# CAMPUS ROAD DESIGN

Thesis for the Degree of B. S.
MICHIGAN STATE COLLEGE
H. F. Neumann
1947

# Campus Road Design

A Thesis Submitted to

The Faculty of

MICHIGAN STATE COLLEGE

of

AGRICULTURE AND APPLIED SCIENCE

By

H. F. Neumann

Candidate for the Degree of

Bachelor of Science

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## ACKNOWLEDGMENT

Grateful acknowledgment is hereby extended to Professor D. J. Hall and members of the Civil Engineering faculty of Michigan State College; to T. B. Simon and members of the Buildings and Utilities Engineering Division, for their kind and helpful suggestions made during the design and preparation of this thesis.

## INTRODUCTION AND PURPOSE

The tremendous increase of enrollment on the campus has caused many problems; one of which is the need for more available building space. To help ease this situation the College is moving the present greenhouses, from several positions on the campus, to a single position south of the Judging Pavilion, in the center of an open field.

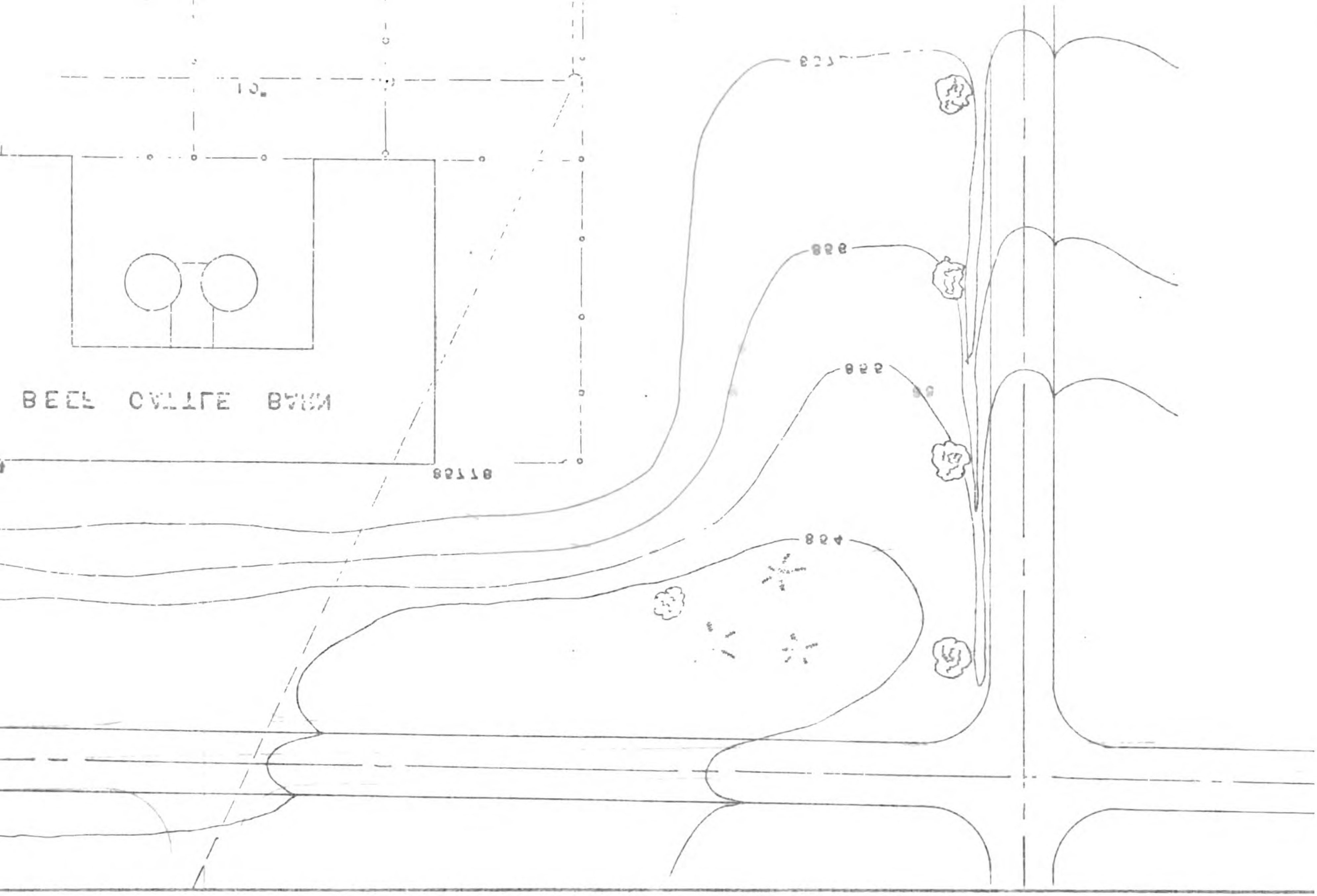
The purpose of this thesis is to provide a plan and proposal for a road which will service the greenhouses in their new location. In addition to servicing the greenhouses, this road will ease a traffic problem at the Judging Pavilion during stock shows by providing a turning loop and parking area for the extra traffic. The plan will be designed so as to conform to the landscaping scheme of the rest of the campus.

