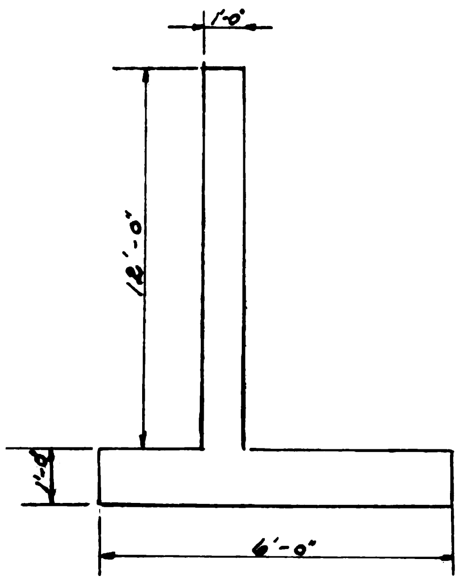
$$d = \frac{3730}{.874x12x40} = 8.9"$$

A_s = .0077x12x12 = 1.11 sq. in.

Use 7/8 ϕ bars spaced at 6"

u = 64.7#/sq. in. o.k.

Design of 12' wall



Weight of wall	1800#
Weight of stem	900#
Weight of earth	4200#
	6900#

Earth pressure = 2110# applied 4.33'

(1) Overturning M. = 9125 ft.#

Resisting M. = 24150 ft.#

$$F.S. = \frac{24150}{9125} = 2.64$$ o.k.

(2) Sliding factor = 2110#

Resisting factor = 2760#

$$F.S. = \frac{2760}{2110} = 1.31$$ o.k.

(3) X = 2.18"

$c = 3 - 2.18 = .82"$

$s = \frac{6900}{6}\left(1 - \frac{6x182}{6}\right) = $ 2090# comp. toe
207# comp. heel

Design stem

$P = \frac{25x(12)^2}{2} = 1800\#$ applied at 4'

$M = 7200$ ft.#

$d = \left(\frac{7200}{107.7}\right)^{\frac{1}{2}} = 8.2$ say 9"

Shear

$d = \frac{1800}{1874x12x40} = 4.3"$

$A_s = .0077x12x9 = .83$

Use 3/4" ∅ bars spaced 6"

$u = 49\#/sq. in.$ o.k.

Design toe

Ordinate = 1125

B.M. = 1925 ft.#

Shear = 2570#

$d = \frac{1925}{107.7} = 4.25$

$d = \frac{2570}{.875x12x40} = 6.1$ use 9"

$A_s = .0077x12x9 = .83$ sq. in.

Use 3/4" bars spaced 6"

u = 69.5# o.k.

Design heel

Ordinate = 1110

B.M. = 5350# ft.

Shear = 2115#

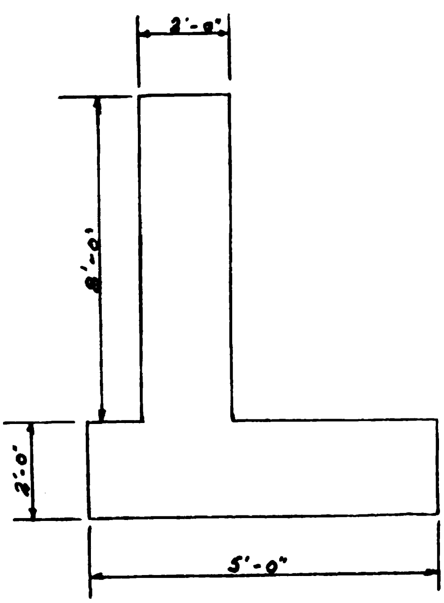
$d = \left(\frac{5350}{107.7}\right)^{\frac{1}{2}} = 7.1$ say 9"

$d = \frac{2115}{.875 x 12 x 40} = 5"$

$A_s = .0077 x 12 x 9 = .83$
Use 3/4" ∅ bars spaced 6"

u = 57# o.k.

Design 8' gravity wall



Weight of stem	2300#
weight of footing	1500#
Weight of earth	1860#
	5660#

Earth pressure = 1250# applied 3.33'

(1) Overturning moment = 4170 ft.#

Resisting moment = 16,515 ft.#

$$F.S. = \frac{16515}{4170} = 3.96 \quad o.k.$$

(2) Sliding factor = 1250

Resisting factor = 2260

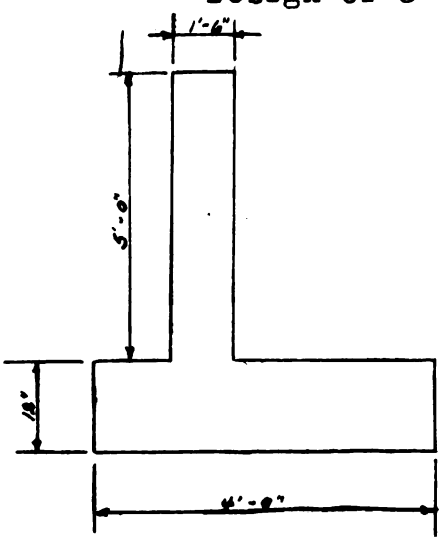
$$F.S. = \frac{2260}{1250} = 1.81 \text{ o.k.}$$

