CONNECTICUT RIVER FLOOD CONTROL PROJECT

NORTHAMPTON, MASS.

CONNECTICUT & MILL RIVERS, MASSACHUSETTS

ANALYSIS OF DESIGN

FOR

LOCAL PROTECTION WORKS

ITEM N. 3

DIVERSION CANAL. OXBOW BRIDGE AND
DIKE ALONG EAST BANK MILL RIVER
PART CONTRACT, PART HIRED LABOR

1939

CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE PROVIDENCE, R.I.

407-670A

CONNECTICUT RIVER FLOOD CONTROL

/ ANALYSIS OF DESIGN

NORTHAMPTON DIVERSION CANAL.

NORTHAMPTON, MASSACHUSETTS

ITEM N.3

CORPS OF ENGINEERS, UNITED STATES ARMY

UNITED STATES ENGINEER OFFICE PROVIDENCE, RHODE ISLAND

NORTHAMPTON DIVERSION CANAL

FISCAL YEAR 1939 UNIT

TABLE OF CONTENTS

		PAGE
PERTINENT DATA.		
I.	INTRODUCTION.	
	A. AUTHORIZATION AND PAST REPORTS.	1
	B. BRIEF DESCRIPTION OF DIVERSION CANAL, DIKE AND APPURTENANT STRUCTURES	1
	C. WORK SUBDIVISIONS OF NORTHAMPTON DIKE	2
II.	SELECTION OF SITE.	
	A. GENERAL LOCATION	3
	B. ALINEMENT OF DIVERSION CANAL	3
	C. DROP-STRUCTURE LOCATION	3
	D. ALINEMENT OF SOUTH AND EARLE STREETS RELOCATION	3
	1. South Street Relocation	3
	2. Earle Street Relocation	4
	E. MILL RIVER DIKE AND WALL ALINEMENT	4
III.	GEOLOGICAL INVESTIGATIONS.	
	A. NATURE OF VALLEY.	5
	B. METHOD AND EXTENT OF EXPLORATIONS	5
	C. SITE	6
	1. Diversion Canal	6
	2. Mill River Dike and Wall	6
	D. DISPOSAL OF EXCAVATION	6
IV.	HYDROLOGY.	
	A. RAINFALL.	8
	1. Maximum storms of record.	8

PAGE

2. Diversion canal design storm 8

B. RUN-OFF.

1. Records 9

2. Percent of runoff 9

3. Unit hydrograph 10

4. Design flood 10

5. Frequency of diversion canal design flood 10

V. LABORATORY AND FIELD INVESTIGATIONS OF SOILS FOR FOUNDATIONS.

A. CLASSIFICATION OF MATERIALS 11a

B. GRAIN SIZE ANALYSIS 11a

C. WATER CONTENT AND VOID RATIO. 13

D. PERMEABILITY 13

E. CONSOLIDATION 13

F. SHEAR AND COHESION 13

G. OTHER TESTS 13

VI. GENERAL DESIGN.

A. MILL RIVER DIKES 14

B. MILL RIVER CLOSURE DIKE 15

C. DIVERSION CANAL

1. General 16

2. Stability of side slopes 16

3. Erosion from hydraulic discharge 17

4. Drop-structure design 17

a. General 17

b. Walls 17

c. Floor 18

PAGE

d. Timber bearing piles 18

e. Drainage 18

f. Steel Sheet Piling Cut-off 18

5. Drop-structure outlet 19

6. Pilot canal 19

7. Bridle Path Overflow Section 19

8. Bridge at Present Ox-Bow 19

D. SOUTH STREET BRIDGE 19

E. RELOCATION OF SOUTH AND EARLE STREETS 20

1. South Street relocation 20

2. Earle Street relocation 20

VII. HYDRAULIC DESIGN.

A. DESIGN CRITERIA 21

B. GENERAL DESCRIPTION 21

C. NATURAL RIVER SECTION 21

D. PAVED DIVERSION CANAL 23

E. DROP-STRUCTURE 23

F. PILOT CANAL 24

G. GENERAL DISCUSSION 25

VIII. STRUCTURAL DESIGN

A. SOUTH ST. BRIDGE, NORTHAMPTON, MASS. 26

1. General Information

a. General description of the structure 26

b. Provisions for expansion and contraction 26

c. Railings 27

d. Curbs 27

PAGE

2. Design data 27

a. General 27

b. Live loads 27

c. Dead loads 28

d. Pier and abutments 28

e. Unit weights 29

f. Earth pressures 29

g. Hydrostatic uplift 29

h. Overturning 29

i. Sliding 30

j. Bearing 30

k. Frost cover 30

l. Path of percolation 30

m. Reinforced concrete 30

(1) Allowable stresses 30

(2) Flexure (fc.) 30

(3) Shear (v). 31

(4) Bond (u.) 31

(5) Bearing (fc) 31

(6) Steel stresses 31

(7) Protective concrete covering 31

B. DROP-STRUCTURE 32

1. Retaining Walls 32

2. Wall Proportions 32

3. Loading 34

4. Pile Spacing Under Walls 34

PAGE

5. Weir and Floor Slab 35

C. STRUCTURES OF MILL RIVER PROTECTION WORKS 36

1. Stop-log structure 36

2. Flood wall 36

3. Highway bridge 37

IX. CONSTRUCTION PROCEDURE.

A. DIVERSION CANAL - CONTRACT WORK N3b

1. Field operations 38

2. Inspection and tests 39

B. DIVERSION CANAL RIPRAP - CONTRACT WORK N3C

1. Field operations 39

2. Inspection and tests 40

C. MILL RIVER PROTECTION WORKS - HIRED LABOR N3d.

1. Field operations 40

2. Inspection and tests 41

X. SUMMARY OF COSTS.

A. GENERAL

B. DIVERSION CANAL - FISCAL YEAR 1939 UNIT - ESTIMATED COST

C. MILL RIVER DIKE - FISCAL YEAR 1940 UNIT - ESTIMATED COST

XI PLATES.

LIST OF PLATES.

APPENDIX A. CONCRETE AND STEEL COMPUTATIONS.

South St. Bridge Pages A1-A39

Drop Structure A40-A122

West St. Stop Log Structures A123-A155

Flood Walls A156-A174

Ox Bow Bridge A175-A184

NORTHAMPTON DIVERSION CANAL

PERTINENT DATA

LOCATION Mill River, Northampton, Massachusetts

HYDRAULIC DESIGN DATA

Drainage Area	52 sq.mi.
Maximum Flood of Record	7,500 sec.ft.
Discharge, Diversion Canal Design Flood	20,000 sec.ft.
Slope of Riprap-lined Canal Section	.0022
Maximum Design Velocity in Riprap-lined Canal	12 ft./sec.
Maximum Velocity of Bridle Path Overflow Section	4 ft./sec.

CANAL DATA

Length of Diversion Canal	10,700 ft.
Length of Riprap-lined Canal Section	2,882 ft.
Length of Concrete Drop-Structure	115 ft.
Length of Pilot Canal Section	7,200 ft.
Bottom Width of Riprap-lined Canal Section	35 ft.
Bottom Width of Concrete Drop-Structure	100 ft.
Bottom Width of Pilot Canal Section	20 ft.
Side Slopes of Riprap-lined Canal Section and Pilot Canal Section	1 on 3
Bottom Elevation of Diversion Canal (Station C-0+00)	114.75 m.s.l.
Bottom Elevation of Concrete Drop Structure (Station C-28+82.08)	108.41 m.s.l.
Bottom Elevation of Pilot Canal Throughout	99.00 m.s.l.
Bottom Width of Overflow Section at Bridle Path	495 ft.

DIVERSION CANAL QUANTITIES

Excavation (Earth)	75,600 cu.yd.
Riprap	1,540 cu.yd.
Concrete	5,660 cu.yd.
Sheet Piling	14,100 sq.ft.

NORTHAMPTON, MASS.

MILL RIVER DIKE

PERTINENT DATA

Location — Mill River (near West Street) Northampton, Mass.

area protected

Limits of dike design station 0+71 to 23+47

Elevations (above mean sea level)

Top of dike (Station 0+71)	146.20
Top of dike (Station 11+63.5)	145.50
Top of wall (Station 12+25.84)	140.20
Top of wall (Station 16+44)	137.88
Top of dike (Station 23+47)	139.80
Top of dike (Station 23+47)	139.80

PROTECTION WORKS

Mill River Dike Quantities

Total length earth dike	1800 lin. ft.
Total length concrete wall	500 lin. ft.
Impervious fill	13,700 cu. yds.
Random fill	40,760 cu. yds.
Riprap	4,380 cu. yds.
Concrete	1,437 cu. yds.
Reinforcing steel	141,600 lbs.
Steel sheet piling	16,100 sq. ft.

I. INTRODUCTION

I. INTRODUCTION

A. AUTHORIZATION AND PAST REPORTS. - The Northampton dike project is authorized under the Flood Control Act approved June 28, 1938. It is a part of the Connecticut River flood control plan recommended by the District Engineer in "Report of Survey and Comprehensive Plan for Flood Control in the Connecticut River Valley," dated March 20, 1937, approved by the Chief of Engineers, November 29, 1937, and published as House Document No. 455, 75th Congress, 2nd Session.

B. BRIEF DESCRIPTION OF DIVERSION CANAL, DIKE AND APPURTENANT STRUCTURES. - The Diversion Canal will consist of a riprap paved canal approximately 3,500 feet long with a maximum excavated depth of 35 feet between Stations C-0+00 and C-35+00, a concrete drop-structure provided with a weir 6-1/2 feet high, a stilling basin, and a pilot canal 7,300 feet long in the flood plain of the Connecticut River to the existing ox-bow. A concrete, two-span, four-lane highway bridge will be provided across the drop-structure. Approximately 1,380 feet of South Street or Massachusetts State Highway No. 10 is to be relocated. The Earle Street relocation will be 850 feet long and Pyncheon Meadow Road is to be relocated for a distance of 820 feet. On the east or left bank of the Mill River from The New York, New Haven and Hartford Railroad Bridge upstream to West Street Bridge, a concrete wall approximately 12 feet high and about 325 feet long will be constructed. An earth dike approximately 15 feet high and about 1100 feet long, will extend from West Street Bridge upstream to high ground. A stop-log structure will be provided at the east approach of West Street Bridge. Downstream from The New York, New Haven and Hartford Bridge, an earth dike on the left bank will cross Mill River to the right bank and thence to high ground,

thus diverting Mill River into the diversion canal. This dike will be 700 feet long with a maximum height of 23 feet.

C. WORK SUBDIVISIONS OF NORTHAMPTON DIKE. - The local protection work for Northampton is subdivided into the following individual items of work:

Item		Description
N1	-	Inital Fiscal Year 1939 Unit - hired labor.
N2	-	Station 0+00 to high ground over railroad and highway - contract.
N3	-	Diversion Canal and Dike along East Bank Mill River - part contract, part hired labor.
N4	-	Pumping Station plus omitted section - contract.

Items N1 and N2, the earth dike from Station 0+00 to high ground over the Boston and Maine Railroad and U. S. Route No. 5 highway has been covered by a separate analysis of design previously submitted.

This analysis of design covers Item N3, the diversion canal and the protection works along east bank of Mill River.

Item N4, the pumping station and omitted section, will be covered by a separate analysis of design to be submitted in this fiscal year.

II. SELECTION OF SITE

II. SELECTION OF SITE

A. GENERAL LOCATION. - The diversion canal will begin at a point approximately 50 feet south of and downstream from the New York, New Haven and Hartford Railroad bridge and will immediately curve westerly for about 2,400 feet, across the present alinements of Grove and Earle Streets, thence southwesterly across South Street and traversing the silted, old ox-bow in the low-lying flood plain of the Connecticut River for a distance of 8,300 feet to the existing ox-bow.

B. ALINEMENT OF DIVERSION CANAL. - The alinement of the diversion canal between the diversion at Mill River and the drop-structure was determined after an economic study in which full consideration was given to the following factors: (1) the advantageous use of existing topography, (2) the minimum local damage cost, (3) the minimum cost to the Government, and (4) the attainment of hydraulic requirements.

C. DROP-STRUCTURE LOCATION. - The drop-structure location was selected at the most economical site, with regard to hydraulic and foundation requirements and to the alinement of the South Street relocation. The center line of the drop-structure was established 10° 12' off the tangent of the canal curve, which does not impair the functioning of the structure hydraulically and eliminates a skew-bridge which would require a considerable lengthening of the drop-structure.

D. ALINEMENT OF EARLE AND SOUTH STREETS RELOCATION.

1. South Street Relocation. - The relocation of South Street involved economic and layout studies, involving the relationship with the drop-structure and requirements of Massachusetts State Highway Commission

and the City of Northampton. It was determined that the most economic relocation would require 1,380 feet of highway relocation and a two-span, four-lane concrete highway bridge crossing normal to the center-line of the drop structure.

2. Earle Street Relocation. - A consideration of the highway design requirements together with the economies involved determined the selected alinement of Earle Street as relocated.

E. MILL RIVER DIKE AND WALL ALINEMENT. - The alinement of the earth dike downstream from the New York, New Haven and Hartford Railroad bridge was dictated by the hydraulic requirements of Mill River flowing into the diversion canal. The dike will cross the Mill River at a sufficient distance downstream from the railroad bridge to permit the free discharge of Mill River into the diversion canal. The concrete wall upstream from the railroad bridge to West Street bridge was aligned to the east abutment of the railroad bridge in order to provide a smooth flow of Mill River immediately above and through the railroad bridge opening. The dike alinement from West Street Bridge upstream to high ground was kept back some thirty feet from the existing riverbank to avoid interference with the free waterway of the West Street Bridge, which as built presents an obstruction to flow.

III. GEOLOGICAL INVESTIGATIONS

III. GEOLOGICAL INVESTIGATIONS

A. NATURE OF VALLEY. - The diversion canal will extend from the Mill River, at a point upstream of the more densely settled portion of Northampton, to the Ox-Bow Lake of the Connecticut River. The dike will extend along the left bank of the Mill River for a distance of approximately 1600 feet upstream of the entrance to the diversion channel. The higher ground adjacent to these proposed works is formed in glacial lake deposits. Both the Mill and Connecticut Rivers have eroded much of this formation, and the former stream in some places is flowing on a sandstone formation. The flat bottomed Mill River Valley is essentially a flood plain composed chiefly of relatively coarse sediments deposited upon the underlying glacial silts. The westerly side of the much larger Connecticut Valley is a broad flood plain formed by post-glacial erosion and subsequent sedimentation. A natural cut-off of the river just north of Mount Tom has left a remnant of the old river channel in the form of an ox-bow lake.

B. METHOD AND EXTENT OF EXPLORATIONS. - Subsurface explorations were accomplished by means of core borings, auger borings, and test pits. Investigations by core borings, utilizing drive sampling methods were made (1) to determine the character and thickness of the overburden through which the diversion canal will be excavated and on which the dike will be built, and (2) to obtain undisturbed samples of the clay materials from which the physical properties of the deposit were ascertained and used in stability determinations for the side slopes of the canal. Where the depth of the proposed cut was sufficiently shallow and no undisturbed samples were needed, auger borings were used instead of core borings. The location of points of exploration and logs of the holes are shown on Plates Nos. 2 and 20, entitled "Subsurface Explorations".

C. SITE. - 1. Diversion canal. - The bottom of the diversion canal and the distribution of the various overburden formations are shown on Plate No. 3 entitled "Geologic Section." From Station C0+00 to Station C18+00±, the upper portion of the cut (10 to 15 feet) will be made through granular materials graded from gravel to silt, Classes 2 through 9. The lower 5 feet (±) of the cut will be made through a varved clay deposit (Classes 12C and 13C) which extends to a depth of from 30 to 60 feet below the natural ground surface. Underlying this clay deposit, and on top of ledge which occurs between Elevation 60 and Elevation 95, lies a bed of mixed material (chiefly Class 7) approximately 5 to 10 feet thick.

From Station C18+00 to Station C35+00, which includes the drop-structure, the entire excavation will be made in the above-mentioned varved clay deposit which occurs at the ground surface throughout this section, and is underlain by sand and silt deposits, chiefly Classes 6 and 8. From Station C35+00 to the end of the canal at the ox-bow, a shallow cut (averaging less than 5 feet) will be made, almost entirely through swampy land.

2. Mill River Dike and Wall. - The distribution of the various strata in the dike foundations is shown on Plate No. 21 entitled "Geologic Section". The rock floor throughout this area is irregular, occurring between Elevations 85 and 100 mean sea level datum. This is overlaid by glacial lake deposits, (class 12c), which, in turn, underlie coarser river sediments (classes 3, 4, and 5). The upper 5 to 15 feet of overburden consists of artificial fill composed of ashes, cinders, and debris.

D. DISPOSAL OF EXCAVATION. - The material excavated from the canal between Station C0+00 and Station C18+00± will be sidecast. Where this material is found to be suitable, it will be stockpiled for use in the random section of the dike along the Mill River to be constructed at a later

date. It is anticipated that the material from Station C18+00± to the ox-bow will not be suitable for dike construction and will, therefore, be placed in designated spoil areas.

IV. HYDROLOGY

IV. HYDROLOGY

A. RAINFALL. - Rainfall data are collected at 35 rainfall stations in the Mill River watershed and surrounding area. These stations are operated by the U. S. Weather Bureau, State and local agencies, with periods of record ranging from 1 to 103 years. Pertinent general precipitation data are:

Mean annual rainfall	- 43.1	inches (including snow)
Maximum annual rainfall	- 56.7	" " "
Minimum annual rainfall	- 33.4	" " "
Mean annual snowfall	- 58.2	"

Approximate water equivalent of mean annual snowfall - 5.8 inches.

1. Maximum storms of record. - Physical measurements of rainfall during great storms within the Connecticut basin extend back to 1869. Since then the maximum rainfalls have occurred on the following dates: October 3 - 4, 1869; July 12 - 14, 1897; November 3 - 4, 1927; September 16 - 17, 1932; March 18 - 21, 1936; and September 17 - 21, 1938.

The greatest of these rainfalls occurred on September 19 - 21, 1938, with a duration of 68 hours. The maximum average depth of rainfall on 52 square miles equaled 16.3 inches.

2. Diversion canal design storm. - The volume of the canal design storm on the Mill River watershed was obtained from the area-depth graph of the September 1938 storm. The resulting depth of 16.3 inches of rainfall for a drainage area of 52 square miles is greater by 14 per cent than the corresponding depth for any other storm of record in the northeastern United States. All previous storms of record that were studied showed that it is reasonable to assume that a maximum predicted storm

would have a duration of one and one-half days, or 36 hours. The diversion canal design storm distribution was made symmetrical about a vertical time axis, with the peak rainfall occurring at the mid-point of the storm period. The intensity distribution was made proportional to the maximum time-intensity relation for a storm of 36 hours' duration determined by the U. S. Weather Bureau. The assumed storm distribution has been shown by previous studies to produce the maximum peak discharge.

B. RUN-OFF.

1. Records. - Run-off records of the Mill River watershed were not collected prior to October 1938. Since that date, a gaging station has been operated by the U. S. Geological Survey in cooperation with the U. S. Engineer Department at Northampton, Massachusetts. This gage is located 2.5 miles from the mouth of the Mill River and has a drainage area of 52 square miles. A U. S. G. S. gage has been maintained since July 1910 at Goss Heights on the adjoining watershed of Middle Branch of the Westfield River, which has a drainage area of 52.6 square miles. This record was used to compute the general run-off data for the Mill River watershed. Pertinent run-off data are:

Mean annual run-off	-	26.39 inches
Maximum annual run-off	-	46.77 "
Minimum annual run-off	-	16.05 "

The greatest flood of the past 50 years on the Mill River occurred in September 1938. Its peak discharge was estimated to be 7500 c.f.s.

2. Per cent of run-off. - A study of maximum percentages of run-off during the various seasons of the year led to the conclusion that 80 per cent is the maximum probable that could be expected at the time of

a maximum predicted storm. A greater percentage of run-off can occur when the ground is covered with snow, but a storm of the intensity of a maximum predicted storm is not likely to occur at this season of the year. Therefore, an 80 percent run-off factor was adopted to apply to the diversion canal design storm. The September 1938 storm produced a run-off factor of 53 percent on areas adjacent to the Mill River watershed.

3. Unit hydrograph. - The unit hydrograph of the Mill River at the diversion canal was determined from general relations that exist between the topography of the watershed and the shape of the unit hydrograph. These relations were established by a critical analysis of the unit hydrographs and watershed topography obtained at 22 gaging stations in the Connecticut Basin. In order to show the maximum instantaneous rate of peak discharge resulting from a storm with rapidly changing intensities of precipitation, unit hydrographs for rainfall periods of 1-1/2, 3 and 6 hours were determined and utilized. Sufficient records were not available on the Mill River to determine unit graphs from floods of record.

4. Design flood. - The diversion canal design flood was determined by applying the unit hydrographs described above to the design storm, using a run-off factor of 80 percent. The resulting flood gave a peak discharge of 20,000 c.f.s., or 385 c.f.s. per square mile, which is approximately 2.7 times the greatest flood of record, that of September 1938. The existing channel of Mill River through the City of Northampton and above the point of diversion does not have a capacity as great as 20,000 c.f.s. at the present time due to restrictions in the channel and low banks. This will be remedied to a large extent by the proposed Mill River dike work.

5. Frequency of design flood. - The approximate percent chance

of occurrence of the design flood was determined from a general relationship of frequency of instantaneous peak discharge to drainage area established by an analysis of the discharge-frequency relation determined at 14 gaging stations in the Connecticut Basin. From these relations, the design discharge of 20,000 c.f.s. has an approximate percent chance of occurrence of 0.1.

V. LABORATORY AND FIELD INVESTIGATIONS OF SOILS FOR FOUNDATIONS.

V. LABORATORY AND FIELD INVESTIGATIONS OF SOILS FOR FOUNDATIONS.

A. CLASSIFICATION OF MATERIALS. - The Providence District has adopted a convenient system of soil classification having rigidly standardized terms. In this classification soils are divided into 16 classes as shown graphically on Plate No. 4 and described in Table 1. The particular features of this system are (1) it recognizes that accumulations of sediments in nature may be either slight mixtures of various grain sizes, relatively uniform in this respect, or intergradations of these types, (2) it affords a means of rapidly evaluating relative permeabilities, (3) it aids in more accurately showing the distribution and geological relations of the overburden, especially of those portions composed of non-uniformly graded materials, and (4) it contributes to a more reliable classification of soils in the field prior to laboratory confirmation. Even numbers are used to designate materials of uniform texture. Odd numbers designate materials of variable texture. The sizes for gravel, sand, silt and clay are the same as those in the so-called M.I.T. classification with the single exception that the size demarcation between fine silt and coarse clay is not rigidly held at 0.002 mm. but is allowed to vary from 0.006 mm. to 0.0006 mm. This flexibility is introduced in recognition of the fact that natural depositions of fine textured sediments, such as glacial silt (rock flour) behave differently from clays despite similarity of grain-size distribution.

B. GRAIN-SIZE ANALYSIS. - Grain-size curves of samples were obtained by means of sieve and hydrometer analyses. Full use was made of every sample recovered in order to show as accurately as possible the actual geological occurrence.

TABLE NO. 1

CLASS	DESCRIPTION OF MATERIAL
1	Clean Gravel. - Contains little coarse to medium sand.
2	Uniform Coarse to Medium Sand. - Contains little gravel and fine sand.
3	Variable - Graded from Gravel to Medium Sand. - Contains little fine sand.
4	Uniform Medium to Fine Sand. - Contains little coarse sand and coarse silt.
5	Variable - Graded from Gravel to Fine Sand. - Contains little coarse silt.
6	Uniform Fine Sand to Coarse Silt. - Contains little medium sand and medium silt.
7	Variable - Graded from Gravel to Coarse Silt. - Contains little medium silt.
8	Uniform Coarse to Medium Silt. - Contains little fine sand and fine silt.
9	Variable - Graded from Gravel to Medium Silt. - Contains little fine silt.
10	Uniform Medium to Fine Silt. - Contains little coarse silt and coarse clay. Possesses behavior characteristics of silt.
10 C	Uniform Medium Silt to Coarse Clay. - Contains little coarse silt and medium clay. Possesses behavior characteristics of clay.
11	Variable - Graded from Gravel or Coarse Sand to Fine Silt. - Contains little coarse clay.
12	Uniform Fine Silt to Medium Clay. - Contains little medium silt and fine clay (colloids). Possesses behavior characteristics of silt.
12 C	Uniform Clay. - Contains little silt. Possesses behavior characteristics of clay.
13	Variable - Graded from Coarse Sand to Clay. - Contains little fine clay (colloids). Possesses behavior characteristics of silt.
13 C	Variable Clay. - Graded from sand to fine clay (colloids). Possesses behavior characteristics of clay.

C. WATER CONTENT AND VOID RATIO. - The cohesive character of the silt and clay deposits in the diversion canal permitted recovery of 4-7/8" diameter undisturbed samples. The natural water content of these materials was preserved in the field by coating the samples with paraffin. The laboratory was thus able to have at its disposal several samples at various depths in a sufficiently undisturbed condition to obtain accurate void ratios and water contents.

D. PERMEABILITY. - The impervious character of the materials in which the diversion canal is to be excavated precluded the necessity for elaborate permeability tests. Only permeability data by the indirect method of computation from consolidation test data were obtained. A typical load-permeability test is included in the consolidation characteristic curves.

E. CONSOLIDATION. - Consolidation tests were performed on all undisturbed samples obtained. The characteristic curves obtained from a typical test are shown in Plates 5 and 6. The foundation material under the drop-structure is a varved clay material, Class 12 C, with a bearing value considered to be too low to safely support the drop-structure without piling.

F. SHEAR AND COHESION. - Shear tests to obtain the angle of internal friction, ϕ, and the cohesion, c, were performed on all undisturbed samples obtained. The constant strain method of test procedure was used wherein the shearing strain was applied at a constant rate of approximately 0.06" per minute. The results are noted in Section VI, General Design under "Stability of Slopes."

G. OTHER TESTS. - A few other tests such as Atterberg limit and specific gravity were made.

VI. GENERAL DESIGN

VI. GENERAL DESIGN

A. MILL RIVER DIKES. - The Northampton embankment section includes a large section of random material covered on the riverside by a blanket of impervious material, and on the landside by a section of pervious free-draining material. General design criteria for the Northampton Dike include safety, stability, and reduction of seepage and are as follows:

1. The crest of the dike is at such a grade that overtopping at design flood and by wave action will not occur.

2. a. The slopes of the dike are such that they will be stable under all conditions.

b. For the Northampton Dike sections between 10 to 20 feet in height a waterside slope of 1 on 2-1/2 and a landside slope of 1 on 2 are required. The slopes for dike sections greater than 20 feet in height are 1 on 3 for both sides. After a study of the flow of flood waters in the river, 12-inch hand placed riprap over a 6-inch gravel bed was required over critical areas to prevent scour.

3. a. The line of saturation will be well within the landside toe.

b. The dike is designed for a fairly low line of saturation and analyzing the Northampton Dike sections, the flood water will seep very slowly through the impervious blanket of low permeability to the random and pervious sections where, because of a somewhat greater permeability, together with the influence of the rock toe drain, the line of saturation will drop below the landside toe.

4. Seepage and surface run-off behind the dike are to be

collected by the rock toe drain and existing catch basins. Since the dike throughout is founded on soil, seepage through the foundation will not be excessive owing to the 5-foot depth cut-off of impervious material and to natural foundation soil materials of low impermeability. Such seepage through the foundation or dike as may occur will have a very low velocity and will be collected by the rock toe drain. The rock toe drain is connected to existing sewers which in turn will empty into Mill River through existing pipes under the dike. The outlets of the pipes are provided with flap valves and pumping facilities will be provided for the sewers during high water.

5. There is no possibility for free passage of water from riverside to the landside. All pipes, conduits, etc., are either removed from under the dike or encircled with seep rings to prevent free seepage along their surfaces.

6. No material soluble in water is used in any part of the dike and soils laboratory tests have been made of borrow area material for solubility. (See Section V, Paragraph G).

7. The foundation under the dike is sufficiently stable to resist stresses due to the embankment load. (See Section V, Paragraph E).

8. Where the dike crosses West Street, a stop-log gate opening will be provided.

B. MILL RIVER CLOSURE DIKE. - After careful study it was decided, in view of economy and good engineering practice, to modify the standard dike section of the Providence District for this particular stretch of flood protection. The revised design has an impervious core around and above the sheet pile cut-off. The slopes are of random materials with a landside toe drain to carry away any seepage. The slopes are such that

the section is stable for a rapid drop of the river and affords considerable resistance against seepage. The danger of erosion is considered slight as riprap will be provided on the dike. A sheet pile cut-off is necessary throughout the length of the closure dike for the prevention of excess seepage. The dike is designed to satisfy the criteria stated in Paragraph A.

C. DIVERSION CANAL

1. General. - The diversion canal was designed for 20,000 c.f.s. discharge as described in Section VII, Paragraph A.

2. Stability of side slopes. - The stability of the canal side slopes were exhaustively investigated by the Soils Laboratory of the Providence District. Shear tests on all 4-7/8" diameter samples obtained from bore holes BH-45, 46 and 47 were performed. A total of eleven undisturbed samples were recovered from these three bore holes. The value of the angle of internal, ϕ, ranged from 15° 10' to 28° 50' with a weighted average of approximately 20°. The value for cohesion, c, varied from 0.015 T/sq. ft. to 0.19 T/sq. ft. The low value was obtained in only one test, all other tests giving values equal to or greater than 0.06 T/sq. ft. The weighted value allowing for reduction in available cohesion by surface cracking was computed as 0.06 T/sq. ft. These values were accurate enough to be considered the basis on which to analyze the stability of the diversion canal slopes.

The stability of the slopes was analyzed using the simplified "ϕ - Circle Method" originated by Professor Donald W. Taylor of M.I.T. and published in the Journal of the Boston Society of Civil Engineers, Vol. XXIV, No. 3, July 1937. Plate 7 as included herein was obtained by use

of Figure 4, page 213, of the above Journal. With computed values of $\phi = 20° 00'$, c = 120 #/cu. ft. and w = 109 #/cu. ft., and varying values of the factor of safety, F, a family of curves was obtained. By plotting depth of canal cut, H, in feet against slope angle, i, in degrees plate 7 resulted. Use of the chart is as follows: For a given depth of canal cut, say, 30 feet, and a desired factor of safety of 2.0, the side slopes would have to be designed at an angle of approximately 26° with the horizontal. This is almost exactly a side slope of 1 on 2.

Canal side slopes of 1 on 3 were adopted to provide a factor of safety of greater than 2 since the deep portion of the canal is lined on both sides by residential and business buildings.

3. Erosion from hydraulic discharge. - The side slopes of the canal from Station C0+00 to Station C-28+32 will be paved with hand-placed riprap, provided with gravel bedding, to prevent erosion from a maximum discharge velocity of 12 feet per second.

4. Drop-structure design.

a. General. - The drop-structure was designed to pass a discharge of 20,000 c.f.s. safely and to meet the hydraulic requirements as described in Section VII, Paragraph E.

b. Walls. - The walls and wall foundation of the drop-structure were designed to meet the two critical, determining cases, namely, the diversion canal empty and the canal discharging 20,000 c.f.s. The discharge of Mill River at low water stage is approximately 10 c.f.s. resulting in a virtually empty canal. The structural design and assumptions are detailed in Section VIII, Paragraph 8. The walls are of sufficient height to prevent overtopping at a discharge of 20,000 c.f.s.

c. Floor. - The floor of the drop-structure was designed with a minimum depth of 2-1/2 feet with the stilling basin floor increased to 4 feet. These depths include an embedment of 12 inches for the timber bearing piles.

d. Timber bearing piles. - Since the foundation of the drop-structure will be always in a saturated condition, and because of economy, untreated timber bearing piles were selected, the minimum piling spacing is 3 feet. All bearing piles will be driven to refusal or to rock which is at approximate Elevation 64.0 except the wingwall piles which will be driven to carry 20 tons per pile. Alternate bids will be accepted for precast reinforced concrete pile having safe bearing capacity of 40 tons each.

e. Drainage. - An ample drainage system under the drop-structure is provided to relieve uplift. To relieve seepage water pressure behind the walls, 12 inches of gravel backfill will be placed immediately behind the wall stem with a crushed-rock drain at the base and weepholes will be installed.

f. Steel sheet piling. - Steel sheet piling driven to rock is provided at the upstream edge of the drop-structure floor and at the lower end of the stilling basin to prevent undermining. During the early stages of construction when the first bearing piles were being driven, serious slides occurred on the drop-structure excavation slopes due to vibration of the piling hammers driving the wooden piles into the hardpan stratum underlying the thick overburden of varved clay. To prevent further slides and to resist downstream horizontal mass earth movement, sheet piling was driven along the sides of the structure connecting with the upstream

and downstream sheet piling cut-offs, thus completely enclosing the foundation of the main portion of the drop-structure.

5. Drop-structure outlet. - Derrick-placed riprap to a depth of 3 feet and for a distance of 40 feet is provided immediately below the drop-structure to prevent erosion and undermining.

6. Pilot canal. - A pilot canal 20 feet wide with side slopes of 1 on 3 is provided in the old Ox Bow for low water flows of Mill River.

7. Bridle path overflow section. - An embankment at Elevation 119.00 for a bridle path with a 100-foot span bridge crosses the old Ox Bow. The pilot canal will pass under the bridge. In order to provide for a discharge of 20,000 c.f.s., an overflow section 495 feet long at Elevation 106.0 is to be constructed.

8. Bridge at present Ox Bow. - To maintain traffic on a gravel road at Elevation 106.0 leading to Easthampton from Northampton during low flows of the Mill River, a concrete, overflow bridge is to be provided at the point where the pilot canal enters into the present Ox Bow. The cross section of the pilot canal under the bridge will be sufficient to discharge normal flow of Mill River. At 20,000 c.f.s. the entire area will be submerged.

D. SOUTH STREET BRIDGE. - A bridge will be provided where the diversion canal crosses South Street which is on Massachusetts State Highway No. 10. It will be a twin, 50-foot span, four-lane reinforced concrete slab and girder bridge with simply supported ends. The Massachusetts State Highway Commission requires 40 feet width or four-lane traffic bridges on main arterial highways. Sidewalks are provided on both sides of the bridge. The sidewalk on the north or upstream side of the bridge

will not be paved for the present, but will be used as a bridle path because of equestrian traffic. Details of the design of the bridge are described in Section VIII, Paragraph A.

E. RELOCATION OF SOUTH AND EARLE STREETS.

1. South Street relocation. - South Street was designed for a maximum grade 2.4% and the minimum curve radius of 700 feet. A concrete road surface is to be built to the State Highway maintenance line where it changes to a macadam surface, 20 feet wide, thus meeting present road surface conditions. The concrete road will be 20 feet wide except for a short distance at the approaches of the bridge. Cable guard rails are provided at the bridge approaches.

2. Earle Street relocation. - A 20-foot macadam road is designed for the Earle Street relocation. Intersection curves have a minimum radius of 50 feet. It will serve as a substitute for the existing Grove and Earle Streets. Grove Street is a rather important thoroughfare.

VII. HYDRAULIC DESIGN

VII. HYDRAULIC DESIGN

A. DESIGN CRITERIA. - It was decided as a result of study of the hydrology of the watershed that the diversion canal should be designed to carry a discharge of 15,000 c.f.s. efficiently with no appreciable overbank flooding, and a discharge of 20,000 c.f.s. safely without much damage to the canal side slopes.

B. GENERAL DESCRIPTION. - The stretch of river and diversion canal involved may be conveniently segregated into four sections: (1) At the upstream end is a stretch of natural river extending from the Paradise Pond dam down to the point of diversion. There are three bridges over this section of the river, a footbridge, a highway bridge, and a railroad bridge. An earth dike and concrete wall will be located along the left bank in this section. (2) The next section will consist of a uniform excavated diversion canal paved with hand-placed riprap. (3) The third element will be a drop-structure combined with a highway bridge crossing. The drop-structure will insure the maintenance of satisfactory depths in the paved canal section for all discharges, and at the same time will drop the water down to the lower level of the channel to the Connecticut River. (4) The final stretch of the diversion canal will consist of a small pilot canal excavated in the flood plain of the Connecticut River.

C. NATURAL RIVER SECTION AND PROTECTION WORKS DESIGN ALONG RIVER. - 1. The present river section from Paradise Pond dam downstream to the point of diversion is very irregular. It is crossed by a light footbridge, by an arched highway bridge having a very small waterway area, and by a simple girder railway bridge. A low island between the highway and railway bridges has recently been removed, thus providing a slightly increased

waterway section at this point. Low ground adjoins the river on both sides. On the east or left side of the stream, water leaving the main channel could overflow the low ground or the railroad tracks and find its way down to the center of Northampton. To prevent this, a dike and wall extending from the Paradise Pond dam downstream to high ground beyond the point of diversion will be constructed.

2. The earth dike and concrete wall will be built to grades 4 feet and 2 feet, respectively, above the computed profile for a flood of 20,000 c.f.s. The two major bridges cause excessive loss at this flow, as may be seen from the following figures:

Point	Water Surface 20,000 c.f.s.	Elevation Top of Dike	Elevation Top of Wall
High ground at Paradise Pond Dam	142.2	146.2	
West Street Bridge - Upstream	141.5	145.5	
West Street Bridge - Downstream	138.1		140.2
Railroad Bridge - Upstream	137.5		139.5
Railroad Bridge - Downstream	134.8	139.8	
High ground at upper end of Diversion Canal		139.8	

Downstream of the West Street Bridge, the concrete wall is sloped from the top of the stop-log structure, Elevation 143.5, down to Elevation 140.2 in a distance of 36 feet, to protect against the turbulent flow immediately below the bridge.

Downstream of the railroad bridge, the earth dike is given a freeboard of 5 feet. This is done because the dike is on the outside of a sharp curve, and also because it is the most critical section of the dike. Failure of the bridges, or overtopping of the railroad embankment west of the bridge will bypass water into the diversion canal and relieve the dike and wall upstream from the railroad bridge, but no measure of relief will be provided for the section of dike below the railroad bridge. For this

reason, and because of the curvature, mentioned above, a freeboard of 5 feet was selected.

D. PAVED DIVERSION CANAL. - The excavated diversion canal leading from Mill River through a low ridge to the Connecticut River flood plain will be paved with hand-placed riprap to permit high velocities. A mean channel velocity of 12 feet per second was considered to be the maximum permissible. Soil studies indicate that side slopes of 1 on 3 would have ample stability. The bed of the proposed canal, at the point of diversion, was placed at Elevation 114.75 to coincide closely with the bed of the existing stream channel, and the depth of flow at the design discharge of 15,000 c.f.s. was selected as 16.25 feet in order not to cause appreciable flooding of adjacent lands at this discharge. These limitations then - maximum permissible channel velocity, side slopes, depth, and the roughness or riprap - govern the canal dimensions and slope. The roughness factor used in Manning's formula was n = .025. The canal cross section was made approximately trapezoidal with a 35 foot bottom width and 1 on 3 side slopes. The bottom of the canal was depressed one foot in the center, making a shallow V bottom to concentrate small flows there. The canal has a longitudinal slope of .0022.

E. DROP-STRUCTURE. - Since the diversion canal is much shorter than the natural river which it will replace, its slope must be correspondingly steeper. The steeper slope and correspondingly greater velocities would require concrete lining throughout. A drop-structure was therefore introduced to act as a control and prevent excessive velocities in the riprapped canal section and to provide proper dissipation of the energy represented by the remainder of the stream fall.

A bridge crossing of the State highway from Northampton to Easthampton was combined with the drop-structure. The latter was designed to control a discharge of 15,000 c.f.s. in the canal, so that the mean velocity upstream from the drop-structure would not exceed 12 feet per second and, furthermore, to pass 20,000 c.f.s. without endangering the bridge. The structure is made up of a low weir to control the upstream channel, and a stilling pool. Hydraulic model tests are being made at the Alden Hydraulic Laboratory in Worcester, Massachusetts. The results of these tests will be utilized to insure satisfactory operation of the structure. The tail-water to which the structure is subjected is primarily a function of the flood level in the Connecticut River and will have a maximum value of approximately Elevation 132.5 mean sea level under natural conditions, or Elevation 126.5 mean sea level with the Comprehensive Plan of reservoirs in operation. It is not anticipated that these maximum elevations would occur simultaneously with maximum discharges in the Mill River.

F. PILOT CANAL. - Downstream of the stilling pool the water will flow along the swampy bed of a silted, old Ox Bow into the present Ox Bow, and thence into the Connecticut River. The ground elevation in the old Ox Bow varies from 100 to 105 mean sea level. A pilot canal, excavated to Elevation 99 and with a 20-foot base width, will be provided through this section to guide the discharge from the drop-structure. During periods of flood discharge, the entire old Ox Bow may be overflowed without appreciable damage. The embankment of an existing bridle-path along an abandoned trolley right-of-way which crosses the old Ox Bow will be reduced in height to decrease the restriction at that point. A

bridge will be constructed at the point where the old Ox Bow joins the existing Ox Bow, to avoid excessive backwater at that point.

G. GENERAL DISCUSSION. - A discharge of 15,000 c.f.s. will flow in the diversion canal at a uniform depth of 16.25 feet, and will pass the drop-structure with a surcharge of 10 feet.

A discharge of 20,000 c.f.s. will require a head of about 12 feet over the drop-structure weir crest and will flood little or none of the low land adjoining the diversion canal. Where the banks are high, the riprap lining of the channel is carried up 2.00 feet above the flow line for 15,000 c.f.s., and this will provide protection for the flow of 20,000 c.f.s.

The elevation of the highway bridge is governed by other considerations, and is sufficiently high to allow the drop-structure to pass a discharge of approximately 30,000 c.f.s. without being overtopped.

VIII. STRUCTURAL DESIGN

VIII. STRUCTURAL DESIGN

A. SOUTH ST. BRIDGE, NORTHAMPTON, MASS.

1. General Information.

a. General description of the structure. - The type of bridge chosen is a two-span, four-lane, reinforced concrete slab and girder bridge with a total length of 100 feet, face to face of abutments, and 40 feet wide between curbs. A center pier divides the bridge into two equal spans. The bridge carries sidewalks on both sides, the north side sidewalk is not paved for the present. The sidewalks are carried on cantilever brackets attached to the outside girders. Transverse diaphragms for the full width of the bridge on a line with the brackets take up the thrust from these latter and also brace and tie together all girders of each span into a single rigid unit. Pipe recesses for carrying water mains across the bridge are provided under the south side sidewalk slab. A concrete wearing surface 2" thick at the gutters and 3" thick at the crown is to be cast integrally with the roadway slab but was not considered a part thereof in the structural design. The bridge slopes 2" in its full length, the slope being downward from east to west. Two drainage grills are provided on the transverse center line of each span, one in each gutter. A 4-inch gap is provided between the two spans over the pier and a 4-inch clearance has been provided between the ends of the girder and the faces of the abutment backwalls. Raised pattern apron plates span the gaps between the deck slabs at the pier and between the bridge floor and the roadway at the abutments.

b. Provisions for expansion and contraction. - Each bridge span has one fixed end and one expansion end. The bearings for

both the fixed and expansion ends are structural steel plates having a minimum thickness of one inch. They are anchored to the girders and to the abutments and pier respectively with anchor bolts and welded steel straps to prevent sliding of the bridge the bottom bearing plate of the fixed end bearing is provided with a raised one-half-inch lip. A 1/8-inch phosphor bronze plate has been placed between the upper and lower bearing plates of each expansion bearing.

c. Railings. - The bridge railings consist of 3" diameter steel pipe rails with 1-1/2" square steel verticals spaced 6" center to center. The railings will frame into slots provided in the concrete railing posts. Provision has been made to bolt the railings securely to the concrete while permitting motion due to expansion and contraction.

d. Curbs. - The curbs at the request of the Massachusetts State Highway Commission are designed to make it practically impossible for a car to mount either sidewalk. Suitable curb guards are provided to prevent abrasion of the concrete by passing automobiles and trucks.

2. Design data.

a. General. - The structural design of the bridge has in general been executed in accordance with the Standard Specifications for Highway Bridges of the American Association of State Highway Officials except that an allowable unit stress in the steel of 18,000 pounds per square inch was used instead of 16,000 pounds and 800 pounds per square inch in concrete instead of 900 pounds.

b. Live loads. - The live loads used in the design of the bridge are as follows: -

For the roadway, type H20 loading with impact allowance as determined by the formula $I^2 = \frac{50}{L+125}$ in which I^2 is the impact in per

cent of the live load and L the length in feet of the portion of the span which is loaded to produce maximum stress in the member considered.

For the south sidewalk a uniform live load of 100 pounds per square foot with no impact.

For the north sidewalk a uniform live load of 150 pounds per square foot with no impact.

c. Dead loads. - The dead loads used were the actual estimated weights of the structure.

d. Pier and abutments. - The pier size was determined by minimum dimensions required to provide proper support for the bridge rather than by actual superimposed loads. The abutments were figured to resist earth pressure forces of an equivalent liquid pressure of 40 pounds per foot per foot of depth and of the vertical loads due to the weight of the abutment plus the superimposed bridge loads. No impact allowance was made for live loads on abutments and pier. Both are carried on timber piles to be driven to rock or refusal. The maximum load per pile will be twenty tons. The abutments were designed as cantilever walls, but because bridge expansion bearings sometimes tend to "freeze" in position account was taken of the fact that the abutments may then act as simple beams supported at the upper and lower ends and reinforcement was provided to take care of such a possibility. To prevent hydrostatic pressure from being built up behind the abutment walls, a gravel backing one foot thick will be placed at the rear faces of the abutments for the full height of the stems and weepholes provided to carry off the water.

e. Unit Weights. - The following unit weights for materials were assumed:

Water 62.5 pounds per cubic foot.

Dry earth 100 pounds per cubic foot

Saturated earth 125 pounds per cubic foot

Concrete 150 pounds per cubic foot

Structural steel 489.6 pounds per cubic foot

f. Earth pressures. - In computing active earth pressures equivalent fluid pressures were used. They are as follows:

Equivalent liquid pressure of dry earth = 40 pounds per cubic foot.

Equivalent liquid pressure for saturated earth = 83 pounds per cubic foot.

g. Hydrostatic uplift.

(1) Riverside of sheet piling, full head due to headwater.

(2) Landside of sheet piling.

(a) At landward toe, full head due to tailwater.

(b) At sheet piling, full head due to tailwater plus one-half the difference between headwater and tailwater.

(c) At intermediate points, the uplift was assumed to vary uniformly with the distance from the toe.

h. Overturning. - The resultant of all external loads, including hydrostatic uplift and excluding base pressure, does not fall within the middle third under every condition but under no condition is the allowable bearing value of the piling exceeded.

i. Sliding. - The total horizontal forces due to external loads shall not exceed the resistance available from friction and passive resistance. The coefficient of friction used is 0.45.

j. Bearing. - The total bearing pressure, equal to the sum of hydrostatic pressure plus the remaining effective base pressure, shall in no case exceed the maximum allowable bearing value of 20 tons per pile.

k. Frost cover. - All footing bases shall lie at least 4 feet beneath the ground surface to avoid heaving by frost action.

l. Path of percolation. - Except where steel sheet piling is driven to rock, the minimum path of percolation shall be determined as follows: Wall with sheet pile cut-off and with filter on landside five times the head of water for wall with stem up to 5'0" above the base and four times the head of water with stem greater than 5'0" above the base.

m. Reinforced Concrete.

(1) Allowable stresses. - The allowable working stresses in concrete are based on an average ultimate compressive strength in 28 days of 3400 pounds per square inch for Class "A" concrete and 3000 pounds per square inch for Class "B" concrete.

(2) Flexure (fc).

	Lbs. per sq. in.
Extreme fibre stress in compression	800
Extreme fibre stress in compression adjacent to supports of continuous or fixed beams or rigid frames	900

	Lbs. per sq. in.
(3) Shear (v)	
Beams with no web reinforcement and without special anchorage	60
Beams with no web reinforcement but with special anchorage of longitudinal steel	90
Beams with properly designed web reinforcement and with special anchorage of longitudinal steel	180
Footings where longitudinal bars have no special anchorage	60
Footings where longitudinal bars have special anchorage	90
(4) Bond (u).	
In beams, slabs and one way footings	100
Where special anchorage is provided	200
The above stresses are for deformed bars.	
(5) Bearing (fc).	
Where a concrete member has an area at least twice the area in bearing	500
(6) Steel stresses	
Tension	18,000
Web reinforcement	16,000

(7) Protective concrete covering.

Type of members	Minimum cover in inches
Roadway slabs	1-1/2
Girders beams	2
Members poured directly against the ground	4

	Minimum cover in inches
Members exposed to earth or water but poured against forms	3

For secondary steel, such as temperature and spacer steel, the above minimum cover may be decreased by the diameter of the temperature or spacer steel rods.

B. DROP-STRUCTURE

1. Retaining Walls. - For reasons of economy, a simple cantilever wall section was selected as best adapted to the special excavation and foundation problems arising at the site. From the standpoint of structural requirements, this type of construction will resist the external forces as safely as either a gravity or buttress wall.

2. Wall Proportions. - Several factors influenced the selection of wall proportions. The physical characteristics of the material excavated is such that, to avoid prohibitive excavation costs, the heel of the wall was made as short as possible, within practical limits. Since the wall is to be supported on piles, it was necessary to provide sufficient base thickness for adequate pile embedment. It was deemed desirable to adopt a minimum spacing for all reinforcing steel of 6 inches, wherever practically feasible. This limitation reflected itself in the stem thickness, which is a function of the toe width and side batter of the wall stem. The riverside face of the stem forming the boundary of the channel cross section was held vertical in all cases. In order to provide sufficient base width, the toe was extended into the channel thus forming a portion of the channel boundary on the bottom.

The upstream wingwalls are curved so as to furnish a smooth transition between the riprapped approach channel and the concrete drop structure. Since the security of these walls is of paramount importance, the proportions were so selected as to insure all around adequacy. The heel of the wall was made generous to provide a base extending well into the earth backfill. A toe was added only so far as to give reasonable pile spacing. In all sections of the wingwall the top of the base is kept well below the surface of the riprap, or sufficiently removed from any action that might tend to render the wall unstable. The wall will be built in sections with a stepped footing to avoid complicated forming details. Any attempt to construct the base as an evenly tapering section would have resulted in field bending of reinforcing steel, which for the size bars used (1-1/4") would be extremely difficult.

The retaining wall downstream from the bridge abutment and parallel to the channel center line, was proportioned so as to cator to the varying wall height and special local loading conditions. As pointed out in foregoing discussion, the toe of these wall sections could be extended well into the channel proper, thus serving as a portion of the channel boundary. The heel was made only as long as was necessary from a consideration of general stability and wood pile spacing.

The downstream wingwalls were designed with toe and heel of equal length. The height is varying throughout its entire length. Since the wall is on a straight line, the base was made sloping to fit in with the side slopes of the riprapped retreat channel. Considerable economy was effected in this manner without sacrificing the general stability.

3. Loading. - In view of the special backfill conditions and the provision of weepholes at the base of the stem, it was found that, with one exception, the condition of the unsaturated earth gave maximum bending moments in the stem and base. When the flow is such as to give considerable water depth in the channel, the backfill will be saturated to an equal elevation and balance the hydrostatic pressure. Similarly, when the water is low in the channel the water table in the surrounding backfill will be drawn down and the pressure will be relieved by the drainage system back of the walls.

The zone of the hydraulic jump within the drop structure is the one exception referred to in the previous paragraph. Here the ground water level might conceivably be high while the water surface in the channel is low, by virtue of the hydraulic jump action. Cognizance of this special condition was taken and allowance made therefor in the design.

4. Pile Spacing Under Walls. - Unfavorable foundation conditions due to the occurrence of an extensive varved clay deposit have made it necessary to support the retaining walls on piles. Wood piles were selected with a maximum allowable load per pile of 20 tons. Except for the upstream wingwalls where a close spacing is inevitable, a minimum of 3' center to center of pile, was selected.

Bearing diagrams for the most extreme loading conditions were computed. The piles were so arranged that in no case would the 20 tons per pile be exceeded. Where the action of uplift was uncertain, it was considered ineffectual as far as reducing the load transmitted to the piles.

The manner in which the horizontal force exerted on the retaining walls will be resisted does not lend itself to exact structural analysis. Batter piles are eliminated because of the extreme congestion resulting

from the close spacing of wood piles and the line of steel sheet pile cut-off curtains at the upstream and downstream extremity of the drop structure. Where the toe of the wall butts against the floor system of the structure, no further consideration need be given since the horizontal force will be easily transmitted through the floor slab and equalized by a thrust from the opposite wall. The wingwalls having no support from a floor slab, will be held secure in a horizontal direction by virtue of the rigidity of the connection between the wood pile and the concrete base, the resistance of the multiple pile support to lateral movement, and the resistance of the steel sheet pile curtain to horizontal displacement. All bases will be keyed together to insure interaction between wall sections.

5. Weir and Floor Slab. - The floor of the drop structure is also of reinforced concrete and consists of a low gravity section flanked upstream by a 2.5-foot thick horizontal floor slab, downstream by a sloping 2.5-foot thick tail slab extending into a 4-foot thick slab forming the bottom of the stilling pool. The weir is cut through by two slots, each three foot wide, one near the east abutment and the other near the west face of the pier. Stop logs across these slots will provide flexibility in the control of low flows of water over the drop structure. The entire floor area will be supported by timber piles generally spaced 6'0" center to center both ways and will be driven to rock or refusal. The piles will project 1'0" into the concrete. The floor area is divided into sections by transverse and longitudinal expansion joints, each section being reinforced with top and bottom steel to distribute the loading to the pile supports and to provide for temperature changes within the section.

C. STRUCTURES OF THE MILL RIVER PROTECTION WORKS. - The following reinforced concrete flood control and incidental structures are described below: (1) Stop-log structure; (2) Flood wall; (3) Highway bridge.

1. Stop-log structure. - The stop-log structure across West Street starts at Station M-11+60.47, and ends at Station M-12+25.84. It is made up of three units; (a) counterfort type retaining wall at south end of earth dike; (b) stop-log structure proper; and (c) "T" type cantilever wall.

(a) The counterfort type retaining wall is designed to resist a principal load produced by the earth of the earth dike. The wall has an overall height of 21'0" and is approximately 6 inches higher than the earth dike.

(b) The stop-log structure proper, keyed into the counterfort type wall at the north end and into the "T" type cantilever wall at the south end, has three spans of approximately 12'0" each. The two intermediate stop-log supports are structural steel "A" frames. The principal load which the structure, having an overall height of 21'0", is designed to resist, is the assumed head of water 6 inches below top of structure.

(c) The "T" type cantilever wall has a buttress at the junction of the stop-log structure proper. The overall height of the wall at this point is 21'0" and slopes to an overall height of 15'2" at the south end. The principal loads which this wall is designed to resist are the reaction of the stop-log structure proper, loaded with assumed maximum head of water, and a head of water which is assumed to be 6" ± below top of wall stem at all points along its length.

2. Flood wall. - The reinforced concrete flood wall extends from the end of the stop-log structure at Station M-12+25.84 to Station M-16+59. The "T" type cantilever wall is used throughout, except at the intersection

of the New York, New Haven and Hartford Railroad at Station M-15+52. Here, a reinforced concrete sill is used below and between the rails. In times of flood, this gap may be closed by sandbags. The overall height of wall varies from 9' 6" to 21' 0". The principal load which the wall is designed to resist is the head of water assumed to be 6" ± below the top of wall.

The secondary loading of structures of "1" and "2" is the earth fill on the landside of the structures.

3. Highway bridge. - The highway bridge spans the channel which empties into Ox Bow Lake. The intersection of center lines of bridge and channel is at Station C-107+85.30. The structure is a four span continuous slab bridge, fixed at intermediate and freely supported at end supports. It has an overall length of 63'0" back-to-back of abutments and an overall width of superstructure of 17'4". The roadway width is 16'0". The rails are black galvanized iron pipe. The substructure consists of solid piers and "T" type cantilever abutments and wings with spread footings on timber piling. The structure has been designed according to the A.A.S.H.O. specifications, using H-15 truck train loading.

IX. CONSTRUCTION PROCEDURE

IX. CONSTRUCTION PROCEDURE

A. DIVERSION CANAL - CONTRACT WORK N3b. - 1. Field operations. -

The contract was let on June 26, 1939 and construction commenced on July 11th; it is contemplated that the work will be completed by December 1, 1939, in one construction season.

The following tabulation presents a proposed time limit of operations:

CONSTRUCTION PROGRAM

Designation	Quantity	Time Limit of operations (Calendar year 1939)	No. of working days	Daily rate of construction
Preparation of Site	6-1/4 acres	July 10-July 20	10	0.6 acres
Temporary Detour of State Highway Route No. 10	500 feet	July 10-July 16	5	100 feet
Excavation	75,600 c.y.	July 15-Dec. 1	100	756 cu. yds.
Placing of Steel Sheet Piling	24,660 s.f.	Aug. 10-Oct.10	40	615 sq. ft.
Driving Timber Piling	27,900 ft.	Aug. 15-Oct.15	40	698 feet
Concrete Drop-Structure	4,000 c.y.	Sept.20-Nov. 1	30	133 cu. yds.
Concrete-South Street Bridge	1,310 c.y.	Sept.20-Nov.20	40	33 cu. yds.
Earle and South Sts. Embankment	10,000 c.y.	Aug. 1 - Aug.15	10	1,000 cu. yds.
Earle and South Sts. Surfacing	4,300 s.y.	Aug.10-Sept.10	20	215 sq. yds.
Earle and South Sts. Concrete	350 c.y.	Nov. 1 - Nov.10	7	50 cu. yds.
Placing of Gravel Bedding	700 c.y.	Oct.20-Nov. 20	20	35 cu. yds.

Designation	Quantity	Time limit of operations (Calendar year 1939)	No. of working days	Daily rate of construction
Hand-placed Riprap	400 c.y.	Nov. 1 - Nov. 15	10	40 cu.yds.
Derrick-placed Riprap	1,140 c.y.	Nov. 1 - Dec. 1	20	57 cu.yds.

2. Inspection and tests. - Field inspection of all portions of the construction work will be made. Progress reports including log of work accomplished and of the number of workers on the job will be made.

Field and laboratory tests of embankment materials, concrete and other materials will be made in order to control the quality of the work.

B. DIVERSION CANAL RIPRAP - CONTRACT WORK N3C

1. Field operations. - The contract was let on June 27, 1939 and construction commenced on July 17th. It is contemplated that the work will be completed by January 13, 1940, in one construction season.

The following tabulation presents a proposed time limit of operations:

CONSTRUCTION PROGRAM

Designation	Quantity	Time limit of operations (Calendar year 1939)	No. of working days	Daily rate of construction
Excavation	500 c. y.	July 15-July 27	5	50 c. y.
Placing of gravel bedding	7,150 c. y.	July 15-Nov. 15	80	90 c. y.
Hand-placed riprap	14,300 c. y.	July 17-Dec. 1	90	159 c. y.

2. Inspection and tests. - Field inspection of all portions of the construction work will be made. Progress reports including log of work accomplished and of the number of workers on the job will be made.

C. MILL RIVER PROTECTION WORKS-HIRED LABOR N3d.

1. Field operations. - Assuming that the field work will commence October 1st, it is contemplated that the work will be completed by July 1, 1940.

The following tabulation presents a proposed time limit of operations:

CONSTRUCTION PROGRAM

Designation	Quantity	Time limit of operations (Calendar Year)	No. of working days	Daily rate of construction
Preparation of site	6 acres	Sept.20-Oct. 10	15	0.4 acres
Excavation	80,700 c.y.	Oct. 1-Dec. 20 Mar. 1-May 1	60 40	807 cu. yds.
Placing of steel sheet piling	16,945 s.f.	Oct.10 - Nov.10	20	847 sq. ft.
Driving timber piling	9,400 l. f.	Oct.10 - Nov. 1	15	627 lin.ft.
Embankment	59,040 c.y.	Oct.15 - Nov.15 Apr. 1 - June 1	20 40	990 cu. yds.
Concrete stop-log structure and flood wall	1,160 c.y.	Oct.15 - Nov.15 Apr. 1 -June 15	20 50	16 cu. yds.
Concrete highway bridge	220 c.y.	Nov. 1-Nov. 25	15	15 cu. yds.
Placing of gravel bedding	2,035 c.y.	Nov. 1 - Dec. 1 Apr. 1 -June 15	20 50	30 cu. yds.

Designation	Quantity	Time limit of operations (Calendar Year)	No. of working days	Daily rate of construction
Hand-placed riprap	3,180 c.y.	Nov. 1 - Dec. 1 Apr. 1 - June 20	20 40	53 cu.yds.
Placing topsoil on dike	3,080 c.y.	May 15 - June 15	20	154 cu.yds.

2. Inspection and tests. - Field inspection of all portions of the construction work will be made. Progress reports, including log of work accomplished and of the number of workers on the job will be made.

X. SUMMARY OF COSTS

X. SUMMARY OF COSTS

A. GENERAL. - The total estimated construction cost of the diversion canal and the Mill River protection works is $628,700, including 10 percent for contingencies and 15 percent for engineering and overhead, and is subdivided into the following work items:

1. The cost of the excavation of the diversion canal completed is $106,000.

2. The total estimated cost of the diversion canal - Fiscal Year 1939 Unit - is $264,700.

3. The estimated cost of placing the riprap, constructing a small overflow, concrete bridge and completing the excavation from Station C-0+00 to C-1+50 and from Station C-106+00 to C-109+00, which is expected to be done during the next fiscal year, is $101,000.

4. The total estimated cost of the Mill River dike - Fiscal Year 1940 Unit - is $157,000.

B. DIVERSION CANAL - FISCAL YEAR 1939 UNIT - ESTIMATED COST. - The estimated construction cost of the diversion canal, Fiscal Year 1939 Unit, is $264,700, including 10 percent for contingencies and 15 percent for engineering and overhead, and is distributed as follows:

1.	Excavation and Backfill	$31,300
2.	Steel Sheet Piling	36,040
3.	Timber Piling	31,760
4.	Drainage	3,180
5.	Reinforced Concrete	86,030
6.	South Street Bridge	34,290
7.	Relocation of Earle and South Streets	28,730

8.	Hand-placed Riprap	$ 2,530
9.	Derrick-placed Riprap	5,790
10.	Miscellaneous	5,050
	TOTAL	$264,700

1. The excavation and backfill item includes all excavation for diversion canal including the drop-structure, bridge and drainage system, all excavation for the relocations of Earle and South Streets, and all backfill adjacent to the drop-structure and bridge abutments.

2. The steel sheet piling includes furnishing, placing and driving the sheet piles for the drop-structure.

3. The timber piling includes furnishing, placing and driving the piles for the drop-structure.

4. The drainage item includes the furnishing and placing of screened gravel, crushed stone drains, tile pipe drains for the drop-structure.

5. Reinforced concrete includes the cement, copper water stops, steel reinforcement, and all concrete in the drop-structure walls, weir and floor.

6. South Street Bridge item includes the concrete for the abutments, center pier and the two spans, bridge railing, special bridge bearing plates and sheet lead.

7. Relocation of Earle and South Streets include embankment fill, concrete and bituminous surfacing, gravel for the roads and the highway guard rail.

8. Hand-placed riprap includes the furnishing and placing of the rock for the riprap.

9. Derrick-placed riprap includes the furnishing and placing of the rock.

10. The miscellaneous item includes miscellaneous iron and steel, drop-structure railing and pre-cast concrete stop-log for the drop-structure weir.

C. MILL RIVER DIKE - FISCAL YEAR 1940 UNIT- ESTIMATED COST. - The estimated construction cost of the Mill River dike and appurtenant structures Fiscal Year 1940 Unit - is $157,000 , including 10 percent for contingencies and 15 percent for engineering and overhead, and is distributed as follows:

1.	Excavation and backfill	$ 10,293
2.	Embankment	45,933
3.	Steel sheet piling	21,582
4.	Timber piling	1,861
5.	Riprap	30,195
6.	Drainage	3,363
7.	Concrete	39,762
8.	Miscellaneous	4,011
		$157,000

1. The excavation and backfill item includes all excavation and backfill for the concrete walls, cut-off trench, completion of diversion canal, drainage system and stop-log structure.

2. The embankment includes the borrow pit excavation, handling, hauling, placing and rolling of all materials in the dike.

3. The steel sheet piling includes furnishing, placing and driving piles for the walls, closure dike and drop-structure.

4. The timber piling includes furnishing, placing and driving piles for the bridge near the Ox Bow.

5. Hand-placed riprap includes the furnishing and placing of the rock for the riprap including the gravel bedding.

6. The drainage item includes the furnishing and placing of screened gravel, crushed stone drains, porous concrete and tile pipes,

manhole connections and the grouted stone gutters.

7. Reinforced concrete includes cement, copper water stops, aggregate and steel reinforcement for all the concrete in the walls, Ox Bow Bridge and stop-log structure.

8. The miscellaneous item includes the concrete sidewalk, miscellaneous metal and structural steel for the stop-log structure, timber stop-logs, pipe handrail, gravel for roads and macadam road surfacing.

XI. PLATES

LIST OF PLATES

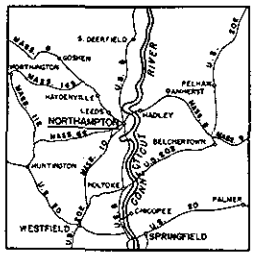
DIVERSION CANAL

Plate No.	
1	Project Location.
2	Record of Subsurface Explorations.
3	Geologic Section.
4	Diagram Showing Limits of Soil Classes.
5	Consolidation Test, Void Ratio and Compressibility.
6	Consolidation Test, Permeability and Coefficient of Consolidation.
7	Stability of Canal Slopes.
8	General Plan and Profile, Station C-0+00 to C-3+75.
9	General Plan and Profile, Station C-3+75 to C-25+76.
10	General Plan and Profile, Station C-25+76 to C-52+80.
11	General Plan and Profile, Station C-52+80 to C-78+65.
12	General Plan and Profile, Station C-78+65 to C-106+00.
13	Typical Canal Sections.
14	Drop-structure, Plan and Profile
15	Drop-structure, Piling Layout.
16	Drop-structure, Drains and Joints.
17	South Street Bridge, General Plan.
18	Earle and South Streets Relocations.

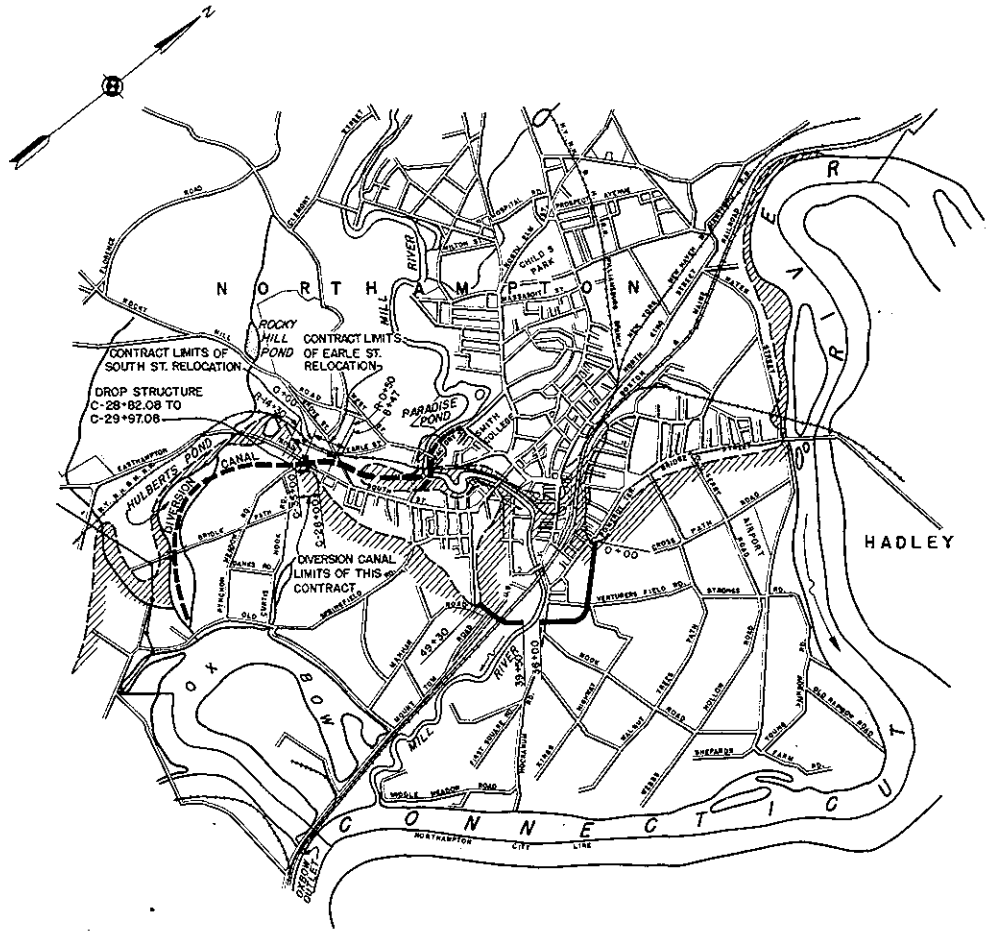
LIST OF PLATES

MILL RIVER DIKE

Plate No.	
19	Project Location
20	Record of Subsurface Explorations
21	Geologic Section
22	Borrow Areas
23	Composite grain size curves of materials in Borrow Areas
24	Compaction curves for materials in Borrow Areas
25	Plan and Profile, Dike and Diversion Canal Entrance
26	Plan and Profile, Diversion Canal Outlet
27	Diversion Canal, Plan and Sections C-(-1+40) to C1-50.
28	Bridge at Oxbow, Concrete Details
29	Embankment Details
30	Drainage Profile and Details
31	Concrete Wall Details No. 1
32	Concrete Wall Details No. 2
33	Concrete Wall Details No. 3
34	Concrete Wall Details No. 4
35	Stop-log Structure Details No. 1
36	Stop-log Structure Details No. 2
37	District Organization Chart.



LOCATION MAP



VICINITY MAP

SCALE: 1" = 1600'

LEGEND

- Diversion Canal
- Dike Under Construction
- Future Construction
- Overflow Limits of the March 1936 Flood

KEY	DATE	REVISION (Indicated by Δ)	REV.BY	CK.BY	AP.BY
Δ	9/28/39	Sheets No. 31A & 31B added	P.C.H.	A.D.A.	J.S.B.
Δ	8/14/39	Sheet No. 44 added	P.C.H.	N.A.J.	J.S.B.
Δ	8/14/39	CT-4-1670 superseded by CT-4-1833	P.C.H.	N.A.J.	J.S.B.

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

DIVERSION CANAL - FISCAL YEAR 1939 UNIT

PROJECT LOCATION AND INDEX

CONNECTICUT & MILL RIVERS MASSACHUSETTS

IN 46 SHEETS SCALE: 1 IN. = 1600 FT. SHEET NO. 1.

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., MAY 1939

SUBMITTED: K. B. Nelson, SENIOR ENGINEER, HEAD, DESIGN SECTION

APPROVAL RECOMMENDED: J. S. Bourne, PRINCIPAL ENGINEER, CHIEF, F.C. ENGINEERING DIV.

APPROVED: Jos. Snodgrass, LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

DESIGNED: P. C. Hancock, ASST. ENGINEER

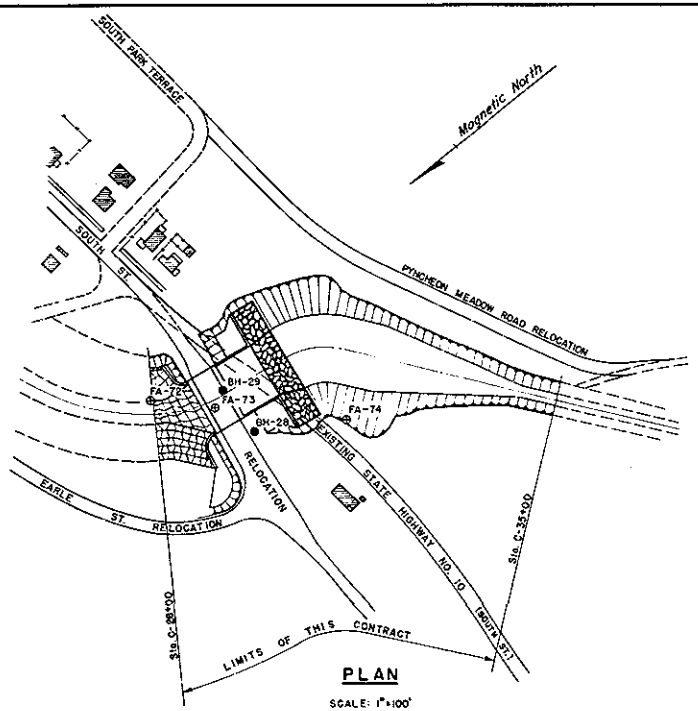
DRAWN: J.P.K. TRACED: J.T.-J.S.B. CHECKED: C.C.R.

FILE NO. CT-4-1641

N.3b

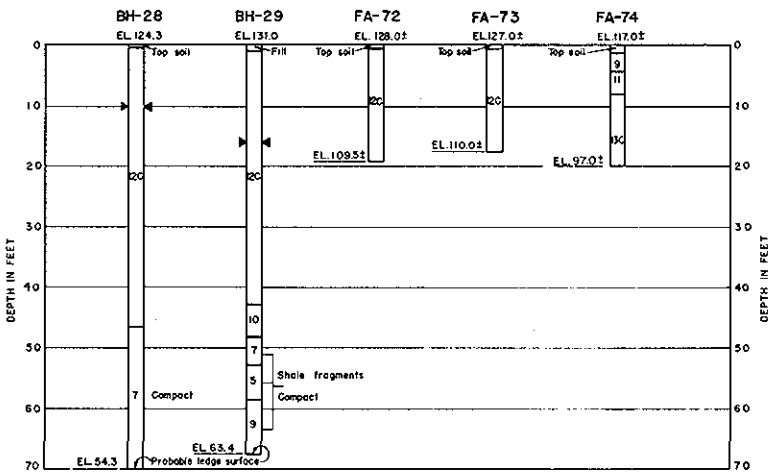
1

PLATE NO. 1



PLAN

SCALE: 1" = 100'



RECORD OF BORINGS

LEGEND

- ● BH—Drive sample bore hole
- ⊕ FA—Auger boring
- ⊳|⊲ Water table at time of exploration

NOTES

Elevations refer to Mean Sea Level Datum

DESCRIPTION OF NUMERICAL CLASSES

1. Variable-Graded from Gravel to Coarse Sand – Contains little medium sand.
2. Uniform Coarse to Medium Sand- Contains little gravel and fine sand.
3. Variable-Graded from Gravel to Medium Sand-Contains little fine sand.
4. Uniform Medium to Fine Sand- Contains little coarse sand and coarse silt.
5. Variable-Graded from Gravel to Fine Sand-Contains little coarse silt.
6. Uniform Fine Sand to Coarse Silt- Contains little medium sand and medium silt.
7. Variable-Graded from Gravel to Coarse Silt- Contains little medium silt.
8. Uniform Coarse to Medium Silt- Contains little fine sand and fine silt.
9. Variable-Graded from Gravel to Medium Silt- Contains little fine silt.
10. Uniform Medium to Fine Silt- Contains little coarse silt and coarse clay. Possesses behavior characteristics of silt.
10C. Uniform Medium Silt to Coarse Clay- Contains little coarse silt and medium clay. Possesses behavior characteristics of clay.
11. Variable-Graded from Gravel or Coarse Sand to Fine Silt- Contains little coarse clay.
12. Uniform Fine Silt to Clay – Contains little medium silt and fine clay (colloids). Possesses behavior characteristics of silt.
12C. Uniform Clay- Contains little silt. Possesses behavior characteristics of clay.
13. Variable-Graded from Coarse Sand to Clay- Contains little fine clay (colloids). Possesses behavior characteristics of silt.
13C. Variable Clay- Graded from sand to fine clay (colloids). Possesses behavior characteristics of clay.

DATE	REVISION	REV BY	CK. BY	AR. BY
6-27-39	Pyncheon Meadow Road revision	WOJ	FJR	PED

CONNECTICUT RIVER FLOOD CONTROL
NORTHAMPTON DIKE
DIVERSION CANAL – FISCAL YEAR 1939 UNIT

SUBSURFACE EXPLORATIONS

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 46 SHEETS — SCALE: 1 IN. = 100 FT. — SHEET NO. 2

U. S. ENGINEER OFFICE, PROVIDENCE, R. I., MAY 1939

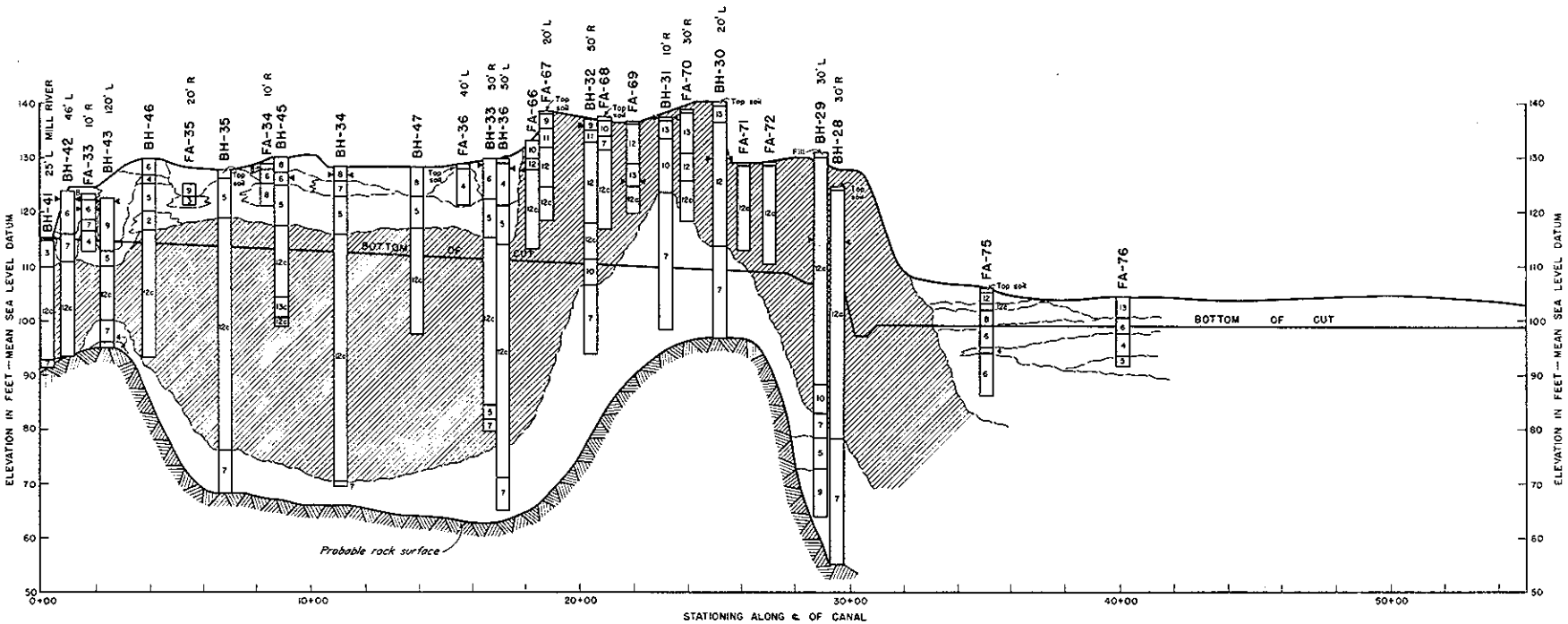
SUBMITTED: Frank J. Rabbitt, Jr., Chief, Geology Section, Head, Geology Section
APPROVAL RECOMMENDED: U. S. Osborne, Principal Engineer, Chief, F. C. Engineering Div.
APPROVED: Wm. Sanders, Lt. Colonel, Corps of Engineers, District Engineer

COMPILED: Asst. Engineer
DRAWN: EPS; TRACED: JBA & KMB; CHECKED: F. N. J.

FILE NO. CT-2-1167

PLATE NO. 2

N. 3b (2)



NOTES

For description of numerical classes see Table No. 2

LEGEND

- BH — Drive sample bore hole
- FA — Auger boring
- R — Right of canal ℄
- L — Left of canal ℄
- Glacial lake deposit (clay)

DATE	REVISION	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

DIVERSION CANAL

GEOLOGIC SECTION

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 1 SHEETS — SCALE: HOR. 1 IN. = 200 FT. VERT. 1 IN. = 10 FT. — SHEET NO. 1

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. APRIL 1939

SUBMITTED: Henry B. Gehlert, SENIOR GEOLOGIST, HYD. GEOLOGY SECTION

APPROVAL RECOMMENDED: J. B. Burns, PRINCIPAL ENGINEER, CHIEF, C. ENGINEERING DIV.

APPROVED: J. Morgan, LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

DESIGNED: W. A. Sleeth, ASST. ENGINEER

DRAWN: E. P. L. TRACED: W. E. L. CHECKED: W. H. J.

FILE NO. CT-2-1166

PLATE NO. 3

PROVIDENCE DISTRICT SOIL CLASSIFICATION

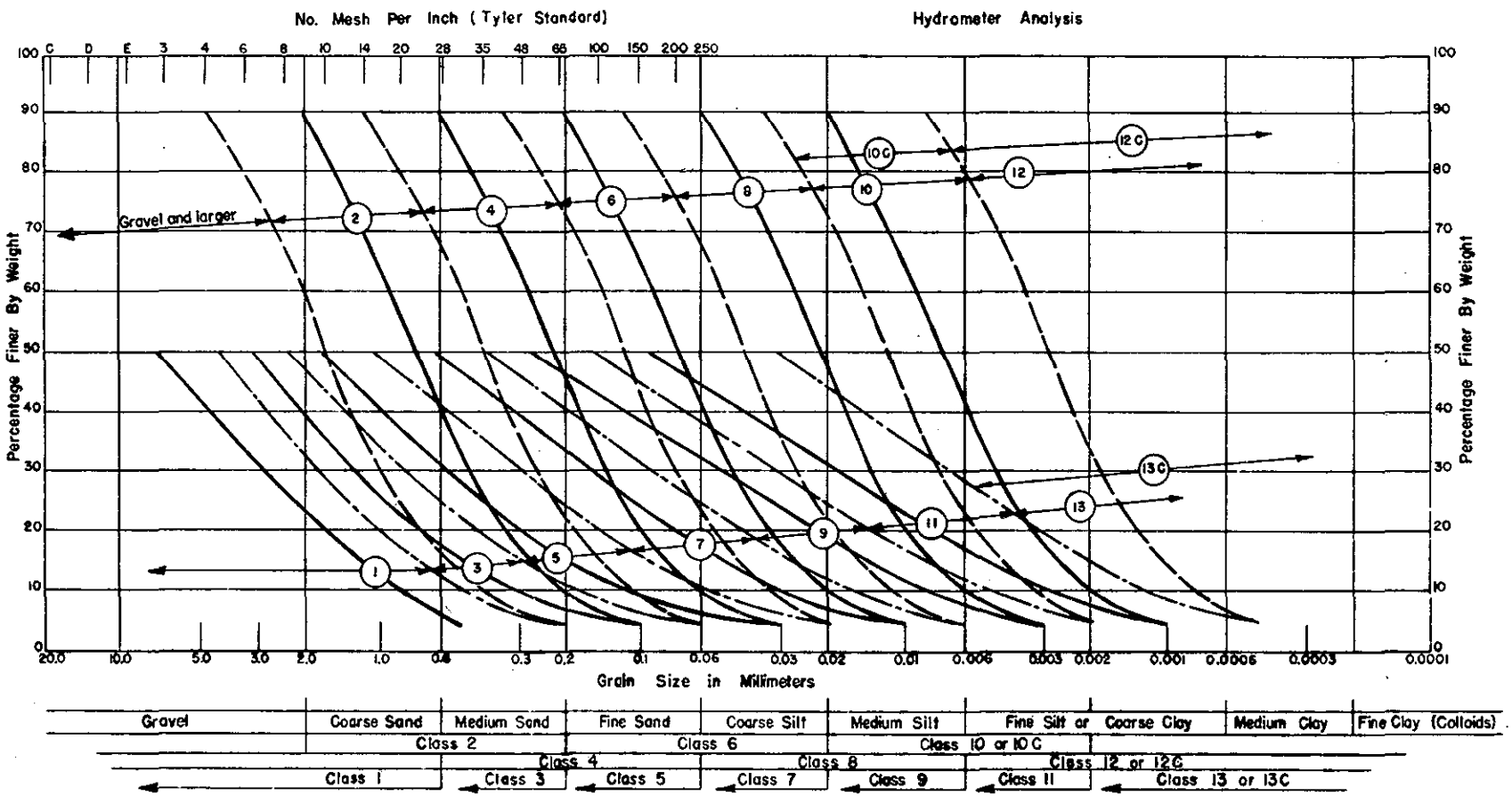


DIAGRAM SHOWING LIMITS OF SOIL CLASSES

PLATE NO. 4

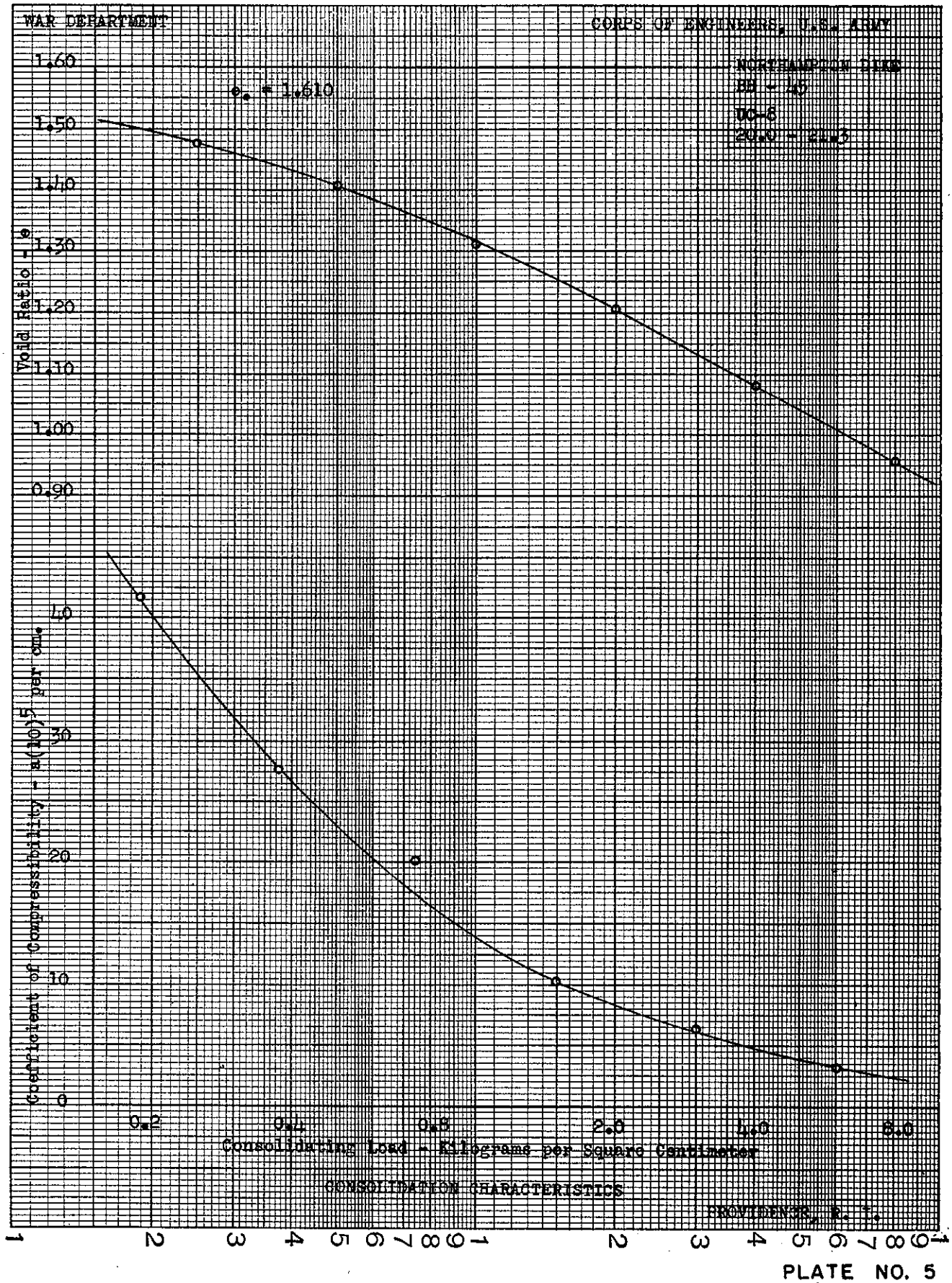

WAR DEPARTMENT
CORPS OF ENGINEERS, U.S. ARMY
NORTHAMPTON DIKE
BH - 45
DC-6
20.0 - 21.3
e₀ = 1.610
Void Ratio - e
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
Coefficient of Compressibility - a(10)-5 per cm.
40
30
20
10
0
0.2
0.4
0.8
2.0
4.0
8.0
Consolidating Load - Kilograms per Square Centimeter
CONSOLIDATION CHARACTERISTICS
PROVIDENCE, R. I.

PLATE NO. 5

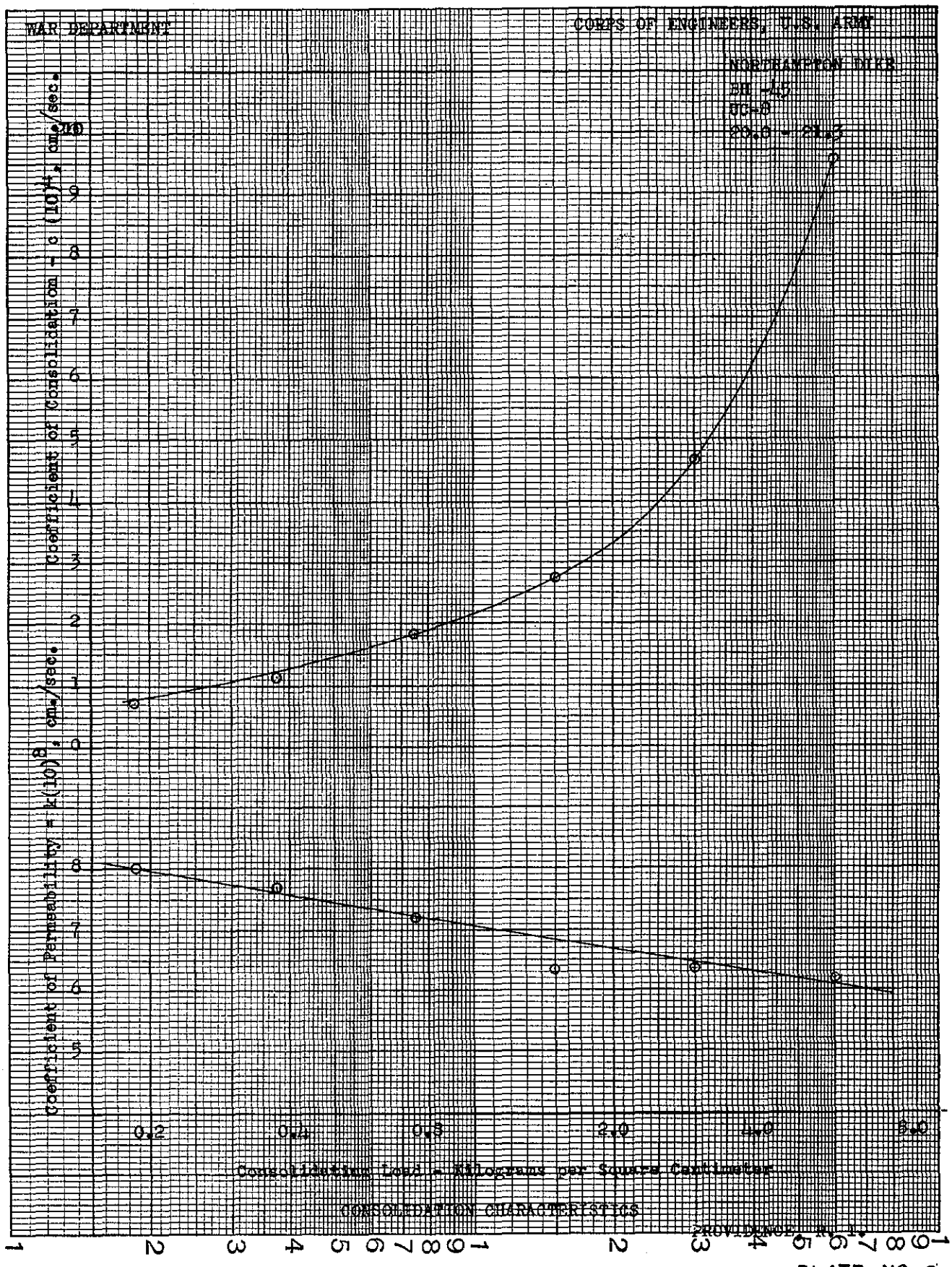

WAR DEPARTMENT
CORPS OF ENGINEERS, U.S. ARMY
NORTHAMPTON DIKE
BH -45
UC-8
20.0 - 21.3
Coefficient of Permeability = k(10)8, cm./sec.
Coefficient of Consolidation = c (10)4, cm.²/sec.
0.2
0.4
0.8
2.0
4.0
8.0
Consolidation Load - Kilograms per Square Centimeter
CONSOLIDATION CHARACTERISTICS
PROVIDENCE, R.I.

PLATE NO. 6

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

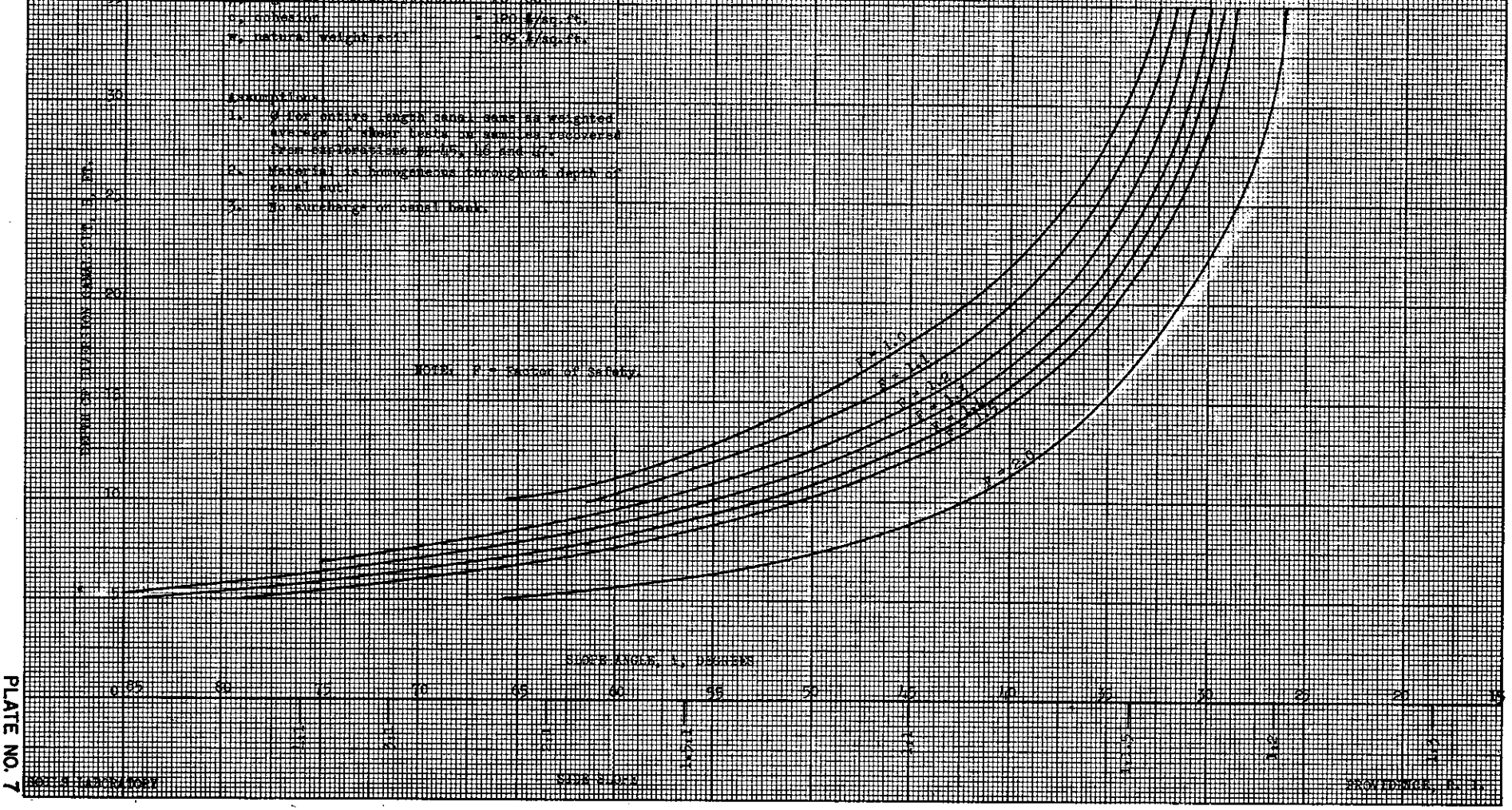
STABILITY OF
DIVERSION CANAL SLOPES
NORTHAMPTON, MASS.

ϕ, angle of internal friction = 26° 00'
c, cohesion = 120 #/sq. ft.
γ_n, natural weight soil = 95 #/cu. ft.

Assumptions:

1. ϕ for entire length canal same as weighted average of shear tests on samples recovered from exploratory holes 8-1, 10 and 11.
2. Material is homogeneous throughout depth of canal cut.
3. No surcharge on canal bank.