# THE SURVEY

The usual survey of the involved and surrounding area was made with a plane table and alidade, and the data plotted to scale on the map. Centerline stations were established at 100 foot intervals and the profile was run with a level and rod. The profile data was recorded in a field book, and drawn to scale on a standard profile form.

Data on the existing drainage system was obtained from the Buildings and Utilities Engineering Division.

BULL BARN
MEATS LAB.
858.32
858.32
858.23
858.25
BEEF CATTLE BARN
857.54
857.78
HYDRANT
SHEEP & CATTLE
10" EXISTING STORM SEWER
8"
10"
14"
EXISTING STORM SEWER
B.M. SOUTH BASE
ELEV. 858.02
TEL. POLE
P R O P O S E D
R O A D
P A R K I N G
P R O P O S E D
G R E E N H O U S E S
TEL. POLE
HYDRANT
HYDRANT
GREENHOUSE AREA SITE PLAN
MICHIGAN STATE COLLEGE
DATE: 4-19-1947
SCALE-1"=40'
SURVEYED BY- H.K. H.N.
DRAWN BY- H.N.
CONTOUR INTERVAL = 1 FOOT


BEEF CATTLE BARN
856
855
854

## THE CONCRETE DESIGN

The design was made possible through the cooperation and assistance of the Portland Cement Association and the Michigan State Highway Department.

The proposed road is assumed to fall under the classification of a "lightly traveled primary route*". This assumption was made because of the relative position of the road, and the Stock Judging Pavilion. During periods of stock shows, the road will provide an excellent turning circle for the heavy trucks used in the transportation of livestock. The stresses developed from the above mentioned loading will be the primary factor in the concrete design, as service for the greenhouses will never produce equivalent loadings.

Computations were made for a pavement life of 30 years, using the modulus of rupture as 700 PSI, and protected corners. The value of "k", modulus of subgrade reaction was taken as 100**#/sq. in./sq. in., and the maximum axle loading as 9000*** pounds.

Referring to the table it is found that the maximum thickness of concrete "d" required is 6.35 inches. We will use 6.5 inches for ease in construction. The necessary preliminary computations were made, and "d" was obtained from a graph* based on Westergaard's formula.

$$S = \frac{3.36\,P}{d^2}\left[1 - \frac{\sqrt{\frac{a}{l}}}{0.925 + \frac{0.22\,a}{l}}\right]$$

* Concrete Pavement Design -- Portland Cement Association.

***- Michigan State Highway Department

# PAVEMENT DESIGN FOR PRIMARY ROUTE-LIGHT TRAVEL

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| WHEEL LOAD IN POUNDS | | | LOAD REPITIONS | | REQ'D SAFETY FACTOR | (COL. 2)(COL. 4) FOR WHEEL LOADS HAVING SAFETY FACTOR LESS THAN 2 | ALLOW-ABLE STRESS $\frac{MR}{SF}$ (PSI) | REQ'D VALUE "d" (INCHES) |
| BY GROUPS STATIC | MAX FOR GROUP + 20% IMPACT | NUMBER PER DAY ONE DIRECTION | ANTICIPATED FOR 30 YR. PERIOD | CUMULATED FOR EACH LOAD PLUS HEAVIER LOAD | | | | |
| under 4000 | 4800 | 198 | 2,170,000 | over 100,000 | 2.0 | ——— | 350 | 6.3 |
| 4000–5000 | 6000 | 13 | 142,350 | " " | " | ——— | " | " |
| 5000–6000 | 7200 | " | " | " " | " | ——— | " | " |
| 6000–7000 | 8400 | 6 | 65,700 | 132,495 | " | ——— | " | " |
| 7000–8000 | 9500 | 4 | 43,800 | 66,700 | 1.91 | 420,480,000 | 366 | 6.35 |
| 8000–9000 | 10800 | 1.5 | 16,425 | 22,995 | 1.67 | 177,390,000 | 419 | 6.25 |
| 9000-10,000 | 12,000 | .6 | 6570 | 6570 | 1.42 | 78,840,000 | 476 | 6.1 |
| Subtotals cols 4, 7, & 13 for wheel load with S.F. less than 2 | | | 66,795 | | | 676,140,000 | | |
| Weighted average for wheel loads with S.F. less than 2 | 10,100 | | 66,795 | | 1.91 | | 366 | 6.35 |

# PAVEMENT DESIGN FOR PRIMARY ROUTE-LIGHT TRAVEL

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| 4000-5000 | 6000 | 13 | 142,350 | " | " | ———— | " | " |
| 5000-6000 | 7200 | " | " | " " | " | ———— | " | " |
| 6000-7000 | 8400 | 6 | 65,700 | 132,495 | " | ———— | " | " |
| 7000-8000 | 9500 | 4 | 43,800 | 66,700 | 1.91 | 420,480,000 | 366 | 6.35 |
| 8000-9000 | 10800 | 1.5 | 16,425 | 22,995 | 1.67 | 177,390,000 | 419 | 6.25 |
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in which

S = more tensile stress in PSI.