(3) X = 2.21
c = 2.5 - 2.21 = .29'

$$s = \frac{5660}{5}\left(1 \pm \frac{6x.29}{5}\right) = \begin{matrix} 1530\# \text{ comp. toe} \\ 738\# \text{ comp. heel} \end{matrix}$$

.7506 tons earth pressure o.k.

Design of 5' gravity wall



Weight of stem	1125
Weight of footing	600
Weight of earth	960
	2685

Earth pressure = 610# applied 2.33

(1) Overturning M. = 1425 ft.#

Resisting M. = 5245 ft.#

F.S. $= \frac{5245}{1425} =$ 3.68 o.k.

(2) Sliding factor = 610#

Resisting factor = 1475#

F.S. $= \frac{1475}{610} =$ 2.42 o.k.

(3) X = 1.42

c = 2-1.42 = .58

$s = \frac{2685}{4}\left(1 \pm \frac{6x.58}{4}\right) =$ 1255# comp. toe
87# comp. heel

INSTRUCTIONS

Dumping grounds for excavated dirt must be found by contractor, and price bid must include hauling.

"Weep holes" shall be placed in retaining walls every 20 feet, and shall consist of 4" tile. The weep holes on the north retaining walls shall be on top of footing and drain onto street. Those on the south walls shall drain by direct connection to storm sewer under sidewalk.

The north catch basin under the bridge shall be connected to the south storm sewer. This sewer shall be placed two feet under sidewalk from station 9-00 to station 5-00 - 6" in diameter, and from station 5-00 to connection with sewer at Cedar street it shall be a 12" sewer and laid to a 1% grade.

The present sewer located under Saginaw street is 5½ feet below grade at Summit street, 6 feet below at the railroad, and only 3 feet below at Larch street. From the railroad to Larch it is a 36" pipe. This sewer will have to be moved north 5 feet behind the retaining wall and at its present grade.

The elevation of the invert of the 12" storm sewer under the sidewalk at station 5-00 will be 113.00'

city datum. Since the Grand River high water mark is 111.00' there is sufficient allowance for drainage.

The retaining walls, footing, road base and sidewalk shall be constructed with expansion joints every 50 feet.

Back fill behind retaining walls and abutments shall be sloped down away from the walls.

All water and gas mains, and all telephone, telegraph and electric light lines shall be moved at owners' expense as required.

ESTIMATE OF COST.

EARTHWORK:				
CUT	30,000 cu. yd.	@ $.50	$15,000.00	
FILL	3,800 " "	@ $.25	950.00	
DITCHING	200 " "	@ $1.00	200.00	$16,150.00
CONCRETE:				
BRIDGES & ABUTMENTS	520 cu. yd.	@ $20.00	$10,400.00	
RETAINING WALLS	1225 " "	@ "	$24,500.00	
PARK STAIRS	30 " "	@ "	600.00	
CURB	2100 feet	@ $.50	1,050.00	
PAVEMENT (10")	5600 sq. yd.	@ $2.00	11,200.00	
SIDEWALK	5000 sq. ft.	@ $.25	1,250.00	$49,000.00
ASPHALT SURFACE	7200 sq.yd.	@ $1.00	$7,200.00	$7,200.00
STEEL:				
GIRDERS & BED PLATE	171 tons	@ $50.00	$8,550.00	
ERECTION	170 "	@ $15.00	2,890.00	
REINFORCING:				
BRIDGE & ABUTMENTS	82,000 lb.	@ $.05	4,100.00	
RETAINING WALLS	135,060 "	@ "	6,750.00	$22,290.00
DRAIN:				
12" TILE	1000 feet	@ $.75	$ 750.00	
6" "	1300 "	@ $.50	650.00	
CATCHBASINS	4	@ $35.00	140.00	
4" TILE WEEP HOLES	65	@ $1.00	65.00	
RELAY 30" & 36" SEWERS	900 feet	@ $1.00	900.00	$ 2,505.00

TOTAL	$98,070.00
ENGINEERING (5%)	$ 4,903.50
DAMAGES	$ 5,000.00
TOTAL	$107,973.50
BOND INTEREST (5%)	$ 5,398.50
GRAND TOTAL	$113,372.00

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