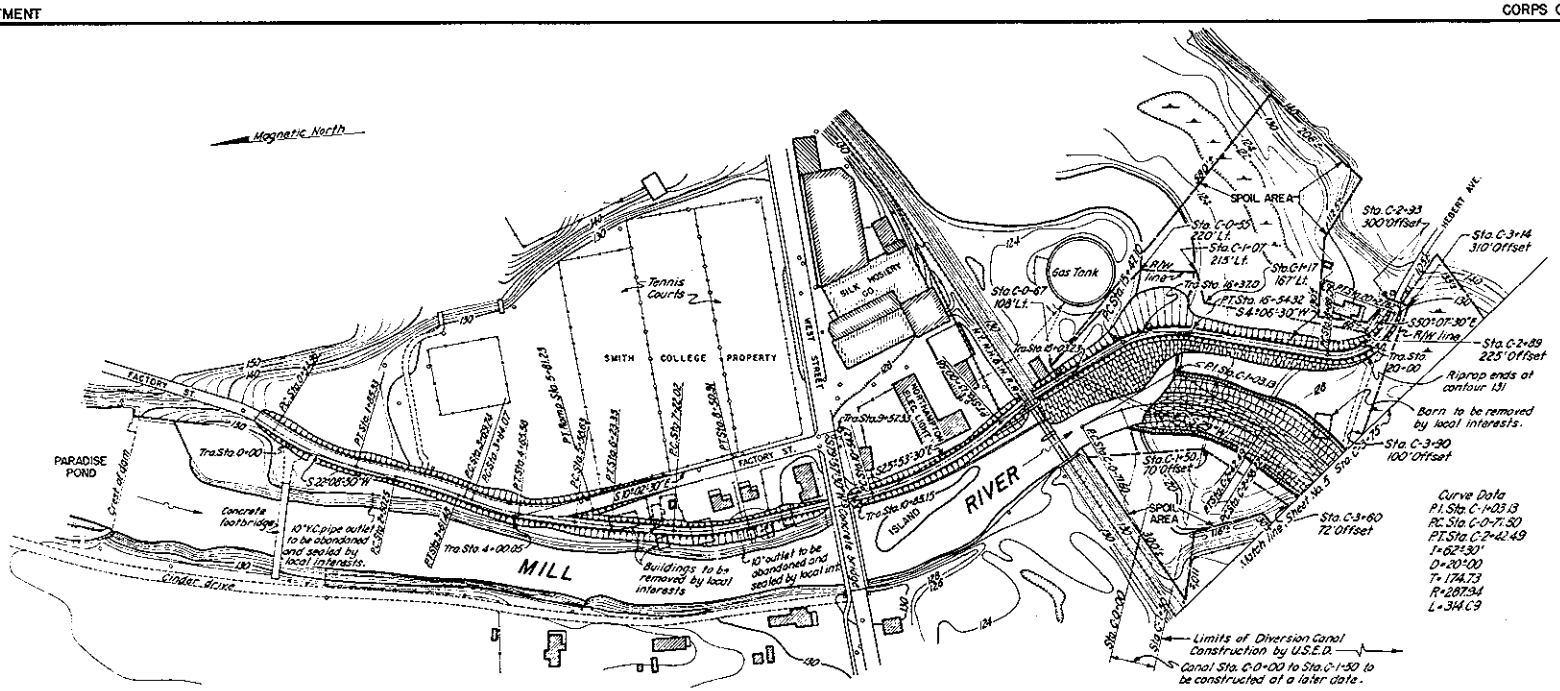
NOTE: F = factor of safety.



SOIL & MECHANICS LABORATORY

PROVIDENCE, R. I.

PLATE NO. 7

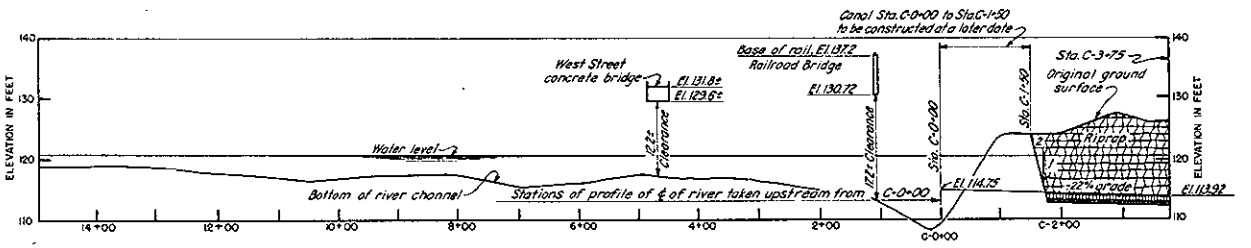


PLAN

SCALE: 1" = 100'

NOTE

Canal stations are prefixed by "C".
Riprap to be placed later, by Contract.
Elevations refer to Mean Sea Level Datum.
Limits of spoil area already established by the city.



PROFILE ON ℄ RIVER AND DIVERSION CANAL

SCALE: HOR. 1" = 100' VERT. 1" = 10'

DATE	REVISION	REV BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

DIVERSION CANAL — FISCAL YEAR 1939 UNIT

PLAN AND PROFILE

STA. C-0+00 TO STA. C-3+75

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 10 SHEETS — SCALE: 1 IN. = 100 FT. — SHEET NO. 4

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., MARCH 1939

SUBMITTED: Donald A. R. ... SENIOR ENGINEER, HEAD, DESIGN SECTION

APPROVAL RECOMMENDED: D. B. Strauss, PRINCIPAL ENGINEER, CHIEF, FLOOD ENGINEERING DIV.

APPROVED: W. Scranton, LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

DESIGNED BY: P. C. Hammond, ASST. ENGINEER

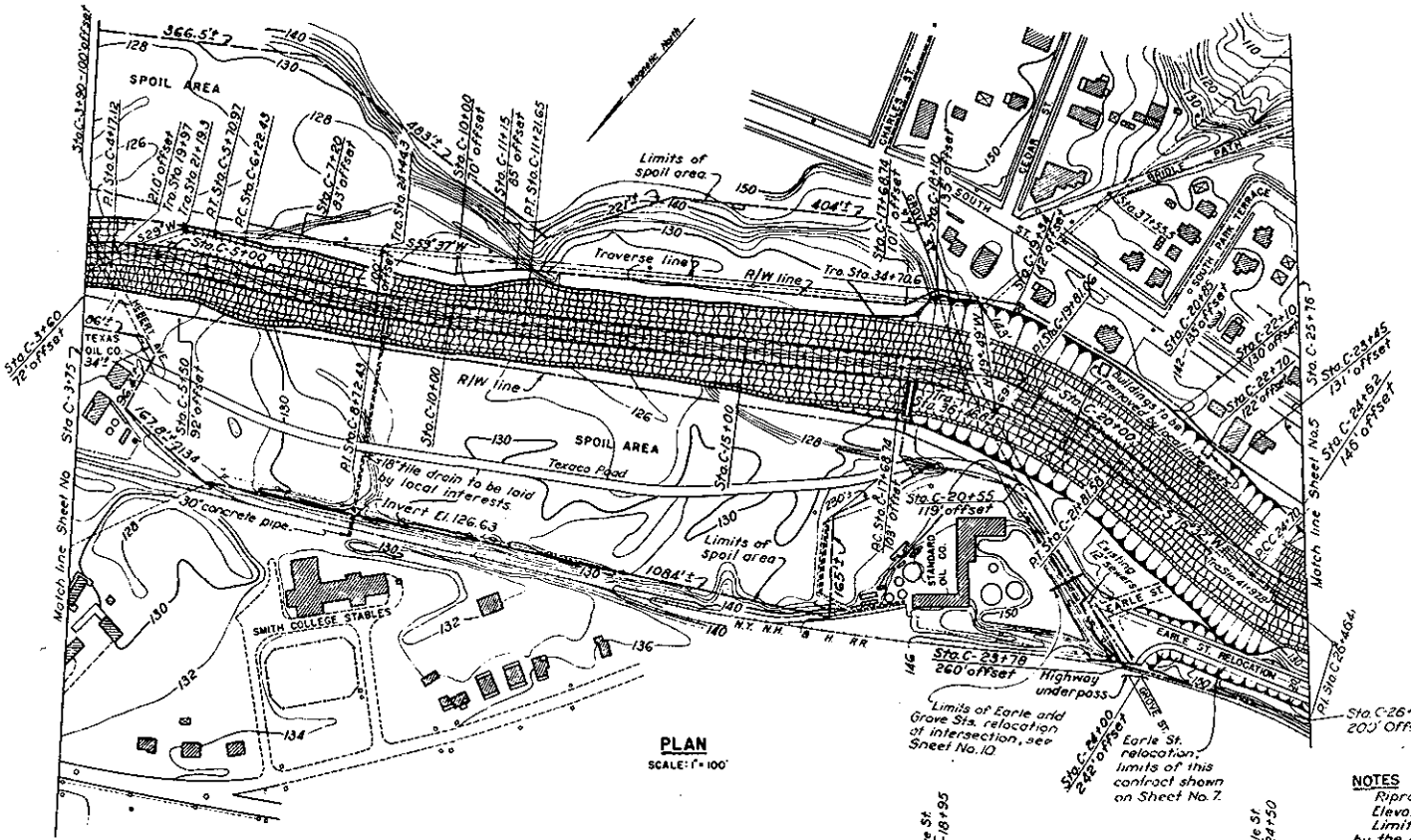
DRAWN BY: H.A.O. TRACED BY: D.F.B. CHECKED BY: C.D.J.

FILE NO. CT-4-1384

PLATE NO. 8

N. 30

4



PLAN

SCALE: 1" = 100'

Curve Data

P.I. Sta. C-4+17.12
P.C. Sta. C-2+58.22
P.T. Sta. C-5+70.97
I = 25°-00'
D = 8°-00'
T = 158.90'
R = 716.77'
L = 312.75'

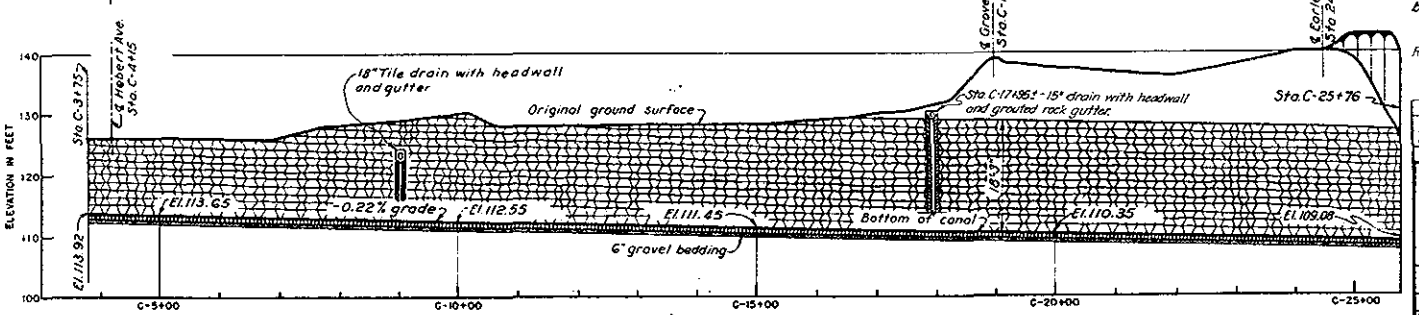
P.I. Sta. C-8+72.43
P.C. Sta. C-6+22.43
P.T. Sta. C-11+21.65
I = 7°-30'
D = 1°-30'
T = 250.00'
R = 3814.46'
L = 499.22'

P.I. Sta. C-19+81.06
P.C. Sta. C-17+68.74
P.T. Sta. C-21+61.58
I = 33°-00'
D = 8°-00'
T = 212.32'
R = 716.779'
L = 412.84

P.I. Sta. C-26+46.41
P.C. Sta. C-24+70.00
P.C.C. Sta. C-27+96.81
I = 53°-30'
D = 16°-22'11"
T = 350.00'
R = 176.41'
L = 326.81'

NOTES

Riprap to be placed later, by contract.
Elevations refer to Mean Sea Level Datum
Limits of spoil area already established by the city
Stations along canal have prefix "C".
All work shown on this sheet except Earle St. Relocation to be done by others.



PROFILE ON ℄ DIVERSION CANAL

SCALE: HOR. 1" = 100'
VERT. 1" = 10'

DATE	REVISION	REV BY	CK BY	AP BY
6-22-39	Texaco road shown	F.C.H.	[illegible]	[illegible]

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

DIVERSION CANAL - FISCAL YEAR 1939 UNIT

PLAN AND PROFILE NO. 1

STA. C-3+75 TO STA. C-25+76

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

W 46 SHEETS — SCALE 1 IN = 100 FT. — SHEET NO 4

100' 0 100' 200'

U. S. ENGINEER OFFICE, PROVIDENCE, R.I., MAY 1939

SUBMITTED: [illegible] SENIOR ENGINEER, HEAD, DESIGN SECTION

RECOMMENDED: [illegible] PRINCIPAL ENGINEER, CHIEF, ENGINEERING DIV.

APPROVED: [illegible] COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DESIGNED: F. C. Hammond, ASST. ENGINEER

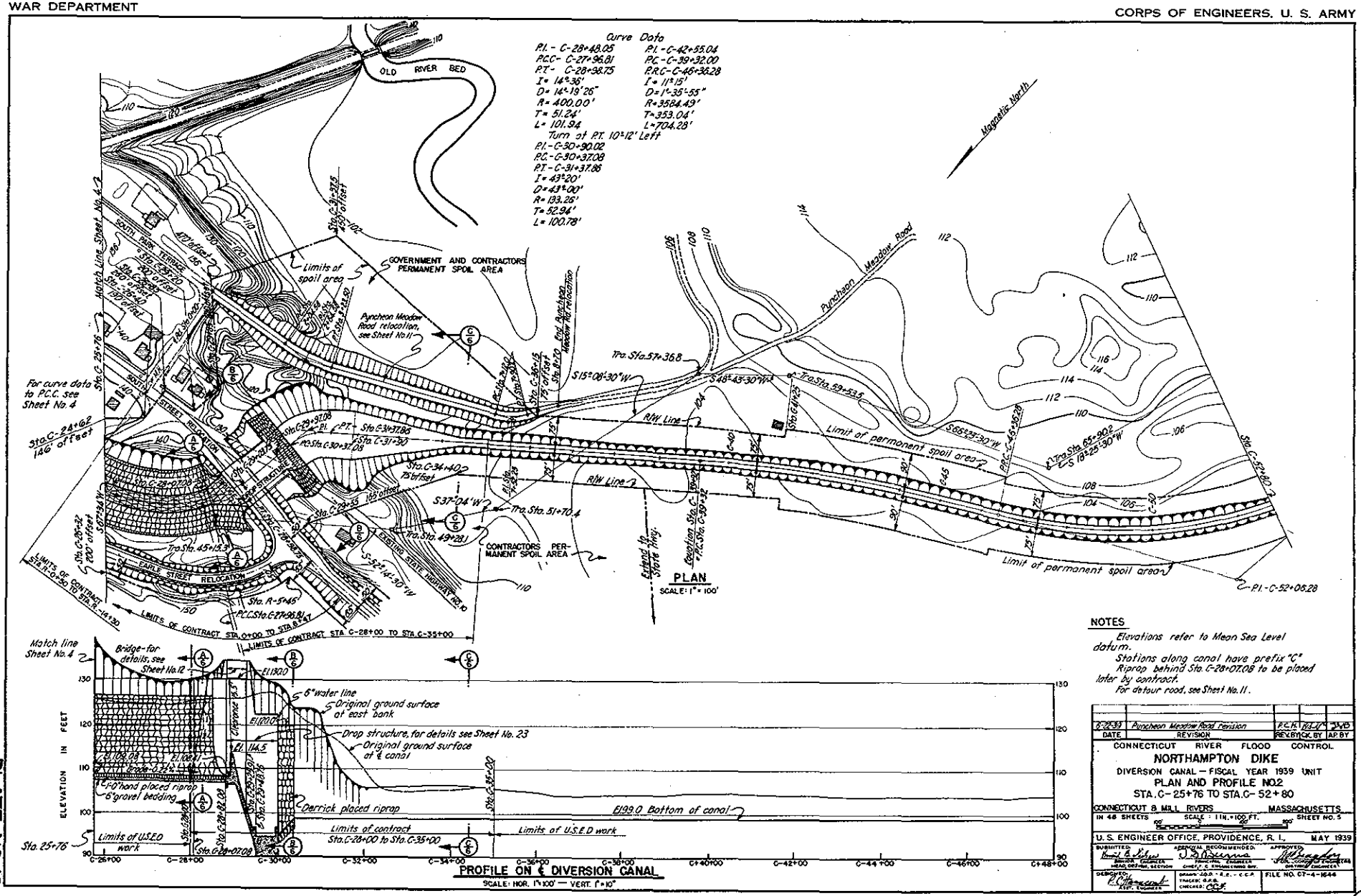
DRAWN: E.Z.
TRACED: A.S.
CHECKED: [illegible]

FILE NO. CT-4-1643

PLATE NO. 9

N. 3b

4



PLAN
SCALE: 1" = 100'

PROFILE ON ℄ DIVERSION CANAL
SCALE: HOR. 1" = 100' — VERT. 1" = 10'

NOTES

Elevations refer to Mean Sea Level datum.

Stations along canal have prefix "C"

Riprap behind Sta. C-28+07.08 to be placed later by contract.

For detour road, see Sheet No. 11.

DATE	REVISION	REV. BY	CK. BY	AP. BY
6-29-39	Pyncheon Meadow Road Revision	P.C.H.	[illegible]	[illegible]

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

DIVERSION CANAL — FISCAL YEAR 1939 UNIT

PLAN AND PROFILE NO. 2

STA. C-25+76 TO STA. C-52+80

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

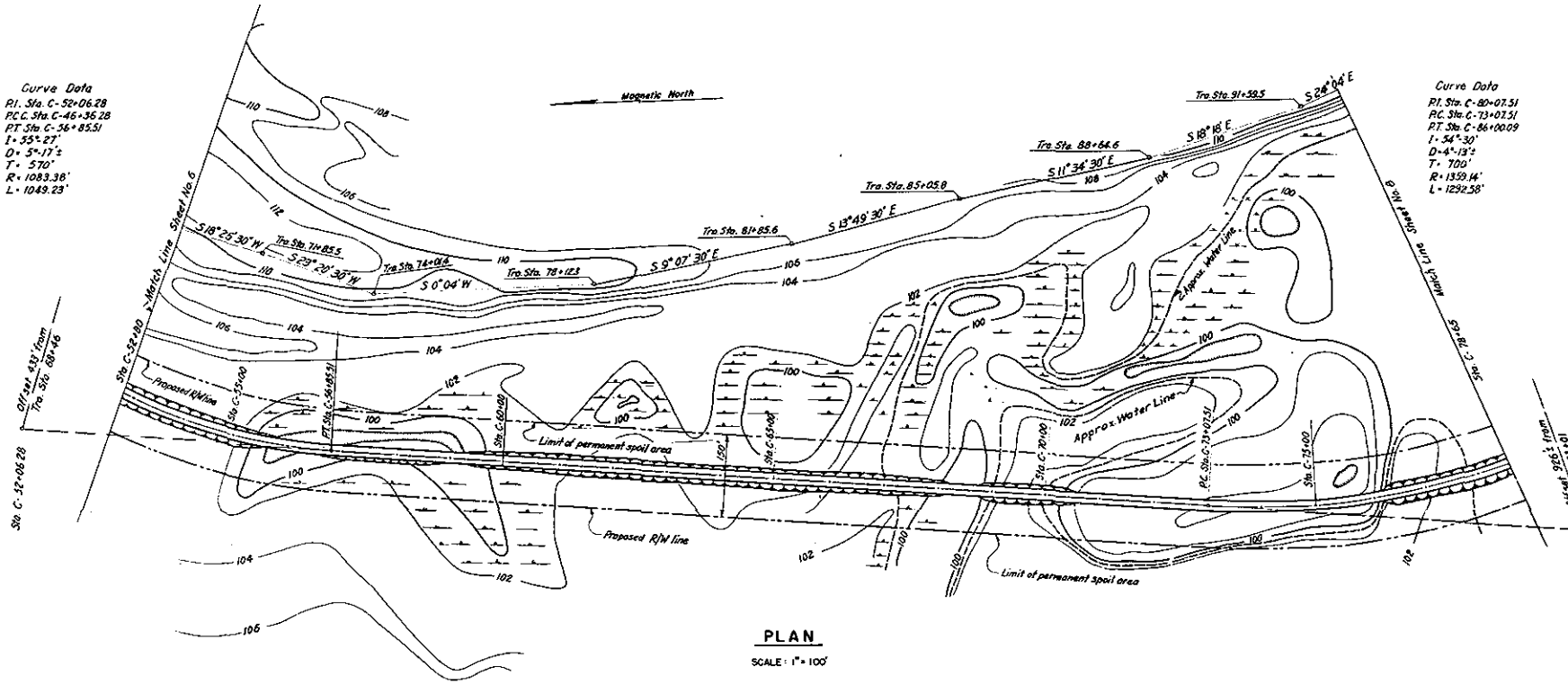
IN 48 SHEETS — SCALE: 1 IN. = 100 FT. — SHEET NO. 5

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — MAY 1939

SUBMITTED: Senior Engineer, Head, Design Section — APPROVAL RECOMMENDED: Principal Engineer, Chief, C. & Enhancing Div. — APPROVED: Colonel, Corps of Engineers, District Engineer

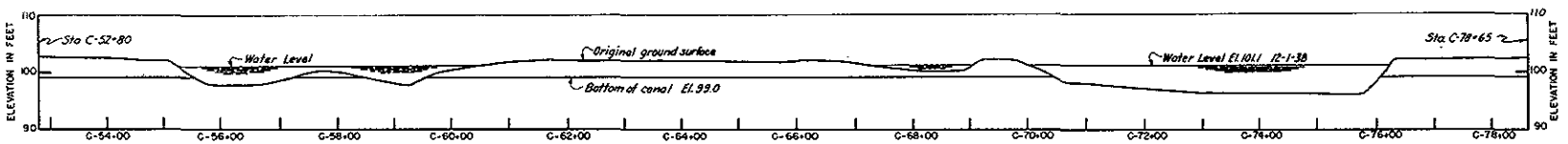
DESIGNED: Asst. Engineer — DRAWN: J.O.D. - R.E. - C.C.P. — TRACED: G.A.B. — CHECKED: [illegible] — FILE NO. CT-4-1644

PLATE NO. 10



PLAN

SCALE: 1" = 100'



PROFILE ON ℄ DIVERSION CANAL

SCALE VERT.: 1" = 10'
HOR.: 1" = 100'

NOTE

Elevations refer to Mean Sea Level Datum.

DATE	REVISION	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

DIVERSION CANAL - FISCAL YEAR 1939 UNIT

PLAN AND PROFILE

STA. C-52+80 TO STA. C-78+65

CONNECTICUT & MILL RIVERS MASSACHUSETTS

TWO SHEETS SCALE: 1" = 100 FT. SHEET NO. 7

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., MARCH 1939

SUBMITTED: SENIOR ENGINEER, HEAD, DESIGN SECTION

APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, R.E. ENGINEERING DIV.

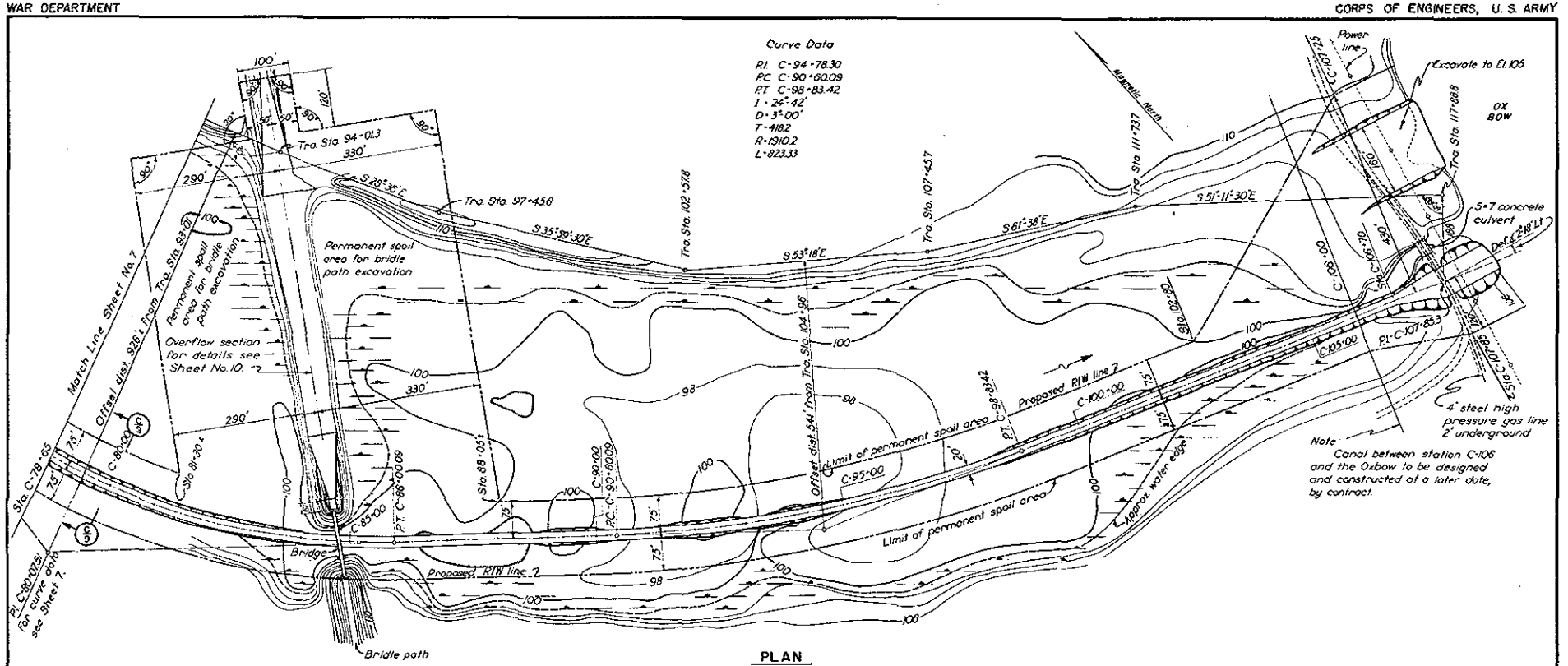
APPROVED: LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

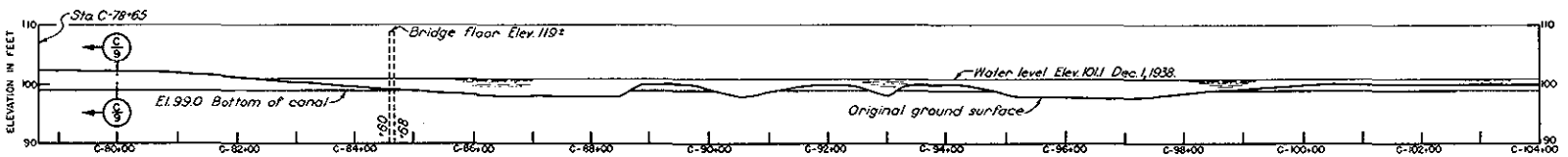
DESIGNED: ART CONTRACTS

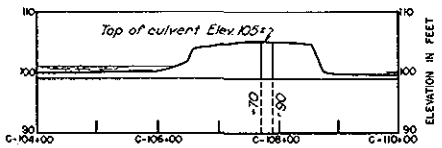
DRAWN BY: J.S.D. TRACED BY: W.A.V. CHECKED BY: C.G.F.

FILE NO. CT-4-1387

PLATE NO. 11







PROFILE ON ℄ DIVERSION CANAL

SCALE: VERT. 1" = 10'
HOR. 1" = 100'

NOTE

Elevations refer to Mean Sea Level Datum.

DATE	REVISION	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

DIVERSION CANAL - FISCAL YEAR 1939 UNIT

PLAN AND PROFILE

STA. C-78+65 TO STA. C-109+00

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 10 SHEETS — SCALE: 1 IN. = 100 FT. — SHEET NO. 8

U. S. ENGINEER OFFICE, PROVIDENCE, R. I., MARCH 1939

SUBMITTED: Harold B. Lakin, SENIOR ENGINEER, HEAD, DESIGN SECTION

APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, R.C. ENGINEERING DIV.

APPROVED: W. Hampton, LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

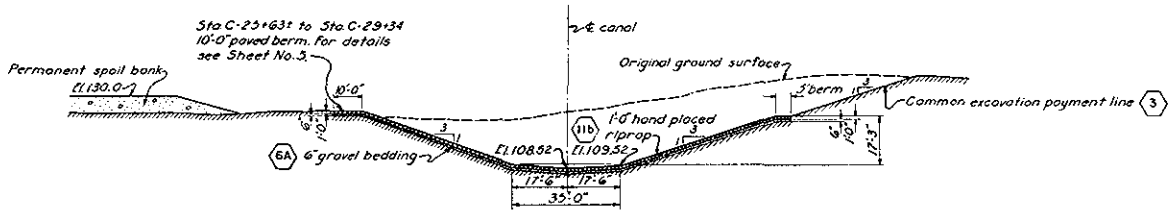
DESIGNED: R. C. Hanscomb, ASST. ENGINEER

DRAWN BY: E.E. & J.C.D.
TRACED BY: A.A.C.
CHECKED BY: C.C.W.

FILE NO. CT-4-1388

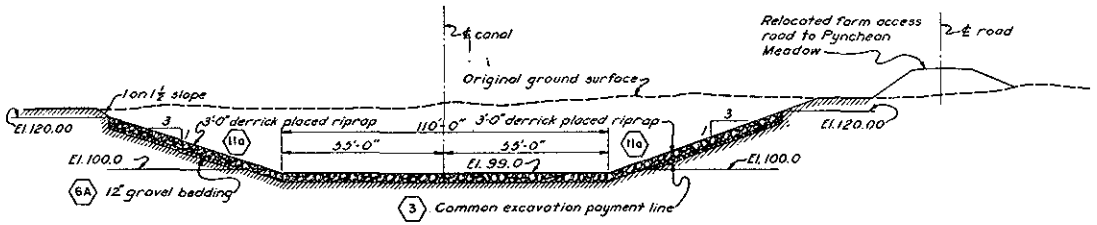
PLATE NO. 12

N. 3a



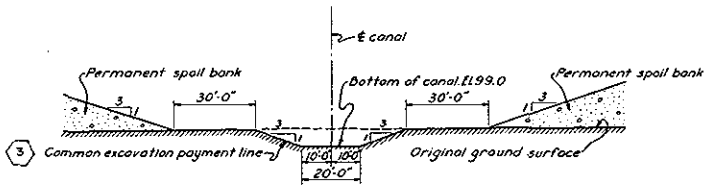
SECTION $\frac{A}{5}$ AT STA. C-28+30

TYPICAL FROM STA. C-28+00± TO STA. C-28+07.08



SECTION $\frac{B}{5}$ AT STA. C-30+37.08

TYPICAL WITHOUT RIPRAP FROM STA. C-30+37.08 TO STA. C-31+90.00



SECTION $\frac{C}{5}$ AT STA. C-34+40.00

TYPICAL FROM STA. C-34+40.00 TO STA. C-35+00

NOTES

Elevations refer to Mean Sea Level Datum.
Stations along the canal are prefixed by letter "C".
Figures in hexagons indicate item numbers under which payment will be made.

DATE	REVISION	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

DIVERSION CANAL-FISCAL YEAR 1939 UNIT

TYPICAL SECTIONS

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

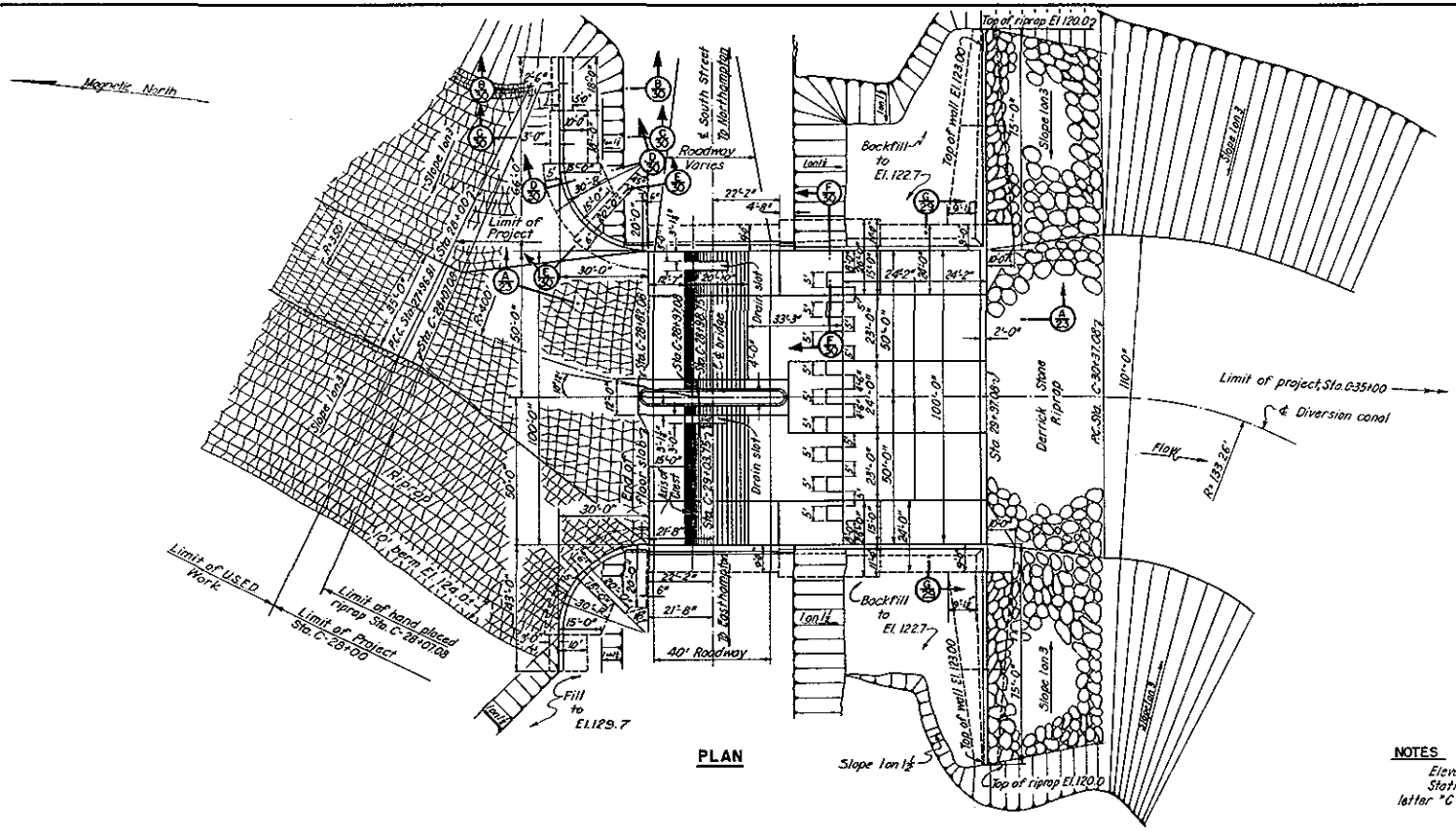
IN 46 SHEETS — SCALE: 1 IN. = 20 FT. — SHEET NO. 6

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — MAY 1939

SUBMITTED: Robert B. Fisher, Design Engineer, Hydr. Design Section — APPROVAL RECOMMENDED: J. S. Burns, Executive Engineer, Chief, C. Engineering Div. — APPROVED: W. Crosby, Lt. Colonel, Corps of Engineers, District Engineer

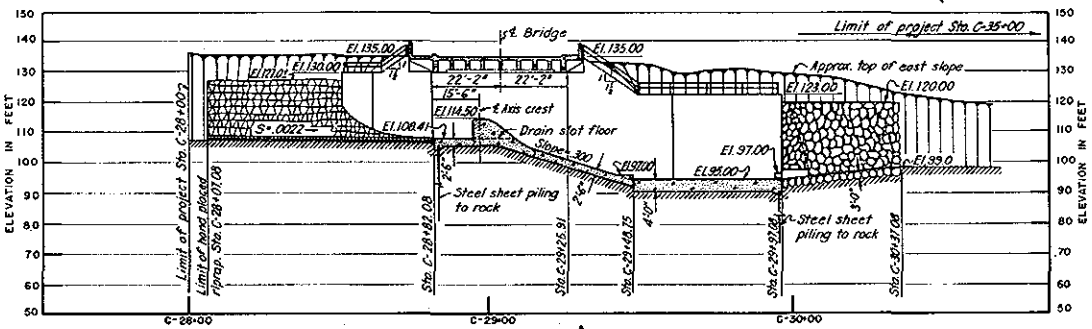
DESIGNED: P. L. Sanborn, Asst. Engineer — DRAWN: J.G.D. TRACED: P.V.S. CHECKED: J.S.P. — FILE NO. CT-4-1845

PLATE NO. 13



NOTES

Elevations refer to Mean Sea Level datum.
Stations along canal are prefixed by letter "C".



DATE	REVISION	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

DIVERSION CANAL-FISCAL YEAR 1939 UNIT

DROP STRUCTURE

PLAN AND SECTION

CONNECTICUT & MILL RIVERS MASSACHUSETTS

IN 46 SHEETS SCALE: 1 IN. = 20 FT. SHEET NO. 23

U.S. ENGINEER OFFICE, PROVIDENCE, R. I. MAY 1939

SUBMITTED: Bernard B. Mason, SENIOR ENGINEER, HEAD, DESIGN SECTION

APPROVAL RECOMMENDED: J. B. Burns, PRINCIPAL ENGINEER, CHIEF, C. T. R. ENGINEERING DIV.

APPROVED: [illegible], LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

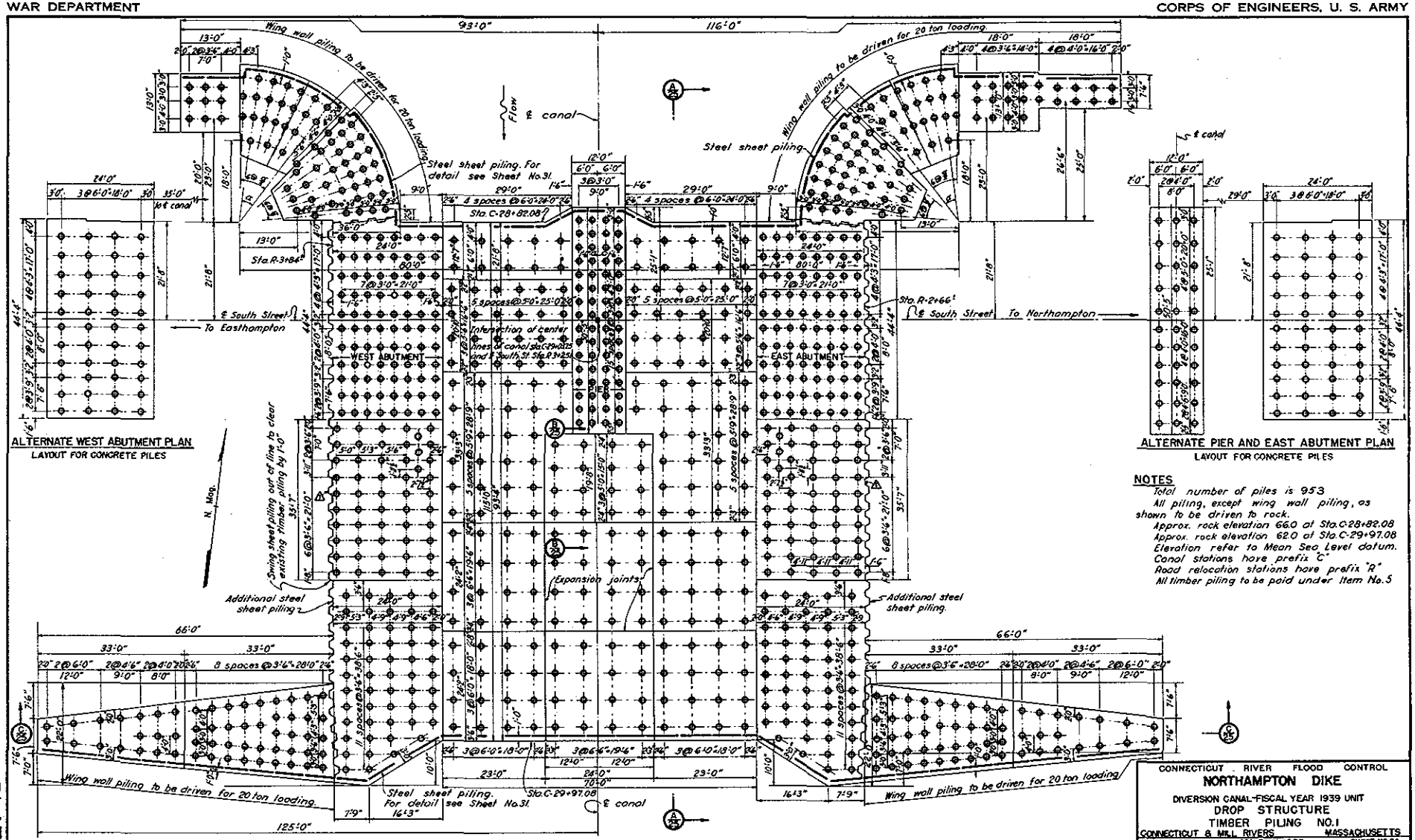
DESIGNED: P. C. Hovsepian, ASST. ENGINEER

DRAWN: W.S.B. TRACED: W.S.B. CHECKED: [illegible]

FILE NO. CT-4-1662

PLATE NO. 14

N.3b



ALTERNATE WEST ABUTMENT PLAN
LAYOUT FOR CONCRETE PILES

ALTERNATE PIER AND EAST ABUTMENT PLAN
LAYOUT FOR CONCRETE PILES

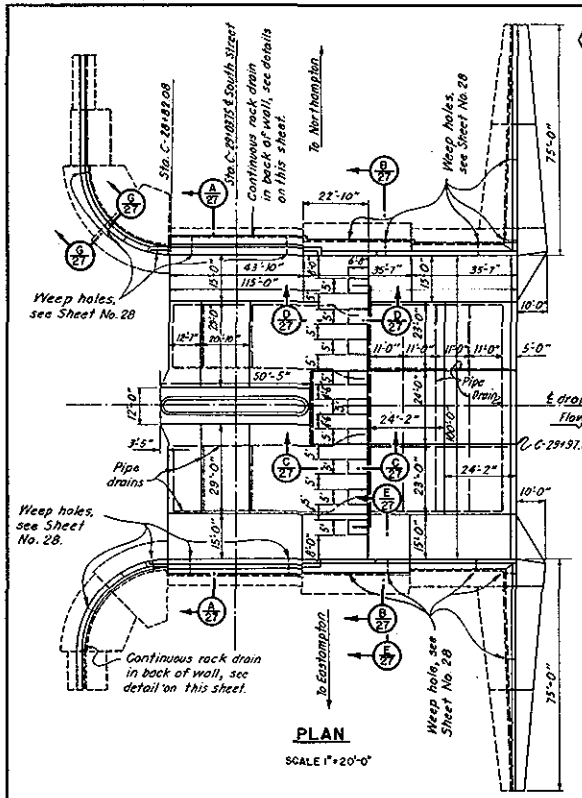
NOTES

Total number of piles is 953
All piling, except wing wall piling, as shown to be driven to rock.
Approx. rock elevation 66.0 at Sta. C-28+82.08
Approx. rock elevation 62.0 at Sta. C-29+97.08
Elevation refer to Mean Sea Level datum.
Canal stations have prefix "C"
Road relocation stations have prefix "R"
All timber piling to be paid under Item No. 5

DROP STRUCTURE PILING PLAN

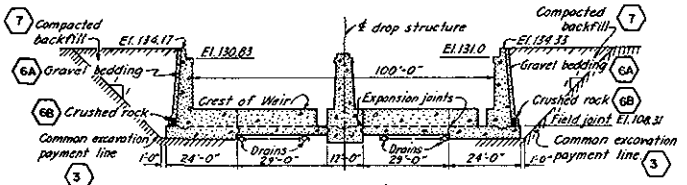
KEY	DATE	REVISION (indicated by △)	REVBY	CK. BY	AP BY
△	9/28/39	Additional steel sheet piling and respacing of timber piling.	LCS	RAE	JWD

CONNECTICUT RIVER FLOOD CONTROL
NORTHAMPTON DIKE
DIVERSION CANAL-FISCAL YEAR 1939 UNIT
DROP STRUCTURE
TIMBER PILING NO. 1
CONNECTICUT & MILL RIVERS — MASSACHUSETTS
IN 46 SHEETS — SCALE: 1" = 10' FT. — SHEET NO. 24
U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — MAY 1939
SUBMITTED: Chief, Design Section — APPROVAL RECOMMENDED: Principal Engineer, Chief, Engineering Div. — APPROVED: Lt. Col., Corps of Engineers, District Engineer
DESIGNED: Asst. Engineer — DRAWN: R.A.R. — TRACED: J.P. — CHECKED: — FILE NO. CT-4-1863



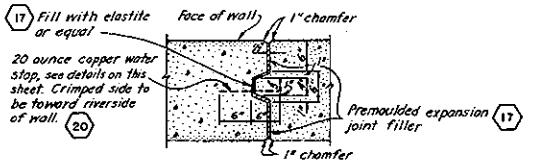
PLAN

SCALE 1" = 20'-0"



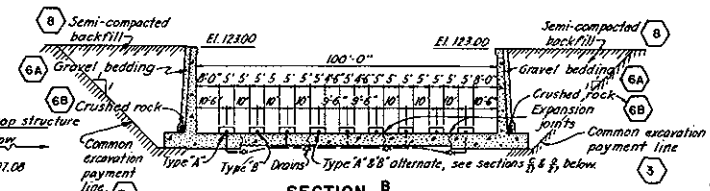
SECTION A/27

SCALE 1" = 20'-0"



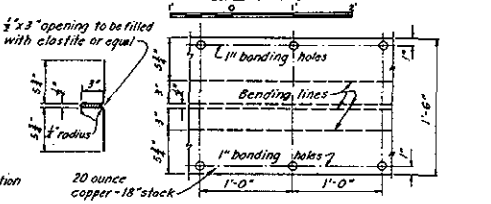
DETAIL OF EXPANSION JOINT IN WALL

SCALE 1" = 1'-0"



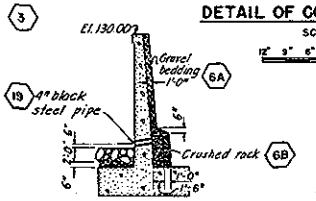
SECTION B/27

SCALE 1" = 20'-0"



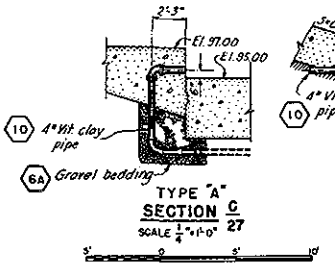
DETAIL OF COPPER WATER STOP

SCALE 1½" = 1'-0"



SECTION G/27

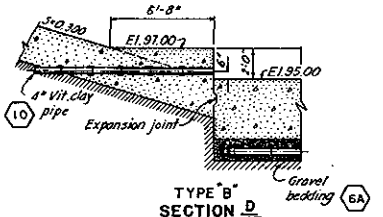
SCALE 1" = 10'-0"



TYPE "A"

SECTION C/27

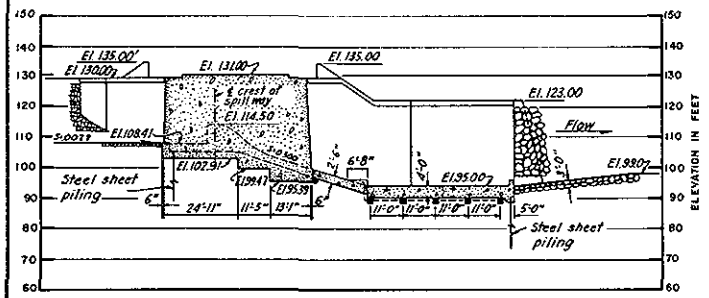
SCALE ¼" = 1'-0"



TYPE "B"

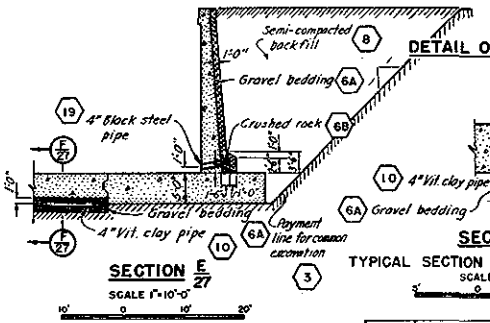
SECTION D/27

SCALE ¼" = 1'-0"



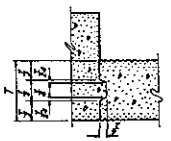
SECTION ALONG ℄ DROP STRUCTURE

SCALE 1" = 20'-0"



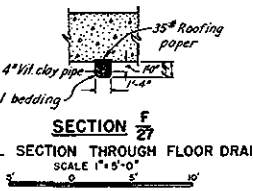
SECTION E/27

SCALE 1" = 10'-0"



DETAIL OF EXPANSION JOINT IN FLOOR

SCALE ¼" = 1'-0"



SECTION F/27

TYPICAL SECTION THROUGH FLOOR DRAIN

SCALE 1" = 5'-0"

NOTES

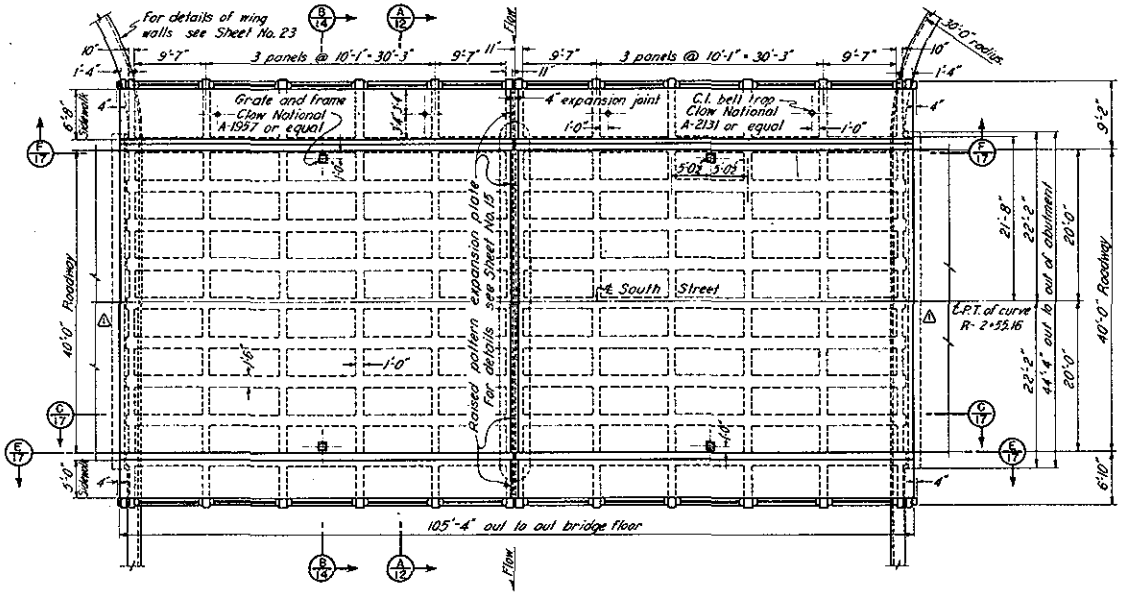
Reinforcement not shown.
Wood piling and steel sheet piling not shown.
—o—o— indicates Vit. clay pipe laid with open joints.
All joints in wall stems to be provided with copper water stops.
Elevations refer to Mean Sea Level datum.
Stations along canal have prefix "C".
Figures in hexagons indicate item number under which payment will be made.
All exposed corners shall be chamfered 1 inch or as directed by contracting officer.

DATE	REVISION	REV. BY	CK. BY	AP. BY

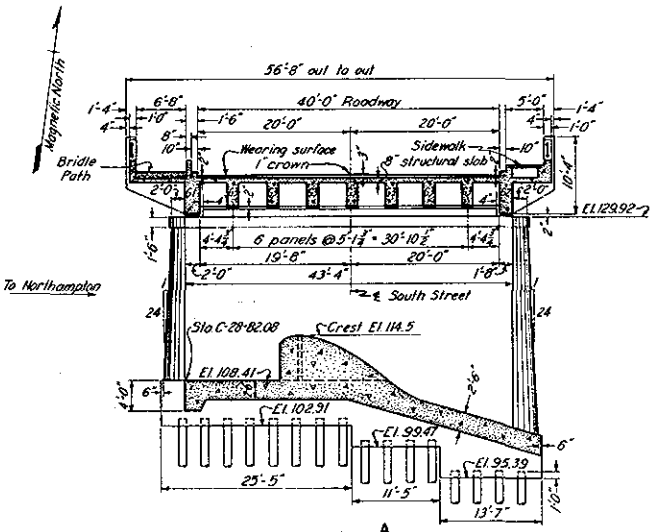
CONNECTICUT RIVER FLOOD CONTROL
NORTHAMPTON DIKE
DIVERSION CANAL - FISCAL YEAR 1939 UNIT
DROP STRUCTURE
DRAINS AND JOINTS
CONNECTICUT & MILL RIVERS MASSACHUSETTS
IN 46 SHEETS SCALE 1IN=20FT SHEET NO. 27
U. S. ENGINEER OFFICE, PROVIDENCE, R. I. MAY 1939
SUBMITTED: HEAD, DESIGN SECTION — APPROVAL RECOMMENDED: CHIEF, C. ENGINEERING BRV. — APPROVED: DISTRICT ENGINEER
DESIGNED: ASST. ENGINEER — DRAWN: P. A. B. TRACED: W. A. CHECKED: C.C.P.
FILE NO. CT-4-1466

PLATE NO. 16

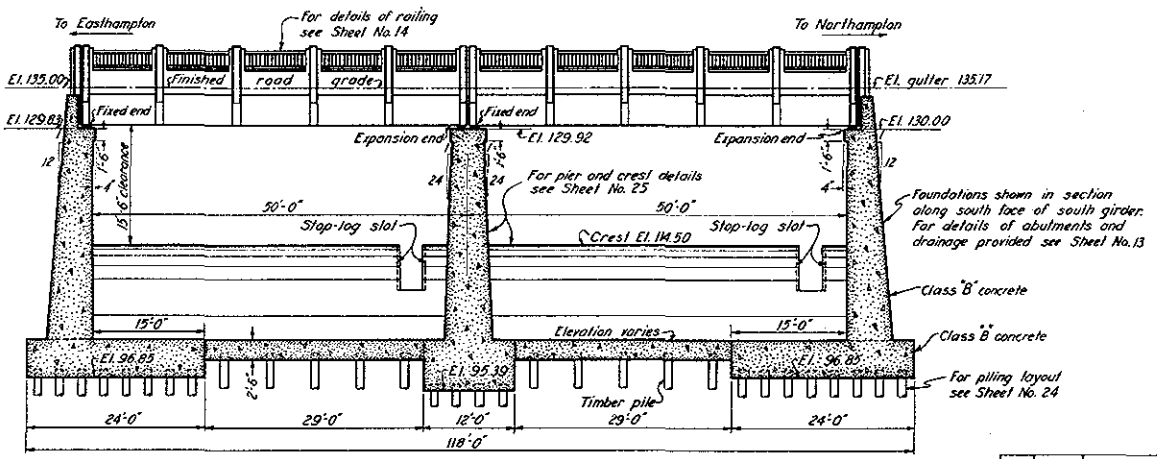
N.3b



PLAN



SECTION A/12



SOUTH ELEVATION

NOTES

All exposed corners shall be chamfered one inch or as directed by contracting officer.

For bridge details see Sheets No. 14 & 15.

Hand rubbed finish on exterior faces of deck, including brackets, pilasters, & posts, and inside faces of all handrail posts.

Elevations refer to Mean Sea Level Datum

Canal stations have prefix "C".

Concrete in deck shall be class A and payment will be made under item No. 15.

All other concrete except pavement shall be class B and payment will be made under Item No. 17.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY
△	12-12-39	Conc. pavement changed to bit. macadam and end expansion plates deleted.	P.C.H.	[illegible]	[illegible]

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

DIVERSION CANAL – FISCAL YEAR 1939 UNIT

SOUTH STREET BRIDGE

GENERAL PLAN AND PROFILE

CONNECTICUT & MILL-RIVERS MASSACHUSETTS

IN 46 SHEETS SCALE: 1/8 IN. = 1 FT. SHEET NO. 12

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. MAY 1939

SUBMITTED: Henry B. Nelson, Senior Engineer, Head, Design Section

APPROVAL RECOMMENDED: J. S. Burns, Principal Engineer, Chief, C. Engineering Div.

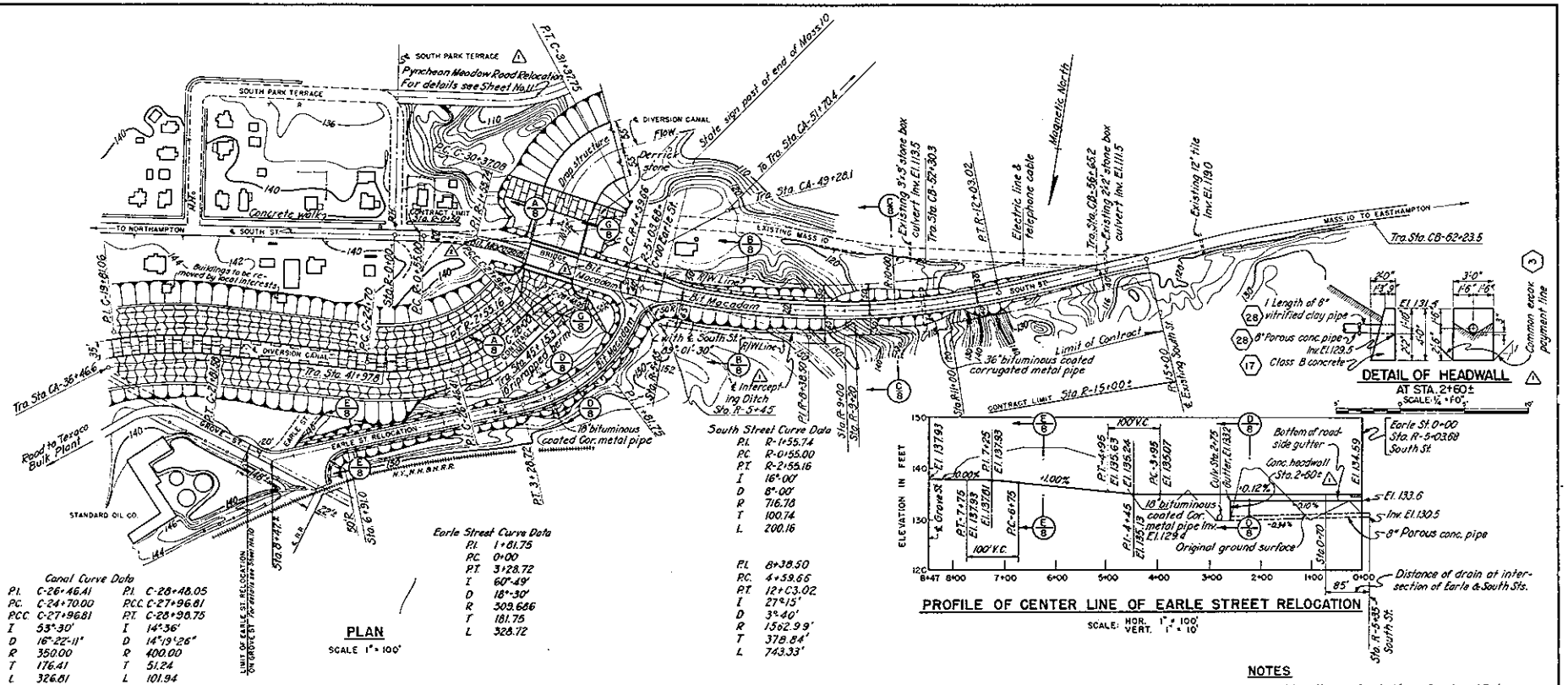
APPROVED: [illegible], Lt. Colonel, Corps of Engineers, District Engineer

DESIGNED: E. C. Hancock, Asst. Engineer

DRAWN: J.L.B. TRACED: A.S. CHECKED: [illegible]

FILE NO. CT-4-1651

PLATE NO. 17



Canal Curve Data

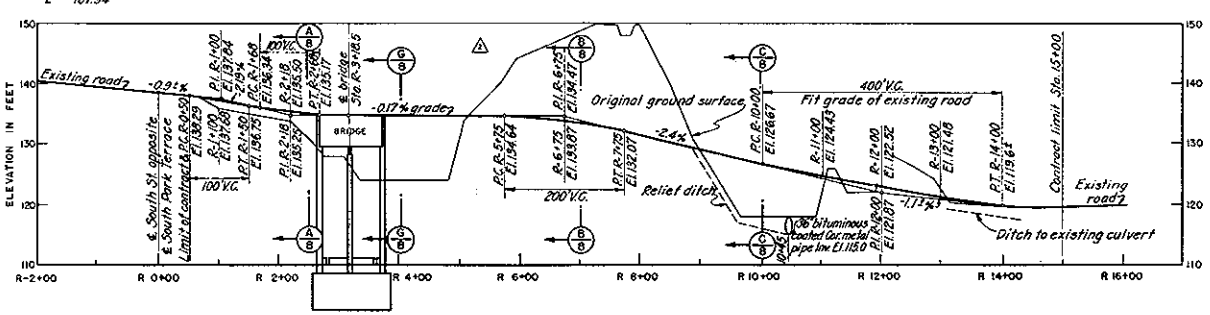
P.I.	C-26+46.41	P.I.	C-28+48.05
P.C.	C-24+70.00	P.C.C.	C-27+96.81
P.C.C.	C-27+96.81	P.T.	C-28+98.75
I	53°-30'	I	14°-36'
D	16°-22'-11"	D	14°-19'-26"
R	350.00	R	400.00
T	176.41	T	51.24
L	326.81	L	101.94

Earle Street Curve Data

P.I.	1+81.75
P.C.	0+00
P.T.	3+28.72
I	60°-49'
D	18°-30'
R	309.686
T	181.75
L	328.72

South Street Curve Data

P.I.	R-1+55.74	P.I.	R-8+38.50
P.C.	R-0+55.00	P.C.	4+59.66
P.T.	R-2+55.16	P.T.	12+C3.02
I	16°-00'	I	27°-15'
D	8°-00'	D	3°-40'
R	716.78	R	1562.99'
T	100.74	T	378.84'
L	200.16	L	743.33'



PROFILE OF CENTER LINE OF SOUTH STREET RELOCATION

SCALE: HOR. 1" = 100' VERT. 1" = 10'

NOTES

Elevations refer to Mean Sea Level Datum.
Stations on South Street have prefix "R".
Stations on Canal have prefix "C".
Existing pavement from Sta. R-0+90± to Sta. R-2+45± and from Sta. R-12+70± to Sta. R-14+60± to be removed by contractor, and will be paid for under Item No. 2.
Contour interval is 2 feet.
For balance of R/W see Sheets No. 4 & 5.
Figures in hexagons indicate items under which payment will be made.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY
△	12/12/39	Conc. paving changed to bit. macadam	P.C.H.	F.W.	39/13
△	9/6/39	Earle St. Drainage, Pynchon Meadow Rd.	P.C.H.	F.W.	3513

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

DIVERSION CANAL - FISCAL YEAR 1939 UNIT

EARLE & SOUTH STREETS RELOCATION

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 48 SHEETS — SCALE: 1 IN. = 100 FT. — SHEET NO. 7

U. S. ENGINEER OFFICE, PROVIDENCE, R. I., MAY 1939

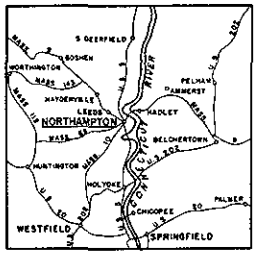
SUBMITTED: Senior Engineer, Hydr. Design Section — APPROVAL RECOMMENDED: Principal Engineer, Chief C. C. Engineering Div. — APPROVED: Colonel, Corps of Engineers, District Engineer

DESIGNED: Asst. Engineer — DRAWN: J.R.D. — TRACED: F.B.M. & H.W.H. — CHECKED: — FILE NO. CT-4-1646

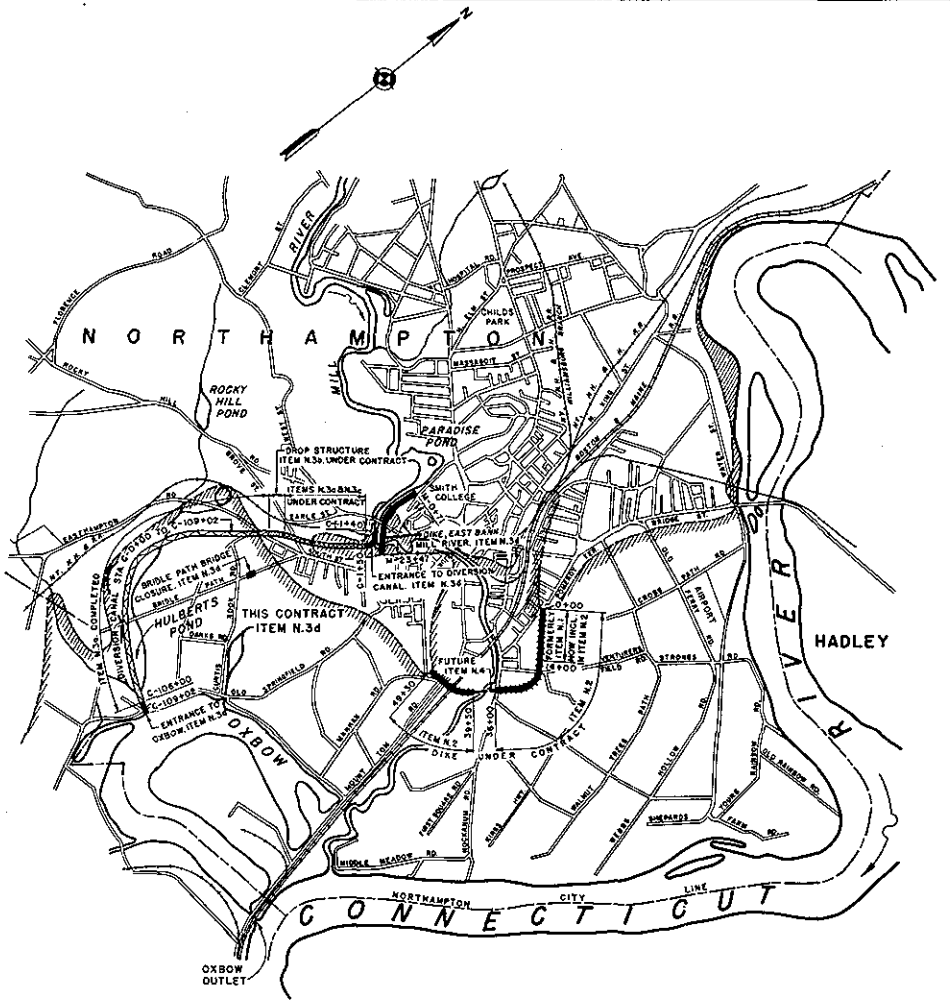
N. 3b

7

PLATE NO. 18



LOCATION MAP



VICINITY MAP

SCALE 1" = 1600'

INDEX TO DRAWINGS

SHEET NO.	DESCRIPTION	FILE NO.
1	PROJECT LOCATION AND INDEX	CT-4-1903
2	SUBSURFACE EXPLORATIONS	CT-2-1187
3	BORROW AREAS	CT-2-1188
4	GENERAL PLAN	CT-4-1904
5	PLAN AND PROFILE DIKE AND DIVERSION CANAL ENTRANCE	CT-4-1905
6	PLAN AND PROFILE- DIVERSION CANAL OUTLET	CT-4-1906
7	DIVERSION CANAL- PLAN AND SECTIONS FROM STA. C-(-1+40) TO STA. C-1+50	CT-4-1907
8	BRIDGE AT OXBOW- CONCRETE DETAILS	CT-4-1908
9	BRIDGE AT OXBOW- STEEL REINFORCEMENT	CT-4-1909
10	BRIDLE PATH BRIDGE CLOSURE	CT-4-1910
11	EMBANKMENT DETAILS	CT-4-1911
12	DRAINAGE PROFILE AND DETAILS	CT-4-1912
13	CONCRETE WALL- DETAILS NO. 1	CT-4-1913
14	CONCRETE WALL- DETAILS NO. 2	CT-4-1914
15	CONCRETE WALL- DETAILS NO. 3	CT-4-1915
16	CONCRETE WALL- DETAILS NO. 4	CT-4-1916
17	CONCRETE WALL- STEEL REINFORCEMENT NO. 1	CT-4-1917
18	CONCRETE WALL- STEEL REINFORCEMENT NO. 2	CT-4-1918
19	CONCRETE WALL- STEEL REINFORCEMENT NO. 3	CT-4-1919
20	CONCRETE WALL- STEEL REINFORCEMENT NO. 4	CT-4-1920
21	STOP-LOG STRUCTURE- CONCRETE DETAILS NO. 1	CT-4-1921
22	STOP-LOG STRUCTURE- CONCRETE DETAILS NO. 2	CT-4-1922
23	STEEL SHEET PILING- SCHEDULES AND DETAILS	CT-4-1923
24	STOP-LOG STRUCTURE- CENTER SUPPORT DETAILS	CT-4-1924
25	STOP-LOG STRUCTURE- STEEL REINFORCEMENT NO. 1	CT-4-1925
26	STOP-LOG STRUCTURE- STEEL REINFORCEMENT NO. 2	CT-4-1926
27	STOP-LOG STRUCTURE- STEEL REINFORCEMENT NO. 3	CT-4-2138
28	STOP-LOG STRUCTURE- STEEL REINFORCEMENT NO. 4	CT-4-2139
29	REINFORCEMENT SCHEDULE NO. 1	CT-4-1929
30	REINFORCEMENT SCHEDULE NO. 2	CT-4-1930
31	REINFORCEMENT SCHEDULE NO. 3	CT-4-1931
32	REINFORCEMENT SCHEDULE NO. 4	CT-4-1932
33	RAMP DETAILS- STA. M-0+92 TO STA. M-1+38	CT-4-1934

LEGEND

- Item N.2 Fiscal Year 1939 Section, Dike (including former Item N.1)
- Item N.3a Fiscal Year 1939 Unit, Excavation of Diversion Canal
- Item N.3b Fiscal Year 1939 Unit, Diversion Canal Drop Structure
- Item N.3c Fiscal Year 1939 Unit, Riprap, Diversion Canal
- Item N.3d Fiscal Year 1940 Unit, Dike East Bank Mill River and Completion of Diversion Canal
- Item N.4 Future Construction, Pumping Station plus Omitted Section
- Overflow Limits, March 1936 Flood

KEY	DATE	REVISION (Indicated by △)	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

PROJECT LOCATION AND INDEX

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

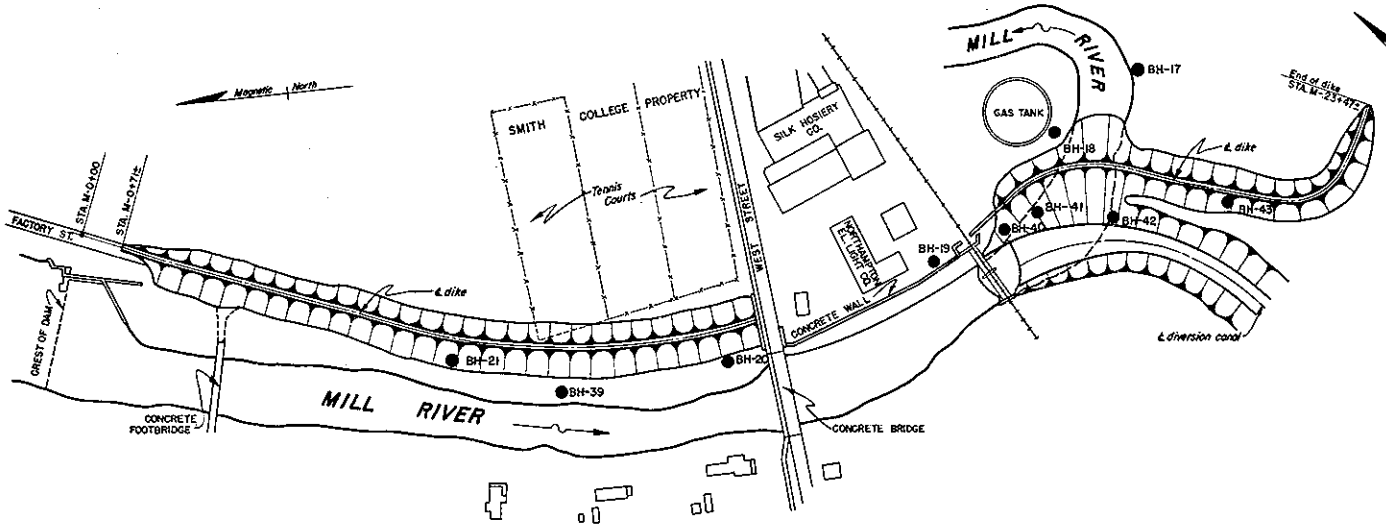
IN 33 SHEETS — SCALE 1 IN. = 1600 FT. — SHEET NO. 1

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — SEPT., 1939

SUBMITTED: Assist. Engineer, Hland. Hydraul. Section — APPROVAL RECOMMENDED: Principal Engineer, Chief F. & Embankments Div. — APPROVED: Lt. Colonel, Corps of Engineers, District Engineer

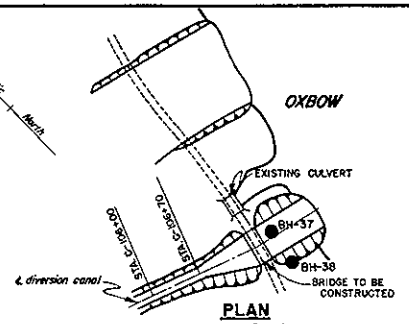
DESIGNED: Asst. Engineer — DRAWN: A.A.R. TRACED: A.F. CHECKED: — FILE NO. CT-4-1903

PLATE NO. 19



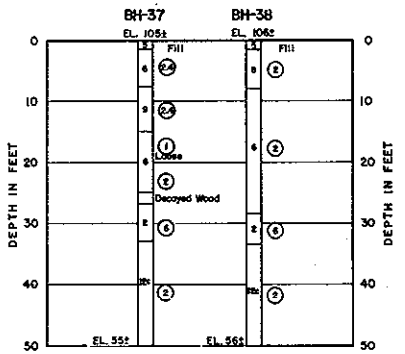
PLAN

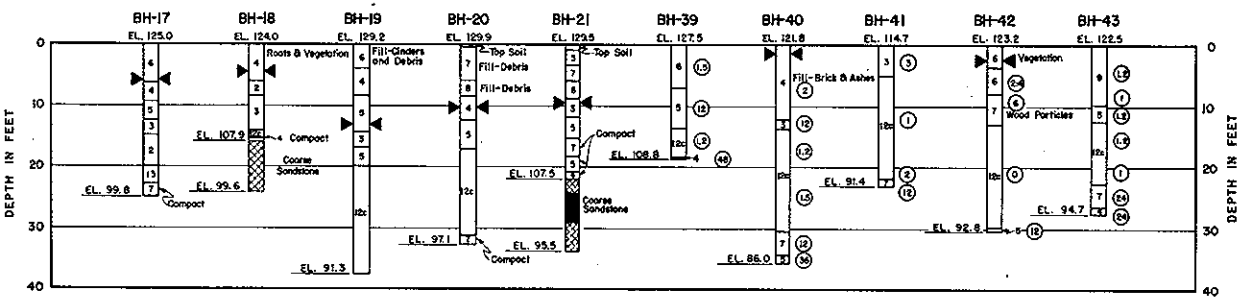
SCALE 1" = 100'



PLAN

SCALE 1" = 100'





NOTES

Elevations refer to Mean Sea Level Datum. Numbers in circles indicate number of blows required to drive 2" O.D. sample spoon one foot. Spoon driven by 300 pound hammer dropped 18 inches.

LEGEND

- Sound rock.
- Weathered or fractured rock.
- Water table at time of exploration.
- Drive sample bore hole.

DESCRIPTION OF NUMERICAL CLASSES

1. Variable - Graded from Gravel to Coarse Sand - Contains little medium sand.
2. Uniform Coarse to Medium Sand - Contains little gravel and fine sand.
3. Variable - Graded from Gravel to Medium Sand - Contains little fine sand.
4. Uniform Medium to Fine Sand - Contains little coarse sand and coarse silt.
5. Variable - Graded from Gravel to Fine Sand - Contains little coarse silt.
6. Uniform Fine Sand to Coarse Silt - Contains little medium sand and medium silt.
7. Variable - Graded from Gravel to Coarse Silt - Contains little medium silt.
8. Uniform Coarse to Medium Silt - Contains little fine sand and fine silt.
9. Variable - Graded from Gravel to Medium Silt - Contains little fine silt.
10. Uniform Medium to Fine Silt - Contains little coarse silt and coarse clay. Possesses behavior characteristics of silt.
10a. Uniform Medium Silt to Coarse Clay - Contains little coarse silt and medium clay. Possesses behavior characteristics of clay.
11. Variable - Graded from Gravel or Coarse Sand to Fine Silt - Contains little coarse clay.
12. Uniform Fine Silt to Clay - Contains little medium silt and fine clay (colloids). Possesses behavior characteristics of silt.
12a. Uniform Clay - Contains little silt. Possesses behavior characteristics of clay.
13. Variable - Graded from Coarse Sand to Clay - Contains little fine clay (colloids). Possesses behavior characteristics of silt.
13a. Variable Clay - Graded from sand to fine clay (colloids). Possesses behavior characteristics of clay.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

SUBSURFACE EXPLORATIONS

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 33 SHEETS — SCALE 1 IN. = 100 FT. — SHEET NO. 2

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — SEPT., 1939

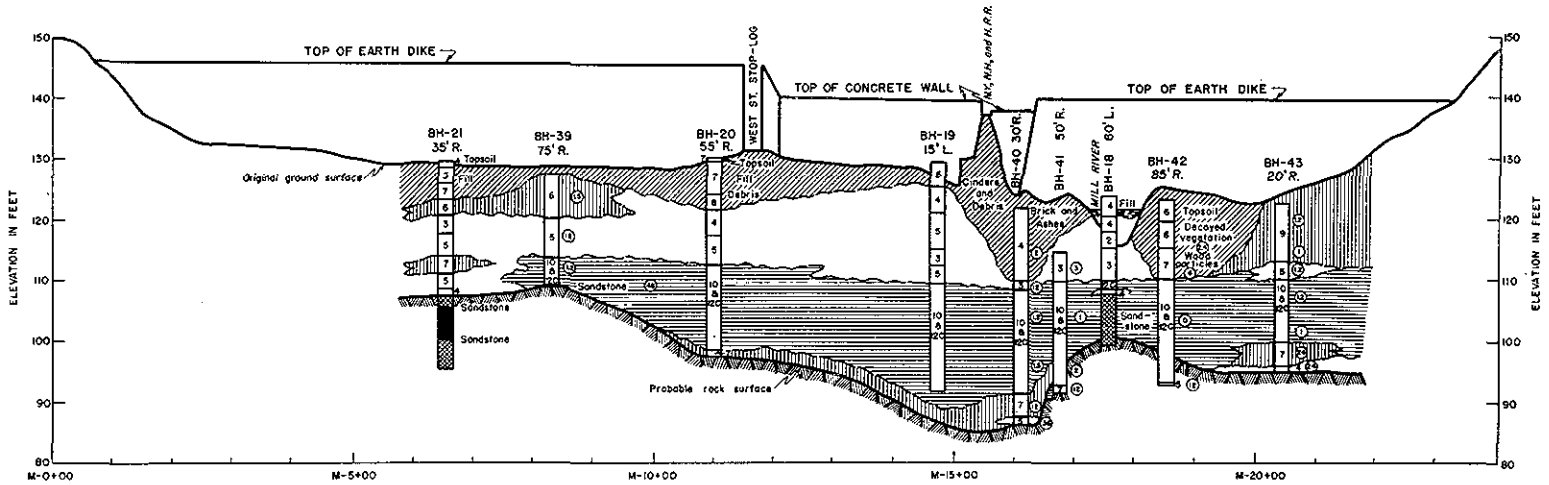
SUBMITTED: LEONARD BLOODGOOD, HEAD, GEOLOGY SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF F. C. ENGINEERING DIV. — APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

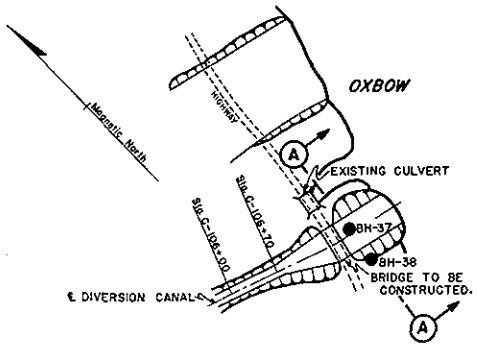
COMPILED: JUNIOR ENGINEER — DRAWN: F.R.S. TRACED: R.M.H. CHECKED: W.C.L.

FILE NO. CT-2-1187

N.3d

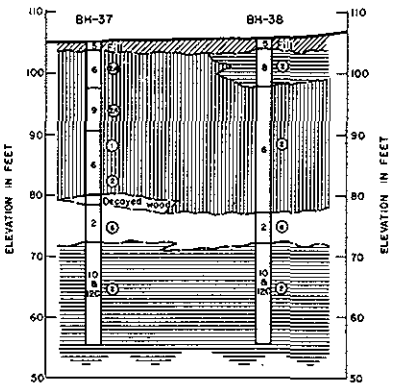
PLATE NO. 20





PLAN

SCALE: 1" = 100'



SECTION A-A

SCALE: HOR. 1 IN.= 20 FT.
VERT. 1 IN = 10 FT.

LEGEND

- Sound bedrock.
- Weathered bedrock.
- Artificial fill.
- Impervious formation.
- Moderately impervious formation.
- Pervious formation.
- BH Drive sample bore hole.

NOTES

Ground surface and stationing is that along ℄ of dike shown on Plate No.

L indicates landside of dike ℄.

R indicates riverside of dike ℄.

Elevations refer to Mean Sea Level Datum.

Numbers in circles indicate number of blows required to drive 2" O.D. sample spoon one foot. Spoon driven by 300 pound hammer dropped 18 inches.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

GEOLOGIC SECTION

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

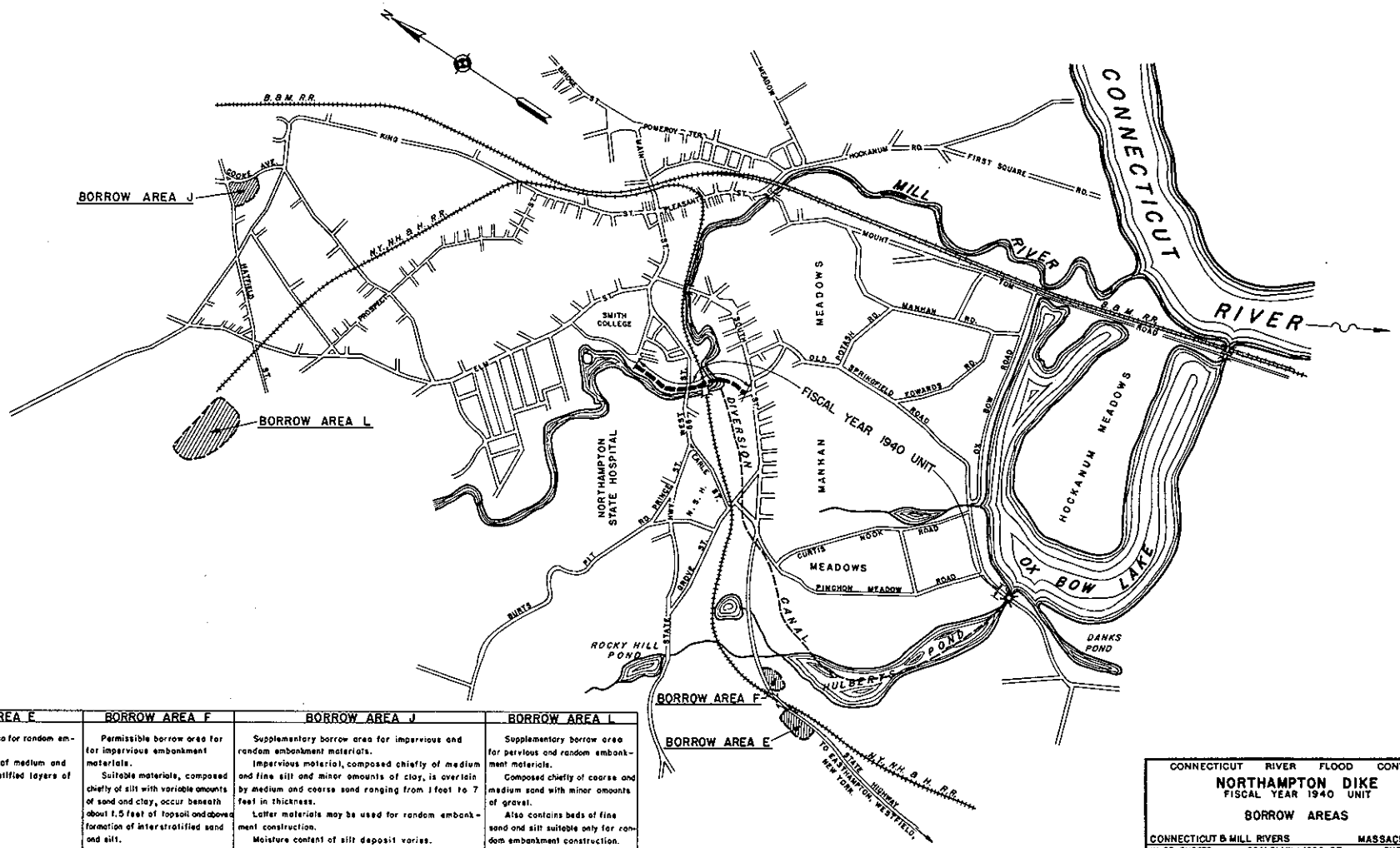
IN 1 SHEET — SCALE: HOR. 1 IN.= 100 FT. VERT. 1 IN. = 10 FT. — SHEET NO. 1

U. S. ENGINEER OFFICE, PROVIDENCE, R. I., 1939

SUBMITTED: M. S. BERGQUIST, HEAD, GEOLOGY SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF F. C. ENGINEERING DIV. — APPROVED: LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

COMPILED: ASST. ENGINEER — DRAWN: W.F.B. TRACED: W.H.W. CHECKED: — FILE NO. CT-Z-1189

PLATE NO. 21



BORROW AREA E	BORROW AREA F	BORROW AREA J	BORROW AREA L
Permissible borrow area for random embankment materials. Overburden consists of medium and fine sand with interstratified layers of silt. Area is wooded.	Permissible borrow area for for impervious embankment materials. Suitable materials, composed chiefly of silt with variable amounts of sand and clay, occur beneath about 1.5 feet of topsoil and above a formation of interstratified sand and silt. Moisture content of accepted material slightly above that required for satisfactory compaction. Area is wooded.	Supplementary borrow area for impervious and random embankment materials. Impervious material, composed chiefly of medium and fine silt and minor amounts of clay, is overlain by medium and coarse sand ranging from 1 foot to 7 feet in thickness. Latter materials may be used for random embankment construction. Moisture content of silt deposit varies. Content of some portions above that necessary for satisfactory compaction. Area is also reserved for use in construction of other portions of Northampton Dike.	Supplementary borrow area for pervious and random embankment materials. Composed chiefly of coarse and medium sand with minor amounts of gravel. Also contains beds of fine sand and silt suitable only for random embankment construction. Area is also reserved for use in construction of other portions of Northampton Dike.

KEY	DATE	REVISION (indicated by △)	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

BORROW AREAS

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 33 SHEETS — SCALE: 1 IN. = 1000 FT. — SHEET NO. 3

U.S. ENGINEER OFFICE, PROVIDENCE, R. I. — SEPT. 1939

SUBMITTED: FRANK BELLINI, CHIEF ENGINEER, HEAD, GEOLOGY SECTION

APPROVAL RECOMMENDED: D. DONAHUE, ASSISTANT ENGINEER, CHIEF P. & R. ENGINEERING BR.

APPROVED: [illegible], DISTRICT ENGINEER

COMPILED: [illegible], ASS'T ENGINEER

DRAWN: P.G.S. TRACED: P.T.S. CHECKED: [illegible]

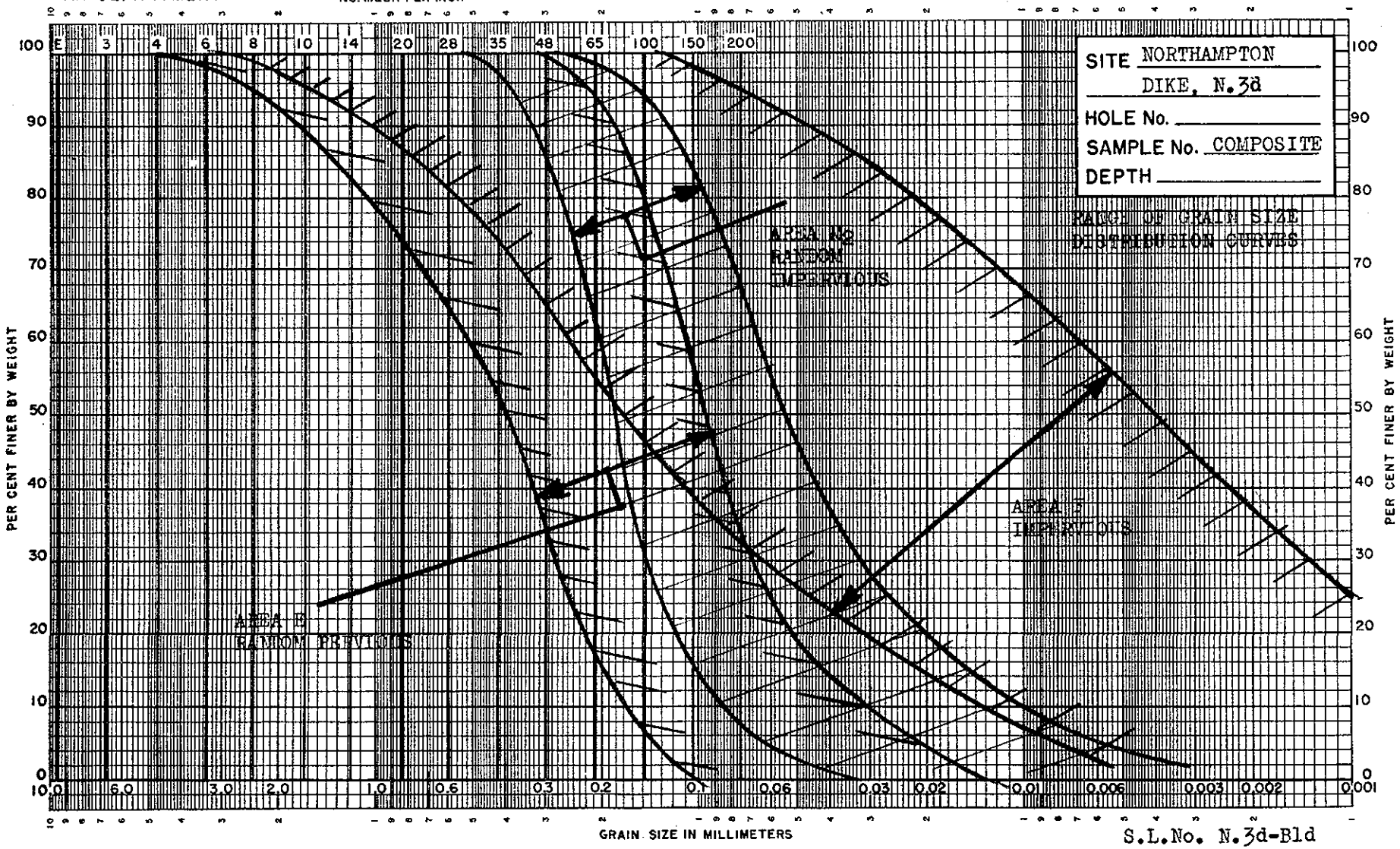
FILE NO. CT-2-1188

PLATE NO. 22

N.3d

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



S.L.No. N.3d-B1d

Gravel	Coarse Sand	Medium Sand	Fine Sand	Coarse Silt	Medium Silt	Fine Silt or	Coarse Clay
Class 1	Class 2		Class 6		Class 10 or 10C		Class 12 or 12C
		Class 4		Class 8			
	Class 3		Class 5	Class 7	Class 9	Class 11	Class 13 or 13C

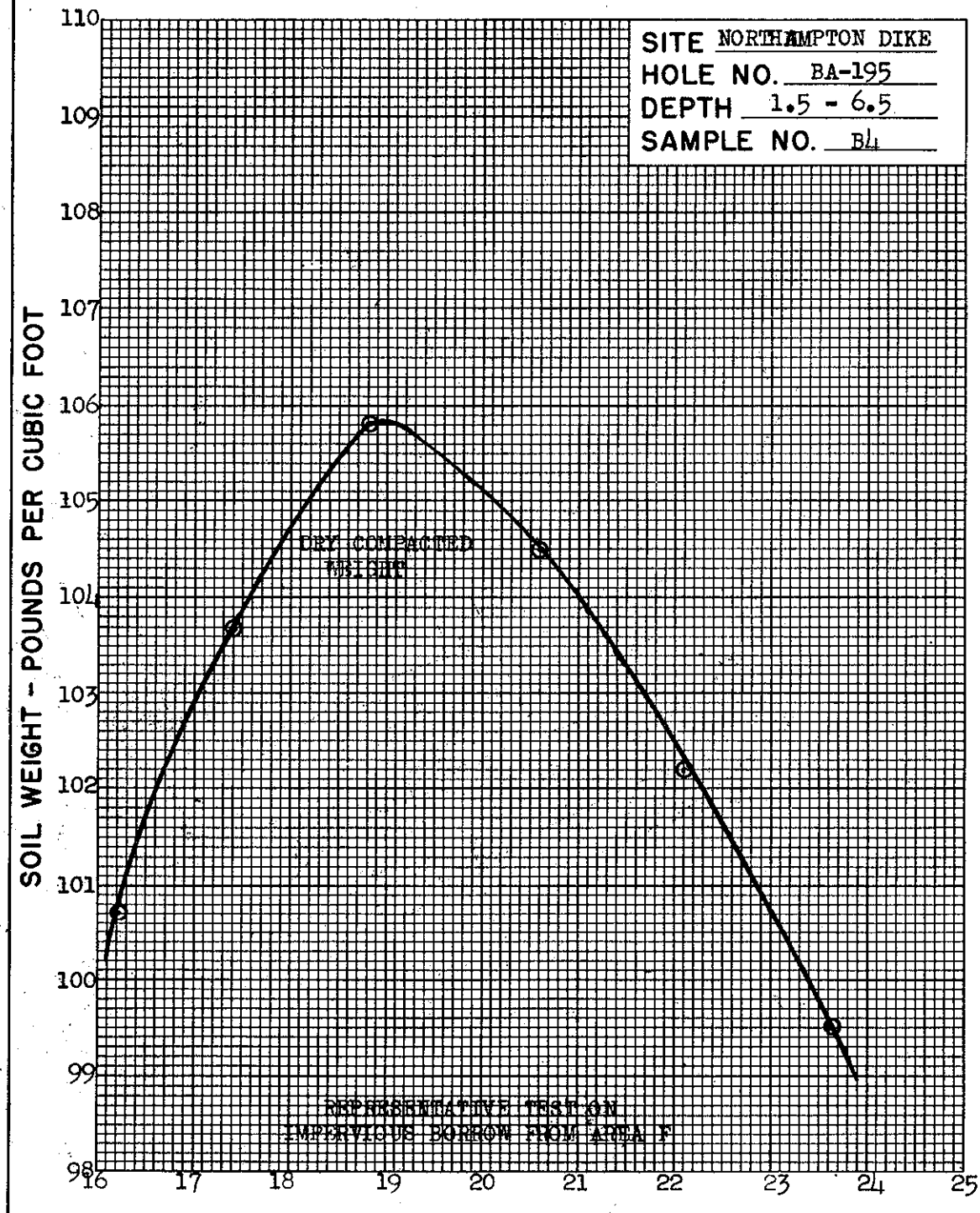
SOILS LABORATORY

MECHANICAL ANALYSIS

PROVIDENCE, R.I.