P = wheel load in pounds placed on slab corner.

d = thickness in inches of a concrete slab at the corner.

a = radius in inches of the circular area equivalent to the contact of the tire with pavement.

l = radius of relative stiffness defined by the equasion

$$l = \sqrt[4]{\frac{E\,d^3}{12(1-u^2)k}}$$

in which

E = modulus elasticity of concrete.

u = Poisson's ratio for concrete.

k = modulus of subgrade reaction in pounds per square inch per inch.

It is generally accepted that concrete slabs perform best when they are slightly stressed in compression. This fact eliminates numerous expansion joints, with the usual maximum distance between joints being between 300-600 feet. Since the proposed road is 940 feet long, it was decided that two expansion joints located at stations 3+00 and 6+00 will be adequate. Contraction joints of the dummy-grove type will be used at 30 foot intervals to control cracking.

The use of steel in concrete road design does not increase the resistance of an unbroken slab or add to its strength in any way. The sole function of the steel is to hold together the fractured faces of slabs after cracks have been formed, so as to aid in load transmission.

The area of steel required in a one foot width of slab is computed from the formula,

$$A = \frac{L\,f\,W}{2\,S}$$

in which

A = area in square inches of steel running in the direction in which L is measured.

L = the distance in feet between free transverse joints.

W = the weight in pounds of one square foot of concrete slab.

f = the coefficient of friction between slab and subgrade.

s = allowable working stress in steel in PSI.

The value of f for average use is 1.5* then

$$A = \frac{(300)(1.5)(81.3)}{(2)(28000)}$$

A = .65 sq. in./ft. of width use ½"Φ bars spaced at 4.5"** for longitudinal steel.

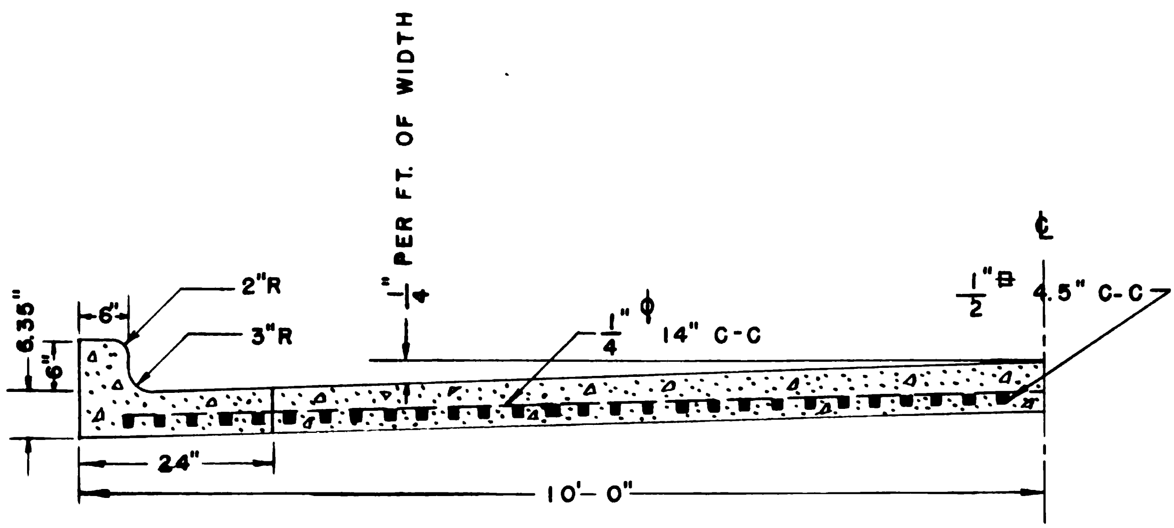
$$A = \frac{(10)(1.5)(81.3)}{(2)(28000)}$$

A = .028 sq. in./ft. of length use ¼"Φ bars @ 14" for traverse steel.

