

THESIS

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SUPPLEMENTARY
MATERIAL
IN BACK OF BOOK

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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
MICHIGAN STATE COLLEGE
of
AGRICULTURE AND APPLIED SCIENCE

By

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Candidates for the Degree of
Bachelor of Science

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THESIS

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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

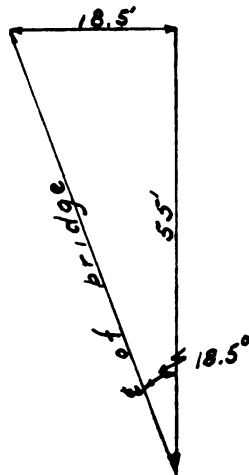
May 31, 1930.

DESIGN SINGLE TRACK BRIDGE

Coopers E₆₀ 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

$$\text{Load \#2} \quad \frac{8772 + 258 \times 2 - 15 \times 66}{58} = 1448 \text{ K Max.}$$

$$\text{Load \#3} \quad \frac{10062 + 288 \times 3 - (120 + 45 \times 63)}{58} = 137.2 \text{ K}$$

$$I = 8 \frac{300}{300 + \frac{L^2}{100}} = 144.8 \quad \frac{300}{300 + \frac{58^2}{100}} = 130 \text{ K}$$

$$\text{Total live shear} = 274.8 \text{ K}$$

Maximum Bending Moment

$$\text{Load \#3} \quad \frac{(3232.5+174 \times 5)}{2} - 345 = 1331 \text{ K ft.}$$

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

$$\text{Load\#5} \quad \frac{(5244+213 \times 4)}{2} - 1245 = 1803 \text{ K ft.}$$

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

$$\text{Total live bending moment} = 3485 \text{ K ft.}$$

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	<u>6130#/ft.</u>	

$$6130 \times 29 = 178 \text{ K Dead shear}$$

$$\text{Total shear} = 178 + 275 = 453 \text{ K}$$

$$178 \times 14.5 = 2580 \text{ K ft. Dead B.M.}$$

$$\text{Total B.M.} = 2580 + 3485 = 6065 \text{ K ft.}$$

$$S = \frac{I}{c} = \frac{M}{s} = \frac{6065000 \times 12}{16000 \times 5} = 910$$

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

Select 36" rolled I Beam Carnegie CB 362

$$300 \text{ \#/ft. Area} = 88.23 \text{ sq. in. Depth of section } 36.851$$

1. The first part of the paper is devoted to a general discussion of the problem of the existence of a solution of the system of equations (1) for a given set of initial conditions. It is shown that the system of equations (1) has a unique solution for a given set of initial conditions if the functions $f_i(x, y, z, t)$ are continuous and satisfy the Lipschitz condition with respect to the variables x, y, z .

2. In the second part of the paper, the problem of the existence of a solution of the system of equations (1) for a given set of initial conditions is solved for the case of a linear system of equations. It is shown that the system of equations (1) has a unique solution for a given set of initial conditions if the matrix of the coefficients of the system of equations is non-singular.

3. In the third part of the paper, the problem of the existence of a solution of the system of equations (1) for a given set of initial conditions is solved for the case of a nonlinear system of equations. It is shown that the system of equations (1) has a unique solution for a given set of initial conditions if the functions $f_i(x, y, z, t)$ are continuous and satisfy the Lipschitz condition with respect to the variables x, y, z .

4. In the fourth part of the paper, the problem of the existence of a solution of the system of equations (1) for a given set of initial conditions is solved for the case of a system of equations with a delay. It is shown that the system of equations (1) has a unique solution for a given set of initial conditions if the functions $f_i(x, y, z, t)$ are continuous and satisfy the Lipschitz condition with respect to the variables x, y, z .

5. In the fifth part of the paper, the problem of the existence of a solution of the system of equations (1) for a given set of initial conditions is solved for the case of a system of equations with a delay and a non-local condition. It is shown that the system of equations (1) has a unique solution for a given set of initial conditions if the functions $f_i(x, y, z, t)$ are continuous and satisfy the Lipschitz condition with respect to the variables x, y, z .

