A STUDY TO DETERMINE THE ECONOMICAL DESIRABILITY OF FLOOD PREVENTION ON THE SYCAMORE MUNICIPAL GOLF COURSE

Thesis for the Degree of B. S.

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Drainage

Civil eng. Hydraulic engineering

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A Study To Determine The Economical
Desirability Of Flood Prevention On
The Sycamore Municipal Golf Course

A Thesis Submitted to
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By

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REASONS FOR CONSIDERATION OF

THIS PROJECT

This subject was selected as a project for thesis for several reasons.

1. Up to the present time there has been no map made of the Sycamore Golf Course.

2. This course is always the last to be in shape for play in the spring of the year.

3. No observations have been previously made as to the maximum flood stage of the creek.

4. The velocity of the creek at flood stage is such that it is eroding the banks at its bends.

5. It is a fairly new course, being built on old swamp land, and has no adequate system of drainage at present.

METHOD OF PRESENTATION

OF THE SUBJECT

This thesis is divided into several subject heads as:

1. Topographic Survey and map.

2. Design and construction of dyke.

3. Selection of drainage system and its location.

4. Consideration of size and type of pump.

5. Cost analysis.

6. Conclusions as to the feasibility of such a system of flood prevention.

TOPOGRAPHIC SURVEY AND MAP

The Sycamore Golf Course of Lansing is located in the southeastern portion of the city just south and adjacent to Mt. Hope Avenue and west of Sycamore Creek. The entrance to the course is just opposite the intersection of Lindberg Drive and Mt. Hope Avenue.

Inasmuch as the course was formed by the filling in of swamp land, which resulted in a natural settlement of the fill, portions of the course are caused to become flooded, creating an abnormal situation in regard to proper drainage of the course. In fact, the general level of the course is so low that any perceptible rise in the creek level causes portions of the course to become flooded. At the time of construction, the general level of the course was such that no unusual situations were encountered in regard to annual spring floods.

Another contributing factor causing excessive flooding of the course is that the topography of the surrounding land is such as to provide a watershed tending to drain on the course.

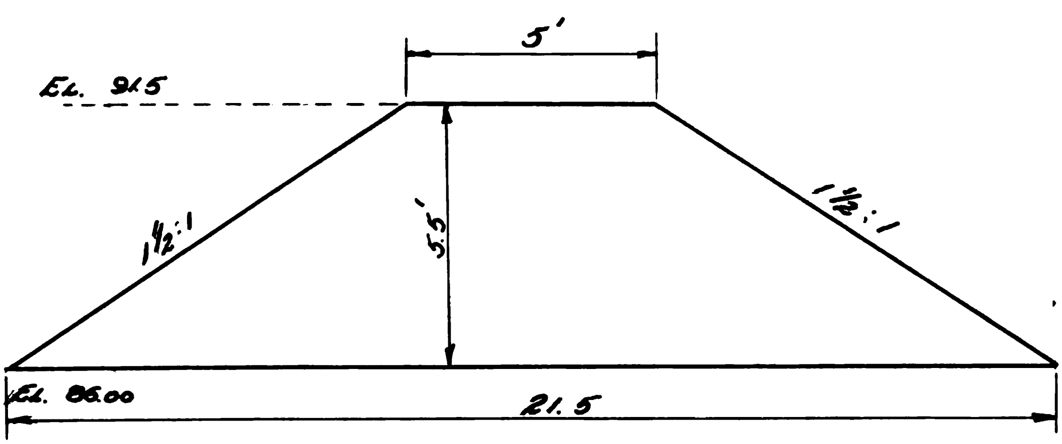
In view of the above mentioned facts, a suitable topographic map* of the area is necessary to determine the methods of correcting this condition.

*Map in inside of back cover.

DESIGN AND CONSTRUCTION OF DYKE

The purpose of the dyke is to keep the low portions of the golf course, which are at an elevation considerably lower than the flood stage of the river, from becoming flooded during the early spring months. Water collecting in such a manner is difficult to remove and necessarily results in the closing of the course until the water has been taken care of. A dyke, as proposed, will limit the flood flow of the river to the channel formed by the construction of a dyke on the one side and the bank, which is of adequate height to take care of any flow which might ever occur.

