HOUSATONIC RIVER FLOOD CONTROL

EAST BRANCH
DAM & RESERVOIR

EAST BRANCH NAUGATUCK RIVER

(UPPER NAUGATUCK RIVER, ABOVE TORRINGTON)

CONNECTICUT

DESIGN MEMORANDUM NO. 7

DETAILED DESIGN OF STRUCTURES

U.S. Army Engineer Division, New England
Corps of Engineers Waltham, Mass.

FEBRUARY 1962

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM 54, MASS.

ADDRESS REPLY TO:
DIVISION ENGINEER

REFER TO FILE NO.

NEDGW

19 February 1962

SUBJECT: East Branch Dam and Reservoir - East Branch Naugatuck River - Housatonic River Basin, Connecticut - Design Memorandum No. 7 - Detailed Design of Structures

TO: Chief of Engineers
ATTENTION: ENGCW-E
Department of the Army
Washington 25, D. C.

There is submitted for review and approval Design Memorandum No. 7 - Detailed Design of Structures for the East Branch Dam and Reservoir - East Branch Naugatuck River - Housatonic River Basin, Connecticut, in accordance with EM 1110-2-1150.

FOR THE DIVISION ENGINEER:

JOHN WM. LESLIE
Chief, Engineering Division

Incl
Des Mem No. 7
Detailed Design of
Structures
(10 cys)

FLOOD CONTROL PROJECT

EAST BRANCH DAM AND RESERVOIR

EAST BRANCH NAUGATUCK RIVER

HOUSATONIC RIVER BASIN
CONNECTICUT

DESIGN MEMORANDA INDEX

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2	Site Geology	18 Dec 1961	12 Jan 1962
3	General Design	18 Dec 1961	25 Jan 1962
4	Relocations	21 Nov 1961	20 Dec 1961
5	Concrete Materials	20 Nov 1961	7 Dec 1961
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7	Detailed Design of Structures	19 Feb 1962	

EAST BRANCH DAM AND RESERVOIR

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U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
OFFICE OF THE DIVISION ENGINEER
WALTHAM 54, MASS.

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February 1962

A. INTRODUCTION

1. Purpose. - The purpose of this memorandum is to facilitate the review by higher authority of the structural design of the various features of the project. The basic criteria, typical design computations, and other data pertinent to the design are presented herein.

2. Scope. - This memorandum covers the following structures: outlet works, spillway, lining and retaining walls.

3. Previous Reports. - No previous report on the structural design of these structures has been submitted. The latest previous description of the proposed structures is set forth as part of the recommended project plan in Design Memorandum No. 3 - General Design, submitted on 18 December 1961 and approved on 25 January 1962.

4. Location of Project. - The East Branch Reservoir Project is located within the City of Torrington, Connecticut. The reservoir is formed by a dam located on East Branch Naugatuck River 3.0 miles above its confluence with the West Branch Naugatuck River and about 2.5 miles above Torrington and a spillway located in the west abutment adjacent to the Dam. The reservoir extends up the East Branch Naugatuck River about 1.4 miles. The total drainage area of East Branch of the Naugatuck River is 14.0 square miles and the drainage area at the damsite is 9.25 square miles.

5. Description of Proposed Structures. - a. General. - A description at each of the principal elements of the proposed plan of improvement for the East Branch Reservoir Project is presented in the following paragraphs. See General Plan, Plate No. 1.

b. Dam. - The dam to be constructed across East Branch of the Naugatuck River is composed of a rock and rolled earth fill embankment 700 feet in length and having a maximum height of 92 feet above the streambed. The top elevation is at 881 feet above m.s.l. which provides for an 11-foot spillway surcharge and a 5-foot freeboard. The top width of the dam is 20 feet, with a 14-foot gravel surface roadway. Highway guard rails will not be provided since access will be limited to official use only. Access to the top of the dam will be from the relocated Newfield Road on the east abutment. On the basis of the foundation conditions, the availability and characteristics of borrow materials, and the utilization of materials from required excavations, an embankment section has been selected which consists of large earth fill zones of compacted gravelly silty sand (glacial till), an upstream rock fill zone, a small downstream rock fill toe, rock slope protection, gravel bedding, a pervious internal wick drain, and a pervious drainage blanket in the downstream portion of the embankment. The rock will be obtained from required rock excavations, and the glacial till will be obtained from a borrow area upstream of the dam. The more pervious surficial phases of the borrow materials and materials from required earth excavation will be utilized in the downstream portion of the earth fill. Gravel bedding and drainage materials will be furnished by the contractor from approved sources. The embankment slopes have been tentatively established at 1 on 3 and 1 on 2.5 for the upstream and downstream slopes, respectively, on the basis of experience with other designs using similar materials. Seepage through the embankment will be controlled by the arrangement of zones of materials with different permeabilities. Seepage through the embankment foundation will be controlled by an impervious foundation cut-off to bedrock, a contiguous grout curtain in the bedrock, a pervious drainage blanket and a downstream rock fill toe. Both the blanket and the rock fill toe will be in contact with the bedrock surface. The above described embankment section is considered to be tentative pending completion of all subsurface investigation and embankment design studies. The details of the final embankment section will be presented in the Design Memorandum on Foundations and Embankments.

c. Outlet Works. - The outlet works are located on the west bank of the river under the dam and founded on rock. It consists of an inlet channel, an inlet structure, a conduit, a stilling basin and an outlet channel. See Plate Nos. 2, 3, 4 and 5.

(1) The inlet channel is excavated in earth and rock and has a bottom width of 10 feet, an elevation of 797 feet, m.s.l. and an approximate length of 55 feet. The side slopes are 1 on 2 and will be protected by 2 feet of rock on gravel bedding.

(2) The inlet structure is a reinforced concrete structure and consists of a drop inlet and a conduit transition having an overall length of 30 feet with an invert elevation of 795 feet, m.s.l. No gates will be provided. A structural steel trash rack is provided at the drop inlet.

(3) The 36-inch circular conduit is 432 feet long sloping from an upstream invert elevation of 795 to an invert elevation of 794 at the outlet portal. The conduit is precast 36" diameter reinforced concrete pipe on a concrete saddle founded on rock. A grout ring will be provided in line of the foundation cut-off and two seepage collars will also be provided.

(4) The stilling basin is of reinforced concrete and founded on rock. It has an overall length of 61 feet, its bottom width flares from 3 feet at the portal to 12 feet in a distance of 35 feet with a drop in elevation from 794.0 to 782.0. The horizontal floor of the stilling basin is 24 feet long. An end sill and baffle blocks are incorporated in the design. Anchors and drainage holes will be provided.

(5) The outlet channel excavated in rock and earth is 15 feet wide and approximately 280 feet long having a 2 percent downward slope from elevation 783 at the end of the stilling basin.

d. Spillway. - The spillway is located in the west abutment adjacent to the dam and separated from the embankment by a concrete retaining wall. The spillway is a chute channel type and is uncontrolled, fixed-crest trapezoidal weir having a crest length of 100 feet and a crest elevation of 865 feet, above m.s.l. The weir is a concrete ogee section founded on rock. The structure has a maximum discharge capacity of 13,900 c.f.s. (the outflow for the spillway design flood) under the design surcharge of 11 feet. Flood discharges over the structure will occur infrequently and no improvement is planned in the valley immediately below the spillway discharge channel.

The spillway approach channel excavated in rock and earth is about 300 feet long. It has a maximum elevation of 860 and a minimum width at 97.5 feet at the weir. The spillway discharge channel excavated in rock and earth is about 770 feet long. The discharge channel bottom width varies from 97.5 feet at the weir bucket to 40 feet in a distance of about 374 feet; it slopes down from invert elevation 860 at the weir bucket to elevation 844 in about 228 feet, thence to elevation 800 in about 310 feet and thence to the river with a downward slope, at 10 percent. A concrete gravity wall will separate the spillway channel from the dam embankment. The excavated materials from the spillway are used in the proposed embankment as rock and random fills. Excavation operations will proceed at a rate that will allow the excavated materials to be placed in the embankment with minimum stockpiling. See Plate Nos. 6, 7 and 8.

e. Reservoir Clearing. - A permanent pool will not be provided. Therefore, no area in the reservoir will be cleared. This is in conformity with the recommendations of the U.S. Fish and Wildlife Service to mitigate losses to fish and wildlife due to the project.

f. Staff and Recording Gages. - A series of staff gages and a recording gage of the bubbler type will be provided for reading and recording reservoir stages. The bubbler gages will be housed in a concrete structure located on top of the dam.

g. Access Roads. - The site is located on Newfield Road (a town road) which will be relocated. The reconstructed Newfield Road will be adjacent to the left end of the dam and will serve as the main access road. Access to the top of dam will be limited for official use only.

Access to the reservoir area will be via existing Newfield Road which will be provided with access to the relocated road.

B. HYDROLOGY

6. General. - The Design Memorandum No. 1, Hydrology and Hydraulic Analysis, submitted on 20 November 1961 and approved on 7 December 1961, includes the basic data and hydrological requirements for the spillway and outlet works. A summary of the hydrology criteria is given below.