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	<u>1270#/sq. ft.</u>

Free span = 4.00' - 1.35' = 2.65'

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

$$d = \left(\frac{8925}{.0077 \times 16000 \times .874 \times 12} \right)^{\frac{1}{2}} = 3.63" \quad \text{use 3"}$$

$$D = 3 + 2 = 5"$$

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

Try d = 4"

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

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

Select $\frac{1}{2}" \phi$ bars at 4" centers

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

$$\text{use } d = 6" \quad D = 6" + 2" = 8" \text{ slab}$$

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Design Four Track Bridge

Clear span 54' 0

Center to center of bearing 55'

Shear

$$\text{Load\#2} \quad \frac{6948+228 \times 7 - 15 \times 63}{55} = 138 \text{ K Max.}$$

$$\text{Load\#3} \quad \frac{8772+258 \times 4 - (120+45 \times 60)}{55} = 129 \text{ K}$$

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

Total live shear = 264.5 K single track

$$264.5 \times 4 \times .75 = 793.5 \text{ K}$$

Bending moment

$$\text{Load\#4} \quad \frac{4276.5+193.5 \times 2.5}{2} - 720 = 1660 \text{ K ft. Max.}$$

$$\text{Load\#5} \quad \frac{5244+213 \times 2.5}{2} - 1245 = 1643 \text{ K ft.}$$

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

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

$$3210 \times 4 \times .75 = 9630 \text{ K ft.}$$

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
	<u>20800#/ft.</u>	

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 4 972 sq. in.

• The first step in the process of creating a new product is to identify a market need. This is often done through market research, which involves gathering information about potential customers and their needs. Once a market need has been identified, the next step is to develop a concept for a product that meets that need. This is often done through brainstorming and prototyping. Once a concept has been developed, the next step is to create a business plan. This involves determining the costs of production, the pricing strategy, and the marketing strategy. Once a business plan has been created, the next step is to secure funding. This can be done through a variety of methods, including bank loans, venture capital, and crowdfunding. Once funding has been secured, the next step is to manufacture the product. This involves sourcing materials, hiring workers, and setting up a production line. Once the product has been manufactured, the next step is to distribute it. This can be done through a variety of methods, including direct sales, retail stores, and online sales. Finally, the last step in the process is to monitor the product's performance in the market. This involves tracking sales, customer feedback, and market trends. If the product is not performing well, the company may need to make changes to the product or the marketing strategy.

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

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#
	<hr/> 34,500#

$$\text{Weight of earth on heel} = 10,000\#$$

$$\text{Earth pressure} = 5500\# \text{ applied 7' from bottom of footing}$$

$$(1) \quad \text{Overturning moment} = 38600 \text{ ft. } \#$$

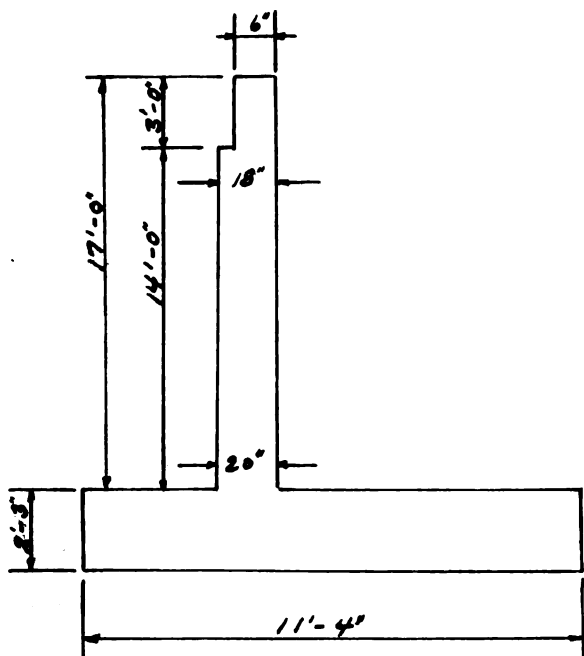
$$\text{Resisting moment} = 205600 \text{ ft. } \#$$

$$\text{Factor of safety} = 5.3$$

$$(2) \quad \text{Sliding force} = 5500\#$$

$$\text{Resisting force} = 44500 \times .4 = 17800\#$$

$$\text{Factor safety} = 3.2$$



$$(3) \quad X = 4.18'$$

$$e = 5 - 4.18 = .82'$$

$$S = \begin{array}{l} 6000\# \text{ compression toe} \\ 2200\# \text{ compression heel} \end{array} \quad \text{o.k.}$$