PLATE NO. 23

COMPACTION CHARACTERISTICS



Class 13

MATERIAL SCREENED OUT

Minimum Size, mm. -

Per Cent by weight -

No. Blows/Layer 25

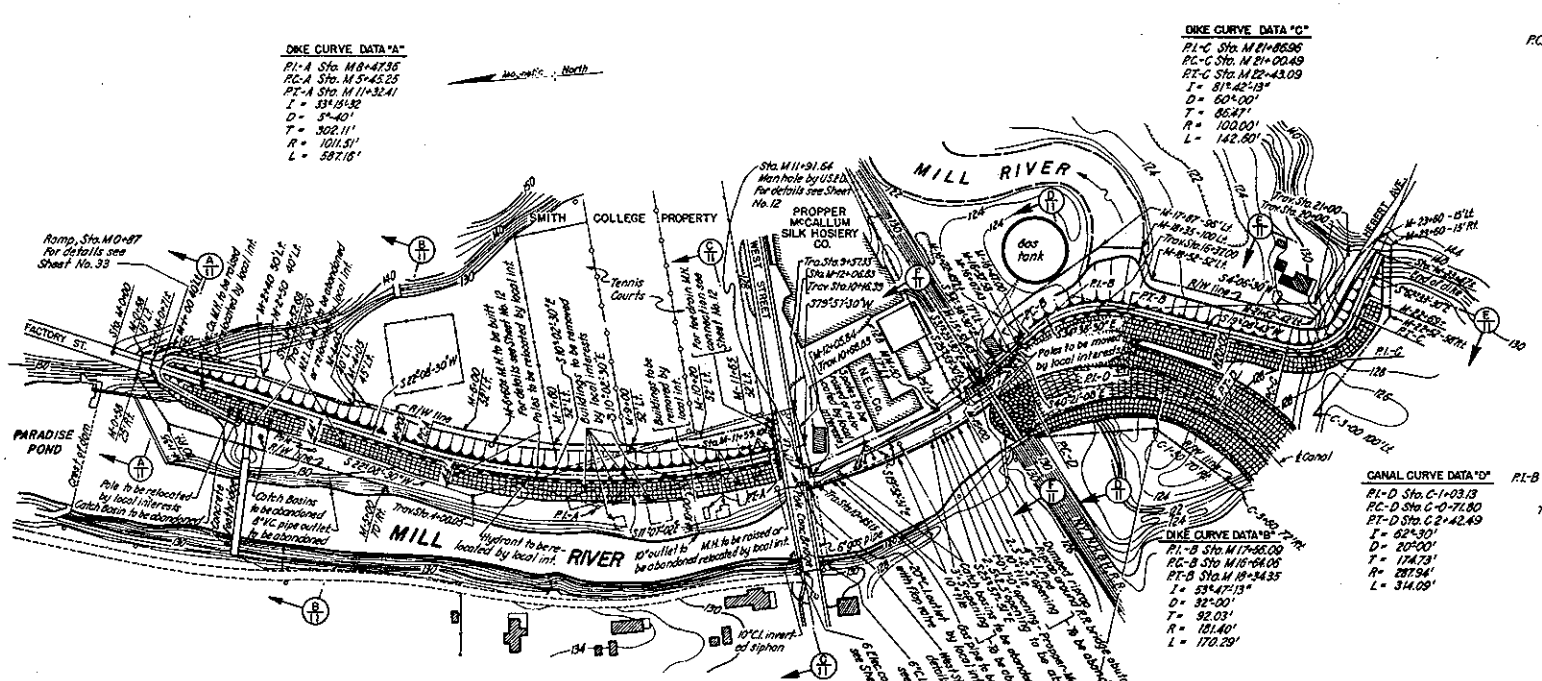
Area of Tamper, sq. in. 3.02

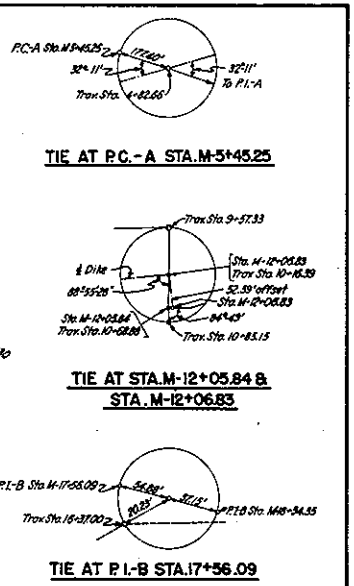
Weight of Tamper, lbs. 5.5

Fall of Tamper, in. 12

e at w(opt) = 0.633

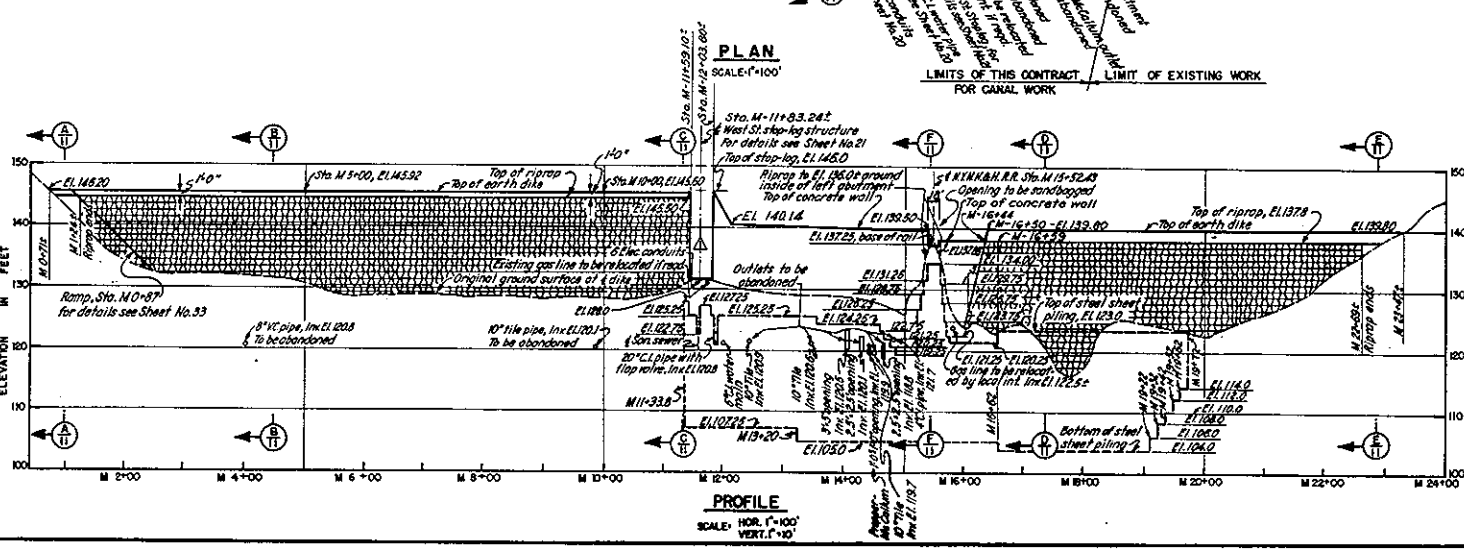
S.L.No.N.3d-C1d





NOTES

Dike stations are prefixed by "M"
Canal stations are prefixed by "C"
Elevations refer to Mean Sea Level datum.
Canal work ends at Sta. C-1+50.
For wall details see Sheets No. 13 to 16 incl.
For plan and profile of Diversion Canal see Sheet No. 7.
All steel sheet piling on this sheet shall have section modulus of 5.4 inches cubed, and weigh not less than 22 pounds per sq ft. See schedule on Sheet No. 23 for details of stop-log, see Sheet No. 23.



KEY	DATE	REVISION (Indicated by △)	REVISED BY	APB'D
△	1/5/40	Stop-log Gate widened	P.C.H.	A.J.F.

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

PLAN AND PROFILE

DIKE AND DIVERSION CANAL ENTRANCE

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 33 SHEETS — SCALE: 1" = 100 FT. — SHEET NO. 6

U. S. ENGINEER OFFICE, PROVIDENCE, R. I., SEPT., 1939

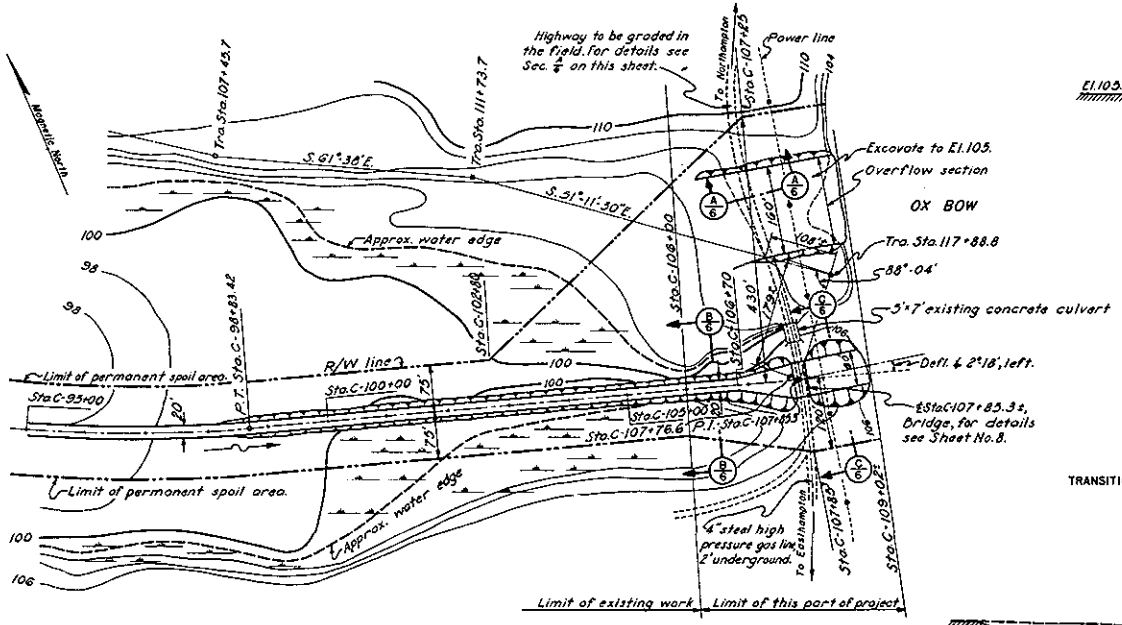
SUBMITTED: Raymond Rickel, SENIOR ENGINEER, HYDR. DESIGN SECTION — APPROVAL RECOMMENDED: D. W. Morgan, PRINCIPAL ENGINEER, CHIEF F. C. ENGINEERING BRY. — APPROVED: A. M. Rankin, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DESIGNED: E. C. Lamoureux, ASS'T. ENGINEER — DRAWN: M.A.B. & W.E.A. — TRACED: G.A.B. — CHECKED: G.P.T. JR.

FILE NO. CT-4-1905

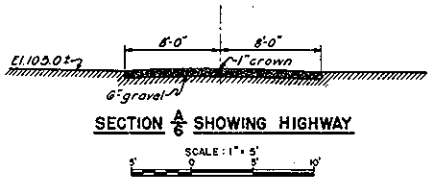
PLATE NO. 25

N.3d



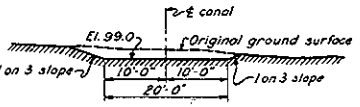
PLAN

SCALE: 1" = 100'



SECTION A/6 SHOWING HIGHWAY

SCALE: 1" = 5'

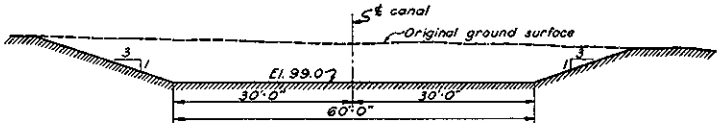


SECTION B/6

AT STA. C-106+45

TYPICAL FROM STA. C-106+00 TO STA. C-106+70±
TRANSITION TO SECTION C/6 FROM STA. C-106+70± TO STA. C-107+76.6±

SCALE: 1" = 10'



SECTION C/6

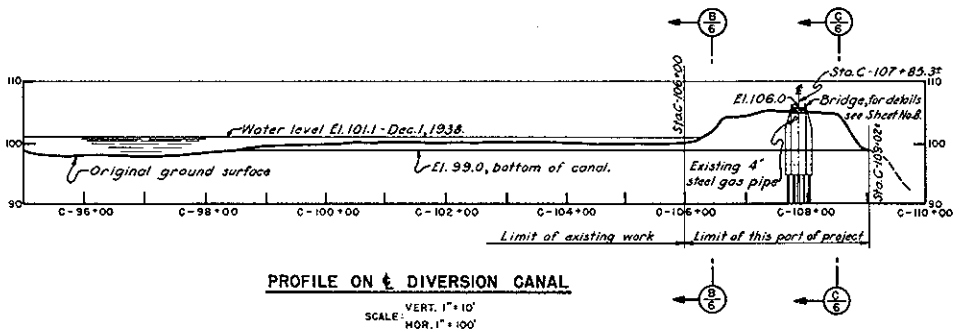
AT STA. C-108+50

TYPICAL FROM STA. C-107+76.6± TO STA. C-109+02±

SCALE: 1" = 10'

NOTES

Elevations refer to Mean Sea Level Datum.
Canal stations are prefixed by the letter "C."



PROFILE ON ℄ DIVERSION CANAL

SCALE: VERT. 1" = 10'
HOR. 1" = 100'

KEY	DATE	REVISION (Indicated by △)	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

PLAN AND PROFILE

DIVERSION CANAL OUTLET

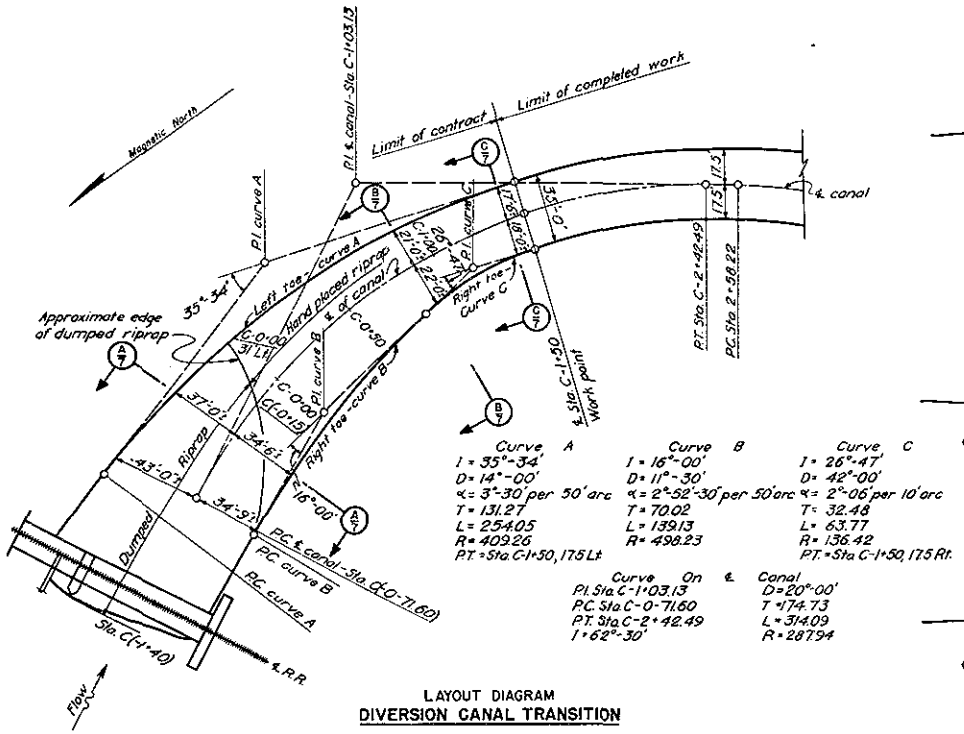
CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 30 SHEETS — SCALE 1 IN. = 100 FT. — SHEET NO. 8.

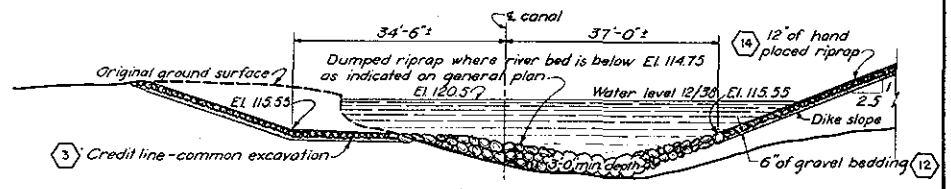
U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — SEPT., 1939

SUBMITTED: SENIOR ENGINEER, HEAD, DESIGN SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, C. ENGINEERING DIV. — APPROVED: DISTRICT ENGINEER

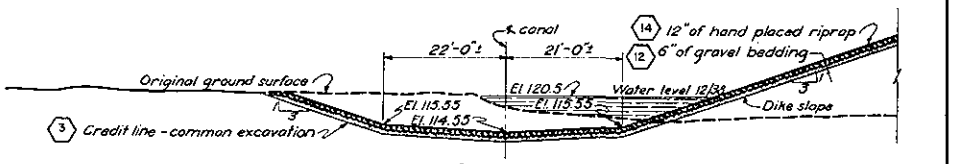
DESIGNED: ASST. ENGINEER — DRAWN: W.E.B. TRACED: P.V.B. CHECKED: — FILE NO. CT-4-1906



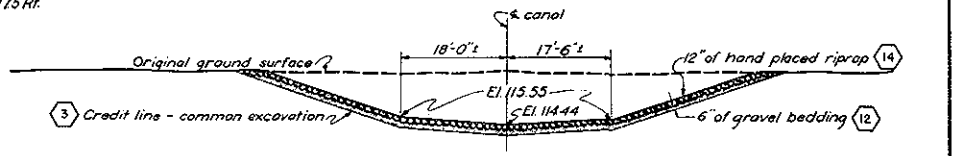
LAYOUT DIAGRAM
DIVERSION CANAL TRANSITION
SCALE: 1" = 30'



SECTION A/7 — STA. C-0-35±
SCALE: 1" = 10'



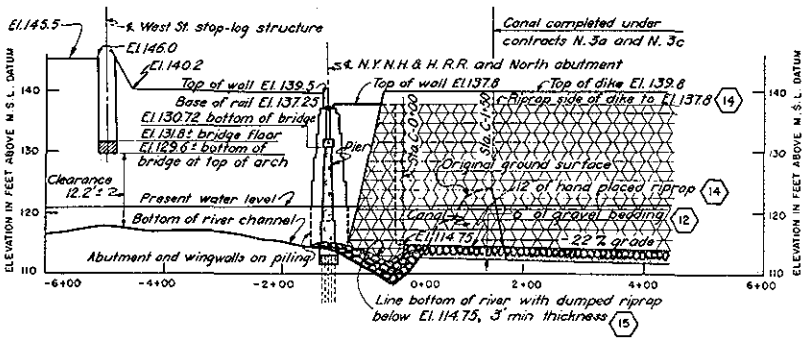
SECTION B/7 — STA. C-0+90±
SCALE: 1" = 10'



SECTION C/7 — STA. C-1+40±
SCALE: 1" = 10'

NOTES

Elevations refer to Mean Sea Level Datum.
Canal stations are prefixed by letter "C".
Figures in hexagons indicate item numbers under which credit will be made.



PROFILE MILL RIVER & CANAL
SCALE: HOR., 1" = 100'
VERT., 1" = 10'

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

DIVERSION CANAL — PLAN AND SECTIONS
FROM STA. C-(-1+40) TO STA. C-1+50

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 33 SHEETS — SCALE 1 IN. = 30 FT. — SHEET NO. 7

U. S. ENGINEER OFFICE, PROVIDENCE, R. I., SEPT., 1939

SUBMITTED: Senior Engineer, Head, Design Section
APPROVAL RECOMMENDED: Principal Engineer, Chief, C. Engineering Div.
APPROVED: Colonel, Corps of Engineers, District Engineer

DESIGNED: Asst. Engineer
DRAWN: J.K.O.
TRACED: J.K.O.
CHECKED: O.C.F.

FILE NO. CT-4-1907

N. 3d

PLATE NO. 27

Subject: NORTHAMPTON
Computation: SO. ST. BR. - ABUT.
Computed by: RSM Checked by: _____ Date: 4/27/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

ANALYSIS - ABUT. BASE El. 96.85

CASE I, Bridge constructed, uplift to elevation of weep holes, no flow over weir.

Stability

		Force ↓↑	Force ⇆	Arm	Moment ↻	Moment ↺
C1	150 × 3.4 × 32 ↓	16,300		16.9		276 000
C2	150 × 2.75 × 32/2 ↓	6,600		19.6		129 000
C3	150 × 5 × 24 ↓	18000		12.0		216,000
E4	100 × 33 × 2.75/2 ↓	4,550		20.7		94 000
E5	100 × 33 × 2.6 ↓	8,600		22.7		195,000
B1	↓	13,500		16.0		216,000
U1	62.5 × 6 × 24 ↑	9000		12.0	108,000	
E6	40 × 47²/2 →		33600	13.67	458,000	
E7	40 × 6²/2 →		700	2.0	1,000	
		57,550			567,000	1,126,000
						567 000
						559,000

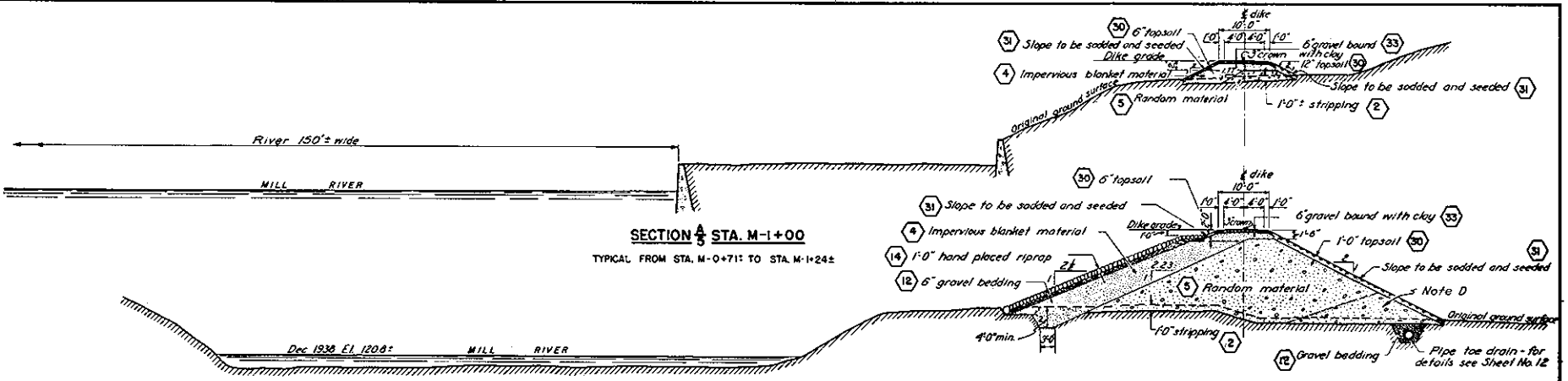
$\frac{\Sigma M}{\Sigma V}$: 559,000/57,550 = 9.7 ; e = 12.0 - 9.7 = 2.3

$f = \frac{57,550}{24}\left(1 \pm \frac{6 \times 2.3}{24}\right) = \begin{matrix} 3750 \ \#/\square' \\ 1000 \ \#/\square' \end{matrix}$

Stem steel

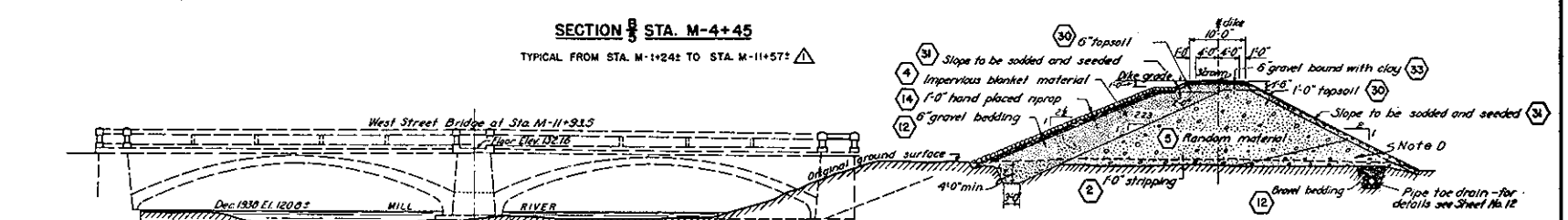
h	5'	10'	15'	20'	25'	29'	34'
$P = 40\left(\frac{ht^2}{2}\right)^2$	980#	2880#	5780	9680	14,580	19,220	25,920
$M = P \times \frac{ht^2}{3}$	2280'#	11,500	32,800	70,700	131,000	198,600	311,000
d	18.5"	41.5"	46.5	51.5	56.5	60.5	64.5
$A_s = \frac{M}{f_s jd}$	.09□"	.21	.53	1.04	1.75	2.47	3.63
$v = \frac{V}{bjd}$	12 #/□"	—	—	—	—	—	38
Steel furnished	.63□"						4.69□"

A-30



SECTION A/5 STA. M-1+00

TYPICAL FROM STA. M-0+71± TO STA. M-1+24±

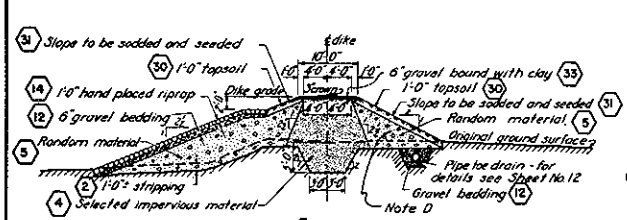


SECTION B/5 STA. M-4+45

TYPICAL FROM STA. M-1+24± TO STA. M-11+57± △1

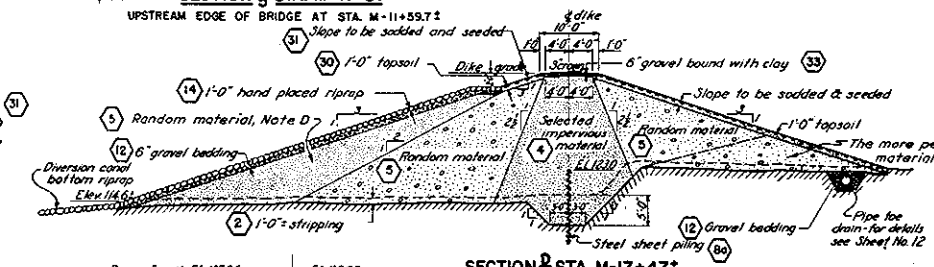
SECTION C/5 STA. M-11+31

UPSTREAM EDGE OF BRIDGE AT STA. M-11+59.7±



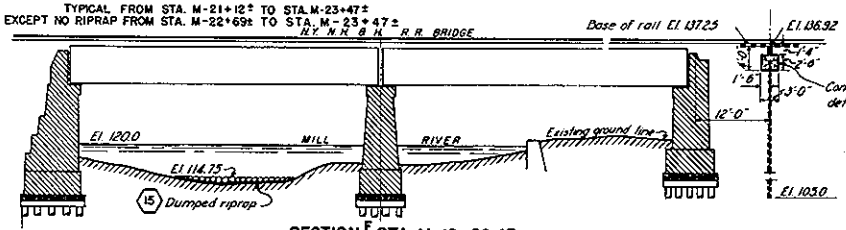
SECTION E/5 STA. M-23+12±

TYPICAL FROM STA. M-21+12± TO STA. M-23+47±
EXCEPT NO RIPRAP FROM STA. M-22+69± TO STA. M-23+47±



SECTION D/5 STA. M-17+47±

TYPICAL FROM STA. M-16+50± TO STA. M-21+12±
EXCEPT NO SHEET PILING FROM STA. M-19+72 TO STA. M-21+12



SECTION F/5 STA. M-15+52.43

TYPICAL FROM STA. M-15+43.43 TO STA. M-15+61.43

NOTES

Dike stations have prefix "M".
Elevations refer to Mean Sea Level Datum.
Figures in hexagons indicate item number under which credit will be made.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY
△1	11/5/40	Embankment ends at Sta. M-11+57±	F.C.S.	G.L.W.	F.C.S.

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

EMBANKMENT DETAILS

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 33 SHEETS — SCALE: 1 IN. = 10 FT. — SHEET NO. 11

U. S. ENGINEER OFFICE, PROVIDENCE, R. I., SEPT. 1939

SUBMITTED: Karl B. Weber, Lieutenant Colonel, Corps of Engineers, Head, Design Section

APPROVAL RECOMMENDED: F. A. Burns, Principal Engineer, Chief, F. C. Consulting Div.

APPROVED: W. Wheeler, Lt. Col., Corps of Engineers, District Engineer

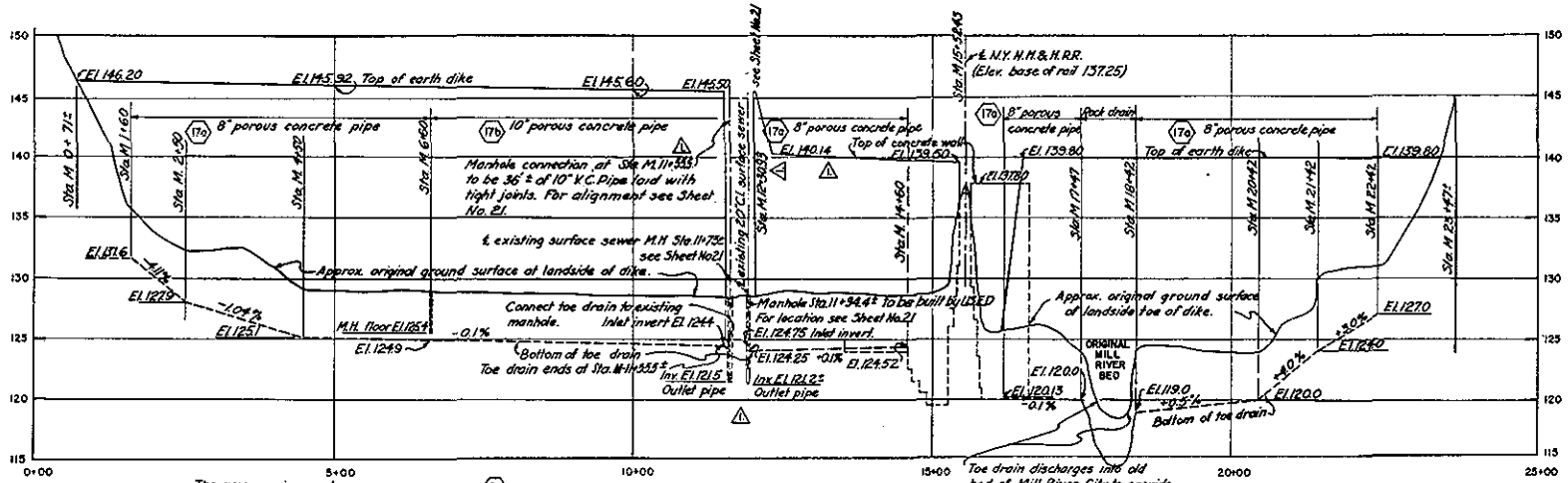
DESIGNED: F. C. Stewart, Principal Engineer

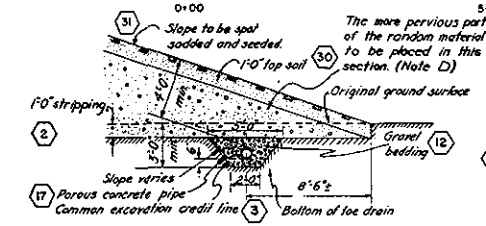
DRAWN: R.A.D. J.J.C.; TRACED: L.H.F.; CHECKED: F.C.S.

FILE NO. CT-4-193

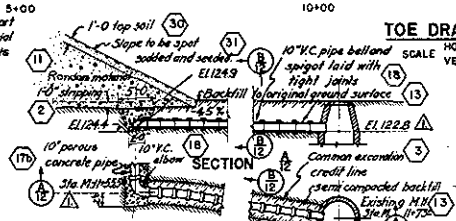
PLATE NO. 29

N. 36

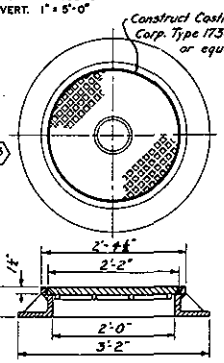




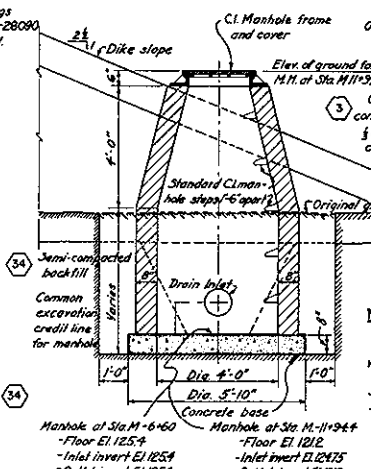
MINIMUM DEPTH
SCALE 1/4" = 1'-0" (Note D)



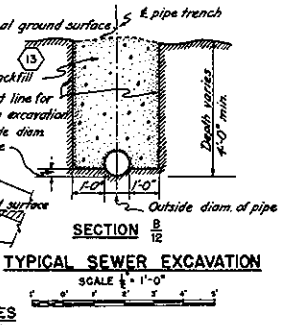
TOE DRAIN SEWER CONNECTION AT M 11+73±
SCALE 1/4" = 1'-0"



DETAIL OF MANHOLE FRAME AND COVER
2 REQUIRED TOTAL WEIGHT 600 LBS.
SCALE 1" = 1'-0"



TYPICAL DETAIL OF BRICK MANHOLES
TWO REQUIRED AT STAS. M-6+60 & M-11+94.4
SCALE 1/4" = 1'-0"



SECTION B/12

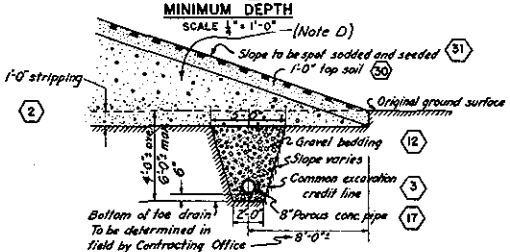
TYPICAL SEWER EXCAVATION
SCALE 1/4" = 1'-0"

NOTES

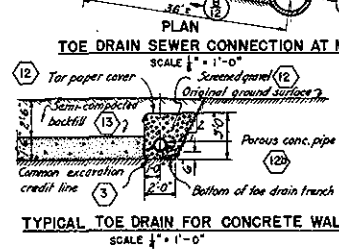
Elevations refer to Mean Sea Level Datum

Figures in hexagons indicate item numbers under which credit will be made.

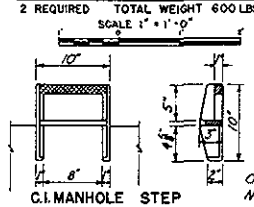
For location of manhole at Sta. M 6+60, see Sheet No. 5. For manholes at M 11+73± and 11+94± see Sheet No. 21.



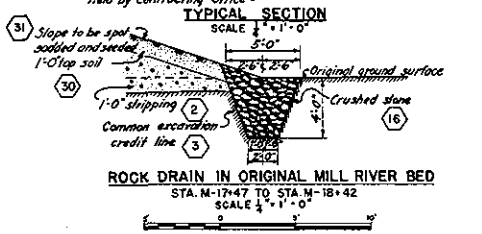
TYPICAL SECTION
SCALE 1/4" = 1'-0"



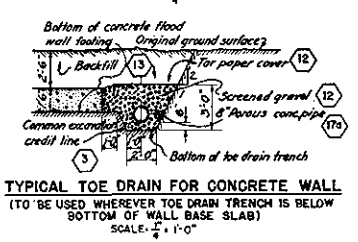
TYPICAL TOE DRAIN FOR CONCRETE WALL
SCALE 1/4" = 1'-0"



C.I. MANHOLE STEP
8 REQUIRED TOTAL WEIGHT 92 LBS.
SCALE 1 1/2" = 1'-0"



ROCK DRAIN IN ORIGINAL MILL RIVER BED
STA. M-17+47 TO STA. M-18+42
SCALE 1/4" = 1'-0"



TYPICAL TOE DRAIN FOR CONCRETE WALL
(TO BE USED WHEREVER TOE DRAIN TRENCH IS BELOW BOTTOM OF WALL BASE SLAB)
SCALE 1/4" = 1'-0"

TYPICAL TOE DRAIN CROSS SECTIONS

KEY	DATE	REVISION (Indicated by △)	REV BY	CK. BY	AP. BY
△	11/8/40	Stop-log widened	F.C.J.	H.J.J.	J.A.P.

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

DRAINAGE PROFILE AND DETAILS

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 33 SHEETS — SCALE: 1/8" = 1 FT — SHEET NO. 12

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., SEPT., 1939

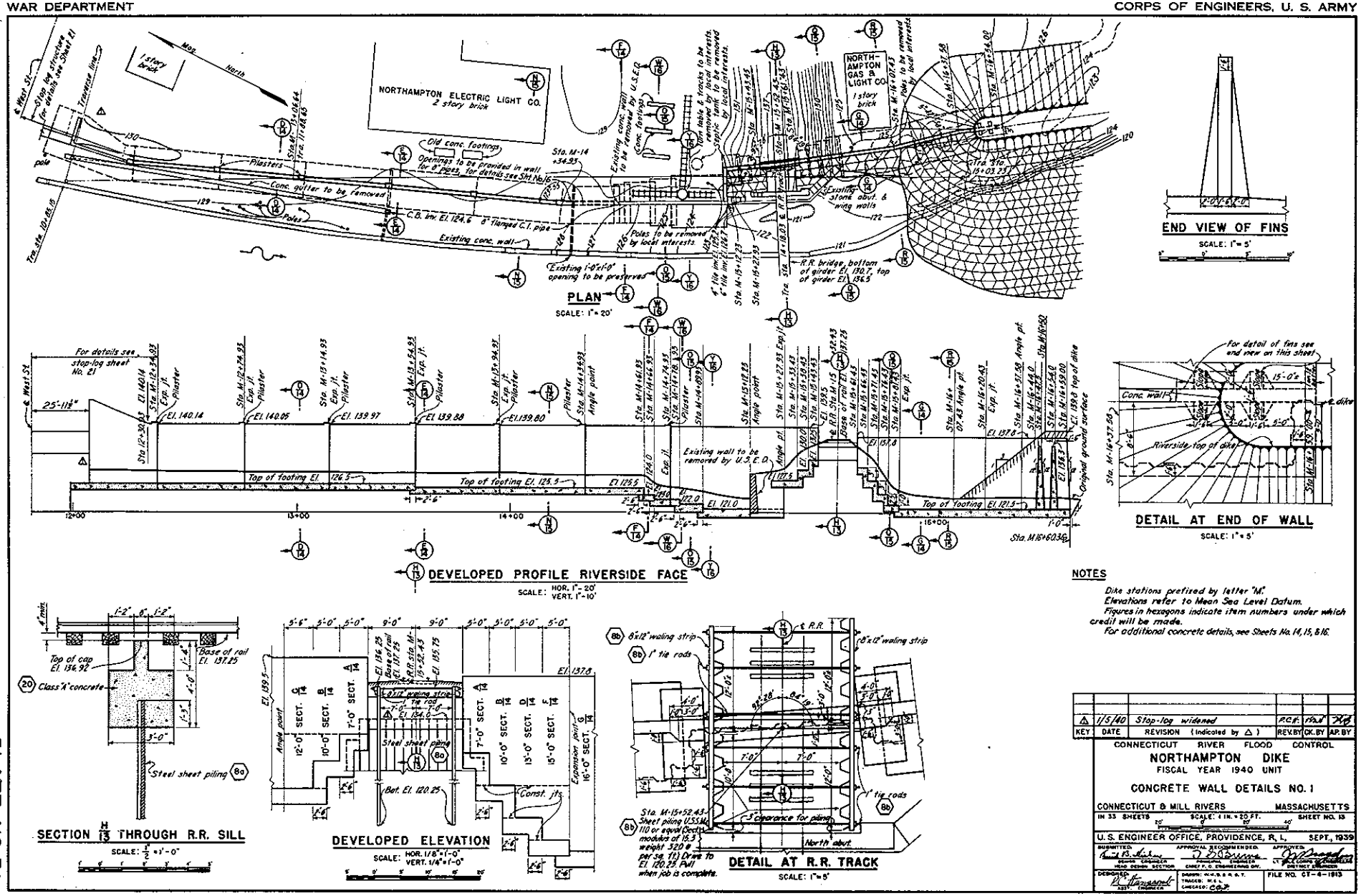
SUBMITTED: HEAD, DESIGN SECTION — APPROVAL RECOMMENDED: CHIEF, C. E. ENGINEERING DIV. — APPROVED: DISTRICT ENGINEER

DESIGNED: ASST. ENGINEER — DRAWN: R.B.Y. TRACED: E.M.L. CHECKED: Jr. J. K.

FILE NO. CT-4-1912

PLATE NO. 30

N.3d



NOTES

Dike stations prefixed by letter "M".
Elevations refer to Mean Sea Level Datum.
Figures in hexagons indicate item numbers under which credit will be made.
For additional concrete details, see Sheets No. 14, 15, & 16.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY
△	1/5/40	Stop-log widened	P.C.F.	[illegible]	[illegible]

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

CONCRETE WALL DETAILS NO. 1

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 33 SHEETS — SCALE: 1 IN. = 20 FT. — SHEET NO. 13

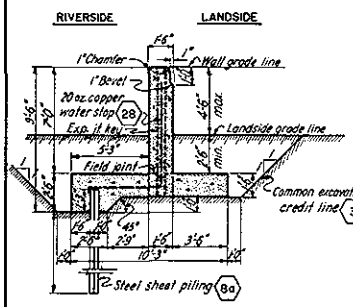
U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — SEPT., 1939

SUBMITTED: [illegible] HEAD DESIGN SECTION — APPROVAL RECOMMENDED: [illegible] CHIEF, ENGINEERING DIV. — APPROVED: [illegible] LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DESIGNED: [illegible] ASST. ENGINEER — DRAWN: M.H.S. & H.A.T. — TRACED: M.H.S. — CHECKED: [illegible] — FILE NO. CT-4-1913

PLATE NO. 31

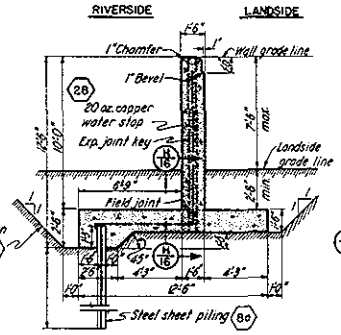
N3d



7'-0" WALL SECTION A/13

TYPICAL BETWEEN STA. M-15+38.43 & STA. M-15+43.43 AND BETWEEN STA. M-15+61.43 & STA. M-15+66.43

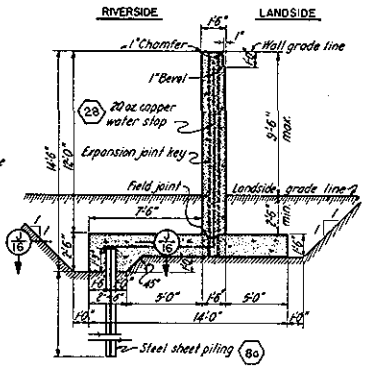
SCALE: 1/4" = 1'-0"



10'-0" WALL SECTION B/13

TYPICAL BETWEEN STA. M-15+33.43 AND STA. M-15+38.43 AND BETWEEN STA. M-15+66.43 AND STA. M-15+71.43

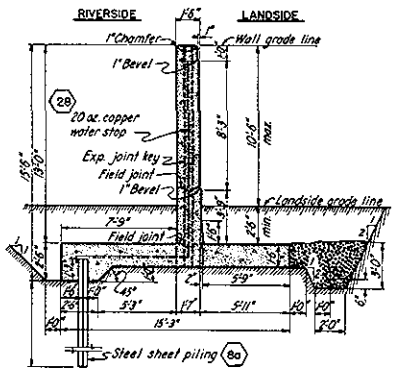
SCALE: 1/4" = 1'-0"



12'-0" WALL SECTION C/13

TYPICAL BETWEEN STA. M-15+27.93 AND STA. M-15+33.43

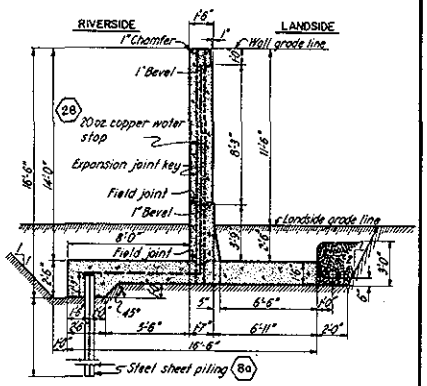
SCALE: 1/4" = 1'-0"



13'-0" WALL SECTION D/13 △

TYPICAL BETWEEN STA. M-12+34.93 AND STA. M-13+54.93 AND BETWEEN STA. M-15+71.43 AND STA. M-15+76.43

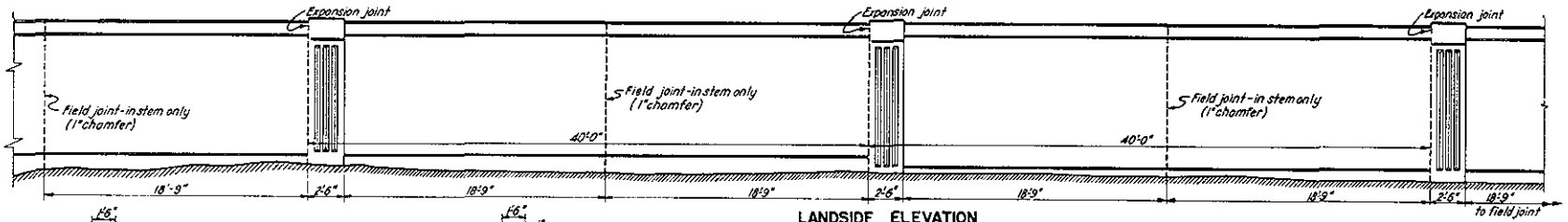
SCALE: 1/4" = 1'-0"



14'-0" WALL SECTION E/13

TYPICAL BETWEEN STA. M-13+54.93 AND STA. M-14+61.93

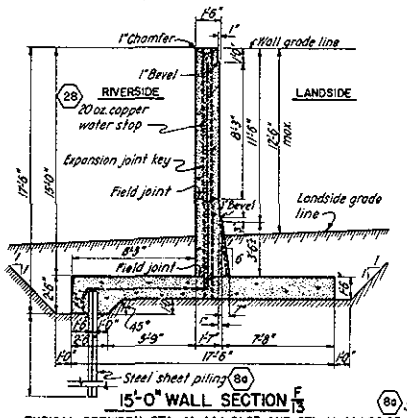
SCALE: 1/4" = 1'-0"



LANDSIDE ELEVATION

TYPICAL BETWEEN STA. M-12+25.84 AND STA. M-15+43.43
SIMILAR, BUT WITHOUT PILASTERS OR ARCHITECTURAL TREATMENT BETWEEN STA. M-15+61.43 AND STA. M-16+59.00

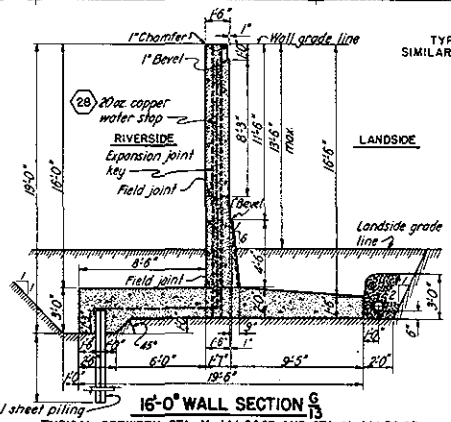
SCALE: 1/4" = 1'-0"



15'-0" WALL SECTION F/13

TYPICAL BETWEEN STA. M-14+61.93 AND STA. M-14+66.93 AND WITHOUT BEVEL AT BASE, AS SHOWN BY DOTTED LINES, BETWEEN STA. M-15+76.43 AND STA. M-15+81.43

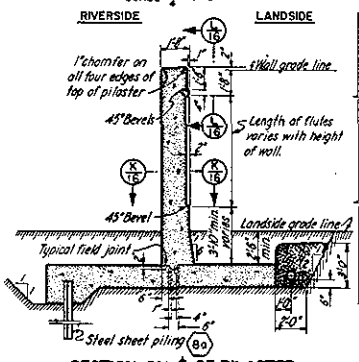
SCALE: 1/4" = 1'-0"



16'-0" WALL SECTION G/13

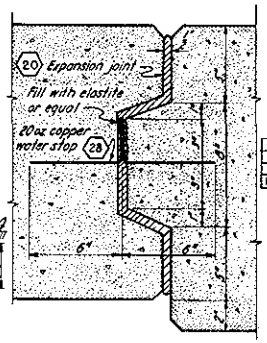
TYPICAL BETWEEN STA. M-14+66.93 AND STA. M-14+78.93 AND WITHOUT BEVEL AT BASE, AS SHOWN BY DOTTED LINES, BETWEEN STA. M-15+81.43 AND STA. M-16+59.00

SCALE: 1/4" = 1'-0"



SECTION ON ℄ OF PILASTER

SCALE: 1/2" = 1'-0"



DETAIL OF EXPANSION JOINT

SCALE: 3/4" = 1'-0"

NOTES

For steel reinforcement details see Sheets Nos. 17 to 20
For general plan see Sheet No. 13
All exposed edges shall be chamfered as shown or as directed by Contracting Officer.
All concrete shown on this sheet to be Class "A" and payment will be made under Item No. 20
Figures in hexagons indicate item number under which credit will be made.
For details of copper water stop see Sheet No. 18

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY
△	1/13/40	(Sec. D) start of wall changed	P.C.R.		

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

CONCRETE WALL DETAILS NO. 2

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 33 SHEETS — SCALE: 1/4" = 1 FT. — SHEET NO. 14

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — SEPT., 1939

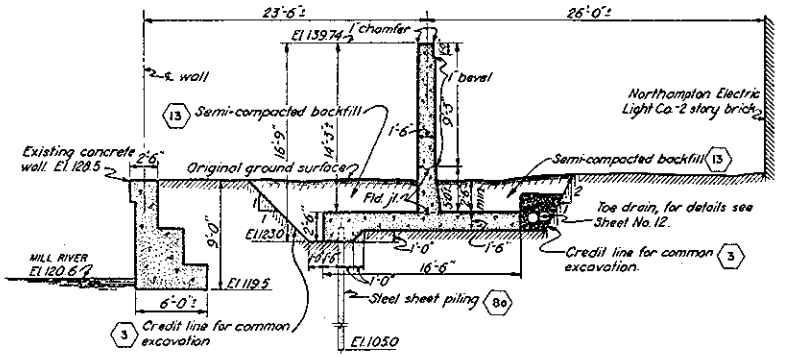
SUBMITTED: Henry J. Dike, Senior Engineer, Head, Design Section
APPROVAL RECOMMENDED: C. B. Brown, Principal Engineer, Chief F. C. Engineering Div.
APPROVED: W. Sanders, Colonel, Corps of Engineers, District Engineer

DESIGNED: K. S. Hammond, Asst. Engineer
DRAWN: R.B.T. TRACED: G.E.D. CHECKED: C.O.J.

FILE NO. CT-6-1914

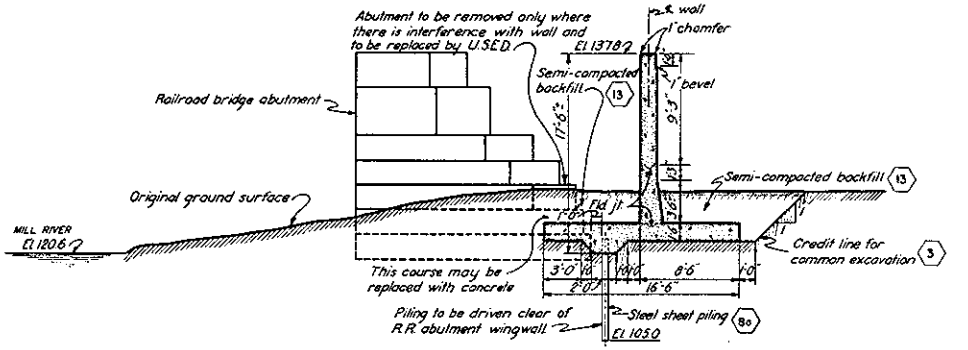
PLATE NO. 32

N.3d



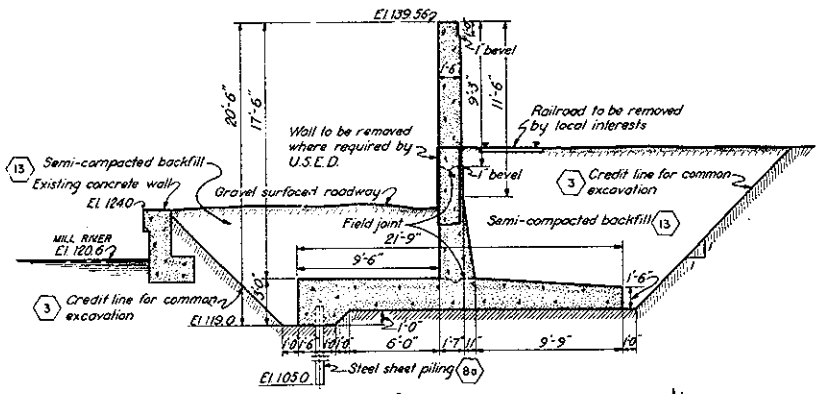
SECTION N/13 AT STA. M-14+17.5

SCALE: 1" = 5'



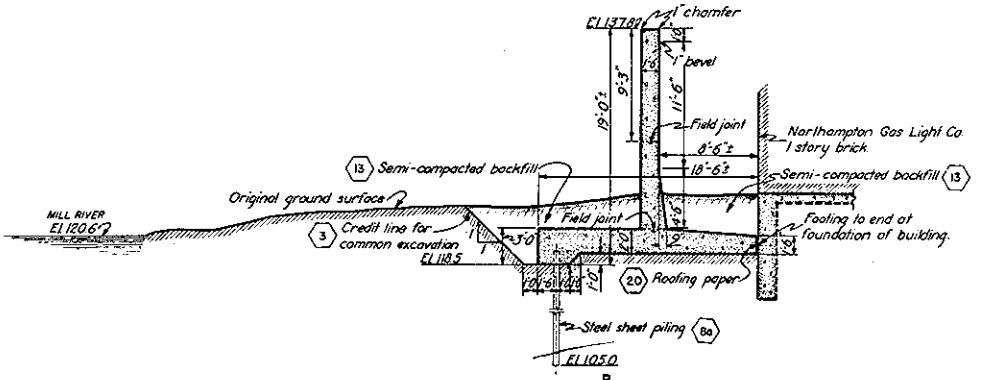
SECTION O/15 AT STA. M-15+77.0

SCALE: 1" = 5'



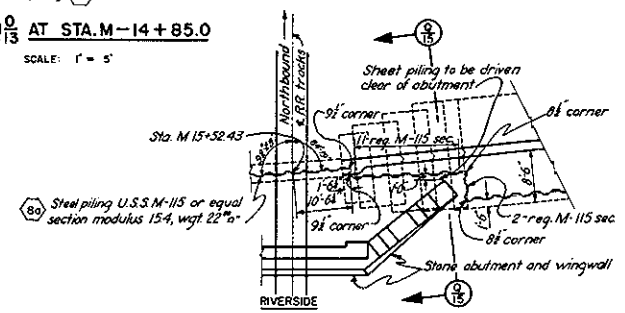
SECTION O/13 AT STA. M-14+85.0

SCALE: 1" = 5'



SECTION R/13 AT STA. M-16+04.8

SCALE: 1" = 5'



DETAIL AT R.R. ABUTMENT

SCALE: 1" = 10'

NOTES

All concrete shown on this sheet to be Class "A" and credit will be made under item No. 20.

All exposed edges shall be chamfered as shown or as directed by contracting officer.

Elevations refer to Mean Sea Level Datum.

For further wall details see Sheets No. 13, 14, & 16.

Figures in hexagons indicate item numbers under which credit will be made.

For steel reinforcement details see Sheets No. 17 to 20.

KEY	DATE	REVISION Indicated by △	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

CONCRETE WALL DETAILS NO. 3

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 33 SHEETS — SCALE: 1 IN. = 10 FT. — SHEET NO. 15

U.S. ENGINEER OFFICE, PROVIDENCE, R. I., SEPT. 1939

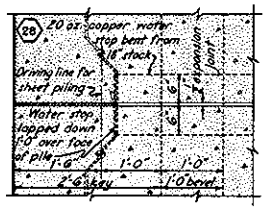
SUBMITTED: EDGAR ENGINEER, HEAD DESIGN SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF F.C. ENGINEERING DIV. — APPROVED: LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DESIGNED: ARMY ENGINEER — DRAWN: H.S.H. TRACED: J.E.O. CHECKED

FILE NO. CT-4-195

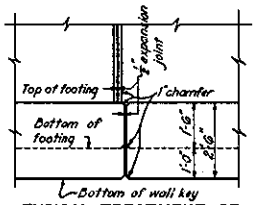
PLATE NO. 33

N.3d



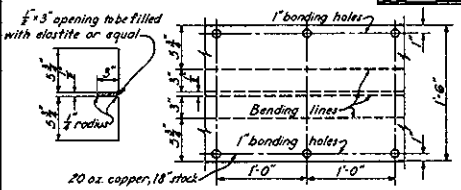
SECTION $\frac{J}{14}$

SCALE: 1" = 1'-0"



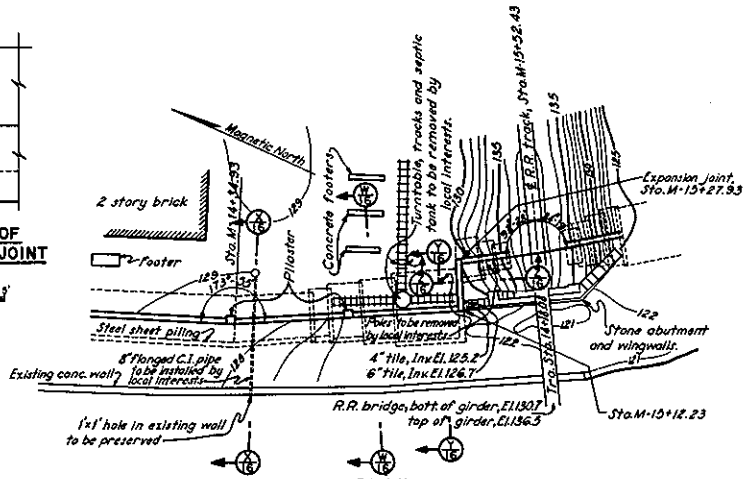
TYPICAL TREATMENT OF FOOTING AT EXPANSION JOINT

SCALE: $\frac{1}{4}$" = 1'-0"



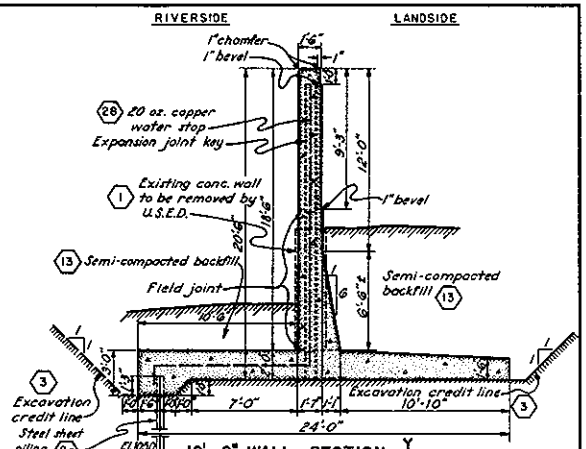
DETAIL OF COPPER WATER STOP (28)

SCALE: $1\frac{1}{2}$" = 1'-0"



PLAN

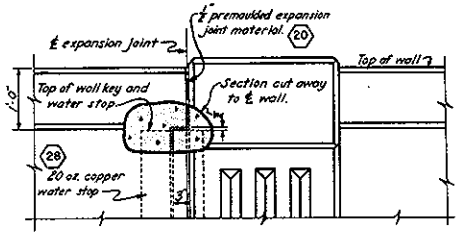
SCALE: 1" = 20'



18'-0" WALL SECTION $\frac{Y}{16}$

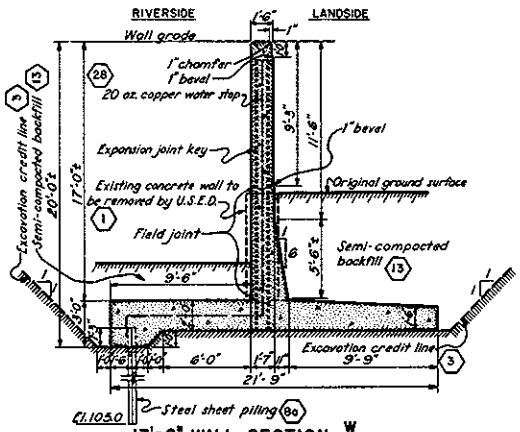
TYPICAL BETWEEN STA. M-14+89.93 & STA. M-15+12.23

SCALE: $\frac{1}{4}$" = 1'-0"



SECTION $\frac{L}{14}$

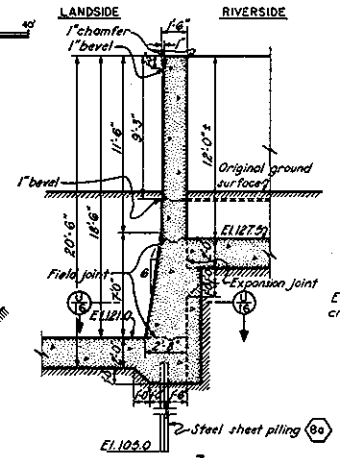
SCALE: 1" = 1'-0"



17'-0" WALL SECTION $\frac{W}{16}$

TYPICAL BETWEEN STA. M-14+78.93 & STA. M-14+89.93

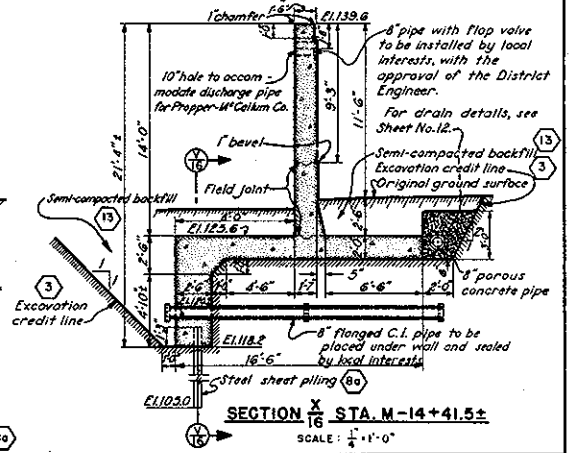
SCALE: $\frac{1}{4}$" = 1'-0"



SECTION $\frac{Z}{16}$

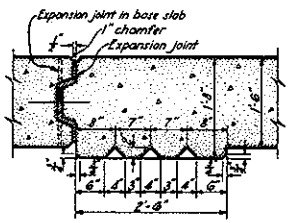
TYPICAL BETWEEN STA. M-15+12.23 & STA. M-15+27.93

SCALE: $\frac{1}{4}$" = 1'-0"



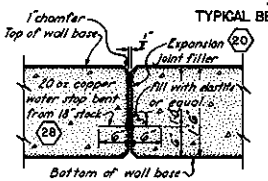
SECTION $\frac{X}{16}$ STA. M-14+41.5±

SCALE: $\frac{1}{4}$" = 1'-0"



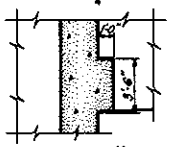
SECTION $\frac{K}{14}$

SCALE: 1" = 1'-0"



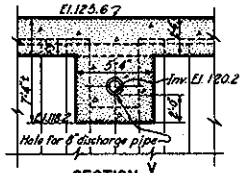
SECTION $\frac{H}{14}$

SCALE: 1" = 1'-0"



SECTION $\frac{U}{16}$

SCALE: $\frac{1}{4}$" = 1'-0"



SECTION $\frac{V}{16}$

SCALE: $\frac{1}{4}$" = 1'-0"

NOTES

Elevations refer to Mean Sea Level Datum.

Figures in hexagons indicate item numbers under which credit will be made.

All exposed corners shall be chamfered 1" or as directed by the contracting officer.

All concrete on this sheet shall be Class A and credit will be made under Item No. 20.

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

CONCRETE WALL DETAILS NO. 4

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 33 SHEETS — SCALE: 1/4 IN. = 1 FT. — SHEET NO. 16.

U.S. ENGINEER OFFICE, PROVIDENCE, R. I., SEPT. 1939

SUBMITTED: Henry B. Hatch, Senior Engineer, Head, Design Section

APPROVAL RECOMMENDED: O. J. Sherman, Principal Engineer, Chief F. C. Engineering Div.

APPROVED: W. Wheeler, Lieut. Colonel, Corps of Engineers, District Engineer

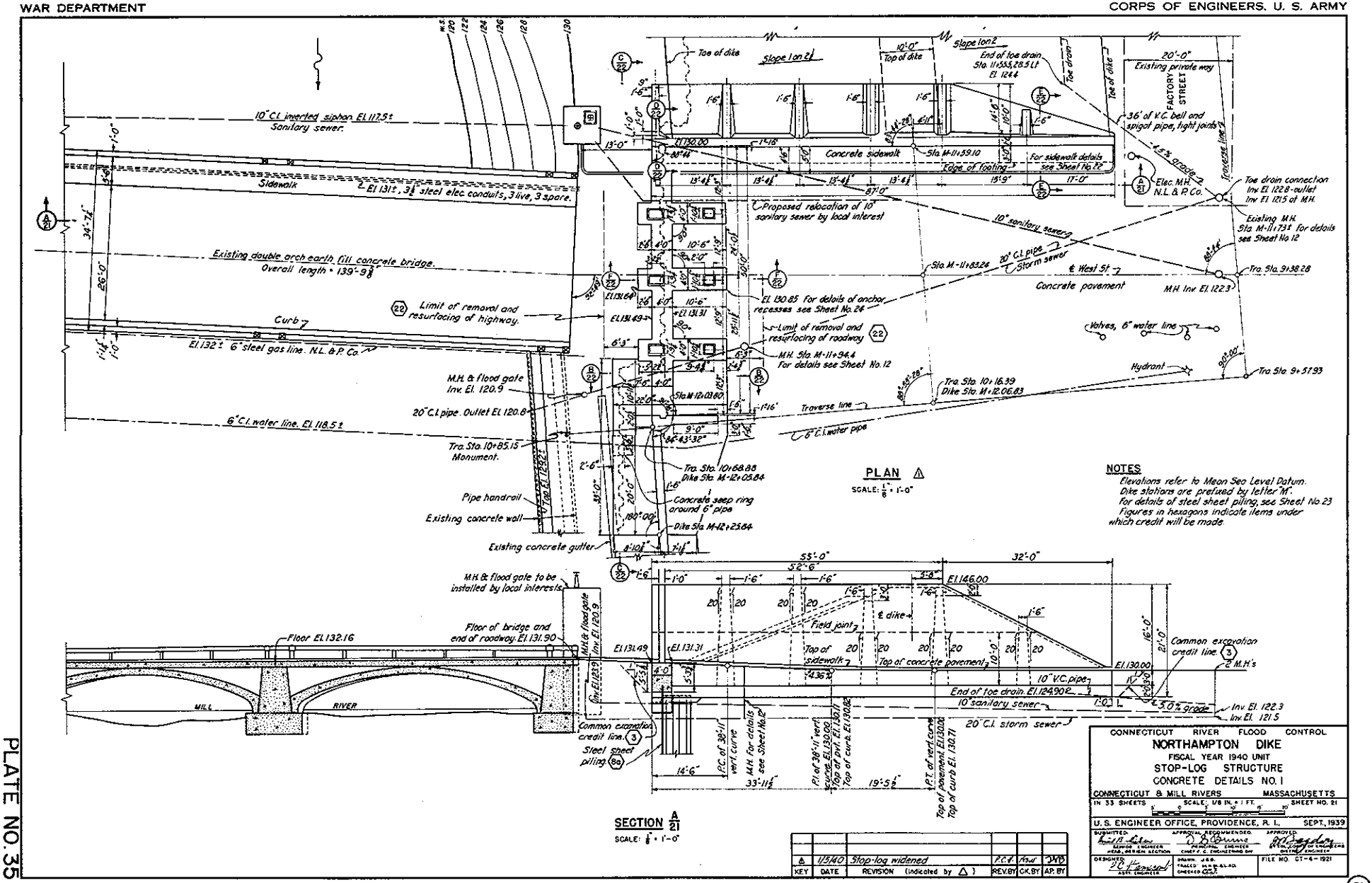
DESIGNED: P. C. Hazard, Asst. Engineer

DRAWN: J.B.B. • W.R.B. • R.S.H. TRACED: R.K.S. CHECKED: C.O.J.

FILE NO. CT-4-1918.

PLATE NO. 34

N.3d



KEY	DATE	REVISION (indicated by △)	REV. BY	CK. BY	AP. BY
△	1/5/40	Stop-log widened	P.C.K.	Fouf	JWB

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

STOP-LOG STRUCTURE

CONCRETE DETAILS NO. 1

CONNECTICUT & MILL RIVERS — MASSACHUSETTS

IN 33 SHEETS — SCALE: 1/8 IN. = 1 FT. — SHEET NO. 21

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — SEPT., 1939

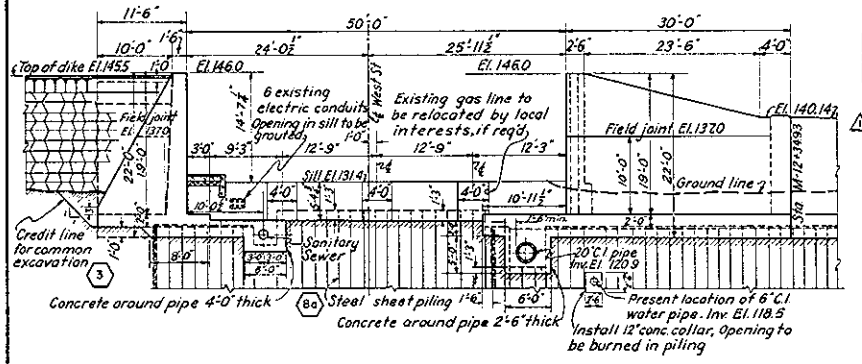
SUBMITTED: Senior Engineer, Head, Design Section — APPROVAL RECOMMENDED: Principal Engineer, Chief F. C. Engineering Div. — APPROVED: Colonel, Corps of Engineers, District Engineer

DESIGNED: Asst. Engineer — DRAWN: J.E.B. — TRACED: M.B.E.L.A.D. — CHECKED

FILE NO. CT-4-1921

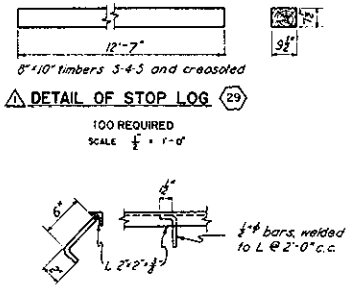
PLATE NO. 35

N.3d



△ ELEVATION C/21

SCALE 1/8" = 1'-0"



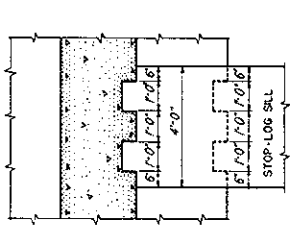
△ DETAIL OF STOP LOG (29)

100 REQUIRED

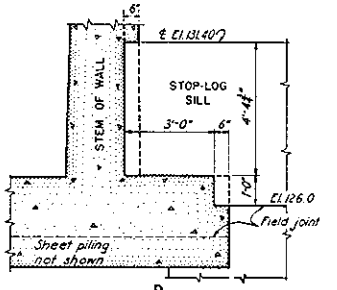
SCALE 1/2" = 1'-0"

DETAILS OF CURB GUARD (26)

SCALE 1 1/2" = 1'-0"



PLAN AT EL. 131.40

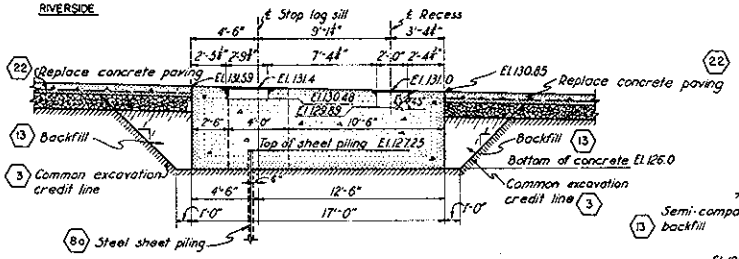


SECTION D/21

DETAIL OF KEY BETWEEN STOP-LOG SILL AND WALL

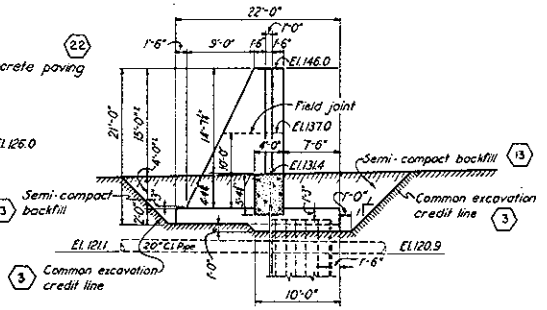
SCALE 1/2" = 1'-0"

RIVERSIDE



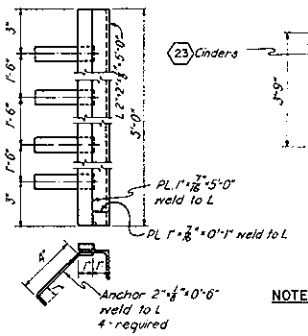
SECTION F/21

SCALE 1/4" = 1'-0"



SECTION B/21

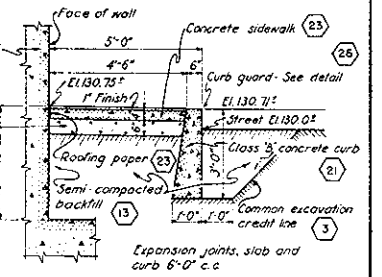
SCALE 1/8" = 1'-0"



DETAIL OF FOOT PLATE RABBET ANGLE

1-REQUIRED - AS SHOWN
1-REQUIRED - OPP. HAND

SCALE 3" = 1'-0"



SIDEWALK SECTION E/21

SCALE 1/2" = 1'-0"

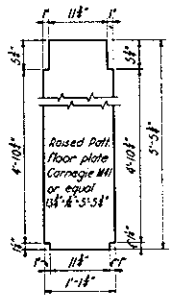
NOTES

Elevations refer to Mean Sea Level Datum.

All exposed corners to be chamfered as directed by the contracting engineer.

All concrete on this sheet except curb shall be class "A" and credit will be made under Item 20, except as shown.

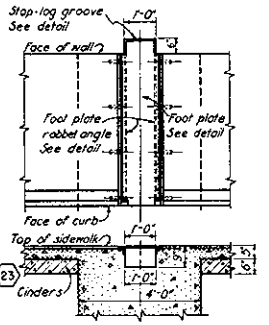
Figures in hexagons indicate item numbers under which credit will be made.



DETAIL OF SIDEWALK FOOT PLATE AT STOP-LOG SILL

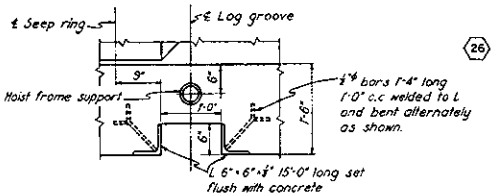
1-REQUIRED

SCALE 1" = 1'-0"



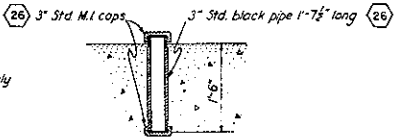
SIDEWALK DETAIL AT STOP-LOG SILL

SCALE 1/2" = 1'-0"



DETAIL OF STOP-LOG GROOVE

SCALE 1" = 1'-0"



DETAIL OF HOIST SOCKET

SCALE 1" = 1'-0"

KEY	DATE	REVISION (Indicated by △)	REV. BY	CK. BY	AP. BY
△	1-5-40	Stop-log gate widened	[illegible]	[illegible]	[illegible]

CONNECTICUT RIVER FLOOD CONTROL

NORTHAMPTON DIKE

FISCAL YEAR 1940 UNIT

STOP-LOG STRUCTURE

CONCRETE DETAILS NO. 2

CONNECTICUT & MILL RIVERS MASSACHUSETTS

IN 33 SHEETS SCALE 1/2 IN. = 1 FT. SHEET NO. 22

U. S. ENGINEER OFFICE, PROVIDENCE, R. I. SEPT. 1939

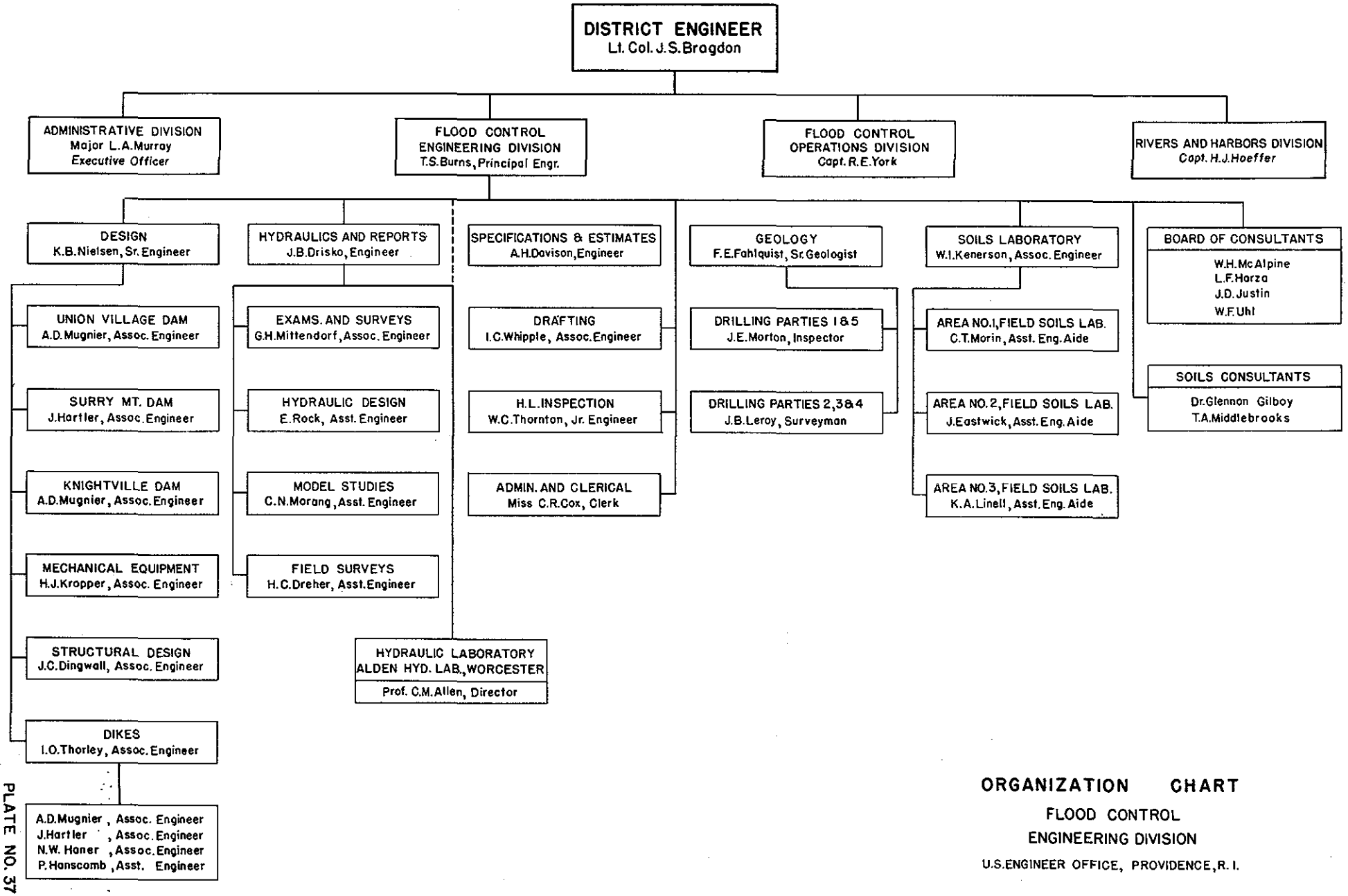
SUBMITTED: Chief, Design Section — APPROVAL RECOMMENDED: Principal Engineer, Chief, C. Engineering Div. — APPROVED: Col. Corps of Engineers, District Engineer

DESIGNED: Asst. Engineer — DRAWN: R.E.T. — TRACED: F.H.B. — CHECKED: [illegible]

FILE NO. CT-4-1922

PLATE NO. 36

N. 3d



ORGANIZATION CHART

FLOOD CONTROL

ENGINEERING DIVISION

U.S. ENGINEER OFFICE, PROVIDENCE, R. I.

PLATE NO. 37

CONNECTICUT RIVER FLOOD CONTROL PROJECT

NORTHAMPTON, MASS.

CONNECTICUT & MILL RIVERS, MASSACHUSETTS

ANALYSIS OF DESIGN

LOCAL PROTECTION WORKS

FISCAL YEAR 1939 UNIT, ITEM N.3
DIVERSION CANAL AND DIKE ALONG EAST BANK MILL RIVER

APPENDIX A

MAY 1939

CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE PROVIDENCE, R.I.

APPENDIX A

COMPUTATIONS

TABLE OF CONTENTS

		Page
I	SOUTH STREET BRIDGE	A1-A39
II	DROP STRUCTURE	A40-A122
III	WEST STREET STOP-LOG STRUCTURES	A123-A155
IV	FLOOD WALLS	A156-A174
V	OX BOW BRIDGE	A175-A184

APPENDIX A

I SOUTH STREET BRIDGE

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 1

Subject: South St. Bridge – Northampton, Mass.

Computation: Roadway Girders

Computed by: E.M.V. Checked by: RSM Date: April 26, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Structural concrete slab is 8" thk.

Roadway girders spaced 5'-2" c.c.

Effective span of roadway girders = 50-0" c.c. brgs.

Design Live Load = Class H-20.

Fraction of wheel load on each interior girder = $\frac{5.17}{4.5} = 1.18$

D.L. – Roadway slab $5.17 \times 100 = 517$ #per lin. ft.

" fill $5.17 \times 31 = 160$ " " "

Girder stem, say 1'-4" + 2'-7" = 515 " " "

Total = 1,192 # " " "

D.L. mom. $= \frac{1}{8} \times 1192\,(50.0)^2 = 373{,}000'$ #

L.L. " $= 1.18 \times 20{,}000 \frac{(23.6)^2}{50.0} = 265{,}000$

I " $= \frac{50}{50+125} \times 265{,}000 = 75500$

Total = 713,500 #'

$t = 8''$; $d = 36.5''$; $\frac{t}{d} = \frac{8}{36.5} = 0.22$; $b = 62''$

$k = 0.348$

$$K = \overset{178}{800} \times 0.22 \overset{0.684}{\left(\frac{2 \times 0.348 - 0.22}{2 \times 0.348}\right)} \left[1 - 0.22 \overset{0.907}{\left(\frac{3 \times 0.348 - 2 \times 0.22}{6 \times 0.348 - 3 \times 0.22}\right)}\right]$$

$= 109$

$M = Kbd^2$; $d = \sqrt{\frac{713{,}500 \times 12}{109 \times 62}} = 35.5''$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 2

Subject: South St. Bridge - Northampton, Mass.

Computation: Roadway Girders

Computed by: E.M.V. Checked by: Date: April 26, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet #1)

D.L. shear = 11.92×25.0 = 29,800#

L.L. " $1.18\left(16{,}000 + \frac{4000 \times 36 + 16000 \times 6}{50}\right)$ = 24,500

I " = $\frac{50}{50+125} \times 24{,}500$ = 7100

Total = 61,400#

Unit shear on section assumed = $\frac{61{,}800}{16 \times \frac{7}{8} \times 35.5}$ = 124 #/□"

$A_s = \frac{713{,}500 \times 12}{\frac{7}{8} \times 35.5 \times 18{,}000} = 15.3$ □"

Try beam 18" wide stem and "d" = 40.5"

$A_s = \frac{769{,}000 \times 12}{\frac{7}{8} \times 40.5 \times 18{,}000} = 14.3$ □" = 8 - $1\frac{1}{4}$" □ bars.

Try d = 46.5

$A_s = \frac{792{,}000 \times 12}{\frac{7}{8} \times 46.5 \times 18{,}000} = 13.0$ □" = 8 - $1\frac{1}{4}$" □ bars.

With 4-bars bent up unit bond stress = $\frac{61{,}400}{4 \times 5 \times \frac{7}{8} \times 46.5}$ = 75 #/□"

Unit shear = $\frac{61{,}400}{18 \times \frac{7}{8} \times 46.5}$ = 83 #/□"

Revised D.L. -	Roadway slab	517# per lin. ft.
	Wearing surface	160
	Girder stem	806
	Total =	1,483 per lin. ft.

Subject: South St. Bridge - Northampton, Mass.
Computation: Roadway Girders.
Computed by: E. M. V. Checked by: Date: April 26, 1939.

U. S. GOVERNMENT PRINTING OFFICE 3—10528

(Continued from sheet #2)

D.L. Mom. $= \frac{1}{8} \times 1483 (50.0)^2 = 464{,}000'\#$

L.L. + I. moms. $= 326000$

Total $= 790{,}000'\#$

$d = \sqrt{\frac{790{,}000 \times 12}{109 \times 62}} = 37.5''$

With "d" = 46.5, $t = 8$, $\frac{t}{d} = \frac{8}{46.5} = 0.17$

$z = 46.5\left[0.348 - 0.17\left(\frac{3 \times 0.348 - 2 \times 0.17}{6 \times 0.348 - 3 \times 0.17}\right)\right] = 12.6''$

$j = \frac{46.5(1 - 0.348) + 12.6}{46.5} = 0.92$

$d = \sqrt{\frac{2 \times 790{,}000 \times 12}{0.348 \times 0.92 \times 62 \times 800}} = 34.5''$

Try "d" = 40."

Unit shear $= \frac{61{,}400 + 320 \times 25}{18 \times 0.92 \times 40.0} = 105.0\#/\square''$ O.K.

Use stirrups.

D.L. Mom. $= \frac{1}{8} \times 1522 (50.0)^2 = 476{,}000'\#$

L.L. + I $= 326000$

Total $= 802{,}000'\#$

$A_s = \frac{802{,}000 \times 12}{0.92 \times 40 \times 18{,}000} = 14.50\,\square''$ $12 - 1\frac{1}{8}''\square$ @ 1.26 $= 15.10\,\square''$ Use.

Unit bond stress on 4-bars $= \frac{69{,}400}{4 \times 4.5 \times 0.92 \times 40.0} = 105\#/\square''$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: South St. Bridge - Northampton, Mass.

Computation: Roadway Girders.

Computed by: E.M.V. Checked by: Date: April 26, 1939.

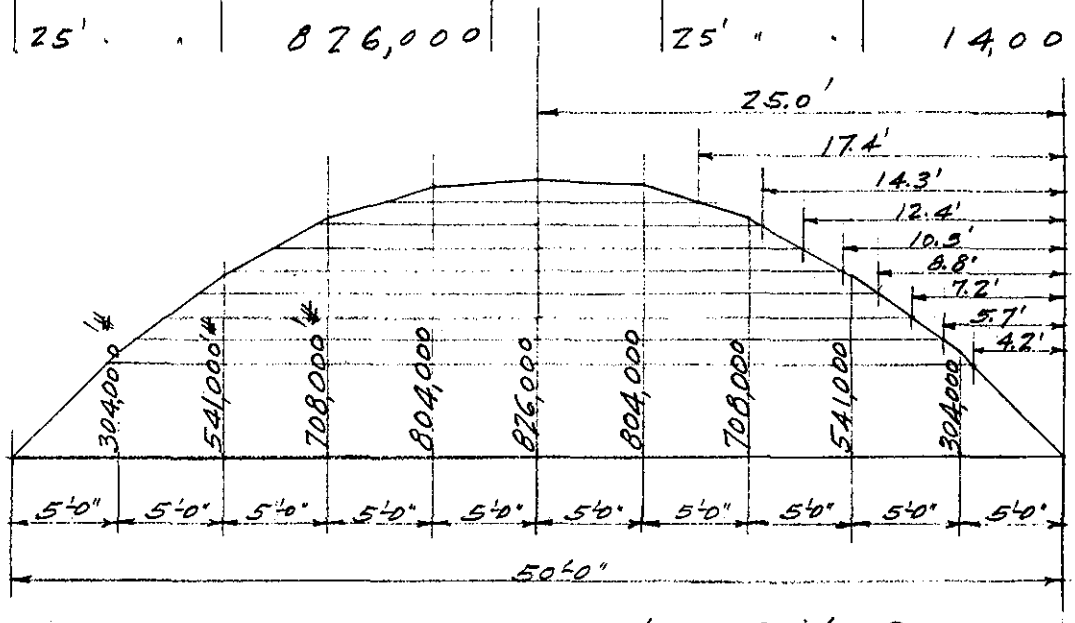
U. S. GOVERNMENT PRINTING OFFICE 3—10528

Table of Moments.

Moment at	Magnitude, Ft. Pds.
5' from end	304,000
10' " "	541,000
15' " "	708,000
20' " "	804,000
25' " "	826,000

Table of Shears.

Shear at	Magnitude. Pds.
5' from end	57,200#
10' " "	43,000
15' " "	32,600
20' " "	22,300
25' " "	14,000



Curve of Bending Moments & Points for Bending Up Bars.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

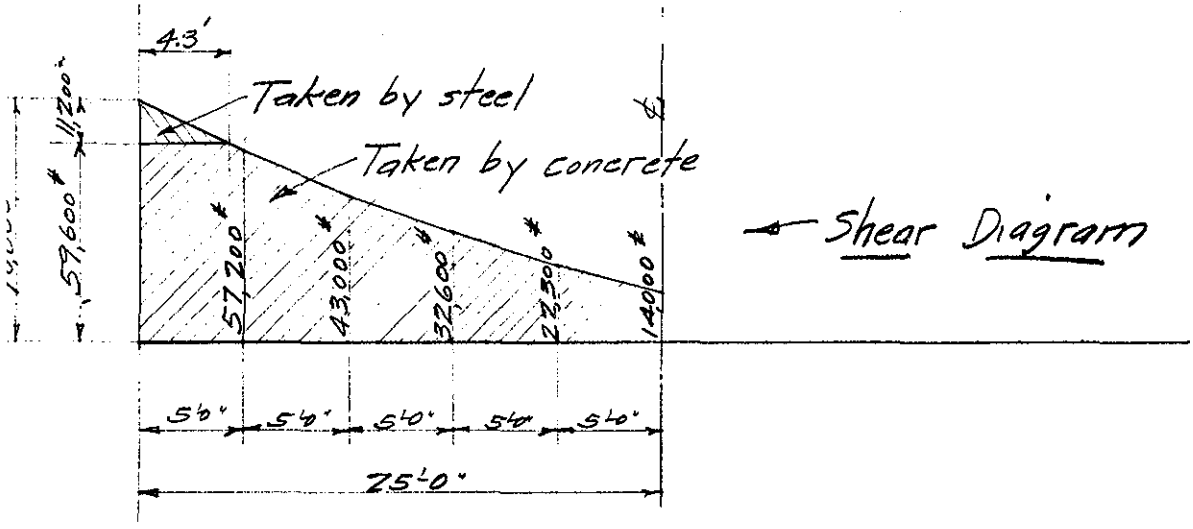
Page 5

Subject: South St. Bridge - Northampton, Mass.

Computation: Roadway Girders

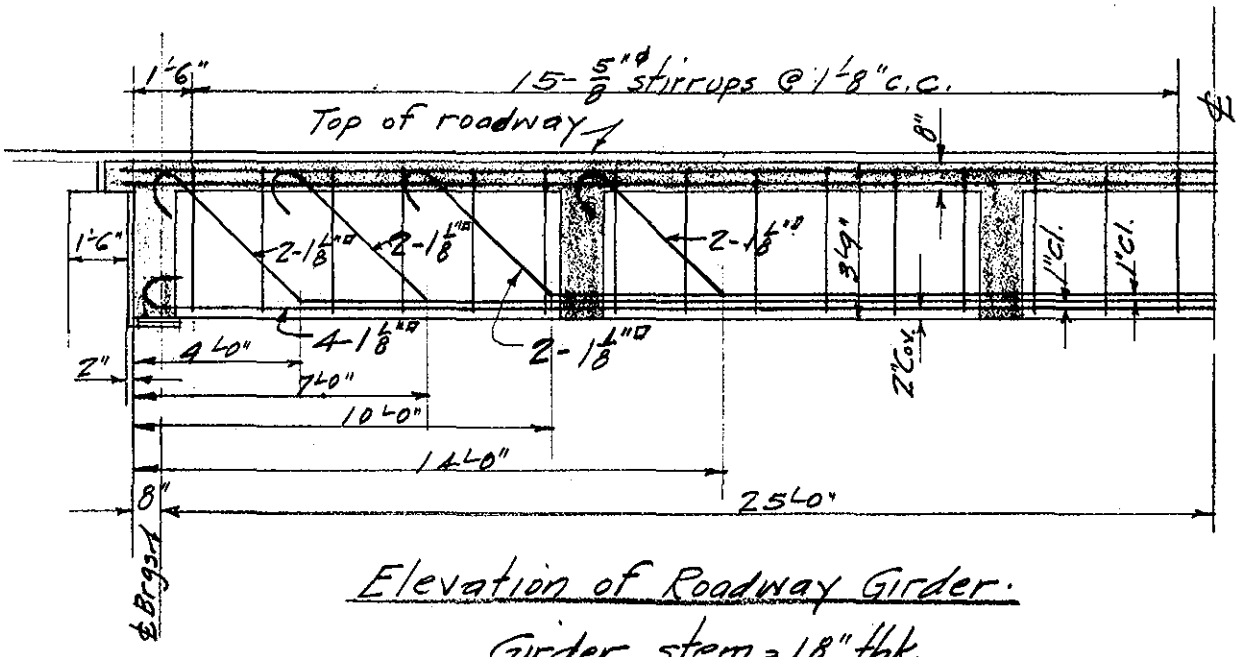
Computed by: E.M.V. Checked by: Date: April 27, 1939

U. S. GOVERNMENT PRINTING OFFICE 3—10528



No. of $\frac{5}{8}$" ϕ stirrups req'd = $\frac{11{,}200 \times \frac{1}{2} \times 51.5}{0.92 \times 40.0 \times 0.306 \times 16000 \times 2} = 0.8$

Use $\frac{5}{8}$" ϕ stirrups, spaced 1'-8" c.c. full length of girder.



Elevation of Roadway Girder.

Girder stem = 18" thk.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 6

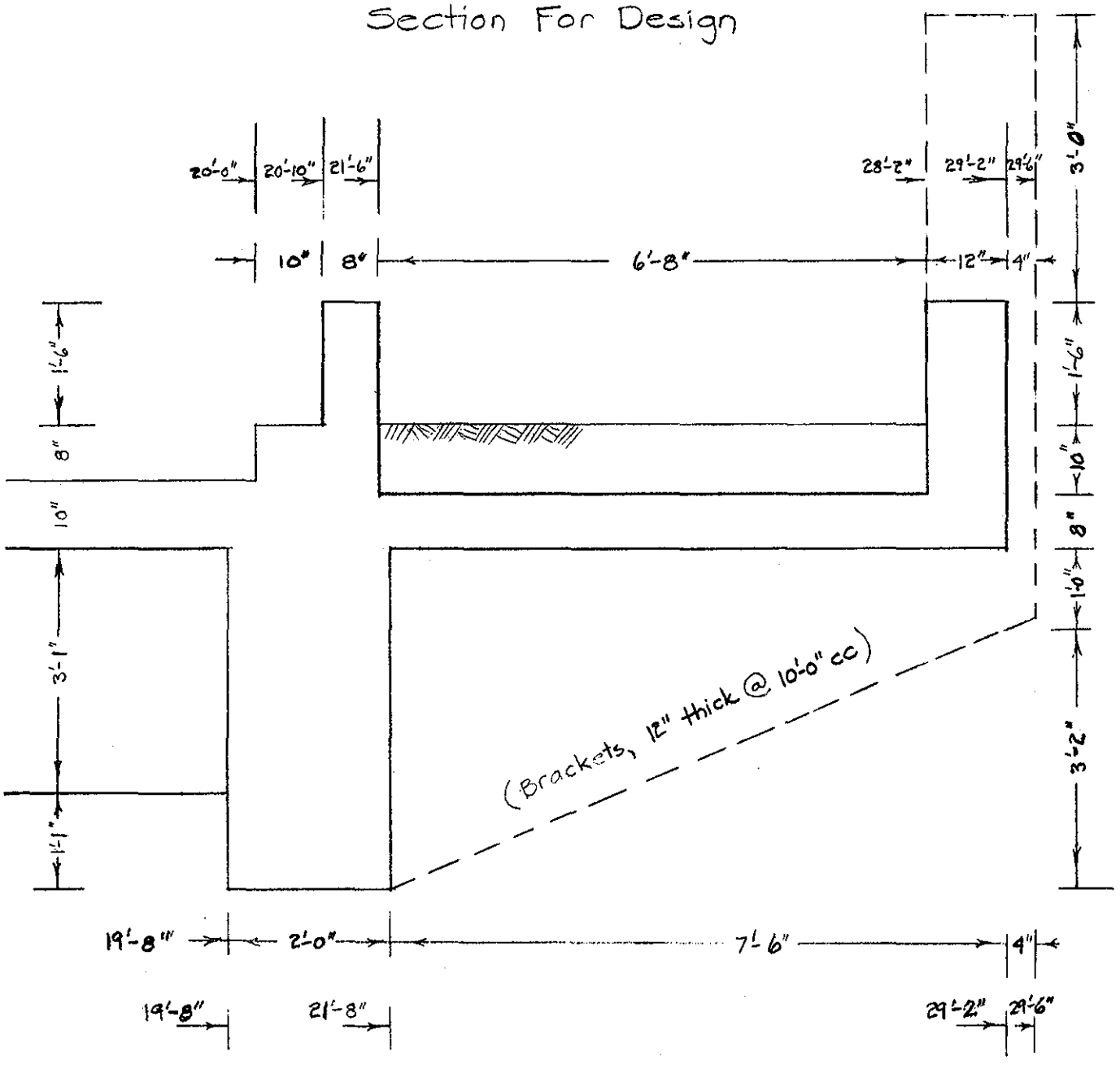
Subject: South St. Bridge - Northampton, Mass.