7. Spillway Design Flood. - The spillway design flood was derived from the estimated probable maximum precipitation over the watershed. The probable maximum precipitation over the basin amounts to 24.0 inches in 24 hours with 19.5 inches occurring in a 6-hour period. Infiltration, surface detention and other losses are assumed at the rate of 0.05 inches per hour, resulting in a total rainfall excess of 22.8 inches. The adopted spillway design flood with a peak inflow of 15,500 c.f.s. was developed by applying the rainfall excess to the adopted unit hydrograph for the net drainage area above the dam. Routing the spillway design flood through the reservoir, assuming the reservoir initially full and that the outlet is inoperative, results in a maximum surcharge elevation of 876 feet m.s.l. and a maximum discharge of 13,900 c.f.s.

8. Flood Control Outlet. - An ungated outlet is provided on the west bank of the stream through the dam to pass the normal flow and to limit the maximum discharge to approximately the channel capacity downstream. With the pool at spillway crest, the resulting discharge is 226 c.f.s. At maximum surcharge the discharge is 243 c.f.s. The estimated channel capacity downstream of the dam is adequate to contain these flows within the river banks.

The discharge capacity of the selected outlet will satisfy diversion requirements using an upstream cofferdam with top elevation 845 feet m.s.l.

9. Freeboard. - A freeboard of 5 feet above the maximum surcharge pool of 11 feet is provided resulting in a top of dam elevation of 881.0 feet m.s.l.

C. HYDRAULIC DESIGN

10. General. - The hydraulic design of the spillway and outlet works is discussed in Design Memorandum No. 1, Hydrology and Hydraulic Analysis. Data pertinent to the design of the spillway and outlet works are given below.

11. Spillway. - The spillway selected is a low ogee crest and the shape is based on a hydraulic design head of 11.0 feet. The upstream face is vertical with a compound circular curve of 2 radii (R_1 = 5.22', R_2 = 2.24'). The equation for the coordinates of the downstream shape is $y = -.0661\ (x)^{1.836}$. To facilitate the

construction of the weir a tangent with a slope of 0.60 is used to separate the parabolic curve from the bucket curvature which has a 10-foot radius. The toe of the weir is set at elevation 861, 1-foot above the proposed channel grade to avoid the possibility of any uneven rock excavation interfering with the flow. From economic studies it was concluded that a spillway length of 100 feet provided the most practical layout. Assuming the reservoir full at the beginning of inflow and neglecting the relatively small discharge through the outlet the maximum pool would be elevation 876.0 with a corresponding discharge of 14,300 c.f.s.

12. Outlet Conduit. - An ungated outlet circular conduit with a diameter of 36 inches was adopted. The conduit has a length (including transition) of about 450 feet. The entrance invert will be at elevation 795 and the portal invert will be at elevation 794.

13. Intake. - The trapezoidal intake channel will have a bottom width of 10 feet and an elevation of 797 feet. A small drop structure is used from the channel to the conduit invert of 795 feet. The crest of the structure, which will also serve as a measuring weir during low flows, is at elevation 798 to insure that the intake for the pool recorder will be submerged. The vertical curve at the intake was determined from the following formula:

$$\frac{X^2}{D^2} + \frac{Y^2}{\left(\frac{2D}{3}\right)^2} = 1 \quad \text{where } D=3 \text{ feet}$$

Since the flow will be suppressed in the horizontal direction by the side walls a simple circular curve with a radius of 10 feet was used instead of an elliptical shape. A transition section of 10 feet length will provide fillets from a 3-foot square section to a circular section with a 3-foot diameter.

14. Trash Racks. - A metal trash rack with a maximum opening of about 4 square feet will span the intake works. The average velocity through the unobstructed openings with the pool at spillway crest will be about 2 feet per second.

15. Stilling Basin. - The stilling basin has been designed for a discharge of 225 c.f.s. which is the outflow with the pool at spillway crest. Using an exit velocity of 1.25 times the mean

velocity of 32.5 feet per second, the equation for the bottom parabola is $y = -(.00977\ x^2 + .0021x)$. The high flare ratio of 7.77 for the apron walls is primarily the result of the long trajectory but it also satisfies the recommended condition of about twice the Froude number which is 3.75. Fillets will be provided for the transition from the circular conduit to the trapezoidal channel.

The adopted design has the horizontal floor of the stilling basin at elevation 782 feet. With a 12-foot width the resultant depth D_2 is 6.6 feet or a water surface elevation of 788.6 feet. The corresponding energy gradient is at elevation 788.7 feet. With this energy gradient, an end sill 3.5 feet high with a discharge coefficient of 3.2 was required to control the tailwater. The stilling basin length of 25 feet is equal to 3.8 times the D_2 depth. This is considered adequate since an end sill and baffle blocks are incorporated in the design. The outlet channel from the stilling basin will have a width of 15 feet and a slope of 2 percent. This will insure that the flow will be continued in the channel and the velocity will approximate the average velocity of 6.5 feet per second in the natural river channel with the design discharge of 225 c.f.s. This resulted in a channel invert elevation at 783 feet at the end sill.

D. GEOLOGY

16. General. - A detailed discussion of geologic conditions, and a record of subsurface investigations is presented in Design Memorandum No. 2, Site Geology, submitted on 18 December 1961 and approved on 12 January 1962.

17. Site Geology. - The entire valley section at the damsite is controlled by bedrock consisting principally of gneiss with some granite and schist which occurs generally at or near the surface, forming rough, steep-sided abutments and a narrow valley bottom. Bedrock is exposed or occurs at relatively shallow depths throughout the spillway and conduit areas.

The overburden occurs as a generally thin mantle of glacial till-like materials consisting largely of variable silty sands and gravels with numerous cobbles and boulders. Scattered surface boulders occur throughout the site area, and heavy concentrations of large boulders and blocks are present on both abutments and in the river channel.

In general, the rock surface is rough and irregular. The structural trend of the bedrock is north-south or roughly normal to the axis of the dam and has a variably steep, westerly dip. For the most part the rocks are thinly foliated and closely jointed, and weathering has occurred to moderate depths along many of the joints and seams. A roughly cubical joint pattern is manifested by two systems of near vertical joints which intersect at an angle of 90° and a system of close-set near horizontal joints. This joint pattern, and the coincidence of spillway and conduit structure excavations with the structural orientation of the rock, will exercise considerable control on breakage and slope excavation. Therefore, while all structures will be founded on sound rock, care will be needed in excavations along the outboard side of the spillway cut, particularly in the excavation to foundation grades for the concrete gravity wall adjacent to the weir. Line drilling may be required at these locations although the rock structure is not conducive to this method. Hydraulic pressure test data indicated a need for limited shallow curtain grouting to reduce under-seepage. Due to the steep inclination of the foliation and pronounced horizontal jointing, anchors should be oriented, wherever possible, in such relation to the rock structure as will assure engagement of the maximum volume of rock.

E. CONCRETE MATERIALS

18. General. - Concrete materials are covered in detail in Design Memorandum No. 5, Concrete Materials, submitted on 20 November 1961 and approved on 7 December 1961.

F. STRUCTURAL DESIGN

19. Purpose. - This section of the Design Memorandum presents the design criteria, basic data and assumptions used in the structural design of the appurtenant structures. A brief description of the structures with loading conditions and assumptions used is included to show the design procedures. Typical computations are included in the Appendix showing the maximum conditions for the critical structures. Additional computations following the same procedure will be made wherever warranted by a change in loading or a reduction in section.

20. Scope. - The structural design of the spillway weir, spillway lining and retaining walls, inlet structure, conduit and stilling basin are included herein.

21. Design Criteria. - a. General. - All working stresses conform to those specified in the Engineering Manual EM 1110-1-2101, "Working Stresses for Structural Design", dated 6 January 1958. Loading conditions, design assumptions and other design criteria are based on the following applicable parts in the Engineering Manual for Civil Works; Standard Practice for Concrete (Part CXX, October 1953); Gravity Dam Design (EM 1110-2-2200, September 1958); Structural Design of Spillways and Outlet Works (Part CXXIV, October 1956) and Retaining Walls (EM 1110-2-2502, dated 29 May 1961). Accepted engineering practice has been employed in cases where the Engineering Manual for Civil Works does not apply.

b. Concrete. - The following table lists the concrete and reinforced concrete stresses used in the design of structures. In each case, the Civil Works Manual exposure classification A (applicable to structures subject to moderately severe weather exposure) has been used.

(1) Structures Other Than Concrete Pipe. -

Flexure	Lbs. per Sq. In.
Extreme fiber stresses in compression	1,050
Extreme fiber stresses in tension (plain concrete)	60
Shear - (v)	
Beams - no web reinforcement	90
Beams with properly designed web reinforcement	240
Footings at critical section	75
Bond - (u) Deformed bars	
Top bars	210
All others	300
Bearings - (fc)	
Load on entire area	750
Load on one-third area or less maximum permissible	1,125
Modular Ratio - (n)	10

(2) Precast Concrete Pipe. - The concrete for precast concrete pipe will have an ultimate working stress of 5,000 p.s.i.

c. Reinforcement. -

(1) Grade and Working Stresses. - All reinforcement in the structures except the concrete pipe including temperature and shrinkage reinforcement was designed for the working stresses of new billet steel, intermediate grade, deformed bars which is 20,000 p.s.i. in flexural tension. The reinforcement will conform to the requirements of Federal Specification QQ-S-632, Type II, Grade C and to ASTM A-305-56T. The reinforcement for concrete pipe shall conform to ASTM A-432-59T deformed bars or ASTM 185-58T welded wire fabric having a minimum yield strength of 50,000 p.s.i.