Design stem

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

$$M = 28,600 \text{ ft. } \#$$

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

$$v = 26\#/\text{sq. in.} \quad \text{o.k.}$$

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

$$\text{Select } 7/8" \text{ square bars at } 6" = 1.53 \text{ sq. in.}$$

$$u = 44.8\#/\text{sq. in.}$$

Design toe

Bending moment = 21150 ft. # acting upward

Shear = 15000#

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

$$v = 98.8\#/sq. \text{ in. use } d = 24" \quad D = 27"$$

Then $v = 59.5\#/sq. \text{ in.}$

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

Select $\left. \begin{array}{l} 7/8" \text{ square bars at } 6" \\ 5/8" \text{ square bars at } 6" \end{array} \right\} 2.31 \text{ sq. in.}$

$$u = 59.7\#/sq. \text{ in.}$$

Design heel

Bending moment = 14500 ft. # acting upward

Shear = 6000#

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

$$v = 47.7\#/sq. \text{ in. use } d = 15" \quad D = 18"$$

Then $v = 38.1\#/sq. \text{ in.}$

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

Select $7/8" \text{ square bars at } 6" = 1.53 \text{ sq. in.}$

$$u = 65.3\#/sq. \text{ in. o.k.}$$

1. The first part of the document is a list of names and titles, including "The Hon. Mr. Justice" and "The Hon. Mr. Justice".

2. The second part of the document is a list of names and titles, including "The Hon. Mr. Justice" and "The Hon. Mr. Justice".

3. The third part of the document is a list of names and titles, including "The Hon. Mr. Justice" and "The Hon. Mr. Justice".

4. The fourth part of the document is a list of names and titles, including "The Hon. Mr. Justice" and "The Hon. Mr. Justice".

5. The fifth part of the document is a list of names and titles, including "The Hon. Mr. Justice" and "The Hon. Mr. Justice".

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7. The seventh part of the document is a list of names and titles, including "The Hon. Mr. Justice" and "The Hon. Mr. Justice".

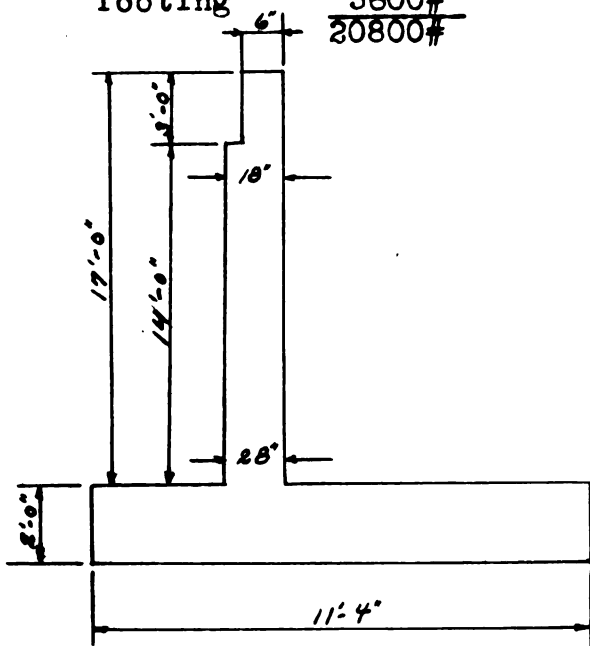
8. The eighth part of the document is a list of names and titles, including "The Hon. Mr. Justice" and "The Hon. Mr. Justice".

9. The ninth part of the document is a list of names and titles, including "The Hon. Mr. Justice" and "The Hon. Mr. Justice".

10. The tenth part of the document is a list of names and titles, including "The Hon. Mr. Justice" and "The Hon. Mr. Justice".