Computation: Upstream Sidewalk

Computed by: CWT Checked by: Date: 4-26-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Section For Design



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

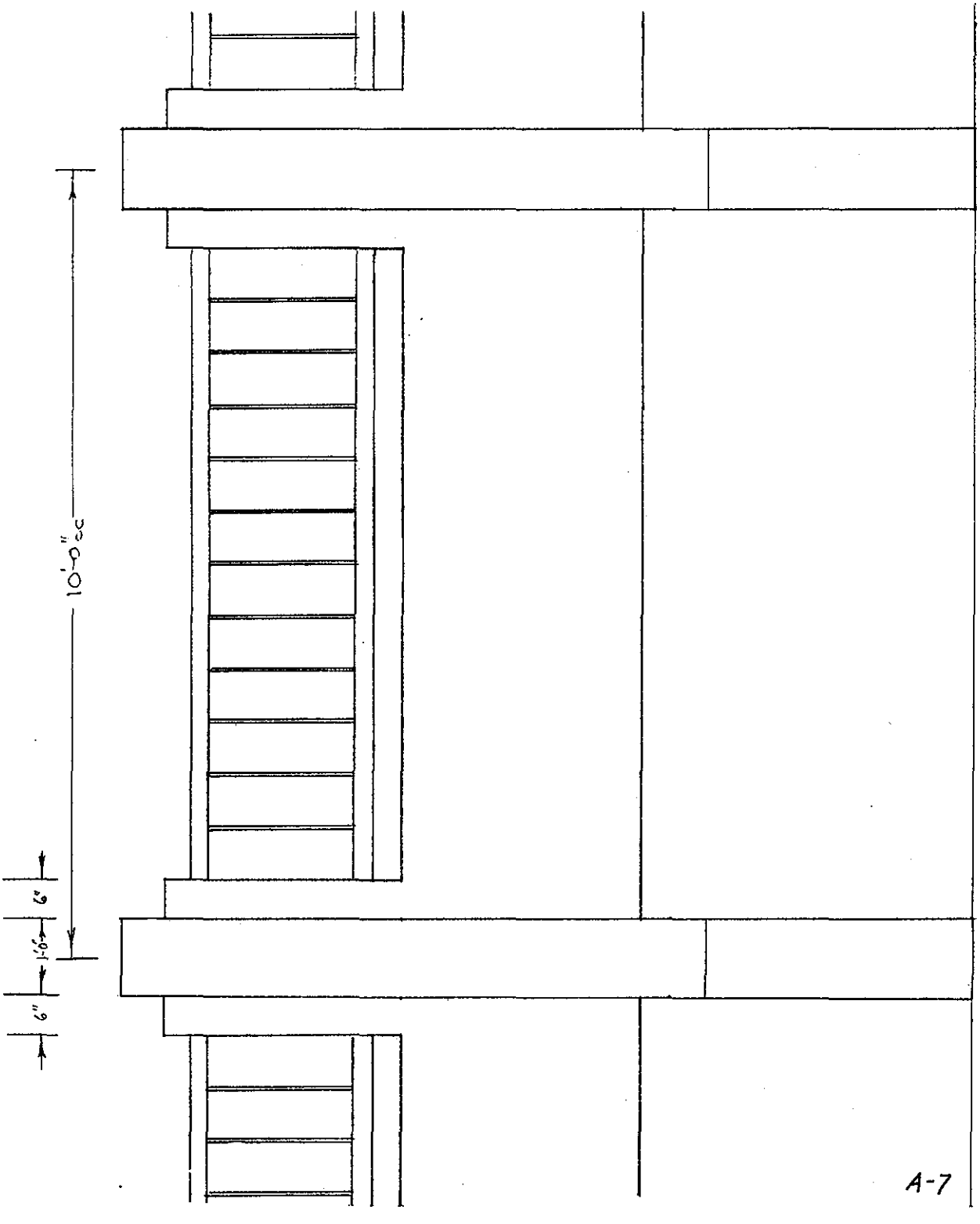
Page 7

Subject: South St. Bridge - Northampton, Mass.

Computation: Upstream sidewalk

Computed by: Curry Checked by: Date: 4-26-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Elevation for Design

A-7

Subject: South St Bridge Northampton, Mass
Computation: Upstream sidewalk
Computed by: CWPM Checked by: RSM Date: 4-26-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Assume the sidewalk slab to act as a continuous slab over the face girder and the railing beam, with maximum moment = $\frac{wL^2}{10}$

Earth filler @ 100#/cu ft = $\frac{10}{12} \times 100$ = 83#/□'

Concrete slab @ 150#/cu ft = $\frac{8}{12} \times 150$ = 100#/□'

Live Load @ 150#/cu.ft. = = 150#/□'

Total 333#/□' ✓

$$M = \frac{wL^2}{10} = \frac{333 \times (6.67 + \cancel{0.5})^2}{10} \times 12 = 20{,}500^{\text{in}\#}/\text{ft.} \quad 18000$$

$$A_s = \frac{M}{f_s j d} = \frac{\cancel{20{,}500}\ 18000}{18{,}000 \times 0.88 \times 6} = 0.\cancel{215}\ .19\ \square''/\text{ft} \text{ ---- use } 5/8''\phi @ 12''cc$$

Secondary steel – minimum of 5/8"φ @ 18" cc.

Railing Beam -

Loading

Weight from slab = 333 × 3.33 = 1111
Weight of rail beam = 1 × 3 × 150 = 450

Total = 1561#/ft ✓

$$M = \frac{wL^2}{12} = \frac{1561 \times 10^2 \times 12}{12} = 156{,}100^{\text{in}\#} \checkmark$$

$$A_s = \frac{M}{f_s j d} = \frac{156{,}100}{18{,}000 \times 0.88 \times 34} = 0.29\ \square'' \text{ --- use } \checkmark\ 2 - 5/8''\phi$$

Subject: South St. Bridge - Northampton, Mass
Computation: Bridle Path
Computed by: CWBM Checked by: Date: 4-26-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Design of Brackets -

Loads -

Weight from slab =	$333 \times 3.33 \times 10$	=	11,100
Weight of rail beam =	$1 \times 3 \times 10 \times 150$	=	4,500
Weight of posts =	$2 \times 3.0 \times 1 \times 150$	=	900
	$1 \times 1 \times 0.5 \times 150$	=	75
	$0.33 \times 7.5 \times 1 \times 150$	=	375
Rail Fence - pipe =	$2 \times 8' \times 7.6$ #/ft.	=	122
rods =	12×10 #	=	120
Total			17,190 # at rail

M (due to concentrated load) =

$M = WL = 17{,}190 \times 7.0 \times 12 = 1{,}444{,}000$ in #

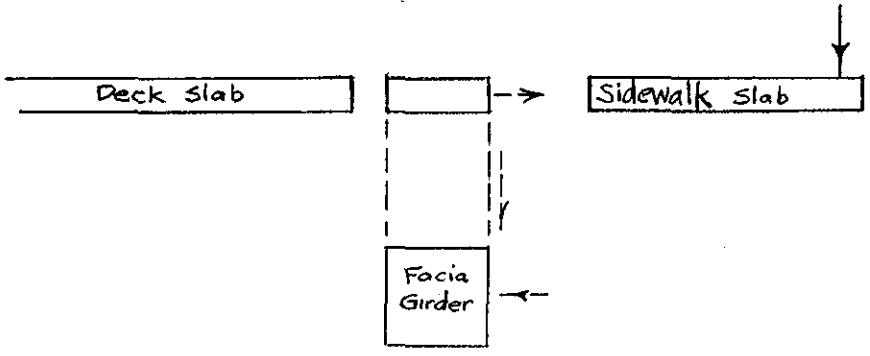
Unit weights of bracket -
at edge - $1 \times 1 \times 1 \times 150 = 150$ #/ft
at girder - $1 \times 1 \times 4.17 \times 150 = 625$ #/ft

M (due to bracket weight)

$M = \frac{L^2}{6}(2w_1 + w_0) = \frac{8.0^2}{6}(2 \times 150 + 625) \times 12 = 118{,}000$ in #

Total moment at girder = 1,562,000 in. #

Assumed distribution of moment



In effect, the cantilever moment is replaced by two forces and a shear, as shown.

Subject South St Bridge Northampton, Mass
Computation Upstream sidewalk
Computed by CWB **Checked by** RSM **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Design of Bracket- (cont'd)

Since the girder will tend to have some distributive effect, both as a beam and as a torque rod, the bracket will be considered to act as a cantilever whose total depth equals the total depth of the girder.

$M = 1{,}562{,}000$ in #

$A_s = \frac{M}{f_s j d} = \frac{1{,}562{,}000}{18{,}000 \times 0.88 \times 56} = 1.76 \square'' $ ---- use $3 - 7/8'' \phi$

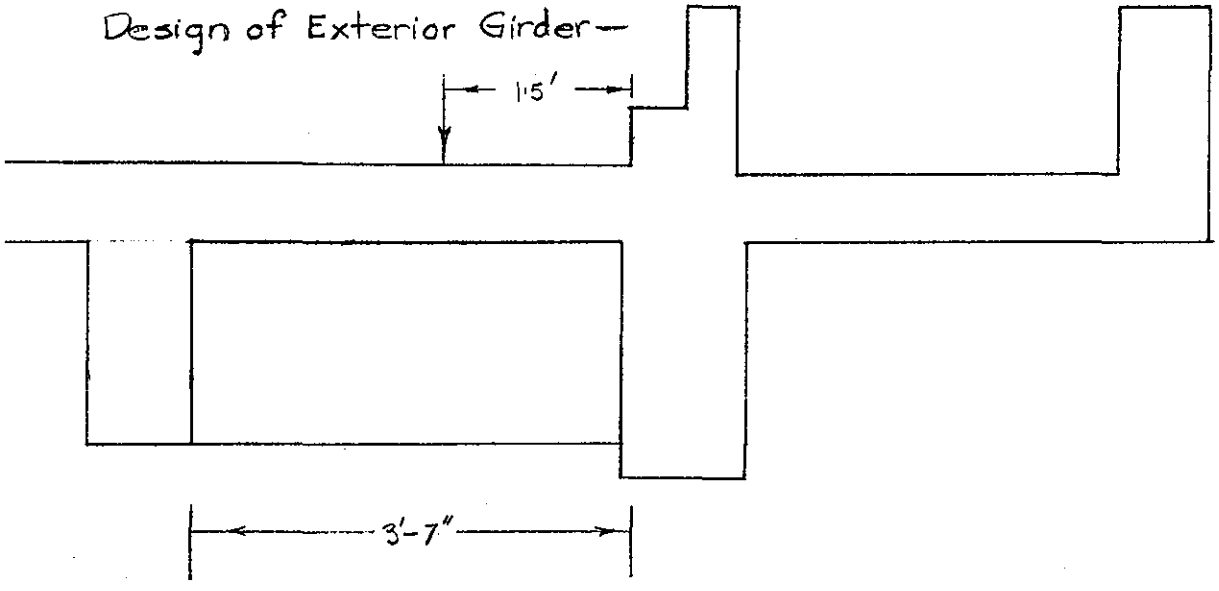
Check on required "d" $= \sqrt{\frac{M}{Kb}} = \frac{1{,}562{,}000}{123 \times 12} = 1060 = 33''$ -

$v = \frac{V}{bjd} = \frac{17{,}190^{\#} + 390^{\#} \times 8'}{12 \times 0.88 \times 56} = 34^{\#}/\square''$ -- OK

Subject South St. Bridge - Northampton, Mass
Computation Upstream Facial Girder
Computed by CWBM **Checked by** RSM **Date** 4-26-39

U. S. GOVERNMENT PRINTING OFFICE 3—10523

Design of Exterior Girder—



Loadings

Uniform – Sidewalk	20,290#/bracket × 5	=	101,450 #
	3.33 × 3.33 × 50	=	55,500 #
Deck	$\frac{10}{12}$ × 1.78 × 50 × 150	=	11,100 #
Diaphragm	4 × 1 × 3.1 × 1.78 × 150	=	3,300 #
Curb	1.56' × 50' × 150	=	11,600 #
Girder	4.83 × 2.0 × 50 × 150	=	72,500 #
Total			255,450 #

Live Load –

H20 loading – truck weighing 20 tons

Impact factor = $\frac{50}{L+125} = \frac{50}{50+125} =$ 29%

Reduction (for width) 14%

Span proportion = $\frac{3.58-1.5}{3.58} =$ 58%

Front wheel 10%

Rear wheel 40%

Subject South St Bridge - Northampton, Mass
Computation Upstream Facial Girder
Computed by CWBM **Checked by** RSM **Date** 4-26-39

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Live Load (cont'd)

Position of load to give maximum moment (14' wheelbase)

Major load at $\frac{14'}{5 \times 2} = 1.4$ ft from ℄

No secondary truck on span.

Wheel loads

Rear wheel $= 40{,}000 \times \frac{40}{100} \times \frac{129}{100} \times \frac{86}{100} \times \frac{58}{100} = 10{,}300$ #

Front wheel $= 1/4 \times 10{,}300 = 2{,}600$ #

Moments

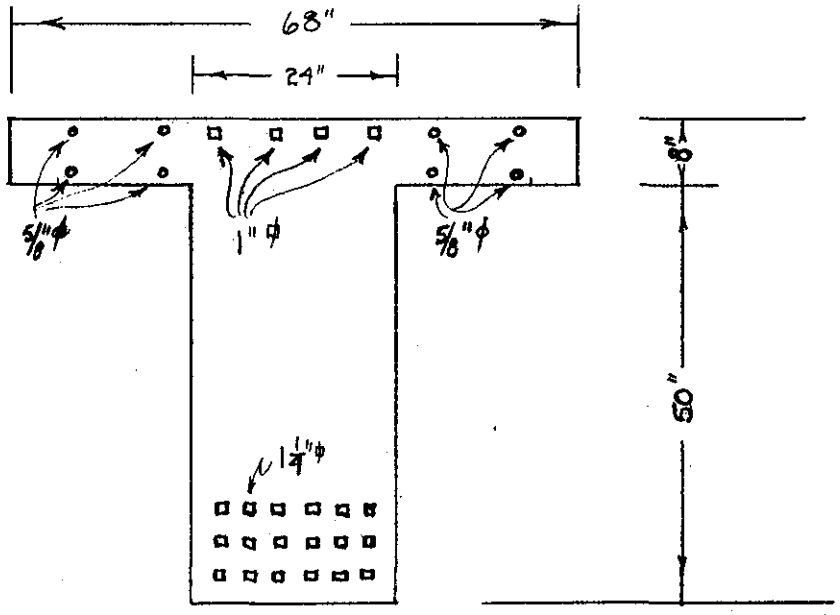
Uniform Load -- $M = \frac{wL}{8} = \frac{255{,}450 \times 50 \times 12}{8} = 19{,}000{,}000$ in #

Conc. Rear Wheel - $M = \frac{Pab}{L} = \frac{10{,}300 \times 23.6 \times 26.4}{50} = 1{,}280{,}000$ in #

" Front " $M = \frac{Pab}{L} = \frac{2{,}600 \times 12.4 \times 23.6}{50} = 152{,}000$ in #

Total ~~20,525,000~~ 20,432,000 in #

Assumed Section



Subject South St Bridge Northampton, Mass
Computation Upstream Facial Girder
Computed by CWBM Checked by RJM Date 4-26-39

U. S. GOVERNMENT PRINTING OFFICE 9—10638

Maximum End Shear

$\frac{1}{2}$ x uniform load = $\frac{1}{2} \times 255{,}450 =$ 127,750#

rear wheel = $1.0 \times 10{,}300 =$ 10,300#

front wheel = $\frac{50-14}{50} \times 2{,}300 =$ 1,650

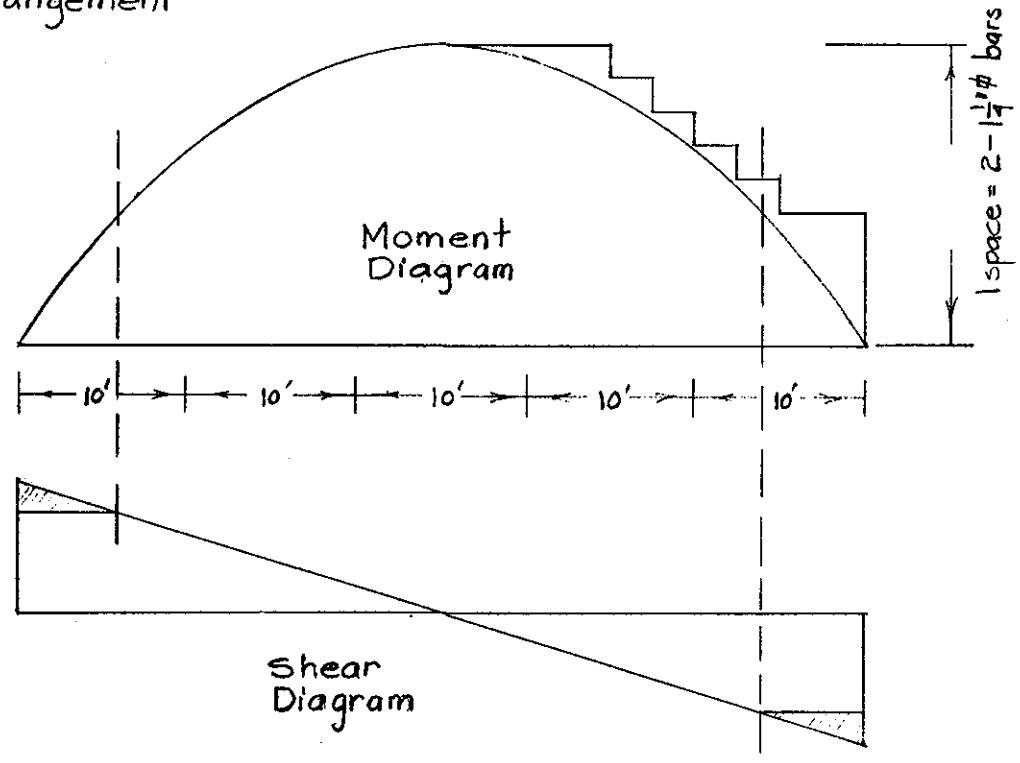
139,700# ✓

Unit shear = $\frac{V}{Ib}(\Sigma Ay) =$

$$\frac{139{,}700}{514{,}847 \times 24}\left(14.9 \times 13.45 + 14.9 \times 16.7 + 48.0 \times 16.7 + 54.4 \times 15.2 + 268.8 \times 5.6\right)$$

$= 122$ #/□"

Bar arrangement



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

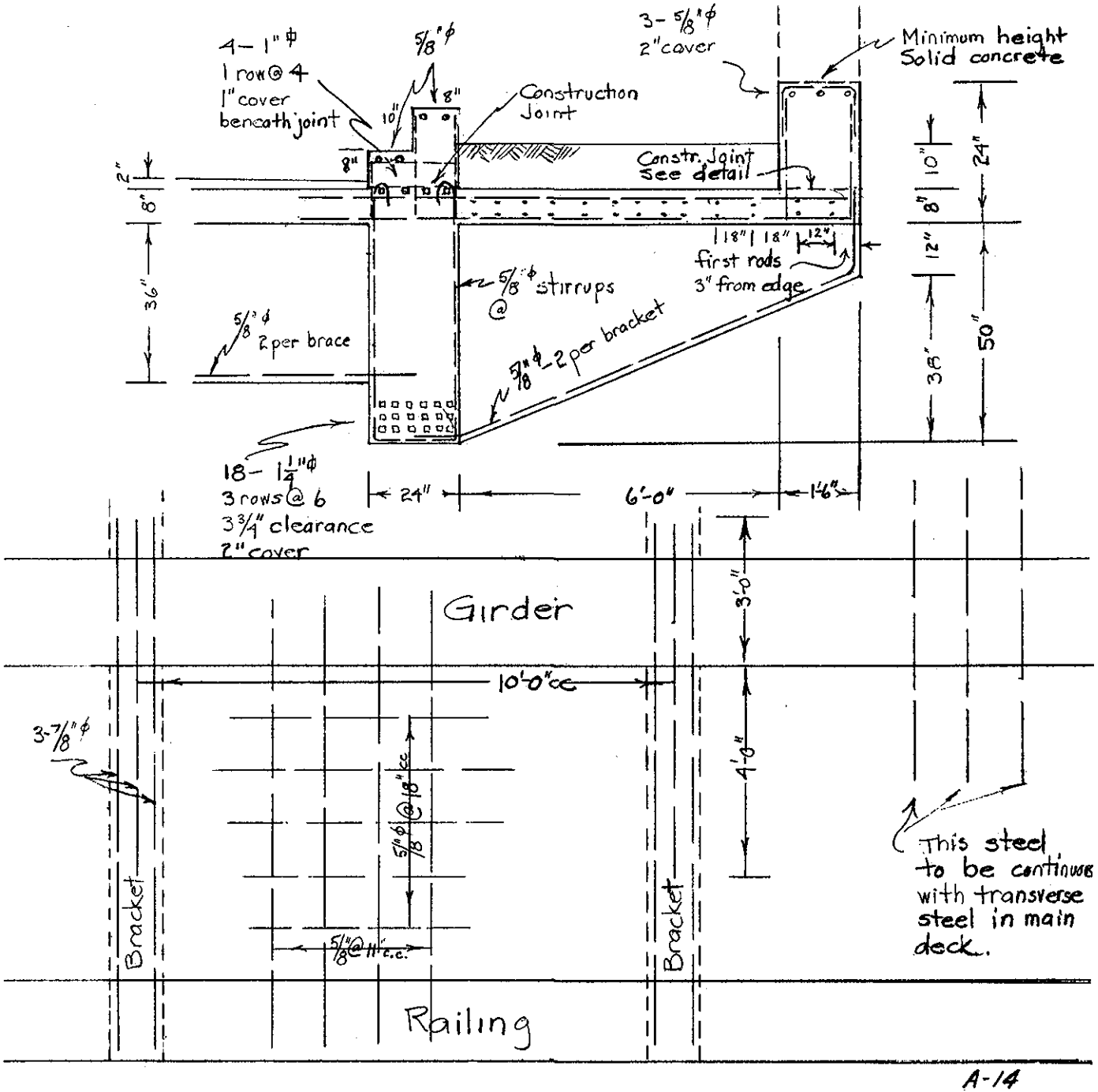
Page 14

Subject: South St Bridge - Northampton Mass.

Computation: Steel Reinforcement - Upstream sidewalk and girder

Computed by: CWB/M Checked by: Date: 4-26-39

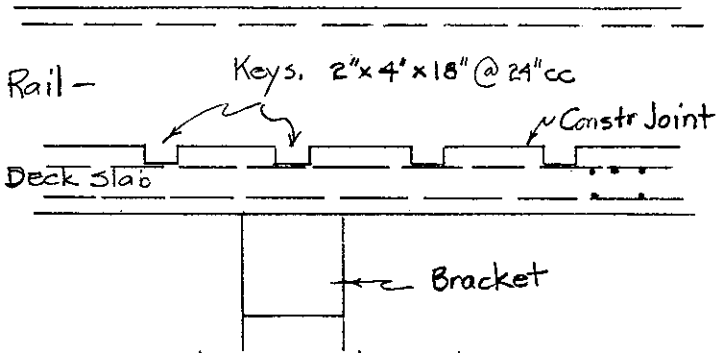
U. S. GOVERNMENT PRINTING OFFICE 3—10588



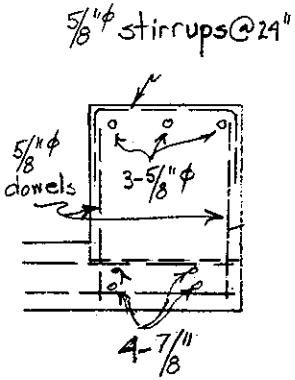
A-14

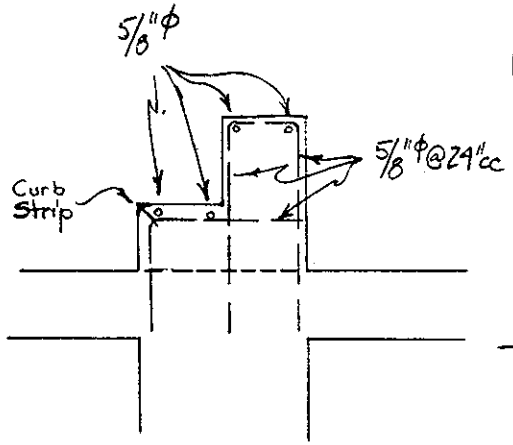
WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject South St Bridge Northampton Mass
Computation Upstream Facial Girder - Steel Reinforcement
Computed by CurtBW Checked by Date 4-26-39
Page 15

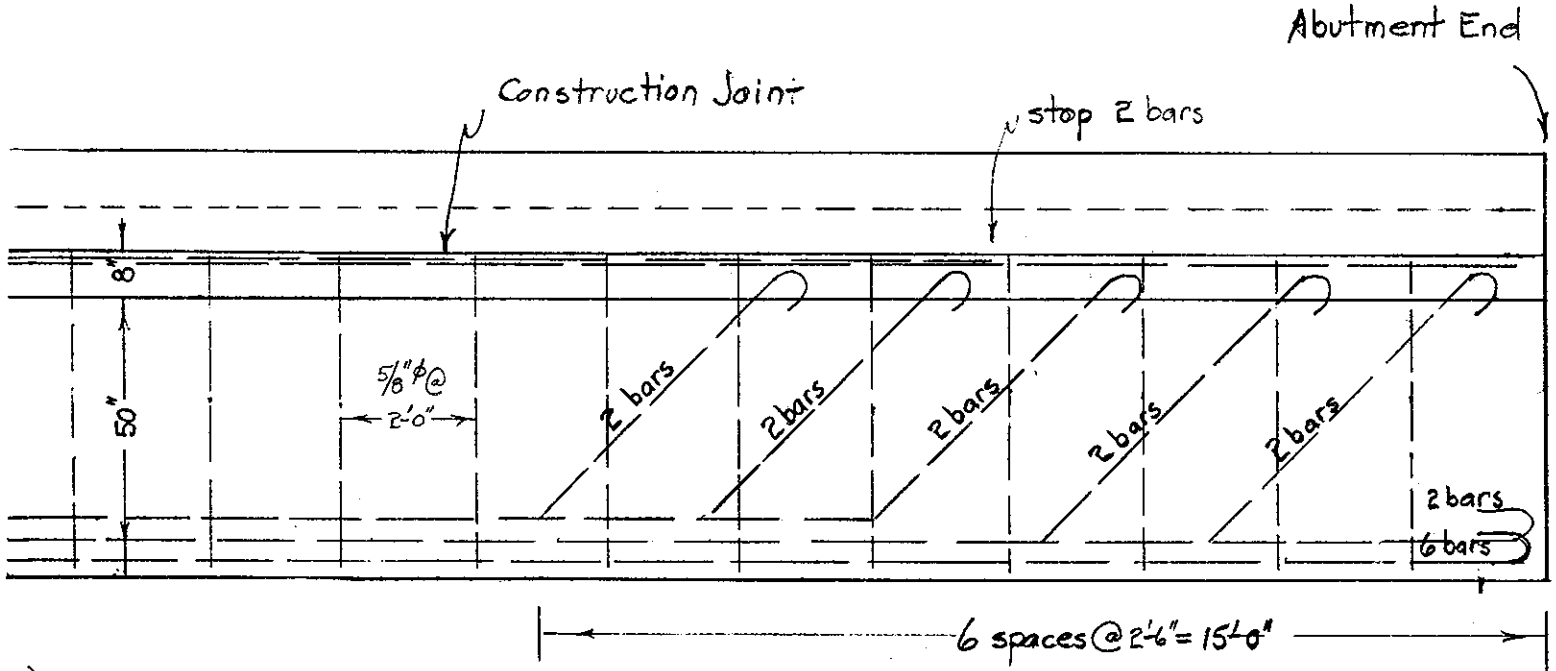


Detail of Railing Beam





Curb Detail



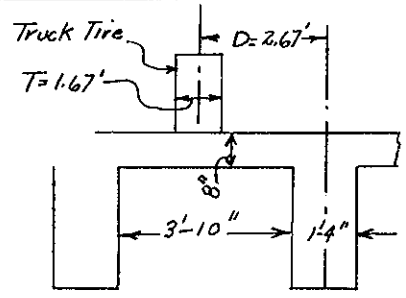
Exterior Girder

U. S. GOVERNMENT PRINTING OFFICE 9—10628

Subject Northampton Mass. - South Street Bridge
Computation Floor Slab – roadway
Computed by R.S.M **Checked by** **Date** 4/26/39

U.S. GOVERNMENT PRINTING OFFICE 3—10528

Floor Slab – roadway



Fully restrained between outside beams

Assume 8" slab thickness + 2 to 3 protective concrete covering

Total dead load $= \frac{10.5}{12} \times 150 = 131\ \#/\square'$

$M_D = 0.8(\frac{1}{8} \times 131 \times 3.83^2 \times 12) = 2310\ ''\#$

$D = 5.33/2 = 2.67'$; $T = 1.67'$

$E = 0.7(2D+T) = 0.7(2 \times 2.67 + 1.67) = 4.9'$

Then the concentrated live load at center of 1' strip $= \frac{16000}{4.9} = 3270\ \#$

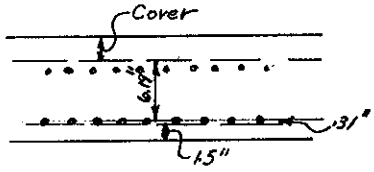
$M_L = 0.8\left(\frac{3270}{2} \times \frac{3.83}{2} \times 12\right) = 30100\ ''\#$

$I = \frac{50}{2+125} = .4$ (approx.)

$M_I = 30{,}100 \times .4 = 12040\ ''\#$

$44450\ ''\#$

$d = \sqrt{\frac{44450}{12 \times 123}} = 5.5''$



Total thickness $= 5.5 + .31 + 1.5 = 7.31''$; 8.0" supplied

$A_s = \frac{44450}{18000 \times .884 \times 6.19} = .46\ \square''$ Use $\frac{5}{8}''\phi$ bars @ 5.5" c.c. $= .67\ \square''$

V

$x = 2.5 \times 6.5 = 16.25$ for 8" slab

$W = \frac{4}{3} \times 16.25 = 21.7'' = 1.8'$, distribution

$V_L = \frac{16000}{1.8} \times \frac{1}{2} = 4440\ \#$

$V_I = .4 \times 4440 = 1780\ \#$

$V_D = 131 \times 3.83/2 = 250\ \#$

V total $6470\ \#$

$v = \frac{6470}{12 \times .884 \times 6.19} = 98\ \#/\square''$ Bend up alternate bars for diag. tension,

Subject: Northampton Mass — South Street Bridge
Computation: Floor Slab - roadway
Computed by: R.S.M Checked by: Date: 4/26/39

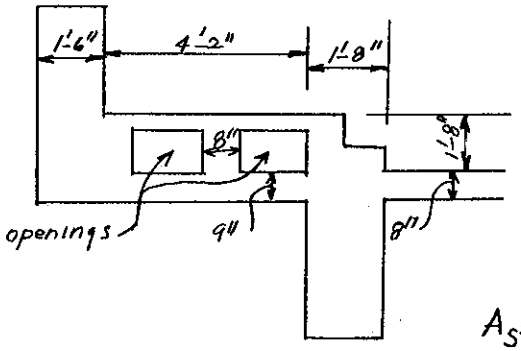
U. S. GOVERNMENT PRINTING OFFICE 3—10523

For negative reinf add 1 bar @ 5½", top of slab.

$$u = \frac{6470}{4.29 \times .884 \times 6.19} = 267\ \#/\square''$$

Floor Slab - downstream sidewalk

Loading = 100 #/□' live load, +50 # sidewalk slab



$$M_D = \frac{150 \times 4.17 \times 4.17 \times 12}{2 \times 8} = 1960''\#$$

$$M_D = \frac{9 \times 150 \times 4.17^2 \times 12}{12 \times 10} = 2340''\#$$

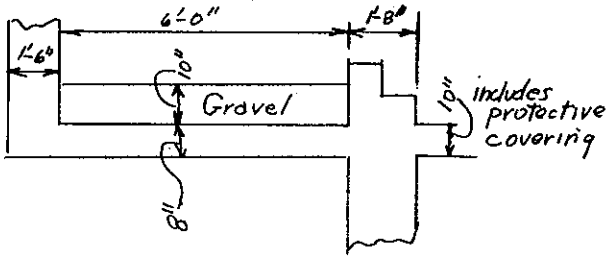
$$4300''\#$$

$$d = \sqrt{\frac{4300}{12 \times 123}} = 1.75'', \text{ negligible}$$

$$A_s = 4300 \div 18000 \times .884 \times 7.19 = .037\ \square''$$

temp. steel governs

Floor Slab - upstream sidewalk



Live loading 150 #/□' including impact
Assume 8" slab
Loading
Dead load = 8/12 × 150 = 100 #/□'
" " = 10/12 × 125 = 104 #/□'
Live load = 150 #/□' = 150 #/□'
354 #/□'

$$M = 354 \times 6^2 \times 12/10 = 13150''\#$$

$$d = \sqrt{\frac{15280}{12 \times 123}} = 3.4'' \text{ req'd}$$

Total thickness = 3.4 + 1.5 + .31 = 5.21 needed, 8" provided

$$A_s = \frac{13150}{18000 \times .884 \times 6.19} = .13\ \square'', \text{ Temp. steel governs}$$

$$V = \frac{354 \times 3}{12 \times .884 \times 6.19} = 16\ \#/\square'' \text{ OK}$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

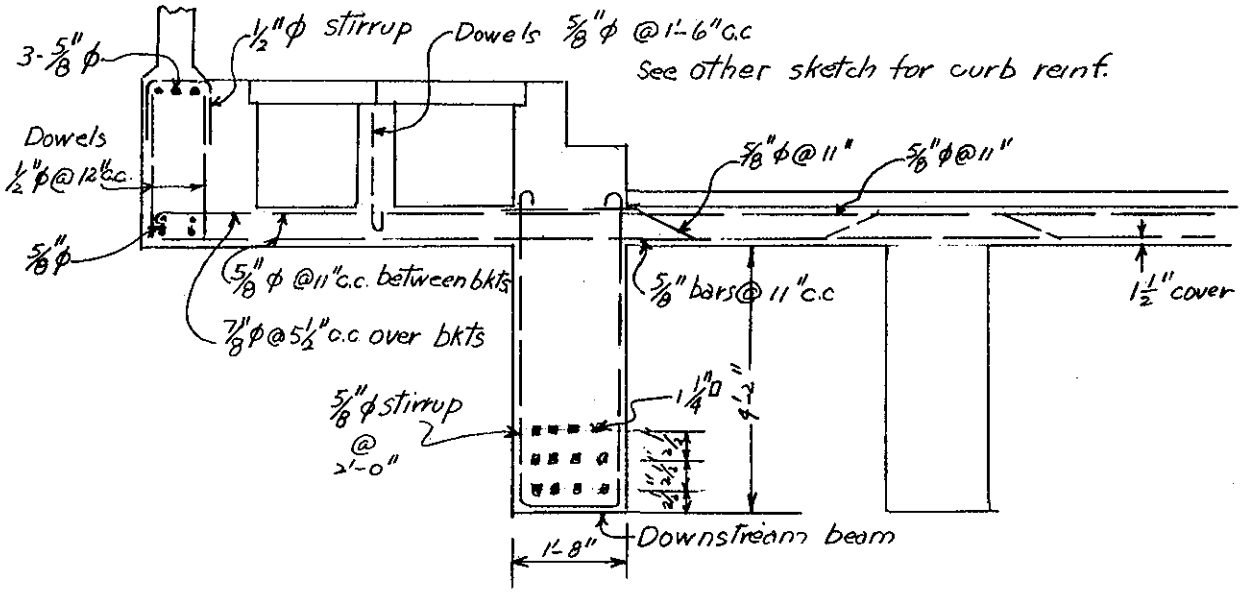
Page 18

Subject Northampton Mass. - South Street Bridge

Computation Slab Steel Arrangement - Stress Steel

Computed by R.S.M. Checked by Date 4/26/39

U. S. GOVERNMENT PRINTING OFFICE 3—10538



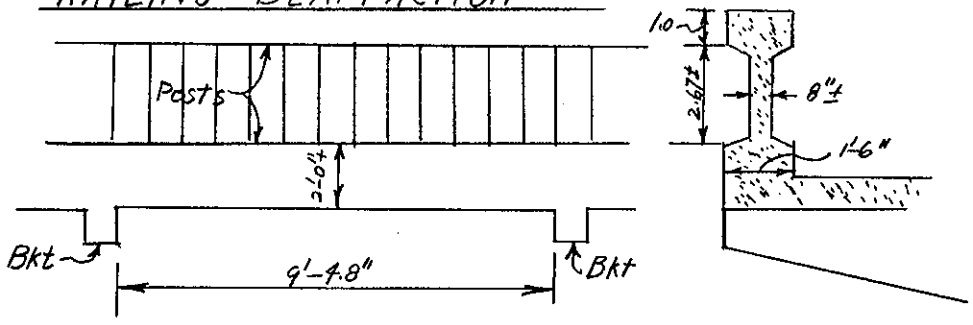
Slab & bkts.

Temp steel - 5/8" φ @ 1'-6" both faces

Subject: Northampton, Mass — South St. Bridge
Computation: Railing - Beam Action
Computed by: R.S.M. Checked by: Date: 4/26/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

RAILING - BEAM ACTION



Loading - from sidewalk = 912 #/lin. ft.

- railing

$1.5 \times 2 = 3.0$
$2.67 \times .67 = 1.8$
$1.5 \times 1.0 = 1.5$
$6.3 \times 150 = 945$ #/lin ft

1857 #/lin. ft.

$M = 1857 \times 9.4 \times 9.4 \times 12/8 = 246000$ "#

$d = \sqrt{\frac{246000}{18 \times 123}} = 10.5''$, 22.6" supplied

$A_s = 246000 / 18000 \times .884 \times 22.6 = .69 \square''$, use 3-5/8" ϕ bars

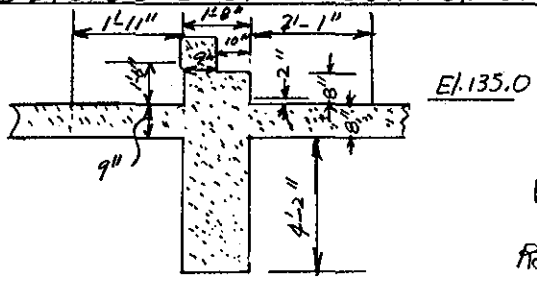
$V = 1857 \times 9.4/2 = 8700$ #

$r = 8700 / 18 \times .884 \times 22.6 = 24$ #/□" O.K.

Subject Northampton, Mass – South Street Bridge
Computation Outside Beam – downstream
Computed by R.S.M **Checked by** ..... **Date** 4/26/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Outside Beam – downstream



L = 50'-0" between supports

Loading – from brackets

Walk – $\begin{cases} 150 \times 2.1 \times 10.4 = & 3280\# \\ 112 \times 2.1 \times 10.4 = & 2350 \end{cases}$

Railing – $945 \times 10.4 =$ 9850

Bkt. – $\frac{1+3}{2} \times 1 \times 150 =$ 300

Bkt. – Concentrated loads = 15780 #

$R = 4 \times 15780 \times \frac{1}{2} = 31560\#$

Beam wt. $5.5 \times 1.67 \times 150 = 1375\#$

$[(10 \times 12) - (18 \times 1)] \times 150/144 = 105$

$131 \times 1.91 = 250$

$(150 + 112) \times 2.1 = 550$

2280#

M_D: $2280 \times \overline{50}^2 \times 12/8 = 8570{,}000$ "#

$(31560 \times 25 \times 12) - [15780 \times (5.2 + 15.6) \times 12) = 5518{,}000$ "#

14,088,000 "#

M_L: $\frac{3.00}{5.33} = 5.63$

$\frac{5.63}{1.145} \times 3912000 = 1920{,}000$ "#

Total = 16,008,000 "#

V: V_D: 2280×25 = 57000

V_D: (Bkt) = 31560

V_{L+I}: 11400×1.286 = 14600

V – Total = 103,160 #

$b'd = \frac{103160}{.884 \times 150} = 780$ □" , $b' = 20"$; d = 39.0" req'd, 53.0" supplied

$A_s = \frac{16{,}008000}{18000 \times .884 \times 53} = 19.1$ □" ; Use $12 - 1\frac{1}{4}$" □ : $A_s = 18.75$, 2 rows

$\Sigma_o = \frac{103{,}160}{150 \times .884 \times 53} = 15.7$ □" , supplied by $4 - 1\frac{1}{4}$" □ bars with the remaining 8 bent up as required

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 21

Subject Northampton, Mass – South St. Bridge

Computation Outside Beam – downstream

Computed by R.S.M. **Checked by** **Date** 4/26/39

U.S. GOVERNMENT PRINTING OFFICE 3—10528

Outside Beam – downstream

f_c actual

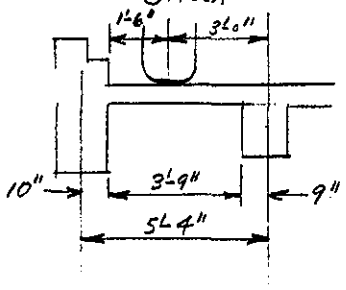
$p = \frac{18.75}{68 \times 53} = .005$ $\qquad \frac{t}{d} = \frac{8}{53} = .15$

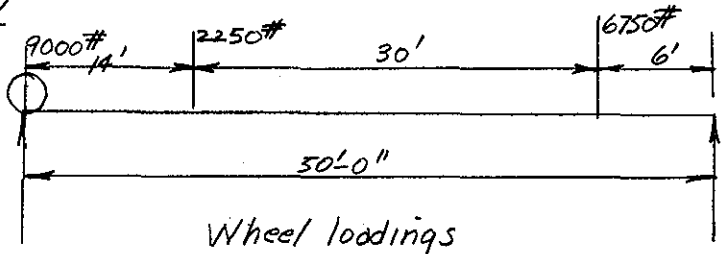
$k = .35$; $j = .93$

$$f_c = \frac{16{,}008{,}000}{\left(1 - \frac{8}{2 \times .35 \times 54.25}\right) 68 \times 8 \times .93 \times 53} = 763 \ \#/\square'' \ \text{OK}$$

Web reinforcement

Shear





Wheel loadings

$\frac{3.0}{5.33} \times 16000$	=	9000
$\times 4000$	=	2250
$\times 12000$	=	6750

V_L – End Shear

$\frac{50}{50} \times 9000$	=	9000
$\frac{36}{50} \times 2250$	=	1620
$\frac{6}{50} \times 6750$	=	810
		11430

V_L – 10'

$\frac{40}{50} \times 9000$	= 7200
$\frac{26}{50} \times 2250$	= 1170
	8370

V_L – 20'

$\frac{30}{50} \times 9000$	= 6000
$\frac{16}{50} \times 2250$	= 720
	6720

V_L – Mid point

$\frac{25}{50} \times 9000$	=	4500
$\frac{11}{50} \times 2250$	=	490
		4990

V_5

$\frac{45}{50} \times 9000$	= 8100
$\frac{31}{50} \times 2250$	= 1400
$\frac{1}{50} \times 6750$	= 140
	9640

$V_{end} = 103160\#$ $\qquad v = 103160 / 20 \times .884 \times 54.25 = 108 \ \#/\square''$

$V_{10'}$

$V_d = 2280 \times 15$	= 34200
V_d(bkt.) = 31560	= 31560
$V_L = 8370 \times 1.33$	= 11,100
V total	76860#

$V_{20'}$

$V_d = 2280 \times 5$	= 11400
V(bkt.)	= 15780
$V_L = 6720 \times 1.33$	= 8940
	36120#

Subject: Northampton Mass— South Street Bridge
Computation: Outside Beam - downstream
Computed by: R.S.M. Checked by: Date: 4/26/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

$v_{10} = 76860/20 \times .884 \times 54.25 = 79.7$ $v = 36120/960 = 37.6$

$v_{11.4} = [76510 - (15780 + 3200)]/960 = 60.0$

V mid point

$V_d =$ 0

V_b (bkt) 0

$V_L = 4990 \times 1.33 = 6650$

V Total = 6650

$v = 6650/960 = 7$

V_5

$V_d = 2280 \times 20 = 45600$

V_d (bkt.) $= 31560$

$V_L = 9640 \times 1.286 = 12400$

$= 89560$

$v = 89560/960 = 93.2$

Moment Calculations

R_5 : R_D bkts. 31560
Uniform 57000
88560
R_L (see page 5) 9640
R_t 2240
100,950

M_5 : $100950 \times 5 \times 12 = 6{,}060{,}000$
$- 2280 \times \frac{5^2}{2} \times 12 = -342000$
5,718,000 "#

R_{10}
88560
8370
2760
99690

M_{10} : $99690 \times 10 \times 12 = 11{,}950{,}000$
$- 2280 \times \frac{10^2}{2} \times 12 = -1{,}368000$
10,582,000 "#

R_{20}
88560
6720
2240
97520

M_{20} : $97520 \times 20 \times 12 = 23{,}400{,}000$
$- 2280 \times \frac{20^2}{2} \times 12 = -5{,}480{,}000$
$- 10 \times 15780 \times 12 = -1{,}890{,}000$
16,030,000 "#

R_{15}
88560
7250
2420
98230

M_{15} : $98230 \times 15 \times 12 = 17{,}620{,}000$
$- 2280 \times \frac{15^2}{2} \times 12 = -3{,}080{,}000$
$- 5 \times 15780 \times 12 = -790{,}000$
13,750,000 "#

Subject Northampton, Mass – South Street Bridge
Computation Outside Beam
Computed by R.S.M. Checked by Date 4/26/39

U.S. GOVERNMENT PRINTING OFFICE 3—10528

Web Reinf.

Bent up bars: Spacing $= \frac{45}{10+45} \times 53 = 43''$, use 3'-6" as limited by moment requirements

Stirrups: bent up reinf. is used to provide for diagonal tension, 5/8" ϕ stirrups will be provided spaced .45 eff. depth or $53 \times .45 = 2'-0''$ in addition

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 24

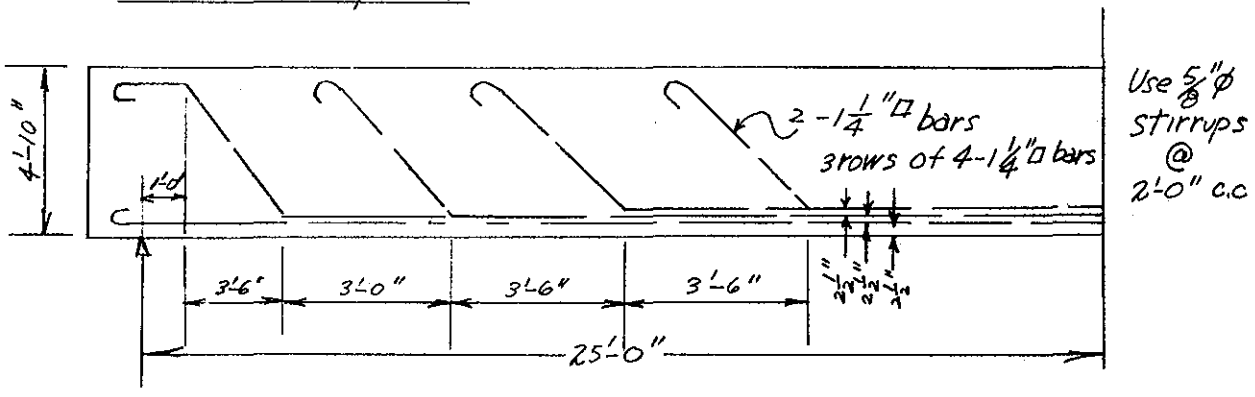
Subject: Northampton, Mass – South Street Bridge

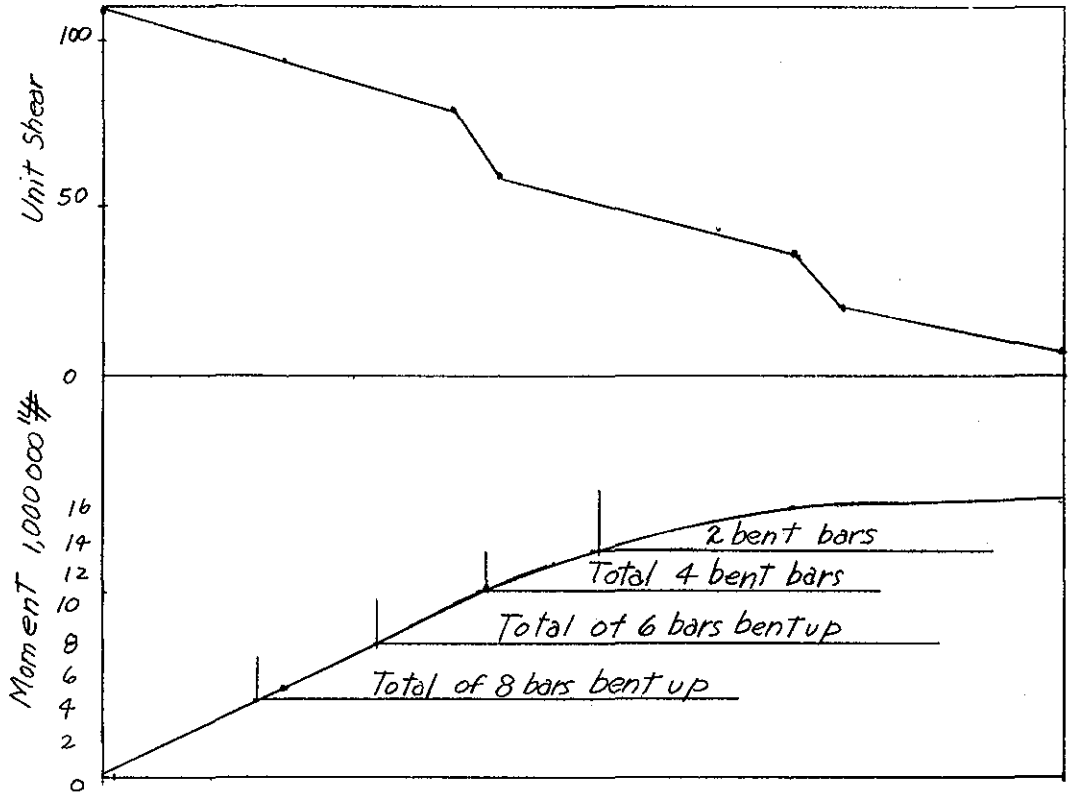
Computation: Outside Beam – downstream

Computed by: R.S.M Checked by: Date: 4/26/39

U. S. GOVERNMENT PRINTING OFFICE 3—10529

Shear Diagram





WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 25

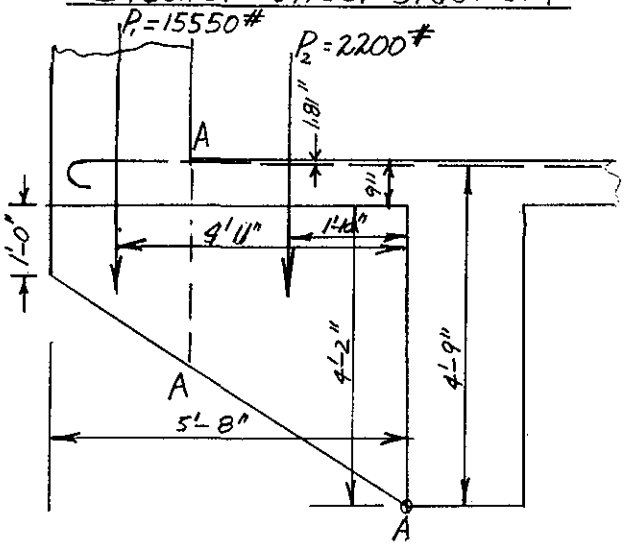
Subject Northampton, Mass – South Street Bridge

Computation Bracket under sidewalk

Computed by RSM **Checked by** **Date** 4/26/39

U. S. GOVERNMENT PRINTING OFFICE 8—10528

Bracket under Sidewalk



$P_1 = 263 \times 2.08 \times 10.4 = 5700$

$945 \times 10.4 = 9850$

$15550\ \#$

$P_2 = 1.0 \times 1.0 \times 5.67 \times 150 = 850$

$\frac{3.17 \times 1.0 \times 5.67 \times 150}{2} = 1350$

$2200\#$

Moment about "A"

$2200 \times 22 = 48400$

$15550 \times 59 = 915{,}000$

Total $963400\ ''\#$

$$A_s = \frac{963{,}400}{18000 \times .884 \times 57} = 1.06\ \square''$$

Use $2 - \frac{7}{8}''\phi$ bars

$$v = \frac{17750}{12 \times .884 \times 57} = 29.5\ \#/\square''$$

$$V_{A\text{-}A} = 450 + 15550 = 16000\#$$

$$v = \frac{16000}{12 \times .884 \times 34} = 44.5\ \#/\square''$$

v (adjusted for min section) $= 44.5 \times \frac{6.5}{5.7} = 51\ \#/\square''$

WAR DEPARTMENT

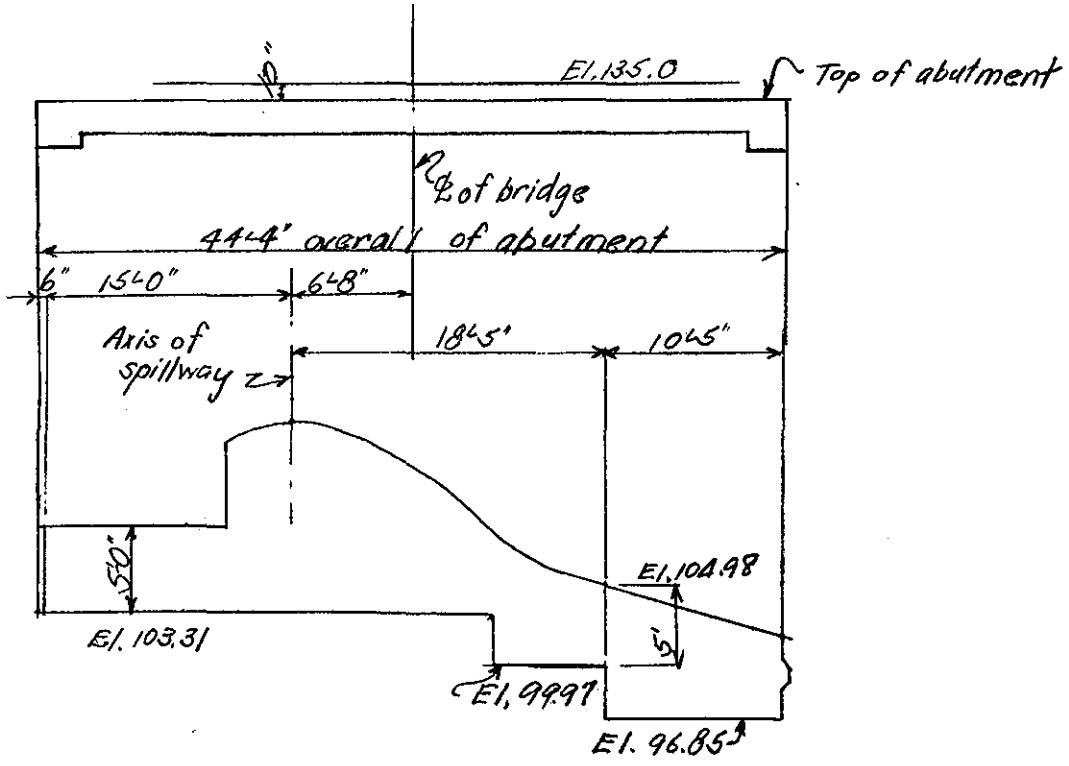
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject NORTHAMPTON -

Computation SOUTH STREET BRIDGE - ABUTMENT DESIGN

Computed by RSM **Checked by** **Date** 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 27

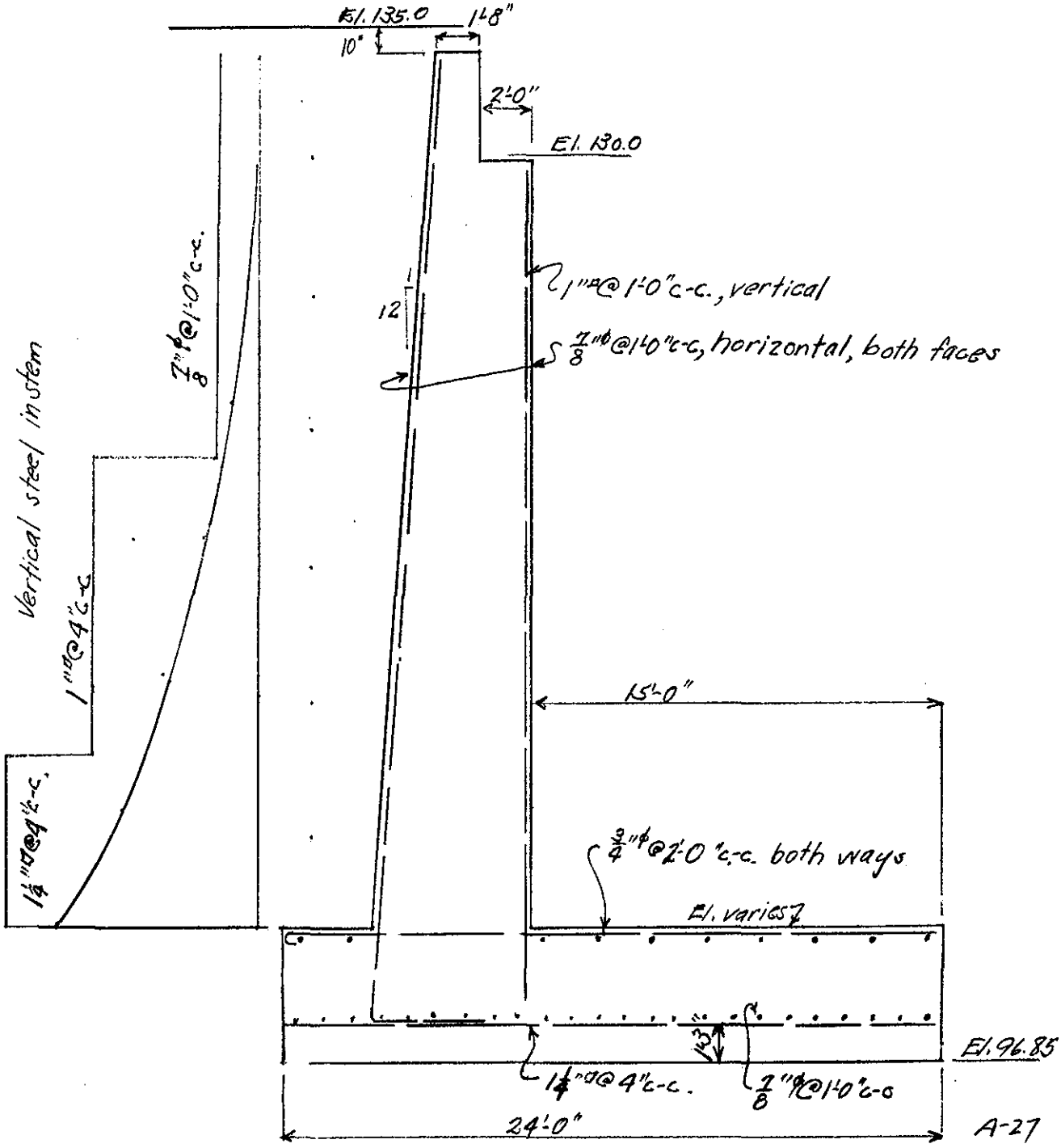
Subject: NORTHAMPTON

Computation: SO. ST. BR. - ABUT

Computed by: RSM Checked by: Date: 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

BASE EL. 96.85 - Steel diagram



A-27

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 28

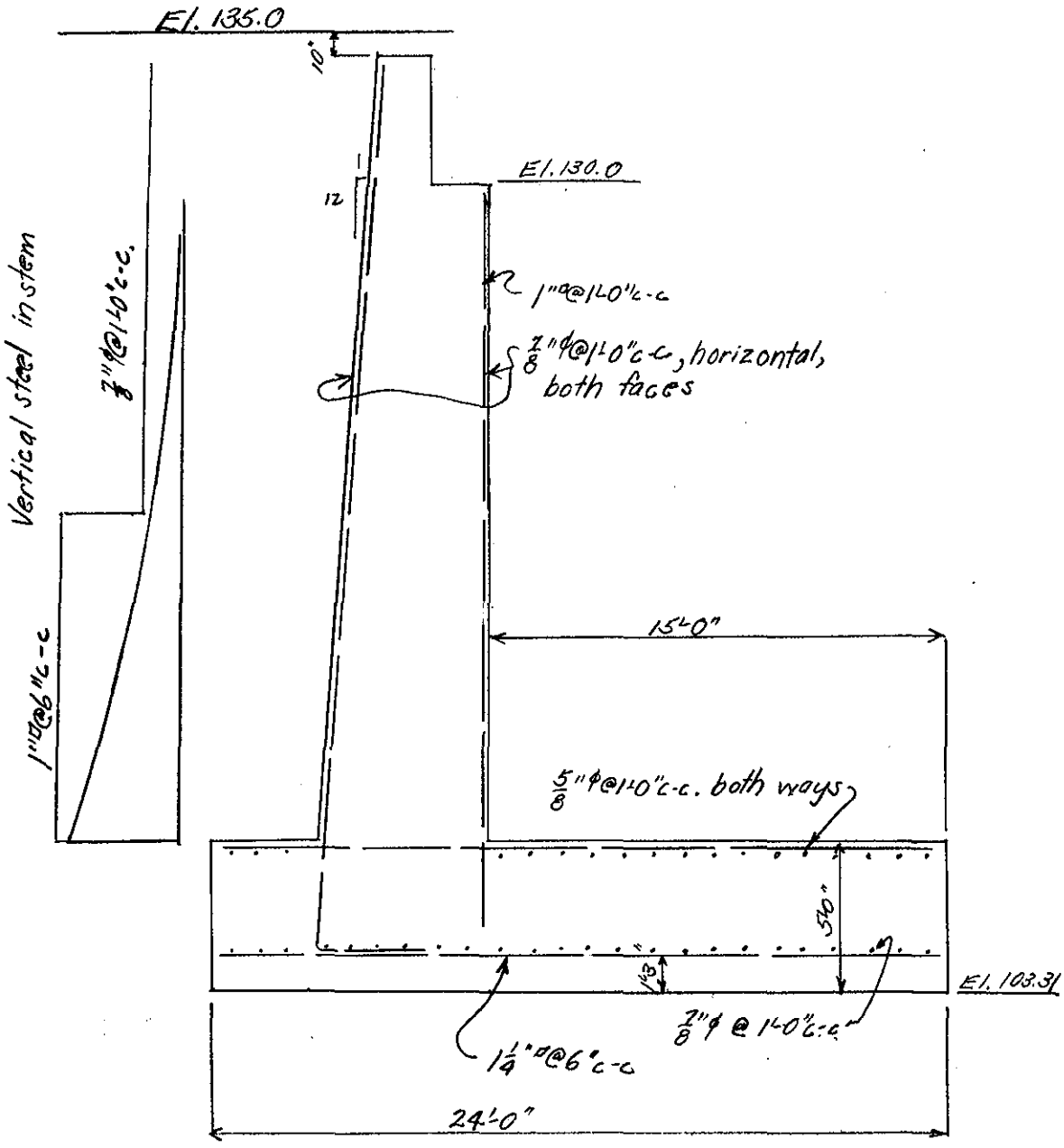
Subject: NORTHAMPTON

Computation: SO. ST. BR. - ABUT.

Computed by: RSM Checked by: ____ Date: 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 3—10593

BASE El. 103.31 - Steel diagram



A-28

WAR DEPARTMENT

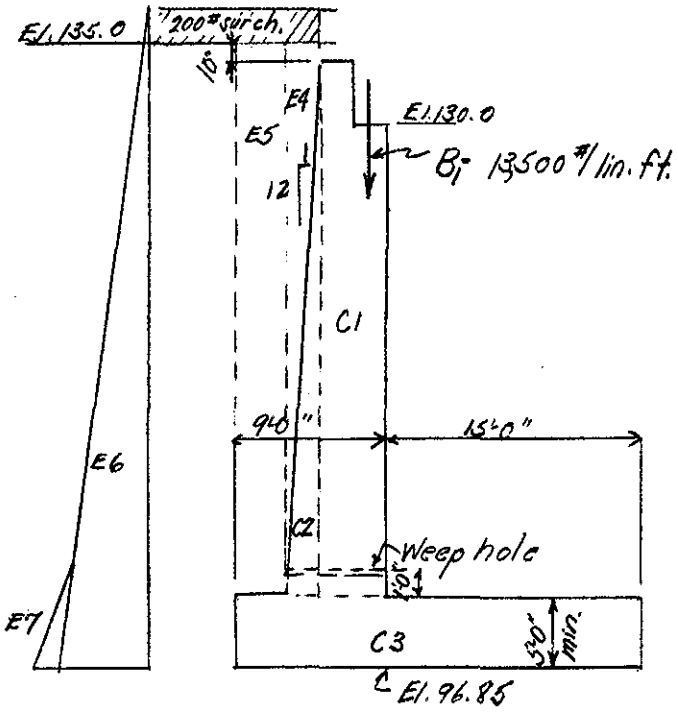
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: NORTHAMPTON

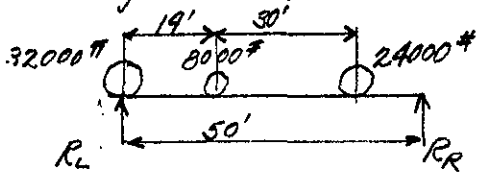
Computation: SO. ST. BR. - ABUT.

Computed by: RSM Checked by: ____ Date: 4/27/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Bridge load - B_1



Live load

$$R_L = \frac{32000 \times 50 + 8000 \times 36 + 24000 \times 6}{50} = 40{,}600\#$$

		per lane
Truck loading	- 4 × 40600 =	162400#
Sidewalk "	- 100 × 4.17 × 52/2 =	10800
" "	- 150 × 6 × 52/2 =	23400
Total.		196,600#

Neglect impact factor

Dead load - 56.5 × .83 × 52 × 150/2 =	183000
3.0 × 1.5 × 52 × 7/2 =	123000
4.17 × 1.75(ave) × 52 × 2 × 150/2 =	57000
945 × 52/2 =	25000
(Neglect diaphragms)	
Total	388,000#

Load per ft. of abutment, $B_1 = \frac{196{,}600 + 388{,}000}{44.4} = 13{,}500$#/lin. ft.

Subject: NORTHAMPTON
Computation: SO. ST. BR. - ABUT.
Computed by: RSM Checked by: _____ Date: 4/27/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

ANALYSIS - ABUT. BASE El. 96.85

CASE I, Bridge constructed, uplift to elevation of weep holes, no flow over weir.

Stability

		Force ↓↑	Force ⇆	Arm	Moment ↻	Moment ↺
C1	150 × 3.4 × 32 ↓	16,300		16.9		276 000
C2	150 × 2.75 × 32/2 ↓	6,600		19.6		129 000
C3	150 × 5 × 24 ↓	18000		12.0		216,000
E4	100 × 33 × 2.75/2 ↓	4,550		20.7		94 000
E5	100 × 33 × 2.6 ↓	8,600		22.7		195,000
B1	↓	13,500		16.0		216,000
U1	62.5 × 6 × 24 ↑	9000		12.0	108,000	
E6	40 × 47²/2 →		33600	13.67	458,000	
E7	40 × 6²/2 →		700	2.0	1,000	
		57,550			567,000	1,126,000
						567 000
						559,000

$\frac{\Sigma M}{\Sigma V}$: 559,000/57,550 = 9.7 ; e = 12.0 - 9.7 = 2.3

$f = \frac{57,550}{24}\left(1 \pm \frac{6 \times 2.3}{24}\right) = \begin{matrix} 3750 \ \#/\square' \\ 1000 \ \#/\square' \end{matrix}$

Stem steel

h	5'	10'	15'	20'	25'	29'	34'
$P = 40\left(\frac{ht^2}{2}\right)^2$	980#	2880#	5780	9680	14,580	19,220	25,920
$M = P \times \frac{ht^2}{3}$	2280'#	11,500	32,800	70,700	131,000	198,600	311,000
d	18.5"	41.5"	46.5	51.5	56.5	60.5	64.5
$A_s = \frac{M}{f_s jd}$	.09□"	.21	.53	1.04	1.75	2.47	3.63
$v = \frac{V}{bjd}$	12 #/□"	—	—	—	—	—	38
Steel furnished	.63□"						4.69□"

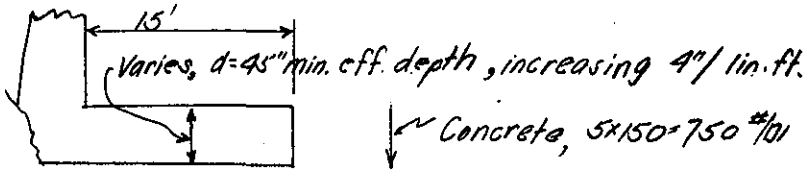
A-30

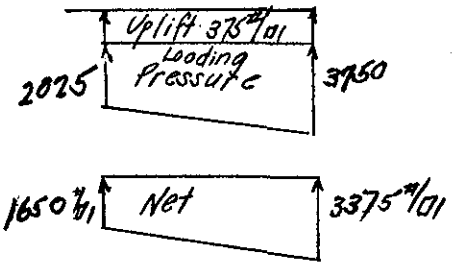
Subject: NORTHAMPTON
Computation: SO. ST. B.R. - ABUT
Computed by: RSM Checked by: Date: 4/27/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

BASE El. 96.85 - CASE I (Con.)

Base steel - riverside





$V = 1650 \times 15 = 24800$ #
$1725 \times 15/2 = 12900$
37700 #

$v = 37700 / 12 \times .884 \times 45 = 79$ #/□"

$M = 24800 \times 7.5 = 186000$ '#
$12900 \times 10 = 129000$
315000 '#

$A_s = \frac{315000 \times 12}{18000 \times .884 \times 45} = 5.3$ □"

Use $1\frac{1}{4}$"□ @ 4" c-c; $A_s = 4.69$ □"

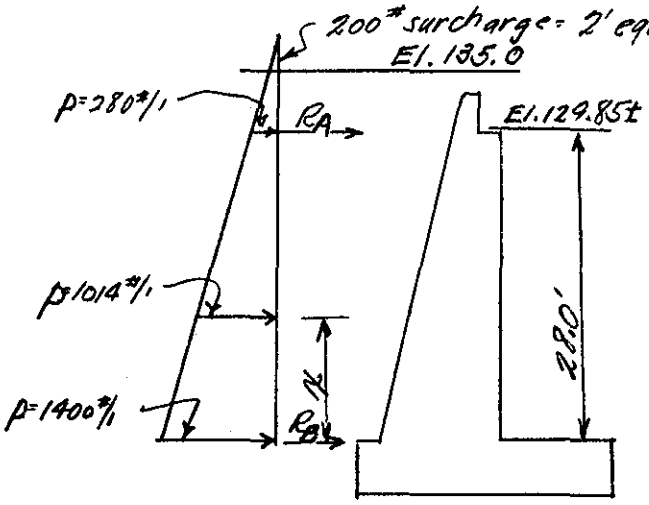
Base steel - landside - CASE III governs

Subject NORTHAMPTON
Computation SO. ST. BR. - ABUT
Computed by RSM **Checked by** **Date** 4/27/39

U. S. GOVERNMENT PRINTING OFFICE 3—10538

BASE EL. 96.85

CASE IV - Assume bridge seat rusted in place, restricting movement of stem at that point



$P_A = 7 \times 40 = 280$ #/'

$P_B = 35.15 \times 40 = 1400$ #/'

$R_B = 280 \times 28/2 = 3920$ #

$\frac{1120 \times 28}{2} \times 2/3 = 10400$

Total 14320 #

M - assume "x" = 9.7'

$P_x = 280 + \frac{1120 \times 18.3}{28} = 1014$ #

Check - $\frac{1014 + 1400}{2} \times 9.7 = 11{,}700$ #

$\frac{280 + 1014}{2} \times 18.3 = 11{,}800$ #

$14320 \times 9.7 = 139000$ '#

$-1014 \times 9.7^2/2 = 47{,}500$

$-386 \times 9.7/2 \times \frac{2 \times 9.7}{3} = 9{,}100$

$-56{,}600$

Total 82,400 '#

d = 55" net

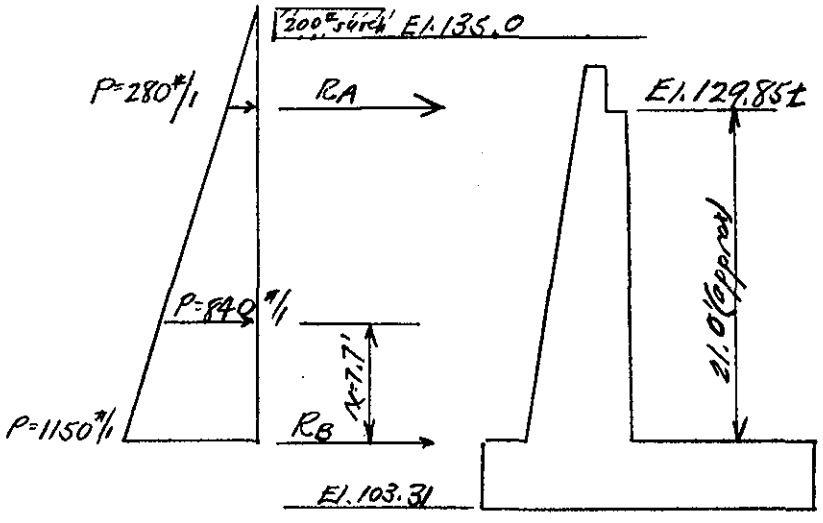
$A_s = 82{,}400 \times 12 / 18000 \times .884 \times 55 = 1.13$ □"

Use 1"□ @ 1'-0" c-c.

Subject: NORTHAMPTON
Computation: SO. ST. BR. ABUT
Computed by: RSM Checked by: Date: 4/27/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

BASE El. 103.31
CASE IV.



$P_A = 7 \times 40 = 280\#/1$

$P_B = 40 \times 28.7 = 1150\#/1$

$R_A = 280 \times 21/2 = 2940$

$\frac{870 \times 21}{2} \times \frac{2}{3} = 6100$

$9040\#$

M- assume $x = 7.7'$

$P_x = 1150 \times 40 \times 7.7 = 840\#$

Check- $\frac{840+1150}{2} \times 7.7 = 7700\#$; $\frac{840+280}{2} \times 13.8 = 7600\#$

$9040 \times 7.7 =$		79,600 ′#
$-840 \times 7.7^2/2 =$	-22,000	
$-310 \times \frac{7.7}{2} \times \frac{2 \times 7.7}{3} =$	-6,000	
Total		-28,000
		51,600 ′#

$A_s = \frac{51{,}600 \times 12}{18{,}000 \times .884 \times 51} = .76\square''$

Use 1"□ @ 14"c-c.

Subject: NORTHAMPTON
Computation: SO. ST. BR - ABUT
Computed by: RSM Checked by: Date: 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

ABUT. BASE El. 96.85

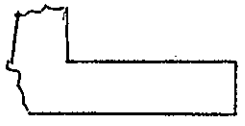
CASE II - Bridge not in place

Stability

$\frac{\Sigma M}{\Sigma V}$ $\frac{559,000-216,000}{57,550-13,500} = 7.8$.

$f = \frac{44050}{24}\left(1 \pm \frac{6 \times 4}{24}\right) = 3670$ #/□' to 0

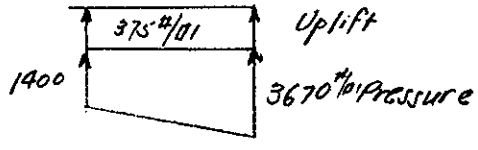
Base - riverside



5×150 #/□' Conc.

$V = 1025 \times 15 = 15,400$ #
$2270 \times 15/2 = 17,700$ #
$33,100$ #

$v = 33,100 / 12 \times .884 \times 45 = 69$ #/□"

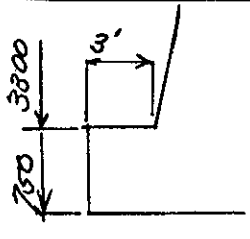


$M = 15400 \times 7.5 = 115,000$ '#
$17,700 \times 10 = 177,000$
$292,000$ '#

$A_s = \frac{292000 \times 12}{18,000 \times .884 \times 45} = 4.88$ □"

Case I governs.

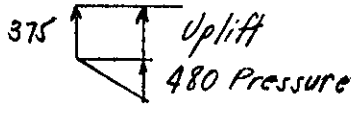
Base - landside



$V = 3675 \times 3 = 11,320$ #
$-480 \times 3/2 = 720$
$10,600$ #

$v = 10,600 / 12 \times .884 \times 45 = 22$ #/□"

$M = 11,320 \times 1.5 = 17,000$ '#
$-720 \times 1 \quad 720$
$16,280$ '#



$A_s = \frac{16,280 \times 12}{18,000 \times .884 \times 45} = .27$ □", use

$\frac{5}{8}$"ϕ @ 1'-0" or $\frac{7}{8}$"ϕ @ 1'-6"

Subject: NORTHAMPTON
Computation: SO. ST. BRIDGE - ABUT.
Computed by: RSM Checked by: ____ Date: 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 8—10528

BASE El. 103.31

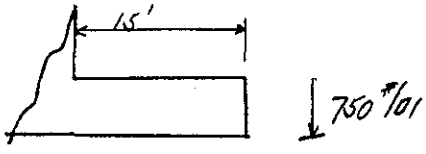
CASE I - Bridge in place, water down

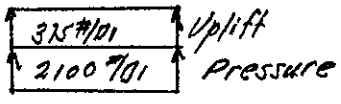
			Force ↓↑	Force ⇄	Arm	Moment ↻	Moment ↺
C1	150 × 3.4 (ave) × 25	↓	12,750		16.9		216,000
C2	150 × 2.17 × 25	↓	4,100		19.4		79,000
C3	150 × 5 × 24	↓	18,000		12.0		216,000
E4	100 × 27 × 2.17/2	↓	2,930		20.1		59,000
E5	100 × 3 × 27	↓	8,100		22.5		182,000
B1		↓	13,500		16.0		216,000
U1	62.5 × 24 × 6	↑	9,000		12.0	108,000	
E6	40 × 34²/2	→		23,100	11.3	262,000	
E7	40 × 7²/2	→		700	2.0	1,000	
			50,380			371,000	968,000
							371,000
							597,000

$\frac{\Sigma M}{\Sigma V}$ = 597,000/50,380 = 11.9', middle third at 8.0'

f = 50,380/24 = 2100 #/□'

Base - riverside





V = 1725 × 15 = 26,000 #

v = 26000/12 × .884 × 45 = 54 #/□"

M = 26000 × 7.5 = 195,000 '#

A_s = 195,000 × 12 / 18,000 × .884 × 45 = 3.28 □"/'

Use 1¼"□ @ 6" c-c ; A_s = 3.13 □"/'

Subject NORTHAMPTON
Computation SO. ST. BR.- ABUT
Computed by RSM **Checked by** **Date** 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 2—10538

BASE EL. 103.31

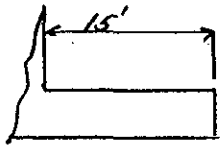
CASE II - Bridge not in place, water down

Stability

$\frac{\Sigma M}{\Sigma V} = \frac{597{,}000 - 216{,}000}{50{,}380 - 13{,}500} = 10.3'$; $e = 12 - 10.3 = 1.7$

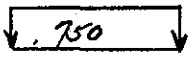
$f = \frac{36{,}880}{24}\left(1 \pm \frac{6 \times 1.7}{24}\right) = 2200\#/\square' \text{ to } 900\#/\square'$

Base steel - riverside



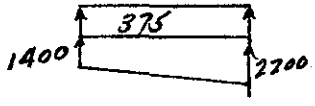
$V = 1025 \times 15 = 15{,}400\#$
$800 \times 15/2 = 6{,}000$
$21{,}400\#$

CASE I Governs



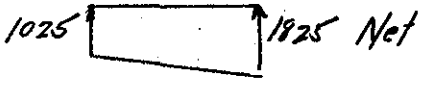
Concrete

$M = 15{,}400 \times 7.5 = 115{,}000$ '#
$6{,}000 \times 10.0 = 60{,}000$
$175{,}000$ '#



Uplift Bearing

CASE I Governs.



Net

Subject: NORTHAMPTON
Computation: SO. ST. BRIDGE - ABUTMENTS
Computed by: RSM Checked by: Date: 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 8—10528

BASE EL. 99.97

CASE I - Bridge in place

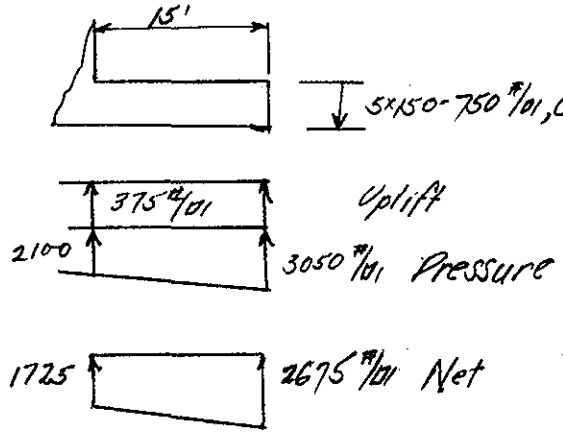
Stability

			Force ↑	Force ←	Arm	Moment ↷	Moment ↶
C1	150×3.4×29	↓	14,800		16.8		250,000
C2	150×2.4×29/2	↓	5,200		19.7		103,000
C3	150×5×24	↓	18,000		12.0		216,000
E4	100×30×2.4/2	↓	3,600		20.5		74,000
E5	100×30×3	↓	9,000		22.5		203,000
B1		↓	13,500		16.0		216,000
U1	62.5×6×24	↑	9,000		12.0	108,000	
E6	40×37²/2	→		29,400	12.3	362,000	
E7	40×5²/2	→		700	2.0	1,000	
			55,100			471,000	1,062,000
							471,000
							591,000

$$\frac{\Sigma M}{\Sigma V} = \frac{591000}{55100} = 10.7, \quad e = 1.3'$$

$$f = \frac{55,100}{24}\left(1 \pm \frac{6\times1.3}{24}\right) = \begin{matrix} 3050 \ \#/\square' \\ 1550 \ \#/\square' \end{matrix}$$

Base - riverside



$V = 1725\times15 = 25,900\#$
$950\times15/2 = 7,100$
$33,000\#$

$v = 33000/12\times.884\times45 = 69\ \#/\square'$

$M = 25,900\times7.5 = 194,000'\#$
$7,100\times10 = 71,000$
$265,000'\#$

$$A_s = \frac{265000\times12}{18,000\times.884\times45} = 4.55\ \square''$$

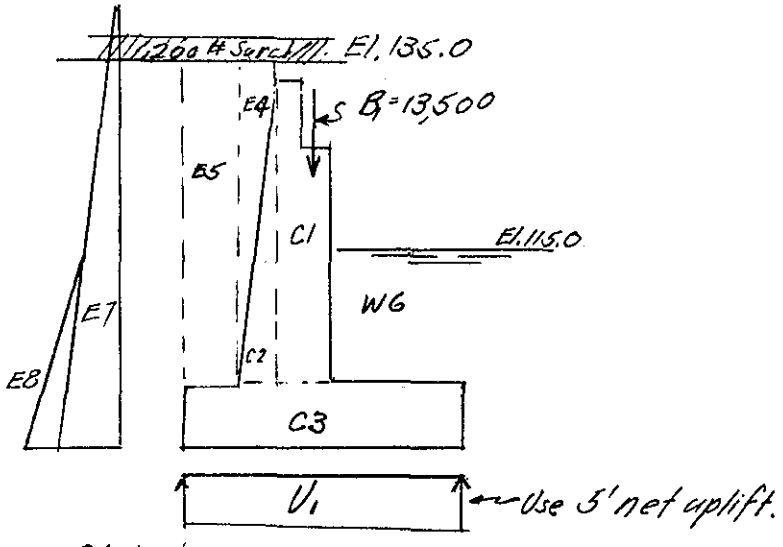
Use $1\frac{1}{4}$"□ @ 4" c-c, $A_s = 4.69\ \square''$

Subject: NORTHAMPTON
Computation: SO. ST. BR. - ABUT
Computed by: RSM Checked by: Date: 4-28-39

U. S. GOVERNMENT PRINTING OFFICE 3—10328

BASE EL. 99.97

CASE III - Bridge in place, flood of 20,000 c.f.s.



Stability

			Force ↓↑	Force ⇄	Arm	Moment ↷	Moment ↶
C1	150×28×3.7	↓	15,500		16.7		260,000
C2	150×29×2.4/2	↓	5200		18.8		98,000
C3	150×5×24	↓	18,000		12.0		216,000
E4	100×20×.8	↓	1,600		19.5		31,000
	125×10×.4	↓	500		19.7		10,000
E5	100×20×3.6	↓	7,200		22.2		160,000
	125×10×3.6	↓	4,500		22.2		100,000
W6	62.5×15×10	↓	9400		7.5		71,000
B1		↓	13,500		16.0		216,000
U1	62.5×5×24	↑	7,500		12.0	90,000	
E7	40×37²/2	→		27,400	12.3	337,000	
E8	40×13²/2	→		4,500	5.0	23,000	
			66,900			450,000	1,162,000
							450,000
							712,000

$$\frac{\Sigma M}{\Sigma V} = \frac{712000}{66900} = 10.6, \quad e = 1.4'$$

$$f = \frac{66900}{24}\left(1 \pm \frac{6 \times 1.4}{24}\right) = 3900\ \#/\square' \text{ to } 1700\ \#/\square'$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject NORTHAMPTON

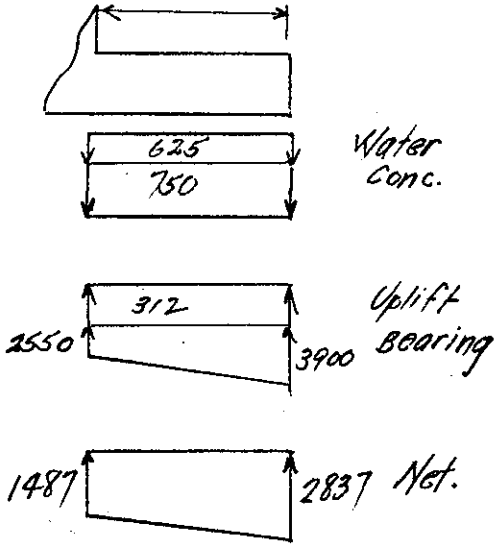
Computation SO. ST. B.R. - ABUT

Computed by RSM **Checked by** **Date** 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 3—10523

BASE EL 99.97
CASE III

Base - riverside



$V = 1487 \times 15 = 22300^{\#}$
$1350 \times 15/2 = 10100^{\#}$
$32400^{\#}$

$w = 32400 / 12 \times .884 \times 45 = 68^{\#}/\square''$

$M = 22300 \times 7.5 = 167{,}000^{'\#}$
$10100 \times 10 = 101{,}000$
$268{,}000^{'\#}$

$A_s = \frac{268{,}000 \times 12}{18{,}000 \times .884 \times 45} = 4.50^{\square''}$

Use $1\frac{1}{4}''\square$ @ 4" c-c

APPENDIX A

II DROP STRUCTURE

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

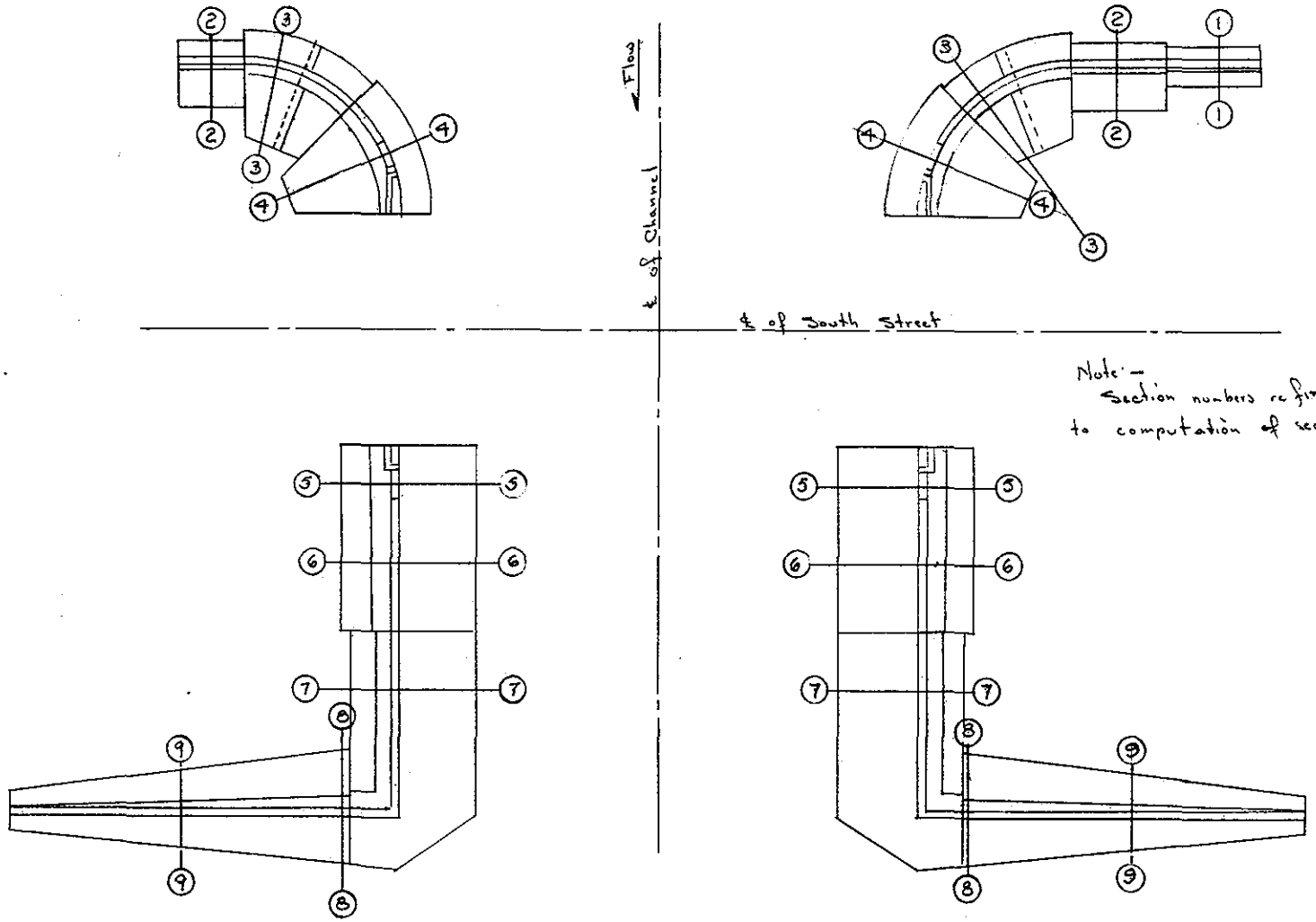
Page .....

Subject: Northampton Drop Structure

Computation: Location of Computed Wall Sections

[redacted] Dr. by H.J.P. Checked by ..... Date: May 1939

U. S. GOVERNMENT PRINTING OFFICE 2—10635



See Section (1) Key Sketch

WAR DEPARTMENT

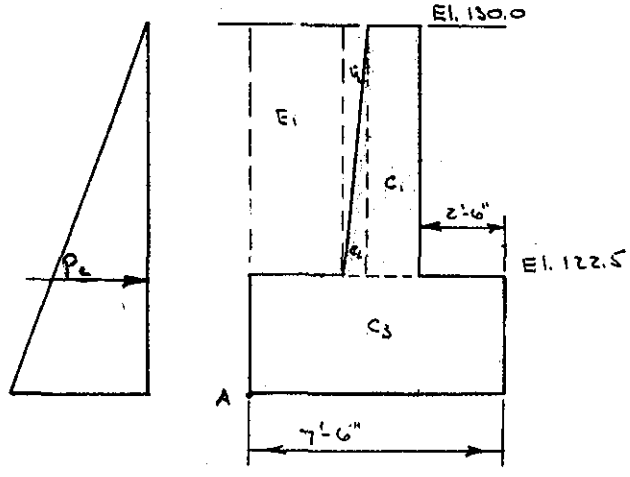
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

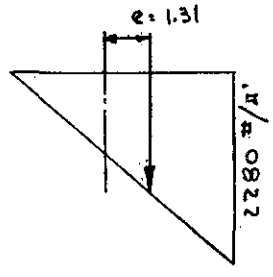
Subject Northampton Drop Structure

Computation Retaining Wall - Section

Computed by H. J. P. **Checked by** W. S. J. **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10528





7.5
5.06
2.44 x 3 = 7.32

Subject Northampton Drop Structure
Computation Retaining Wall (Stability and Bearing)
Computed by H.J.P. **Checked by** W.S.P. **Date**

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↻	MOMENTS ABOUT A ↺
C_1	(7.5)(1.5)(150)	1688				4.25	7175	
C_2	(7.5)(.625)(1/2)(150)	352				3.29	1157	
C_3	(3.5)(7.5)(150)	3940				3.75	14,750	
E_1	(2.88)(7.5)(100)	2160				1.44	3110	
E_2	(7.5)(.625)(1/2)(100)	235				3.08	7250	
P_a	$(11)^2(1/2)(40)$			2420		3.66	8900	
F_r	(8375 x .45) max.				2420			
		$\Sigma V = 8375$		$\Sigma H = 0$			$\Sigma M = 42,342$	

Position of Resultant $= \frac{\Sigma M}{\Sigma V} = \frac{42,342}{8375} = 5.06$

Eccentricity $= 6.06 - 3.75 = 1.31$
Allowable $= \frac{7.5}{6} = 1.25$

Bearing
$8375 = (3)(7.5 - 5.06)(1/2)(p)$ $p = 2280\ \#/\square'$

Subject Northampton Drop Structure

Computation Retaining Walls (Pile Spacing & Bracing)

Computed by H. J. P. **Checked by** M. S. P. **Date**

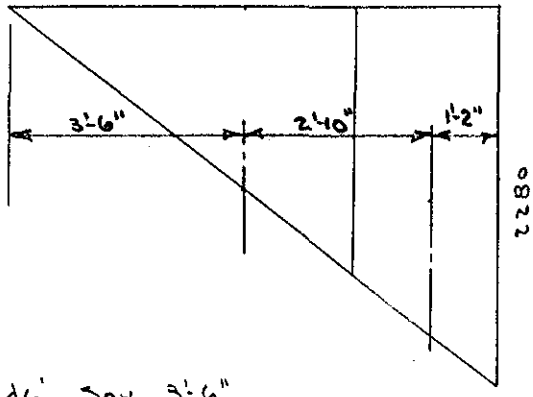
U. S. GOVERNMENT PRINTING OFFICE 3—10528

Assume 2 piles equally loaded

$\frac{8375}{2} = 4188$

Longitudinal spacing of piles assuming maximum loading of 20 tons / pile

$\frac{40,000}{4188} = 9.55'$ Use 6' c. to c.



$\frac{2280}{7.32 \times 2} = 156$

#1 $156x^2 = 4188$

$x = 5.18$

$R = \frac{(5.18)(2)}{3} = 3.46'$ Say 3'-6"

#2 at c of trapezoid

$= 7.32 - 5.18 = 2.14/2 = 1.07'$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Northampton Drop Structure

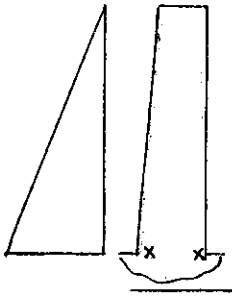
Computation Retaining Wall (Design of Members.

Computed by H.J.P. **Checked by** W.J.P. **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10528

STEM

At x-x



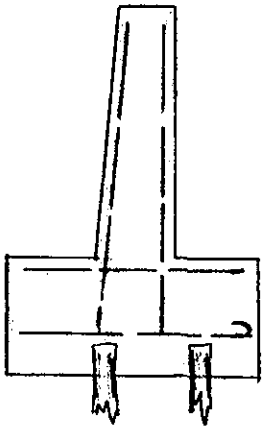
$P_e = (7.5)^2 (1/2)(40) = 1125 (2.5) = 2820^{\text{lb}}$

$d = 18 + 7.5 = 25.5''$

$A_s = \dfrac{2820}{1325 \times 21.0} = .10 \ \square''$ Use 5/8" ϕ @ 1'0" c.c.

BASE

Use 5/8" ϕ - 1'0" cc top and bottom.



Use 5/8" ϕ @ 1'-0" c.c. for all steel.