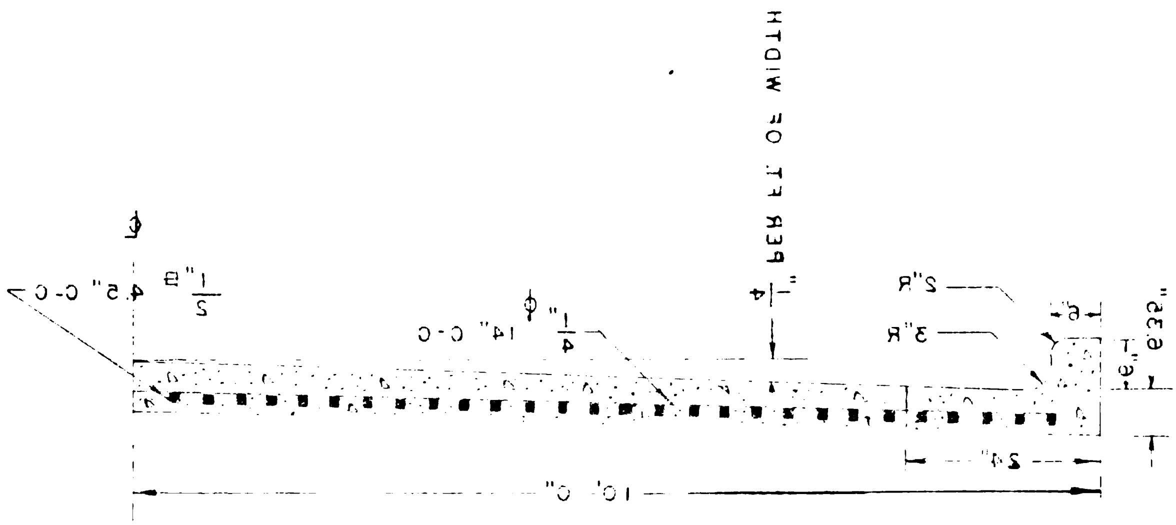
Traverse steel may also be used as tie bars across the longitudinal joint, if the steel is spaced at a distance less than 15 inches center to center, with the first bar at a distance less than 15 inches from the edge of the slab. Deformed bars cannot be used for this purpose as required slippage between steel and concrete would not be available. Very often a grease on bituminous coating on the steel is used to prevent bond.

* PCA

** Reinforced Concrete Design Handbook, Table 3, Pg. 66.




| | |
|---|---|
| MICHIGAN STATE COLLEGE<br>GREENHOUSE ROAD | |
| ROAD CROSSECTION | |
| SCALE - 1" = 2' | DRAWN BY<br>H. F. N. |




| | |
|---|---|
| MICHIGAN STATE COLLEGE<br>GREENHOUSE ROAD | |
| ROAD CROSSECTION | |
| SCALE - 1"=2' | DRAWN BY<br>H.F.N. |

## STORM SEWER DESIGN

Data and information on the existing storm sewers in the area was obtained from the Buildings and Utilities Engineering Division, and the road drainage was designed accordingly.

After studying the contour and profile maps it was evident that comparatively little storm water runoff from the surrounding area would drain on to the pavement, therefore drainage from the road only, need be considered.

Since the existing 14" storm sewer intersects the proposed road near Farm Lane, it is convenient to construct a manhole and catch basins at this intersection, and drain the runoff directly into the existing line.

The high point of the road occurs at station 4+80, necessitating catch basins and a manhole at the intersection of South Shaw Lane and the proposed road. From this position, the runoff is carried to an existing manhole in the 14" line approximately 150 feet north east of the intersection and 55 feet due north of ℄ of South Shaw Lane.

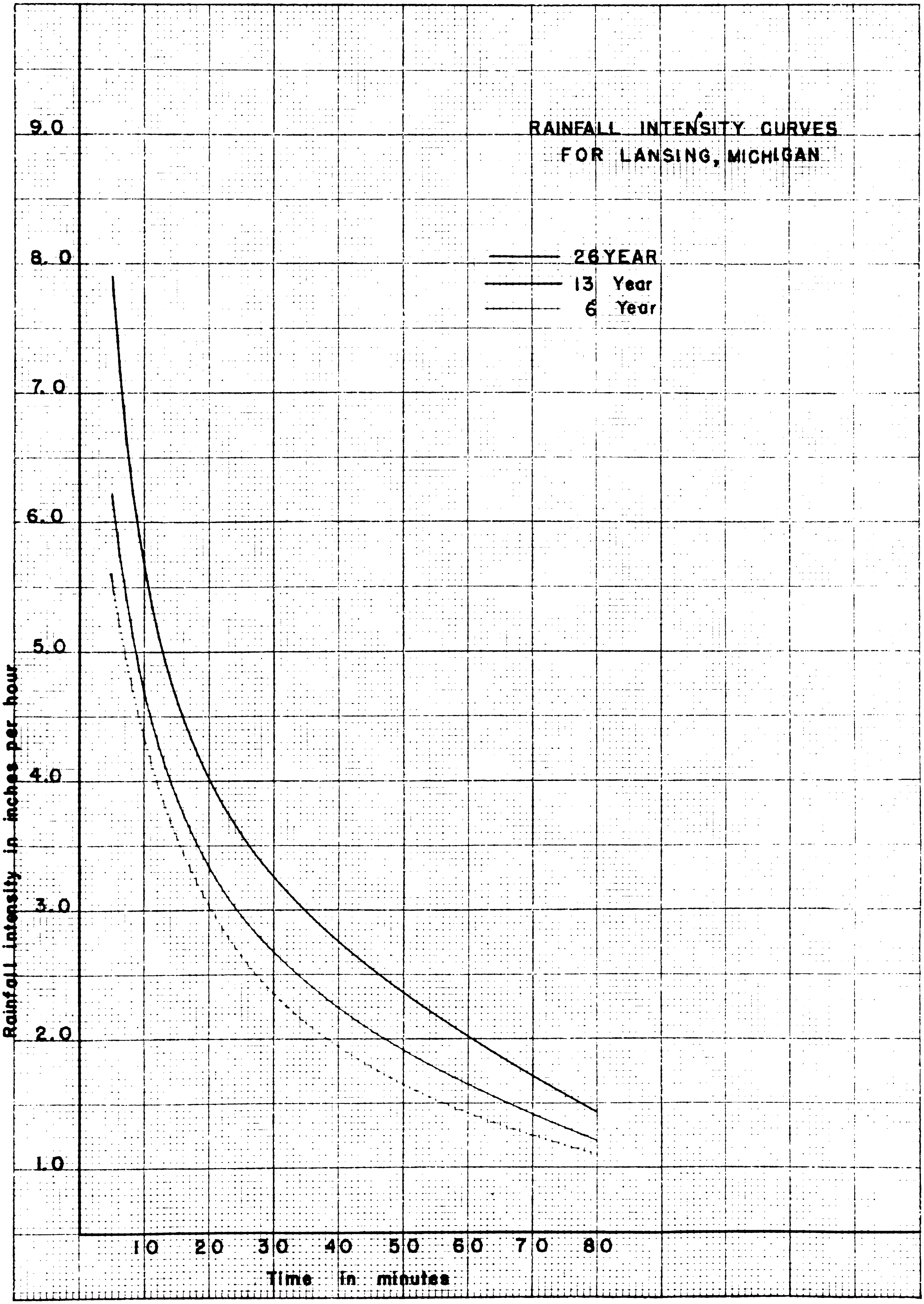
**Storm sewers in this vicinity are designed for a storm frequency period of ten years. Referring to the rainfall intensity curves, using the time of concentration as 12 minutes, and interpolating the 10 year curve between the 6 and 13 year curves, we find the rainfall intensity is 4.15 inches per hour. The coefficient of runoff for concrete is .85.**