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 = $38800 \times .4 = 15500\#$

Factor of safety = 1.7

$$\begin{aligned}
 (3) \quad X &= 4.10' \\
 e &= 6.00 - 4.10 = 1.9' \\
 s &= \begin{array}{ll} 6700\# & \text{compression toe} \\ 170\# & \text{compression heel} \end{array}
 \end{aligned}$$

Design stem

$$P = 7820\# \text{ applied } 8.33'$$

$$B.M. = 65000 \text{ ft. } \#$$

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

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

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

$$\text{Select } 1" \phi \text{ bars at } 4" = 2.35 \text{ sq. in.}$$

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

Design toe

$$\text{Bending moment} = 11,250 \text{ ft. } \# \quad \text{Shear} = 8750\#$$

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

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

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

$$\text{Select } 1" \phi \text{ bars at } 4" = 2.35 \text{ sq. in.}$$

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

1. The first part of the paper discusses the importance of the study of the history of the English language. It is a branch of linguistics which deals with the changes in the English language over time. The study of the history of the English language is important for several reasons. First, it helps us to understand the development of the English language and the factors which have influenced it. Second, it helps us to understand the relationship between the English language and other languages. Third, it helps us to understand the cultural and social context in which the English language has developed. Fourth, it helps us to understand the role of the English language in the world today. Fifth, it helps us to understand the future of the English language.

2. The second part of the paper discusses the history of the English language from its origins to the present. It begins with the prehistoric period, when the English language was first spoken by the Anglo-Saxons. It then discusses the Old English period, the Middle English period, and the Modern English period. It also discusses the influence of other languages on the English language, such as Latin, French, and Greek. It also discusses the influence of social and cultural factors on the English language, such as the Norman Conquest and the Renaissance. It also discusses the influence of technology on the English language, such as the printing press and the internet.

3. The third part of the paper discusses the future of the English language. It discusses the role of the English language in the world today and the challenges it faces. It also discusses the role of the English language in the future and the opportunities it offers. It also discusses the role of the English language in the development of the world and the challenges it faces. It also discusses the role of the English language in the development of the future and the opportunities it offers.

Design heel

Bending moment = 23380 ft. # Shear = 4680#

$$d = \left(\frac{23380}{107.7} \right)^{\frac{1}{2}} = 14.75" \quad \text{say } 15" \quad D = 13"$$

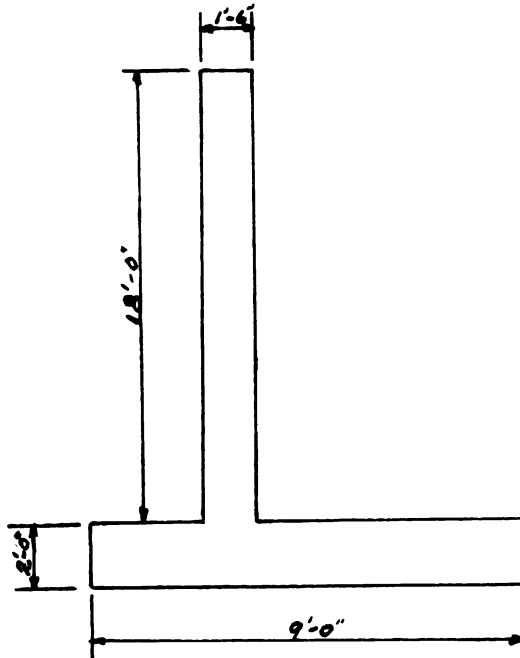
$$d = \frac{4680}{.874 \times 12 \times 40} = 11.15"$$

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

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

$$u = 63.8\#/\text{sq. in.}$$

DESIGN OF RETAINING WALLS



$$f_c = 650\# \quad f_s = 16000\#$$

$$t = .41 \times 20 = 8.2' \quad \text{say } 9'$$

Assume thickness of base 2'

Design stem

$$\text{Total pressure} \quad \frac{1}{2} \times 25 \times (18)^2 = 4050\#$$

applied 6' above top footing

$$M_B = 292000\# \text{ ft}$$

$$d = \left(\frac{292000}{107.7 \times 12} \right)^{\frac{1}{2}} = 15"$$

$$\text{Total thickness of stem} = (15-3) = 12"$$

$$A_s = .0077 \times 12 \times 15 = 1.39 \text{ sq. in.}$$

$$\text{Use } 7/8" \phi \text{ bars spaced } 5" \text{ c-c} = 1.44 \text{ sq. in.}$$

$$v = \frac{4050}{12 \times 15 \times (7/8)} = 25.7 \#/\text{sq. in.} \quad \text{o.k.}$$

$$u = \frac{4050}{(12/5) \times 2.75 \times .875 \times 15} = 46.7 \#/\text{sq. in.} \quad \text{o.k.}$$