See Section 2, Key Sketch

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

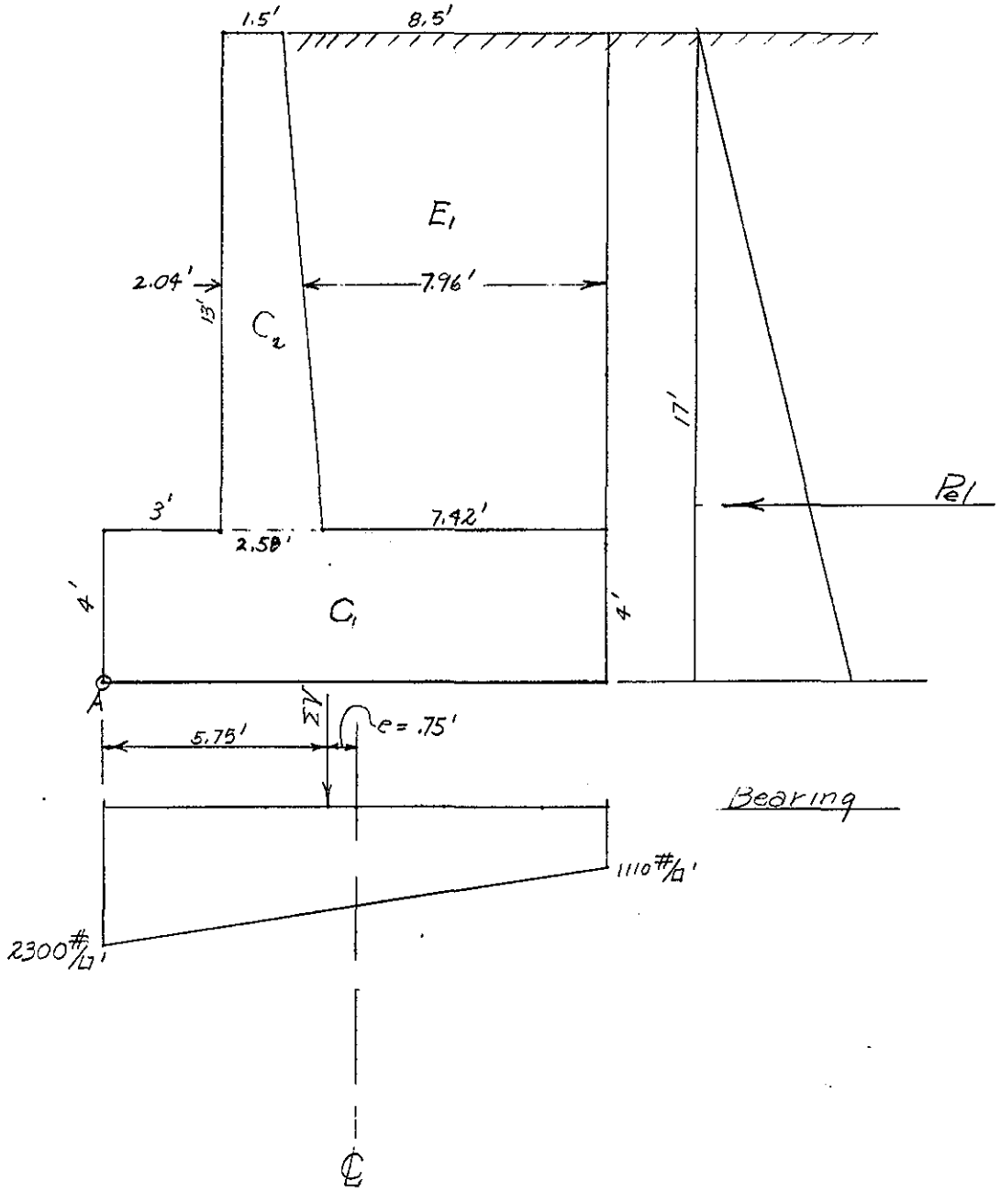
Page 1

Subject: Northampton, Mass.

Computation: Stability 13' wall - Section II

Computed by: R.H.M. Checked by: W. S. Jr. Date: 4-29-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Note: Thickness of base slab changed from 4' to 3.5' this does not materially change stability computations merely giving slightly smaller bearing values.

A-45

Subject Northampton, Mass

Computation Stability - 13' Wall

Computed by R.H.M Checked by W. S. D. Date 4-29-39

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↻	MOMENTS ABOUT A ↺
C_1	4X13X150	7800				6.50	50700	
C_2	2.04X13X150	3980				4.02	16000	
E_1	7.96 X 13X100	10350				9.02	93360	
P_{e1}	17^2 X 1/2 X 40				5780	5.67		32770
		ΣV = 22130		ΣH = 5780				
Fr	0.45X22130			(9960)	OK against sliding			
		22130	0	5780	5780		160060	32770
		ΣV = 22130 #↓		ΣH = 0			ΣM = 127290 '#↻	

$$\text{Position of Resultant} = \frac{\Sigma M}{\Sigma V} = \frac{127290}{22130} = 5.75'$$

$\frac{1}{3}$ Base = 4.33'

e = 6.5 − 5.75 = .75'

$$B.P. = \frac{22130}{13}\left(1 \pm \frac{6 \times .75}{13}\right) = 1700(1 \pm .35) = \begin{cases} 2300\ \#/\square' \\ 1110\ \#/\square' \end{cases}$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

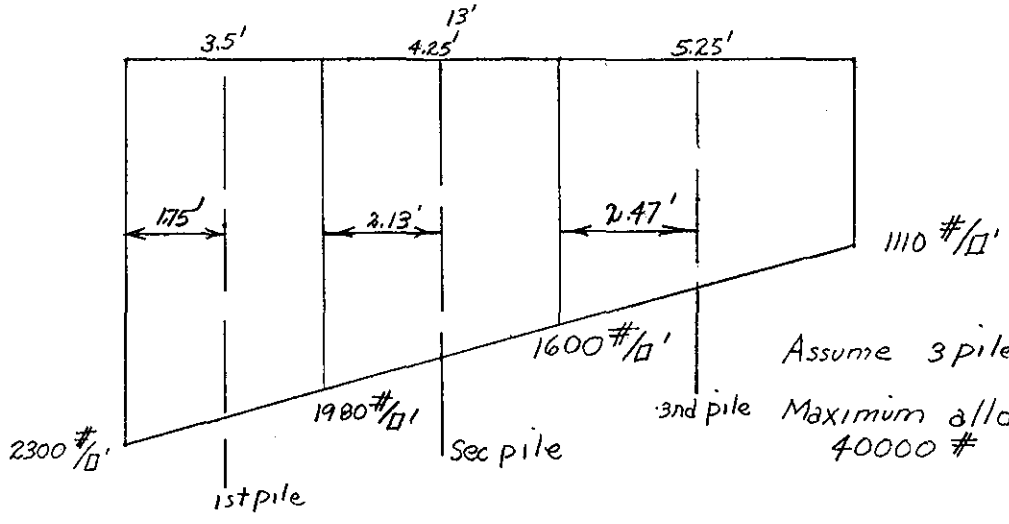
Page 3

Subject: Northampton, Mass.

Computation: Piling - 13' wall

Computed by: R.H.M. Checked by: W. S. J. Date: 4-29-39

U. S. GOVERNMENT PRINTING OFFICE 9—10528



Assume 3 piles per row

Maximum allowable pile load = 40000 #

$\frac{22130.}{3} = 7380$ #/ft , $\frac{40000}{7380} = 5.42'$

Use 5.25' between rows

1st pile

2300
1980
2 | 4280
2140 × 3.5 × 5.25 = 39300 # OK for first pile

2nd pile

1980
1600
2 | 3580
1790 × 4.25 × 5.25 = 39900 # OK for second pile ✓

3rd pile

1600
1110
2 | 2710
1355 × 5.25 × 5.25 = 37300 # O.K for third pile ✓

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 4

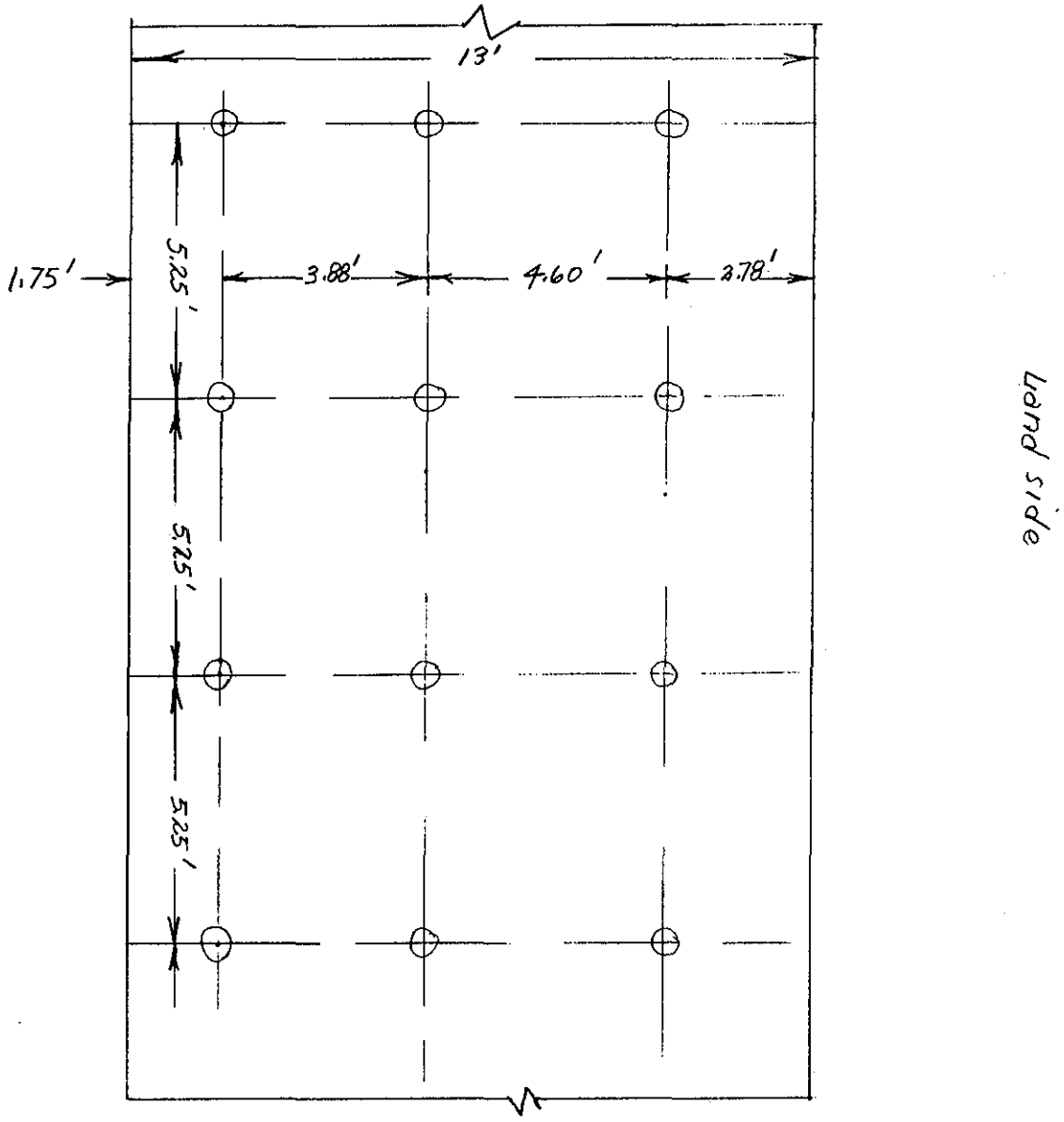
Subject Northampton, Mass

Computation Piling -

Computed by R.H.M. Checked by W. S. Jr. Date 4-29-39.

U. S. GOVERNMENT PRINTING OFFICE 3—10328

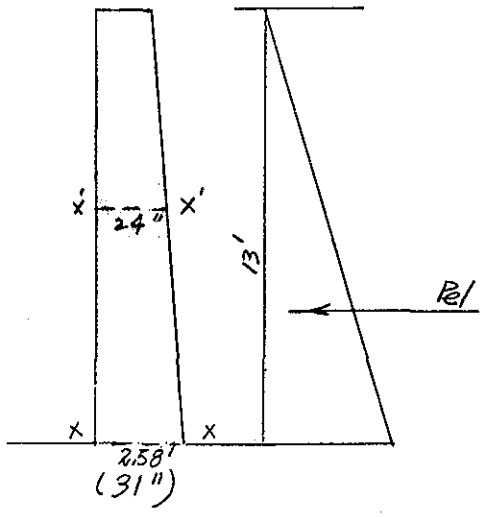
Plan for piling



A-48

Subject: Northampton, Mass.
Computation: Stem Steel - 13' stem.
Computed by: R.H.M. Checked by: W. S. Jr. Date: 4-29-39

U.S. GOVERNMENT PRINTING OFFICE 3—10528



Stem Steel:

Section x---x

$Pel: 13^2 \times \frac{1}{2} \times 40 = 3380 \times 4.33 = 14640^{\#}$

$d = \sqrt{\frac{14640}{123}} = \sqrt{119} = 10.9''$ OK.

Use $31 - 3.5 = 27.5''$

$Shear = \frac{3380}{12 \times .884 \times 27.5} = \frac{3380}{292}$

$= 11.6^{\#}/\square''$ OK.

$Area\ steel = \frac{12 \times 14640}{18000 \times .884 \times 27.5}$

$= \frac{175680}{437250} = .40\ \square''$

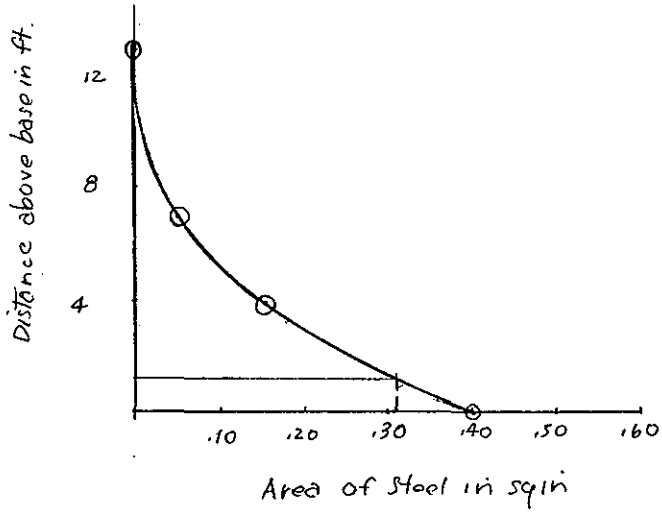
Section x'---x'

$Pel: 6^2 \times \frac{1}{2} \times 40 = 720 \times 2 = 1440^{\#}$

Use $d = 24 - 3.5 = 20.5''$

$A_s = \frac{12 \times 1440}{18000 \times .884 \times 20.5} = \frac{17280}{326000} = .05\ \square''$

Steel Area Curve



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

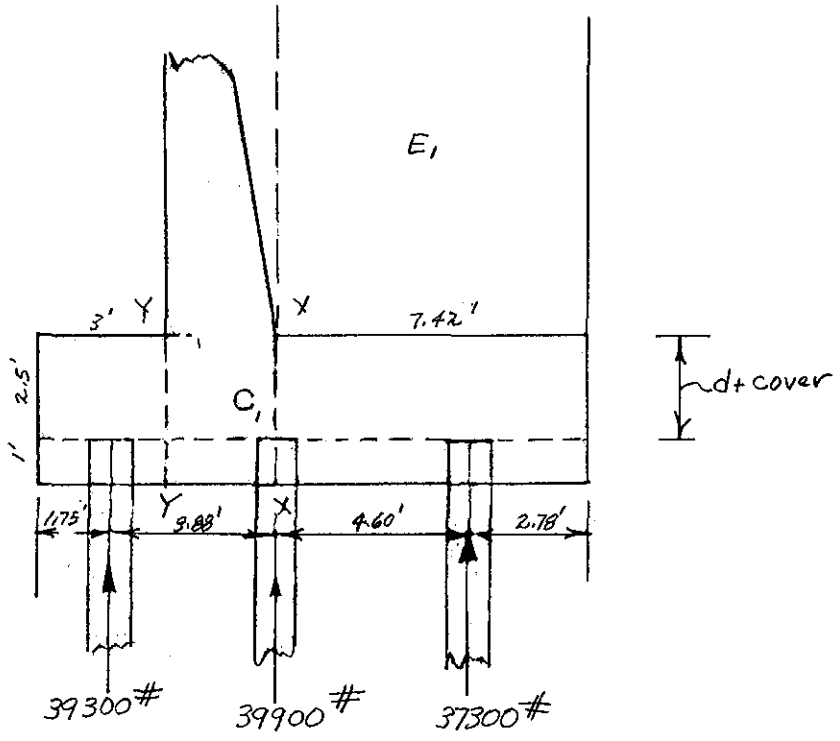
Page 5b

Subject Northampton, Mass.

Computation Design of transverse base steel

Computed by R.H.M. Checked by Date

U.S. GOVERNMENT PRINTING OFFICE 3—10528



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 6

Subject: Northampton Mass.

Computation: Design of Transverse Base Steel – Wall with 13' Stem

Computed by: R.H.M. Checked by: W. S. J. Date:

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Landside Base Slab (Top Steel) Section at X - - - X

E_1 $13 \times 7.42 \times 5.25 \times 100 = 50640 \times 3.71 = 187900$

C_1 $3.5 \times 7.42 \times 5.25 \times 150 = 20410 \times 3.71 = 75700$

$71050^{\#}\downarrow$ $263600^{\#}\curvearrowright$

Pile $37300 \times 4.64 = 173100^{\#}\curvearrowleft$

$\Sigma V = 33750^{\#}\downarrow$ $\Sigma M = 90500^{\#}\curvearrowright$

$d = \sqrt{\frac{90500}{123}} = \sqrt{736} = 27.1''$ O.K. Use $30'' - 3'' = 27''$

$\text{Shear} = \frac{33750}{12 \times 5.25 \times .884 \times 27} = \frac{33750}{1500} = 22.5^{\#}/\square''$ O.K.

$A_s = \frac{12 \times 90500}{18000 \times .884 \times 27 \times 5.25} = \frac{1{,}086{,}000}{2{,}253{,}800} = .48\,\square''$ Use $\frac{7}{8}''\phi$ @ 12" c.c

Riverside Slab (Bottom Steel) Section at Y - - - Y.

C_1: $3 \times 3.5 \times 5.25 \times 150 = 8270 \times 1.5 = 12410^{\#}\curvearrowright$

pile: $= 39300 \times 1.25 = 49130^{\#}\curvearrowleft$

$31030^{\#}\downarrow$ $36720^{\#}\curvearrowleft$

$d = \sqrt{\frac{36720}{123}} = \sqrt{299} = 17.3''$ O.K. Use $30 - 4.5 = 25.5''$

$\text{Shear} = \frac{31030}{12 \times .884 \times 25.5 \times 5.25} = \frac{31030}{1410} = 22^{\#}/\square''$ O.K

$A_s = \frac{12 \times 36720}{18000 \times .884 \times 25.5 \times 5.25} = \frac{440{,}600}{2{,}126{,}300} = .21\,\square''$

Use $\frac{5}{8}''\phi$ @ 12" c.c

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 7

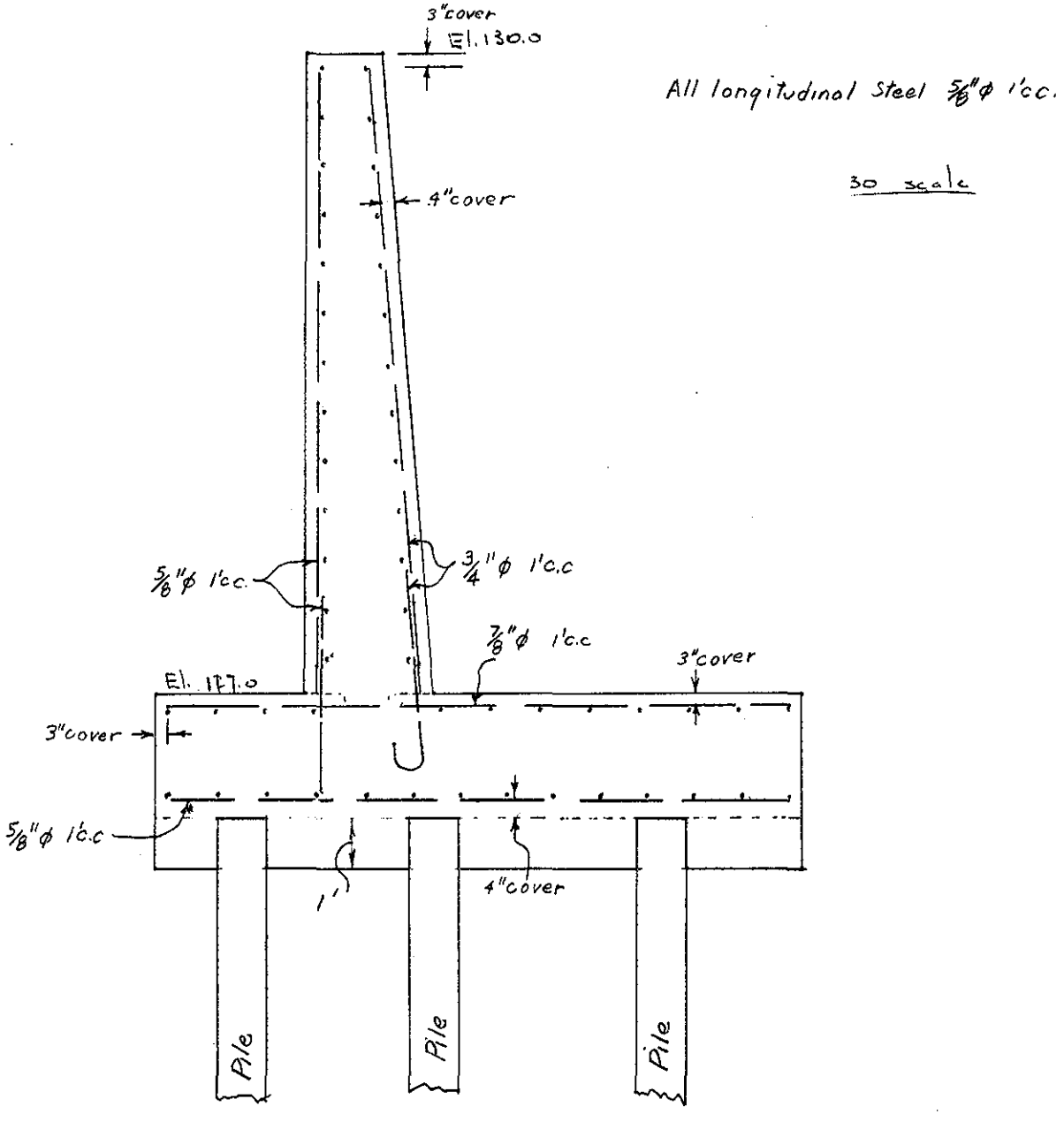
Subject: Northampton, Mass.

Computation: Steel Diagram 13' Stem

Computed by: R.H.M. Checked by: Date: 4-29-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Steel Diagram



A-52

See Section 3, Key Sketch

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 1

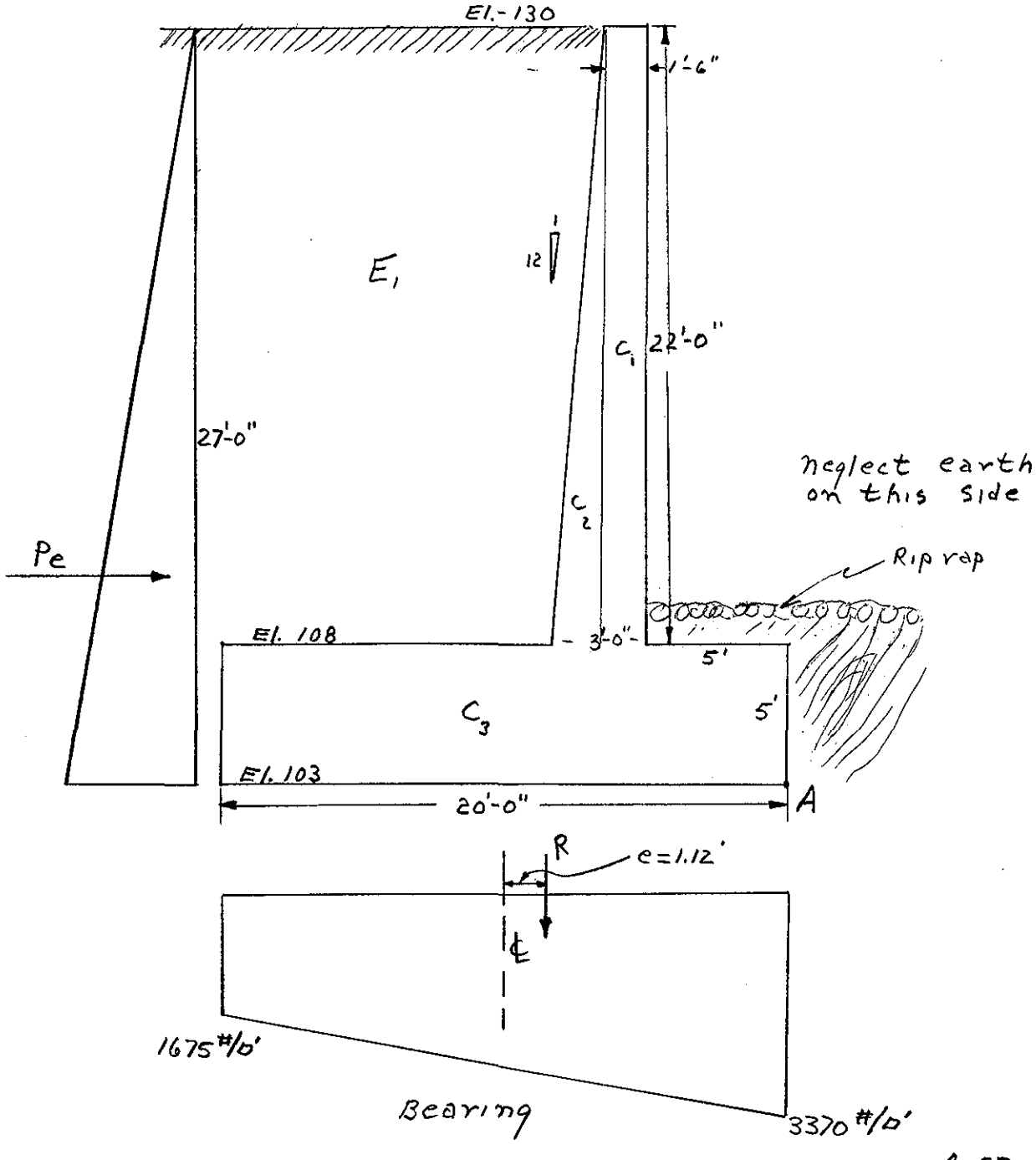
Subject Northampton Mass Sect. III

Computation Stability of Wall

Computed by M.B.J. Checked by R.H.M. Date 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Assume river down, dry earth both sides, entire load on piles.



A-53

Subject Northampton Mass

Computation Stability of Wall

Computed by M.S.Jr. Checked by R.H.M. Date 4/28/39

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↻	MOMENTS ABOUT A ↺
C_1	1.5×22×150	4950				5.75		28,500
C_2	1.5×22×½×150	2480				7.00		17,400
C_3	5×20×150	15000				10.0		150,000
E_1	12.75×22×100	28000				13.63		382,000
P_a	27^2×40×½			14,600		9.0	131,500	
F_r	(max 50,430×.45)				14,600			
				14600	14600		131,500	577,900
		ΣV = 50,430		ΣH = 0			ΣM = 446,400'#	

Position of Resultant $\Big\} = \frac{\Sigma M}{\Sigma V} = 8.88'$ O.K.

$e = \frac{20}{2} - 8.88 = 1.12'$

$$\text{Bearing} = \frac{50,430}{20}\left(1 \pm \frac{6 \times 1.12}{20}\right) = 2520 \begin{cases} 1.336 = 3370 \ \#/\square' \\ .664 = 1675 \ \#/\square' \end{cases}$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

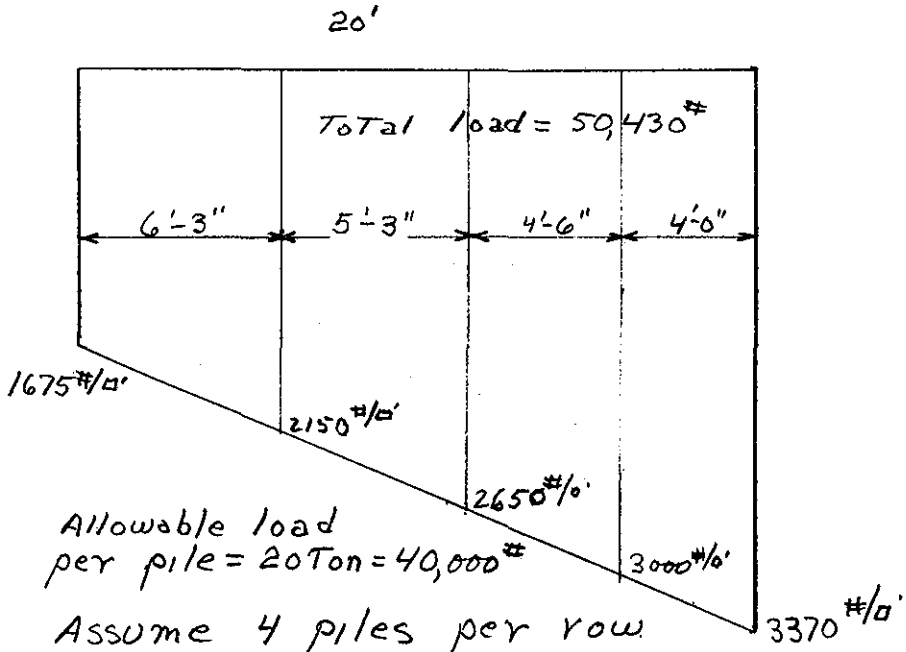
Page 3

Subject Northampton Mass

Computation Pile Spacing

Computed by W. S. J. Checked by R.H.M. Date 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Allowable load per pile = 20 Ton = 40,000#

Assume 4 piles per row

$\frac{50,430}{4} = 12,600$ #/FT $\qquad \frac{40000}{12,600} = 3.18'$

say 3' between rows

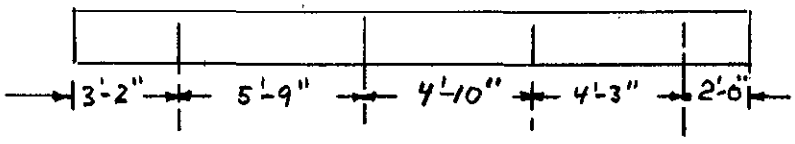
3370
3000
6370 ÷ 2 = 3185# × 3 × 4 = 38300# per pile O.K.

2650
3000
5650 ÷ 2 = 2825 × 4.5 × 3 = 38100# per pile O.K.

2150
2650
4800 ÷ 2 = 2400 × 5.25 × 3 = 37,800# per pile O.K.

2150
1675
3825 ÷ 2 = 1912 × 6.25 × 3 = 36,000# per pile O.K.

Due to uniformity of loading, piles will be placed at center of trapezoid.



Theoretical pile spacing

A-56

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 4

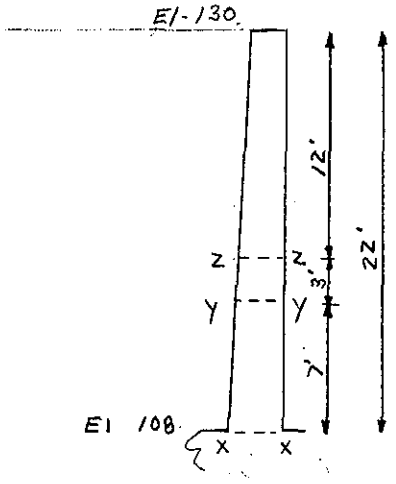
Subject Northampton Mass

Computation Stem

Computed by W. S. P. Checked by R. H. M. Date 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Stem Design



Mom X-X

$22^2 \times \frac{1}{2} \times 40 = 9670 \times \frac{22}{3} = 71{,}000'^{\#}$

$d = \sqrt{\frac{71{,}000}{123}} = \sqrt{576} = 24''$ 34"d O.K.

$A_s = \frac{71{,}000 \times 12}{18000 \times .884 \times 34} = 1.57 \square''$ use 1"ϕ - 6"c.c.

Shear $= \frac{9670}{12 \times .884 \times 34} = 27^{\#}/\square''$ O.K.

Bond $= \frac{9670}{6.20 \times .884 \times 34} = 52^{\#}/\square''$ O.K.

Mom Y-Y

$15^2 \times \frac{1}{2} \times 40 \times \frac{15}{3} = 22{,}500'^{\#}$

$d = \sqrt{\frac{22{,}500}{123}} = \sqrt{183} = 13.5''$ 29"d O.K.

$A_s = \frac{22{,}500 \times 12}{18000 \times .884 \times 29} = .585 \square''$

Shear O.K. Bond O.K.

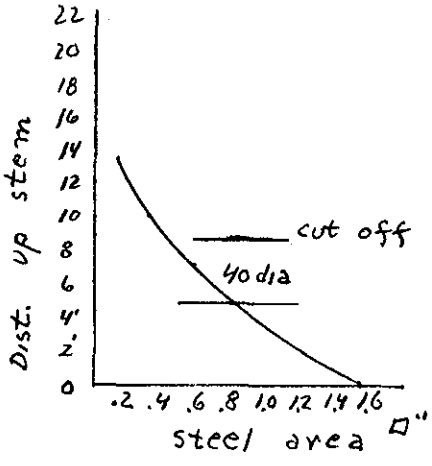
Mom Z-Z

$12^2 \times \frac{1}{2} \times 40 \times \frac{12}{3} = 11{,}500'^{\#}$

$A_s = \frac{11{,}500 \times 12}{18000 \times .884 \times 26.5} = .327 \square''$

Shear, Bond, & d, O.K.

Curve of steel required



use 1"ϕ - 6"cc at bottom.

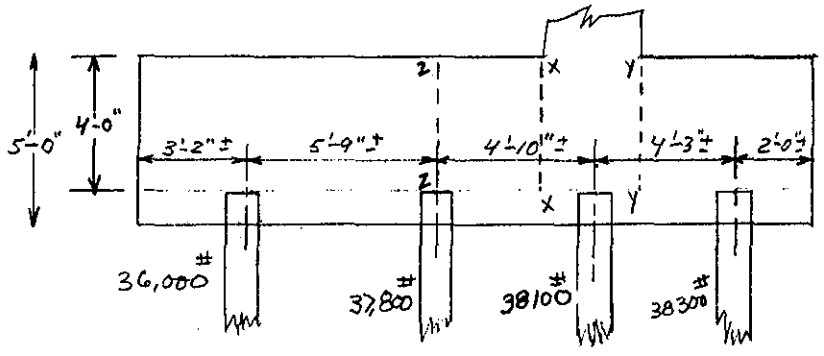
cut one off 8'-6" up

cut other off 13' up and splice to $\frac{3}{4}$"ϕ

Subject Northampton Mass
Computation Base
Computed by M. S. D. Checked by R.H.M. Date 5/1/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Base Design



Base will be designed on possible 20 Ton pile load

Mom at x-x

Loads down - Earth = 28,000# x 6.37' = 178,500'#
Concrete = 9,000# x 6.00' = 54,000'#
37,000# ↓ 232,500'# ↶

Loads up - Pile ÷ 3 = 12,600# x 3' = 37,800'#
Pile ÷ 3 = 12,000# x 8.9' = 107,000'#
24,600# ↑ 144,800'# ↶
Σ = 12,400# ↑ Σ = 87,700'# ↶

$d = 4'-0" - 4" = 44"$

Shear $\frac{12,400}{12 \times .884 \times 44} = 26^{\#/\square''}$ O.K.

$d = \sqrt{\frac{87,700}{123}} = 26.8"$ 44" O.K.

$A_s = \frac{87,700 \times 12}{18000 \times .884 \times 44} = \frac{1,050,000}{700,000} = 1.50^{\square''}$

This base slab is evidently too thick.
Try a 4' overall base depth

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Northampton Mass.

Computation: Base

Computed by: W.S.P. Checked by: R.H.M. Date: 5/1/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Mom at x-x

Loads down – Earth – 28,000# × 6.37 = 178,500
Concrete – 7,200# × 6.00 = 43,200
35,200# 221,700'#

Assume upward loads remain the same 24,600# 144,800'#
10,600# 76,900'#

$$\text{Shear} = \frac{10,600}{12 \times .884 \times 32} = 31\#/\square'' \quad \text{O.K.}$$

depth = 4'-0" – 1' pile – 4" cover = 32" d

$$\text{required } d = \sqrt{\frac{76,900}{123}} = 25'' \qquad 32'' \text{ O.K.}$$

$$A_s = \frac{76900 \times 12}{18000 \times .884 \times 32} = \frac{924,000}{510,000} = 1.8\ \square''$$

Mom at z-z

Loads down – Earth = 19,800# × 4.5 = 89,100'#
Concrete = 5,400# × 4.5 = 24,300'#
25,200# 113,400'#

Loads up – pile ÷ 3 = 12,000# × 5.75 = 69,000'#
13,200# 44,400'#

$$\text{Shear } \frac{13,200}{12 \times .884 \times 32} = 38.8\#/\square'' \quad \text{O.K.}$$

$$A_s = \frac{44,400 \times 12}{510,000} = 1.04\ \square'' \quad \text{O.K.}$$

Mom at y-y

Loads down – Concrete = 3000# × 2.5 = 7,500'#
Loads up – pile ÷ 3 = 12,800# × 3.0 = 38,300'#
9,800# 30,800'#

depth = 4'-0" – 1' pile – 3" Cover = 33" d O.K.

$$A_s = \frac{30,800 \times 12}{18000 \times .884 \times 33} = \frac{370,000}{525,000} = .71\ \square'' \quad \text{O.K.}$$

A-58

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 7

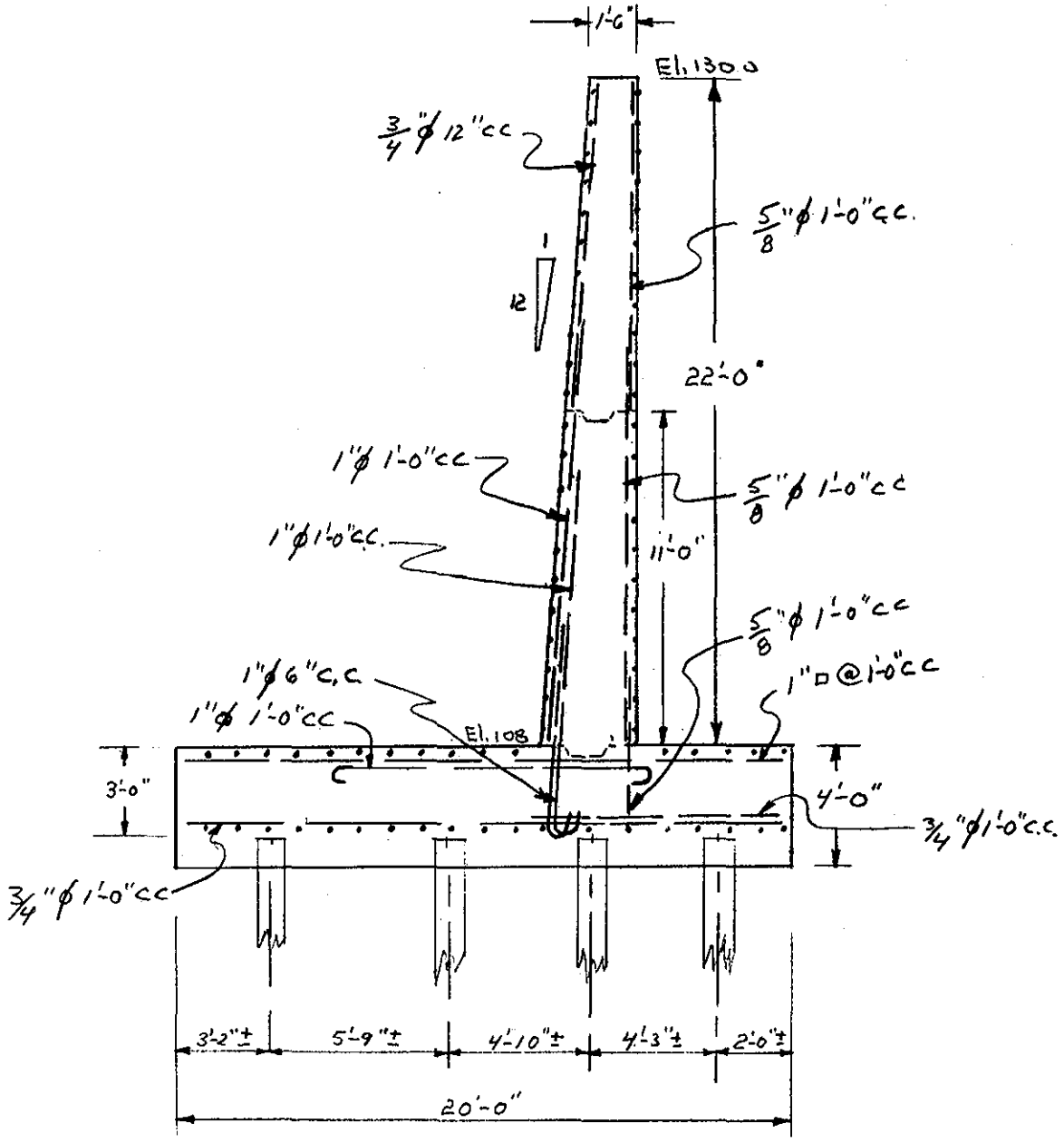
Subject Northampton Mass

Computation

Computed by M. S. P. Checked by Date 5/1/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Designed Section



A-59

See Section 9, Key Sketch

WAR DEPARTMENT

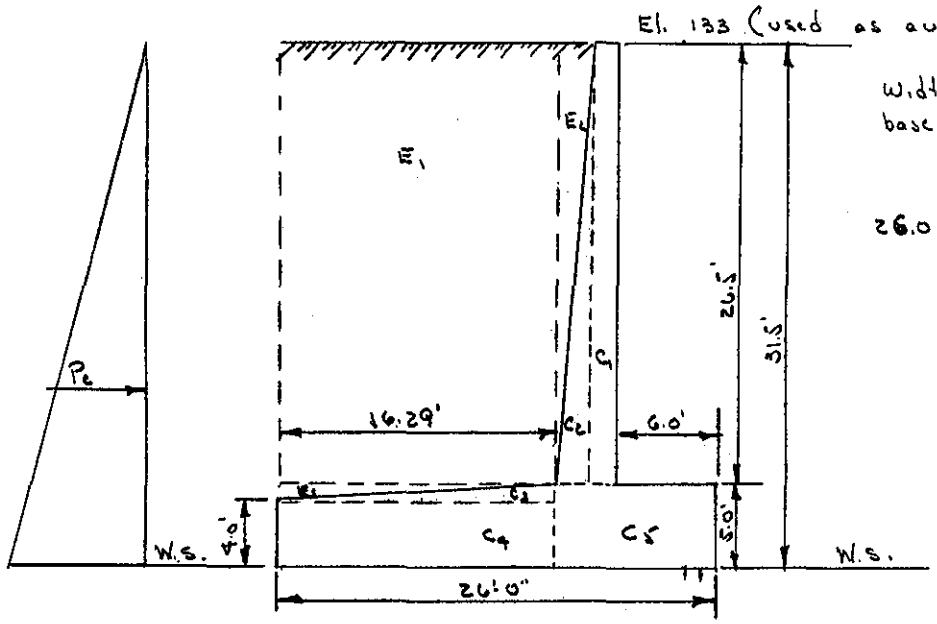
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Northampton Drop Structure Sect IV

Computation Retaining Wall

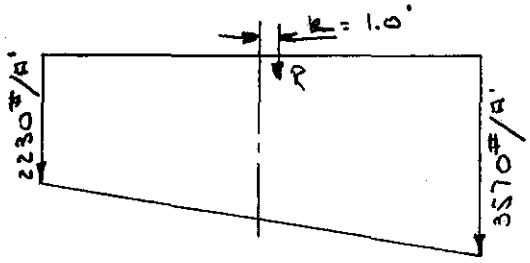
Computed by N.J.P. **Checked by** R.H.M. **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Width at bottom of base = 18 + 26.5
= 44.5" = 3.71

26.0 − 3.71 − 6 = 16.29



Subject Northampton Drop Structure
Computation Retaining Wall (Stability and Bearing
Computed by H.J.P. **Checked by** R.H.M. **Date**

Water down, no uplift.

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↻	MOMENTS ABOUT A ↺
C_1	(26.5)(1.5)(150)	5960				19.25	114,800	
C_2	(26.5)(2.21)(1/2)(150)	4390				17.76	78,000	
C_3	(16.29)(1)(1/2)(150)	1220				10.86	13,250	
C_4	(4)(16.29)(150)	9760				8.15	79,600	
C_5	(9.71)(5)(150)	7280				21.15	154,000	
E_1	(16.29)(26.5)(100)	43,100				8.15	352,000	
E_2	(2.21)(26.5)(1/2)(100)	2930				17.03	49,900	
E_3	(16.29)(1)(1/2)(100)	815				5.43	4420	
P_e	(31.5)²(1/2)(40)			19,850		10.5	208,300	
		$\Sigma V = 75,455$		$\Sigma H =$			$\Sigma M = 1,054,270$	

$$\left.\begin{array}{l}\text{Position of}\\ \text{Resultant}\end{array}\right\} = \frac{\Sigma M}{\Sigma V} = \frac{1,054,270}{75,455} = 14.0$$

Eccentricity = 14.0 − 13.0 = 1.0
Allowable = $\frac{26}{6}$ = 4.33

Soil Pressure = $\frac{75,455}{26}\left(1 \pm \frac{6}{26}\right)$ = 3570 #/□' & 2230 #/□'

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Northampton Drop Structure

Computation Retaining walls (Pile Loading + Spacing.)

Computed by H. J. P. **Checked by** R.H.M. **Date**

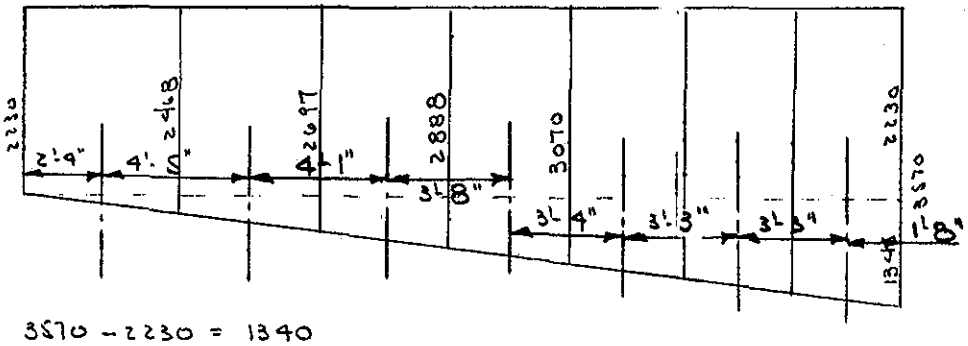
U. S. GOVERNMENT PRINTING OFFICE 3—10838

Assume 7 piles equally loaded

$$\frac{75,455}{7} = 10,750\ \#/\text{pile}$$

Pile spacing (longitudinally)

$$\frac{40,000}{10,750} = 3.72' \quad \text{Say } 3'\text{-}6''\ \text{c. to c.}$$



$3570 - 2230 = 1340$

$$\frac{1340}{26} = 51.6$$

#1 $\quad 2230x + \frac{51.6x^2}{2} = 10,750$

$$x^2 + 86.5x - 417 = 0$$

$$x = -\frac{86.5 \pm \sqrt{86.5^2 + (417)(4)}}{2}$$

$$= 4.6'$$

$$R = \frac{(2230)(\cancel{4.6})(2.3) + \frac{51.6}{2}(4.6)^2(3.06)}{(2230)(\cancel{4.6}) + \frac{51.6}{2}(\cancel{4.6})^2}$$

$$= 2.35' \quad \text{Say } 2'\text{-}9''$$

#2 $\quad x^2 + 86.5x - (2)(417) = 0$

$$x = -86.5 \pm \sqrt{(86.5)^2 + (4)(834)}$$

$$= 8.85 - 4.6 = 4.25 \checkmark$$

$$R = \frac{(2468)(\cancel{4.25})(2.125) + (229)(1/2)(\cancel{4.25})(2.84)}{(2468)(\cancel{4.25}) + (229)(1/2)(\cancel{4.25})}$$

$$= 2.16 + 4.6 = 6.76 \quad \text{say } 6'\text{-}9'' \checkmark$$

Subject Northampton Drop Structure
Computation Retaining walls (Pile loading, cont.)
Computed by H.J.P. **Checked by** R.H.M. **Date**

U.S. GOVERNMENT PRINTING OFFICE 8—10528

#3 $x^2 + 86.5x - (3)(417) = 0$

$x = \frac{-86.5 \pm \sqrt{(86.5)^2 + (4)(1251)}}{2}$

$= 12.75 - 8.85 = 3.9$ ✓

$R = \frac{(2697)(\cancel{3.9})(1.95) + (191)(1/2)(\cancel{3.9})(2.6)}{(2697)(\cancel{3.9}) + (191)(1/2)(\cancel{3.9})}$

$= 1.98 + 8.85 = 10.83$ ✓ Say 10'-10"

#4 $x^2 + 86.5x - (4)(417) = 0$

$x = \frac{-86.5 \pm \sqrt{(86.5)^2 + (4)(1668)}}{2}$

$x = 16.25 - 12.75 = 3.50$ ✓

$R = \frac{(2888)(\cancel{3.5})(1.75) + (182)(\cancel{3.5})(1/2)(2.33)}{(2888)(\cancel{3.5}) + (182)(1/2)(\cancel{3.5})}$

$= 1.77 + 12.75 = 14.52$ ✓ Say 14'-6"

#5 $x^2 + 86.5x - (5)(417) = 0$

$x = \frac{-86.5 \pm \sqrt{(86.5)^2 + (4)(2085)}}{2}$

$= 19.6 - 16.25 = 3.35$

$R = \frac{(3070)(\cancel{3.25})(1.63) + (165)(\cancel{3.25})(1/2)(2.16)}{(3070)(\cancel{3.25}) + (165)(1/2)(\cancel{3.25})}$

$= 1.64 + 16.25 = 17.89$ Say 17'-10"

#6 $x^2 + 86.5x - (6)(417) = 0$

$x = \frac{-86.5 \pm \sqrt{(86.5)^2 + (4)(2502)}}{2}$

$= 22.85 - 19.6 = 3.25$ ✓

R = Say at mid point of section because difference is negligable

$= 1.63 + 19.6 = 21.23$ ✓ Say 21'-3"

#7 $x^2 + 86.5x - (7)(417) = 0$

$x = \frac{86.5 \pm \sqrt{86.5 + (4)(29.19)}}{2}$

$= 25.9$ OK (.1 is due to accumulative error)

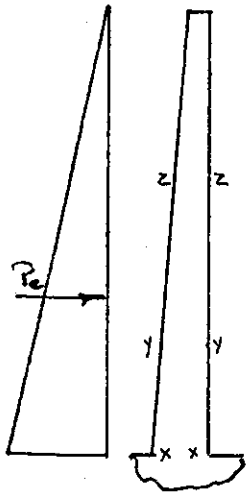
$26 - 22.85 = 3.15$ ✓

R (see above)

$= 1.58 + 22.85 = 24.43$ ✓ Say 24'-4"

Subject Northampton Drop Structure.
Computation Retaining Walls (Design of Stem.
Computed by ..... **Checked by** R.H.M. **Date** .....

U. S. GOVERNMENT PRINTING OFFICE 3—10528



At x-x

$P_e \quad (26.5)^2(1/2)(40) = 14{,}050 \times 8.83 = 124{,}000$

$d = 18 + 26.5 = 44.5''$

$d' = \sqrt{\frac{124{,}000}{123}} \quad 31.8'' < 44.5$ ok

$A_s = \frac{124{,}000}{1325 \times 40} = 2.32 \square''$

At y y

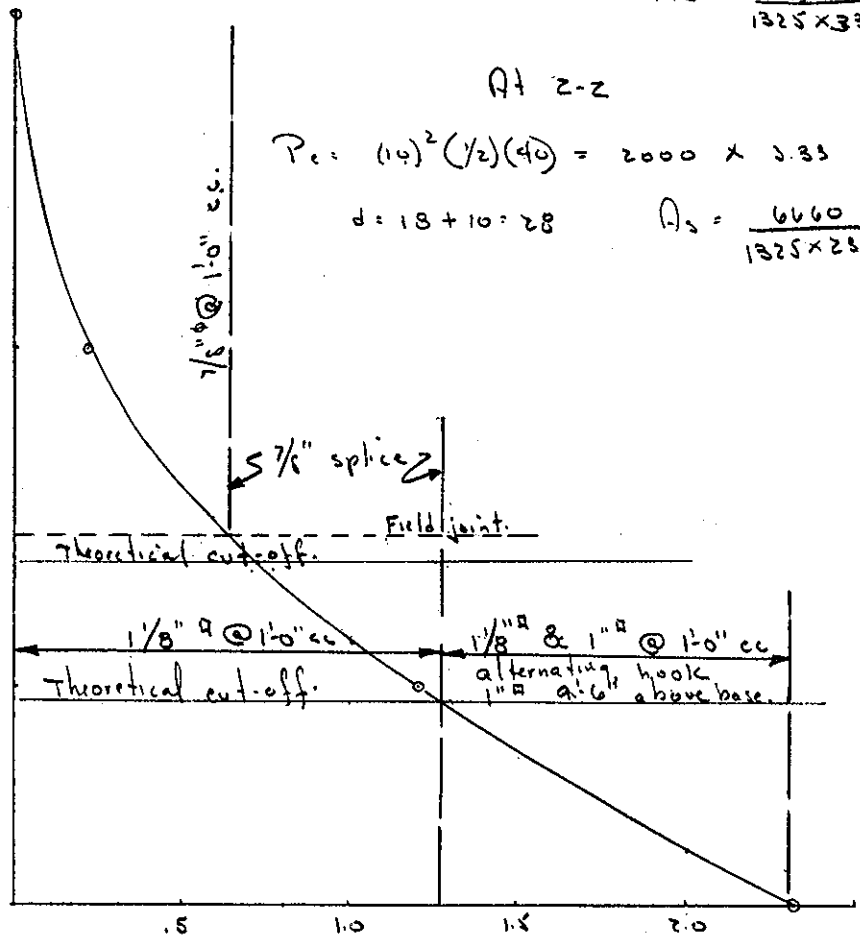
$P_e = (20)^2(1/2)(40) = 8000 \times 6.66 = 53{,}300^{\#}$

$d = 18 + 20 = 38''$ $\quad A_s = \frac{53{,}300}{1325 \times 33.5} = 1.20 \square''$

At z-z

$P_e = (10)^2(1/2)(40) = 2000 \times 3.33 = 6660^{\#}$

$d = 18 + 10 = 28$ $\quad A_s = \frac{6660}{1325 \times 23.5} = .217$



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

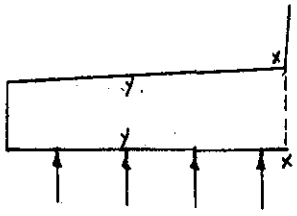
Subject Northampton Drop Structure

Computation Retaining Walls (Design of Base.

Computed by H. J. P. **Checked by** R.H.M. **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10538

At x-x



E_1	(16.29)(26.5)(100) = 43,100	×	8.15	=	352,000
E_2	(16.29)(1)(½)(100) = 815	×	10.86	=	8,840
C_1	(16.29)(1)(½)(150) = 1220	×	5.43	=	6625
C_2	(4)(16.29)(150) = 9760	×	8.15	=	79,600
P_1	= -10750	×	1.79		
P_2	-10750	×	5.46	=	331,000
P_3	-10750	×	9.54		
P_4	-10750	×	13.96		
	ΣV = 11,895			ΣM =	116,065

$$d = \sqrt{\frac{116,065}{123}} = 31" < 60 \text{ OK.}$$

$$A_s = \frac{116065}{1325 \times \cancel{54.5}\ 48.5} = \cancel{1.58}\ \square" \quad 2.0\ \square"$$

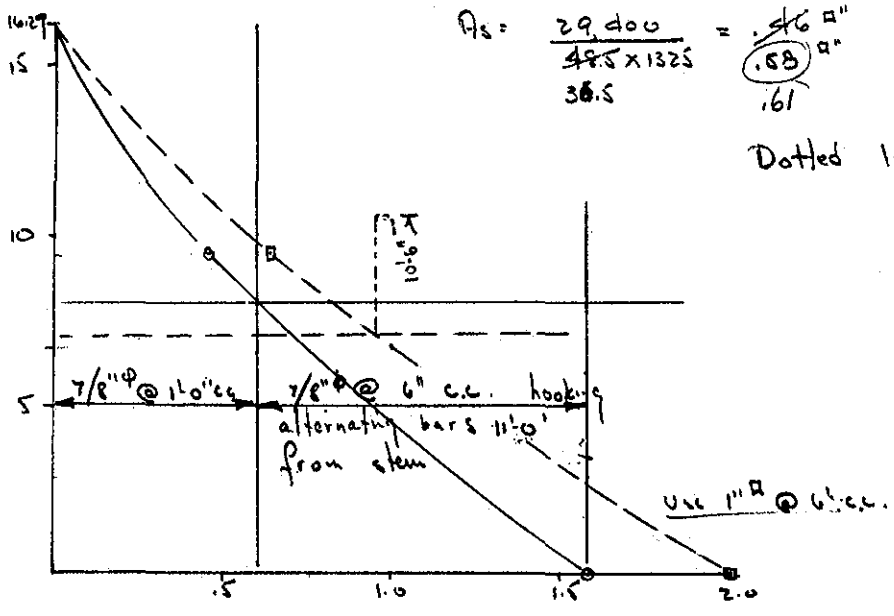
At y-y

$$d = \frac{6.75}{16.29} + 4.0 = 4.415 = 53"$$

E_1	(6.75)(27.09)(100) = 18,300	×	3.38	=	61,800
C_2	(6.75)(4.42)(150) = 4970	×	3.38	=	15,100
P_1	= 10,750	×	4.42		47,500
				ΣM =	29,400

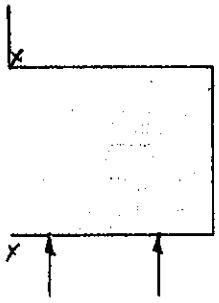
$$A_s = \frac{29,400}{\cancel{48.5} \times 1325\ 36.5} = \cancel{.46}\ \square" \quad \cancel{.58}\ \square" \quad .61$$

Dotted line is revision



Subject: Northampton Drop Structure
Computation: Retaining Wall (Design of Riverside Base.)
Computed by: ..... Checked by: R.H.M. Date: .....

U. S. GOVERNMENT PRINTING OFFICE 8—10528



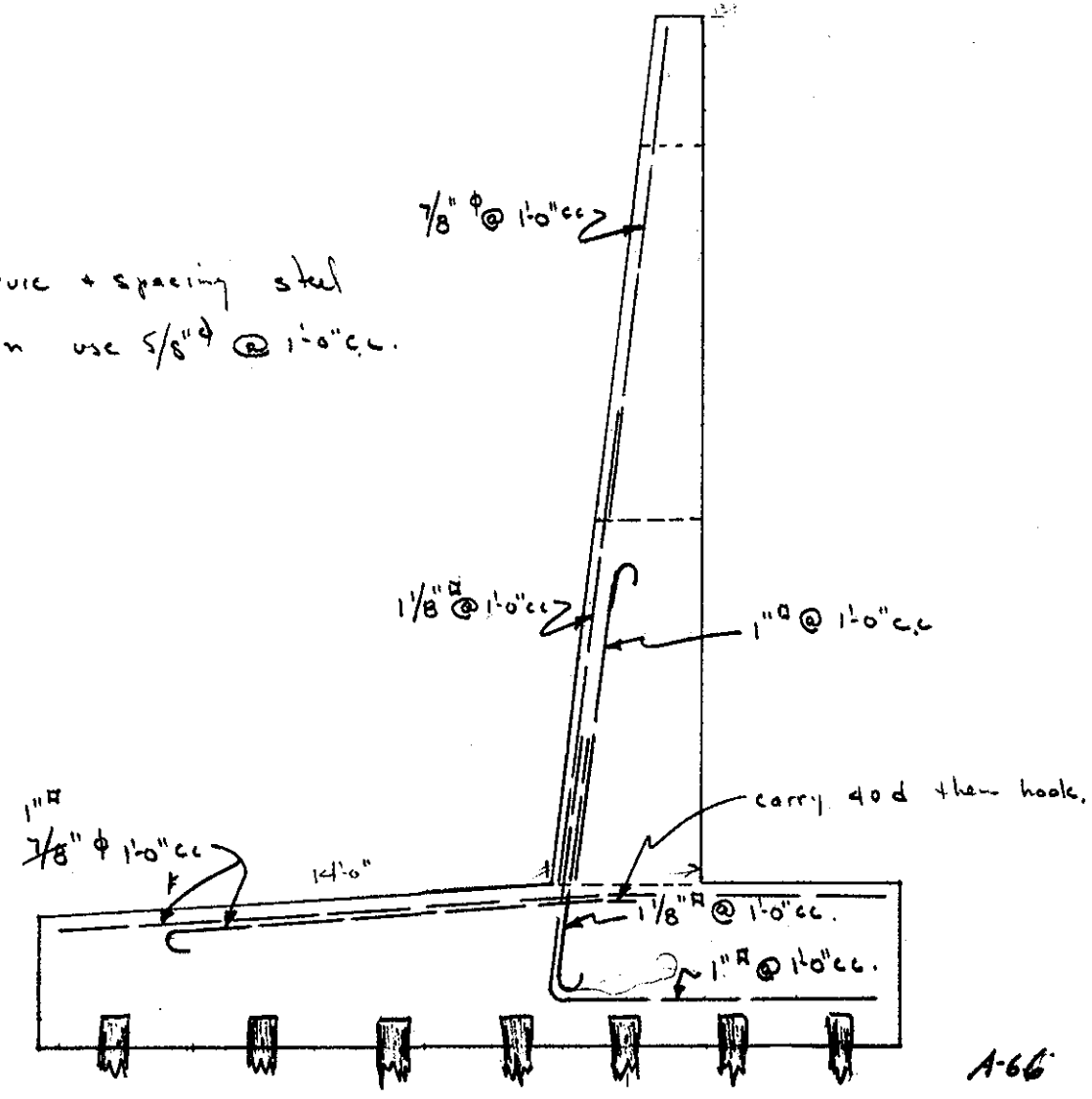
$C \quad (6)(5)(150) = 4500\ (3) = 13,500$

$P_1 = (10,750)(4.33) = 58,200$

$P_2 = (10,750)(1.08 =$

$\Sigma M = 44,700$

$d = 5 - 1 = 4.0'$ $\quad A_s = \dfrac{44,700}{1325 \times 44.5} = .75\ \square''$



A-66

See Section 5, Key Sketch

WAR DEPARTMENT

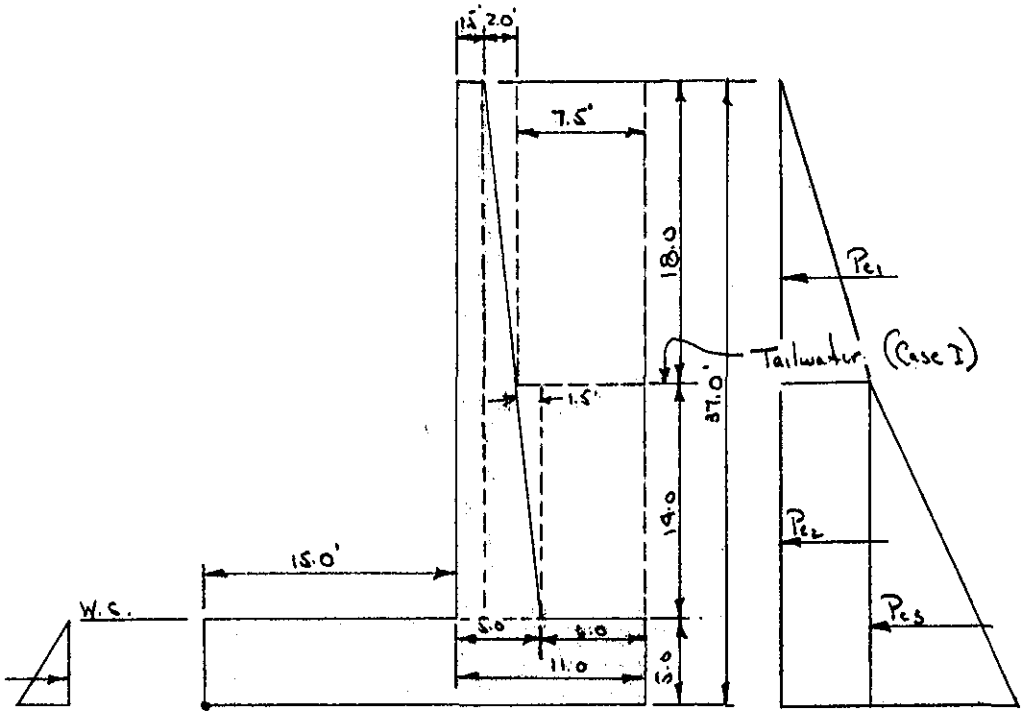
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

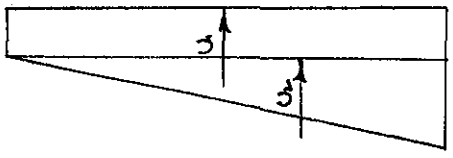
Subject Northampton

Computation Retaining Wall

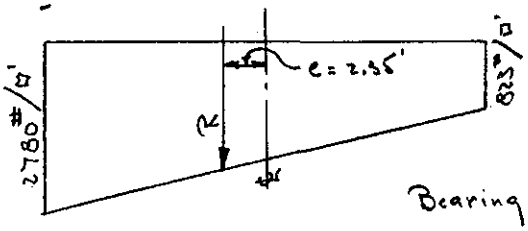
Computed by H.W.P. **Checked by** **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10528

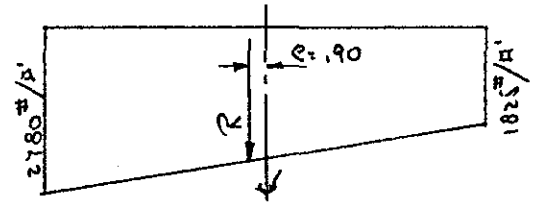




Uplift Diagram.



Bearing (Case I)



A-67

Subject Northampton

Computation Retaining Wall (Stability and Bearing (Case I)

Computed by _____ **Checked by** _____ **Date** _____

Case I (with 19' of Tailwater, 5' of flow in channel)

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↻	MOMENTS ABOUT A ↺
C_1	(32)(1.5)(150)	7,200				15.75	113,500	
C_2	(32)(3.5)(1/2)(150)	8,400				17.67	148,200	
C_3	(26)(5)(150)	19,500				13.0	253,000	
E_1	(18)(7.5)(100)	13,500				22.25	300,500	
E_2	(2)(18)(1/2)(100)	1800				17.73	31,900	
E_3	(6)(14)(125)	10,500				23.0	242,000	
E_4	(14)(1.5)(1/2)(125)	1310				19.5	25,600	
U_1	(26)(5)(62.5)		8120			13.0		105,500
U_2	(9)(26)(1/2)(62.5)		7320			17.33		127,000
P_w	$(5)^2(1/2)(62.5)$			782		1.67	1305	
P_{e1}	$(18)^2(1/2)(40)$				6480	25.0		162,000
P_{e2}	(18)(19)(40)				13,680	9.5		130,000
P_{e3}	$(19)^2(1/2)(83)$				14,960	6.33		94,700
		$\Sigma V = 46,770$		$\Sigma H = 34,338$			$\Sigma M = 496,805$	

Position of Resultant $= \frac{\Sigma M}{\Sigma V} = \frac{496,805}{46,770} = 10.65$

Eccentricity $= 13 - 10.65 = 2.35$

Bearing $\frac{46,770}{26}\left(1 \pm \frac{(6)(2.35)}{26}\right) = 2780\#/\square' \text{ \& } 823\#/\square'$

Subject _____

Computation Retaining Wall (Stability and Bearing) (Case II

Computed by _____ **Checked by** _____ **Date** _____

Case II (water down, no uplift)

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↻	MOMENTS ABOUT A ↺
C_1	See Case I							
C_2		35,100				—	514,700	
C_3								
E_1	(6)(32)(100)	19,200				23.0	442,000	
E_2	(3.5)(32)(1/2)(100)	5,600				18.83	105,500	
P_e	$(37)^2(1/2)(90)$				27,400	12.33		338,000
		$\Sigma V = 59,900$		$\Sigma H = 27,400$			$\Sigma M = 724,200$	

Position of Resultant $= \frac{\Sigma M}{\Sigma V} = \frac{724,200}{59,900} = 12.1$

Eccentricity $= 13 - 12.1 = .9$.

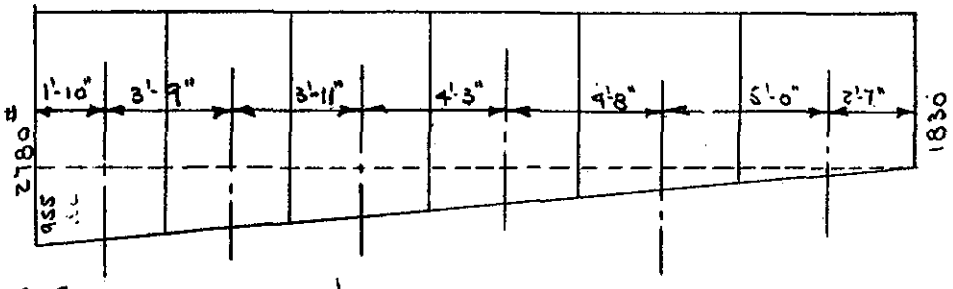
Bearing $= \frac{59,900}{26}\left(1 \pm \frac{(6)(.9)}{26}\right) = 2780\ \#/\square' \ \&\ 1830\ \#/\square'$

Subject Northampton
Computation Retaining Walls (Pile loading & Spacing)
Computed by H.J.P. **Checked by** **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10523

Assume 6 piles equally loaded then $\frac{59900}{6} = 10{,}000^{\#}$/pile.

Longitudinal spacing of piles $= \frac{40{,}000}{10{,}000} = 4'\text{-}0''$ c.c.



$\frac{955}{26} = 36.7$ Increment.

#1 $1830x + \frac{36.7}{2}x^2 = 10{,}000$

$x^2 + 99.8x - 545 = 0$

$x = \frac{-99.8 \pm \sqrt{99.8^2 + (4)(545)}}{2} = 5.2'$ $R = \frac{5.2}{2} = 2.6$ say 2'-7"

#2 $x^2 + 99.8x - (2)(545) = 0$

$x = -99.8 \pm \sqrt{99.8^2 + (4)(1090)} = 10.0 - 5.2 = 4.8$

$R = 10.0 - 2.4 = 7.6$ Say 7'-7" / 2'-7" / 5'-0"

#3 $x^2 + 99.8x - (3)(545) = 0$

$x = \frac{-99.8 \pm \sqrt{99.8^2 + 4(1635)}}{2} = 14.4 - 10 = 4.4$

$R = 14.4 - 2.2 = 12.2$ Say 12'-3" / 7'-7" / 4'-8"

#4 $x^2 + 99.8x - (4)(545) = 0$

$x = \frac{-99.8 \pm \sqrt{99.8^2 + 4(2180)}}{2} = 18.5 - 14.4 = 4.1$

$R = 18.5 - 2.05 = 16.45$ Say 16'-6" / 12'-3" / 4'-3"

A-70

Subject Northampton
Computation Retaining Walls (Pile loading + spacing, con.)
Computed by H.J.P. **Checked by** **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10528

#5 $x^2 + 99.8x + (5)(545) = 0$

$$x = \frac{-99.8 \pm \sqrt{99.8^2 + (4)(2725)}}{2} = 22.35 - 18.5 = 3.85$$

$R = 22.35 - 1.93 = 20.42$ say 20'-5"
16'-6"
3'-11"

#6 $x^2 + 99.8x + (6)(545) = 0$

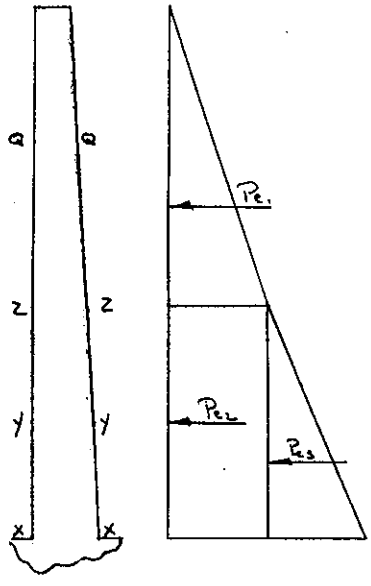
$$x = \frac{-99.8 \pm \sqrt{99.8^2 + 4(3270)}}{2} = 26 \text{ check.}$$

$R = 26 - 22.35 = 3.65$

$R = 26 - 1.83 = 24.17$ say 24'-2"
20'-5"
3'-9"

Subject Northampton
Computation Retaining Wall (Design of Stem Case I)
Computed by H.J.P. **Checked by** **Date**

U.S. GOVERNMENT PRINTING OFFICE 3—10528



At x-x

P_{e1} $(18)^2(1/2)(40) = 6480 \times 20 = 129{,}600$
P_{e2} $(18)(14)(40) = 10{,}100 \times 7 = 70{,}700$
P_{e3} $(14)^2(1/2)(83) = 8{,}150 \times 9.33 = 76{,}000$
$\Sigma H = 24{,}730$ $\Sigma M = 276{,}300$

$d = 18 + \frac{(32)(12)}{9} = 60.7''$ Say $60''$

$d' = \sqrt{\frac{276{,}300}{123}} = 47.3'' < 60$ OK.

$A_s = \frac{276{,}300}{1325 \times 55.5} = 3.76 \square''$

Unit Shear $\frac{24{,}730}{10.5 \times 60} = 39\#/\square'' < 60$ OK.

At y-y

P_{e1} $(18)^2(1/2)(40) = 6480 \times 13 = 84{,}750$
P_{e2} $(18)(7)(40) = 5050 \times 3.5 = 17{,}700$
P_{e3} $(7)^2(1/2)(83) = 2030 \times 4.66 = 9480$
ΣM $111{,}930$

$d = 18 + \frac{(25)(12)}{9} = 51''$ $A_s = \frac{111{,}930}{1325 \times 46.5} = 1.82 \square''$

At z-z

P_{e1} $(18)^2(1/2)(40) = 6480 \times 6 = 38{,}880$

$d = 18 + \frac{(18)(12)}{9} = 42''$ $A_s = \frac{38{,}880}{1325 \times 37.5} = .78 \square''$

At Q-Q

$P_{e1} = (8)^2(1/2)(40) = 1280 \times 5.33 = 6840$

$d = 18 + \frac{(8)(12)}{9} = 28.5$ $A_s = \frac{6840}{1325 \times 24} = .21 \square''$

WAR DEPARTMENT

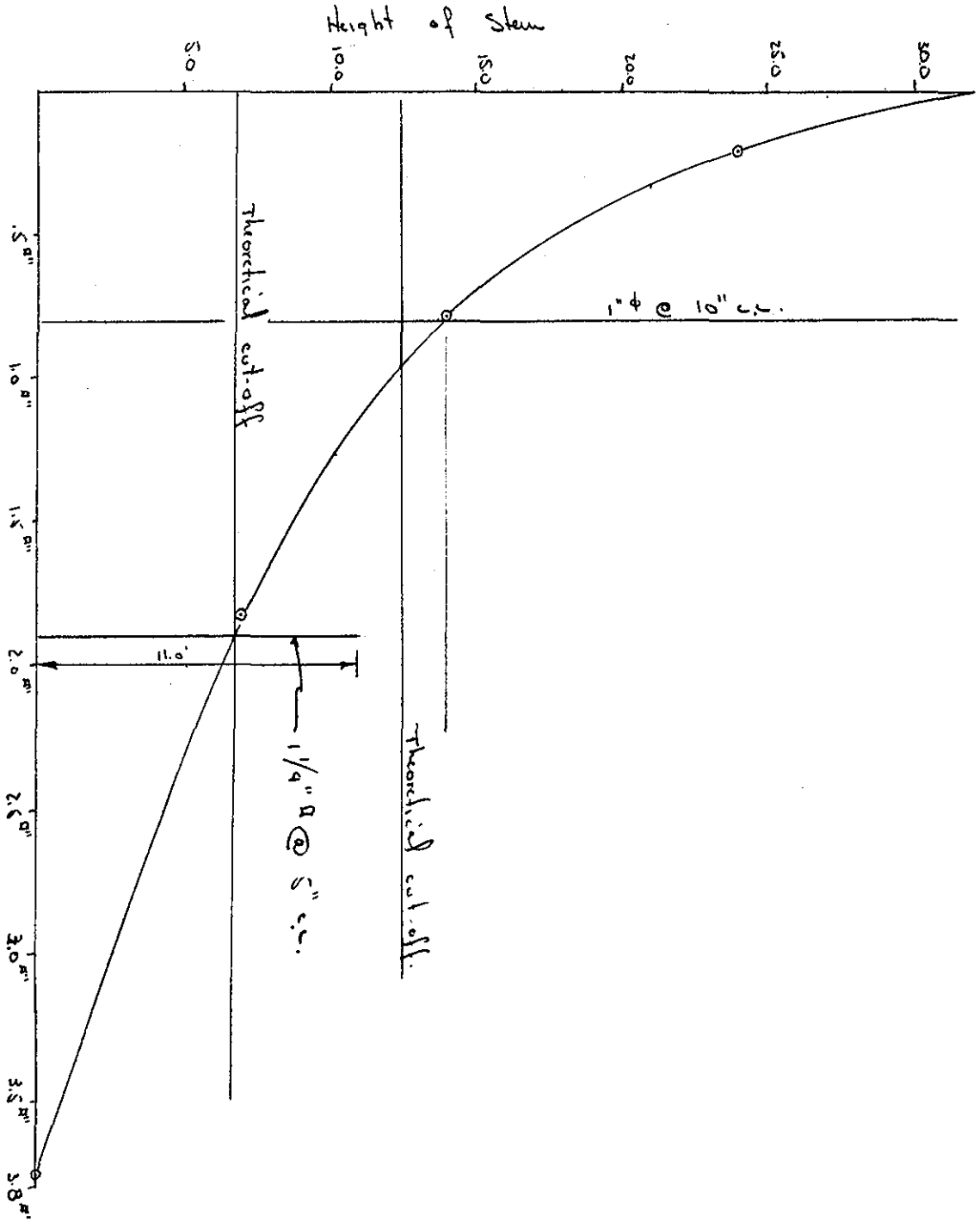
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Northampton

Computation Steel Curve for Stem

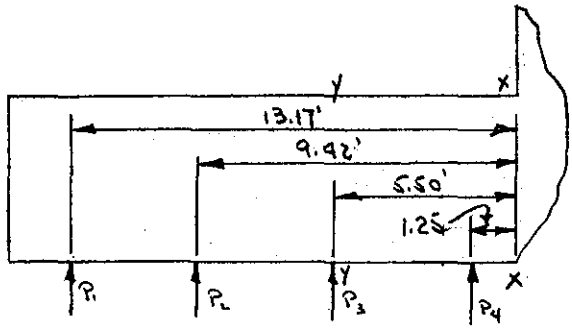
Computed by H. J. P. **Checked by** **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Subject: Northampton
Computation: Retaining Walls (Design of Toe) (Case II)
Computed by: H.J.P. Checked by: Date:

U. S. GOVERNMENT PRINTING OFFICE 3—10528



At x-x

C (15)(5)(150) = 11,250 × 7.5 = 84,500
P_1 = 10,000 × 13.17
P_2 10,000 × 9.42 = 293,400
P_3 10,000 × 5.50
P_4 10,000 × 1.25
ΣV = 28,750 ↑ ΣM = 208,900

$d = \sqrt{\frac{208900}{125}} = 41.2 < 60$ ok.

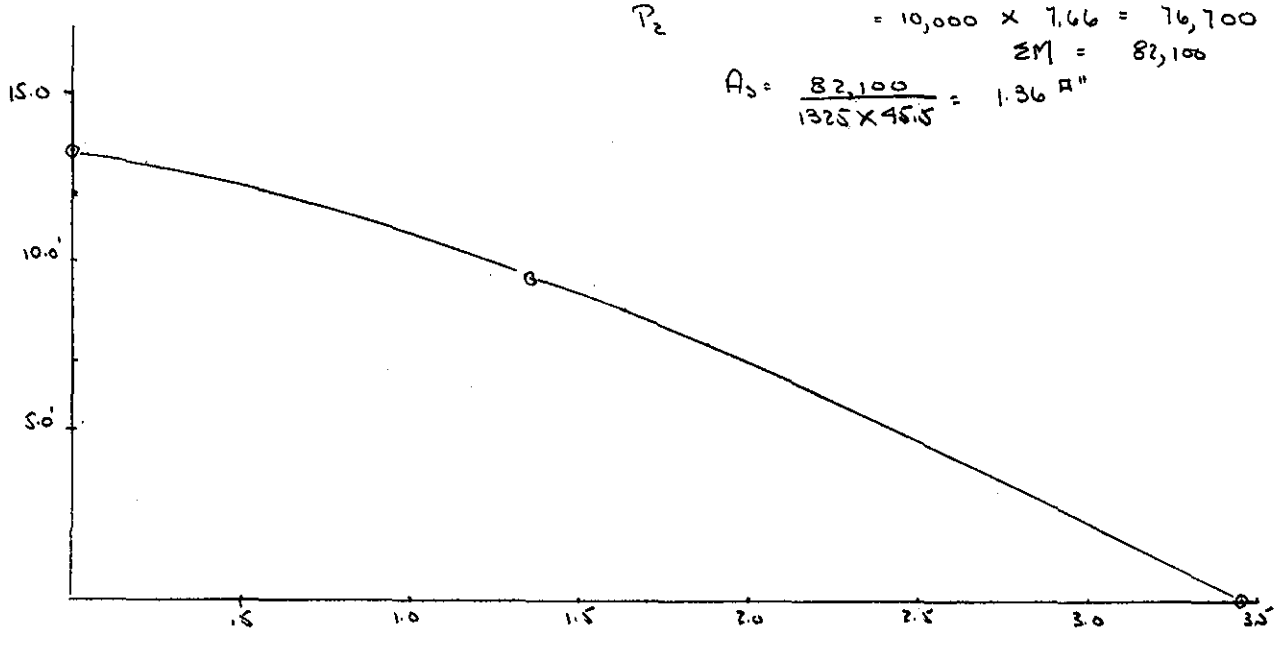
$A_s = \frac{208,900}{1325 \times 45.5} = 3.46$ □"

Unit Shear $= \frac{28,750}{10.5 \times 60} = 46$ #/□" < 60 ok.

At y-y

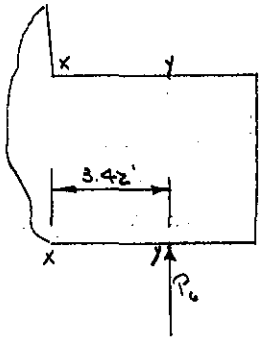
C = (9.5)(5)(150) = 7125 × 4.75 = - 33,800
P_1 = 10,000 × 3.92 = 39,200
P_2 = 10,000 × 7.66 = 76,700
ΣM = 82,100

$A_s = \frac{82,100}{1325 \times 45.5} = 1.36$ □"



Subject Northampton
Computation Retaining Wall (Design of Heel)
Computed by N.J.P. **Checked by** ..... **Date** .....

U. S. GOVERNMENT PRINTING OFFICE 3—10528



At x-x

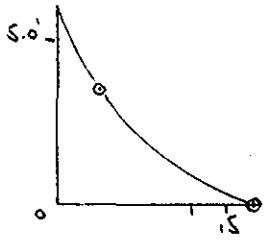
E_1	(6)(18)(100)	= 10,800	× 3.0	=	32,400
E_2	(6)(14)(125)	= 10,500	× 3.0	=	31,500
C_1	(6)(5)(150)	= 4500	× 3.0	=	13,500
P_6		= 10,000	× 3.42	=	−34,200
			ΣM	=	43,200

$$A_s = \frac{43,200}{1325 \times 55.5} = .59 \text{ □}''$$

At y-y

E_1	(258)(18)(100)	= 1800	× .79	
E_2	(258)(14)(125)	= 1750	× .79	
C_1	(258)(5)(150)	= 750	× .79	
	ΣM	(4300)(258)(.79)	=	8780

$$A_s = \frac{8780}{1325 \times 55.5} = .12 \text{ □}''$$



WAR DEPARTMENT

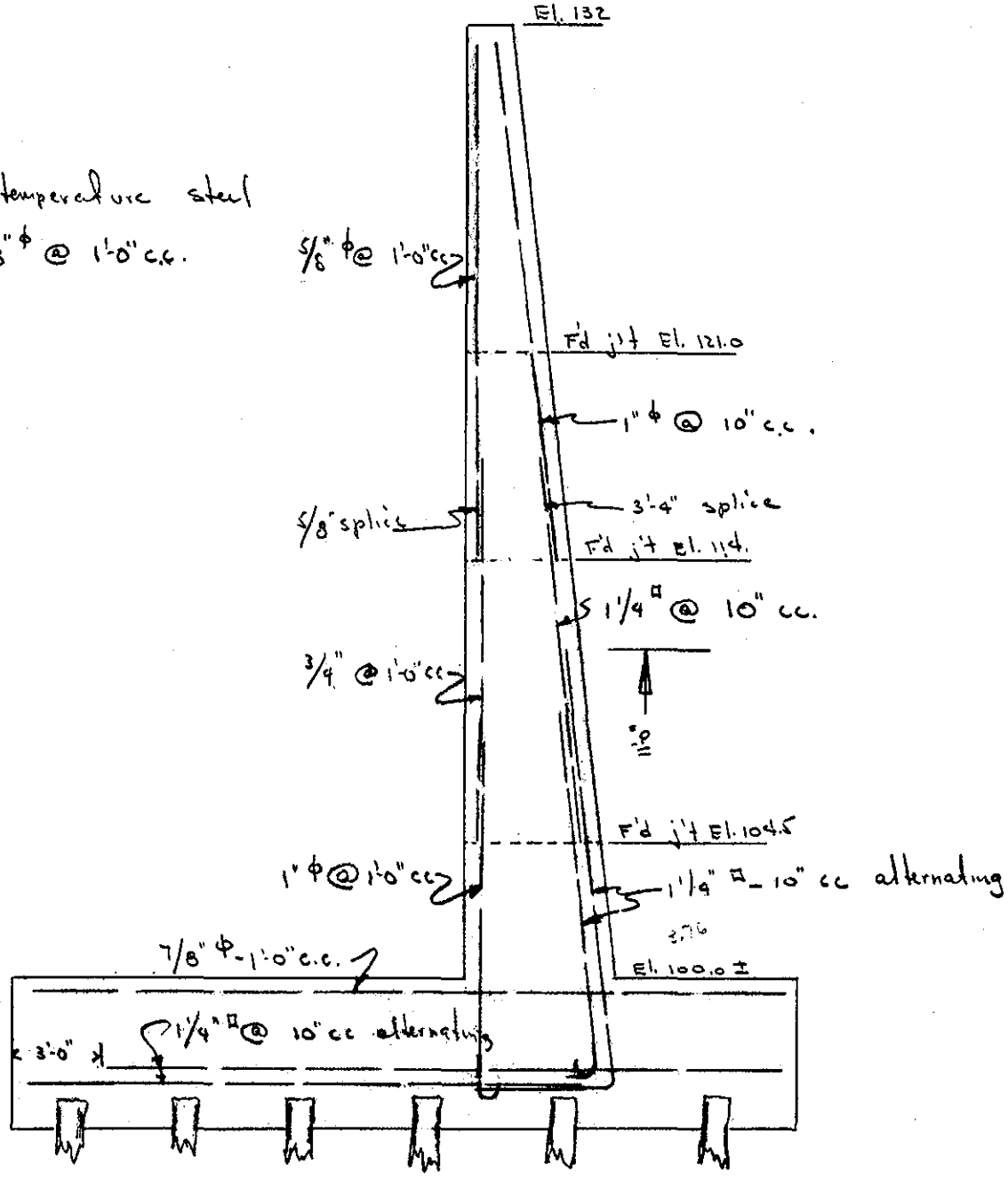
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Northampton

Computation Retaining Wall Steel Diagram

Computed by ..... **Checked by** ..... **Date** .....

U. S. GOVERNMENT PRINTING OFFICE 3—10528



A-76

See Section 6, Key Sketch

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

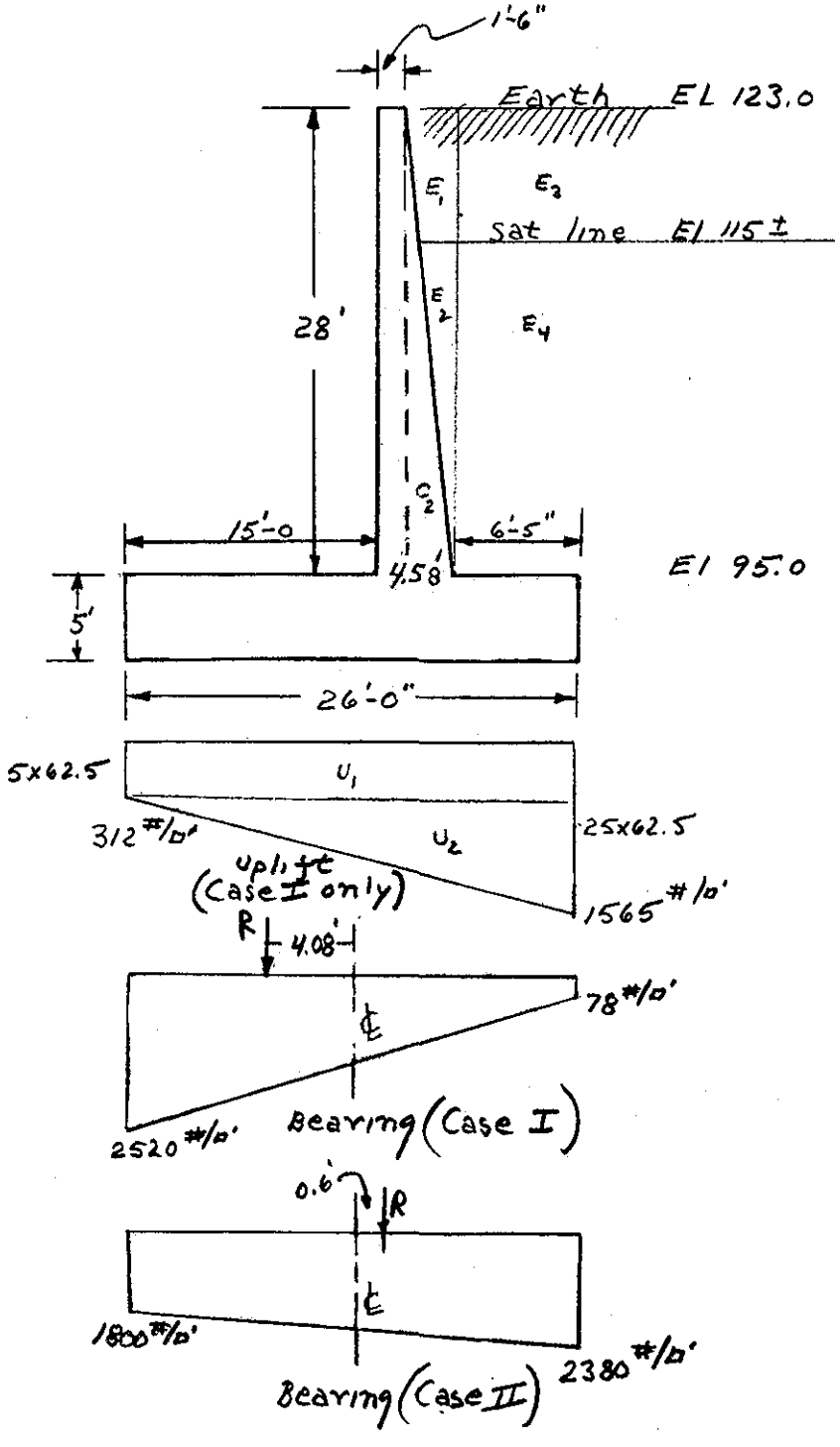
Page 3

Subject Northampton Mass

Computation Stability

Computed by M. S. Jr. Checked by Date 5/2/39

U. S. GOVERNMENT PRINTING OFFICE 3—10628



A-77

Subject

Computation

Computed by Checked by Date

Case I – Saturated fill

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↻	MOMENTS ABOUT A ↺
C_1	(1.5)(28)(150)	6300				10.25		64500
C_2	(3)(28)(½)(150)	6300				7.50		47,250
C_3	(5)(26)(150)	19500				13.0		254,000
E_1	(2.58)(8)(100)	2060				7.71		15,900
E_2	(2.18)(20)(125)(½)	2720				7.14		19,400
E_3	(8)(6.42)(100)	5130				3.21		16,450
E_4	(6.42)(20)(125)	16,000				3.21		51,250
P_e	$(8)^2(\frac{1}{2})(46)$				1280	27.67		35,400
P_{es}	(8)(40)(25)				8000	12.5		100,000
P_{we}	(25)(½)(83)				25900	8.33		216,000
U_1	(312)(26)		8100			13.0	105,000	
U_2	(253)(½)(26)		16,300			8.66	141,000	
	Wall can't slide due to slab in river bottom.			→ 35,180				
		58,010	24,400	35,180	35,180		246,000	820,150
		ΣV = 33,610#		ΣH = 0			ΣM = 574,150	

Position of Resultant $= \frac{\Sigma M}{\Sigma V} = 17.08'$ O.K. – Middle third = 17.33'

Eccentricity $= \frac{26}{2} - 17.08 = -4.08'$

Bearing $= \frac{33,610}{26}\left(1 \pm \frac{6 \times 4.08}{26}\right) = 1300 \begin{cases} 1.94 = 2520 \ \#/\square' \\ .06 = 78 \ \#/\square' \end{cases}$

A-78

Subject

Computation

Computed by Checked by Date

Case II Dry fill

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↷	MOMENTS ABOUT A ↶
C_1		6300						64,500
C_2		6300						47,250
C_3		19500						254,000
E_1+E_2	$(28)(3)(\frac{1}{2})(100)$	4200				3.21		13,500
E_3+E_4	$(6.42)(28)(100)$	18000				3.21		57,800
P_e	$(33^2)(\frac{1}{2})(40)$				21,800	11.0		240,000
		54,300		21,800	21,800			
		$\Sigma V = 54,300$		$\Sigma H = 0$			$\Sigma M = 677,050$	

Position of Resultant $\Big\} = \frac{\Sigma M}{\Sigma V} = 12.4'$ O. K.

Eccentricity $= \frac{26}{2} - 12.4 = 0.6'$

Bearing $= \frac{54,300}{26}\left(1 \pm \frac{6 \times .6}{26}\right) = 2090 \begin{cases} 1.138 = 2380\ \#/\square' \\ .862 = 1800\ \#/\square' \end{cases}$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 6

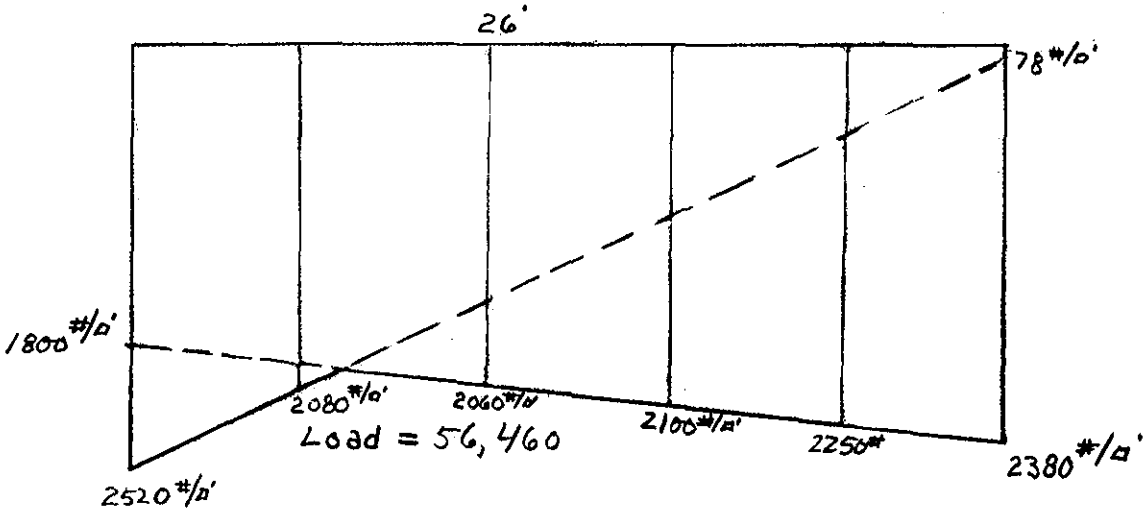
Subject Northampton Mass

Computation Pile Spacing

Computed by M. S. Jr. Checked by ..... Date 5/2/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Combined Bearings

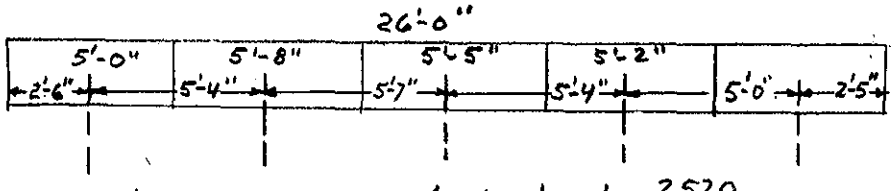


This gives max. pile loading for both cases.

Pile load = 20 Tons = 40,000#

Assume 5 piles per row

$\frac{56,460^{\#}}{5} = 11,300^{\#}$ $\frac{40,000}{11,300} = 3.52'$ Say 3'-6" between rows



1st pile carries 5' of load $\begin{array}{r} 2520 \\ 2080 \\ \hline 4600 \end{array} \div 2 = 2300 \times 5 \times 3.5 = 40,000^{\#}$ O.K

2nd pile carries 5'-8" of load $2000 \times 5.67 \times 3.5 = 39,800^{\#}$ O.K.

3rd pile carries 5'-5" of load $\begin{array}{r} 2100 \\ 2060 \\ \hline 4160 \end{array} \div 2 = 2080 \times 5.41 \times 3.5 = 39,500^{\#}$ O.K.

4th pile carries 5'-2" of load $\begin{array}{r} 2100 \\ 2250 \\ \hline 4350 \end{array} \div 2 = 2175 \times 5.16 \times 3.5 = 39,400^{\#}$ O.K.