The equation used in computing the diameter of the sewer pipe is

$$Q = AIR^*$$

in which

* Water Supply and Sewerage - Steel, Pg. 335.



RAINFALL INTENSITY CURVES
FOR LANSING, MICHIGAN
26 YEAR
13 Year
6 Year
Rainfall intensity in inches per hour
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
10
20
30
40
50
60
70
80
Time in minutes

Q = quantity in cubic feet per second.

A = drainage area in acres.

I = Rainfall intensity in inches per hour.

R = coefficient of runoff.

Considering first the quantity to be drained by MH-1 and designing for a minimum velocity of 3 feet per second, we find, referring to the table, a pipe 8" in diameter is needed. The existing 14" sewer will adequately carry this required capacity, and 8" lines will be used connecting each catch basin with the manhole.

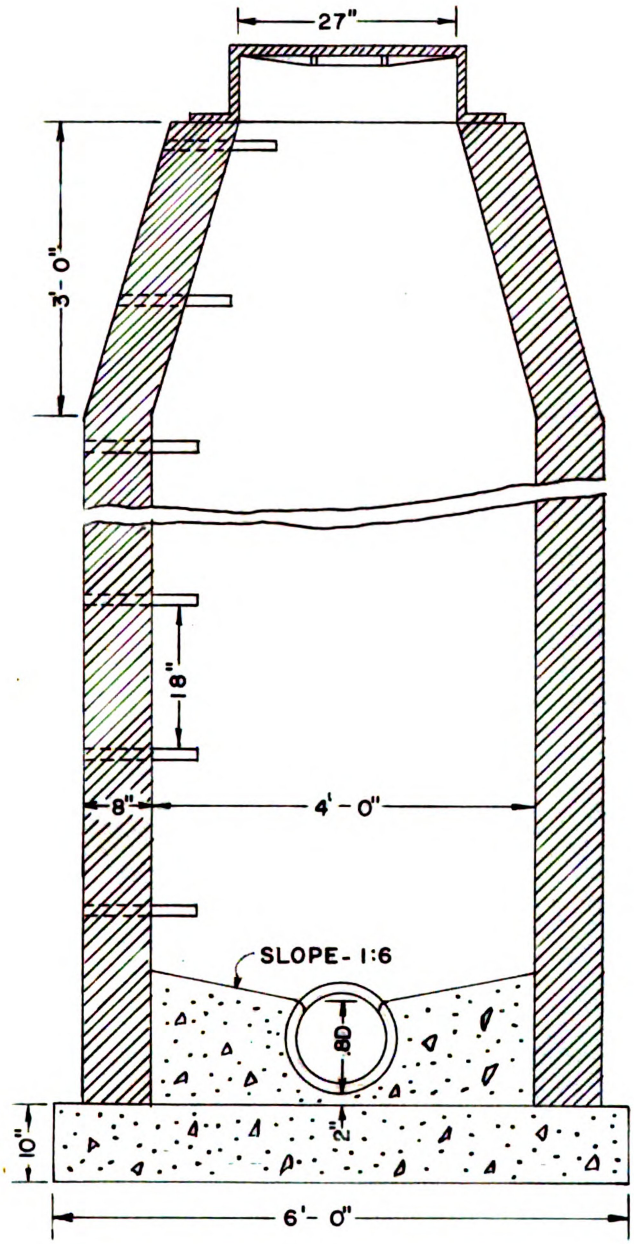
The quantity of storm water flowing into MH-2 is such that an 8" line will have the desired capacity, so an 8" pipe will be used to drain each catch basin into the manhole. The usual practice is to use a minimum diameter of 10" for storm sewers, therefore a 10" line will be installed from MH-2 MH-3.