(2) Spacing. - The clear distance between parallel bars will not be less than $1\frac{1}{2}$ times the diameter of round bars except that in no case will the clear distance between parallel bars be less than 1 inch, or $1\frac{1}{2}$ times the maximum size of the coarse aggregate.

(3) Minimum Cover for the Main Reinforcement. - The minimum cover for main steel reinforcement to surface was maintained at 4" except for concrete pipe where the clear distance inside will be 3" and outside 1".

(4) Splices. - All splices will be lapped 30 diameters to develop by bond, the total working strength of the bars. Splices in the main reinforcement at points of maximum moment have been avoided in the design.

(5) Temperature and Shrinkage Reinforcement. - Temperature and shrinkage reinforcement will be provided where the main reinforcement extends in only one direction. Such reinforcement will provide for a ratio of steel area to concrete area (bd) of 0.002 with a minimum of .0012 in each face up to a maximum of #6 bars at 12" cc.

d. Structural Steel. - Structural steel was designed for the working stresses of ordinary bridge and building steel (yield point 33,000 p.s.i. minimum) which conforms to the specifications for the Design, Fabrication and Erection of Structural Steel for

Buildings, issued by the American Institute of Steel Construction. Allowable design working stresses conform to those given in the *Engineering Manual for Civil Works* using a basic stress of 20,000 p.s.i.

e. Increase in Normal Working Stresses. - No increase in normal allowable stresses were used.

22. Basic Data and Assumptions. -

a. Controlling Elevations of Dam and Appurtenant Structures (m.s.l.). -

Top of Dam	881.0
Spillway Crest	865.0
Maximum Water Surface just upstream at spillway weir	876.0
Conduit intake invert	795.0
Conduit outlet invert	794.0

b. Loads. -

(1) Dead Loads. - The following unit weights for materials were used:

MATERIAL	UNIT WEIGHT (lbs/cu. ft.)			
	Dry	Saturated	Moist	Submerged
Rockfill	120	140	130	78
Gravel Bedding & Pervious Fill	135	147	142	85
Earth Fill	130	145	140	83
Concrete (Plain & Reinforced)	150			
Steel	490			

(2) Live Loads. - The following live loads were used:

Water	62.5 lbs. per cu. ft.
Wind	30 lbs. per sq. ft.
Equipment	as furnished by manufacturer
Snow	40 lbs. per sq. ft.

c. External Water Pressure. - Triangular distribution of the water pressure in the reservoir pool on the spillway and abutments was used. Tailwater pressure was taken at 60% of full value for the spillway section.

d. Internal Water Pressure. - Uplift pressure under the dam was assumed effective on 100% of the area of the base, varying uniformly from tailwater head at the toe to full headwater at the heel for the main spillway.

e. Earth Pressure. - Earth pressures were determined in general accordance with EM 1110-2-2502, Retaining Walls, dated 29 May 1961. "At rest" pressures were used in all cases.

f. Earthquake Forces. - Because of the small size of the structures involved, earthquake forces are not a factor and were disregarded.

g. Ice Pressure. - Horizontal forces due to ice pressure are not a factor and were disregarded.

h. Frost Protection. - On the basis of temperature records and frost penetration depth curves derived by the Arctic Construction and Frost Effects Laboratory of the Corps of Engineers, a minimum frost protective cover of 4 feet above foundation level will be used for any structures founded on earth.

23. Main Spillway Weir and Lining. -

a. Description. - The ogee shaped weir is 100 feet in length with crest elevation at 865.0 and channel bed elevation at 860.0. At the east end of the weir, the abutment is a gravity type wall and at the west end there is a short section of concrete lining anchored to the rock. Contraction joints in the weir will be provided at a 25'-0" spacing and in the gravity wall at 27'-0" maximum spacing.

b. Spillway Stability. - The following loading conditions were investigated in the design.

Case I - Reservoir empty, dead load of weir and wind load on the downstream face.

Case II - Reservoir to spillway crest, no tailwater, uplift varying from full headwater at the heel to 0 at the toe.

Case III - Omitted.

Case IV - Reservoir at maximum surcharge elevation of 876.0 and maximum tailwater elevation at 866.1, uplift varying from maximum headwater at heel to maximum tailwater at toe.

Case V - Same as Case I, except earthquake acceleration in a downstream direction and no wind.

Case VI - Same as Case II, with earthquake acceleration added in the upstream direction.

c. Spillway Design. - Maximum bearing is only 1200 psf under Case V loading and the resultant falls within the middle third of the base for all conditions of loading. Under Case IV loading the shear friction coefficient was found to be 29.1 and rock anchors will not be required.

d. Spillway Lining. - Rock anchors holding the 1'-0" thick lining to the rock face were figured for a head of approximately 8.5 feet. Rock anchors will be #10 bars sunk 10'-0" into the rock and are spaced to hold a 48 sq. ft. area. Reinforcing steel will be #6 bars at 1'-0" in both direction.

e. Gravity Wall. - The gravity wall was designed for a rapid drawdown condition assuming a moist soil loading and no uplift. An at rest coefficient of 0.5 was used.

24. Inlet Structure. - The inlet structure consists of gravity type side walls upstream of the small weir, a U type section leading to the transition section, and a transition section starting as a 3'-0" square section and ending as a 3'-0" diameter circle. The gravity type walls were analyzed similar to the spillway gravity section. The U shaped section was designed considering a 5-foot differential head on the outside plus the submerged earth pressure. The transition section was designed as a continuous frame loaded with water to the spillway crest and submerged fill above the top. Only nominal steel is required.

25. Conduit Pipe. - The pipe manufacturer will be required to furnish a pipe for a load of 84,000 lbs. per running feet of pipe satisfying the following conditions: Applying a load factor of 3, at least three sections of pipe shall be tested by the three edge bearing method to determine the load to produce a .01 inch crack and the load at ultimate strength. The test load required to produce a .01 inch crack shall be based on a factor of safety of not less than 1.33. The test load to produce failure shall be based on a factor of safety of at least 2.0.

26. Stilling Basin. - The stilling basin consists of 1'-0" lining anchored to the rock on both sides of the channel and a small section of gravity training wall above the lining on one side only. The base slab is a 2'-6" thick slab anchored to the rock. The lining and base slab were designed for a net head of 10 feet.

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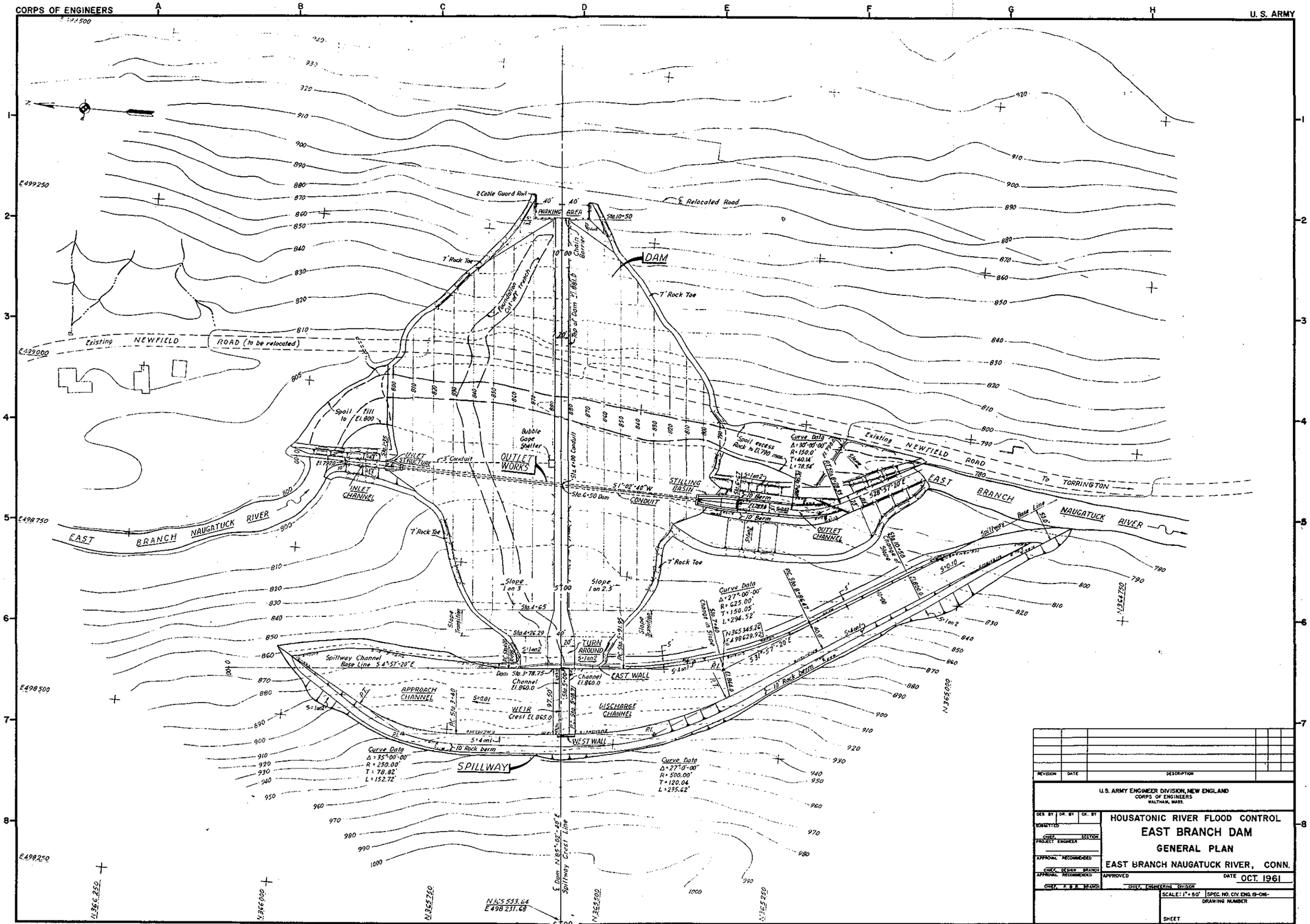