5th pile carries 4'-10" of load $\begin{array}{r} 2250 \\ 2380 \\ \hline 4630 \end{array} \div 2 = 2315 \times 4.83 \times 3.5 = 39,200^{\#}$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

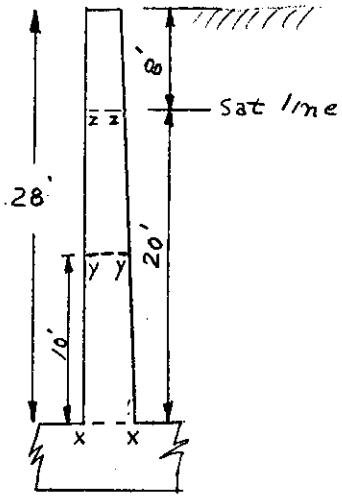
Page 7

Subject: Northampton Mass

Computation: Stem Design

Computed by: W. S. J. Checked by: Date: 5/2/39

U. S. GOVERNMENT PRINTING OFFICE 3—10598



Width at x-x = 4.58'

4.58' = 55," Less 3" Cover = 52" d

Mom at x-x

$(8^2)(\frac{1}{2})(40) = 1280^{\#} \times 22.67' = 29,000'^{\#}$

$(8)(40)(20) = 6400^{\#} \times 10.0' = 64,000'^{\#}$

$(20^2)(\frac{1}{2})(83) = 16,600^{\#} \times 6.67' = 111,000'^{\#}$

$24,280'^{\#}$ $204,000'^{\#}$

$$\text{Shear} = \frac{24.280}{12 \times .884 \times 52} = 44^{\#}/\square'' \quad \text{O.K.}$$

$$A_s = \frac{204,000 \times 12}{18000 \times .884 \times 52} = 2.96^{\square''}$$

Use $1\frac{1}{4}''\square$ @ 6" c.c.

$$\text{Bond} = \frac{24,280}{10 \times .884 \times 52} = 52.8^{\#}/\square'' \quad \text{O.K.}$$

Mom at y-y

$(8^2)(\frac{1}{2})(40) = 1280^{\#} \times 12.67 = 16,200'^{\#}$

$(8)(40)(10) = 3200^{\#} \times 5.0 = 16,000'^{\#}$

$(10^2)(\frac{1}{2})(83) = 4150^{\#} \times 3.33 = 13,800'^{\#}$

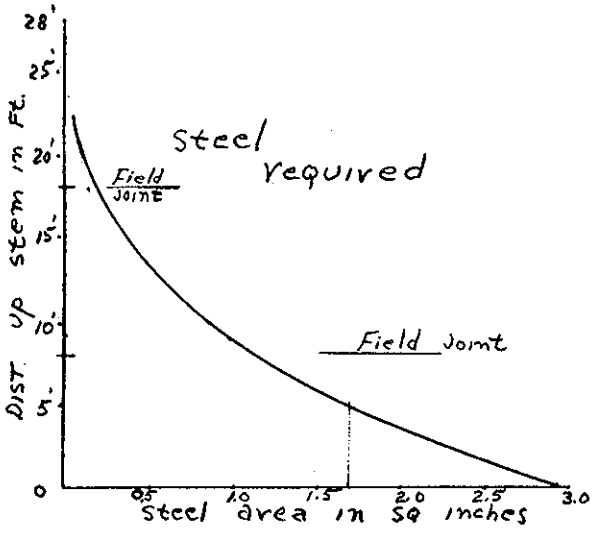
$8,630^{\#}$ $46,000'^{\#}$

$$A_s = \frac{46,000 \times 12}{18000 \times .884 \times 39} = .89^{\square''}$$

Mom at z-z

$(8^2)(\frac{1}{2})(40) = 1280^{\#} \times 2.67 = 3,420'^{\#}$

$$A_s = \frac{3,420 \times 12}{18000 \times .884 \times 26} = .1^{\square''}$$



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 8

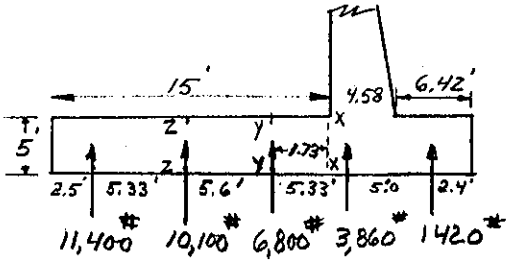
Subject: Northampton Mass

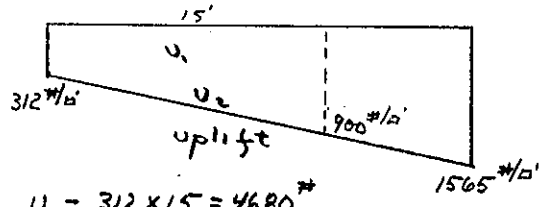
Computation: Base Design

Computed by: M.S.J. Checked by: Date: 5/3/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Riverside Base – Case I Governs





$U_1 = 312 \times 15 = 4680^{\#}$

$U_2 = \frac{900-312}{2} \times 15 = 8820^{\#}$

Mom at x-x

P_3	6,800#	× 1.73	=	11,750'#
P_2	10,100#	× 7.33	=	74,000'#
P_1	11,400#	× 12.66	=	144,000'#
U_1	4,680#	× 7.5	=	35,000'#
U_2	8,820#	× 5.0	=	44,000'#
	41,800#↑			308,750'# ↻
C	11,200#↓	× 7.5	=	84,000'# ↺
	ΣV = 30,600#↑			ΣM = 224,750'# ↻

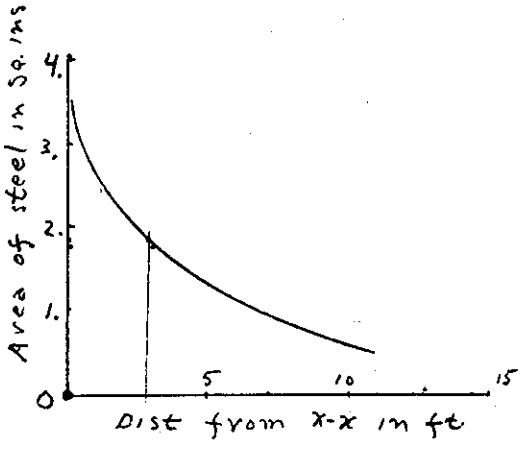
$$\text{Shear} = \frac{30,600}{12 \times .884 \times 45} = 65^{\#/\square''} \quad \text{O.K.}$$

$$d = \sqrt{\frac{224,000}{123}} = 42.3'' \qquad 45'' \text{ O.K.}$$

$$A_s = \frac{224,000 \times 12}{18000 \times .884 \times 45} = 3.75^{\square''}$$

Use $1\frac{1}{4}''^{\square}$ @ $4\frac{1}{2}''$ c.c.

$$\text{Bond} \quad \frac{30,600}{13.3 \times .884 \times 45} = 59^{\#/\square''}$$



Mom at y-y

P_2	= 10,100#	× 5.6	=	56,500'#
P_1	= 11,400#	× 10.9	=	124,300'#
U_1	= 4180	× 6.7	=	28,000'#
U_2	= 7900	× 4.5	=	35,600'#
	33,580			244,400'#
C	= 10,000	× 6.7	=	67,000'#
	ΣV = 23,580#			ΣM = 177,400'#

$$A_s = \frac{177,400 \times 12}{18000 \times .884 \times 45} = 2.96^{\square''}$$

Mom at z-z

P_1	= 11,400	× 5.33	=	60,800'#
U_1	= 2,440	× 3.91	=	9,550'#
U_2	= 2,540	× 2.61	=	6,620'#
	16,380			77,050'#
C	= 5,860	× 3.91	=	22,900'#
	$A_s = .9^{\square''}$			54,150'#

A-82

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 9

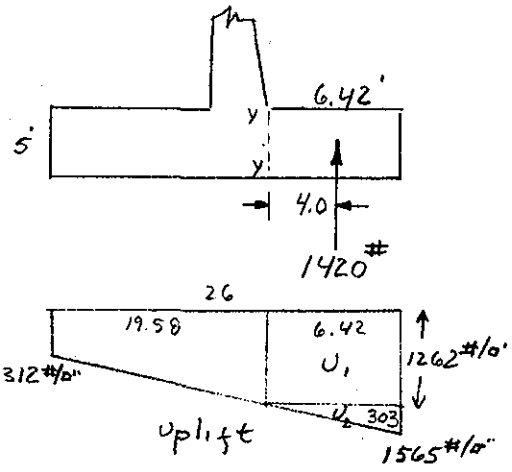
Subject Northampton Mass

Computation Base Design

Computed by M.S.P. Checked by Date 5/3/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Landside Base – Case I Governs



$$\begin{array}{r} 1565 \\ 312 \\ \hline 1253 \end{array} \times \frac{19.58}{26} = \begin{array}{r} 950 \\ 312 \\ \hline 1262 \end{array}$$

$1565 - 1262 = 303$

$U_1 = 1262 \times 6.42 = 8{,}100^{\#}$

$U_2 = 303 \times 6.42 \times \frac{1}{2} = 972^{\#}$

Mom Y-Y

$E_3 = (8)(6.42)(100) = 5130 \times 3.21 = 16{,}500'^{\#}$

$E_4 = (20)(6.42)(125) = 16{,}000 \times 3.21 = 51{,}300'^{\#}$

$C = (5)(6.42)(150) = 4800 \times 3.21 = 15{,}400'^{\#}$

$25{,}930^{\#} \qquad 83{,}200'^{\#}$

Pile $1420 \times 4 = 5680$

U_1 $8100 \times 3.21 = 26{,}000$

U_2 $972 \times 4.3 = 4180$

$10{,}492 \qquad 35{,}860$

$\Sigma = 15{,}438^{\#}\downarrow \qquad 47{,}340'^{\#}$

$$A_s = \frac{47{,}340 \times 12}{18000 \times .884 \times 45} = .79\ \square''$$

1" ϕ @ 12" c.c.

$$\text{Bond} = \frac{15{,}438}{3.14 \times .884 \times 45} = 124\ ^{\#}/\square''$$ O.K.

Shear O.K

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

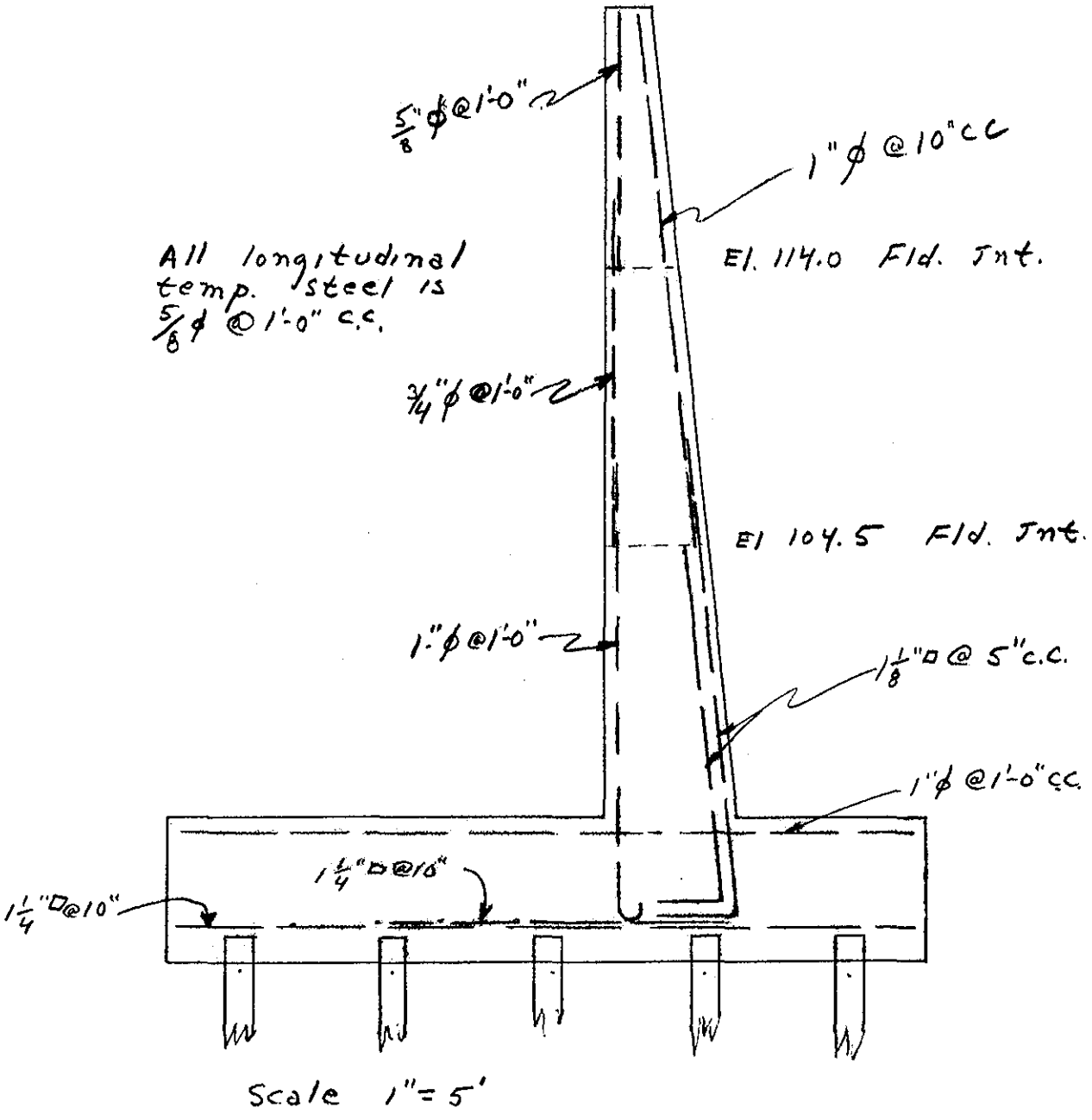
Page 10

Subject Northampton Mass

Computation Designed Section

Computed by W. S. P. Checked by Date May 1939

U. S. GOVERNMENT PRINTING OFFICE 3—10528



A-84

See Section 7, Key Sketch

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 1

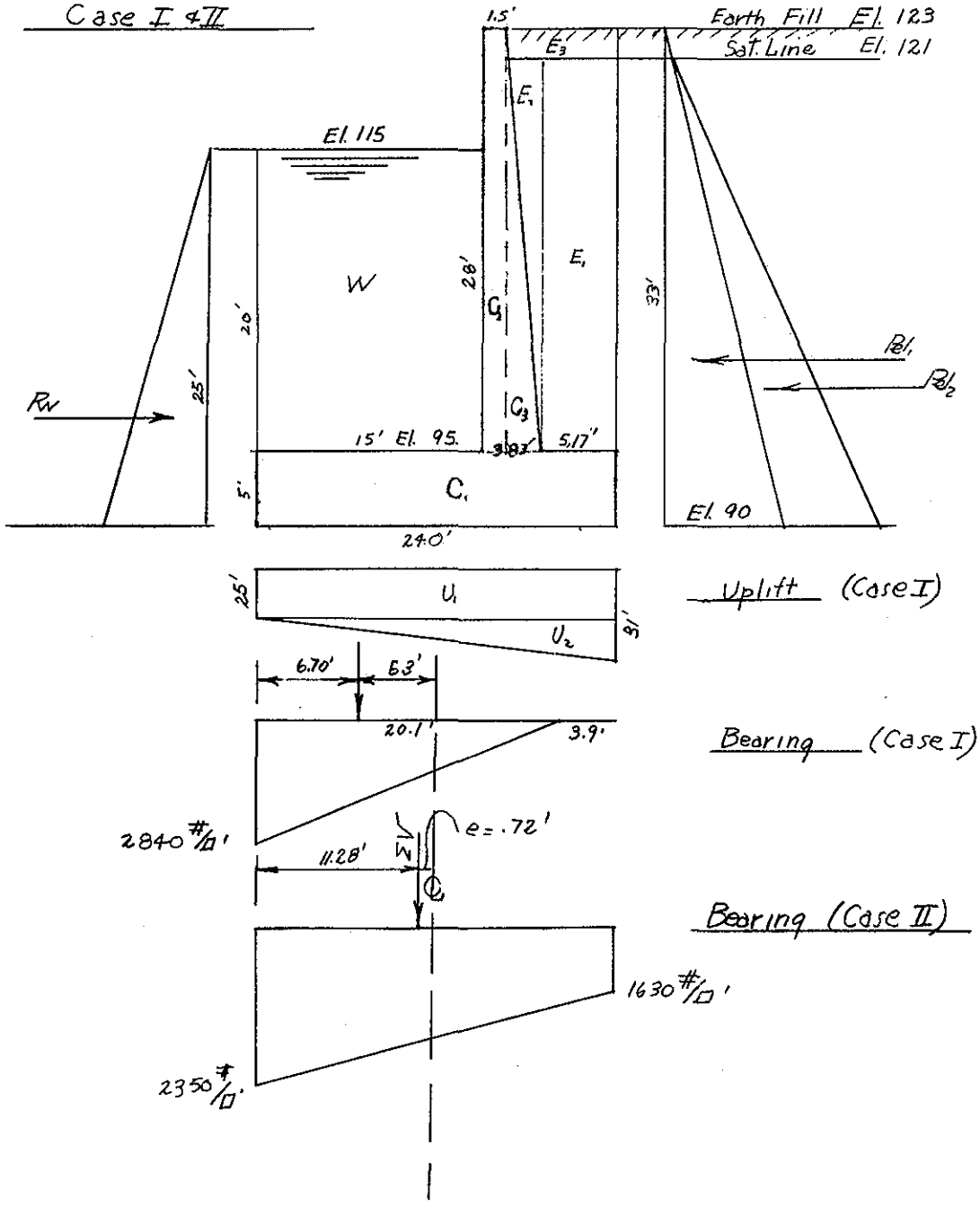
Subject: Northampton

Computation: Stability & Steel Design

Computed by: R.H.M. Checked by: Date: 5-3-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Case I & II



Subject Northampton

Computation Stability - Case I - Water up on riverside

Computed by R.H.M. Checked by _____ Date _____

Case I - Water up on Riverside

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↻	MOMENTS ABOUT A ↺
C_1	5x24x150	18750				12.00	225000	
C_2		6300				15.75	99230	
C_3		4890				17.28	84500	
E_1	26x5.17x125	16800				21.41	359690	
E_2	26x2.17x½x125	3530				18.11	63930	
E_3	2x7.42x100	1480				20.29	30030	
W	20x15x62.5	18750				7.50	140630	
P_w	23^2x½x62.5			19560		8.33	162930	
P_{e1}					21780	11.00		239580
P_{e2}	31^2x½x(83-40)				20660	10.33		213420
U_1	25x24x62.5		37500			12.00		450000
U_2	6x24x½x62.5		4500			16.00		72000
		70500	42000	19560	42440			
	ΣV=	28500	ΣH	22880				
		70500	42000				1,165900	975000
		ΣV=28500#↓		ΣH=			ΣM= 190900 '#↻	

$$\text{Position of Resultant} = \frac{\Sigma M}{\Sigma V} = \frac{190900}{28500} = 6.70'$$

$\frac{1}{3}$ Base = 8'

$e = 12 - 6.70 = 5.3'$

$$B.P. = \frac{28500}{3 \times 6.70}\begin{pmatrix}2\\0\end{pmatrix} = \frac{28500}{20.1}\begin{pmatrix}2\\0\end{pmatrix} = 1420 \begin{cases} 2 = 2840\ \#/\square'\ P.B.R \\ 0 = 0\ \#/\square'\ P.B.L \end{cases}$$

Subject Northampton Mass

Computation Stability = Case II - Water down; dry earth on landside

Computed by R.H.M. **Checked by** _____ **Date** _____

Case II - Water down

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↻	MOMENTS ABOUT A ↺
C_1	5X24X150	18750				12.00	225000	
C_2	1.5X28X150	6300				15.75	99230	
C_3	2.33X½X28X150	4890				17.28	84500	
E_1	5.17X28X100	14480				21.41	310020	
E_2	2.33X½X28X100	3260				18.05	58840	
Pel	33^2X½X40				21780	11.00		239580
	ΣV=	47680		ΣH=	21780			
		47680	0				777590	239580
		ΣV=47680 #↓		ΣH=			ΣM= 538000 '# ↻	

$\frac{1}{3}$ Base = 8.00'

$$\text{Position of Resultant} = \frac{\Sigma M}{\Sigma V} = \frac{538000}{47680} = 11.28' \qquad e = 12 - 11.28 = .72'$$

$$B.P. = \frac{47680}{24}\left(1 \pm \frac{6 \times .72}{24}\right) = 1990(1 \pm .18) = 1990 \begin{cases} 1.18 = 2350\ \#/\square' \text{ P.BR} \\ .82 = 1630\ \#/\square' \text{ P.BL} \end{cases}$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

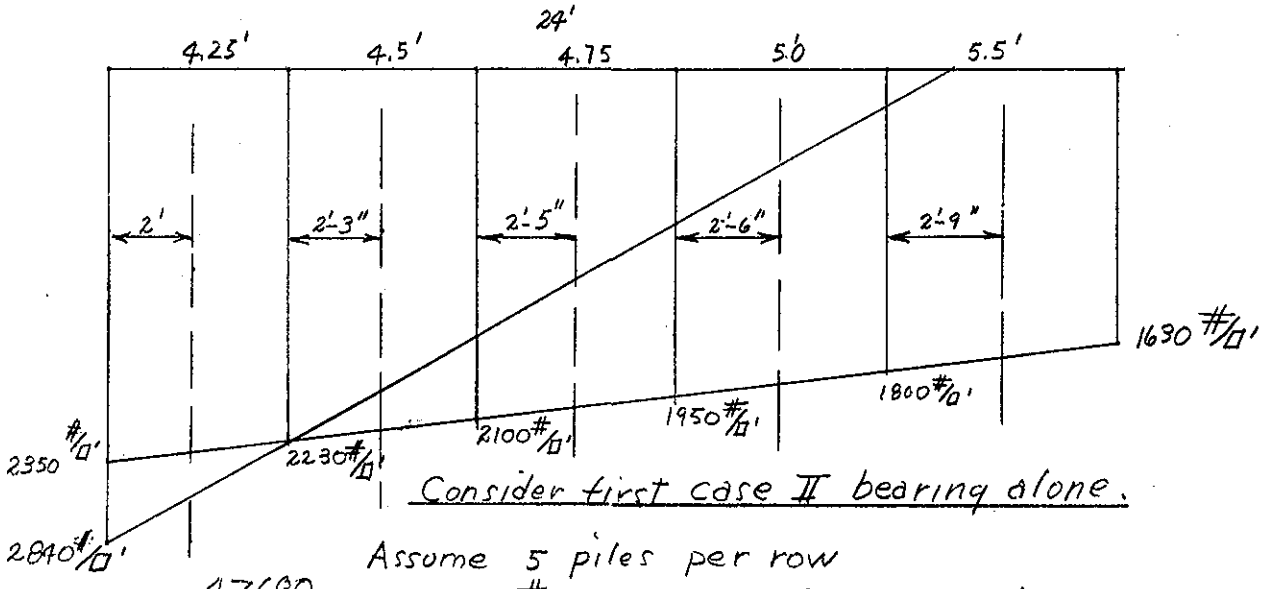
Page 4

Subject: Northampton

Computation: Pile loading & spacing

Computed by: R.H.M. Checked by: Date:

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Consider first case II bearing alone.

Assume 5 piles per row

$\frac{47680}{5} = 9540$ #/pile for one foot of wall

$\frac{40,000}{9540} = 4.19'$ call it 4' between rows of piles

(1) 2350
2230
2 | 4580
2290 × 4.25 × 4 = 38930# OK for 1st pile

(2) 2230
2100
2 | 4330
2165 × 4.5 × 4 = 38970 # OK for sec. pile

(3) 2100
1950
2 | 4050
2025 × 4.75 × 4 = 38480 # OK for 3rd pile

(4) 1950
1800
2 | 3750
1875 × 5.00 × 4 = 37500 # OK for 4th pile

(5) 1800
1630
2 | 3430
1715 × 5.5 × 4 = 37730 # OK for 5th pile

Subject: Northampton
Computation: Pile loading & spacing
Computed by: R.H.M. Checked by: Date:

U. S. GOVERNMENT PRINTING OFFICE 8—10528

We must now consider effect of Case I. bearing on 1st pile

$$\begin{array}{r} 2840 \\ 2230 \\ \hline 2\,\big)\,5070 \\ \hline 2535 \end{array} \times 4.25 \times x = 40000^{\#}$$

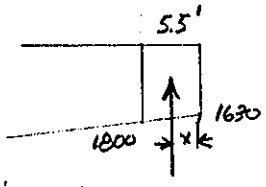
$$x = \frac{40000}{2535 \times 4.25} = \frac{40000}{10770} = 3.71' \quad \text{Use } 3.5' \text{ between rows}$$

instead of 4' The various pile loads then become as follows

1) $2535 \times 4.25 \times 3.5 = 37700^{\#}$
2) $2165 \times 4.50 \times 3.5 = 34100^{\#}$
3) $2025 \times 4.75 \times 3.5 = 33700^{\#}$
4) $1875 \times 5.00 \times 3.5 = 32800^{\#}$
5) $1715 \times 5.50 \times 3.5 = 33000^{\#}$

<u>To find points of application for pile loads</u>

Use formula for center of gravity of trapezoid.

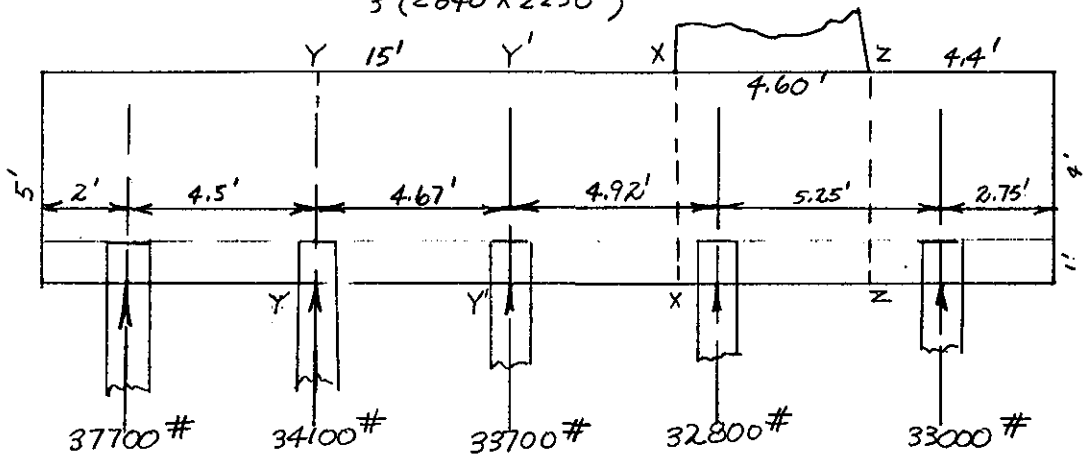


1) for pile #5 $x = \frac{5.5(1630 + 2 \times 1800)}{3(1630 + 1800)} = 2.80'$

$\frac{5.5}{2} =$ 2.75' or 2.80' This is close enough for our purpose save perhaps for extreme riverside pile.

2) pile #4 : $\frac{5}{2} = 2.5'$ 3) pile #3 : 2.38' 4) pile #2 : 2.25'

5) Pile #1 $x' = \frac{4.25(2840 + 2 \times 2230)}{3(2840 \times 2230)} = 2.04'$ call it 2'



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Northampton

Computation: Design of Transverse Base Steel

Computed by: R.H.M. Checked by: Date:

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Section at x---x (Case II)

C_1 : $5 \times 15 \times 150 = 11250 \times 7.5 = 84380$ '#

pile #1 : $\frac{37700}{3.5} = 10770 \times 13.0 = 140010$

pile #2 : $\frac{34100}{3.5} = 9740 \times 8.5 = 82790$

pile #3 : $\frac{33700}{3.5} = 9630 \times 3.83 = 36880$

$\Sigma V = 18890$ #, $\Sigma M = 175300$ '#

$d = \sqrt{\frac{175300}{123}} = \sqrt{1430} = 37.9''$ OK.

Use $48 - 4.5 = 43.5''$

Shear $= \frac{18890}{12 \times .884 \times 43.5} = \frac{18890}{461} = 41$ #/□" OK.

$A_s = \frac{12 \times 175300}{18000 \times .884 \times 43.5} = \frac{2{,}103{,}600}{691700} = 3.04$ □" Case I governs

Section Y---Y

C_1 : $5 \times 6.5 \times 150 = 4880 \times 3.25 = 15860$ '#

pile #1 : $= 10770 \times 4.5 = 48470$ '#

$\Sigma M = 32610$ '#

$A_s = \frac{12 \times 32610}{18000 \times .884 \times 43.5} = \frac{391300}{691700} = .57$ □" Case I governs

Section z---z (Water down)

C_1 : $4.4 \times 5 \times 150 = 3300 \times 2.2 = 7260$ '#

E_1 $4.4 \times 28 \times 100 = 12320 \times 2.2 = 27100$ '#

Pile #5 : $\frac{33000}{3.5} = 9430 \times 1.65 = 15560$ '#

$\Sigma M = 18800$ '#

$A_s = \frac{12 \times 18800}{18000 \times .884 \times 43.5} = \frac{225600}{691700} = .33$ □" Case I governs

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Northampton

Computation Design of Transverse Base Steel

Computed by R.H.M. **Checked by** **Date**

U.S. GOVERNMENT PRINTING OFFICE 8—10528

Investigation of Case I — Case I Governs

Section at x---x

C_1 : $5 \times 15 \times 150 = 11250 \times 7.5 = 84380$ '#

W : $20 \times 15 \times 62.5 = 18750 \times 7.5 = 140630$ '#

30000 #↓ 225000 '#

U_1 : $25 \times 15 \times 62.5 = 23440 \times 7.5 = 175800$ '#

U_2 : $\frac{5}{8} \times 6 \times 15 \times \frac{1}{2} \times 62.5 = 1760 \times 5 = 8800$ '#

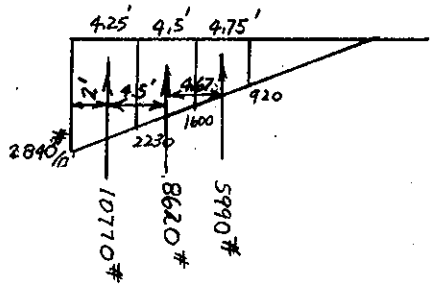
Pile #1 : $\frac{37700}{3.5} = 10770 \times 13 = 140010$ '#

Pile #2 : $= 8620 \times 8.50 = 73270$ '#

Pile #3 : $= 5990 \times 3.83 = 22940$ '#

50580 #↑ 420800 '#

$\Sigma V = 20580$ #↑ $\Sigma M = 195800$ '#



$$d = \sqrt{\frac{195800}{123}} = \sqrt{1590} = 40'' \text{ OK. Use } 48 - 3.5 = 44.5''$$

$$\text{Shear} = \frac{20580}{12 \times .884 \times 44.5} = \frac{20580}{472} = 44\ \#/\square'' \text{ OK}$$

$$A_s = \frac{12 \times 195800}{18000 \times .884 \times 44.5} = \frac{2{,}349{,}600}{707550} = 3.32\ \square''$$

Section Y---Y

C_1 : $5 \times 6.5 \times 150 = 4880 \times 3.25 = 15860$ '#

W : $20 \times 6.5 \times 62.5 = 8130 \times 3.25 = 26420$ '#

42280 '#

U_1 : $25 \times 6.5 \times 62.5 = 10160 \times 3.25 = 33020$ '#

U_2 : $\frac{6.5}{24} \times 6 \times \frac{1}{2} \times 6.5 \times 62.5 = 330 \times 2.17 = 720$ '#

Pile #1 : $\frac{37700}{3.5} = 10770 \times 4.5 = 48470$ '#

82210 '#

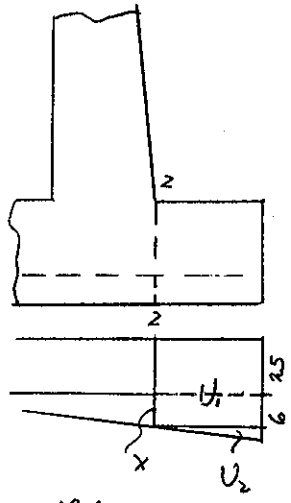
$\Sigma M = 39930$ '#

$$A_s = \frac{12 \times 39930}{18000 \times .884 \times 44.5} = \frac{479160}{707550} = .68\ \square''$$

Subject Northampton
Computation Transverse Base Steel
Computed by R.H.M. **Checked by** **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Section 2 - - 2 (Case I) Top Steel



C_1 : 4.4 X 5 X 150 = 3300 X 2.2 = 7260 '#

E_1 : 4.4 X 26 X 125 = 14300 X 2.2 = 31460 '#

E_2 : 4.4 X 2 X 100 = 880 X 2.2 = 1940 '#

40660 '#

U_1 : 29.9 X 4.4 X 62.5 = 8220 X 2.2 = 18080 '#

U_2 : 1.1 X 4.4 X $\frac{1}{2}$ X 62.5 = 147 = 150 '#

18230 '#

ΣM = 22430 '#

$$A_s = \frac{12 \times 22430}{18000 \times .884 \times 43.5} = \frac{269160}{691700} = .39 \square''$$

$$x = \frac{19.6}{24} \times 6 = 4.9'$$

Section Y' - - Y' (Another section on riverside thought necessary)

C_1 : 5 X 11.17 X 150 = 8380 X 5.59 = 46840 '#

W = 20 X 11.17 X 62.5 = 13960 X 5.59 = 78040 '#

124880

U_1 : 25 X 11.17 X 62.5 = 17450 X 5.59 = 97550 '#

U_2 : $\frac{11.17}{24}$ X 6 X 11.17 X $\frac{1}{2}$ X 62.5 = 975 X 3.72 = 3630 '#

pile #1 : $\frac{37700}{3.5}$ = 10770 X 9.17 = 98760 '#

pile #2 = 8620 X 4.67 = 40260 '#

240200 '#

ΣM = 115320 '#

$$A_s = \frac{12 \times 115320}{18000 \times .884 \times 44.5} = \frac{1,383,800}{707550} = 1.96 \square''$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 9

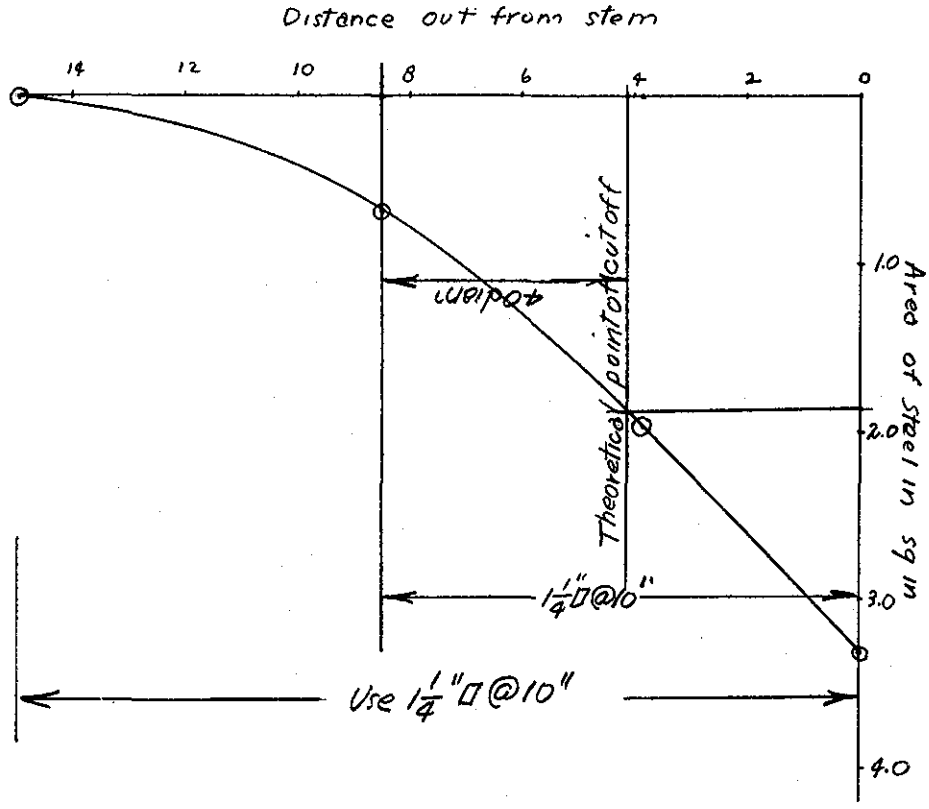
Subject: Northampton

Computation: Transverse Base Steel

Computed by: R.H.M. Checked by: Date:

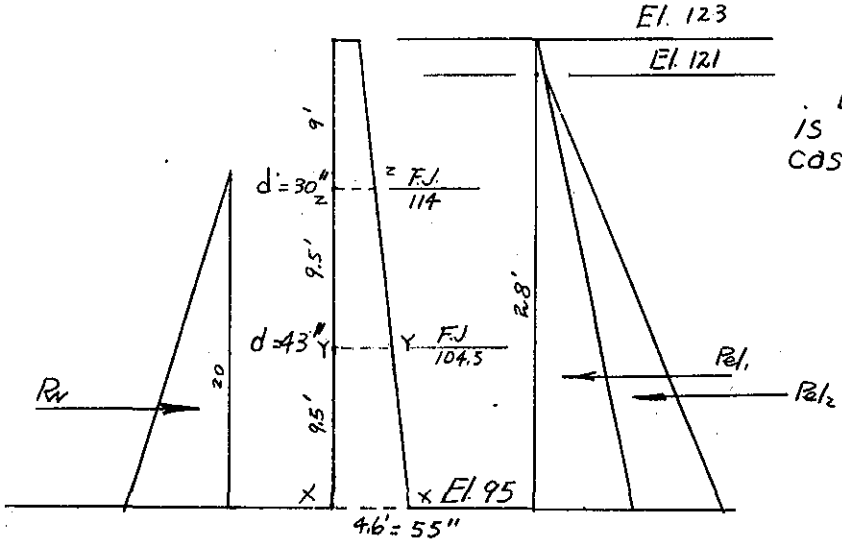
U. S. GOVERNMENT PRINTING OFFICE 3—10828

Curve of Steel Areas



Subject Northampton
Computation Design of Stem Steel
Computed by R.H.M. **Checked by** **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10523



By inspection case I is seen to be governing case.

Section X---X

Pel_1 : $28^2 \times \frac{1}{2} \times 40 = 15680 \times 9.33 = 146290$ '#
Pel_2 : $26^2 \times \frac{1}{2} \times 43 = 14530 \times 8.66 = 125830$ '#
30210 272120 '#
P_w : $20^2 \times \frac{1}{2} \times 62.5 = 12500 \times 6.66 = 83250$ '#
$\Sigma H = 17710$ $\Sigma M = 188870$ '#

$d = \sqrt{\frac{188870}{123}} = \sqrt{1545} = 39.4''$ O.K Use $55 - 3.5 = 51.5''$

$\text{Shear} = \frac{17710}{12 \times .884 \times 51.5} = \frac{17710}{546} = 32\ \#/\square''$ OK

$A_s = \frac{12 \times 188870}{18000 \times .884 \times 51.5} = \frac{2,266,400}{818900} = 2.77\ \square''$

Section Y---Y

Pel_1 : $18.5^2 \times \frac{1}{2} \times 40 = 6850 \times 6.17 = 42260$ '#
Pel_2 : $16.5^2 \times \frac{1}{2} \times 43 = 5850 \times 5.50 = 32180$ '#
12700 74440
P_w : $10.5^2 \times \frac{1}{2} \times 62.5 = 3450 \times 3.50 = 12080$ '#
$\Sigma H = 9250$ # $\Sigma M = 62360$ '#

$d = \sqrt{\frac{62360}{123}} = \sqrt{507} = 22.5''$ O.K. Use $43 - 3.5 = 39.5''$

$\text{Shear} = \frac{9250}{12 \times .884 \times 39.5} = \frac{9250}{419} = 22\ \#/\square''$ OK

$A_s = \frac{12 \times 62360}{18000 \times .884 \times 39.5} = \frac{748000}{628000} = 1.19\ \square''$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Northampton

Computation Design of Stem Steel

Computed by R.H.M. **Checked by** **Date**

U. S. GOVERNMENT PRINTING OFFICE 3—10523

Section z - - - z

Pel. : $9^2 \times \frac{1}{2} \times 40 = 1620 \times 3 = 4860$ #

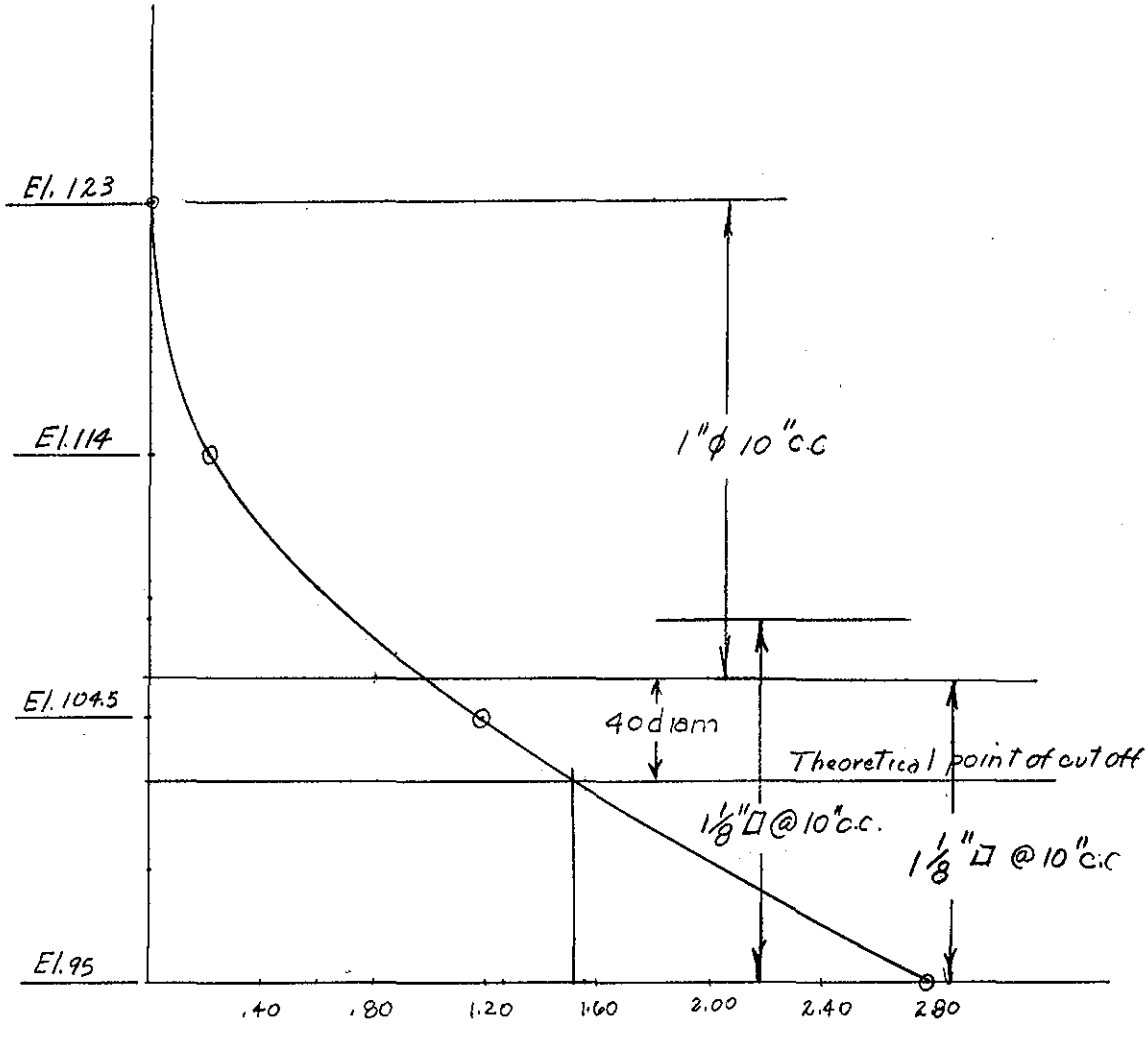
Pel. : $7^2 \times \frac{1}{2} \times 43 = 1050 \times 2.33 = 2450$ #

$\Sigma H = 2670$ $\Sigma M = 7310$ #

"d" o.k by inspection

$$A_s = \frac{12 \times 7310}{18000 \times .884 \times 26.5} = \frac{87720}{421000} = .21 \square''$$

Curve of Steel Areas



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

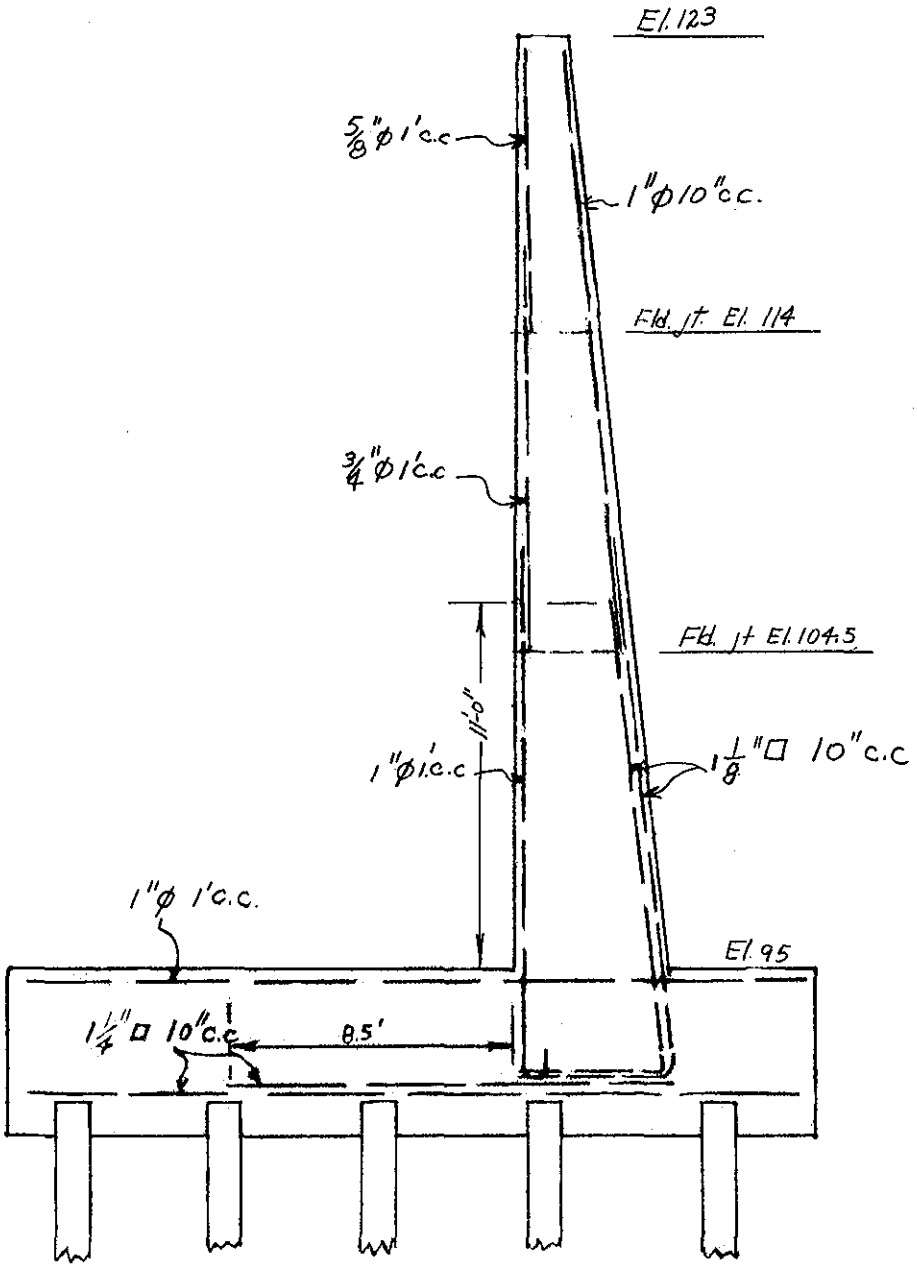
Page 12

Subject Northampton

Computation Steel Diagram

Computed by R.H.M. Checked by Date

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Note: This steel was designed with one eye on adjoining sections and some of the steel was made heavier to make for uniformity with these other sections which was thought desirable.

A-96

See Section 8, Key Sketch

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

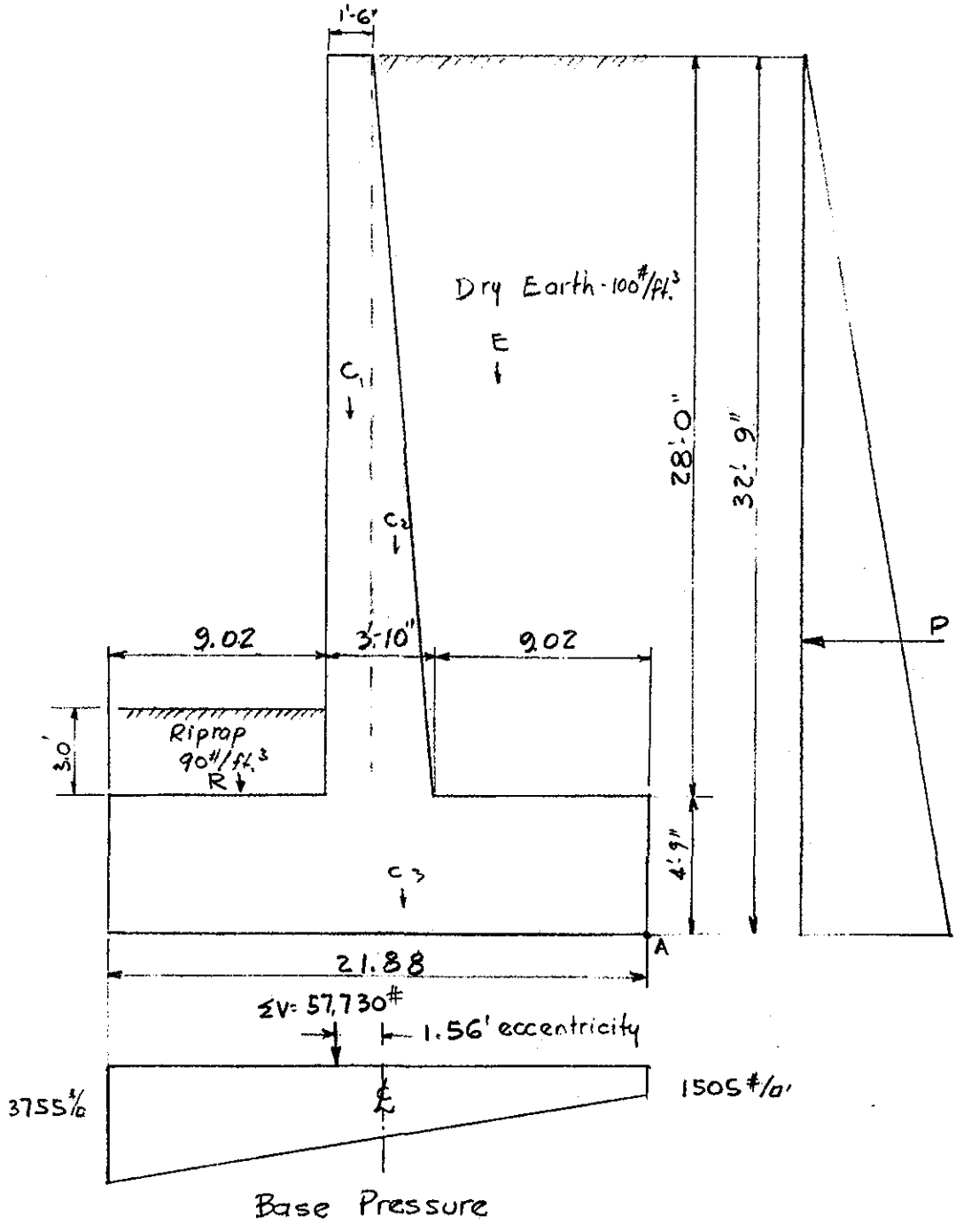
Page 1

Subject: Northampton Drop Structure

Computation: Retaining Wall Section #6

Computed by: T. J. S. Checked by: Date: 5-3-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



A-97

Subject Northampton Drop Structure

Computation Retaining Wall Section #6 Stability

Computed by T. J. S. Checked by _____ Date 5-3-39

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↻	MOMENTS ABOUT A ↺
C_1	1.5×150×28.0	6,300				12.10		76,230
C_2	2.33×50×28×1/2	1,600				10.57		17,300
C_3	4.75×150×21.88	15,600				10.94		170,900
E	11.35×100×28.0	31,800				5.67		180,400
R	9.02×90×3.0	2,430				17.37		42,200
P	40×(32.75)²×1/2				21,400	10.92		234,000
		ΣV = 57,730#		ΣH =			ΣM =	721,030'#

Position of Resultant $= \frac{\Sigma M}{\Sigma V} = \frac{721{,}030}{57{,}730} = 12.5'$ ecc. = 12.5 − 10.94 = 1.56

Assuming no piles, soil pressure $= \frac{57{,}730}{21.88}\left(1 \pm \frac{6 \times 1.56}{21.88}\right) = 3755\#/\square'$, $1505\#/\square'$

Subject Northampton Drop Structure
Computation Retaining Wall - Section #6 Piling
Computed by T. J. S. **Checked by** **Date** 5-3-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Assume 5 Piles equally loaded spaced 3'-6" long.

$\frac{57,730}{5} = 11,546\#/\text{Pile}$ $\qquad \frac{3755-1505}{21.88} = 103\ \#/\text{ft.}$

#1) $x\cdot\left(\frac{1505 \times 2 + 103x}{2}\right) = 11546\#$

$x^2 + 29.2x - 224 = 0 \qquad x = 6.31$

$$C.G. = \frac{\frac{1505 \times (6.31)^2}{2} + \frac{103 \times (6.31)^3}{3}}{11546} = 3.34'$$

#2) $x\cdot\left(\frac{2155 \times 2 + 103x}{2}\right) = 11546\# \qquad x = 4.82'$

say C.G. = 2.5'±

#3) $x\cdot(2652 + 51.5x) = 11,546\# \qquad x = 4.04'$

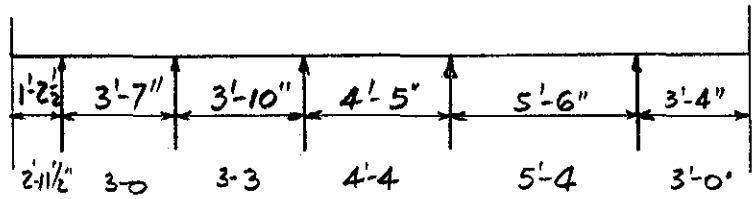
say C.G. = 2.1±

#4) $x\cdot(3065 + 51.5x) = 11,546\# \qquad x = 3.55'$

say C.G. = 1.9'±

#5 $x(3430 + 51.5x) = 11,546\# \qquad x = 3.21'$

say C.G. = 1.8'±



Use dimen. 2'-11½" 3-0 3-3 4'-4 5'-4 3'-0"

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 4

Subject: Northampton Drop Structure

Computation: Retaining Wall - Section #6 Base Slab Design

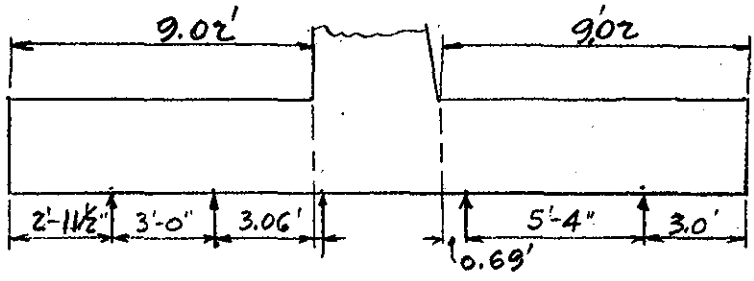
Computed by: T. J. S. Checked by: Date: 5-3-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Vertical downward loads:-

@ Toe:- $(4.75 \times 150) + (3 + 90)$
$= 982\ \#/\square'$

@ Heel:- $2800 + 712 = 3512\ \#/\square'$



Design of Toe:-

$M = 11546 \times 9.06 - 982 \times \overline{9.02}^2/2 = 64{,}800'\#$ $\quad d = \sqrt{\frac{64{,}800}{123}} = 23''$ Req.

$V = 11546 \times 2 - 982 \times 9.02 = 14{,}220\ \#$ $\quad$ 41" Furn.

$A_s = \frac{64{,}800 \times 12}{18000 \times 0.884 \times 41} = 1.20\ \square''$

$v = \frac{14{,}220}{12 \times 0.884 \times 41} = 33\ \#/\square''$

M @ pt. 3.06' out $= 11546 \times 3 - 982 \times \overline{5.96}^2/2 = 17{,}140'\#$

$A_s = \frac{17{,}140}{64{,}800} \times 1.20 = 0.32\ \square''$

Design of Heel:-

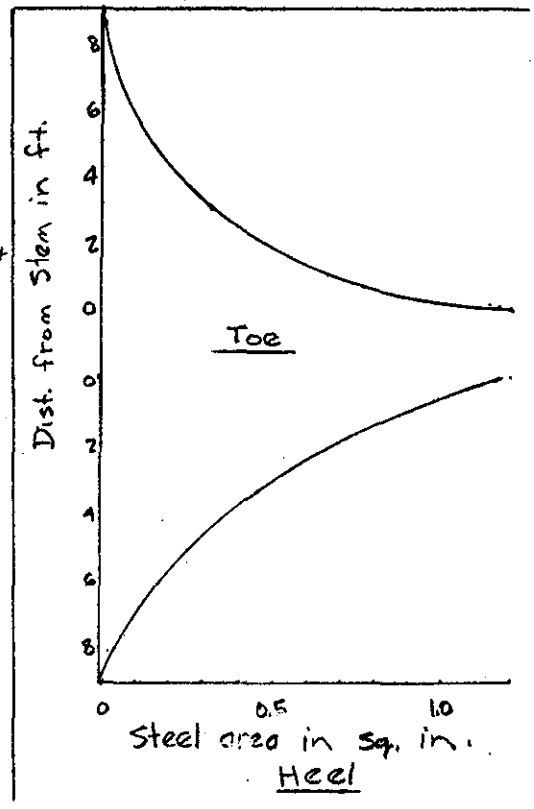
$M = 3512 \times \overline{9.02}^2/2 - 11546 \times 6.71 = 65{,}300'\#$

$V = 3512 \times 9.02 - 11546 \times 2 = 8510\ \#$

$A_s = \frac{65300 \times 12}{18000 \times 0.884 \times 42} = 1.17\ \square''$

M @ pt. 3.36' out $= 3512 \times \overline{5.66}^2/2 - 11546 \times 2.67 = 25{,}600'\#$

$A_s = \frac{25600}{65300} \times 1.17 = 0.46\ \square''$



A-100

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Northampton Drop Structure

Computation Retaining Wall - Section #6 - Design of Stem

Computed by T.J.S. **Checked by** **Date** 5-3-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

M @ Base = $40 \times \overline{28}^3/6 = 141{,}000'\#$ $\quad d = \sqrt{\frac{141{,}000}{123}} = 34''$ Req.

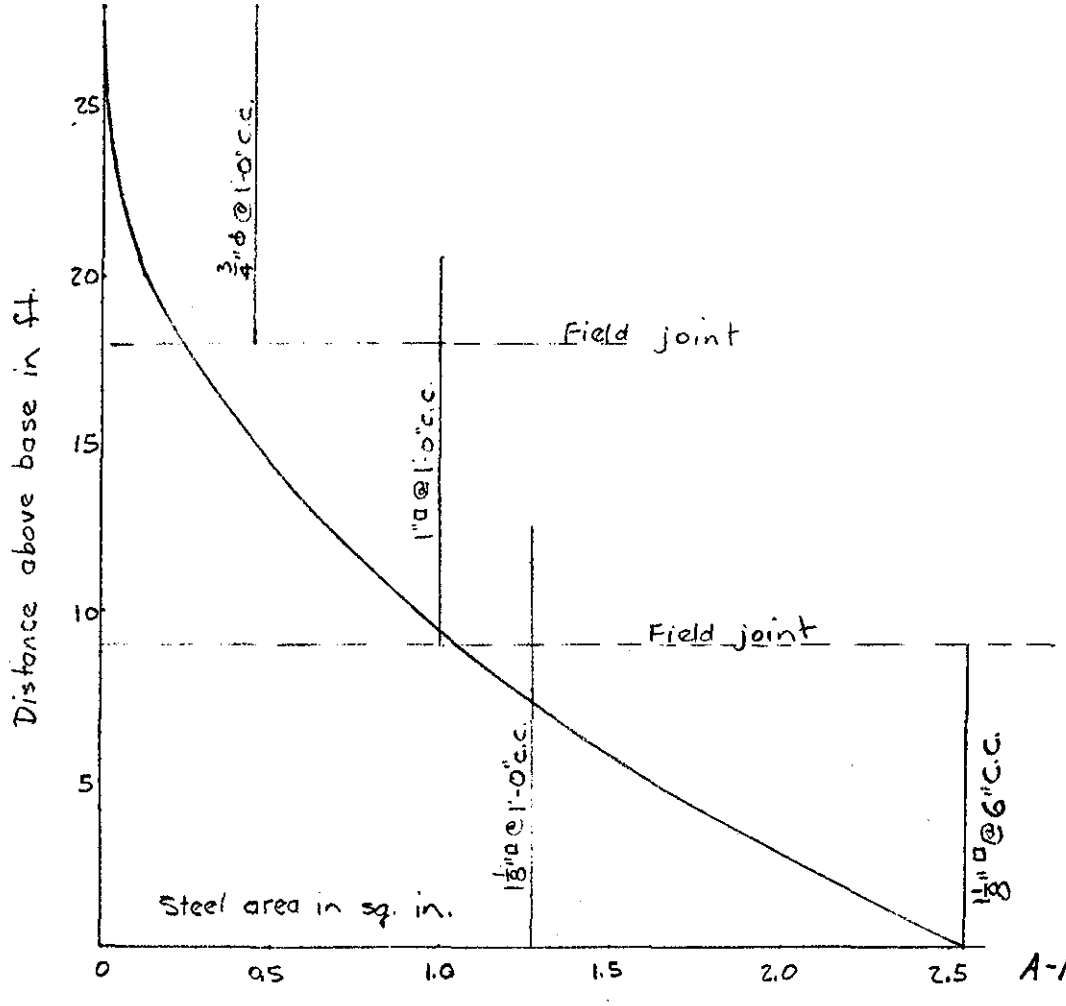
$A_s = \frac{141{,}000 \times 12}{18000 \times 0.884 \times 42} = 2.54 \square''$ $\quad$ 42." Furn.

M @ pt. 10' up = $40 \times \overline{18}^3/6 = 39{,}000'\#$

$A_s = \frac{39000 \times 12}{18000 \times 0.884 \times 32} = 0.92 \square''$

M @ pt. 20' up = $40 \times \overline{8}^3/6 = 3420'\#$

$A_s = \frac{3420 \times 12}{18000 \times 0.884 \times 22} = 0.12 \square''$



A-101

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

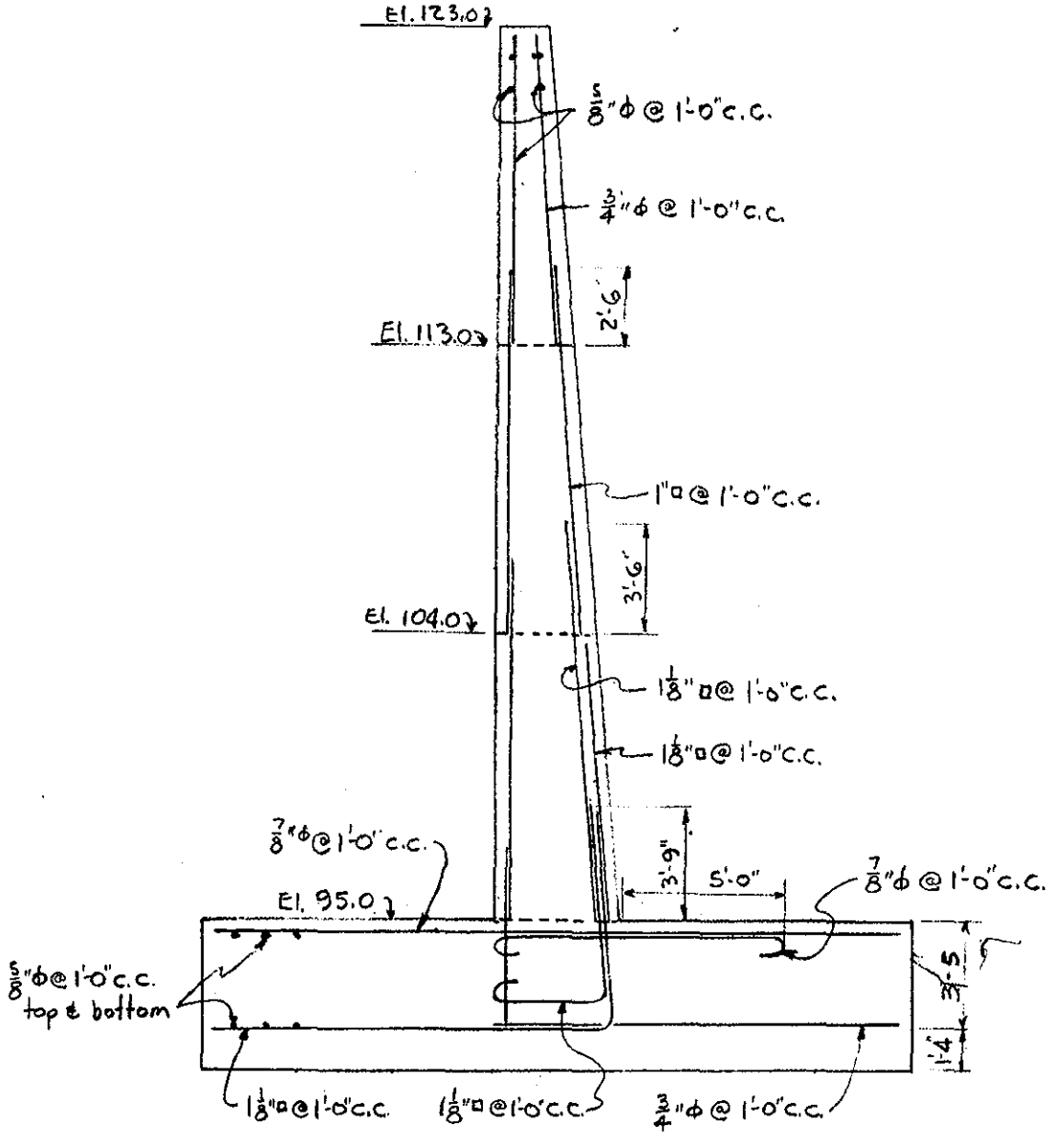
Page 6

Subject Northampton Drop Structure

Computation Retaining Wall - Section #6 Reinforcement

Computed by T. J. S. Checked by ..... Date 5-3-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



A-102

See Section 9, Key Sketch

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

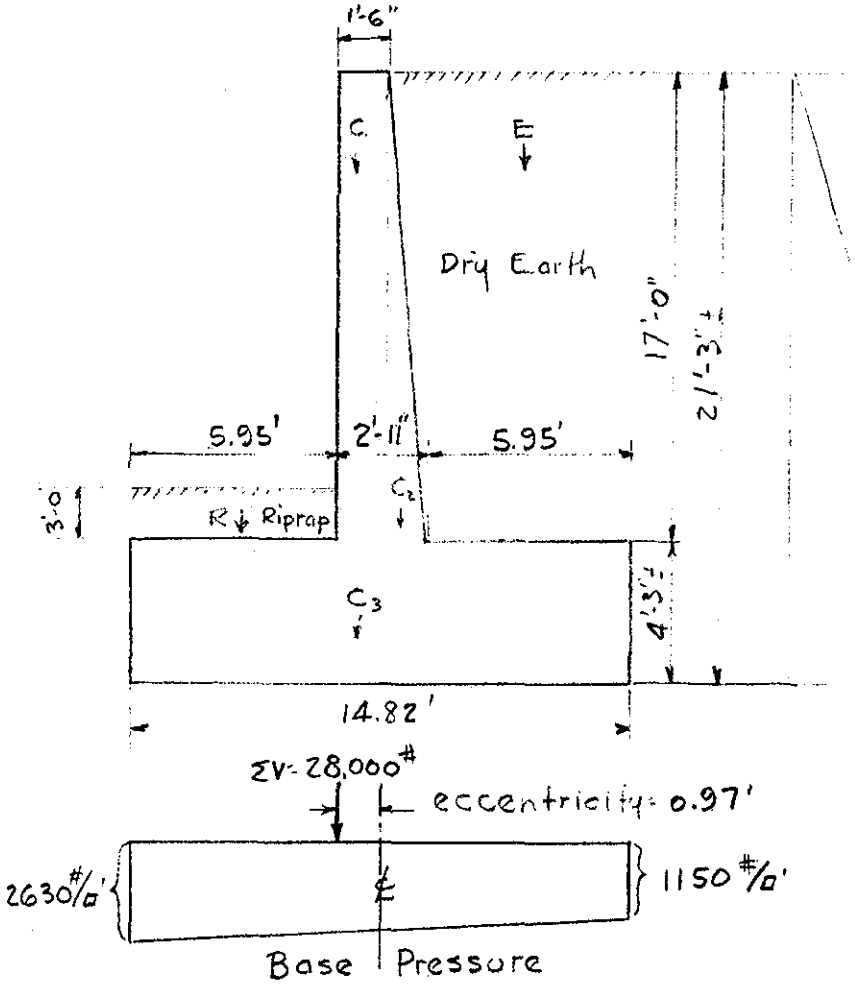
Page 1

Subject: Northampton Drop Structure

Computation: Retaining Wall - Section # 5

Computed by: To J. S. Checked by: Date: 5-3-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



A-103

Subject Northampton Drop Structure

Computation Retaining Wall - Section #5 - Stability

Computed by T. J. S. Checked by _____ Date 5-3-39

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↻	MOMENTS ABOUT A ↺
C_1	1.5×150×17.0	3,830				8.12		31,100
C_2	1.42×50×17.0×½	600				6.9		4,140
C_3	4.25×150×14.82	9,450				7.41		70,000
E	7.37×100×17.0	12,510				3.68		46,060
R	5.95×90×3.0	1,610				11.84		19,050
P	40×(21.25)²×½				9050	7.08		64,100
		ΣV = 28,000#		ΣH =			ΣM =	234,450'#

Position of Resultant $= \frac{\Sigma M}{\Sigma V} = \frac{234,450}{28,000} = 8.38'$ eccentricity = 8.38 - 7.41 = 0.97

Assuming no piles, earth pressure = $\frac{28,000}{14.82}\left(1 \pm \frac{6 \times 0.97}{14.82}\right) = 2630\#/\square'$ / $1150\#/\square'$

Subject Northampton Drop Structure
Computation Retaining Wall - Section #5 - Piles
Computed by T. J. S. **Checked by** **Date** 5-3-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Use 3 Piles equally loaded spaced @ 4'-9" ± c.c. longitudinally

Pile load = $\frac{28000}{3}$ 9330 #/Pile $\frac{2630 - 1150}{14.82} = 100$ #/'

#1) $\frac{x(1150 \times 2 + 100x)}{2} = 9330\#$

$x^2 + 68.75x = 413$ $x = 6.36$

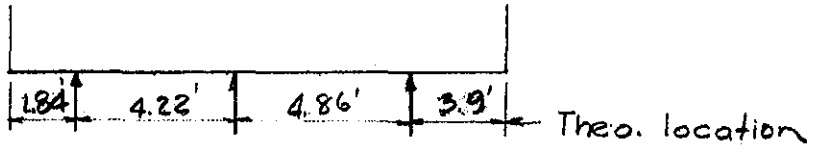
$$C.G = \frac{\frac{1150 \times (6.36)^2}{2} + \frac{100 \times (6.36)^3}{3}}{9330} = 3.9'$$

#2) $1786x + 50x^2 = 9330\#$ $x = 4.62'$

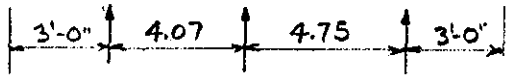
C.G. say 2.4'

#3) $2248x + 50x^2 =$ $x = 3.84$

C.G. say 2.0'



because of the sloping base we may assume the following pile locations



WAR DEPARTMENT

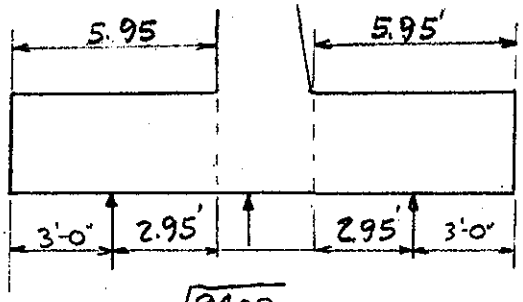
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Northampton Drop Structure

Computation: Retaining Wall - Section #5 Reinforcement

Computed by: T. J. S. Checked by: Date: 5-3-39

U. S. GOVERNMENT PRINTING OFFICE 8—10528



Vertical downward loads:-

@Toe:- $(4\times150)+(3\times90) = 870\#/\square'$

@Heel:- $600+1400 = 2000\#/\square'$

Design of Toe:-

$M = 9330\times2.95 - 870\times\overline{5.95}^2/2 = 12{,}100'\#$

$V = 9330 - 870\times5.95 = 4150\#$

$A_s = \dfrac{12{,}100\times12}{18000\times0.884\times32} = 0.29\square''$

$v = \dfrac{4150}{12\times0.884\times32} = 13\#/\square''$

$d = \sqrt{\dfrac{9400}{125}} = 27.7''$ Req.

32" Furn.

Use $\frac{3}{4}''\phi$ @ 1'-0" c.c. $A_s = 0.44\square''$ Furn.

Design of Heel:-

$M = 2000\times\overline{5.95}^2/2 - 9330\times2.95 = 7{,}900'\#$

$A_s = \dfrac{7{,}900\times12}{18000\times.884\times32} = 0.19\square''$

Same steel as in Toe

Design of Stem:-

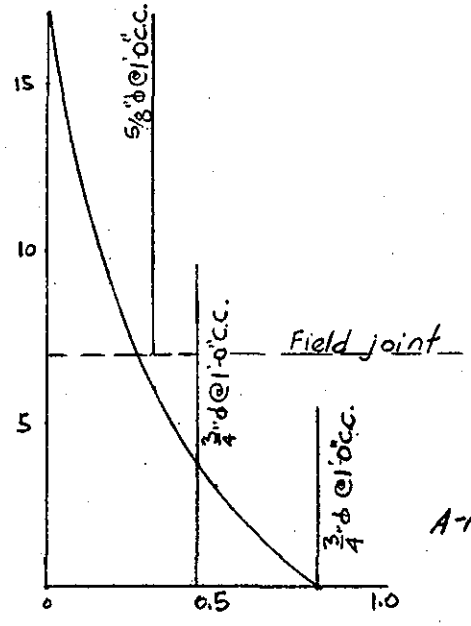
M @ Base $= 40\times\overline{17}^3/6 = 32{,}800'\#$

$d = \sqrt{\dfrac{32800}{125}} = 16.4''$ Req. 31 Furn.

$A_s = \dfrac{32{,}800\times12}{18000\times0.884\times31} = 0.8\square''$

M @ Pt. 3' up $= 40\times\overline{14}^3/6 = 18{,}300'\#$

$A_s = \dfrac{18{,}300\times12}{18000\times.884\times28} = 0.5\square''$



A-106

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

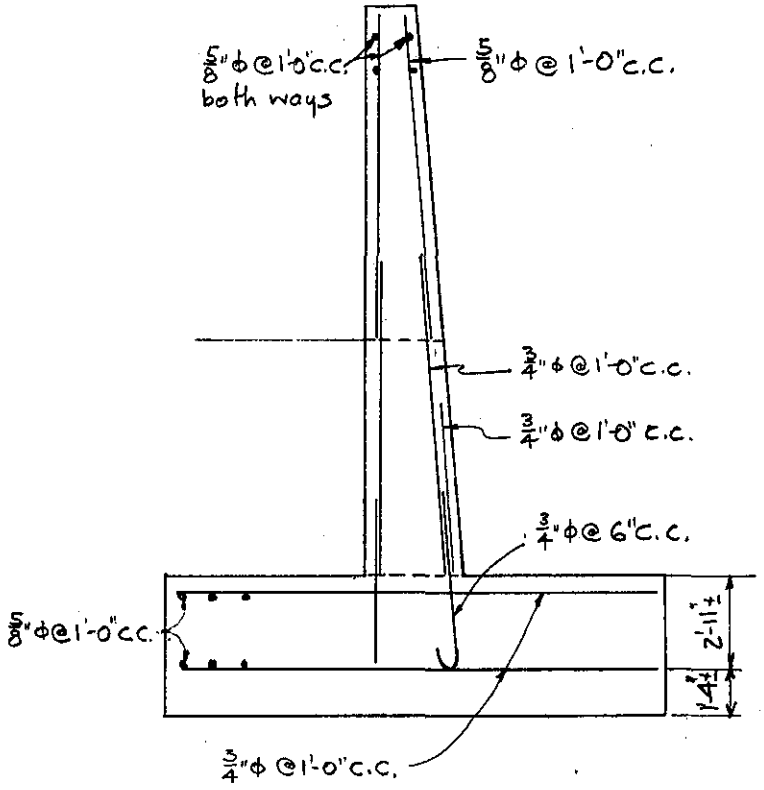
Page 5

Subject Northampton Drop Structure

Computation Retaining Wall Section #5

Computed by T. J. S. Checked by Date 5-3-39

U. S. GOVERNMENT PRINTING OFFICE 3—10638



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 1

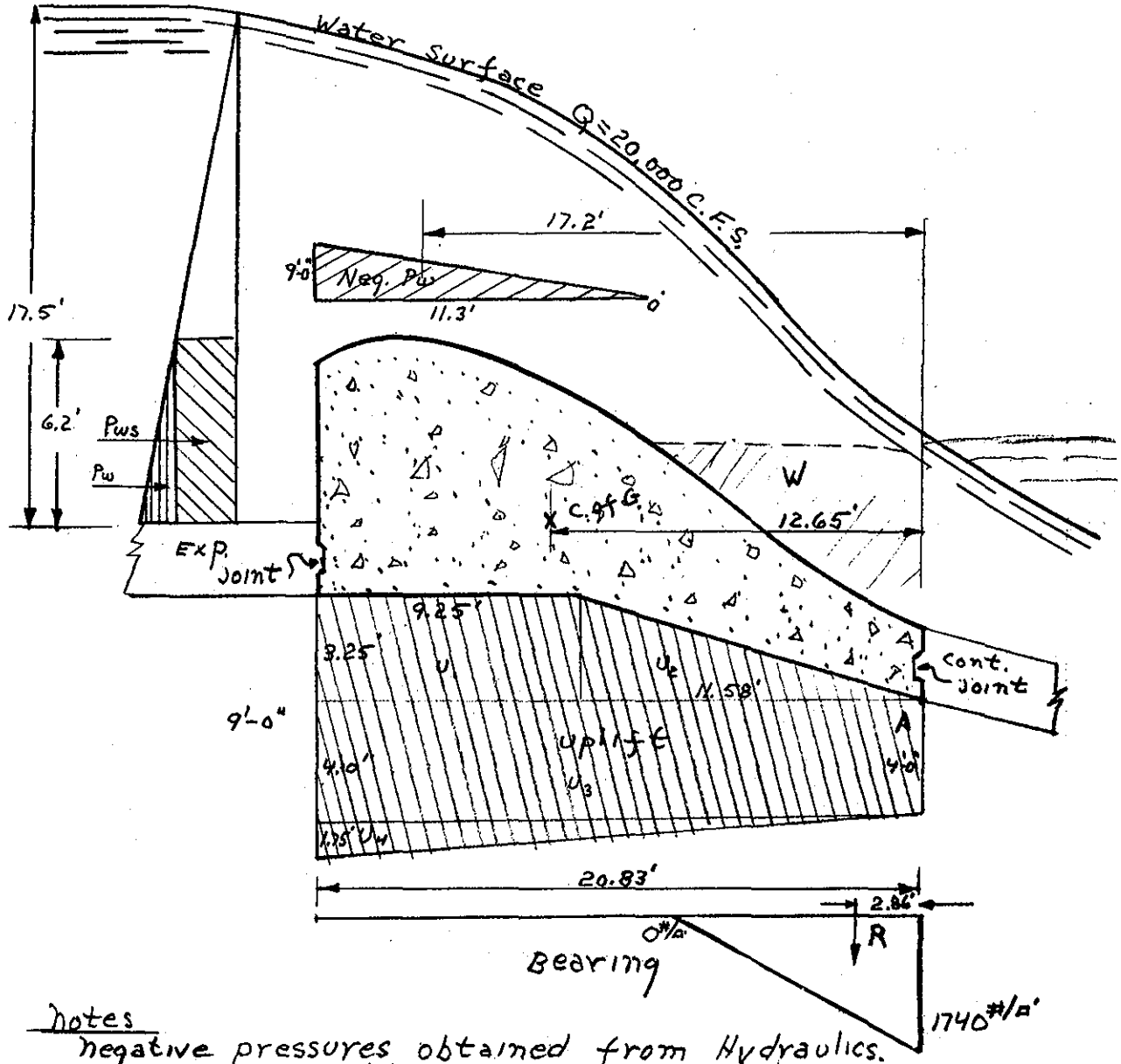
Subject: Northampton Mass

Computation: Stability of Weir

Computed by: W. S. Jr. Checked by: Date: 4/27/39

U. S. GOVERNMENT PRINTING OFFICE 8—10528

Case I



Notes

negative pressures obtained from Hydraulics.
C. of G. of weir obtained mechanically, using a model.
Area of weir = 123.6 □' by planimeter.
Uplift from usual assumptions - 50% behind sheet pile to tailwater at toe.
Dimensions obtained from large scale section.

A-108

Subject Northampton Mass

Computation Stability of Weir

Computed by W.S.Jr. Checked by R.H.M. Date 4/27/39

Case I

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↻	MOMENTS ABOUT A ↺
C	123.6 x 150	18100				12.65		229,000
W	9.5 x 6.5 x ½ x 62.5	1930				3.16		6,100
NPw	9.0 x 11.3 x ½ x 62.5		3184			17.20	54,700	
U1	9.25 x 3.25 x 62.5		1880			16.21	30,500	
U2	11.58 x 3.25 x ½ x 62.5		1175			7.71	9,056	
U3	4 x 20.83 x 62.5		5210			10.41	54,200	
U4	1.75 x 20.83 x ½ x 62.5		1140			13.90	15,820	
Pws	11.3 x 62.5 x 6.2			4380		9.10	39,900	
Pw	6.2² x ½ x 62.5			1205		8.01	9,650	
		20,030	12,589	5585			213,820	235,100
		ΣV = 7,441		ΣH =			ΣM = 21,280	

$$\left.\begin{array}{l}\text{Position of}\\ \text{Resultant}\end{array}\right\} = \frac{\Sigma M}{\Sigma V} = 2.86'$$

$$\text{Bearing} = \frac{7,441}{3 \times 2.86} \begin{cases} \times 0 = 0 \ \#/\square' \\ \times 2 = 1740 \ \#/\square' \end{cases}$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Northampton Mass

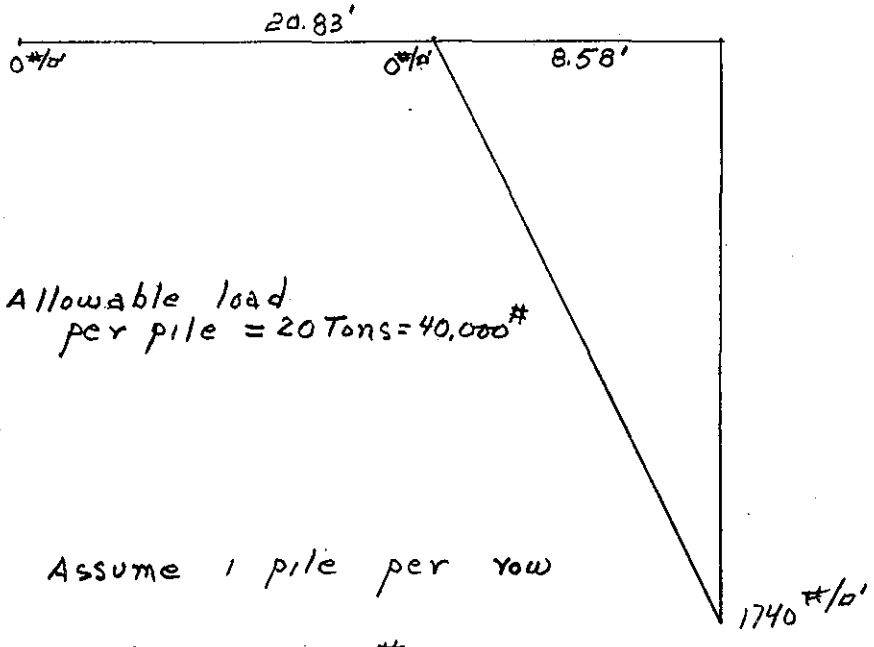
Computation: Piles Under Weir

Computed by: M. S. J. Checked by: Date: 4/27/39

U.S. GOVERNMENT PRINTING OFFICE 3—10528

Case I

Pile Spacing



Allowable load per pile = 20 Tons = 40,000#

Assume 1 pile per row

$1740 \times \frac{1}{2} \times 8.58 = 7441^{\#}$

$\frac{40,000}{7441} = 5.4'$ use 5'-3" between rows

This case will not govern

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 4

Subject Northampton Mass

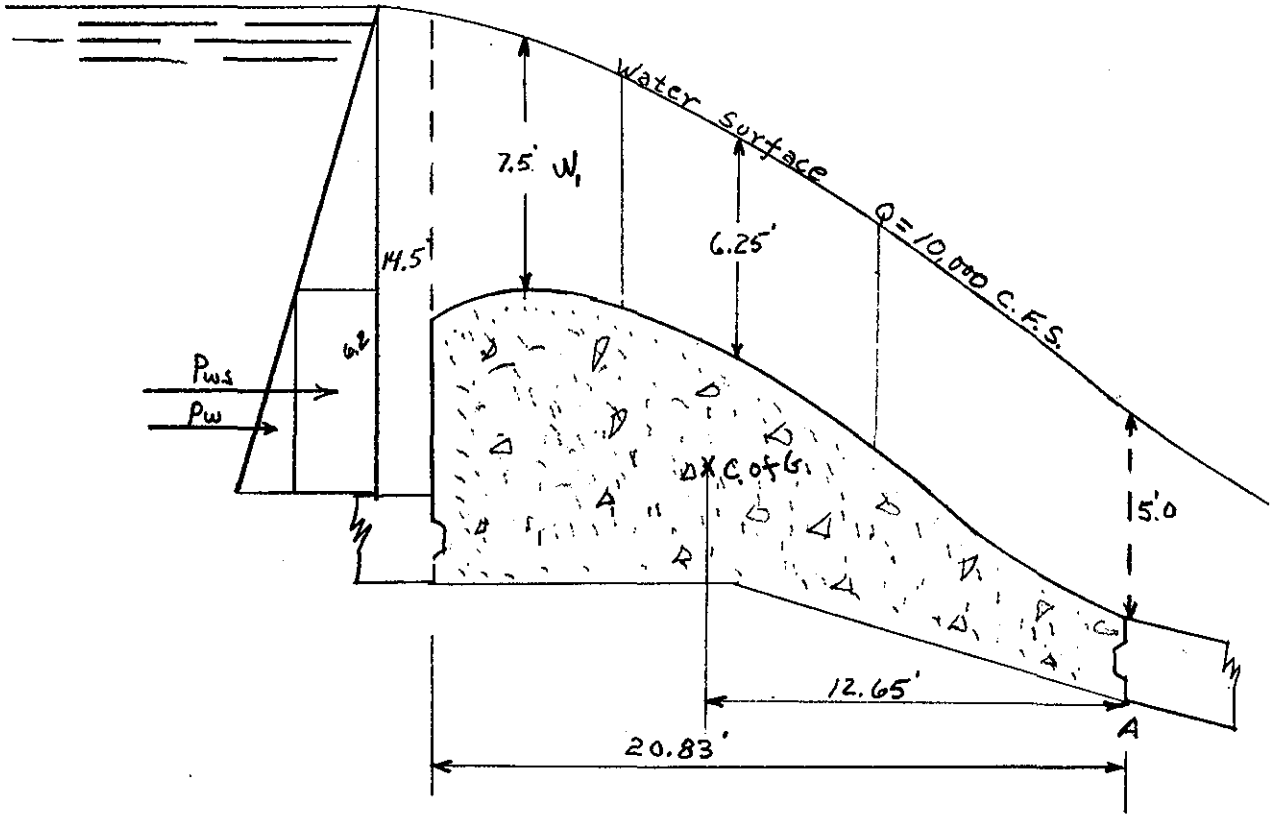
Computation Stability of Weir

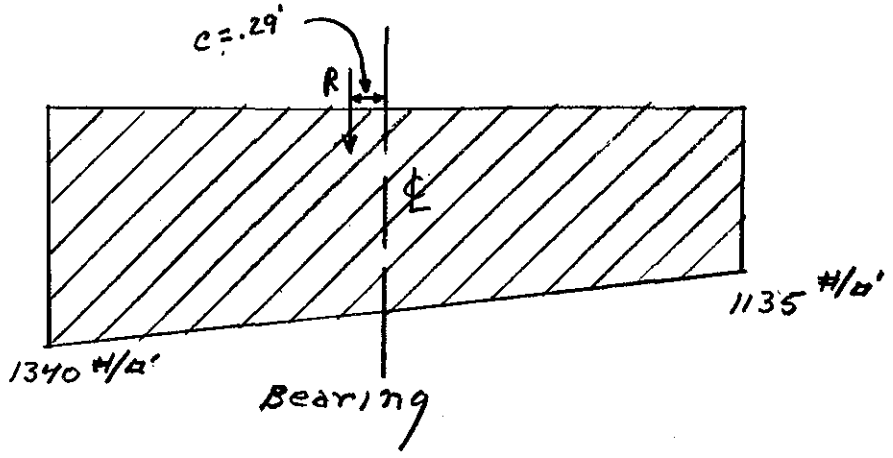
Computed by M. S. J. Checked by Date 4/27/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Case II

Q = 10,000 c. f. s., no uplift, no negative P.#/□'





A-111

Subject Northampton Mass.

Computation Stability of Weir

Computed by W. S. Jr. Checked by _____ Date 4/27/39

Case II

FORCES ACTING		↓	↑	→	←	ARM	MOMENTS ABOUT A ↷	MOMENTS ABOUT A ↶
C		18100				12.65		229,000
W_1	2.5×5.75×62.5	2700				17.96		48,500
W_2	6.25×7.5×62.5	2930				11.30		33,000
W_3	5×7.5×62.5	2350				3.75		8,000
P_{ws}	8.3×62.5×6.2			3220		9.10	29,300	
P_w	$6.2^2 \times \frac{1}{2} \times 62.5$			1205		8.01	9,650	
		26,080		4425			38950	318500
		ΣV=26,080		ΣH=			ΣM=279,550	

$$\left.\begin{array}{l}\text{Position of}\\ \text{Resultant}\end{array}\right\} = \frac{\Sigma M}{\Sigma V} = 10.7' \text{ to } R$$

$$e = \frac{20.83}{2} - 10.7 = -.29'$$

$$\text{Bearing} = \frac{26,080}{20.83}\left(1 \pm \frac{6 \times .29}{20.83}\right) = 1240 \begin{cases} 1.085 = 1340 \ \#/\square' \\ .915 = 1135 \ \#/\square' \end{cases}$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 6

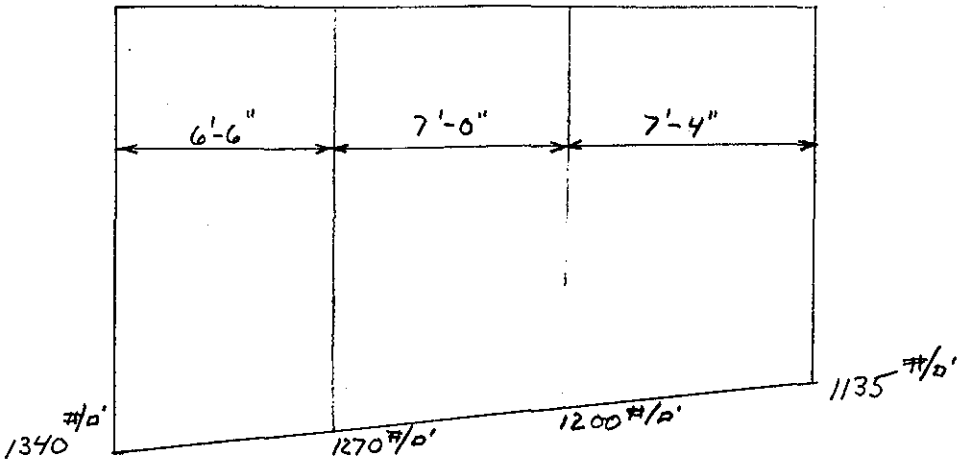
Subject: Northampton Mass

Computation: Piles Under Weir

Computed by: M.S.J. Checked by: Date: 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Case II
Pile Spacing



Allowable load per pile = 20 Tons = 40,000 #
Assume 3 piles per row

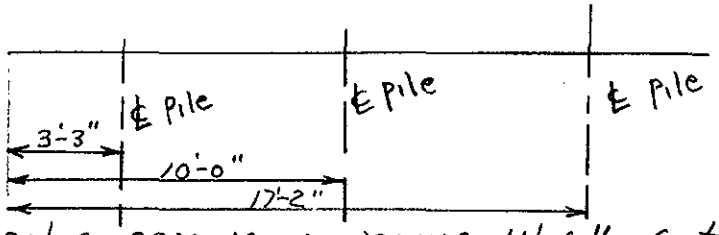
$\frac{26080}{3} = 8693$ #/Ft $\qquad \frac{40,000}{8693} = 4.6'$

use 4'-6" between rows

1270
1340
2610 ÷ 2 = 1305 # × 6.5 × 4.5 = 38,200 #/pile O.K.

1200
1270
2470 ÷ 2 = 1235 # × 7.0 × 4.5 = 38,800 #/pile O.K.

1200
1135
2335 ÷ 2 = 1167 # × 7.33 × 4.5 = 38400 #/pile O.K.



3 piles per row, rows 4'-6" c. to c.

A-113

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 7

Subject: Northampton Mass

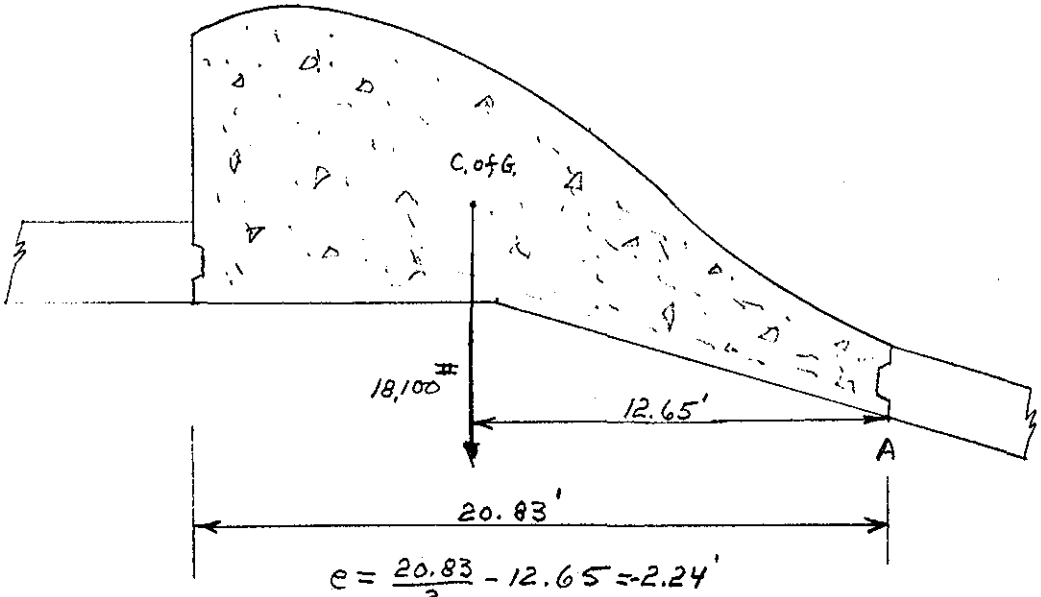
Computation: Stability of Weir

Computed by: W. S. Jr. Checked by: Date: 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

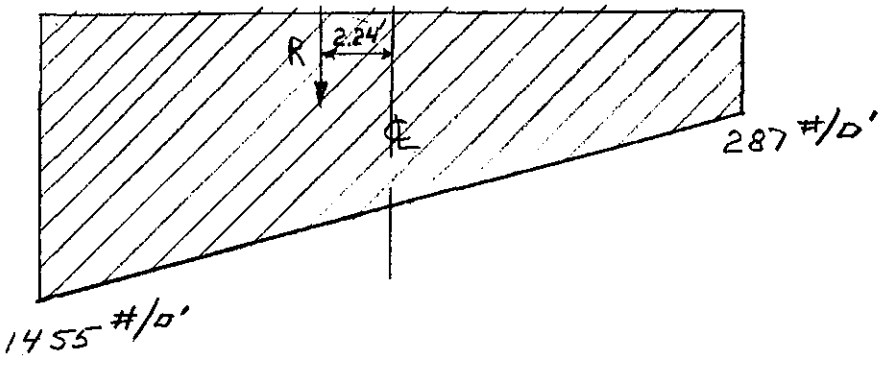
Case III

Water down, dead loads only



$$e = \frac{20.83}{2} - 12.65 = -2.24'$$

$$\text{Bearing} = \frac{18100}{20.83}\left(1 \pm \frac{6 \times 2.24}{20.83}\right) = 870 \begin{cases} 1.67 = 1455 \ \#/\square' \\ .33 = 287 \ \#/\square' \end{cases}$$



Next page for pile spacing

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Northampton Mass.