# STORM SEWER DESIGN FOR PROPOSED ROAD

| LINE | FROM | TO | AREA (ACRES) | RAINFALL INTENSITY (Inches / hour) | RUNOFF COEFF. | CAPACITY (C.F.S.) | DIAMETER OF PIPE | VELOCITY (Feet / sec) | SLOPE |
|---|---|---|---|---|---|---|---|---|---|
| M. H. I | CATCH BASINS | M.H. I | .211 | 4.15 | .85 | .71 | 8 | 3 | 0.01 |
| PROPOSED LINE | M. H. 2 | M.H. 3 | .22 | 4.15 | .85 | .775 | 8 | 3 | 0.0095 |

# STORM SEWER DESIGN FOR PROPOSED ROAD

| LINE | FROM | TO | AREA (ACRES) | RAINFALL INTENSITY (Inches/Hour) | RUNOFF COEFF | CAPACITY (C.F.S.) | DIAMETER OF PIPE | VELOCITY (Feet/Sec) | SLOPE |
|---|---|---|---|---|---|---|---|---|---|
| M.H.1 | CATCH BASINS | M.H.1 | .211 | 4.15 | .85 | .71 | 8 | 3 | 0.01 |
| PROPOSED LINE | M.H.2 | M.H.3 | .22 | 4.15 | .85 | .775 | 8 | 3 | 0.0059 |

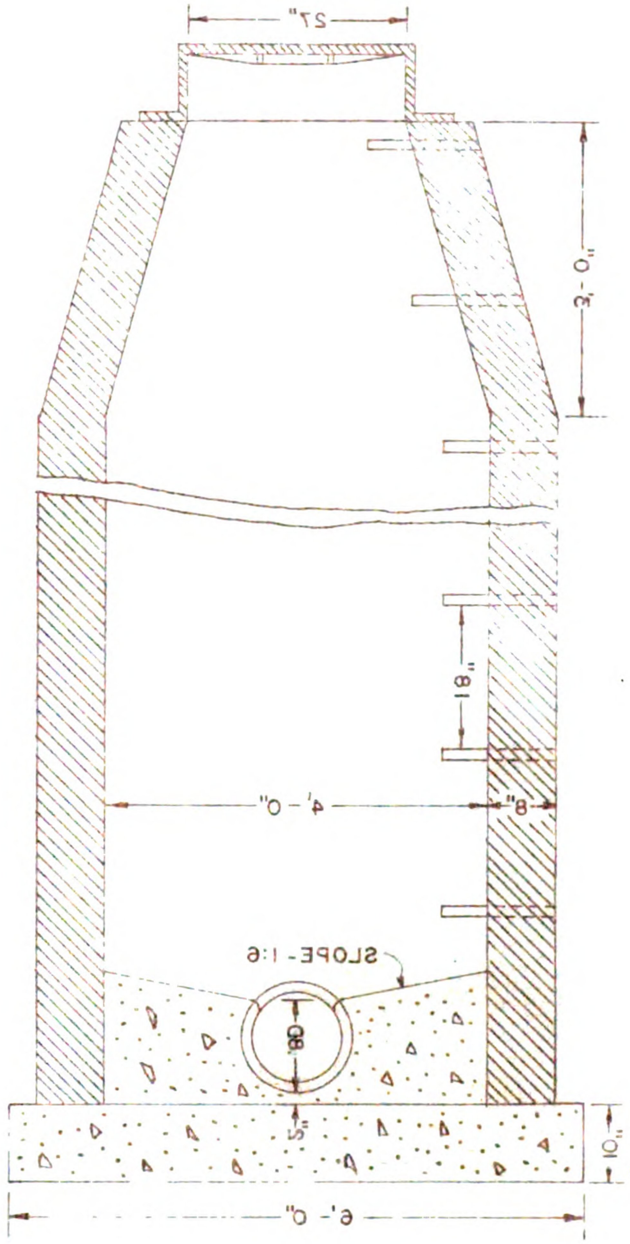



MICHIGAN STATE COLLEGE
GREENHOUSE ROAD

MANHOLE DETAIL

SCALE - 1" = 2'

DRAWN BY
H. F. N.