Horizontal bars use $\frac{1}{2}$ " ϕ

$$(12 \times 18) \times .0025 = .54 \text{ sq. in.}$$

$$.196 \times 2 - .196 = 59 \text{ sq. in./ft of height} \quad \text{o.k.}$$

Design of footing

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

$$\text{Total weight} = 16200 \#$$

$$\text{Moment arm} = 5.22$$

$$X = 2.03$$

(1) F.S. against sliding

$$\frac{16200 \times .4}{5000} = 1.30 \quad \text{o.k.}$$

(2) Overturning

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

Inner cantilever

$$\text{Shear at D} = 6615 \#$$

$$\text{Moment at D} = 233000 \# \text{ft.}$$

use $7/8$ " bars spaced 7"

$$5" \times 1\frac{1}{2}" = 7\frac{1}{2}" \quad \text{say 7"} \quad \text{o.k.}$$

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

$$d \text{ for moment} = \left(\frac{233000}{12 \times 107.7} \right)^{\frac{1}{2}} = 13.5$$

$$u = 77.5\# \quad \text{o.k.}$$

$$v = 30.5\# \quad \text{o.k.}$$

Outer cantilever

$$\text{Downward weight} = 675\#$$

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

$$d = \left(\frac{91,900}{12 \times 107.7} \right)^{\frac{1}{2}} = 8.45"$$

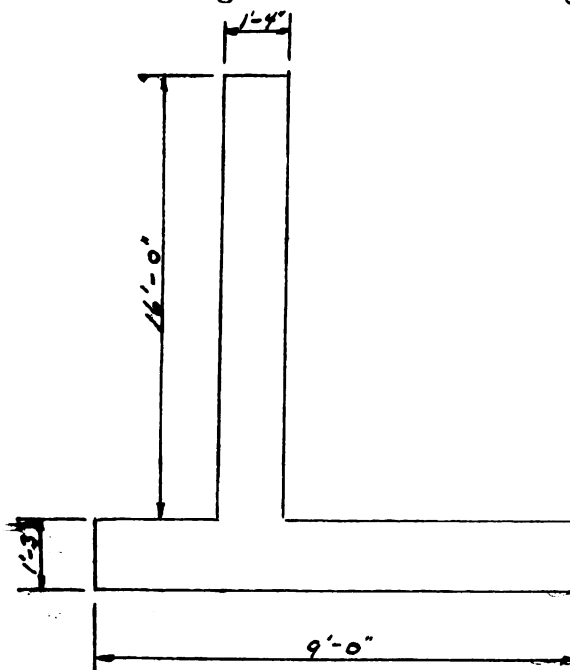
$$V = \left(\frac{3600 - 2700}{2} \right) 2.25 - 675 = 6425\#$$

$$d = \frac{6425}{(12/7) 2.75 \times 80 (7/8)} = 19.6" \quad \text{use 7" spacing}$$

$$u = 77.5\# \quad \text{o.k.}$$

$$v = 30.4\# \quad \text{o.k.}$$

Design of 16' retaining wall



• • • • •

100

• • •

1000

Design stem

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

$$M = 17050 \text{ ft.}\#$$

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

$$d = \frac{3200}{.874 \times 12 \times 40} = 7.63$$

$$A_s = .0077 \times 12 \times 13 = 1.20 \text{ sq. in.}$$

Use 7/8" ϕ bars spaced 6"

$$u = 55.5\# \text{ sq. in. o.k.}$$

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

$$\text{weight of earth } 8550\#$$

$$\text{Earth pressure } 4050 \text{ applied at } 6'$$

$$(1) \text{ Overturning M. } = 24,300 \text{ ft.}\#$$

$$\text{Resisting M. } = 72,900 \text{ ft.}\#$$

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

$$(2) \text{ Sliding F. } = 4050^{\#}$$

$$\text{Resisting F. } = 5520^{\#}$$

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

$$(3) \text{ X } = 3.53$$

$$c = 4.5 - 3.53 = .97$$

$$s = \frac{13770}{9} \left(1 - \frac{6 \times 97}{9} \right) = \frac{2520\# \text{ Comp. toe}}{540\# \text{ " heel}}$$