A dyke as shown in the sketch below is considered as being adequate.



The top width was determined by use of the formula,

$W = 2\sqrt{H}$ $\quad$ $W = 2\sqrt{5.5} = 4.7'$ $\quad$ H = Height of dyke.

The position of the dyke is shown on the map, and as can be seen, originates and terminates in banks which mark the beginning of higher ground and whose elevation is much greater than that as selected for the top elevation of the dyke.

To Determine the Amount of Fill

In order to determine the volume of fill necessary for the construction of the dyke, use was made of the end-area formula,

$$V^1 = \frac{A_0 + A_1}{2} \times L$$

Where, A_0 = Area of cross section at station 0 in square feet.

A_1 = Area of cross section at station 1 in square feet.

L = Distance in feet between stations.

V^1 = Volume of fill in cubic feet.

For the sake of convenience, the volumes are converted to cubic yards, $V = \frac{V^1}{27}$.

Results of the computations are as follows:

Station	Volume of Fill in Cubic Yards
0-1	300
1-2	380
2-3	455
3-4	438
4-5	617
5-6	462
6-7	365
7-8	87
	3104 cu. yds.

allowance for shrinkage (.25) 3104 = 776 cu. yds.
total fill = 3880 cu. yds.

<u>To Determine the Factor of Safety Against Sliding</u>

In order to determine water pressure the formula,

$P = \frac{WH^2}{2}$, is used.

Where, W = 62.4# per cu. ft.

H = Height of dyke in feet

$P = \frac{62.4}{2} \times 5.5^2 = 974.05$ lbs.

The downward pressure exerted by the mass of the dyke is determined from the formula, $P = \frac{(a + b)h}{2} \times w^1$

$= \frac{(5 + 21.5)5.5}{2} \times 100 = 7288$ lbs.

a = top width of the dyke

b = bottom " " " "

h = height of the section

w^1 = unit weight of the fill, 100# per cu. ft.

Assuming the value of the coefficient of friction as being 0.5, the factor of safety may be determined,

$$\text{Safety factor} = \frac{(7288)(0.5)}{974.05} = 5$$

The factor of safety against sliding can be determined in this manner because the flood stage is not continuous and the fill used in the construction of the dyke may be considered as being 100# per cubic foot at all times.

It was deemed advisable to sod the river side of the dyke to provide adequately against erosion by the swift currents in time of high water. Sod has proven to be the most satisfactory form of protection.

To Determine the Amount of Sod

Station	Area of Sod Necessary in Square Yards
0-1	160
1-2	149
2-3	293
3-4	311
4-5	395
5-6	241
6-7	199
7-8	143
total	1890 Sq. yds.

However, in order that the scenic value of the course will in no way be impaired, the top and remaining side of the dyke will have to be seeded, serving only to preserve the beauty of the course and having no value in regard to increasing the quality of the dyke.

<u>To Determine the Area to be Seeded</u>

Station	Area to be Seeded in Square Yards
0-1	460
1-2	282
2-3	484
3-4	582
4-5	720
5-6	432
6-7	399
7-8	384
total	3743 sq. yds.

SELECTION OF DRAINAGE SYSTEM AND ITS LOCATION

Drainage System

A drainage system was found necessary for the following reasons:

1. Portions of the golf course are lower than the creek stage in early spring.

2. There is need of a means of concentrating the drainage to a pump which is to lift the water over the dyke.

Before a tile drainage system could be intelligently designed, an accurate survey had to be made and the course mapped. Insofar as underdrainage generally follows surface drainage, the topographic map can be used.

The map shows possible outlets, boundary lines of the course (fence and creek), and the area of the watershed to be drained by the proposed system.

Outlets for the drains were selected at what was judged to be the most convenient, as well as effective location. If possible, the outlets should not be submerged.

Arrangement of the drains was determined by the topography of the land and, where possible, the slope of the laterals and mains was made to conform with the slope of the ground.