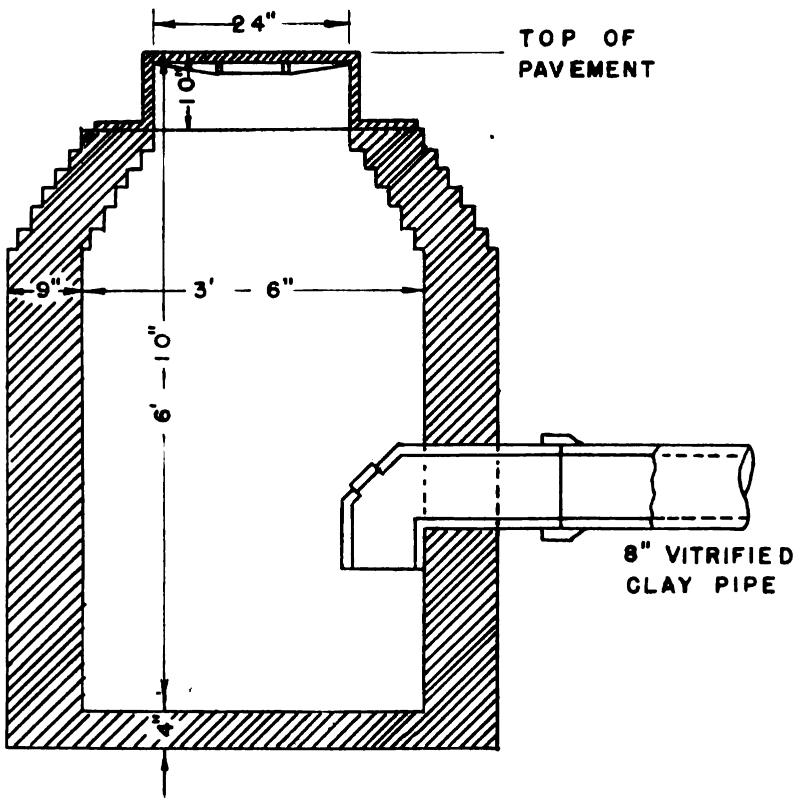



MICHIGAN STATE COLLEGE
GREENHOUSE ROAD

MANHOLE DETAIL

DRAWN BY
H.F.N.

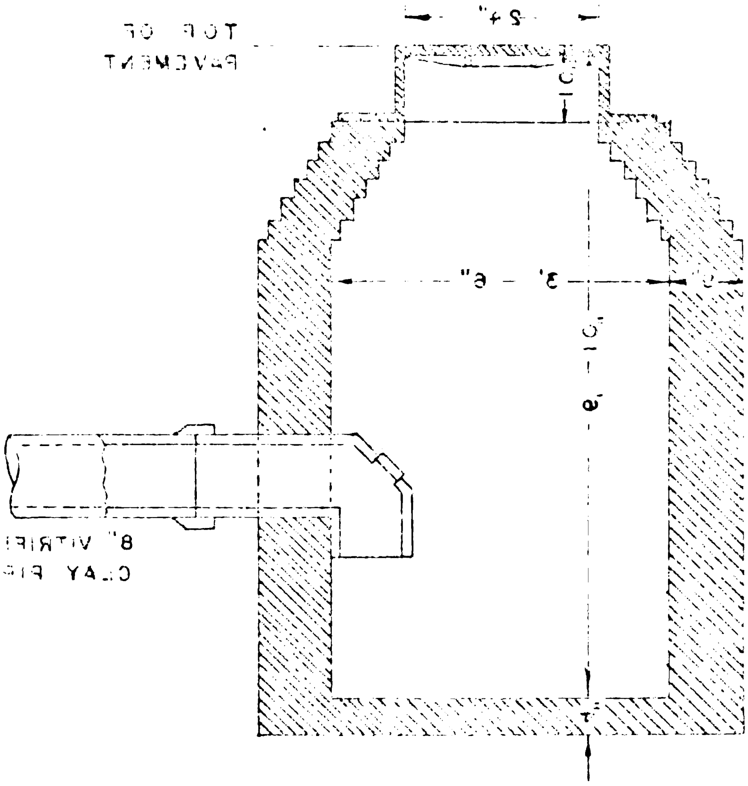
SCALE - 1" = 2'