REVISION	DATE	DESCRIPTION

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED
CHIEF, SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, R & R BRANCH

HOUSATONIC RIVER FLOOD CONTROL
EAST BRANCH DAM
GENERAL PLAN
EAST BRANCH NAUGATUCK RIVER, CONN.

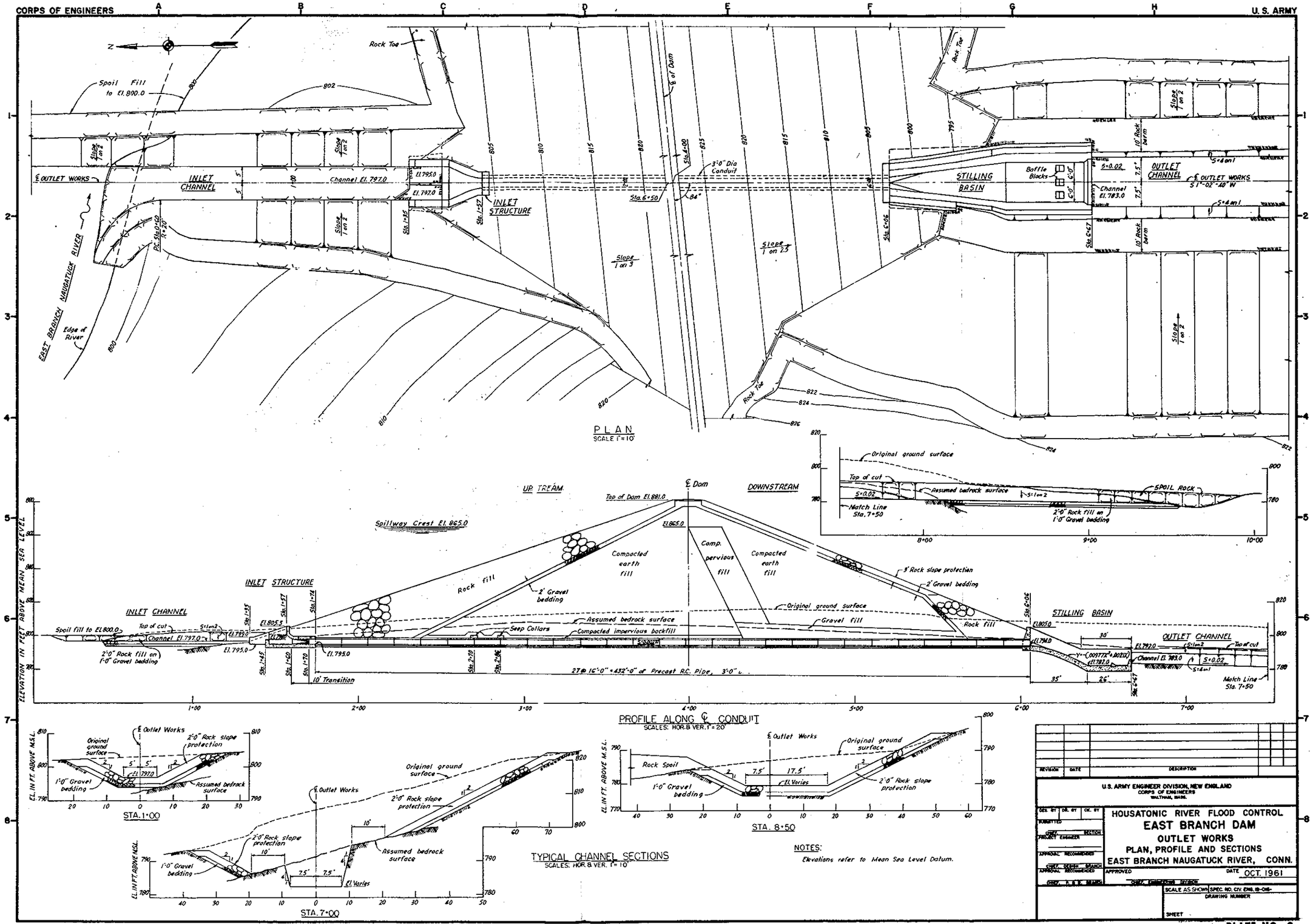
APPROVED
CHIEF, ENGINEERING DIVISION

DATE OCT. 1961

SCALE: 1" = 50'
SPEC. NO. CIV ENG. 19-016-
DRAWING NUMBER
SHEET

PLATE NO. 1

CORPS OF ENGINEERS — U. S. ARMY



NOTES:

Elevations refer to Mean Sea Level Datum.

REVISION	DATE	DESCRIPTION

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED
CHIEF, DESIGN SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, R. & D. BRANCH

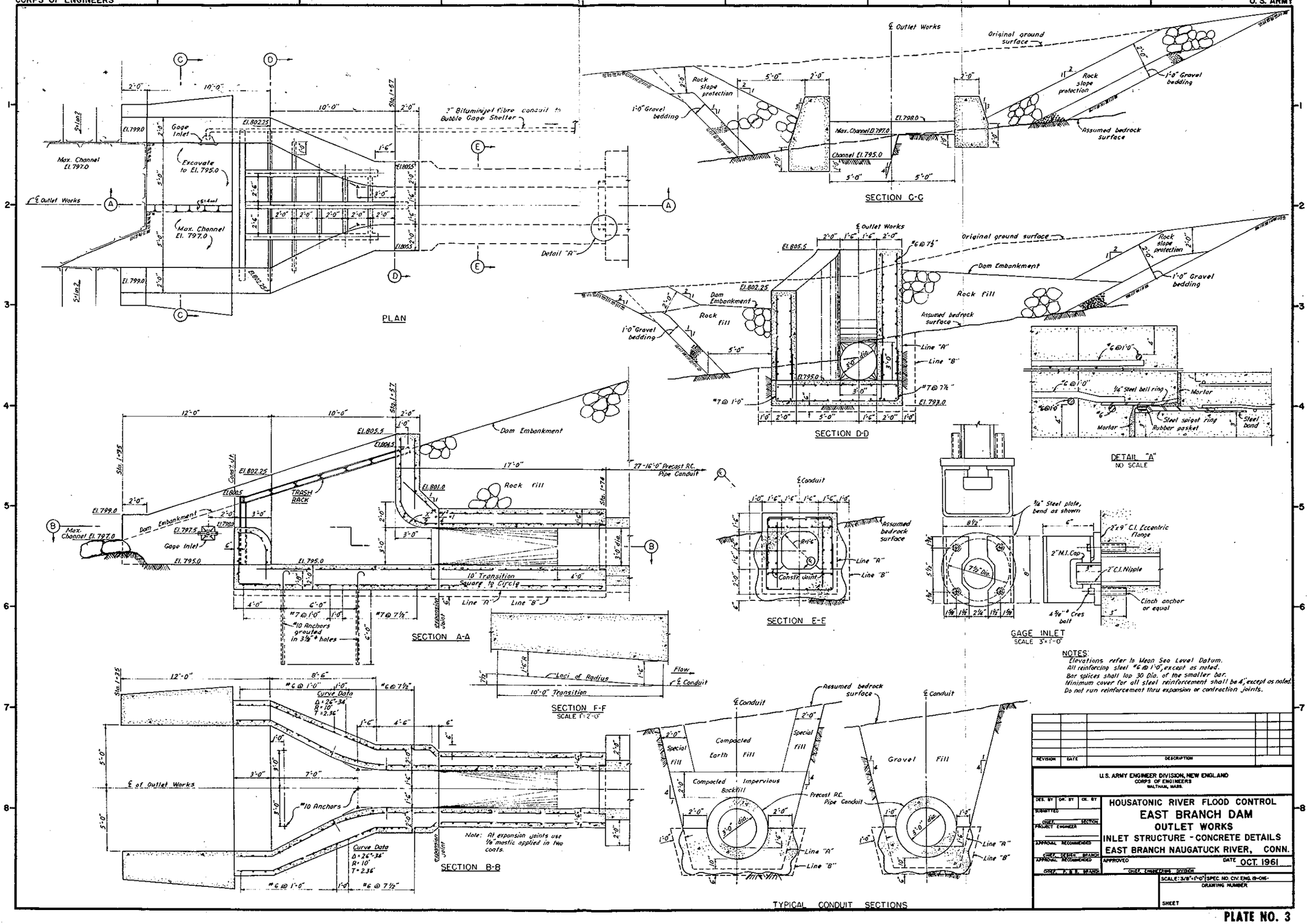
HOUSATONIC RIVER FLOOD CONTROL
EAST BRANCH DAM
OUTLET WORKS
PLAN, PROFILE AND SECTIONS
EAST BRANCH NAUGATUCK RIVER, CONN.