Design toe

Ordinate

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

$$\text{B.M.} = 5900 \text{ ft.}\#$$

$$\text{Shear} = 4840\#$$

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

$$d = \frac{4890}{.874 \times 12 \times 40} = 11.5" \quad \text{say } 12" \quad D = 15"$$

$$A_s = .0077 \times 12 \times 12 = 1.11 \text{ sq. in. Use } 7/8" \phi \text{ bars spaced } 6"$$

$$u = 83\#/\text{sq. in. o.k.}$$

Design heel

$$\text{B.M.} = 14,800 \text{ ft.}\#$$

$$\text{Shear} = 3730\#$$

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

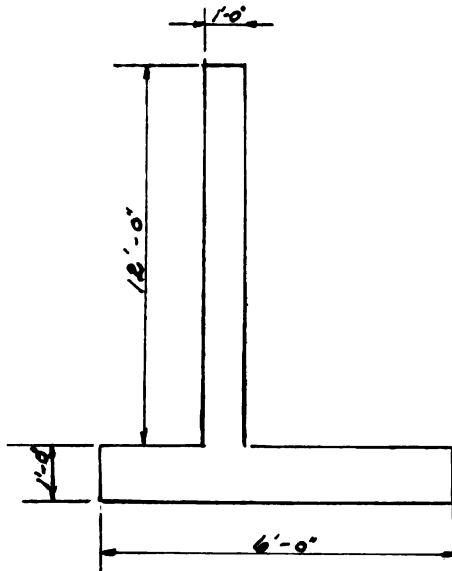
$$d = \frac{3730}{.874 \times 12 \times 40} = 8.9"$$

$$A_s = .0077 \times 12 \times 12 = 1.11 \text{ sq. in.}$$

Use 7/8 ϕ bars spaced at 6"

$$u = 64.7\#/\text{sq. in. o.k.}$$

Design of 12' wall



Weight of wall	1800#
Weight of stem	900#
Weight of earth	4200#
	<u>6900#</u>

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"

$$c = 3 - 2.18 = .82"$$

$$s = \frac{6900}{6} \left(1 - \frac{6 \times 182}{6} \right) = \begin{matrix} 2090\# \text{ comp. } toe \\ 207\# \text{ comp. } heel \end{matrix}$$

Design stem

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

$$M = 7200 \text{ ft.}\#$$

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

Shear

$$d = \frac{1800}{1874 \times 12 \times 40} = 4.3"$$

$$A_s = .0077 \times 12 \times 9 = .83$$

Use 3/4" ϕ bars spaced 6"

$$u = 49\#/\text{sq. in.} \quad \text{o.k.}$$

Design toe

$$\text{Ordinate} = 1125$$

$$\text{B.M.} = 1925 \text{ ft.}\#$$

$$\text{Shear} = 2570\#$$

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

$$d = \frac{2570}{.875 \times 12 \times 40} = 6.1 \quad \text{use } 9"$$

$$A_s = .0077 \times 12 \times 9 = .83 \text{ sq. in.}$$

Use 3/4" bars spaced 6"

$$u = 69.5\# \quad \text{o.k.}$$

Design heel

$$\text{Ordinate} = 1110$$

$$\text{B.M.} = 5350\# \text{ ft.}$$

$$\text{Shear} = 2115\#$$

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

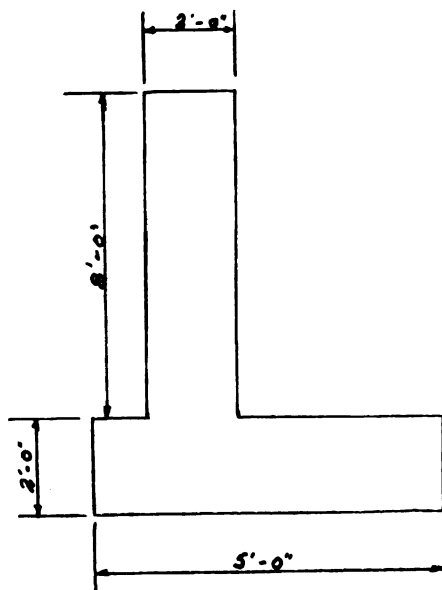
$$d = \frac{2115}{.875 \times 12 \times 40} = 5"$$

$$A_s = .0077 \times 12 \times 9 = .83$$

Use 3/4" ϕ bars spaced 6"

$$u = 57\# \quad \text{o.k.}$$

Design 8' gravity wall



Weight of stem	2300#
weight of footing	1500#
Weight of earth	1860#
	<u>5660#</u>

Earth pressure = 1250# applied 3.33'