MICHIGAN STATE COLLEGE
GREENHOUSE ROAD

CATCH BASIN
DETAIL

| SCALE 1" = 2' | DRAWN BY H.F.N. |
| --- | --- |




MICHIGAN STATE COLLEGE
GREENHOUSE ROAD

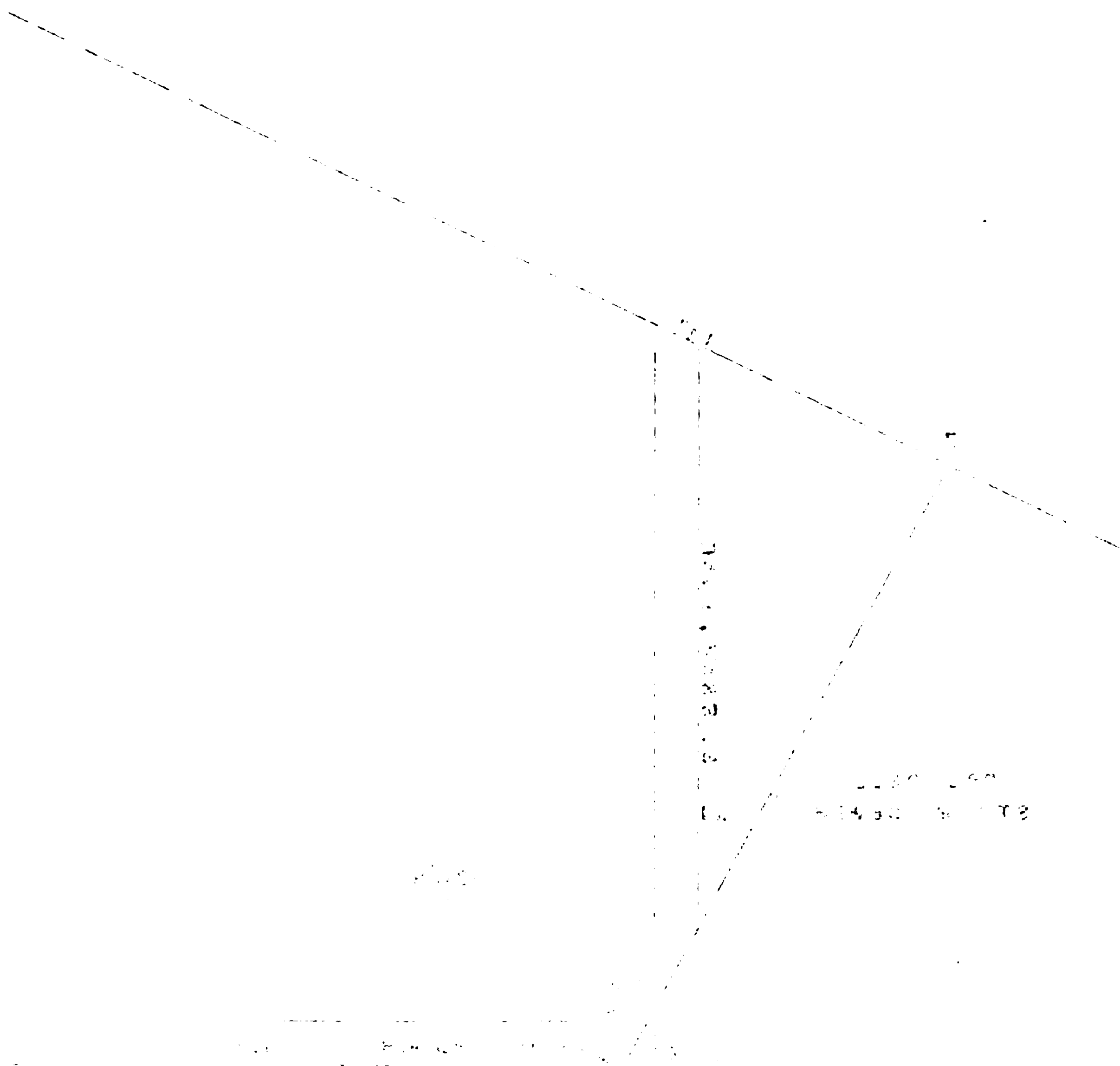
CATCH BASIN
DETAIL

| | |
|---|---|
| DRAWN BY<br>H.F.M. | SCALE 1"=2' |

## ESTIMATION OF QUANTITIES

| ITEM | | QUANTITY |
|---|---|---|
| Fill dirt | | 216 cu. yds. |
| Finishing earth grade | | 3470 sq. yds. |
| Steel (longitudinal) | $\frac{1}{2}$" $\phi$ | 48000 lbs. |
| (transverse) | $\frac{1}{4}$" $\phi$ | 3000 lbs. |
| Concrete | | 416 cu. yds. |
| Catch basins | | 4 |
| 8" pipe (vitrified clay) | | 50 lin. ft. |
| 10" pipe " " | | 150 lin. ft. |
| Manholes | | 2 |

| PLAN | | BY | DATE |
|---|---|---|---|
| NOTE BOOK | SURVEYED | | |
| | PLOTTED | | |
| | ALIGNMENT CHECKED | | |
| | RT. OF WAY CHECKED | | |



## APPROXIMATE COSTS - 1939

| | | |
|---|---|---|
| Fill material | 216 cu. yds. @ $0.60 | $130.00 |
| Leveling subgrade | | 26.00 |
| Water supplied by College | | |
| Steel forms | | 138.80 |
| Reinforcing steel | | 2142.00 |
| Placing reinforcement | | 104.10 |
| Concrete materials | | 2387.00 |
| Mixing & placing | | 1060.00 |
| Finishing | | 1000.00 |
| Curing | | 655.00 |
| Cleaning up | | 16.00 |
| Catch basins | 4 @ $48.80 | 195.20 |
| Manholes | 2 @ $130.00 | 260.00 |
| 8" VC pipe | 50 ft.@ $0.28 | 14.00 |
| 10" VC pipe | 150 ft.@ $0.47 | 70.50 |
| | TOTAL 1939 Cost | $8198.60 |

ENR INDEX 1939 -- 235*

" " 1947 -- 395

$$\frac{\text{1939 Cost}}{\text{1939 Index}} = \frac{\text{1947 Cost}}{\text{1947 Index}}$$

$$\frac{8198.60}{235} = \frac{C}{395}$$

$$C = \frac{(8198.6)(395)}{235} = \$13,780.00$$

* Engineering News Record, April 17, 1947, Pg. 108.