APPROVED — DATE OCT. 1961
CHIEF, ENGINEERING DIVISION

SCALE AS SHOWN | SPEC. NO. CIV. ENG. 19-065-
DRAWING NUMBER
SHEET

PLATE NO. 2

CORPS OF ENGINEERS — U.S. ARMY



NOTES:
Elevations refer to Mean Sea Level Datum.
All reinforcing steel #6 @ 1'-0", except as noted.
Bar splices shall lap 30 Dia. of the smaller bar.
Minimum cover for all steel reinforcement shall be 4", except as noted.
Do not run reinforcement thru expansion or contraction joints.

REVISION	DATE	DESCRIPTION

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

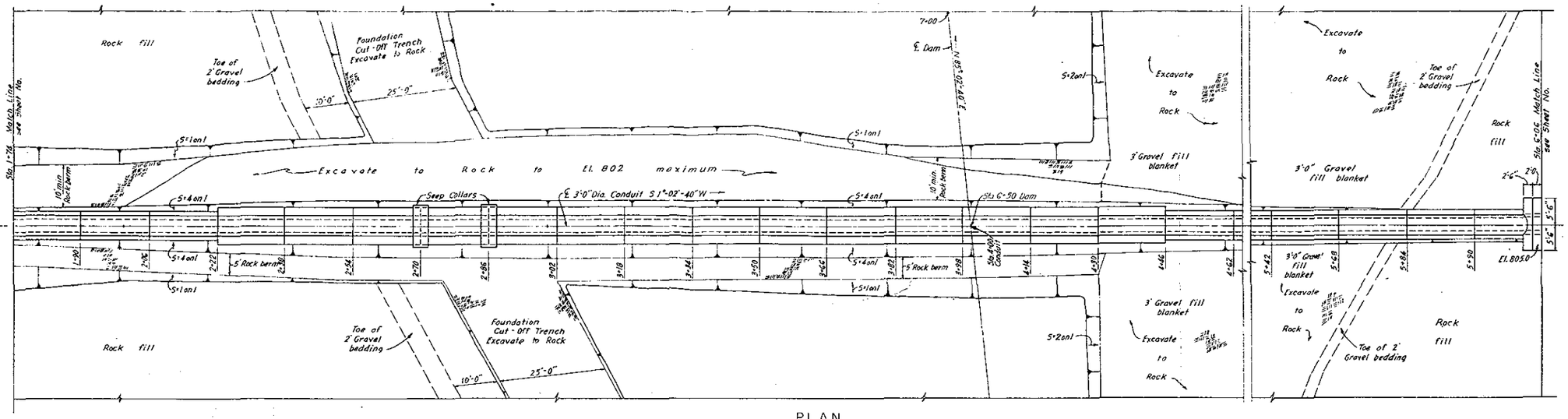
DES. BY | DR. BY | CK. BY
SUBMITTED
CHIEF, SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, P. & R. BRANCH

HOUSATONIC RIVER FLOOD CONTROL
EAST BRANCH DAM
OUTLET WORKS
INLET STRUCTURE - CONCRETE DETAILS
EAST BRANCH NAUGATUCK RIVER, CONN.

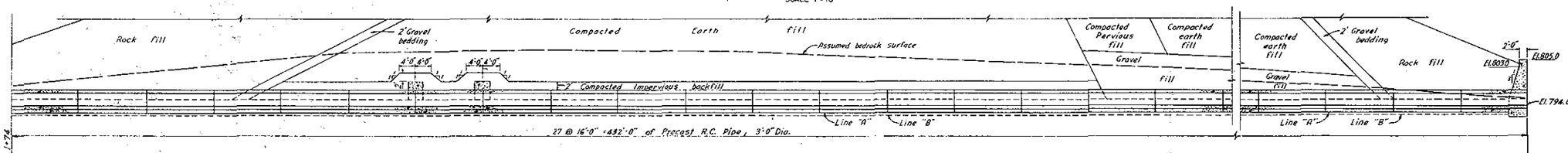
APPROVED — DATE OCT. 1961
CHIEF, INVESTIGATIONS DIVISION
SCALE: 3/8"=1'-0" | SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER
SHEET

PLATE NO. 3

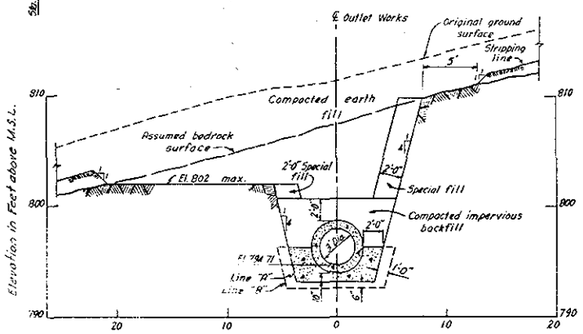
CORPS OF ENGINEERS — U. S. ARMY



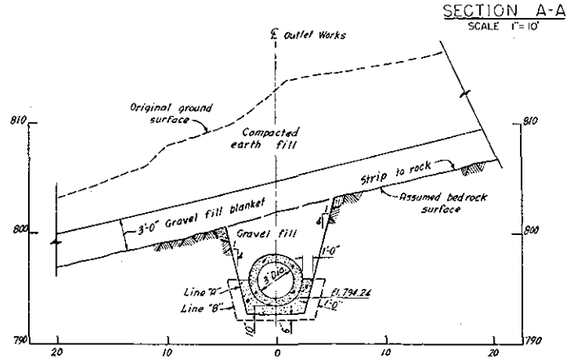
PLAN
SCALE 1"=10'



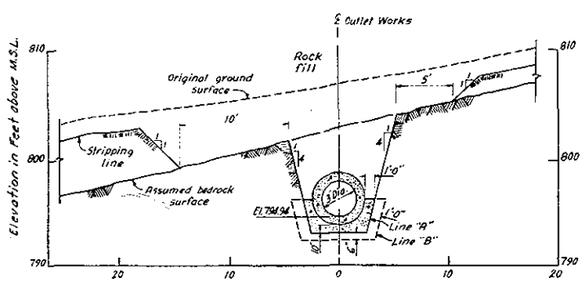
SECTION A-A
SCALE 1"=10'



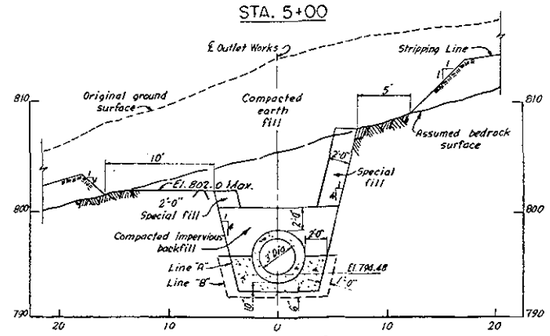
STA. 3+00



STA. 5+00

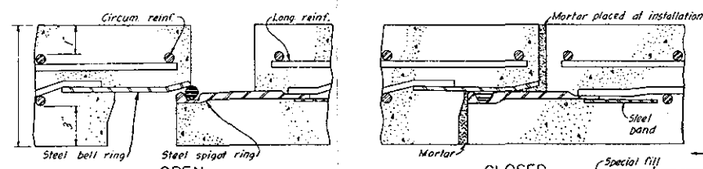


STA. 2+00

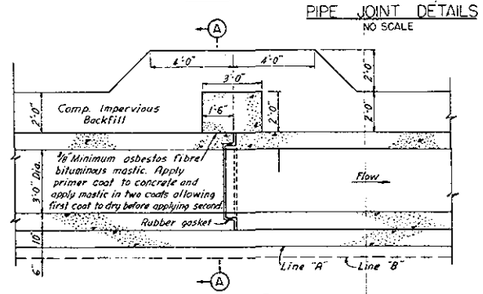


STA. 4+00

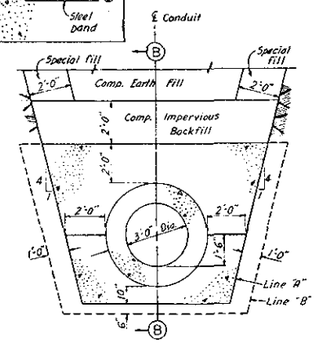
CONDUIT SECTIONS
SCALE 1"=



PIPE JOINT DETAILS
NO SCALE



SECTION B-B
COLLAR DETAILS - STA. 2+70 & 2+86



SECTION A-A

NOTES:

REVISION	DATE	DESCRIPTION

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY
SUBMITTED
CHIEF, SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, P. & R. BRANCH

HOUSATONIC RIVER FLOOD CONTROL
EAST BRANCH DAM
OUTLET WORKS
CONDUIT - PLAN AND SECTIONS
EAST BRANCH NAUGATUCK RIVER, CONN.