(1) Overturning moment = 4170 ft. #

Resisting moment = 16,515 ft. #

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

(2) Sliding factor = 1250

Resisting factor = 2260

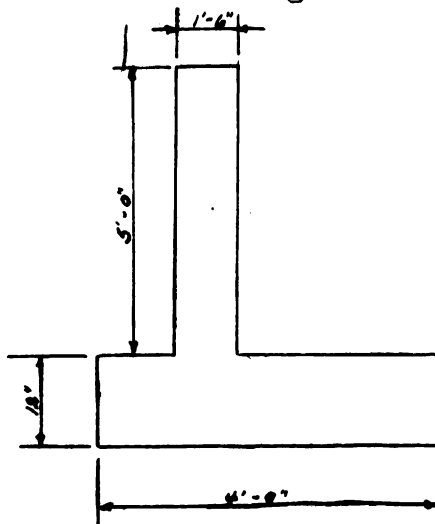
F.S. = $\frac{2260}{1250} = 1.81$ o.k.

(3) $x = 2.21$
 $c = 2.5 - 2.21 = .29'$

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

.7506 tons earth pressure o.k.

Design of 5' gravity wall



Weight of stem	1125
Weight of footing	600
Weight of earth	960
	<u>2685</u>

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 = $\frac{2685}{4} \left(1 \pm \frac{6 \times .58}{4} \right)$ = 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'

• The first step in the process of creating a new product is to identify a market need. This can be done through market research, which involves gathering information about the target market and its needs. Once a market need has been identified, the next step is to develop a concept for a new product that meets this need. This concept should be based on the market research and should take into account the needs and preferences of the target market. The concept should also be feasible, meaning that it can be developed and produced within the available resources and budget. Once a concept has been developed, the next step is to create a prototype of the product. This can be done using a variety of methods, including 3D printing, computer-aided design (CAD), and traditional manufacturing techniques. The prototype should be used to test the product and to gather feedback from potential customers. This feedback can be used to refine the product and to make any necessary changes. Once the product has been refined, the next step is to develop a marketing plan. This plan should outline the strategies and tactics that will be used to promote the product and to reach the target market. The marketing plan should also include a budget and a timeline for the marketing activities. Once the marketing plan has been developed, the final step in the process is to launch the product. This involves producing the product and distributing it to the target market. The product should be launched in a way that maximizes its visibility and reach, and that allows for ongoing monitoring and evaluation of its performance. The product should also be promoted through a variety of channels, including social media, email marketing, and traditional advertising. The final step in the process is to evaluate the product's performance and to make any necessary adjustments. This can be done through ongoing market research and feedback from customers. The product should be evaluated in terms of its sales, its profitability, and its overall impact on the market. If the product is successful, it should be continued to be promoted and distributed. If it is not successful, it should be discontinued and a new product should be developed.

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	<u>200.00</u>	\$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	<u>1,250.00</u>	\$49,000.00

ASPHALT SURFACE	7200	sq.yd..	@ \$1.00	\$7,200.00	\$7,200.00
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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	" "	@ "	<u>6,750.00</u>	\$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	<u>900.00</u>	\$ 2,505.00

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1. The first part of the document is a list of the names of the persons who have been appointed to the various offices of the Board of Directors of the Corporation.

2. The second part of the document is a list of the names of the persons who have been appointed to the various offices of the Board of Directors of the Corporation.

3. The third part of the document is a list of the names of the persons who have been appointed to the various offices of the Board of Directors of the Corporation.

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7. The seventh part of the document is a list of the names of the persons who have been appointed to the various offices of the Board of Directors of the Corporation.

8. The eighth part of the document is a list of the names of the persons who have been appointed to the various offices of the Board of Directors of the Corporation.

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

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