The arrangement used is what is known as the natural system, the laterals making less than forty five degree angles with the mains to avoid retardation of flow.

In general, the practice has been to lay drains $3\frac{1}{2}$ to 4 feet in loam soil, but on the Sycamore Course the soil being principally clay, and it being necessary to keep the outlets of the drains as high as possible, the maximum depth was 2 feet. This depth was deemed sufficient to avoid frost action and would not interfere with growth of grass.

To determine the size of drains, a run-off modulus of $\frac{3}{4}$ was used. This was found to be ample for this vicinity. The drainage area was measured on the map by means of a planimeter.

Division of the course into two drainage areas was necessary because of the elevation of a ridge that crosses the course at green number one. All land north of this ridge is noted as drainage area number one and that to the south is drainage area number two.

In view of the fact that the tile is not very large, it would be cheaper to excavate by hand.

The best time to lay tile in ordinary soil is in the late spring when the ground is in the best condition for digging, but because of the inconvenience and the retarding of the readiness of the course for play, it would be advisable to excavate and place the tile in the late summer, when fewer people desire to play golf.

Estimated cost of trenching, tile, and covering will be found on the cost sheet.

Calculations to determine the size of drain may be found on the following page.

<u>Calculations for Size of Drains</u>

Drainage Area #1 = 20.03 acres

3/4 x 1/24 = .0314

Slope = .8%

Flow = .0314 x 20.03 = 628 c.f.s.

*From discharge diagram for tile drains based on U.S.D.A. formula, $V = 138R^{2/3}S^{\frac{1}{2}}$

diameter = 6"+

Use 500' of 8" mains

1670' of 4" laterals

Drainage Area #2 = 21.92 acres

3/4 x 1/24 = .0314

Slope = .2%

Flow = .0314 x 21.92 = .6883 c.f.s.

From diagram

diameter = 8"+

Use 1020' of 10" mains

2435' of 4" laterals

*Found in, "Drainage and Flood Control Engineering" by G. W. Pickles.

CONSIDERATION OF SIZE AND TYPE OF PUMP

In consideration of the correct style and size of pump to be used, several items must be taken into account. These items include:

1. The amount of water to be pumped over the dyke.

2. The minimum and maximum head under which the pump will be expected to perform.

3. The time which should be allowed for draining of the course, and finally,

4. Whether or not the pumping equipment should be permanently located in a predetermined position, probably near the outlet of the drains.

These items will be considered in the order named.

To Determine the Amount of Water to be Pumped

From previously determined knowledge and observations, the average depth of water over the entire drainage area was considered as being 3 inches. Naturally, water will be deeper in some portions than in others, but based on observatory knowledge this value is acceptable as being a good average.

Drainage Area #1	Drainage Area #2
Area = 20.03 acres	Area = 21.92 acres
Average depth = 3 inches	Average depth = 3 inches
Q = (20.03)(43,560)3/12	Q = 21.92(43560)3/12
Q - 218,126 cubic feet	Q - 238,491 cubic feet

The minimum and maximum head under which the pump will be expected to operate will not vary greatly from 8 to 10 feet. This value, being as low as it is, assures greater efficiency and capacity regardless of which type of pump is ultimately selected.

Time, in determining the size of pump, is a very important item. In selecting the time in which the water must be removed, first consider the following example.

Considering only drainage area #1 for purpose of this discussion.

The total quantity to be removed is roughly 220,000 cubic feet. If this quantity were to be removed in 24 hours, the capacity of the pump would have to be 1140 gallons per minute, if in 30 hours, the capacity would be 930 gallons per minute, and if in 36 hours, the capacity would be 770 gallons per minute. In case the time is either a 24 or 30 hour period, the pump would have to be larger than if a 36 hour period were decided upon. This information would induce the selection of a 36 hour period as the difference in initial cost of the two pumps under consideration is approximately equal to the initial cost of the smaller machine.

As one would suspect, the pumps might either be permanently located or of a portable type. The advantage of the permanently located pump lies in the fact that it would be on the spot ready for operation at a moment's notice. On the other hand, a portable setup might be used to advantage to help drain small portions of the course which would not otherwise be drained in a desirable length of time.