APPROVED
CHIEF, ENGINEERING DIVISION
DATE DEC 1961

SCALE
SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER
SHEET

PLATE NO. 4

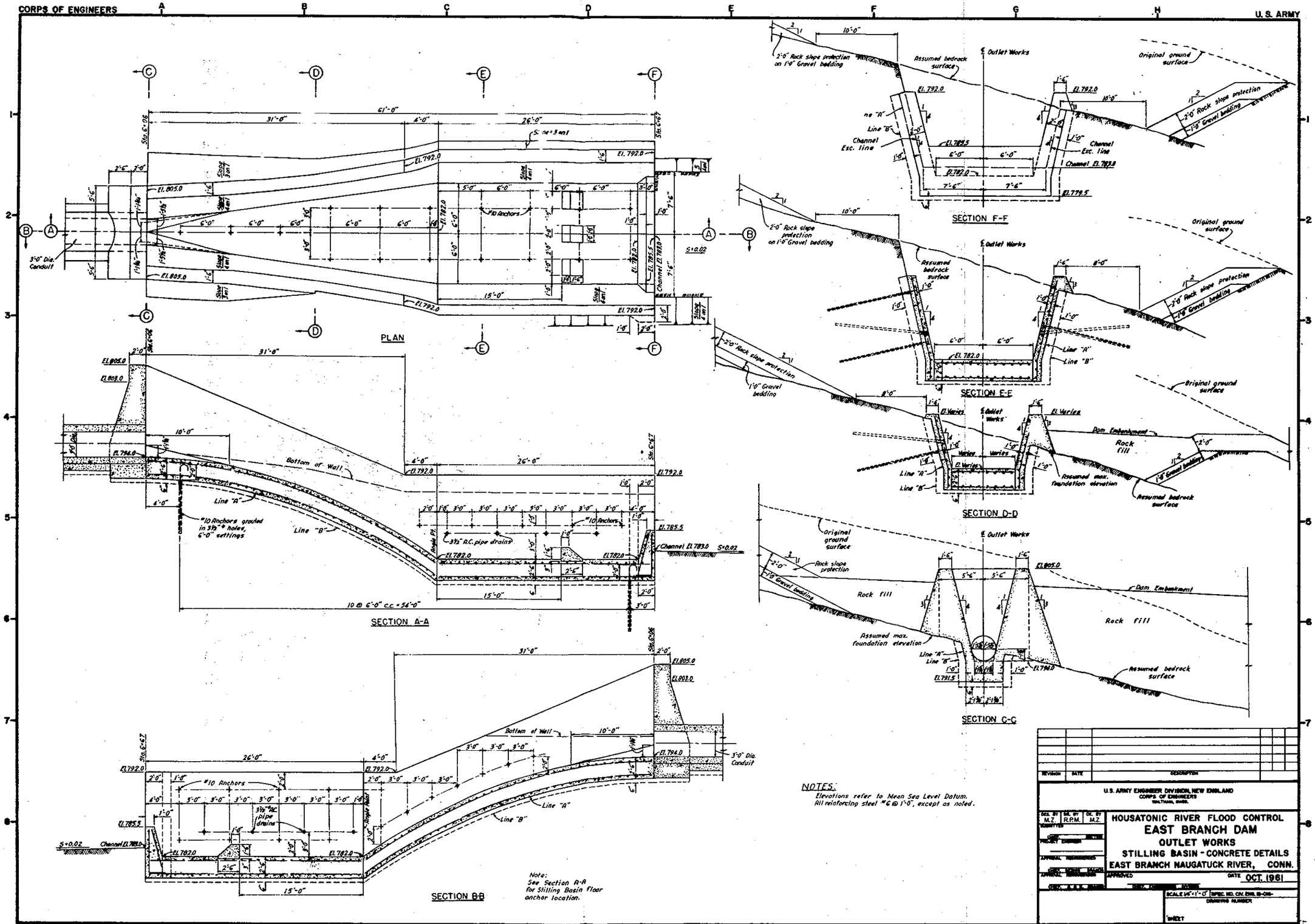
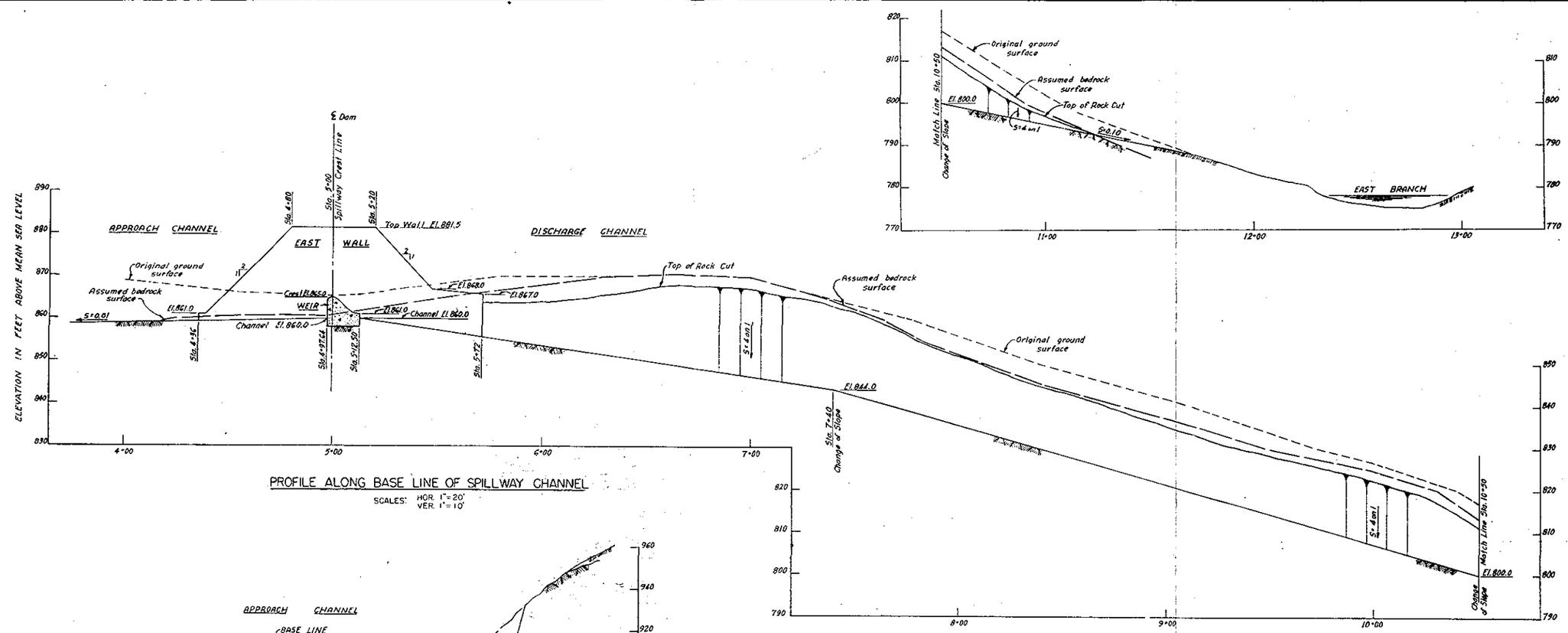

CORPS OF ENGINEERS
U.S. ARMY
PLAN
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
SECTION E-E
SECTION F-F
Bottom of Wall
Line "A"
Line "B"
#10 Anchors grouted in 3½" ϕ holes, 6'-0" settings
3½" A.C. pipe drains
10 @ 6'-0" c.c. = 54'-0"
3'-0" Dia. Conduit
Channel El. 783.0
S=0.02
Assumed bedrock surface
Original ground surface
Rock slope protection
Rock fill
Dam Embankment
Assumed max. foundation elevation
Outlet Works
Note:
See Section A-A for Stilling Basin floor anchor location.
NOTES:
Elevations refer to Mean Sea Level Datum.
All reinforcing steel #6 @ 1'-0", except as noted.
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
HOUSATONIC RIVER FLOOD CONTROL
EAST BRANCH DAM
OUTLET WORKS
STILLING BASIN - CONCRETE DETAILS
EAST BRANCH NAUGATUCK RIVER, CONN.
OCT. 1961