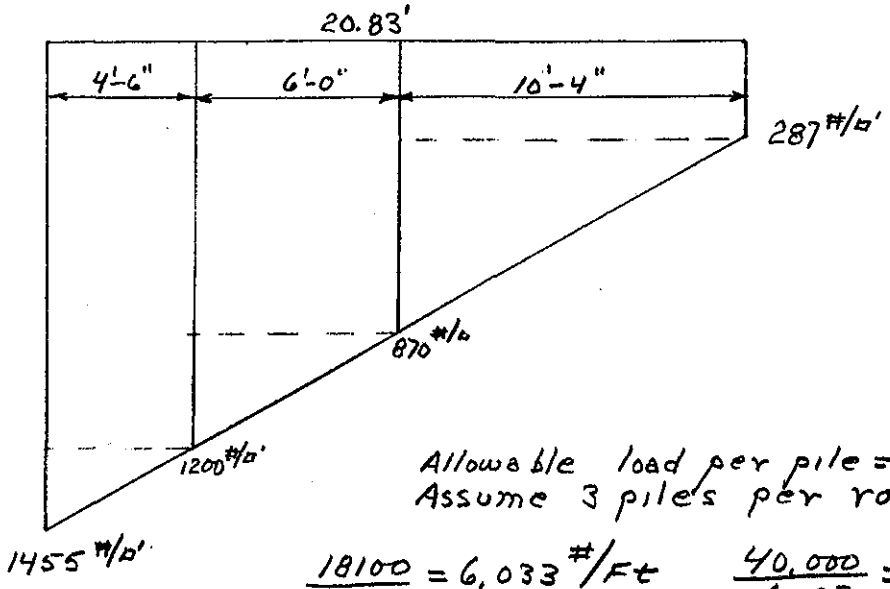
Computation: Piles Under Weir

Computed by: W.S.J. Checked by: Date: 4/28/39

U.S. GOVERNMENT PRINTING OFFICE 3—10628

Case III

Pile Spacing



Allowable load per pile = 20 Tons = 40,000#

Assume 3 piles per row

$\frac{18100}{3} = 6,033$ #/Ft $\quad \frac{40,000}{6,033} = 6.32'$

use 6'-0" between rows

1455
1200
2655 ÷ 2 = 1327# x 4.5 x 6 = 36,000#/Pile OK.

1200
870
2070 ÷ 2 = 1035# x 6 x 6 = 37,300#/Pile O.K.

870
287
1157 ÷ 2 = 578# x 10.33 x 6 = 35,900#/pile O.K.

Pile spacing

4.5 x 1200 = 5400 x 2.25 = 12200'#
4.5 x 255 x ½ = 574 x 1.5 = 860'#
5,974 | 13,060'# = 2.19' to 1st pile

6 x 870 = 5220 x 3 = 15,660'#
6 x 330 x ½ = 990 x 2 = 1980
6210 | 17,640'# = 2.84'
4.5
7.34' to 2nd pile

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Northampton Mass

Computation: Piles Under Weir

Computed by: M. S. L. Checked by: Date: 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Case III

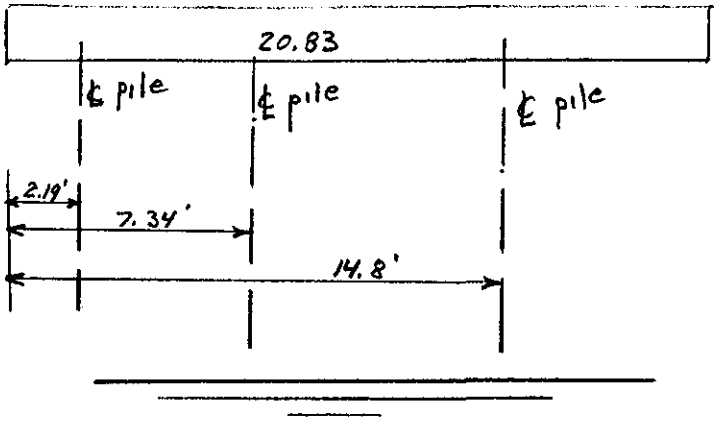
$10.33 \times 287 = 2960 \times 5.16 = 15,300'^{\#}$

$10.33 \times 583 \times \frac{1}{2} = 3010 \times 3.45 = 10,400'^{\#}$

5970 $\quad 25,700'^{\#} = 4.3'$

10.5

$14.8'$ to 3rd pile

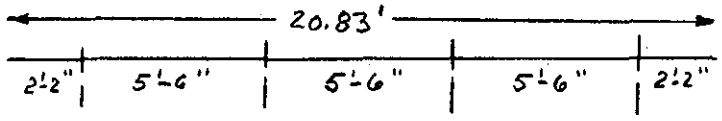


3 piles per row, rows 6'-0" c. to c.

Subject Northampton Mass
Computation Piles Under Weir
Computed by M.S.J. Checked by Date 4/28/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

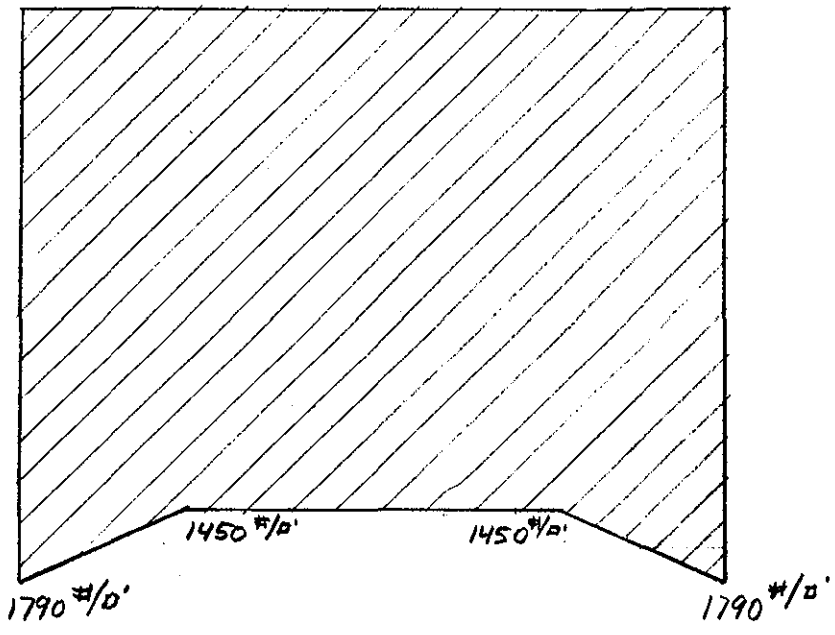
Actual pile spacing



Rows of piles 5'-0" c. to c.

Load per pile = 20 tons = 40,000#

Possible loading diagram with above pile spacing



Center piles $5.5' \times 5' = 27.5^{\square'}$ $\frac{40000}{27.5} = 1450^{\#/\square'}$ ✓

End piles $2.16 + \frac{5.5}{2} = 4.91 \times 5 = 24.6^{\square'}$ $\frac{40,000}{24.6} = 1620^{\#/\square'}$ ✓ (Average)

$$\begin{array}{r} 1620 \\ 1450 \\ \hline 170 \end{array} \times 2 = 340 + 1450 = 1790^{\#/\square'} \text{ Max.}$$

This loading diagram is greater than any of the actual cases, so pile spacing used is <u>O.K.</u>

A-117

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject Northampton, Mass.

Computation Bending in Heel of Weir

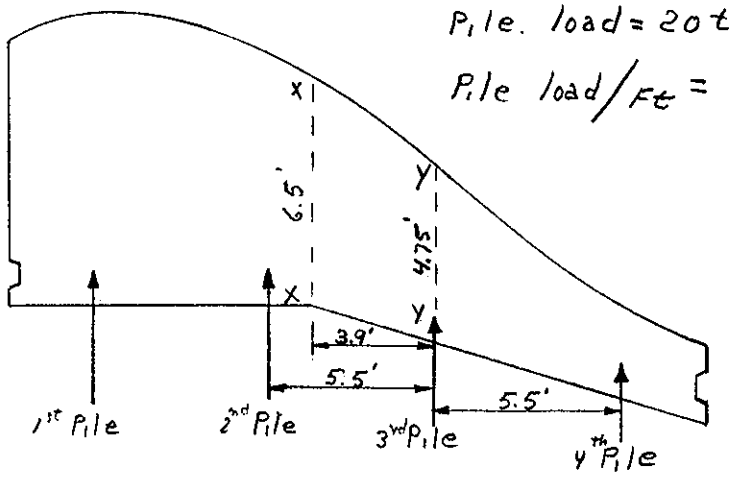
Computed by W. S. J. **Checked by** **Date** 5/4/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Max Condition = 3rd & 4th pile fully loaded.

Pile load = 20 ton = 40,000#

Pile load/ft = $\frac{40,000}{5}$ = 8,000#



Mom at X-X

4th Pile	8000 x 9.4 =	75,100 '#
3rd Pile	8000 x 3.9 =	31,200 '#
	16,000#	106,300 '#
Concrete	6,750#	34,000 '#
	9,250#	72,300 '#

Shear = $\frac{9,250}{12 \times .884 \times 74}$ = 12#/□"

$A_s = \frac{72,300 \times 12}{18000 \times .884 \times 74}$ = .73□"

use 1"φ @ 1'-0" c.c.

Mom at Y-Y

4th Pile	8000 x 5.5 =	44,000 '#
Concrete	3600 x 4.0 =	14,400 '#
	4,400#	29,600 '#

Shear O.K

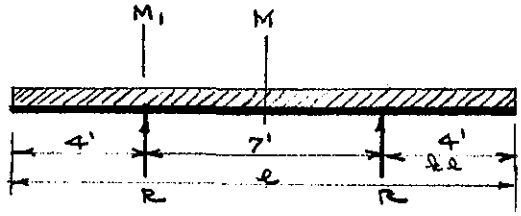
$A_s = \frac{29,600 \times 12}{18000 \times .884 \times 52}$ = .43□"

Subject: NORTHAMPTON DROP STRUCTURE
Computation: FLOOR SLAB
Computed by: ER. Checked by: Date: 4-15-39

U. S. GOVERNMENT PRINTING OFFICE 3—10523

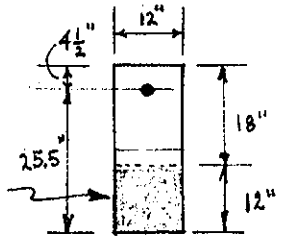
CRITICAL CONDITION:

LOADING



$l = 15$
$k = .266$

21 FT. OF WATER IN CHANNEL (@ = 20,000 cu.)
3.5 " " UPLIFT PRESSURE



SECTION
(TENSION IN TOP OF SLAB)

$17.5 \times 62.5 = 1095$
$2.5 \times 150.0 = 375$
$w = 1470$ #/□' TOTAL

$$M_1 = \frac{wk^2l^2}{2} = \frac{1470(.266)^2(15)^2}{2} = -11{,}800 \text{ ft. lbs.}$$

$$M = \frac{wl^2(1-4k)}{8} = \frac{1470(15)^2(1-1.064)}{8} = -2{,}700 \text{ ft. lbs.}$$

$$R = \frac{1470 \times 15}{2} = 11{,}000 \text{ lbs.}$$

NEGATIVE MOMENT

"d" REQ. $d = \sqrt{\frac{11{,}800 \times 12}{123 \times 12}} = 9.8''$ ACTUAL $d = 25.5''$

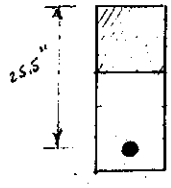
$A_s = \frac{11{,}800 \times 12}{18000 \times .884 \times 25.5} = .35$ □" $\frac{5}{8}''\phi$ 12" c.c. (.31 □"/ft.) (SEE ABOVE SECTION)

$v = \frac{11{,}000}{12 \times .884 \times 25.5} = 41$ #/□" O.K.

POSITIVE MOMENT (USE $M = \frac{wl^2}{12}$)

$$M = \frac{1470 \times (7)^2}{12} = 6000 \text{ ft. lbs.}$$

$A_s = \frac{6000 \times 12}{18000 \times .884 \times 25.5} = .18$ □" ($\frac{5}{8}''\phi$ 12" c.c. .31 □"/ft)



Subject: NORTHAMPTON DROP STRUCTURE
Computation: FLOOR SLAB
Computed by: E.R. Checked by: Date: 4-17-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

UNDER THE MOST EXTREME LOADING CONDITIONS (PAGE 1) 0.35 sq. in. OF STEEL IS REQUIRED PER FOOT OF SLAB (2.5' THICK.). THE SEVERITY OF THE DESIGN CRITERIA MAKE IT REASONABLE TO EXPECT BENDING MOMENTS OF LESSER MAGNITUDE. SINCE 5/8" ϕ - 12" cc GIVES AN AREA OF 0.31 sq. in./ft., AND SINCE THIS SIZE AND SPACING WOULD HAVE TO BE USED FOR TEMPERATURE STEEL, IT IS OBVIOUS THAT TO USE THE 5/8" ϕ STEEL THROUGHOUT IS STRUCTURALLY SUFFICIENT.

THE LOADING CONDITIONS AS ASSUMED FOR THE COMPUTATIONS ARE EXCEEDED AT NO OTHER POINT IN THE FLOOR SLAB. ALTHOUGH IT WOULD BE POSSIBLE TO REDUCE THE STEEL AT SECTIONS WHERE VERTICAL LOADING IS DECREASED, IT WAS DEEMED NOT DESIRABLE BECAUSE OF THE EXISTENCE OF CERTAIN SECONDARY STRESSES. AN APRECIABLE HORIZONTAL THRUST, EXERTED BY THE RETAINING WALLS AND BRIDGE, WILL HAVE TO BE TRANSMITTED THROUGH THE FLOOR SLAB.

WHERE THE SLAB IS 2.5' THICK THE STEEL WILL BE PLACED WITH 4" COVERAGE ON EACH FACE. THIS WILL PUT THE LOWER STEEL INTO THE ZONE ALLOWED FOR PILE EMBEDMENT AND THEREBY INCREASE THE EFFECTIVE DEPTH. WHERE THE SLAB IS 4' THICK THE STEEL CAN BE PLACED ABOVE THE PILE TOPS.

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

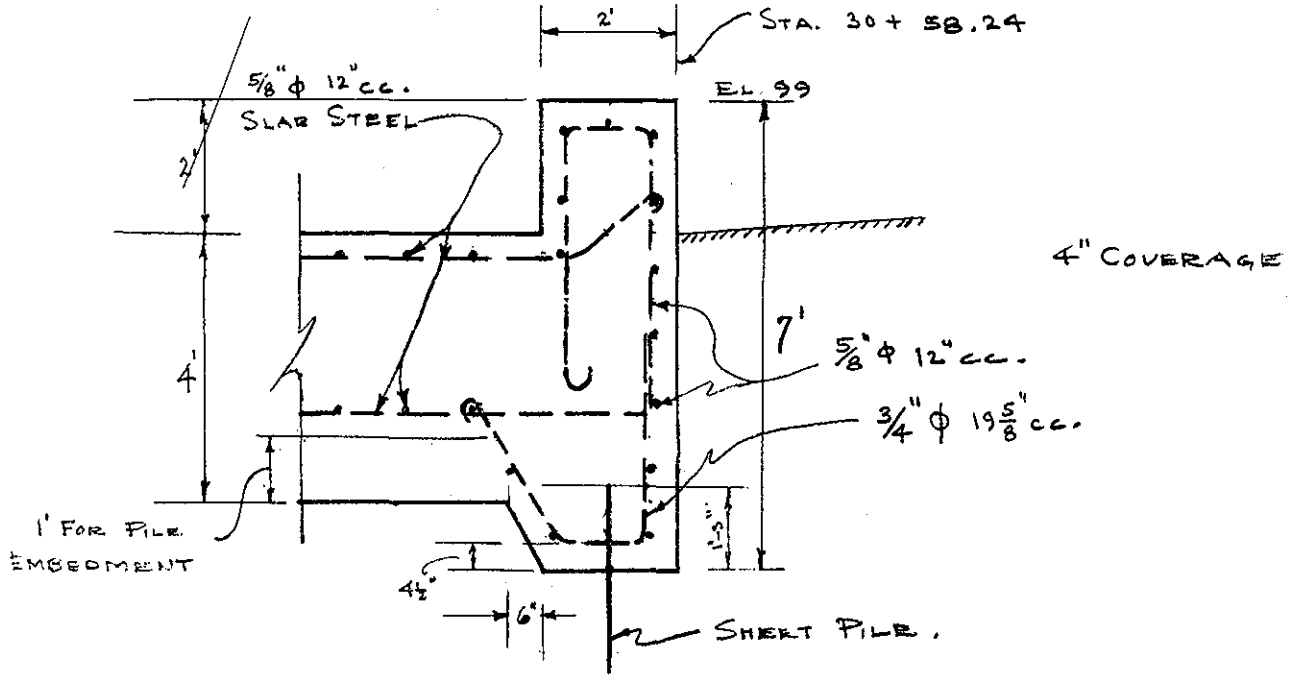
Subject NORTHAMPTON DROP STRUCTURE

Computation FLOOR SYSTEM STEEL

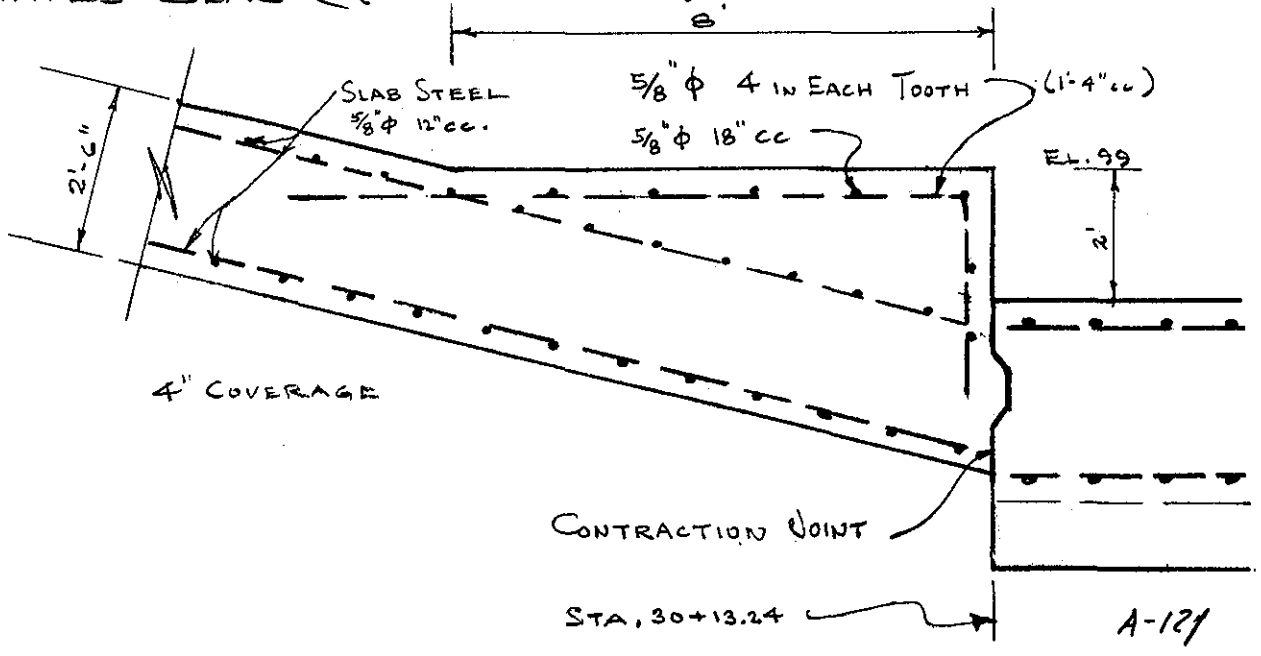
Computed by E.R. **Checked by** **Date** 4-18-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

TERMINAL SILL & CUT-OFF



DENTATED SLAB (APRON TOOTH)



A-121

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

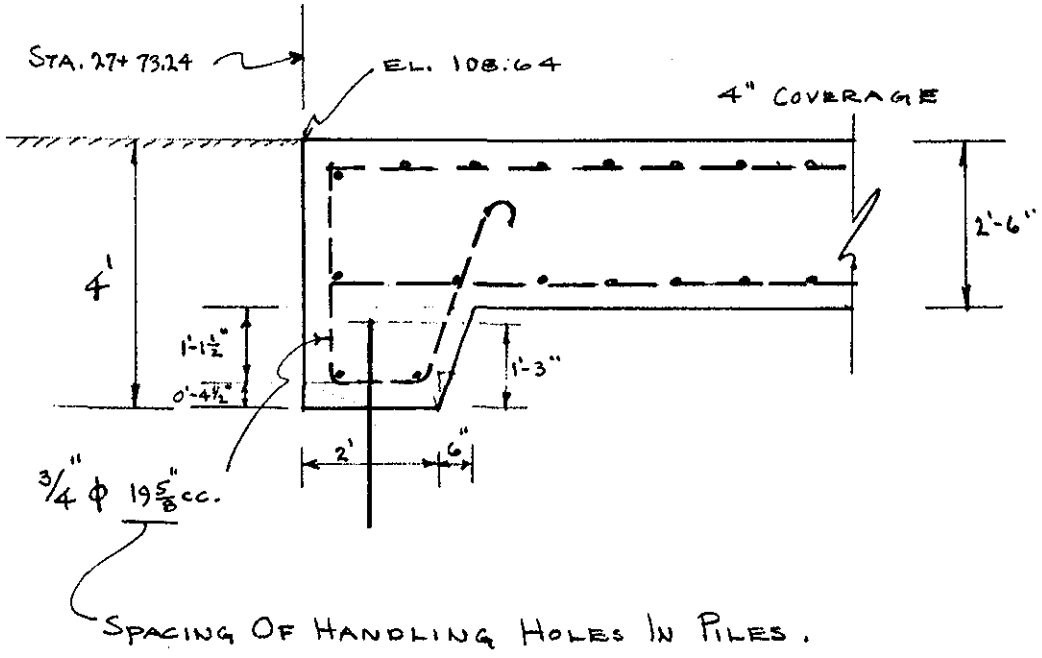
Subject NORTHAMPTON DROP STRUCTURE

Computation FLOOR SYSTEM STEEL

Computed by ER **Checked by** **Date** 4-18-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

CUT-OFF AT UPSTREAM END OF CHANNEL LINING



SPACING OF HANDLING HOLES IN PILES.

APPENDIX A

III WEST STREET STOP-LOG STRUCTURES

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

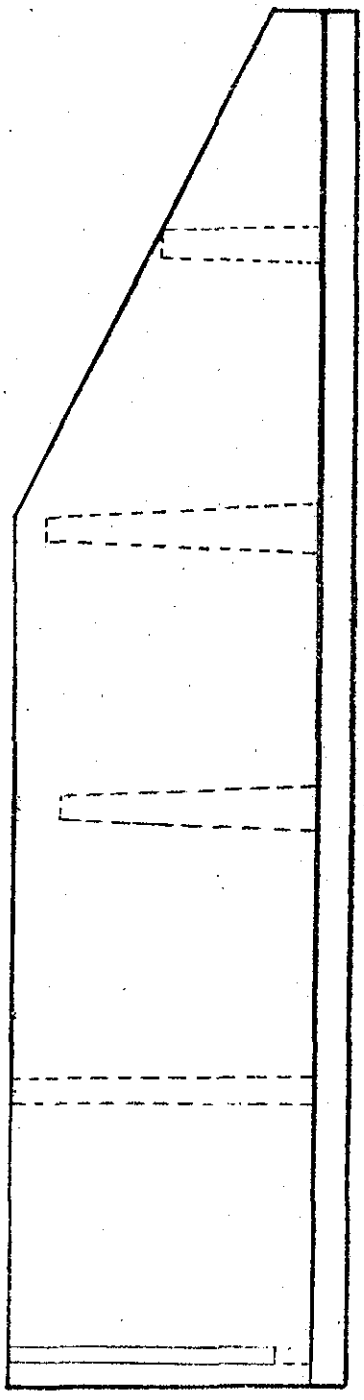
Page 1

Object Northampton Dike

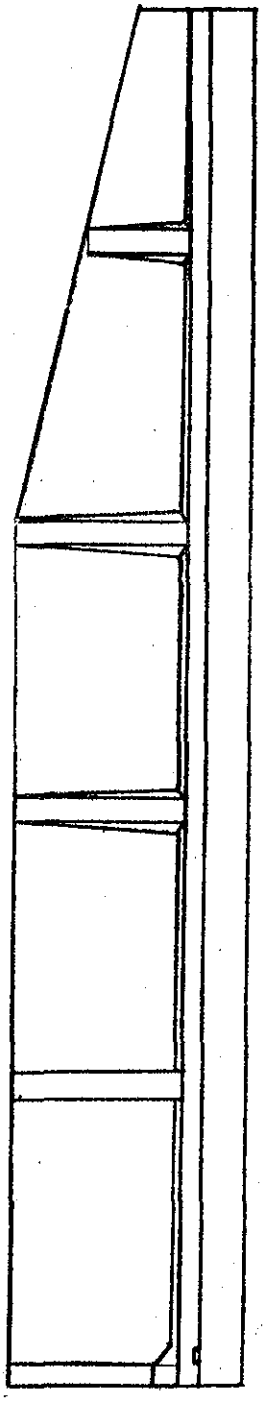
Computation Earth Dike Retaining Wall - North End of Stop-Log Structure

Computed by T.J.S. **Checked by** **Date** 7-20-39

U. S. GOVERNMENT PRINTING OFFICE 3—10598



ELEVATION
ROADWAY SIDE



PLAN

A-123

Project: Northampton Dike
Computation: Stop Log Structure
Computed by: T.J.S. Checked by: Date: 7-20-39

U. S. GOVERNMENT PRINTING OFFICE 3—10526

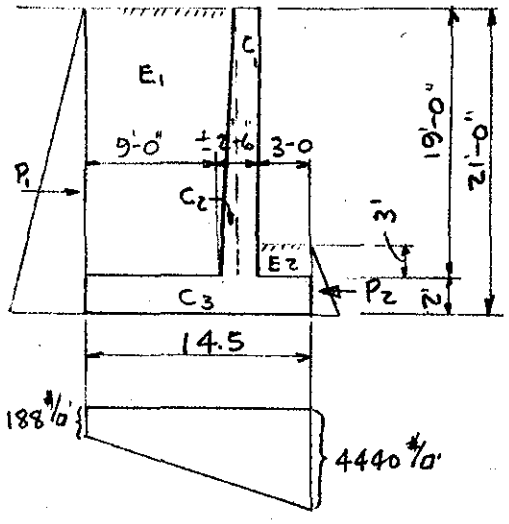
Loads ↓

C_1	$1.5 \times 19.0 \times 150 =$	4280	$\times$ 10.75 =	+ 46,000
C_2	$0.95 \times 19.0 \times \frac{1}{2} \times 25 =$	110	$\times$ 9.68 =	+ 1,090
C_3	$2.0 \times 14.5 \times 150 =$	4350	$\times$ 7.25 =	+ 31,540
E_1	$10.0 \times 19.0 \times 125 =$	23750	$\times$ 5.0 =	+118,750
E_2	$3.0 \times 3.0 \times 100 =$	900	$\times$ 13.0 =	+ 11,700
P_1	$(21)^3 \times \frac{1}{6} \times 70 =$			+ 108,100
P_2	$(5)^3 \times \frac{1}{6} \times 35 =$			- 730
		33,390		316,450'#

Position of Resultant $= \frac{316\,450}{33390} = 9.49'$

eccentricity $= 9.49 - 7.25 = 2.24'$

$$P = \frac{33390}{14.5}\left(1 \pm \frac{6 \times 2.24}{14.5}\right) = \begin{matrix} 4440\ \#/\square' \text{ @ Toe} \\ 188\ \#/\square' \text{ @ Heel} \end{matrix}$$



Toe:-

$$M = 3560 \times \frac{\overline{3}^2}{2} + 880 \times \frac{\overline{3}^2}{6} - 450 \times \frac{\overline{3}^2}{2} = 15340'\#$$

$$As = \frac{15340 \times 12}{18000 \times .884 \times 19.5} = 0.59\ \square''$$

Use $\frac{5}{8}''\phi$ @ 6" c.c. $As = 0.62\ \square''$

Heel:-

@ Wall

$$-M = [(19 \times 125) - 2694] \times \overline{16.25}^2 \times \frac{1}{12} = -7050'\#$$

@ Edge

$$-M = 2040 \times \overline{16.25}^2 \times \frac{1}{12} = -45000'\#$$

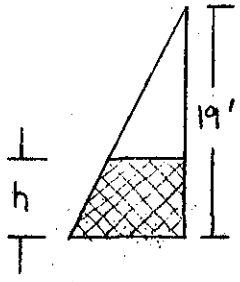
$$As = \frac{45000 \times 12}{18000 \times .884 \times 20.5} = 1.66\ \square''$$

Subject Northampton Dike, Mass.
Computation Retaining Wall
Computed by C.W.B. McM. Checked by T.J.S. Date 7-17-39

U. S. GOVERNMENT PRINTING OFFICE 2—10528

Wall Slab

Panel (1) as a vertical cantilever



$M = \frac{L^2}{6}(2w_1 + w_0)$ $\quad A_s = M/fjd$

$h = 9 \quad M = \frac{9^2}{6}(2 \times 10 \times 70 + 19 \times 70) = 36{,}850$ ft #

$A_s = 36{,}850 / 1320 \times 14.5 = 1.92$ □"

$h = 6 \quad M = \frac{6^2}{6}(2 \times 13 \times 70 + 19 \times 70) = 18{,}900$ ft #

$A_s = 18{,}900 / 1320 \times 14.5 = 0.99$ □"

$h = 3 \quad M = \frac{3^2}{6}(2 \times 16 \times 70 + 19 \times 70) = 5{,}350$

$A_s = 5{,}350 / 1320 \times 14.5 = 0.28$ □"

Panel (5) as a vertical cantilever

$M = wh^3/6 \quad A_s = M/fjd \quad w = 35$

$h = 9 \quad M = 35 \times 9^3/6 = 4250$ ft #

$A_s = 4250 / 1320 \times 14.5 = 0.22$

Subject: Northampton Dike, Mass.
Computation: Retaining Wall
Computed by: C.W.B. McM. Checked by: T.J.S. Date: 7-17-39

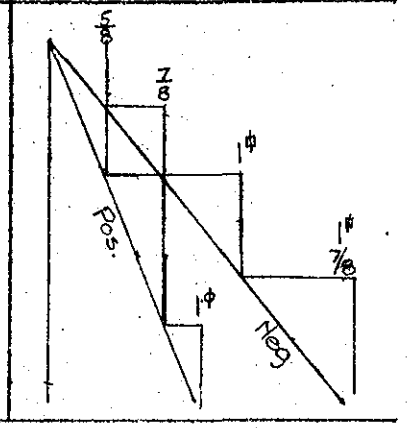
U.S. GOVERNMENT PRINTING OFFICE 3—10638

Wall Slabs

Panels (2) and (3) · Assume $M_{ctft} = \frac{wL^2}{12}$; $w_o = 70$ #/

Horiz. Beam Strips h = distance below crown of wall.

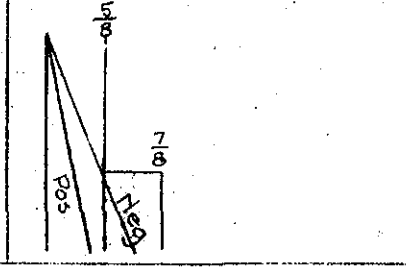
h	ω	V	M	A_s	v	Bar	u	A_s
ft	#/ft²	#	ft #	□"/□'	#/□"	"	#/□"	□"
	70 h	½ω×16.25	⅙ω×16.25²	M/fjd	V/bjd		V/Σjd	0.0 0.6 1.2 1.8
0								
2								
4	210	1705	4,620	0.24				
6								
8	490	3980	10,780	0.56				
10								
12	770	6255	16,940	0.89			123	
14								
16	1050	8530	23,100	1.21				
18	1330	10805	29,270	1.53	70		126	



fjd = 18000 × 0.88 × 14.5 ÷ 12 = 19,140 bjd = 12 × 0.88 × 14.5 = 154 □"

Panels (4) and (5) M = $wL^2/12$ L = 16.25 w_o = 35 h

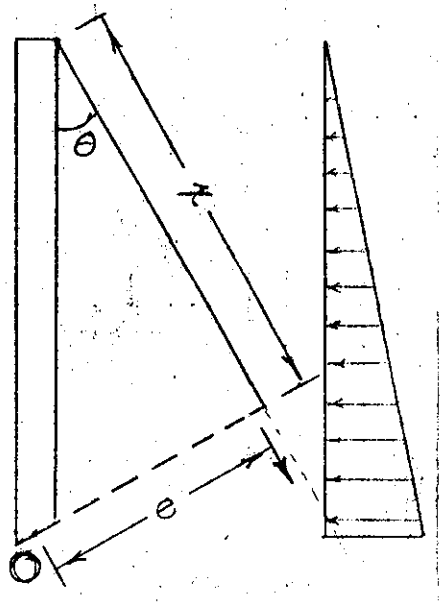
h	ω	V	M	A_s	v	Bar	u	A_s
ft	#/ft²	#	ft #	□"	#/□"	"	#/□"	□"
	35 h	½ωL	⅙ωL²	M/fjd	V/bjd		V/Σjd	0.0 0.6 1.2 1.8
0								
2								
4	105	852	2,310	0.12				
6								
8	245	1990	5,390	0.28				
10	385	3128	8,470	0.45	20			



Object: Northampton Dike
Computation: Retaining Wall
Computed by: C.W.B. McM. Checked by: T. J. S. Date: 7-17-39

U. S. GOVERNMENT PRINTING OFFICE 3—10588

Counterfort Steel – Main Counterforts



Balancing moments at "O"

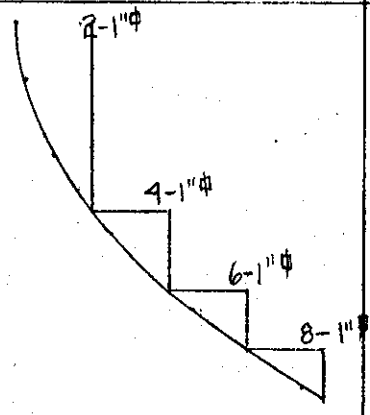
$M = F \times e = \frac{1}{6} w h^3 L$ $\qquad e = h \tan\theta = 0.52\ h$

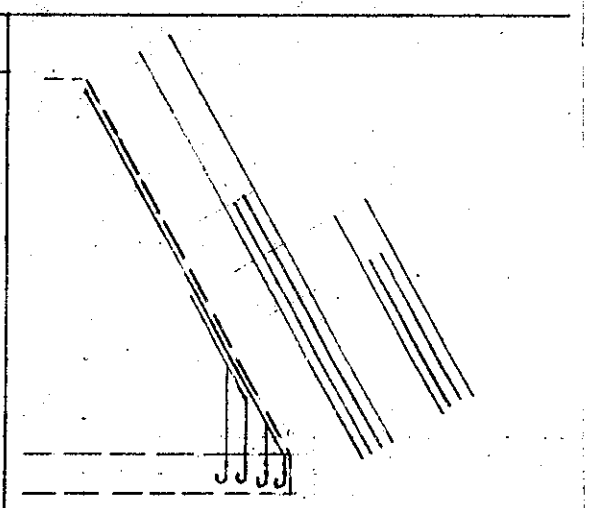
$A_s f_s \times 0.52\ h = \frac{1}{6} \times 70 \times h^3 \times 16.25$

$A_s = \frac{70 \times 16.25}{18{,}000 \times 0.52 \times 6} \times h^2 = 0.0204\ h^2$

$x = h \cos\theta = 0.89\ h$

h	h^2	A_s	0.0 2.0 4.0 6.0 8.0	x
0				
2				
4	9	0.18		2.7
6				
8	49	1.00		6.2
10				
12	121	2.46		9.8
14				
16	225	4.57		13.3
18				
20	361	7.40		16.9





Horizontal and Vertical Steel

Minimum = 5/8"φ @ 12"cc for temperature

Minimum = Shear strength for "strip beams".

$V = \frac{wL}{2}$ $\qquad w = 70h$ for wall beams

$\frac{L}{2} = \frac{1}{2}(16.25 - 1.5)$ $\qquad$ w for base to be taken from diagram on previous sheet.

$= 7.38'$

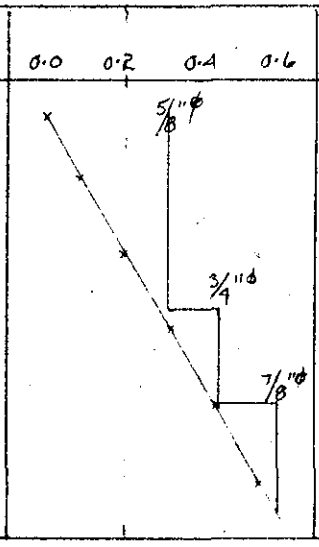
A-127

Subject Northampton Dike, Mass.
Computation Retaining Wall
Computed by C.W.B. McM. Checked by T. J. S. Date 7-17-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

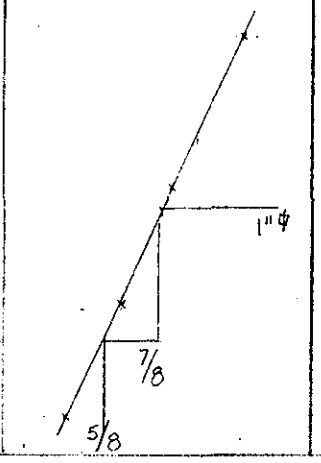
Horizontal Steel $A_s = \frac{V}{f}$

n	ω = 70 h	V 7.38 ω	A_s
0			
4	210	1550	0.09
8	490	3616	0.20
12	770	5683	0.32
16	1050	7749	0.43
20	1330	9815	0.55



Vertical Steel x = distance from toe $\omega = 2500 - 220x$

x	ω	V 7.38 ω	A_s
0	2500	18,450	1.03
2			
4	1620	11,960	0.66
6			
8	960	7,085	0.40
10	300	2,214	0.12



WAR DEPARTMENT

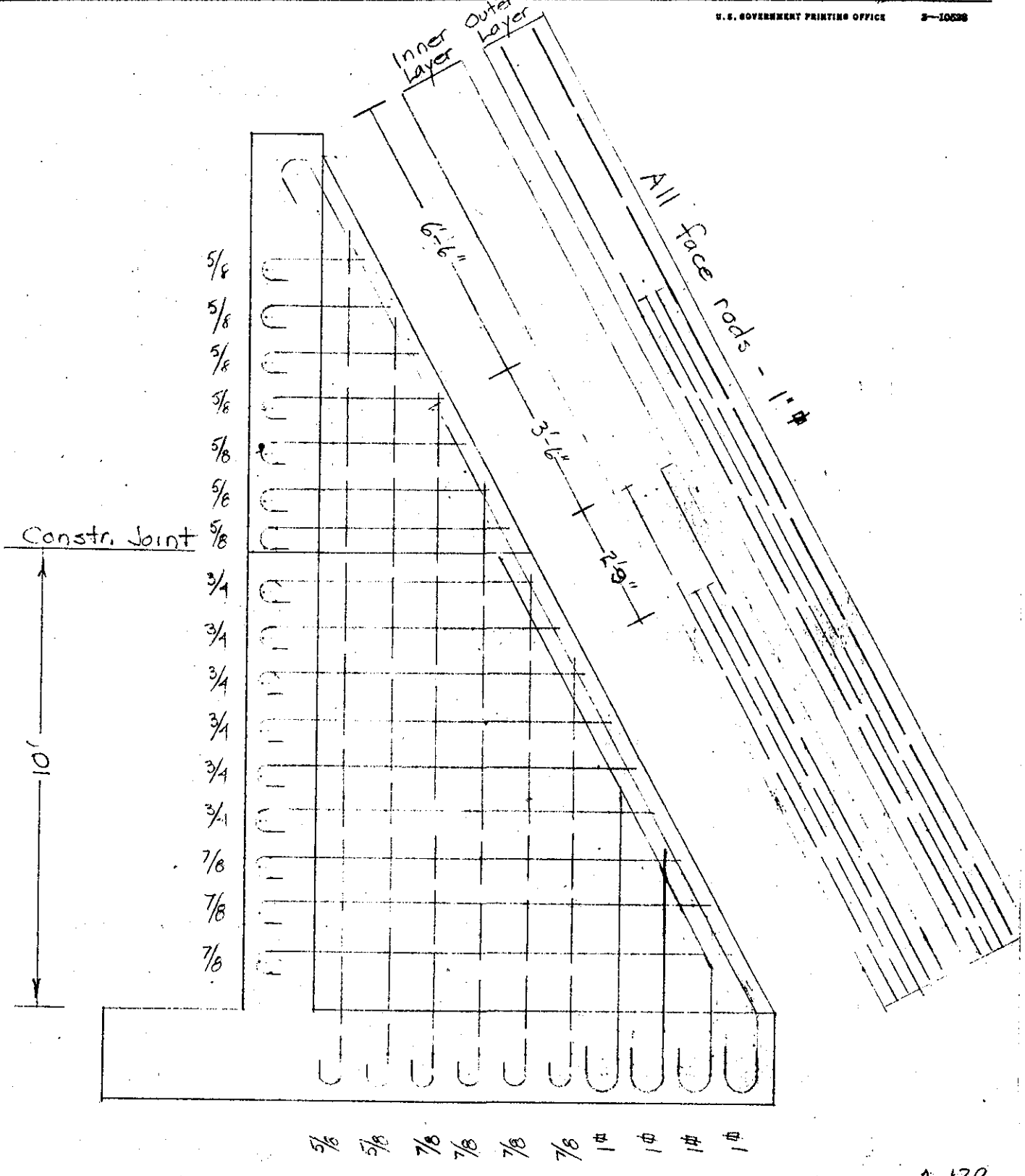
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: Northampton Dike

Computation: Retaining Wall

Computed by: C.W.B. McM. Checked by: T. J. S. Date: 7-17-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



A-129

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page _____

Subject: Northampton Dike

Computation: Stop Log Structure

Computed by _____ Checked by _____ Date _____

U. S. GOVERNMENT PRINTING OFFICE 3—10536

West Street
STOP Log Structure

16 pages

A-130

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

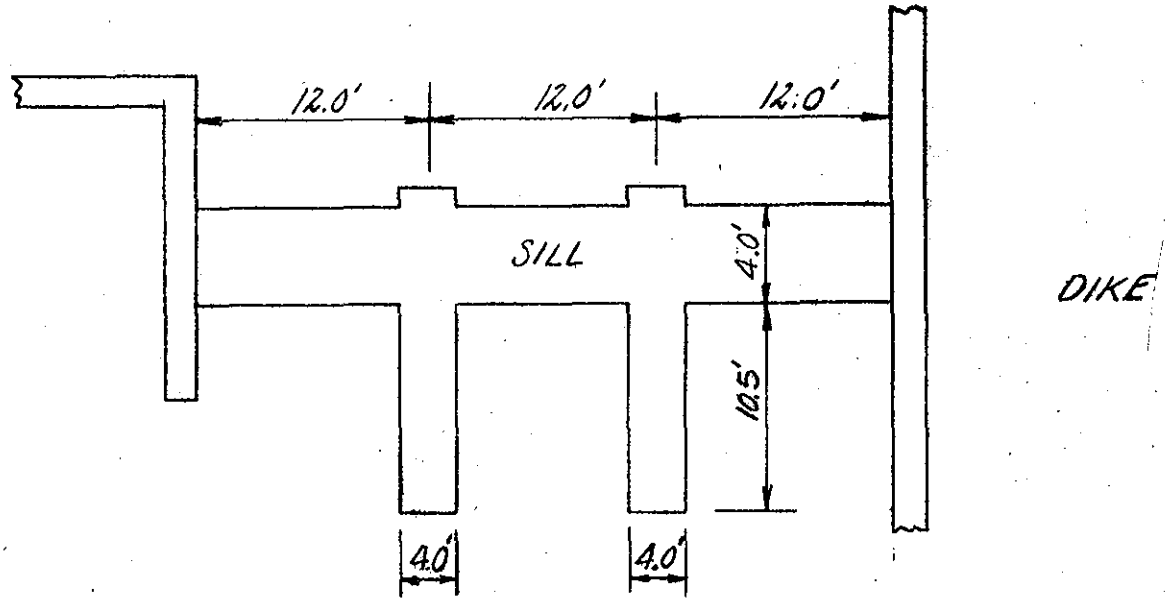
Page 1

Subject: Northampton Dike

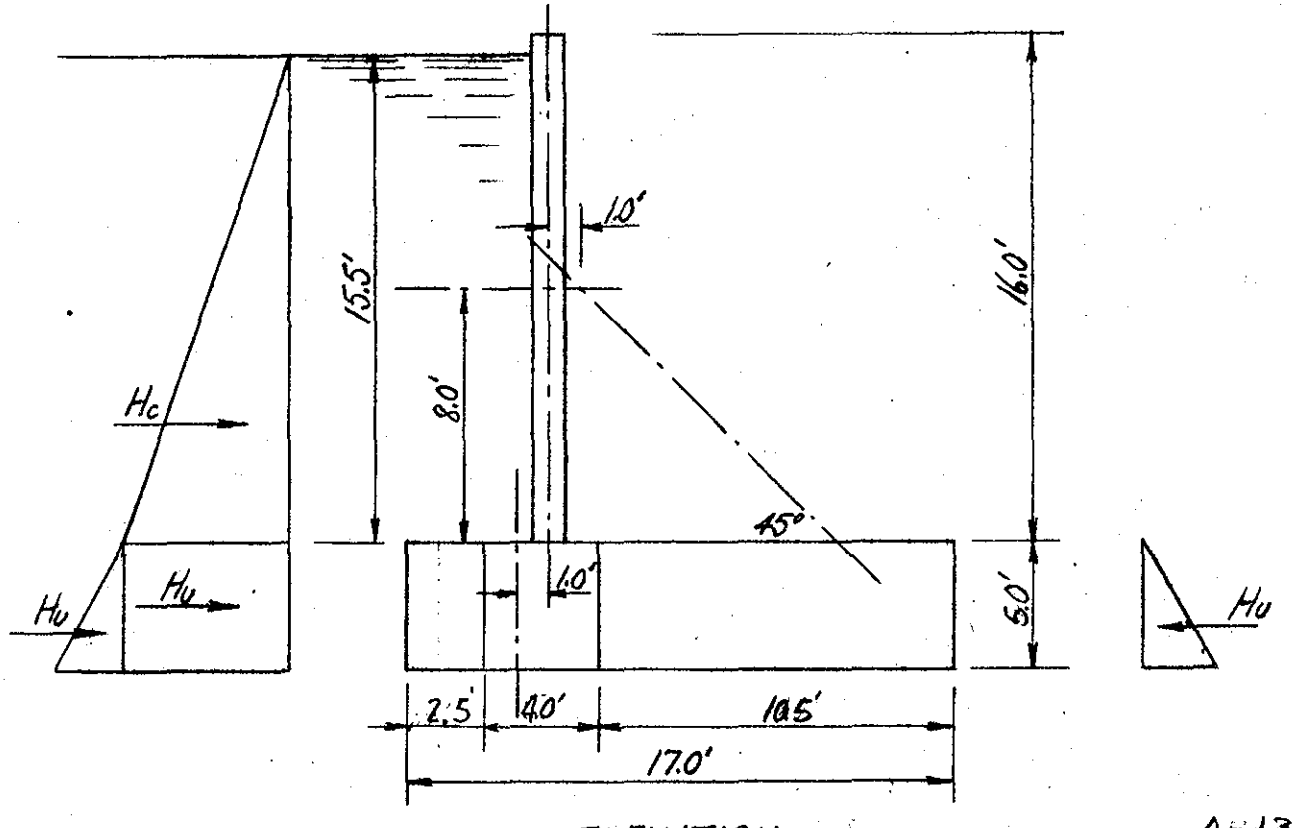
Computation: West Street Stop-Log Structure

Computed by: J.H.B. Checked by: T.J.S. Date: 6-28-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



PLAN



ELEVATION

AF131

Project: Northampton Dike
Computation: West Street Stop-Log Structure
Computed by: L.N.B. Checked by: T. J. S. Date: 6-28-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Horizontal Forces

$H_c = \frac{1}{2} \times 62.5 \times \overline{15.5}^2 \times 12 = 90{,}000^{\#}$ per 12' span

$\Sigma H_u = 15.5 \times 62.5 \times 5.0 + \frac{1}{2} \times 80 \times \overline{5.0}^2 - \frac{1}{2} \times 35 \times \overline{5.0}^2 = 5410\ \#/'$ of length

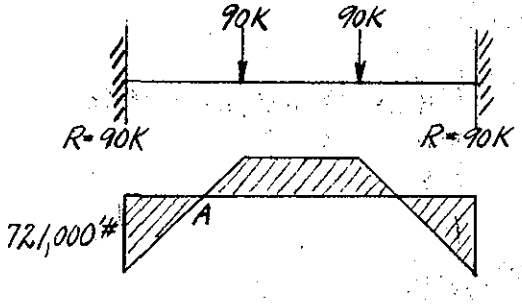
Fixed Horizontal Moment (assuming H_c as concentrated)

$$M_F = \frac{1}{L^2} \Sigma P a b^2 + \frac{wL^2}{12}$$

$$= \frac{90{,}000}{\overline{36}^2}\left(12 \times \overline{24}^2 + 24 \times \overline{12}^2\right) + \frac{5410 \times \overline{36}^2}{12} = 1{,}305{,}000\ '^{\#}$$

Required Width of Sill

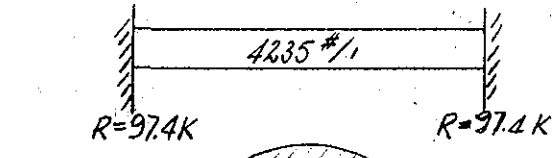
$$d = \sqrt{\frac{M}{Kb}} = \sqrt{\frac{1{,}305{,}000 \times 12}{125 \times 60}} = 45.5'' \quad \text{--- use } 4'\text{-}0'' \text{ width}$$

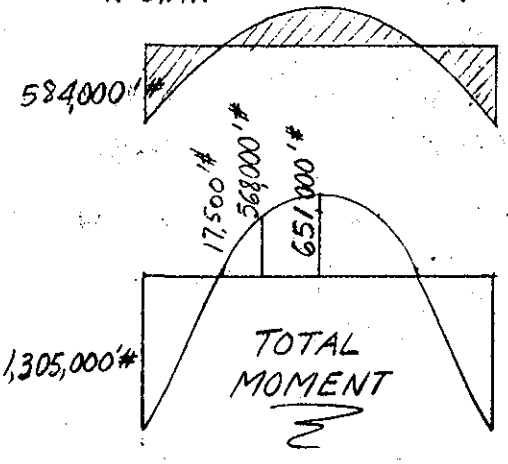


Concentrated Loads

$M_F = \frac{90{,}000}{\overline{36}^2}\left(12 \times \overline{24}^2 + 24 \times \overline{12}^2\right) = 721{,}000^{\#}$

M (simple beam) $= R \cdot a = 1{,}080{,}000\ '^{\#}$





Uniform Load

$5410 \times 36/2 = 97{,}400^{\#} = R$

$M_F = \frac{5410 \times \overline{36}^2}{12} = 584{,}000\ '^{\#}$

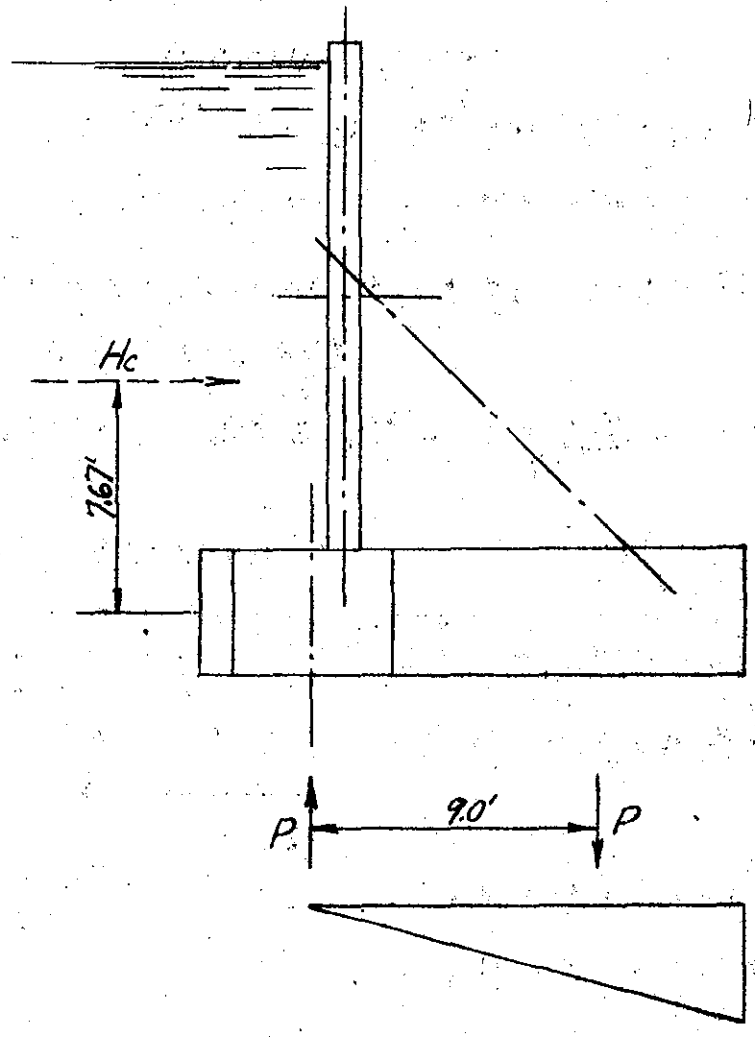
M (simple beam) $= 876{,}000\ '^{\#}$ at center

$M = 779{,}000\ '^{\#}$ at $\frac{1}{3}$ points

$M = 605{,}000\ '^{\#}$ at point A

Project: Northampton Dike
Computation: West Street Stop-Log Structure
Computed by: S.H.B. - C.W.B.M. Checked by: T. J. S. Date: 6-29-39

U.S. GOVERNMENT PRINTING OFFICE 3—10698



The load above the sill is assumed concentrated at the center supports, and the load below is considered as being uniformly distributed over the length of the sill.

$$P = \frac{90{,}000 \times 7.67}{9.0} = 76{,}700\#$$

$$M_F = \frac{1}{L^2}\Sigma Pab^2 = \frac{76700}{36^2}\left(12\times24^2+24\times12^2\right) = 615{,}000'\#$$

$$d\ (\text{required}) = \sqrt{\frac{M}{Kb}} = \sqrt{\frac{615{,}000\times12}{125\times48}} = 35.1''$$

use 5'-0" depth
(for front)

Project Northampton Dike
Computation West Street Stop-Log Structure
Computed by S.H.B - C.W.B.M. Checked by T. J. S. Date 6-29-39

U. S. GOVERNMENT PRINTING OFFICE 9—10538

Base Pressure

Assume 4' width of center support

$\Sigma V = 0$

$P = \frac{1}{2} \times 13.5 \times 4.0 \times p(max.) = 76,700^{\#}$

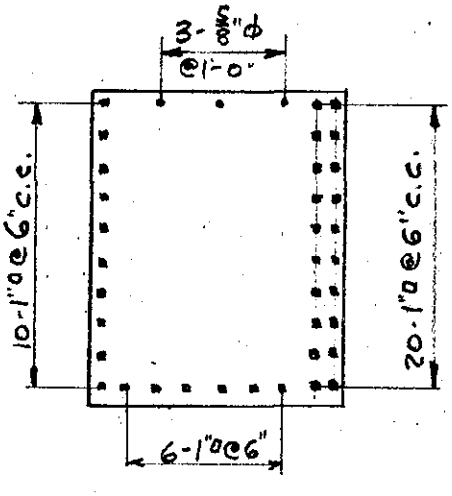
$p(max.) = 2940^{\#}/\square'$

Shear

$\Sigma H = 90,000 + 97,500 = 187,500^{\#}$ at wall end of sill

$v = \frac{187,500}{44 \times 0.88 \times 60} = \frac{V}{bjd} = 78^{\#}/\square''$

Design of Beam

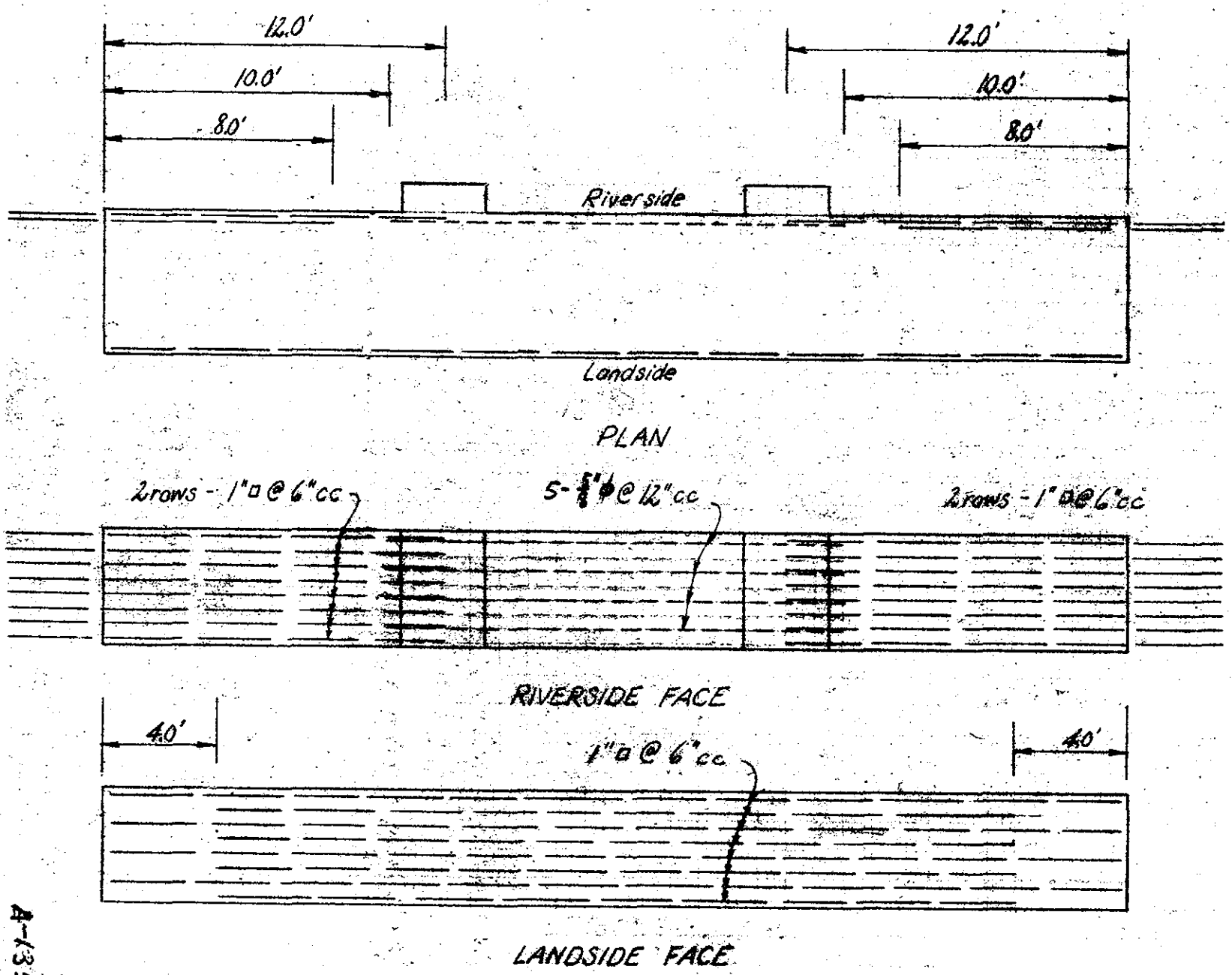


$A_s(bottom) = \frac{61,500 \times 12}{18000 \times 0.88 \times 65.5} = 7.1\square''$

$A_s(Riverside) = \frac{1,305,000 \times 12}{18000 \times 0.88 \times 45} = 21.9\square''$

WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

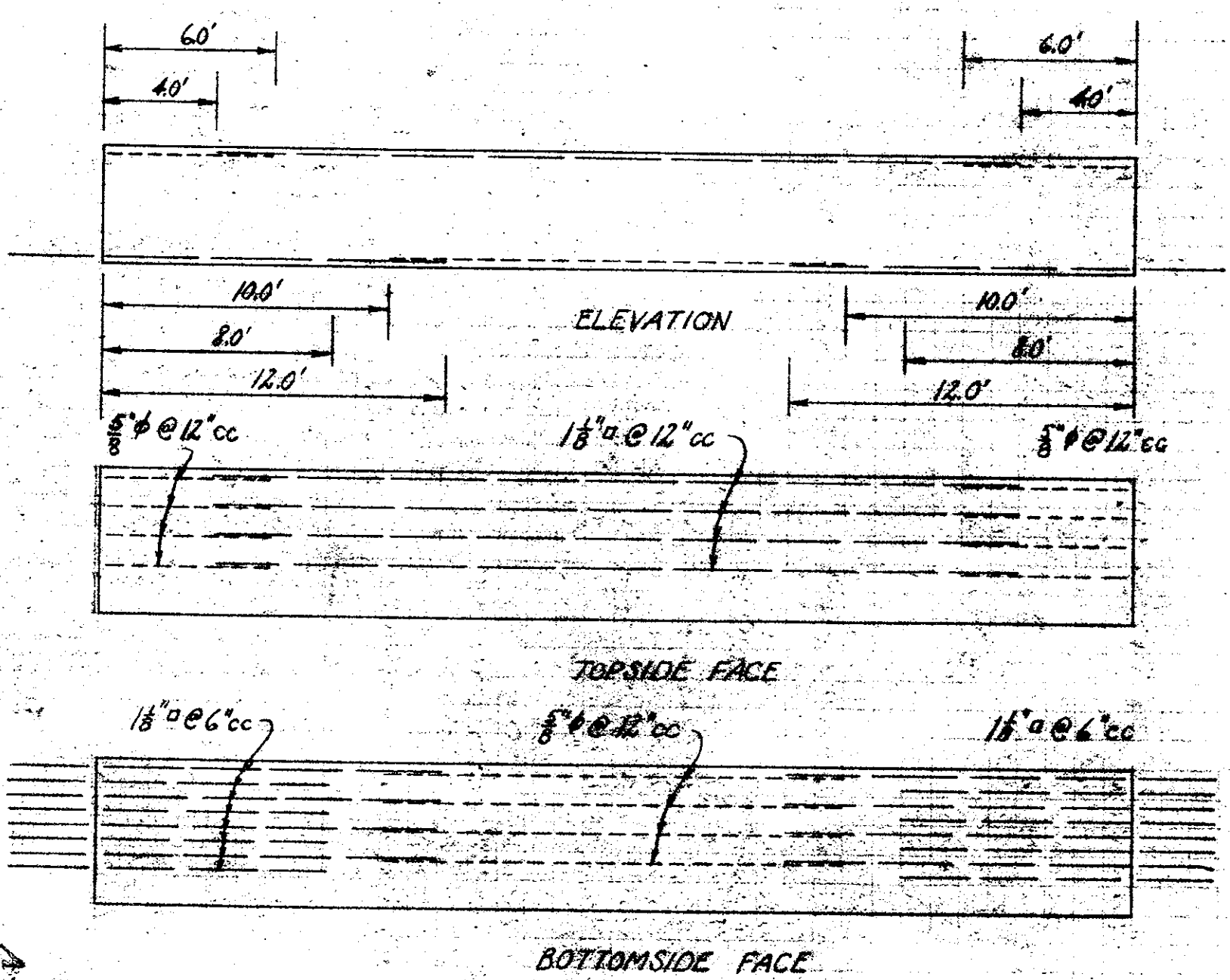
Subject: Northampton Dike
Computation: Brookwest Street Stop-Log Structure
Computed by: C.W.B.M. - C.W.B.M. Checked by: Date: 6-22-39
Page: 5



U.S. GOVERNMENT PRINTING OFFICE 2—10000

WAR DEPARTMENT
U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Project Northampton Dike
Computation West Side Log Structure
Computed by CWBM Checked by Date 6-20-39
Page 6



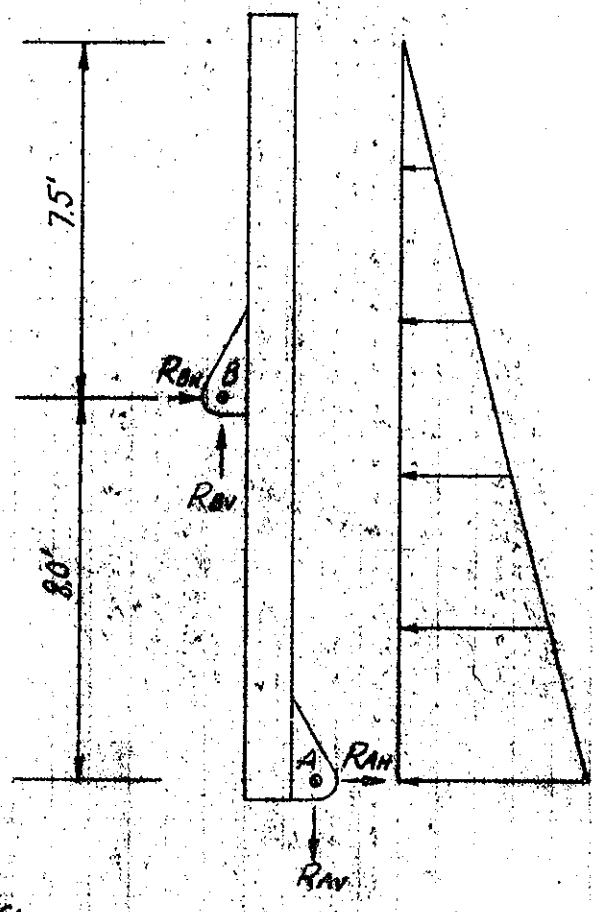
Subject: Northampton Dike
Computation: West Street Stop-Log Structure
Computed by: S.N.B. - CWBM Checked by: T. J. S. Date: 6-30-39

U. S. GOVERNMENT PRINTING OFFICE 3—10535

CENTER SUPPORT BEAM

Assume the following dimensions as starting approximations. Assume also that the reactions at B are equal.

Reactions per foot of wall.



R_B

$$\Sigma M_A = 0$$

$$= \frac{62.5 \times \overline{15.5}^3}{6} - R_{BH} \times 8 - R_{BV} \times 2$$

and $R_{BH} = R_{BV} = 3870$ #/ft.

R_{AV}

$$\Sigma V = 0$$

$$= R_{BV} - R_{AV} = 3870 - R_{AV}$$

and $R_{AV} = 3870$ #/ft.

R_{AH}

$$\Sigma H = 0$$

$$= \frac{62.5 \times \overline{15.5}^2}{2} - R_{BH} - R_{AH}$$

and $R_{AH} = 7500 - 3870 = 3630$ #/ft.

Bending Moments per foot of wall

$$M_B = \frac{wh^3}{6} = \frac{62.5 \times \overline{7.5}^3}{6} = 4380 \text{ '#}$$

$$M_{\mathbb{C}AB} = \frac{wh^3}{6} - \Sigma Pe = \frac{62.5 \times \overline{7.5}^3}{6} - 3870 \times 4 - 3870 \times 1$$

$$= 15{,}840 - 15{,}480 - 3870$$

$$= 3510 \text{ '#}$$

Subject: Northampton Dike
Computation: West Street Stop-Log Structure
Computed by: J.A.B. - CWBM Checked by: T. J. S. Date: 7-1-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Shears per foot of wall

$$V_{BC} = \frac{wh^2}{2} = \frac{62.5 \times 7.5^2}{2} = 1760\#$$

$$V_{BA} = R_{BH} = 1760 = 2110\#$$

$$V_{AB} = R_{AH} = 3630\#$$

Choice of Section

Requirements

(1) Fiber Stress in bending.
(2) Longitudinal Shear Stress.
(3) Buckling of web.
(4) Buckling of flange
(5) Clear depth = 10" + clearance (see stop log size)
(6) Flange width = 2" + clearance (" " " ")

(1) For an approximation

$$S\ req'd = \frac{M}{f} = \frac{4380 \times 12 \times 12}{18{,}000} = 35.0\ in^3$$

(5) Clear depth

$$10" + 1" = 11" \pm$$

(6) Flange width

$$2(2" + 1") + \tfrac{1}{2} = 6\tfrac{1}{2}" \pm$$

Subject: Northampton Dike
Computation: West Street Stop-Log Structure
Computed by: CWBM Checked by: T. J. S. Date: 7-1-39

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Try a 14" CB 30#

$S = 41.8 \quad A = 8.81 \quad d = 13\frac{7}{8}" \quad \text{flange} = 6\frac{3}{4}"$

Fiber Stresses

At point "B" $\quad f = \frac{M}{S} = \frac{4380 \times 12 \times 12}{41.8} = 15{,}170\ \#/\square"$

At $\not{\mathrm{C}}_{AB}$ $\quad f = \frac{P}{A} + \frac{M}{S} = \frac{3870 \times 12}{8.81} \pm \frac{3510 \times 12 \times 12}{41.8}$

$= 5260 \pm 12{,}090 = 17{,}350\ \#/\square"$

Flange Width

Allowable ratio $\frac{\text{Length}}{\text{Flange Width}} = 15$ (max.) $\quad f_c = 18{,}000\ \#/\square"$

Actual ratio $= \frac{8 \times 12"}{6.75"} = 14.2$

Web Buckling

Allowable ratio $\frac{\text{depth}}{\text{thickness}} = 60 \qquad v = 12{,}000\ \#/\square"$

Actual ratio $= \frac{13}{0.27} = 48$

Actual $v = \frac{V}{A} = \frac{3630 \times 12}{8.81} = 4840\ \#/\square"$ (in punching)

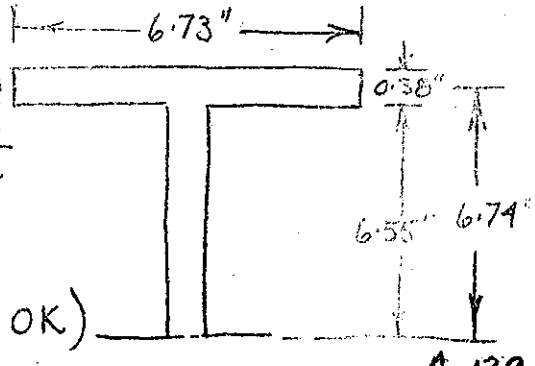
Longitudinal Shear

$v = \frac{VQ}{Ib} =$

$Q = 6.73 \times 0.38 \times 6.74 = 17.4$
$6.55 \times 0.27 \times 3.28 = 5.8$
23.2

$= \frac{3630 \times 12 \times 23.2}{289.6 \times 0.27}$

$= 12{,}900\ \#/\square"$ (slight excess OK)



Project Northampton Dike
Computation West Street Stop-Log Structure
Computed by C.W.B.M. Checked by T. J. S. Date 7-1-39

U.S. GOVERNMENT PRINTING OFFICE 3—10528

CENTER SUPPORT BRACE

Axial Load (see previous sheets) $= 3870 \times 12 \times \sqrt{2} = 65{,}600^{\#}$

Effective Length $= 8\sqrt{2} = 11.3'$

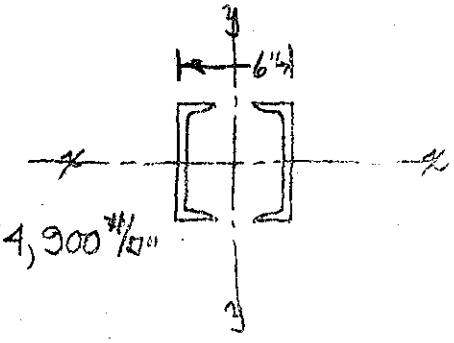
In order to provide stability against swaying prior to the placing of the logs, use a built-up member of approximate width = 6"

Desireable $\frac{L}{r} = 120$ $(f = 10{,}000\ \#/\square'')$

$$r = L/120 = 11.3 \times 12/120 = 1.13''$$

$$A = P/f = 65{,}600\ \#/10{,}000\ \#/\square'' = 6.56\ \square''$$

Try using 2 channels, $6'' \times 10.5^{\#}$



$A = 2 \times 3.07 = 6.14\ \square''$

$r_{xx} = 2.22$ $\quad \frac{L}{r} = \frac{11.3 \times 12}{2.22} = 61$ $\quad f = 14{,}900\ \#/\square''$

$I_{yy} = 2 \times 0.87 + 6.14 \times (3.0 - 0.5)^2 = 40.12$

$r_{yy} = \sqrt{40.12/6.14} = 2.56''$; $\frac{L}{r} = \frac{11.3 \times 12}{2.56} = 53$ $\quad f = 15{,}000\ \#/\square''$

Normal load due to weight of brace

Channels $= 2 \times 10.5 = 21^{\#}$
Plates $= \underline{6.4^{\#}}$
$27.4^{\#}/ft$ vertically

Normal component $= \frac{27.4 \times \sqrt{2}}{2} = 19.4\ \#/ft$

Subject Northampton Dike
Computation West Street Stop-Log Structure
Computed by C. W. B. M. Checked by T. J. S. Date 7-1-39

U. S. GOVERNMENT PRINTING OFFICE 3—10526

Normal load (accidental)

Assume weight of one man hung at center = 200#

Normal component = $200 \times \frac{\sqrt{2}}{2} = 141^{\#}$

Bending moment due to combined forces

$$M = M_o\left(1 + \frac{PL^2}{8EI}\right)$$

$$M_o = \frac{wL^2}{8} + \frac{WL}{4} = \frac{19.4 \times 11.3^2 \times 12}{8} + \frac{141 \times 11.3 \times 12}{4}$$

$$= 3720 + 4780 = 8500^{in\#}$$

$$M = 8500\left(1 + \frac{65{,}600 \times (11.3 \times 12)^2}{8 \times 30{,}000{,}000 \times 30.2}\right) = 8500\,(1 + 0.167) = 9920$$

Max. Fiber Stress

$$f = \frac{P}{A} + \frac{M}{S} = \frac{65{,}600}{6.14} + \frac{9920}{10} = 10{,}700 + 990 = 11{,}700\ \#/\square''$$

Although this stress does not correspond to that for the maximum $\frac{L}{r}$ (14,900 #/□"), this section is required by the pin size (2¾") and by the thickness of the web (to prevent failure by corrosion)

Subject Northampton Dike
Computation West Street Stop-Log Structure
Computed by C.W.B.M. Checked by T.J.S. Date 7-1-39

U. S. GOVERNMENT PRINTING OFFICE 3—10638

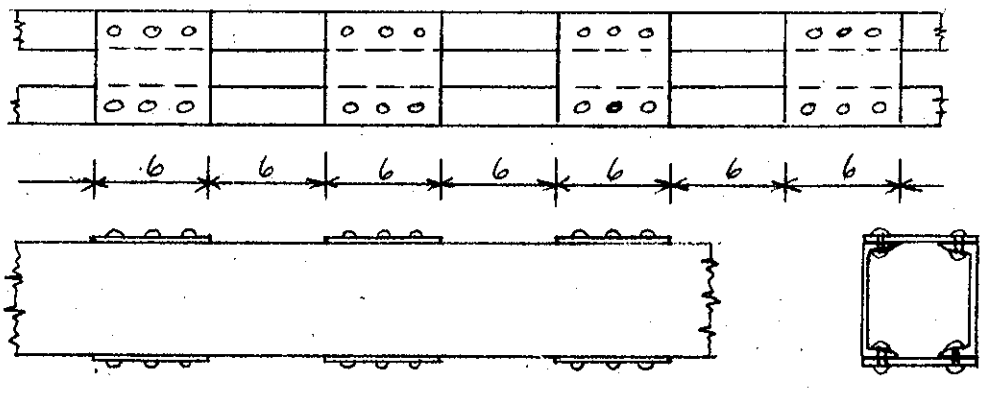
LACING

Latticework of the ordinary type would not be satisfactory, as excessive overlapping would occur. Instead, use batten plates. For specifications see A·R·E·A Steel Bridge Specifications. The regulations shown there result in thicknesses less than those required for corrosion (5/16")

Rivet size is governed by the channel leg and by the clear distance from sheared edges.

Chosen plan.

All rivets to be 1/2"



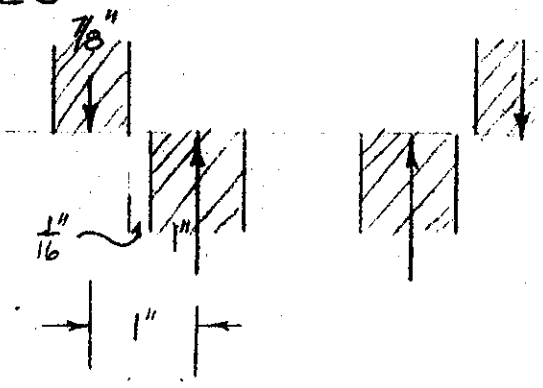
Project Northampton Dike
Computation West Street Stop-Log Structure
Computed by C.W.B.M. Checked by T. J. S. Date 7-1-39

U. S. GOVERNMENT PRINTING OFFICE 3—10332

PINS & PIN PLATES

Bending Moment in Pin

Assume casting thicknesses →



Eccentricity of ears

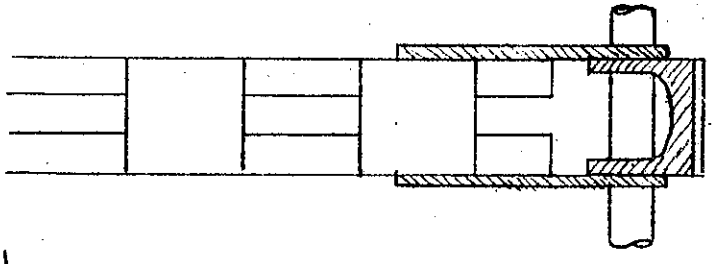
$\frac{1}{2} \times \frac{7}{8}'' + \frac{1}{2} \times 1'' + \frac{1}{16}'' = 1''$

$M = Pe = \frac{65{,}600}{2} \times 1 = 32{,}800''^{\#}$

Req'd diameter (see Carnegie pp 329)

@ $f_s = 18{,}000\ \#/\square''$ — $d = 2\frac{3}{4}''$

Trial Plan



Check on shear in pin

$v = P/A = 65{,}600/2 \times 5.94 = 5{,}500\ \#/\square''$ OK

Plate thickness (Pin plate)

$t = P/bf = 65{,}600/2 \times 2\frac{3}{4} \times 20{,}000 = 0.60''$ ·· use $\frac{5}{8}''$ plate

Connecting plates to [s

Shear force = $65{,}600/2 = 32{,}800^{\#}$

Use $\frac{7}{8}''$ rivets

shear, single @ 13,500 $n = \frac{32\,800}{8\,120} = 4$

bearing on [s @ 20,000 $n = \frac{32{,}800}{20{,}000 \times \frac{7}{8} \times 0.47} = 4.2$ Use 6

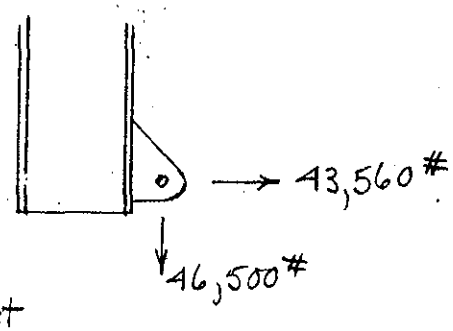
Project Northampton Dike
Computation West Street Stop-Log Structure
Computed by C.W.B.M. Checked by T. J. S. Date 7-1-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

ANCHOR CASTINGS

Loads $3630 \times 12' = 43{,}560^{\#}$
$3870 \times 12 = 46{,}500^{\#}$

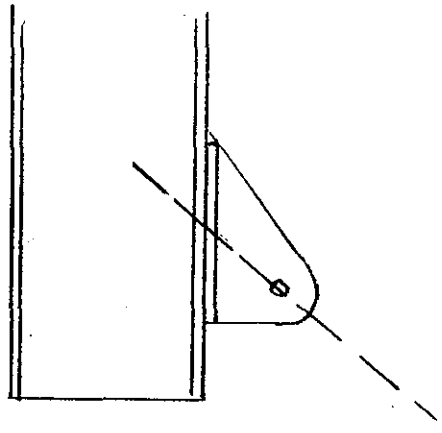
Diagonal $= 64{,}000^{\#}$



Assume 7/8" rivets -

Single shear @ 13,500 #/□" = 8120 #/rivet

$n = \frac{46{,}500}{8{,}120} = 5.8$ rivets



Bearing on I beam @ 24,000 #/□"

$n = \frac{46{,}500^{\#}}{7/8 \times 0.38 \times 24{,}000} = 5.8$ rivets

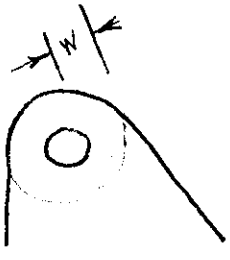
Direct Tension @ 18,000 #/□"

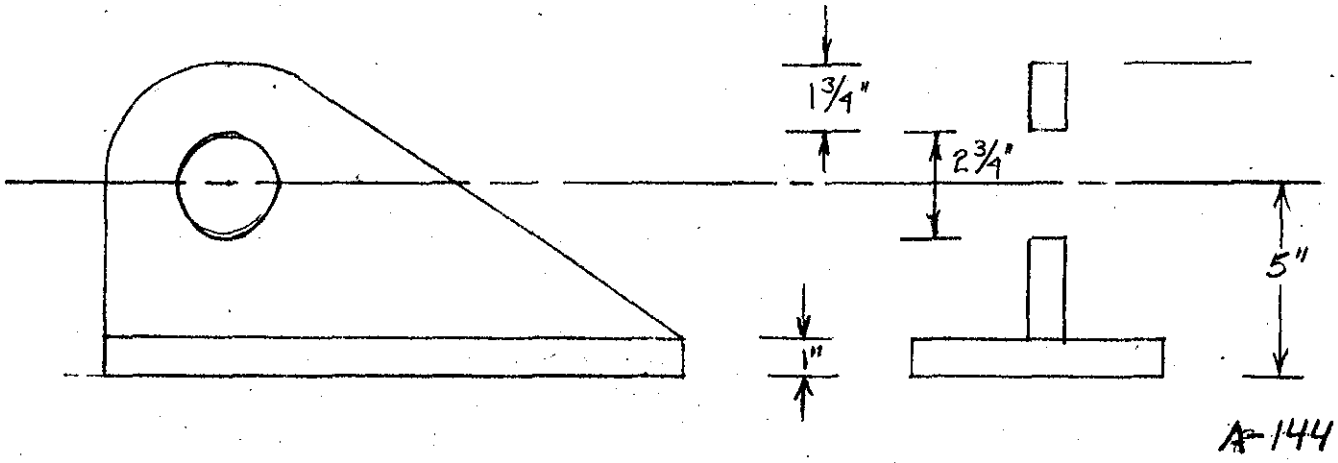
$n = \frac{43{,}560}{0.60 \times 18{,}000} = 4.3$ rivets

Use 6- (3 on @ side)

Tension across neck of casting

$w = \frac{64000}{2 \times 1 \times 18000} = 1\frac{3}{4}''$

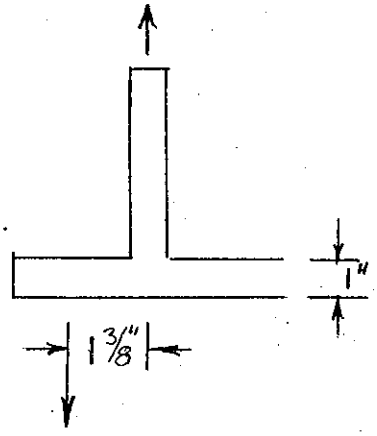




Project: Northampton Dike
Computation: West Street Stop-Log Structure
Computed by: C. W. B. M Checked by: T. J. S. Date: 7-1-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

ANCHOR CASTING



Bending Moment in bed

$M = \frac{64000}{2} \times 1.37 = 44000''\#$

$f = \frac{M}{S} = \frac{6M}{bd^2} = \frac{6 \times 44{,}000}{15 \times 1^2} = 17{,}500\ \#/\square''$

Anchor Rods

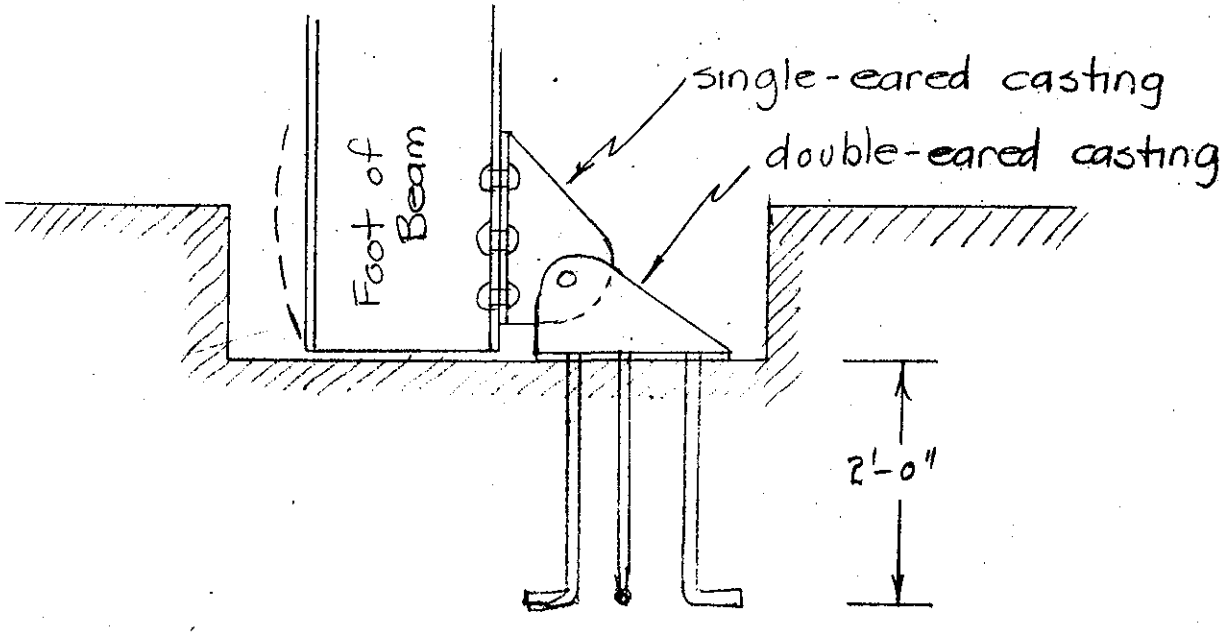
Assume 6 rods –

Pull in each $= \frac{43000}{6} = 7200\#$

Length req'd in embedment @ bond $= 100\#/\square''$

$\Sigma_o (7/8'') = 2.75''$

$L = \frac{7200}{2.75 \times 100} = 26''$ -- use 2 feet (+ hook)



Subject: Northampton Dike
Computation: West Street Stop-Log Structure
Computed by: C.W.B.M. Checked by: T.L.S. Date: 7-1-39

U.S. GOVERNMENT PRINTING OFFICE 3—10528

STRUT CASTINGS (Steel)

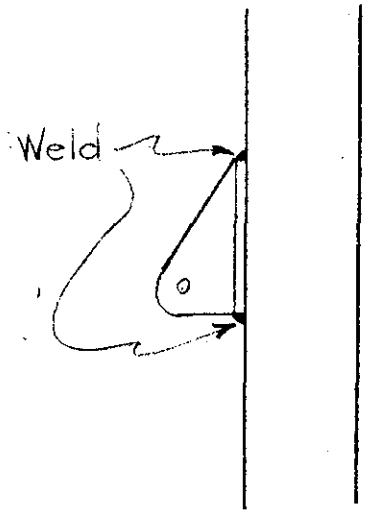
Connection to Vertical Beam

Shear Force = 3870×12 = 46,500#

Weld – 3/8" bead gives 3000#/inch

Length req'd = $\frac{46,500}{3000}$ = 15.5"

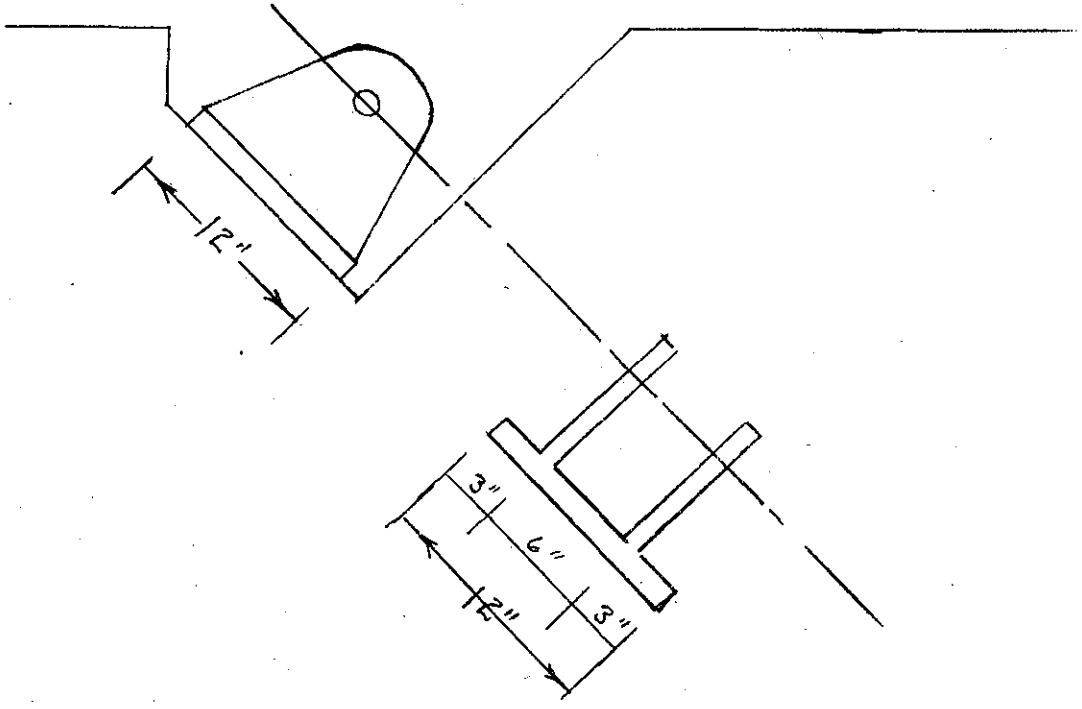
Use a 3/8" bead along all 4 sides



Connection at bottom

Bearing on concrete @ 500#/□"

A = 65,600/500 = 131 □" --- Use a 12"×12" base



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page _____

ject Northampton Dike

nputation _____

nputed by _____ Checked by _____ Date _____

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Retaining Wall, South side of West Street

Stop Log Structure

8 pages

A-147

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

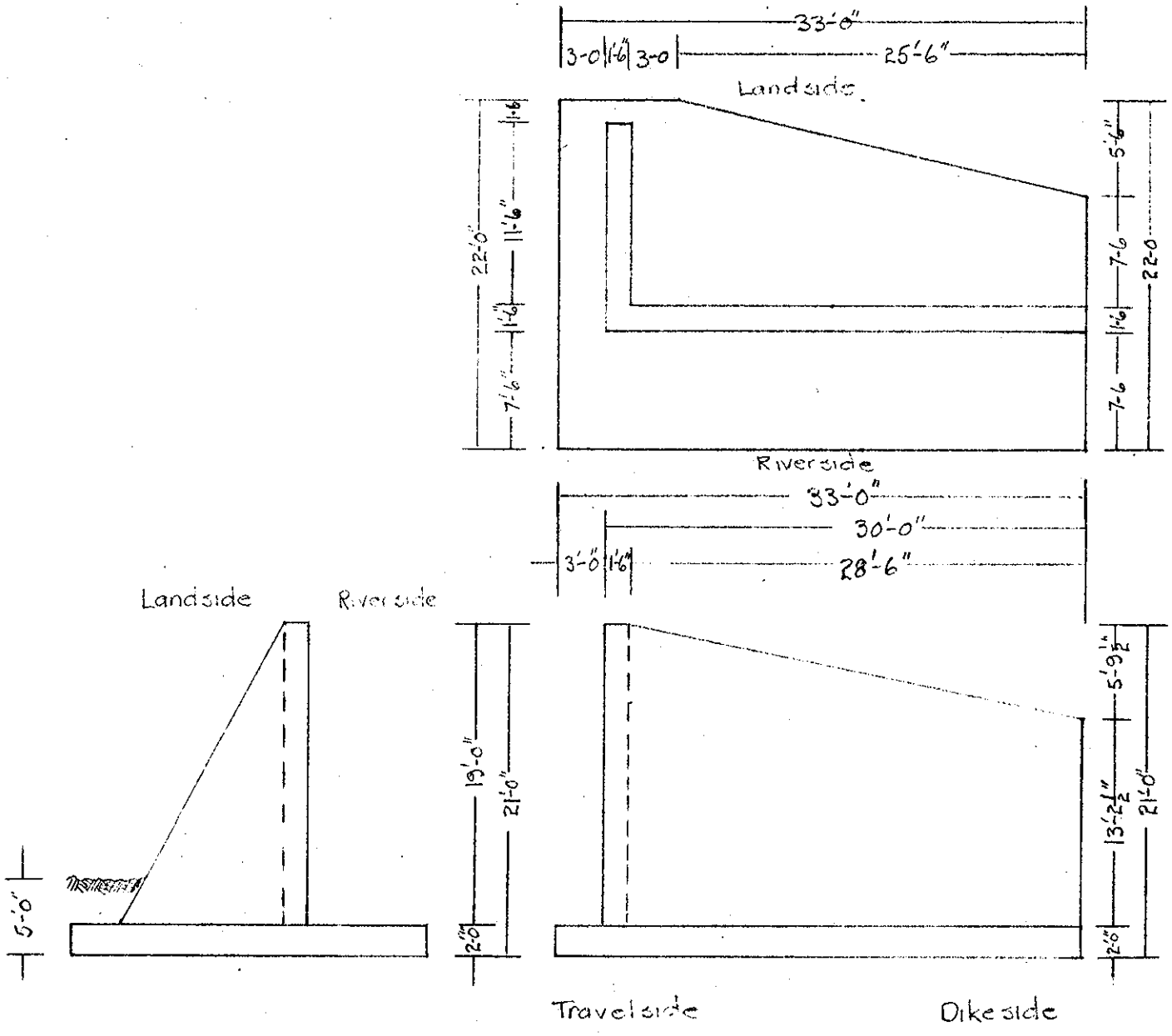
Page 1

Project Northampton Dike

Computation Wall at South End of Stop Log Structure

Computed by C.W.B.M. **Checked by** T.J.S. **Date** 7-2-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

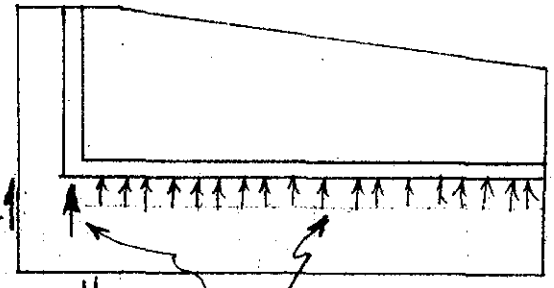


A-148

Subject Northampton Dike
Computation Stop Log Structure
Computed by C.W.B.M. Checked by T.J.S. Date 7-2-39

U.S. GOVERNMENT PRINTING OFFICE 3—10528

Loading Assumptions—

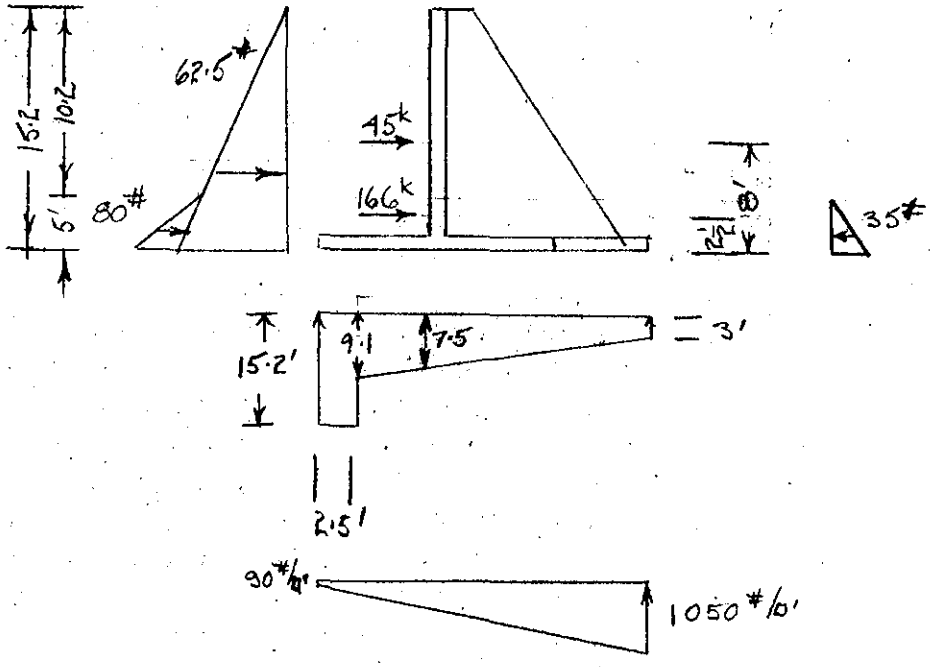


PLAN

Load due to sill
Load due to stoplog
Direct water load

Sill Load (see Design of Sill) = 166,000#

Stop Log Load (" " " ") = $\frac{1}{2}$ x 90,000# = 45,000#



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Project: Northampton Dike

Computation: Stop Log Structure

Computed by: C.W.B.M Checked by: T.J.S. Date: 7-2-39

U.S. GOVERNMENT PRINTING OFFICE 8—10536

	Forces	↓	↑	→	←	Arm	Moments ↻	Moments ↺
62.5	15.2×15.2×30×½			217		5.07	1100	
17.5	5×5×30 ×½			7		1.67	12	
35.0	5×5×30 ×½				13	1.67		22
150	33×22×2	218				11.0	2400	
150	25.5×5.5×2×½		21			20.17		423
150	30×1.5(19×13.2)×½	108				8.25	895	
150	19×11.6×1.5×½	25				13.0	325	
62.5	10.2×33×7.5	158				3.75	592	
125	3×33×7.5	93				3.75	348	
100	3×33×13	128				15.5	1990	
100	3×25.5×5.5		42			20.17		847
62.5	15.2×1.5×33		48			0.75		36
62.5	3×20.5×33		127			11.75		1490
62.5	½(15.2-3)½×20.5×33		129			8.33		1072
62.5	3×5.5×25.5×½	13				20.17	265	
Sill				166		2.5	415	
Logs				45		8.0	360	
		743	369	435	13		8702	3890
		ΣV = 374		ΣH = 422			ΣM = 4812	

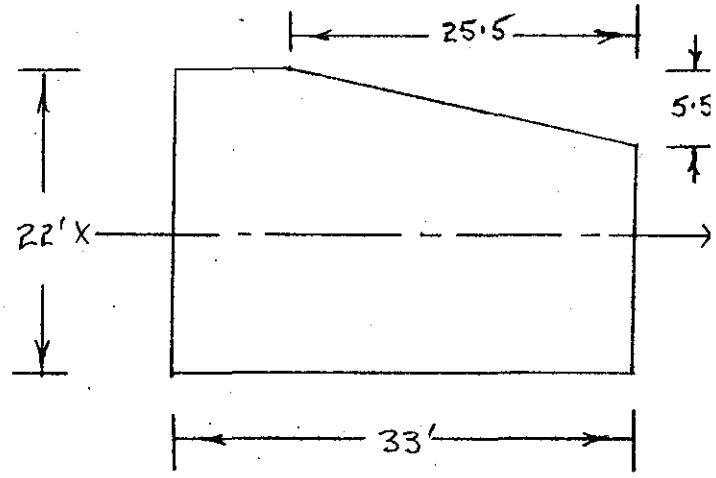
Position of Resultant = $\frac{4812}{374}$ = 12.85'

Subject: Northampton Dike
Computation: Stop Log Structure
Computed by: C.W.B.M. Checked by: T.v.S. Date: 7-2-39

U. S. GOVERNMENT PRINTING OFFICE 3—10598

Approx. Soil Pressures

Elements of Base



Area = 22 × 33 = 726.0
− 25.5 × 5.5/2 = 70.1
655.9

C.G. = 726 × 11 = 7986.0
− 70.1 × 20.17 = 1414.0
6572.0

$\frac{6572}{655.9} = 10.02$

I □ $\frac{bd^3}{12} = \frac{33 \times 22^3}{12} = 29{,}282$
$Ad^2 = 33 \times 22 \times 0.98^2 = 697$
29,979

Triangle $\frac{bd^3}{36} = \frac{25.5 \times 5.5^3}{36} = 118$
$Ad^2 = \frac{1}{2} \times 25.5 \times 5.5 \times 10.13^2 = 7220$
7338

I = 29,980 − 7340 = 22,640

Soil Pressure

$$p = \frac{P}{A} + \frac{My}{I}$$

$$= \frac{374}{656} + \frac{374 \times (1285-10) \times 12}{22{,}640} = 0.57 + 0.56 = 1{,}130\ \#/\square'$$

on landside

$$= \frac{374}{656} - \frac{374 \times (1285-10) \times 10}{22{,}640} = 0.57 - 0.47 = 100\ \#/\square'$$

on riverside

Subject: Northampton Dike
Computation: Stop Log Structure
Computed by: C.W.B.M. Checked by: T.J.S. Date: 7-2-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

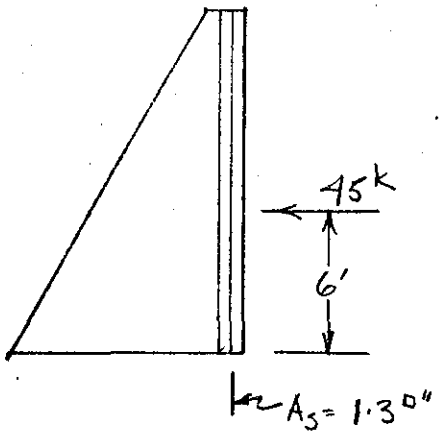
Longitudinal Wall (Parallel to River) – As a cantilever – Water Load –
Steel for 18" wall taken from chart – by Wm Smith, Jr.