The cost of the two setups would be approximately the same. In case the portable pump were selected, its original cost would be greater than as though it were simply mounted on skids. The difference in price would be necessary to construct a suitable foundation for the pump that would be permanently located, making the resulting costs about equal. However, due to the topography of the course and the presence of several small portions at exceedingly low elevation, the portable type of pump would likely prove the more efficient.

After having selected the size of pump and its mounting, another feature of importance is that of priming. Pumps of this type may either be self-priming or what is commonly known as straight pumps. The self-priming pump was selected, at a higher cost, because it would entail no loss of time in setting the machinery to work, and inasmuch as time is such an important item, this feature would be a desired asset.*

*For further information, consult the Novo Engine Company's bulletins on self-priming pumps.

COST ANALYSIS

A cost analysis in a project of this type is of vital importance because it will show the feasibility of this type of flood prevention.

For purposes of convenience, the cost will be divided into three parts. First, the cost of the dyke; second, the cost of the drainage system; and finally the cost of the pumping equipment.

The Cost of the Dyke*

3880 cubic yards of fill @ $.33 per cubic yard	=	$1280.40
1890 square " " sod @ $.10 per square "	=	189.00
Cost of seeding the remaining portion 3743 square yards @ $.015 square yard	=	55.15
		$1524.55

The Cost of the Drainage System*

4,115 feet of 4" pipe @ $50 per 1000 feet	=	$205.75
500 feet of 8" pipe @ $70 per 1000 feet	=	35.00
1,020 feet of 10" pipe @ $80 per 1000 feet	=	81.60
trenching, laying, and backfilling 5635' @ $.10 per ft.	=	533.50
		$885.85

The Cost of Pumping Equipment**

2--4" self priming centrifugal pumps @ $565 = $1130

*All prices and wage scales determined from current issues of the Engineering News-Record.

**Price quoted by local manufacturing company.

The Total Cost

cost of dyke	$1524.55
cost of drainage system	885.85
cost of pumping equipment	1130.00
	$3540.40

This type of pump has a normal gasoline consumption of 1/5 gallon per horsepower hour. Assuming the pumps to be in use on 20 separate occasions and the maximum horsepower to be 15, the annual fuel bill will be,

$$2\left[\frac{15 \times 20 \times 36}{5}\right] \times \text{cost of gasoline}$$

$$4320 \times \$.15 = \$648.00$$

For this type of pump the oil consumption is negligible and its cost may be omitted.

CONCLUSIONS AS TO THE FEASIBILITY OF SUCH A SYSTEM OF FLOOD PREVENTION

The results of this method of flood prevention, as shown conclusively by the cost analysis, would not be satisfactory if the benefits derived were to be judged solely on the increased patronage of the course during the early spring months, or at intervals during the playing season when this course would precede the other courses in the city in opening after periods of intense precipitation.

Several reasons may be advanced for the seemingly high cost of putting a system as proposed by this study into operation. These reasons, in order of their importance, may be listed as:

1. The present attempt at drainage is entirely inadequate, as only a very small portion of the course is affected by the system in use at present. This means that all drain pipe and related equipment would have to be purchased new.

2. In case the present drainage system was expanded to proper proportions, two pumps would be necessary to pump the water from the outlet of the drains over the dyke and into the stream. At present, no pumps are provided, requiring the purchase of two new pumps.

Based on this study, the conclusion finally reached was that the system, as proposed, would serve the particular needs demanded. The conclusions were based on the following points:

1. The cost would not be prohibitive if properly financed over a period of years. Results show that in-

creased proceeds would not serve to pay for this added expense of improvement in a few years.

2. If properly installed and maintained, this system would improve the value of this course from the standpoint of retaining its natural scenic qualities.

3. Allowing for the natural expansion of the city, resulting in a possible increased patronage of this course, the rate at which the debt is erased by this system of flood prevention would tend to be increased.

[redacted]

[redacted]

Pocket has 2 maps