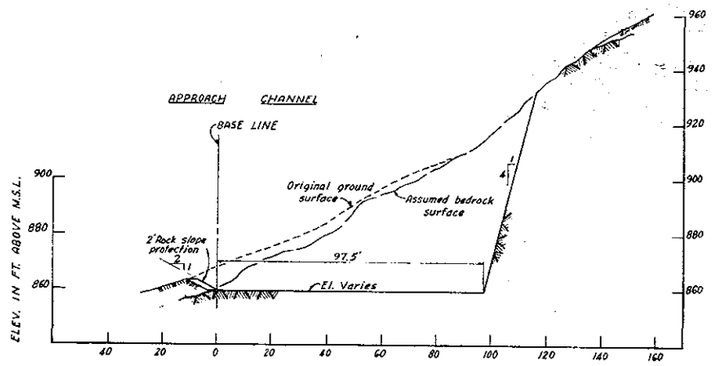
PLATE NO. 5

CORPS OF ENGINEERS U.S. ARMY



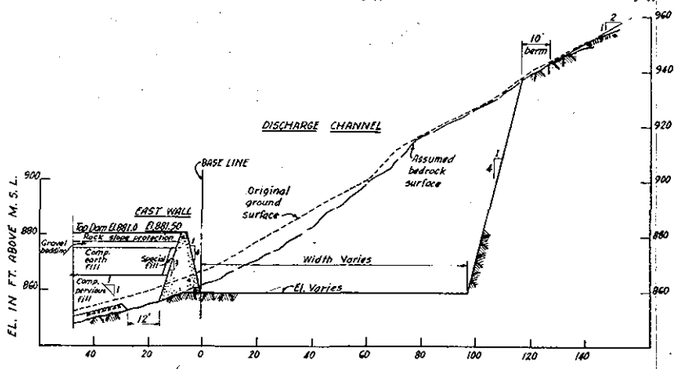
PROFILE ALONG BASE LINE OF SPILLWAY CHANNEL

SCALES: HOR. 1"=20' VER. 1"=10'



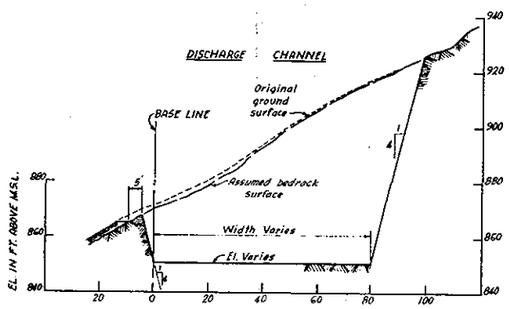
SECTION AT ℄ STA. 4+20

SCALES HOR. & VER. 1"=20'



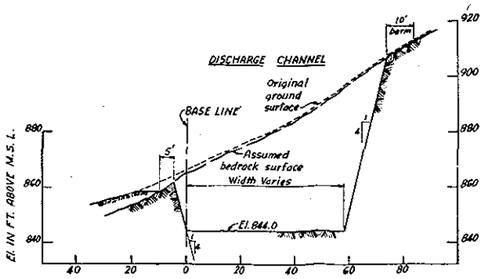
SECTION AT ℄ STA. 5+20

SCALES HOR. & VER. 1"=20'



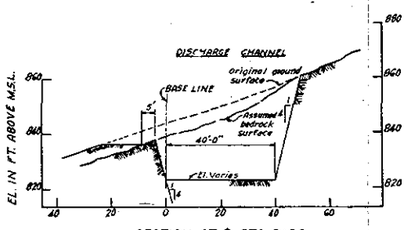
SECTION AT ℄ STA. 6+50

SCALES HOR. & VER. 1"=20'



SECTION AT ℄ STA. 7+40

SCALES HOR. & VER. 1"=20'



SECTION AT ℄ STA. 8+90

SCALES HOR. & VER. 1"=20'

REVISION	DATE	DESCRIPTION

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED
CHIEF, DESIGN BRANCH
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, E. & D. BRANCH

HOUSATONIC RIVER FLOOD CONTROL
EAST BRANCH DAM
SPILLWAY
PROFILE AND SECTIONS
EAST BRANCH NAUGATUCK RIVER, CONN.

APPROVED
DATE OCT. 1961
CHIEF, ENGINEERING DIVISION

SCALE AS SHOWN | SPEC. NO. CIV. ENG. 15-ONE-
DRAWING NUMBER
SHEET

PLATE NO. 6

CORPS OF ENGINEERS U.S. ARMY

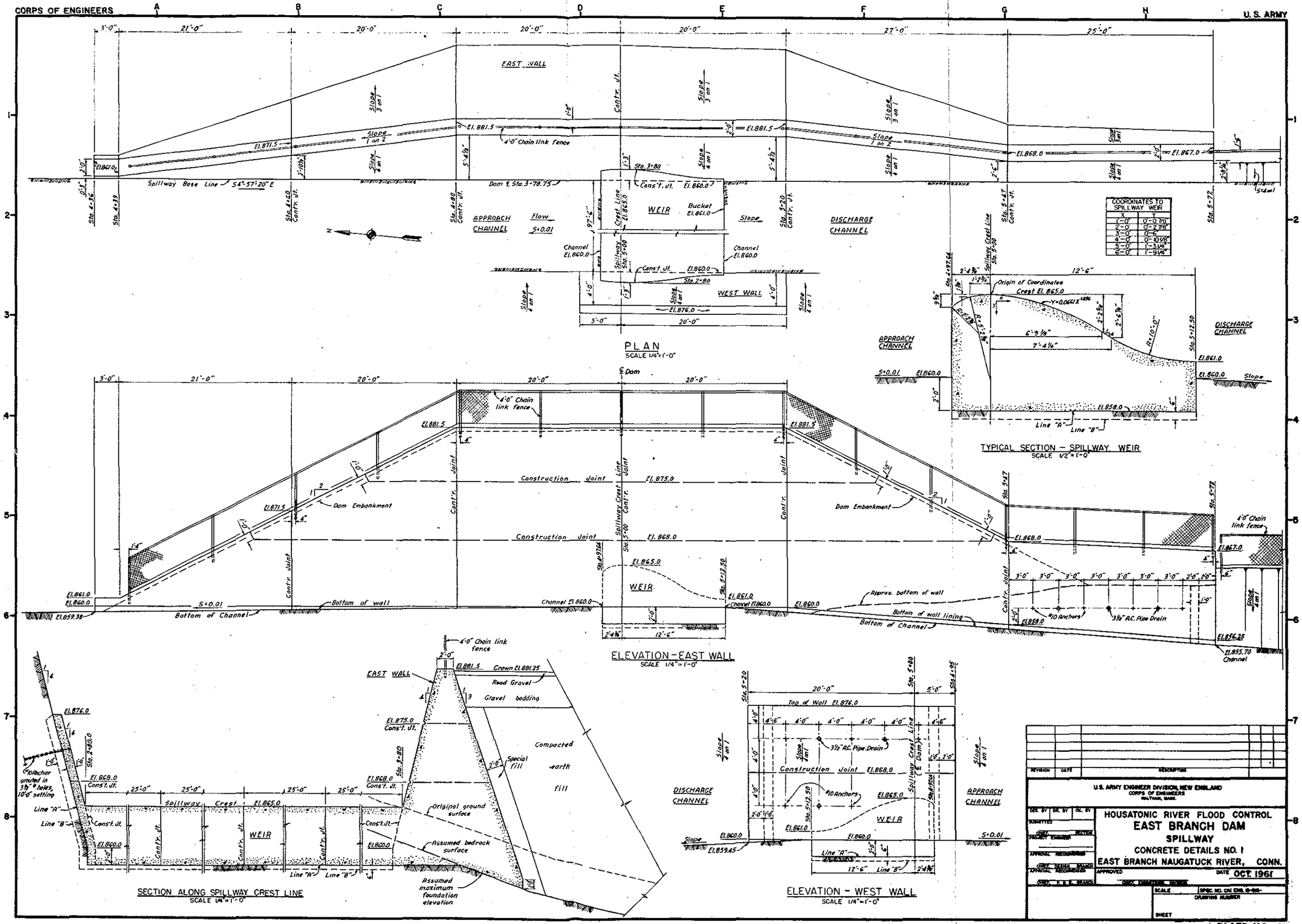
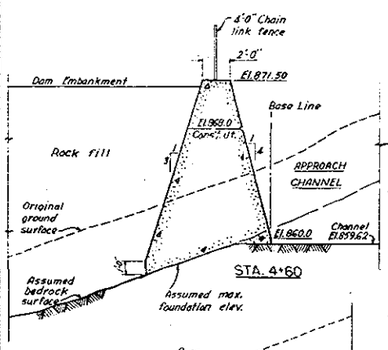
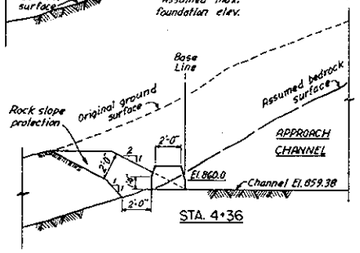