Wall, parallel to highway

As a beam

$M = 45^k \times 6' = 270$ k ft

$A_s = \frac{M}{fjd} = \frac{270{,}000 \times 12}{18{,}000 \times 0.88 \times 13 \times 12} = 1.31 \square''$



Remaining steel – for temperature
$= 5/8''\phi$ @ 12" cc

Shear Force at Bottom = 45^k

Weight down = $\frac{1}{2} \times 13 \times 13 \times 1.5 \times 150 = 19^k$

Normal Force due to moment = $45 \times \frac{6}{13/2} = 45^k$

Total Normal Force = $19 + 45 = 64^k$

Allowable shear – for friction @ 0.70 concrete on concr.

$0.70 \times 64 = 45^k$ – – – – just balances

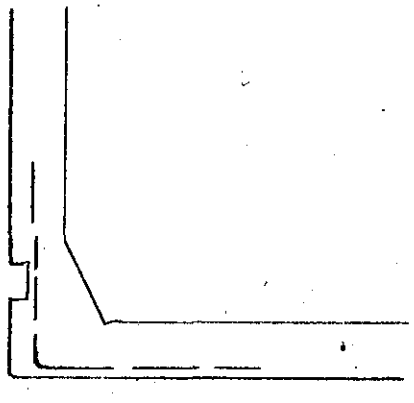
No shear blocks needed.

Precautionary Measure

Place ell bar around corner

$5/8''\phi$ in middle third

$7/8''\phi$ in bottom third



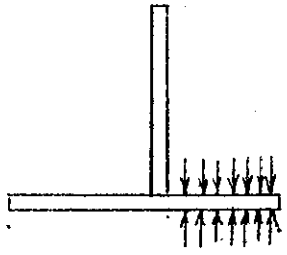
A-152

Project: Northampton Dike
Computation: Stop Log Structure
Computed by: CWBM Checked by: T. J. S. Date: 7-2-39

U. S. GOVERNMENT PRINTING OFFICE 3—10536

Footing Steel - Riverside - As cantilever

Shear at wall



Water	10.2 × 62.5 × 7.5	=	4,800	↓
Earth	3 × 125 × 7.5	=	2,800	↓
Concr.	2 × 150 × 7.5	=	2,250	↓
Uplift	15.2 × 62.5 × 1.5	=	1430	↑
	8.3 × 62.5 × 6.0	=	3110	↑
Soil Press.	27.1 × 7.5	=	2030	↑
Total (V)			3280	↓

$v = V/bjd = 3280/12 \times 0.88 \times 19.5 = 16$ #/□" --- OK

Moment at wall

Water	4800 × 3.75	=	18,000
Earth	2800 × 3.75	=	10,500
Concr.	2250 × 3.75	=	8,500
Uplift	1430 × 6.75	=	9,650
	3110 × 3.0	=	9,330
Soil P.	2030 × 2.96	=	6,010
Total (M)			12,010 ft#

$$A_s = \frac{M}{fjd} = \frac{12{,}010 \times 12}{18{,}000 \times 0.87 \times 19.5} = 0.47 \text{ □"}$$

Subject: Northampton Dike
Computation: Stop Log Structure
Computed by: C.W.B. McCor. Checked by: T. J. S. Date: 7-2-39

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Footing Steel — as a $7\frac{1}{2}$ ft cantilever

Moment at wall

Earth	$3 \times 125 \times 7.5 \times 3.75$	10500
Concr.	$2 \times 150 \times 7.5 \times 3.75$	8450
Uplift	$5 \times 62.5 \times 7.5 \times 3.0$	7000
Soil Press.	$710 \times 7.5 \times 4.5$	24000
		12,050

$$A_s = \frac{M}{fjd} = \frac{12{,}050 \times 12}{18{,}000 \times .87 \times 19.5} = 0.47 \square''$$

Moment at Support Wall

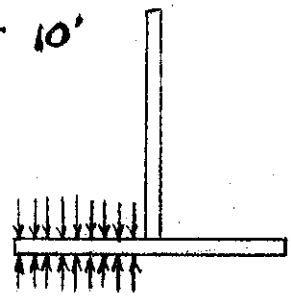
Earth	$3 \times 125 \times 3 \times 1.5$	=	1700
Concr.	$2 \times 150 \times 3 \times 1.5$	=	1350
Uplift	$3 \times 62.5 \times 3 \times 1.5$	=	850
Soil Pr.	$1050 \times 3 \times 1.5$	=	4750
			2550

$$A_s = \frac{M}{fjd} = \frac{2550 \times 12}{18000 \times .87 \times 19.5} = 0.10 \square''$$

Object Northampton Dike
Computation Stop-Log Structure
Computed by C.W.B. McC. Checked by Date 7-2-39

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Footing Steel- Landside- as a cantilever 10'



Shear at wall

Water	None		
Earth	3×100×10	=	3000 ↓
Concrete	2×150×10	=	3000 ↓
Uplift	5×62.5×10	=	3125 ↑
Soil Press.	8 10×10	=	8100 ↑
			4475 ↑

$v = V/bjd = 4475/12 \times 0.87 \times 19.5 = 22\ \#/\square''$

Moment at wall

Earth	3000×5	=	15,000
Concrete	3000×5	=	15,000
Uplift	3125×3.5	=	10900
Soil Press	8100×6.5	=	52000
			32,900

$$A_s = \frac{M}{f_s jd} = \frac{32,900 \times 12}{18,000 \times 0.87 \times 19.5} = 1.26\ \square''$$

APPENDIX A

IV FLOOD WALLS

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page _____

ubject NORTHAMPTON - N3D

omputation Wall, Sta. M-12+23.0 to Sta. M-16+76.0

omputed by RSM Checked by _____ Date 6-26-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Retaining Wall, from Sta. M-12+23.0 to Sta. M-16+76.0

18 pages

A-156

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 1

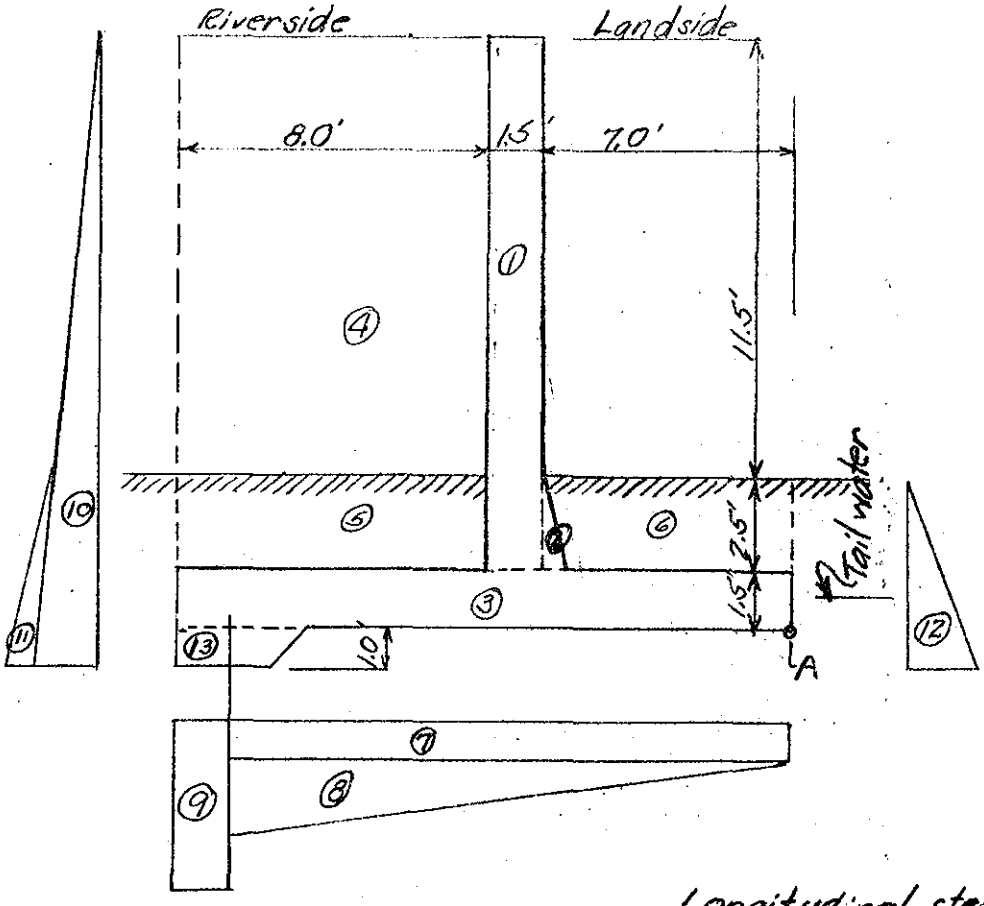
Project: NORTHAMPTON

Computation: Wall, Sta. M-12+23.0 to Sta. M-16+76.0

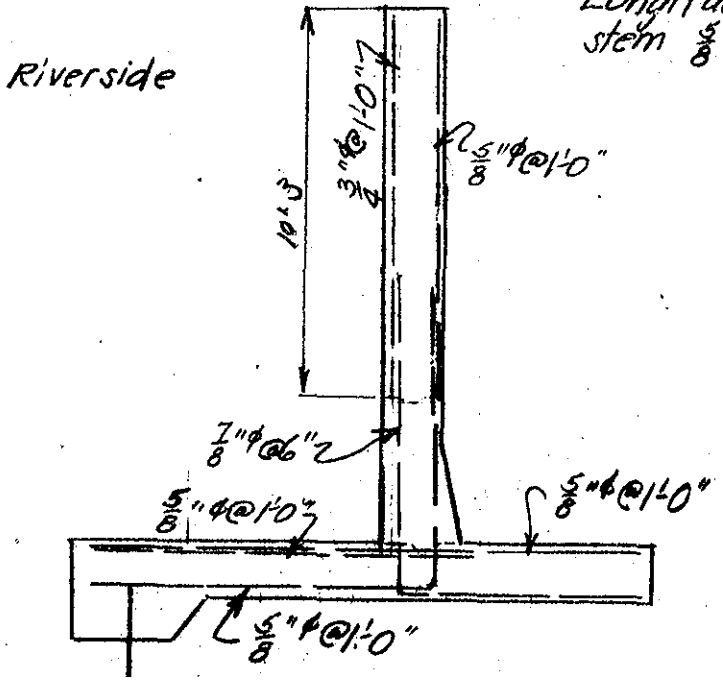
Computed by: RSM Checked by: R.H.M. Date: 6-26-39

U.S. GOVERNMENT PRINTING OFFICE 3—10523

STABILITY - 14' Section



Longitudinal steel in base and stem $\frac{5}{8}$"φ@1'-0" c.-c.



A-157

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Ject NORTHAMPTON

omputation Wall- Sta. M-12+23.0 - Sta. M-16+76.0

omputed by RSM Checked by RHM Date 6-26-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

STABILITY

		Force ↓↑	Force ←→	Arm	Moment ↻	Moment ↺
1	150 × 1.5 × 14 ↓	3,160		7.75		24,500
2	150 × 2.5 × ½ × 5/12 ↓	80		6.86		600
3	150 × 1.5 × 16.5 ↓	3,720		8.25		30,600
4	62.5 × 8 × 11.5 ↓	5,750		12.5		72,000
5	125 × 8 × 2.5 ↓	2,500		12.5		31,300
6	100 × 6.5 × 2.5 ↓	1,630		3.25		5,300
7	62.5 × 1 × 15 ↑	940		7.5	7,100	
8	62.5 × 7.25 × 15/2 ↑	3,400		10	34,000	
9	62.5 × 16.5 × 1.5 ↑	1,550		15.75	24,400	
10	62.5 × 16.5²/2 →		8,520	4.5	38,300	
11	17.5 × 5²/2 →		220	.67	100	
12	35 × 5²/2 ←		440	.67		300
13	150 × 3 × 1 ↓	450		15.0		6,700
		↓ 11,400	→ 8,300		103,900	171,300
						103,900
						67,400

$$\frac{\Sigma M}{\Sigma V} = \frac{67,400}{11,400} = 5.9' \text{ ; third point at } 5.5'$$

$$e = 8.25 - 5.9 = 2.35'$$

$$f = \frac{11,400}{16.5}\left(1 \pm \frac{6 \times 2.35}{16.5}\right) = 690(1 \pm .86) = 1,290\#/\square' \text{ to } 100\#/\square'$$

Sliding factor,

f_f $.45 \times 11400 =$ 5130#

$f_{(passive\ resistance)}$ 3280

$f_f = \frac{wh^2}{2} \times \tan^2\left(45° + \frac{\phi}{2}\right)$ 8410 # total allowable resistance to sliding. OK.

$= \frac{100 \times 5^2}{2} \times \tan^2\left(45° + \frac{26°34'}{2}\right)$

$= 3280\#$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Project: NORTHAMPTON

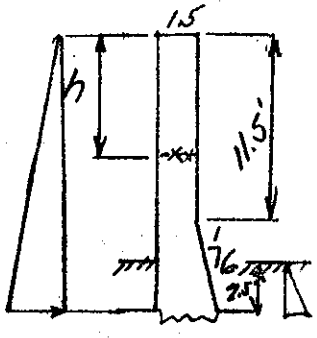
Computation: Wall, Sta. M-12+23 to Sta. M-16+76

Computed by: RSM Checked by: R.H.M. Date: 6-26-39

U. S. GOVERNMENT PRINTING OFFICE 8—10528

DESIGN OF STEM

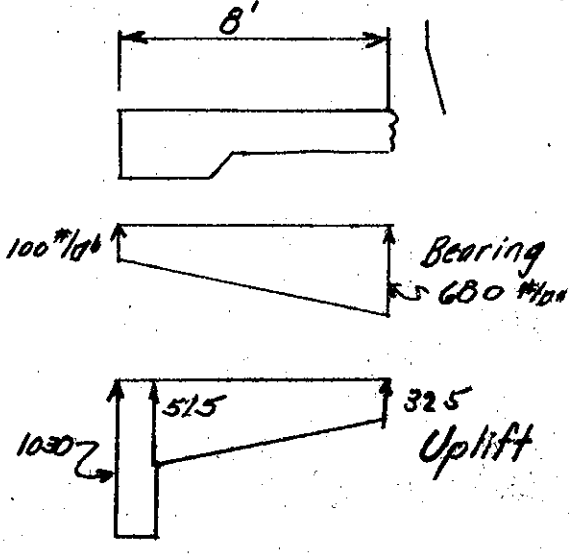
h (ft.)	V #	M '#	v #/□"	A_s □"	d(+3.5")
7	1530	3500	10	.19	18
10	3120	10340	20	.54	18
11.5	4140	15740	27	.82	18
14	6150	28700	30	1.11	23
16	8000	42600	32	1.36	27



This table applies to all sections studied.

$V = wh^2/2$; $M = wh^3/6$; $v = V/bjd$; $A_s = \frac{M}{f_s jd}$; $d_{min} = \sqrt{\frac{M}{Kb}}$

DESIGN OF BASE - RIVERSIDE



Downward loading	62.5×1.25 =	720
	125×2.5 =	312
	150×1.5 =	225
		1257 #/□'

V #	M '#
1257 × 8 = +10050 × 4 =	40200 +
100 × 8 = − 800 × 4 =	3200 −
580 × 8/2 = −2320 × 2.7 =	6240 −
1030 × 1.5 = −1545 × 7.2 =	11100 −
325 × 6.5 = −2110 × 3.3 =	7000 −
190 × 6.5/2 = − 1620 × 4.3 =	2760 −
+ 2655 #	9900 +

$A_s = \frac{9900 \times 12}{18000 \times .884 \times 14.5} = .51$ □"

$v = \frac{2655}{12 \times .884 \times 14.5} = 17$ #/□"

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

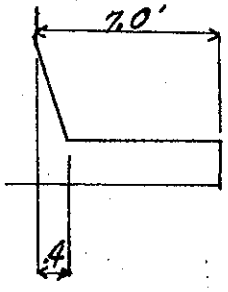
Subject: NORTHAMPTON

Computation: Wall - Sta. M12+23 to Sta. M-16+76

Computed by: RSM Checked by: R.H.M. Date: 6-26-39

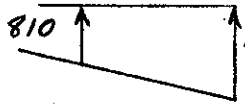
U. S. GOVERNMENT PRINTING OFFICE 3—10528

DESIGN OF BASE - LANDSIDE



Downward loading

100×2.5 =	250	
150×1.5 =	225	
	475 #/□'	



Bearing

Uplift

	V		M	
475×6.6 =	+3140 × 3.3	=	10,350	+
810×6.6 =	-5350 × 3.3	=	17,700	-
480×6.6/2 =	-1590 × 4.4	=	7,000	-
60×6.6 =	-400 × 3.3	=	1,300	-
200×6.6/2 =	-660 × 2.2	=	1,450	-
	-4860#		17,100	'#

$$v = \frac{4860}{12 \times 13.5 \times .884} = 34 \ \#/\square''$$

$$d = \sqrt{\frac{17100}{123}} = 11.8'' ; \ 13.5'' \text{ supplied}$$

$$A_s = \frac{17100 \times 12}{18000 \times .884 \times 13.5} = .96 \ \square''$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

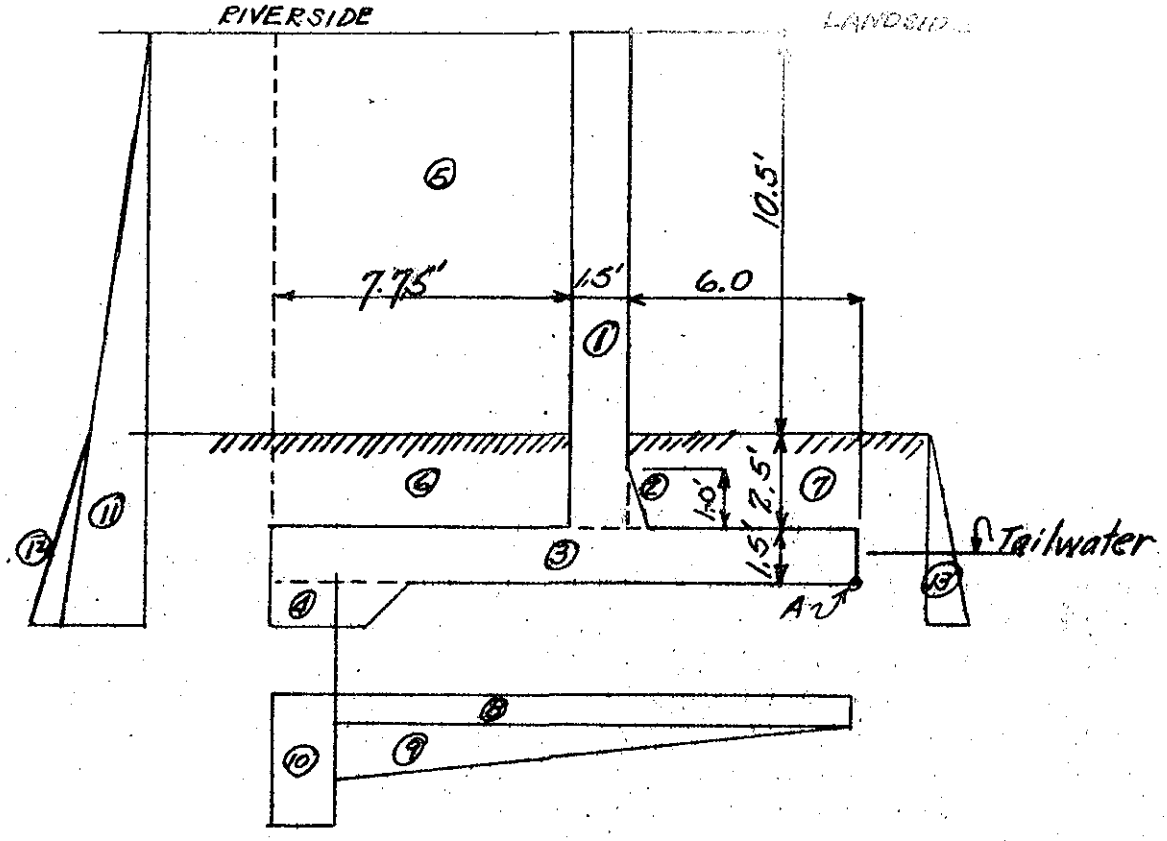
Subject NORTHAMPTON

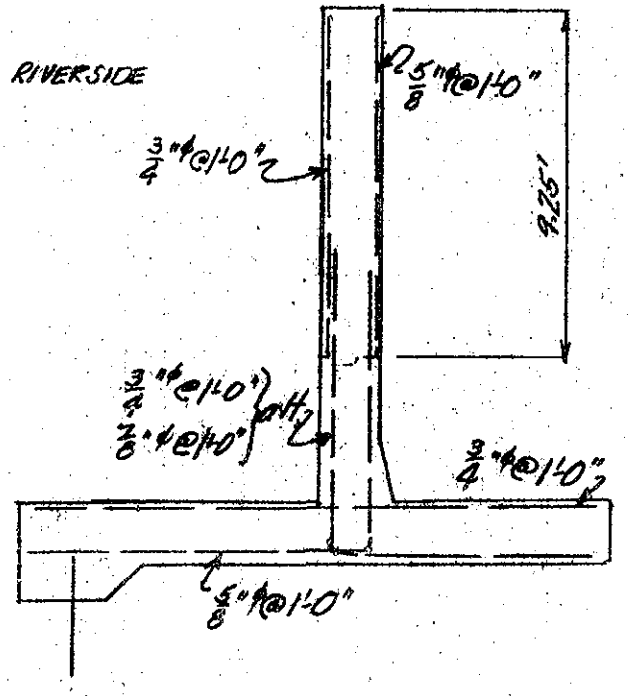
Computation Wall, Sta. M-12+23.0 to Sta. M-16+76.0

Computed by R.S.M. Checked by R.H.M. Date 6-27-39

U.S. GOVERNMENT PRINTING OFFICE D—10528

STABILITY – 13' Section





Longitudinal steel in base and stem 5/8"ϕ@1'-0".

A-161

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: NORTHAMPTON

Computation: Wall, Sta. M-12+23.0 to Sta. M-16+76.0

Computed by: R.S.M. Checked by: R.H.M. Date: 6-30-39

U. S. GOVERNMENT PRINTING OFFICE 3—10523

STABILITY

		Force ↑↓	Force ⇄	Arm	Moment ↶	Moment ↷
1	150×1.5×13 ↓	2,930		6.75	19,800	
2	150×1.5×3/24 ↓	30		5.91	200	
3	150×1.5×15.25 ↓	3,430		7.63	26,200	
4	150×1.0×3 ↓	450		13.75	6200	
5	62.5×7.75×10.5 ↓	5,090		11.37	57,800	
6	125×2.5×7.75 ↓	2,420		11.37	27,700	
7	100×2.5×5.91 ↓	1,480		2.96	4,400	
8	62.5×1×13.75 ↑	860		6.88		5,900
9	62.5×6.75×13.75/2 ↑	2,900		9.17		26,600
10	62.5×15.5×1.5 ↑	1,460		14.50		21,100
11	62.5×15.5²/2 →		7,510	4.17		31,400
12	17.5×5²/2 →		220	.67		100
13	35×5²/2 ←		440	.67	300	
		10,610	7,290		142,600	85,700
					85,100	
					57,500	

$$\frac{\Sigma M}{\Sigma V} = \frac{57{,}500}{10610} = 5.4' \text{ ; third pt. at } 5.08$$

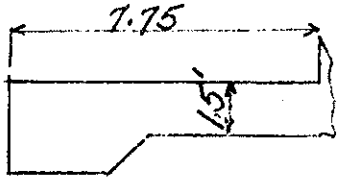
$$f = \frac{10610}{15.25}\left(1 \pm \frac{6 \times 2.22}{15.25}\right) = 700(1 \pm .875) = 1{,}310\ \#/\square' \text{ to } 90\ \#/\square'$$

DESIGN OF STEM - See page 3

Project: NORTHAMPTON
Computation: Wall, Sta. M-12+23.0 to Sta. M-16+76.0
Computed by: R.S.M. Checked by: R.H.M. Date: 6-30-39

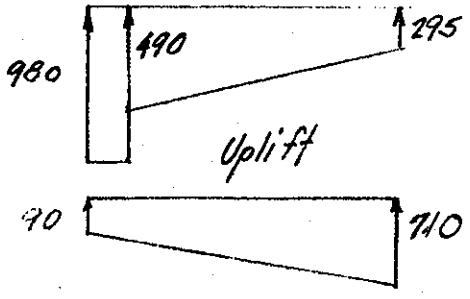
U.S. GOVERNMENT PRINTING OFFICE 3—10528

DESIGN OF BASE - RIVERSIDE



Loading - downward

10.5 × 62.5 =		657
2.5 × 125 =		313
1.5 × 150 =		225
		1195 #/□'

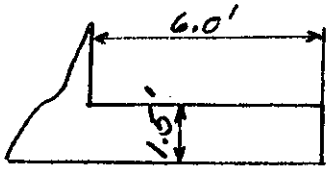


	V	M
+ 1195 × 7.75 =	9290 # × 3.88 =	36000 '# +
− 980 × 1.5 =	1470 # × 7 =	10290 −
− 295 × 6.25 =	1840 # × 3.12 =	5740 −
− 195 × 6.25/2 =	610 # × 4.17 =	2540 −
− 90 × 7.75 =	700 × 3.88 =	2720 −
− 620 × 7.75/2 =	2400 × 2.58 =	6200 −
	2270 #	8510 '# +

$$A_s = \frac{8510 \times 12}{18000 \times .884 \times 14.5} = .44 \ \square''$$

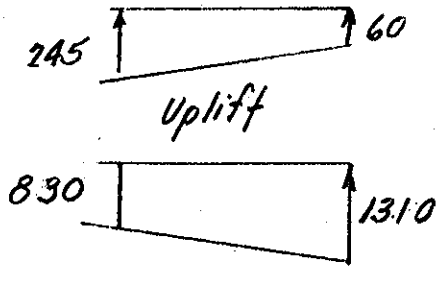
$$v = \frac{2270}{12 \times .884 \times 14.5} = 15 \ \#/\square''$$

DESIGN OF BASE - LANDSIDE



Loading - downward

100 × 2.5 =	250 #
150 × 1.5 =	225
	475 #/□'



	V		M
+ 475 × 6 =	2850 #	× 3	8,500 '# +
− 60 × 6 =	360	× 3	1,100 −
− 185 × 6/2 =	560	× 2	1,100 −
− 830 × 6 =	4980	× 3	15,000 −
− 480 × 6/2 =	1440	× 4	5800 −
	− 4490		14,500 '#

$$A_s = \frac{14,500 \times 12}{18000 \times .884 \times 13.5} = .81 \ \square''$$

$$v = \frac{4490}{12 \times .884 \times 13.5} = 31 \ \#/\square'$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

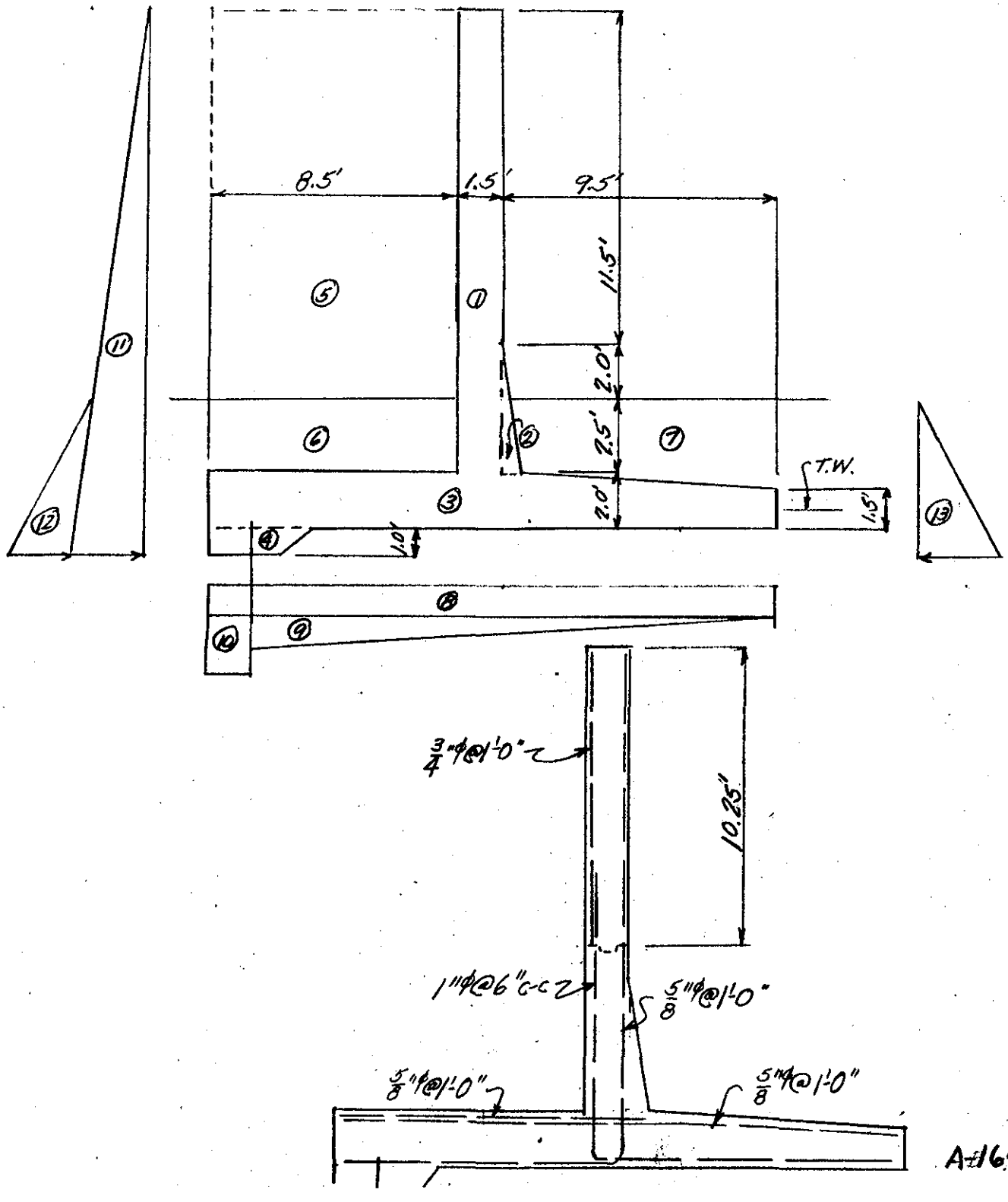
Project: NORTHAMPTON

Computation: Wall- Sta M-12+23.0 to Sta. M-16+76.0

Computed by: RSM Checked by: R.H.M. Date: 6-30-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

STABILITY- 16' Section



A-164

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Project: NORTHAMPTON

Computation: Wall - Sta. M-12+23.0 to Sta. M-16+76.0

Computed by: R.S.M. Checked by: R.H.M. Date: 6-30-39

U. S. GOVERNMENT PRINTING OFFICE 3—10536

STABILITY

			Force ↑↓	Force ⇄	Arm	Moment ↷	Moment ↶
1	150 × 1.5 × 16	↓	3,600		10.75		37,900
2	150 × 4.5 × .75/2	↓	250		9.25		2,300
3	150(19.5×2 - 9.5×.5/2)	↓	5,500		10.0		55000
4	150 × 1.0 × 3	↓	450		18.0		8100
5	62.5 × 8.5 × 13.5	↓	7,170		15.25		109,200
6	125 × 2.5 × 8.5	↓	2,660		15.25		40,600
7	100 × 2.7 × 9.5	↓	2,560		4.6		11,800
8	62.5 × 1 × 18	↑	1,130		9.0	10,100	
9	62.5 × 8.25 × 18/2	↑	4,640		12.0	55600	
10	62.5 × 19 × 1.5	↑	1,780		18.75	33,400	
11	62.5 × $\overline{19}^2$/2	→		11,300	5.33	60,000	
12	17.5 × $\overline{5.3}^2$/2	→		270	.83	200	
13	35.0 × $\overline{5.5}^2$/2	←		540	.83		500
			14640	11,030		159300	265400
							159300
							106,100 #

$\frac{\Sigma M}{\Sigma V} = \frac{106100}{14640} = 7.25'$, third pt. @ 6.5' ; e = 9.75 - 7.25 = 2.50'

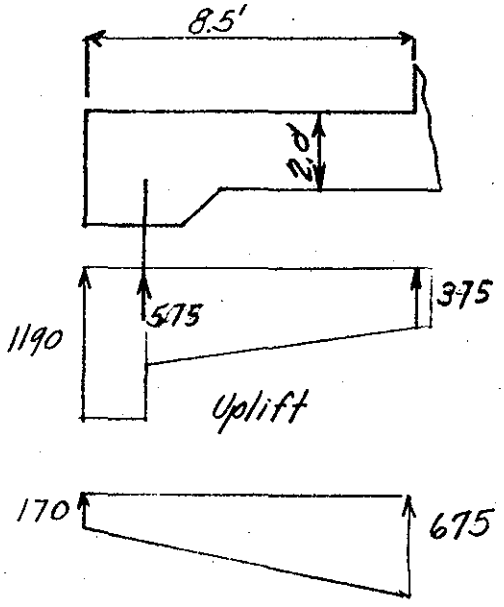
$f = \frac{14640}{19.5}\left(1 \pm \frac{6 \times 2.50}{19.5}\right) = 750(1 \pm .77) = 1330\#/\square' \text{ to } 170\#/\square'$

DESIGN OF STEM - See pg. #3.

Project: NORTHAMPTON
Computation: Wall- Sta. M-12+23 to Sta M-16+76
Computed by: R.S.M. Checked by: R.H.M. Date: 6-30-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

DESIGN OF BASE- Riverside



Loading, downward

62.5 × 13.5 =	845 #	
125 × 2.5 =	312	
150 × 2.0 =	300	
	1457 #/ft	

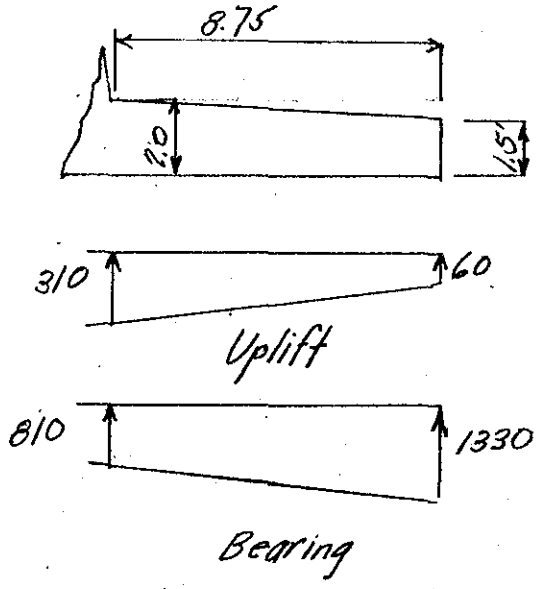
	V		M	
+1457 × 8.5 =	12,380# × 4.25 =		52600 '#	+
−1190 × 1.5 =	1,780 × 7.75 =		13800	−
−375 × 7 =	2,630 × 3.5 =		9200	−
−200 × 7/2 =	700 × 4.67 =		3300	−
−170 × 8.5 =	1450 × 4.25 =		6100	−
−505 × 8.5/2 =	2150 × 2.83 =		6100	−
	3670#		14,100 '#	

$d = \sqrt{\frac{14100}{123}} = 10.7''$; 20.5" supplied

$A_s = \frac{14100 \times 12}{16000 \times .884 \times 20.5} = .52^{\square''}$

$v = \frac{3670}{12 \times .884 \times 20.5} = 17\ \#/\square''$

DESIGN OF BASE - Landside



Downward loading

100 × 2.75 =	275
150 × 1.75 =	262
	537 #/ft

	V		M	
+537 × 8.75 =	4700# × 4.38 =		20,600 '#	+
−60 × 8.75 =	530 × 4.38 =		2,300	−
−250 × 8.75/2 =	1090 × 2.91 =		3,200	−
−810 × 8.75 =	7100 × 4.38 =		31,000	−
−520 × 8.75/2 =	2280 × 5.82 =		13200	−
	6300#		29,100 '#	

$d = \sqrt{\frac{29100}{123}} = 15.4''$; 19.5" supplied.

$A_s = \frac{29100 \times 12}{18000 \times .884 \times 19.5} = 1.13^{\square''}$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

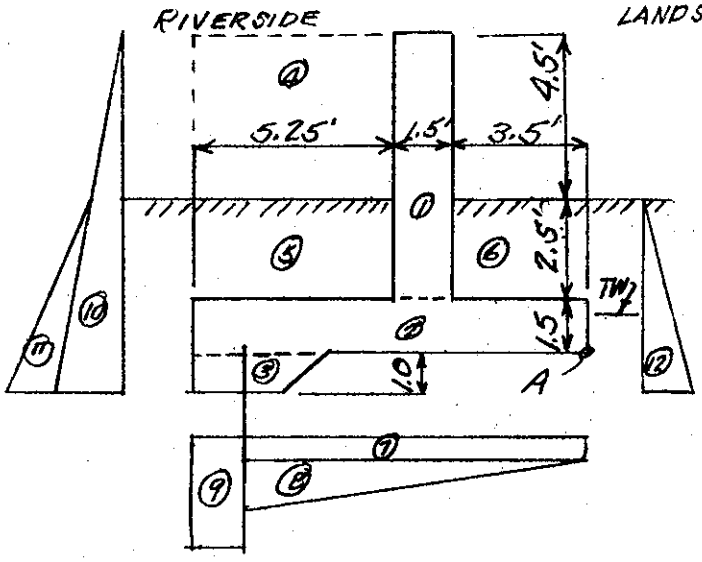
Project: NORTHAMPTON

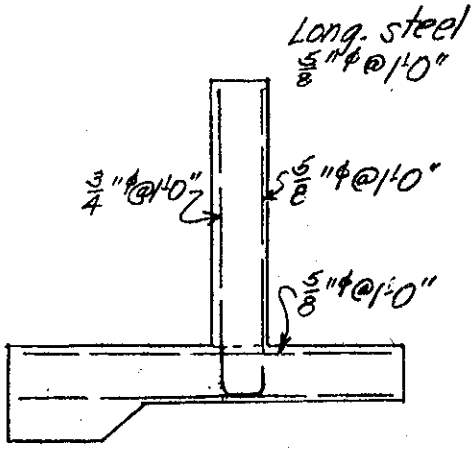
Computation: Wall - Sta. M-12+23.0 to Sta. M-16+76.0

Computed by: RSM Checked by: R.H.M. Date: 6-30-39

U. S. GOVERNMENT PRINTING OFFICE 3—10536

STABILITY - 7' Section





		Force ↓↑	Force ⇄	Arm	Moment ↷	Moment ↶
1	150×7×1.5	↓ 1580		4.25		6,700
2	150×10.25×1.5	↓ 2300		5.13		11,800
3	150×1×3	↓ 450		8.75		3900
4	62.5×4.5×5.25	↓ 1480		7.63		11,300
5	125×2.5×5.25	↓ 1650		7.63		12,600
6	100×2.5×3.5	↓ 880		1.75		1,500
7	62.5×8.75×1	↑ 550		4.38	2400	
8	62.5×3.75×8.75/2	↑ 1000		5.83	5800	
9	62.5×9.5×1.5	↑ 890		9.5	8,500	
10	62.5×9.5²/2	→	2,820	2.17	6,100	
11	17.5×5²/2	→	220	.67	100	
12	35.0×5²/2	←	440	.67		300
		5,900	2,600		22,900	48,100
						22,900
						25,200

$\frac{\Sigma M}{\Sigma V} = \frac{25200}{5900} = 4.27$; third pt. at 3.4 ; $e = 5.12 - 4.27 = .85''$

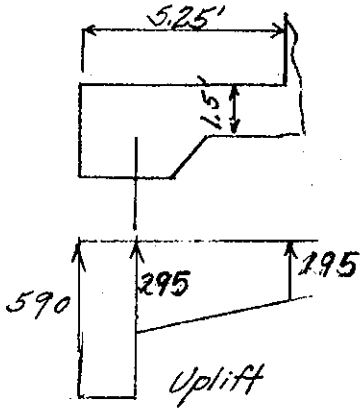
$f = \frac{5900}{10.25}\left(1 \pm \frac{6 \times .85}{10.25}\right) = 575(1 \pm .498) = 860\#/\square'$ to $290\#/\square'$

Subject: NORTHAMPTON
Computation: Wall - Sta. M-12+23.0 to Sta. M-16+76.0
Computed by: RSM Checked by: R.H.M. Date: 6-30-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

DESIGN OF STEM - See pg. 3.

DESIGN OF BASE - Riverside



Downward loading

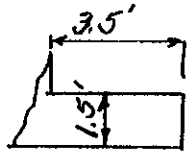
62.5 × 4.5		281
125 × 2.5 =		312
150 × 1.5 =		225
		818 #/□'

	V		M	
+ 818 × 5.25 =	4300#	× 2.62 =	11200'#	+
− 195 × 3.75 =	730	× 1.88 =	1400	−
− 100 × 3.75/2 =	190	× 2.5 =	500	−
− 590 × 1.5 =	885	× 4.5 =	4000	−
− 290 × 5.25 =	1520	× 2.62 =	4000	−
− 290 × 5.25/2 =	760	× 1.75 =	1300	−
	215+		0'#	+

Steel - nominal - temperature steel governs.

Shear - nominal

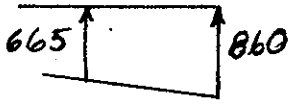
DESIGN OF BASE - Landside



Downward loading

100 × 2.5 =	250
150 × 1.5 =	225
	475 #/□'

	V		M	
+ 475 × 3.5 =	1,660#	× 1.75 =	2900'#	+
− 60 × 3.5 =	210	× 1.75 =	400	−
− 100 × 3.5 × ½ =	175	× 1.17 =	200	−
− 665 × 3.5 =	2330	× 1.75 =	4100	−
− 195 × 3.5 × ½ =	340	× 2.34 =	800	
	1,395		2,600'#	



$$A_s = \frac{2600 \times 12}{18000 \times .884 \times 13.5} = .15^{\square''}$$

$$v = \frac{1,395}{12 \times .884 \times 13.5} = 10\ \#/\square''$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Subject: NORTHAMPTON

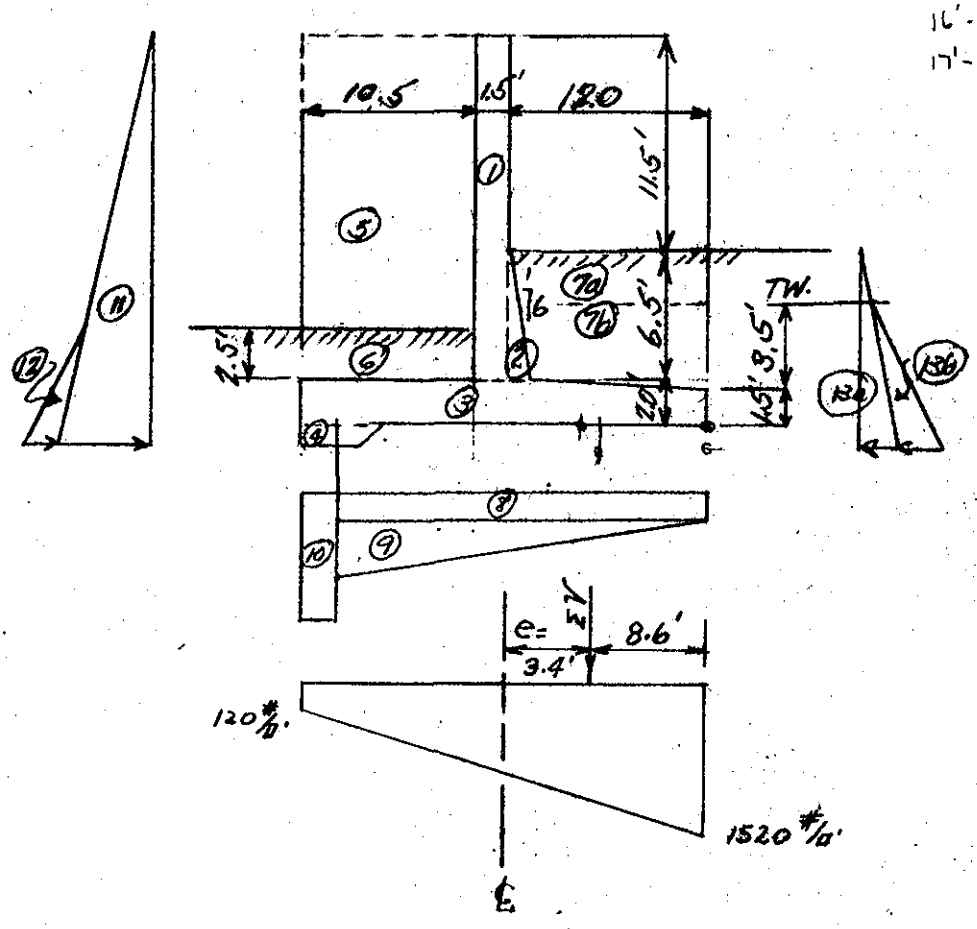
Computation: Wall-Sta. M-12+23.0 to Sta. M-16+76.0

Computed by: RSM Checked by: R.H.M. Date: 8-4-39

U. S. GOVERNMENT PRINTING OFFICE 3—10836

STABILITY- 18' Section

Ht: 13 sec
16'-6" 9'-0" 10'-3"
17'-6" 10'-0" 11'-6"



WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 14

Subject: NORTHAMPTON

Computation: Wall - Sta. M-12+23.0 to Sta. M-16+76.0

Computed by: RSM Checked by: R.H.M. Date: 8-4-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

	Force		Amount ↑↓	Amt. ⇄	Arm	Moment ↻	Moment ↺
1	150×1.5×18	↓	4,050		12.75		51,700
2	150×6.5×1.1/2	↓	540		11.63		6,300
3	150×(2×2.4−.5×12/2)	↓	6750		12.0		81000
4	150×1×3	↓	450		22.5		10,200
5	62.5×15.5×19.5	↓	10,200		18.75		191,500
6	125×2.5×10.5	↓	3,280		18.75		62000
7a	100×3.5×11.5	↓	4,020		5.75		23200
7b	125×3.3×11.5	↓	4750		5.75		27,300
8	62.5×.5×22.5	↑	7,040		11.25	79400	
9	62.5×7.5×22.5/2	↑	5,270		15.0	79000	
10	62.5×21×1.5	↑	1,970		23.25	45900	
11	62.5×$\overline{21}^2$/2	→		13,750	6.0	82500	
12	17.5×$\overline{5.5}^2$/2	→		260	.8	200	
13a	3.5×$\overline{9.5}^2$/2	←		1,580	2.2		3500
13b	4.5×$\overline{6.0}^2$/2	←		810	1.0		800
			19,760	11620		287,000	457500
							287000
							170500

$$\frac{\Sigma M}{\Sigma V} = \frac{170500}{19,760} = 8.6', \text{ middle third at } 8.0 \qquad e = 12 - 8.6 = 3.4'$$

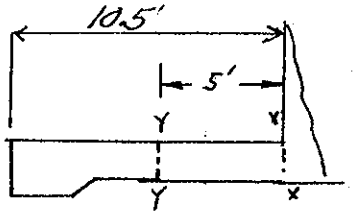
$$b = \frac{19760}{24}\left(1 \pm \frac{6 \times 3.4}{24}\right) = 823(1 \pm .85) = 823 \begin{cases} 1.85 = 1520\ \#/\square'\ \text{P.B.L.} \\ .15 = 120\ \#/\square'\ \text{P.B.R.} \end{cases}$$

Project: NORTHAMPTON
Computation: Wall - Sta. M-12+23.0 to Sta. M-16+76.0
Computed by: RSM Checked by: RHM Date: 8-5-39

U. S. GOVERNMENT PRINTING OFFICE 3—10538

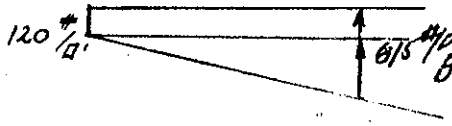
18' SECTION

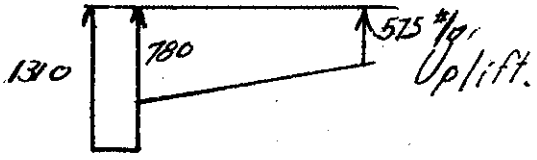
BASE - Riverside



Downward loading

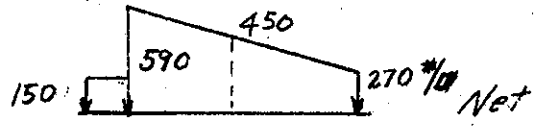
15.5 × 62.5	=	970
2.5 × 125	=	310
2.0 × 150	=	300
		1580 #/□'





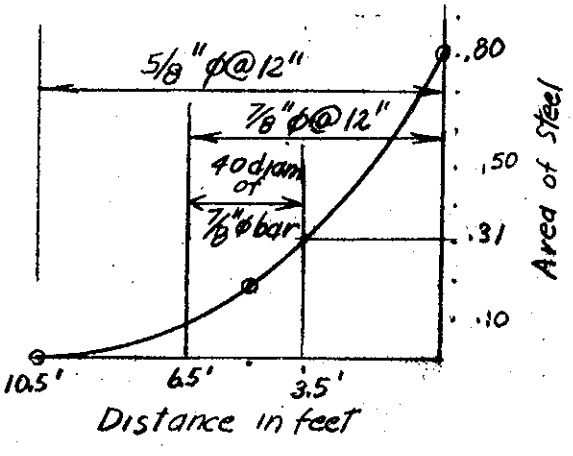
At sect X---X

	V		M
150 × 10.5 =	1580	5.25	8300
120 × 9 =	1080	4.5	4860
320 × 9/2 =	1440	6	8640
	4100 #		21,800 ′#



$$v = \frac{4100}{12 \times 20.5 \times .884} = 19 \ \#/\square''$$

$$A_s = \frac{21800 \times 12}{18000 \times .884 \times 20.5} = 1.80 \ \square'' \text{ at X---X}$$



At sect Y---Y

	V		M
450 × 4 =	1800	2.0	3600
140 × 4/2 =	280	1.33	370
150 × 1.5 =	225	4.75	1070
	2305 #		5040

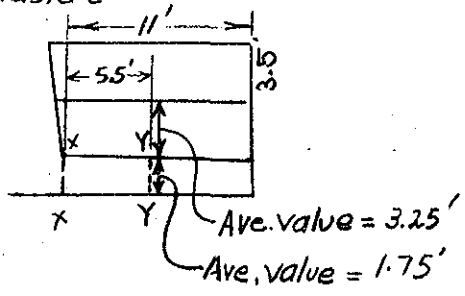
$$A_s = \frac{5040 \times 12}{18000 \times .884 \times 20.5} = .19 \ \square''$$

Project: Northampton - Mass. Wall Sta. M.12+23.0 to Sta M.16+76.0
Computation: Landside Base Steel
Computed by: R.H.M. Checked by: W.H.M. Date: 8/8/39

U. S. GOVERNMENT PRINTING OFFICE 3—10538

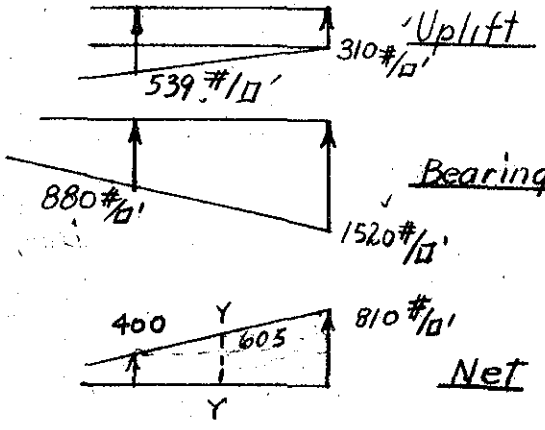
18' Section

Base Landside



Load down (per square foot)

3.5 x 100 = 350
3.25 x 125 = 410
1.75 x 150 = 260
1020 #/□' ↓ ✓



At section X - - - X

V	M
400 x 11 = 4400 x 5.5 =	24200 '# ✓
410 x 11/2 = 2260 x 7.33 =	16570 '# ✓
6660 #↑	40770 '# ↻

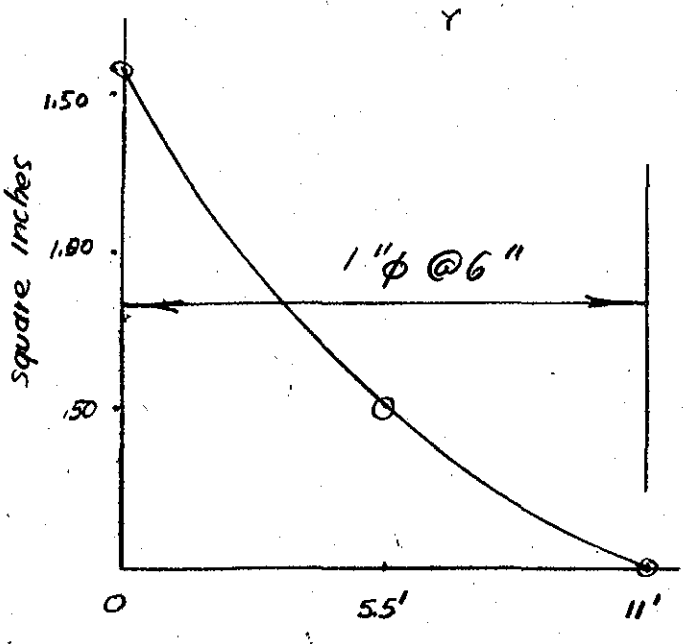
$d = \sqrt{\frac{40770}{123}} = 18.25''$ OK. ✓

Use 24 - 4.5 = 19.5"

$Shear = \frac{6660}{12 \times .884 \times 19.5} = \frac{6660}{207} = 32\ \#/\square''$ OK

$A_s = \frac{40770 \times 12}{18000 \times .884 \times 19.5} = \frac{490000}{310000} = 1.58\ \square''$ ✓

Use 1"φ @ 6" c.c.



At Section Y - - - Y

V	M
605 x 5.5 = 3330 x 2.75 =	9160 '# ✓
205 x 5.5/2 = 565 x 3.67 =	2070 '# ✓
3895 #↑ ✓	11230 '# ↻

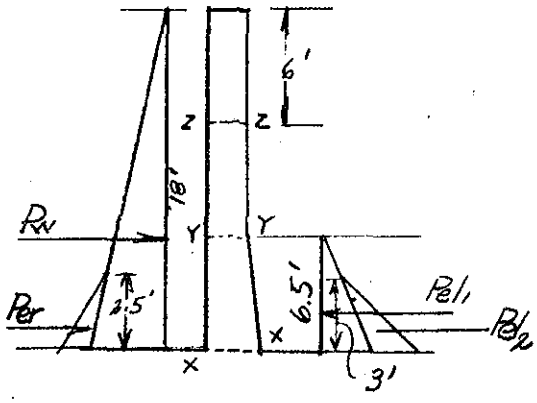
$A_s = \frac{11230 \times 12}{18000 \times .884 \times 16.5} = \frac{134500}{262000} = .51\ \square''$ ✓

$d = \sqrt{\frac{11230}{123}} = 9.6''$ OK. ✓

Subject: Northampton - Mass. Wall Sta. M-12+23.0 to Sta. M-16+76.0
Computation: Design of Stem Steel
Computed by: R.H.M. Checked by: WHM Date: 8/9/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

Design of Stem Steel



At Sect X--X

R_w: $18 \times \frac{1}{2} \times 62.5 = 10130 \times 6 = 60780$ '# ↻

P_{er}: $2.5^2 \times \frac{1}{2} \times 17.5 = 50 \times .83 = 40$

$10180\# \rightarrow 60820$ '# ↻

P_{el_1}: $6.5^2 \times \frac{1}{2} \times 35 = 740 \times 2.17 = 1610$ '# ↺

P_{el_2}: $3^2 \times \frac{1}{2} \times 45 = 202 \times 1.00 = 200$ '# ↺

$942\# \leftarrow 1810$ '# ↺

$\Sigma H = 9240\# \rightarrow \quad \Sigma M = 59010$ '# ↻

$$d = \sqrt{\frac{60820}{123}} = 22.3'' \text{ OK.}$$

Use $30 - 3.5 = 26.5''$.

$$A_s = \frac{59010 \times 12}{18000 \times .884 \times 26.5} = \frac{708000}{421000}$$

$= 1.68\ \square''$ Use 1"□"@6" C.C.

At Sect. Y--Y

R_w: $11.5^2 \times \frac{1}{2} \times 62.5 = 4130 \times 3.83 = 15800$ '# ↻

$$d = \sqrt{\frac{15800}{123}} = 11.5'' \text{ O.K.}$$

Use $18 - 3.5 = 14.5''$.

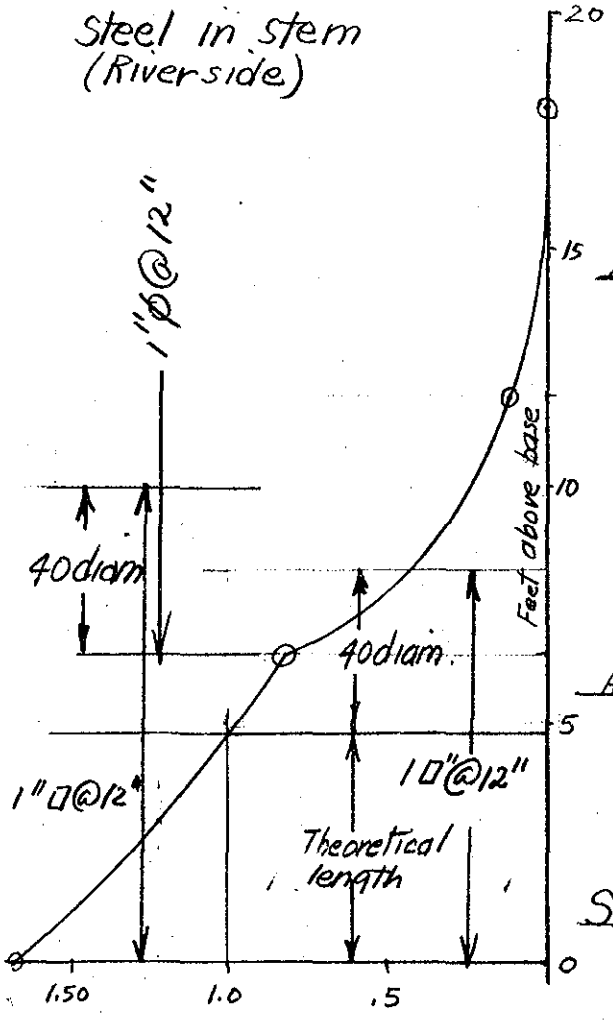
$$A_s = \frac{15800 \times 12}{18000 \times .884 \times 14.5} = \frac{189500}{231000} = .82\ \square''$$

At Sect. Z--Z

R_w: $6^2 \times \frac{1}{2} \times 62.5 = 1125 \times 2 = 2250$ # ↻

$$A_s = \frac{2250 \times 12}{18000 \times .884 \times 14.5} = \frac{27000}{231000} = .12\ \square''$$

Steel in stem
(Riverside)



Area of steel in square inches

Shears

$$S_{X-X} = \frac{9240}{12 \times .884 \times 26.5} = \frac{9240}{281} = 33\ \#/\square'' \text{ OK.}$$

$$S_{Y-Y} = \frac{4130}{12 \times .884 \times 14.5} = \frac{4130}{154} = 27\ \#/\square'' \text{ OK.}$$

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 18

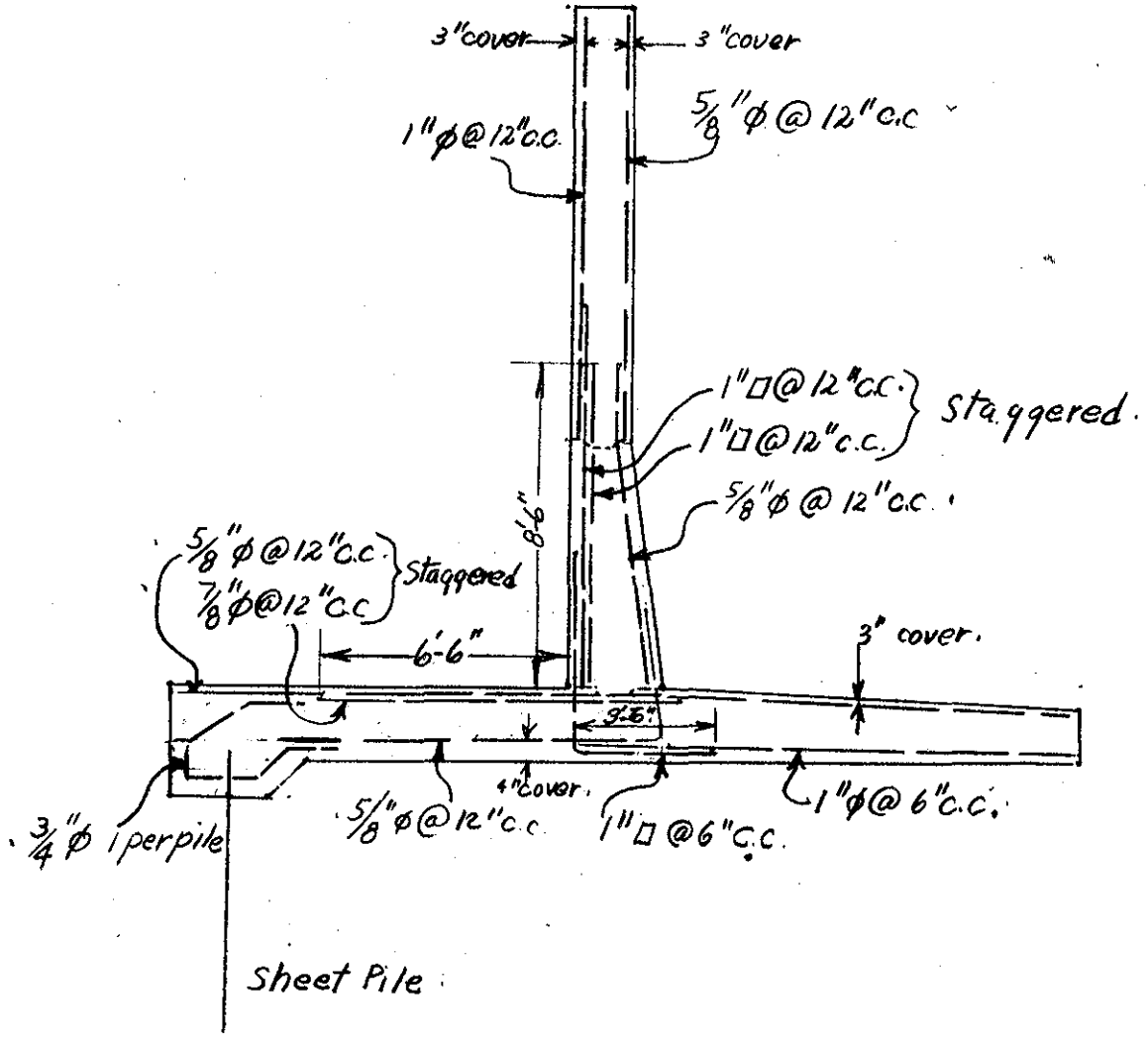
Subject Northampton - Mass. Wall Sta M-12+23.0 to Sta M-16+76.0

Computation Reinforcement

Computed by R.H.M. Checked by W.H.M. Date 8/9/39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

All longitudinal steel 5/8"φ @ 12" c.c.



APPENDIX A

V OX BOW BRIDGE

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

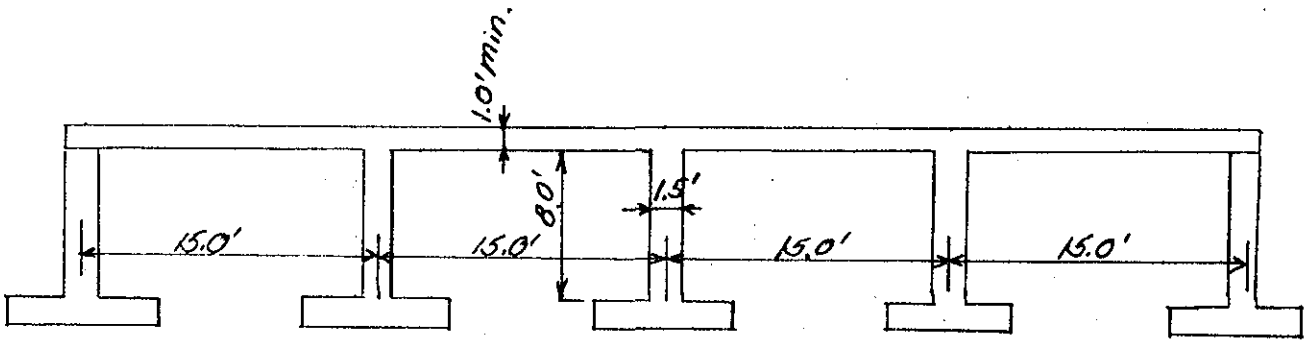
Page 1

ect NORTHAMPTON DIKE

omputation Oxbow bridge

omputed by RSM Checked by T. J. S. Date 8-10-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



Roadway width - 16' + 8" curbs = 17.4'

Liveloading - H-15. - Place two trucks abreast.

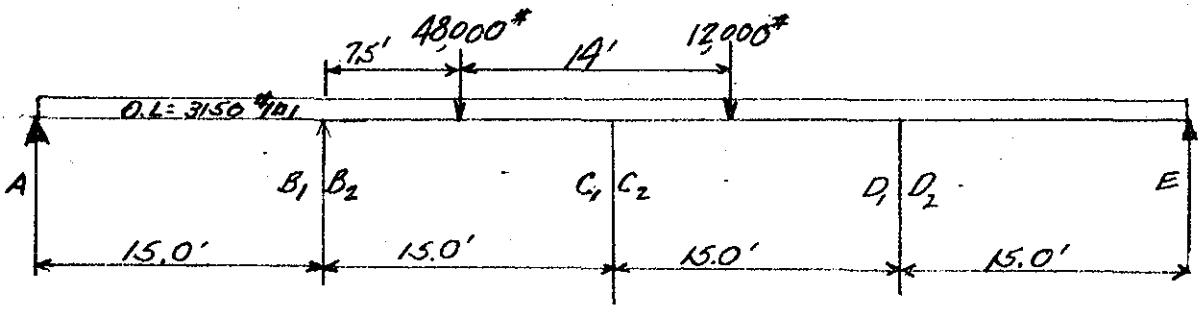
Dead loading -	Slab	17.33 × 1.13 × 150 =	2940 #/lin. ft.
	Curb	.67 × 1 × 2 × 150 =	200
	Rail		10
			3150 #/lin. ft.

Impact factor - $\frac{50}{L+125} = \frac{50}{15+125} = .36$

Project: NORTHAMPTON DIKE
Computation: Oxbow bridge
Computed by: RSM Checked by: T. J. S. Date: 8-7-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

MOMENT - Intermediate span
Position for max. moment as shown.



Live load

$-M_{B2\,\&\,C1} = 48000 \times 15/8 = -90{,}000$ '#

$-M_{C2} = 12000 \times 15 \times .43 \times .57^2 = -25{,}200$ '#

$-M_{D1} = 12000 \times 15 \times .57 \times .43^2 = -19{,}000$

Impact

$-M_{B2\,\&\,C1} = -32400$ '#

$-M_{C2} = -9{,}100$ '#

$-M_{D1} = -6{,}900$ '#

Dead load - int. panel

$-M = 3150 \times 15^2/12 = -59{,}000$ '#

- end panel

$-M = 3150 \times 13^2/8 = -88{,}500$ '#

Total moment (-) at supports

A	0
B_1	-88500
B_2	-181,400
C_1	-181,400
C_2	-93300
D_1	-84900
D_2	-88,500

REACTIONS & SHEARS

$R_A = \frac{5}{8} \times 3150 \times 15 - \ldots = 23{,}600$

$R_{B1} = \frac{3}{8} \times 3150 \times 15 = 17700 + 7000 = 24700$ #

$R_{B2} = 3150 \times 15/2 + 29{,}000 + 8{,}600 - 100 = 56{,}100$ #

Subject: NORTHAMPTON
Computation: Oxbow bridge
Computed by: RSM Checked by: T.J.S. Date: 8-7-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528

REACTIONS & SHEARS - Intermediate span loaded

$R_{C1} = 23{,}600 + 24000 + 8600 + 700 = 56{,}300^{\#}$

$R_{C2} = 23{,}600 + 1{,}900 + 6800 + 2{,}500 = 34{,}800^{\#}$

$R_{D1} = 23{,}600 - 1900 + 5200 + 1{,}900 = 28{,}800^{\#}$

$R_{D2} = 17{,}700 + (87{,}300/15) = 23{,}500^{\#}$

$R_E = 29{,}500 - 5{,}800 = 23{,}700^{\#}$

"d" & "r" FOR MAX. STRESSES

$d = \sqrt{\frac{M}{17.33 \times 123}} = \sqrt{\frac{23{,}200}{17.33 \times 123}} = 10.3''$ req'd.

V (at left end of first pier, maximum)

$(48{,}000 \times 1.36) + (3150 \times 15 \times \frac{5}{8}) + \frac{83900}{15} = 100{,}500^{\#}$

$v = \frac{100{,}500}{17.33 \times 12 \times .884 \times 10} = 55^{\#}/\square''$ OK.

A_s - INTERMEDIATE SPAN
(Moments from pg. 4)

$-A_s = \frac{172{,}000 \times 12}{17.33 \times 18{,}000 \times .884 \times 10} = .74^{\square''}$

$+A_s = \frac{152000 \times 12}{17.33 \times 18{,}000 \times .884 \times 10} = .66^{\square''}$

A_s (center pier)

$A_s = \frac{60{,}200 \times 12}{17.33 \times 18{,}000 \times .884 \times 14.5} = .18^{\square''}$; use steel as required for 1st pier - $\frac{3}{4}''\phi$ @ 1'-0"

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 4

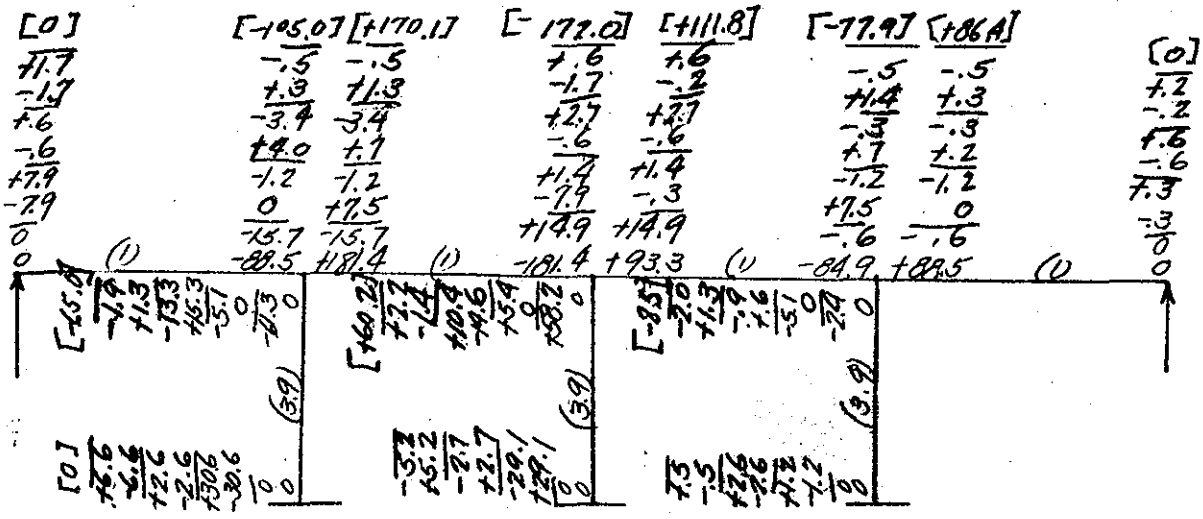
Project: NORTHAMPTON

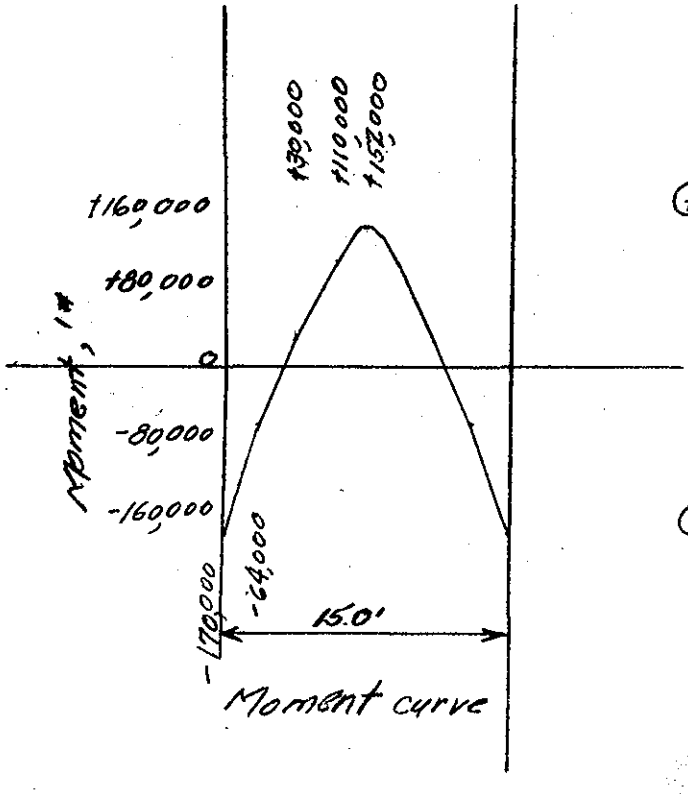
Computation: Oxbow bridge

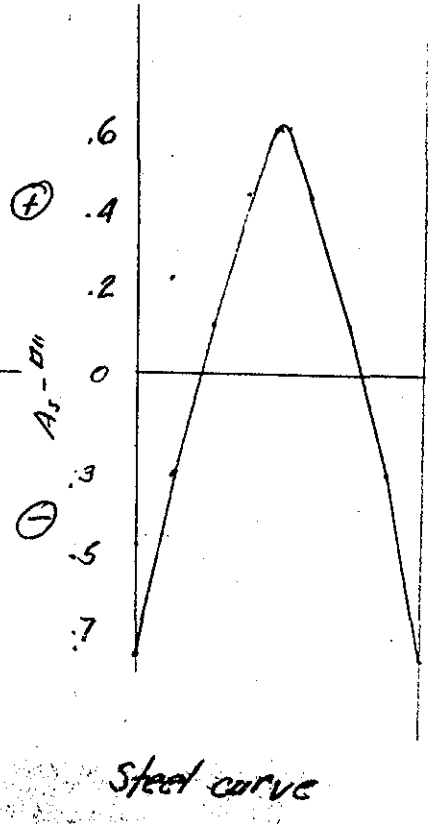
Computed by: RSM Checked by: T.J.S. Date: 8-9-39

U.S. GOVERNMENT PRINTING OFFICE 3—10638

INTERMEDIATE SPAN LOADED







A-178

WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

Page 5

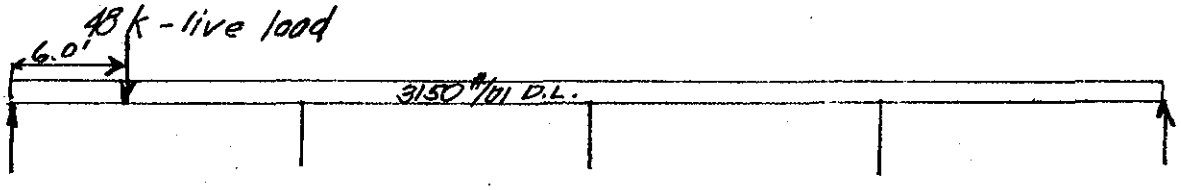
Subject: NORTHAMPTON

Computation: Oxbow bridge

Computed by: TJS Checked by: RSM Date: 8-9-39

U. S. GOVERNMENT PRINTING OFFICE 3—10523

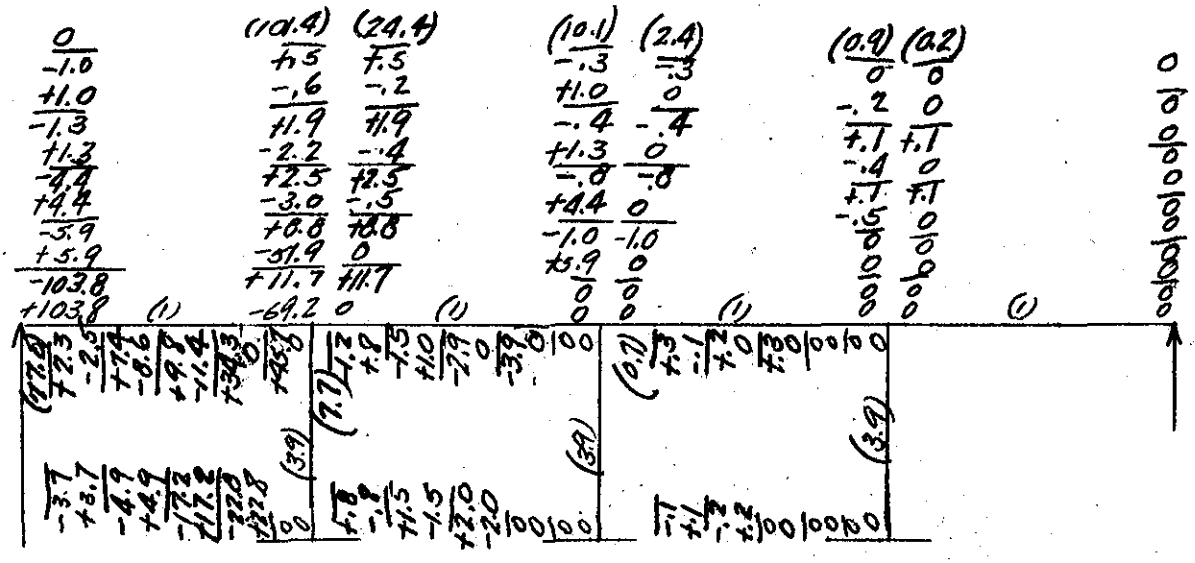
END SPAN LOADED



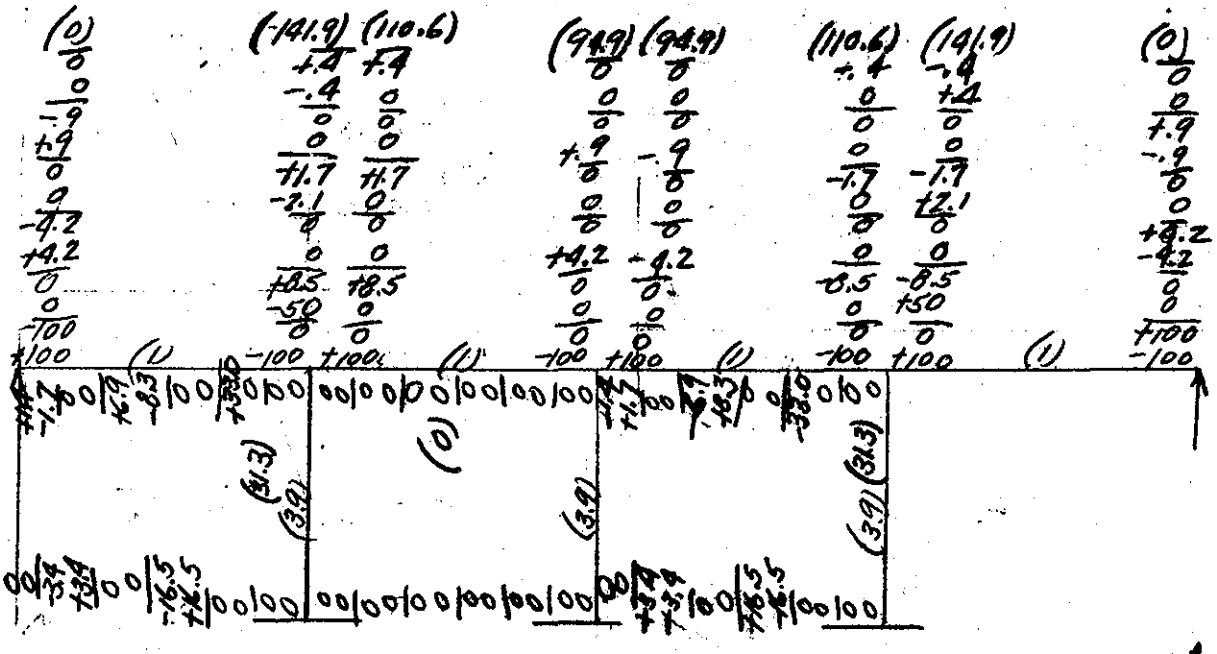
Fixed end moment: $M_1 = 48 \times .4 \times 15 \times .36 = 103.8$ k

$M_2 = 48 \times .16 \times 15 \times .6 = 69.2$ k

Live load



Dead load



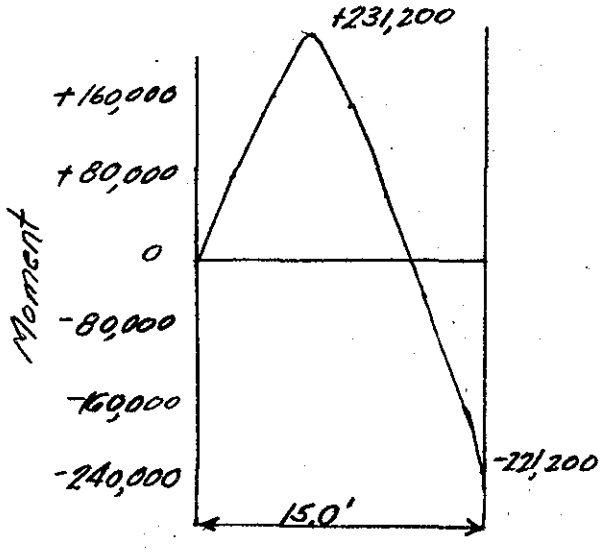
A-179

Subject NORTHAMPTON
Computation Oxbow bridge
Computed by TJS Checked by RSM Date 8-9-39

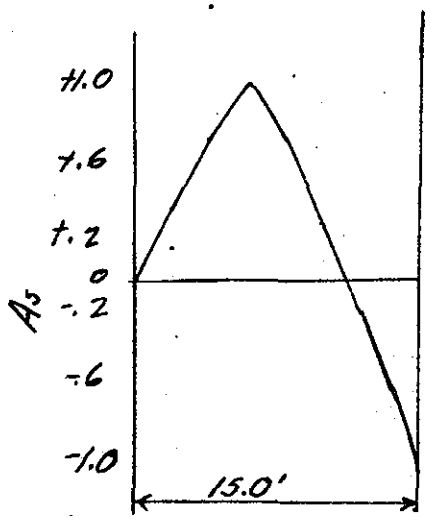
U. S. GOVERNMENT PRINTING OFFICE 3—10528

END SPAN LOADED
Total moment at left side of first pier.

-M		
L.L.		101,400 #
Imp.	.36 × 101,400	36,600
D.L.	$\frac{3150 \times 15^2}{12} \times 1.42$	84,000
		-222,000 #



Moment curve

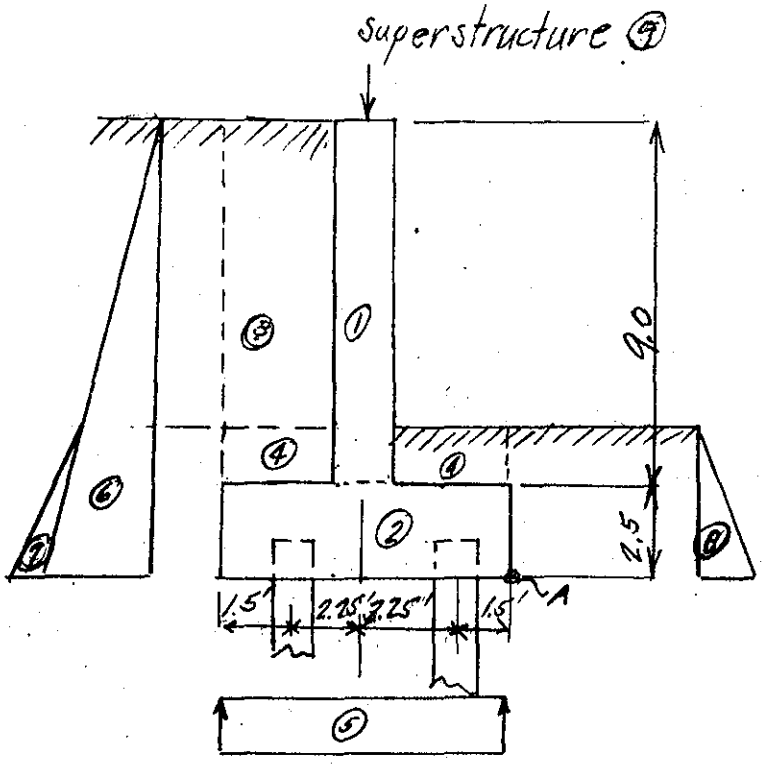


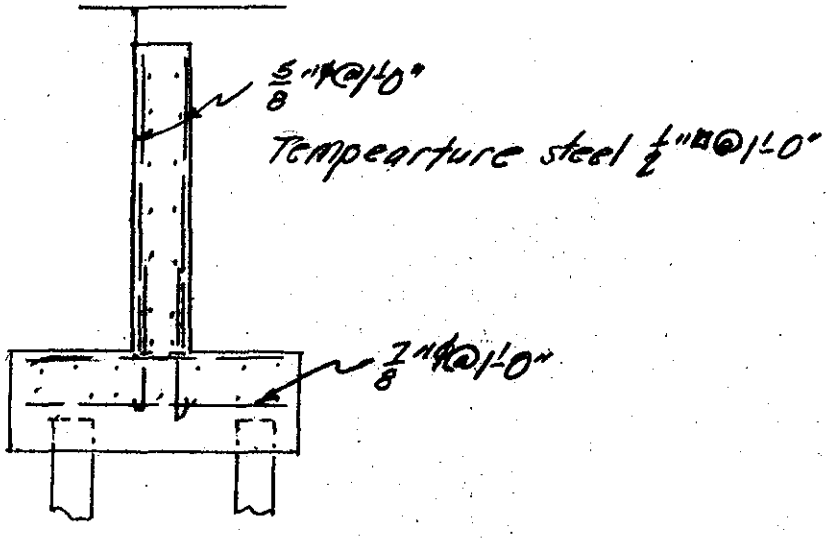
Steel curve

Subject NORTHAMPTON
Computation Oxbow bridge -
Computed by C.V. Neil Checked by T.J.S. Date

U. S. GOVERNMENT PRINTING OFFICE 3—10528

ABUTMENT





WAR DEPARTMENT

U. S. ENGINEER OFFICE, PROVIDENCE, R. I.

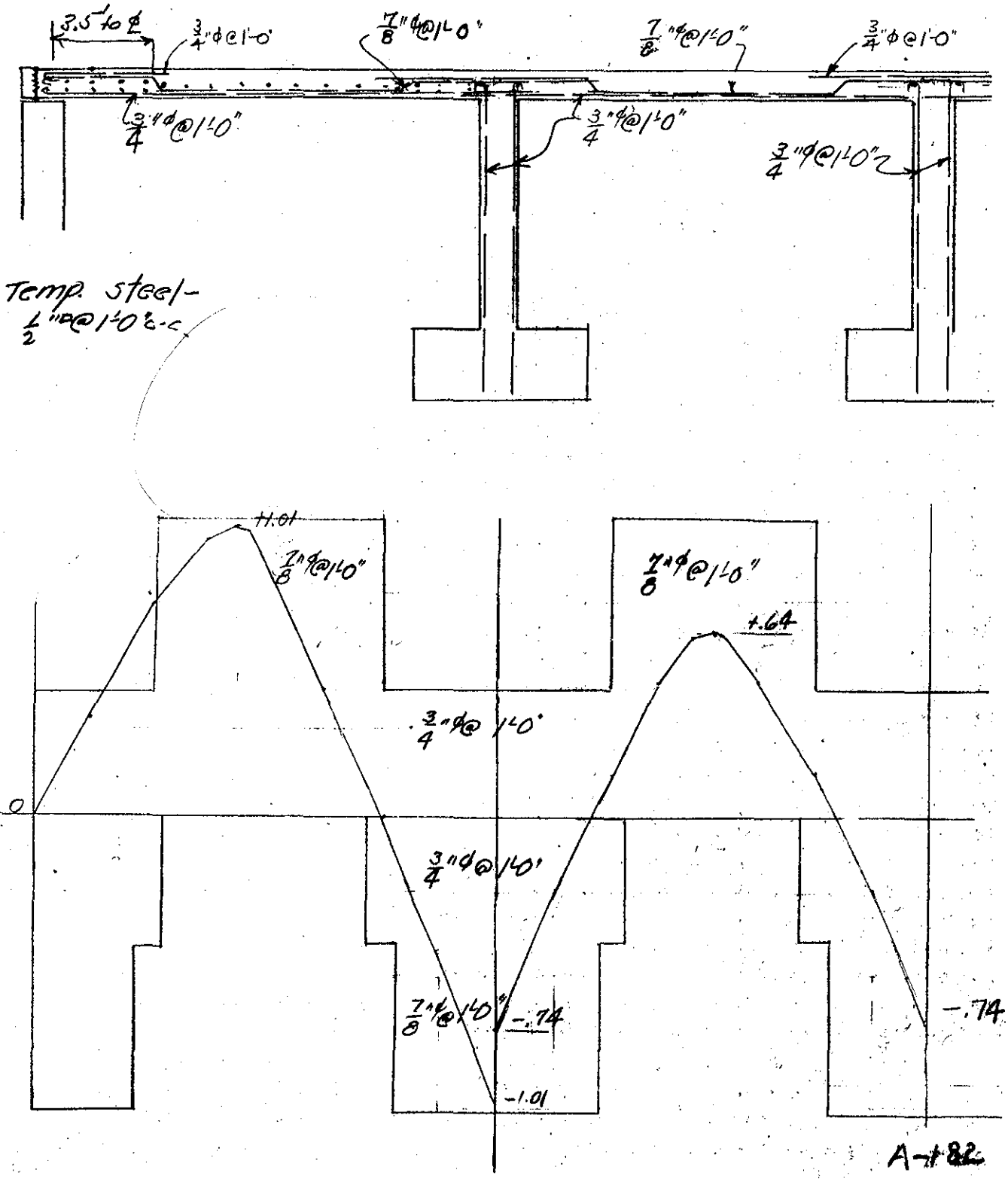
Page 8

Project: NORTHAMPTON

Computation: Oxbow bridge

Computed by: RSM Checked by: T. J. S. Date: 8-8-39

U. S. GOVERNMENT PRINTING OFFICE 3—10528



A-182

Project: NORTHAMPTON
Computation: Oxbow bridge
Computed by: RSM Checked by: T.J.S. Date: 8-10-39

U. S. GOVERNMENT PRINTING OFFICE 3—10588

ABUTMENT

	Force	↓↑	← →	Arm	Moment ↷	Moment ↶
1	150 × 9 × 1.5 ↓	2020		3.75		7,600
2	150 × 2.5 × 7.5 ↓	2810		3.75		10,500
3	100 × 3 × 7.5 ↓	2250		6		13,500
4	125 × 1.5 × 6 ↓	940		3.75		3,560
5	62.5 × 4 × 7.5 ↑	1880		3.75	7,100	
6	$11.5^2 \times 35/2$ →		2310	3.83	8,900	
7	$4.0^2 \times 45/2$ →		360	1.33	500	
8	$4.0^2 \times 80/2$ ←		640	1.33		900
9	↓	1200		3.75		4500
		9,240			16,300	40,600

$\frac{\Sigma M}{\Sigma V} = 24{,}300 / 9{,}240 = 3.35'$; e 1.4'

$P_1 = 9240 \times 6.83 \times \frac{2.65}{4.5} =$ 29,000 # or 14.5 T. per pile

$P_2 = 9240 \times 6.83 \times \frac{1.85}{4.5} =$ 20,500 # or 10.3 T. per pile

Stem

h	M	A_s	Used
6'	1260'#	.05 □"	} ⅝"ϕ @ 1'-0"
9'	4240'#	.22 □"	

Base

$M = \frac{29{,}000}{6.83} \times 2.25 = 9{,}600$ '#

$A_s = \frac{9{,}600 \times 12}{18000 \times .884 \times 14.5^2} = .50$ □" ; Used ⅞"ϕ @ 1'-0"

Subject Northampton Dike
Computation Highway Bridge at Ox Bow
Computed by T. J. S. Checked by R. S. M. Date 8-10-39

U. S. GOVERNMENT PRINTING OFFICE 3—10538

Timber Piling in Piers
Capacity
Dead Load

Slab	1.08×16×15×150	38,800
Curbs	2×1.33×15×150	6000
Rail	7.3#×15	100
Stem	1.5×8.5×17.33×150	33200
Base	2.5×6.5×17.33×150	42300
		120400#

Live Load

Front wheels	$6000\times2\times\frac{1}{15}$ =	1000 ±
Rear "	24000×2 =	48000
		49000#

Total D. & L. Load 169400

$\frac{169400}{2\times21.33}$ = 3970#/' each side

Use 6 Piles - $\frac{169400}{6\times2000}$ = 14.2T use 15 Tons

Length of Piling:- (assume 1'0" dia. + skin friction = 250#/□')

$\frac{2000\times15}{250\times3.14}$ = 38' Length req. Use 40' Length

$M = 3970\times3.25 - 375\times\overline{3.25}^2\times\frac{1}{2} = 10,900$ '#

$A_s = \frac{10900\times12}{18000\times.884\times18} = 0.46$ □"

Use $\frac{7}{8}$"φ @ 1'-0" c.c. with extra bar @ each pile transversely