PLATE NO. 7

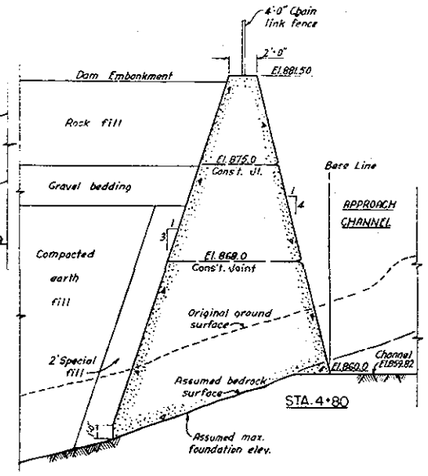
CORPS OF ENGINEERS — U. S. ARMY



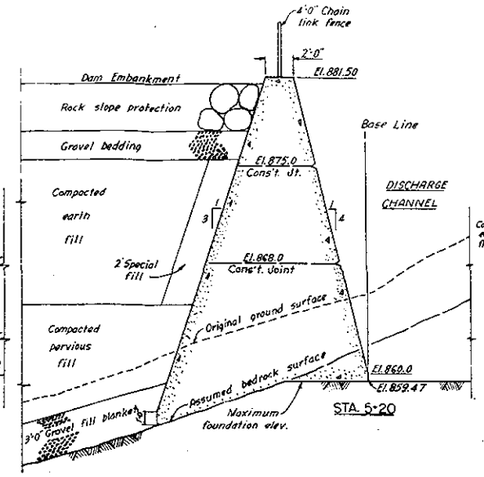
STA. 4+60



STA. 4+36

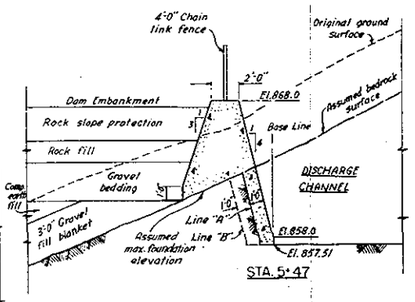


STA. 4+80

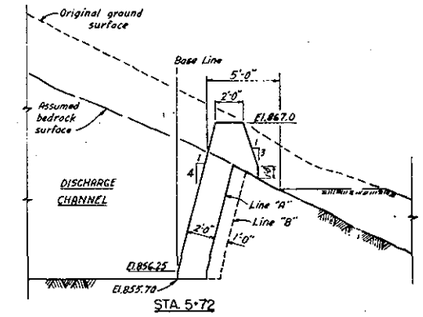


STA. 5+20

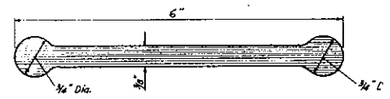
EAST WALL SECTIONS
SCALE 1/4" = 1'-0"



STA. 5+47

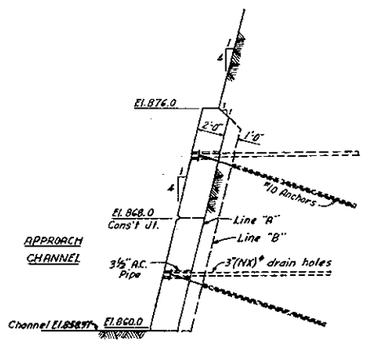


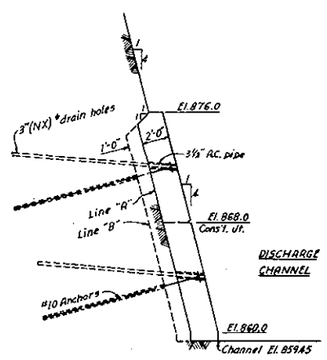
STA. 5+72



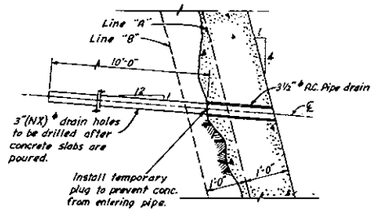
WATERSTOP
FULL SCALE
Waterstops to be continuous

Note: Use either rubber or Polyvinylchloride for Waterstops (see specifications)

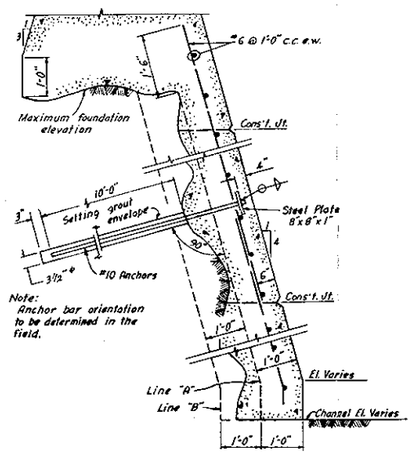




WEST WALL END SECTIONS
SCALE 1/4" = 1'-0"

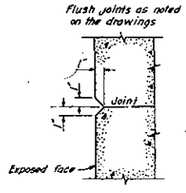


TYPICAL DRAINAGE DETAIL
SCALE 3/4" = 1'-0"

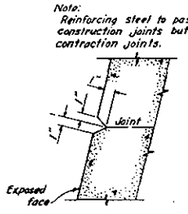


TYPICAL ANCHOR BAR AND REINFORCEMENT DETAIL
SCALE 3/4" = 1'-0"

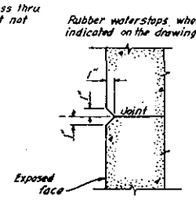
NOTES:
Elevations refer to Mean Sea Level Datum.



CONSTRUCTION JOINT
VERTICAL or HORIZONTAL
Cons't. Jt.



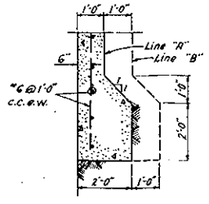
CONSTRUCTION JOINT
SLOPING FACE
Cons't. Jt.



CONTRACTION JOINT
Cont'r. Jt.

Note: At expansion joints use ⅛" mastic applied in two coats.

STRUCTURAL JOINT DETAILS
NO SCALE



TYPICAL END SECTION
SCALE 1/2" = 1'-0"

REVISION	DATE	DESCRIPTION

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY
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PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, E. & D. BRANCH

HOUSATONIC RIVER FLOOD CONTROL
EAST BRANCH DAM
SPILLWAY
CONCRETE DETAILS NO. 2
EAST BRANCH NAUGATUCK RIVER, CONN.

APPROVED
DATE DEC 1961
CHIEF, ENGINEERING DIVISION

SCALE
SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER
SHEET

PLATE NO. 8

NED FORM 223
27 Sept 49

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS

PAGE 1

SUBJECT East Branch Reservoir
COMPUTATION Spillway Stability
COMPUTED BY [illegible] CHECKED BY R.N.W. DATE 7 NOV 1961

LOADING CONDITIONS

CASE I CONSTRUCTION CONDITION -
Dry
30 PSF Wind on Downstream Face
Resultant within mid 1/3

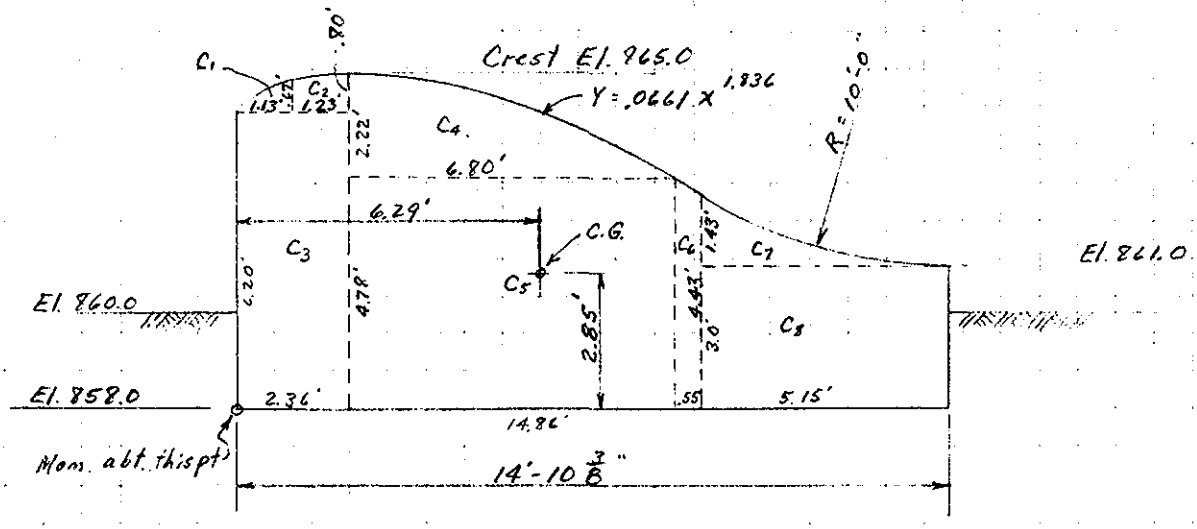
CASE II NORMAL OPERATING CONDITION
Pool at spillway crest
Minimum Tailwater
No Ice
Resultant within mid 1/3 Max $\Sigma H/\Sigma V = 0.65$

CASE IV FLOOD DISCHARGE CONDITION
Pool at max. surcharge
Maximum Tailwater
T.W. at full value for uplift
T.W. at 60% full value for lateral forces
No Ice
Resultant within mid 1/3 Max $\Sigma H/\Sigma V = 0.65$

CASE V CONSTRUCTION CONDITION WITH EARTHQUAKE
Same as CASE I except earthquake acceleration in a downstream direction and no wind.
Resultant within base

CASE VI NORMAL OPERATING CONDITION WITH EARTHQUAKE
Same as CASE II except earthquake acceleration in an upstream direction.
Resultant within base Max $\Sigma H/\Sigma V = 0.85$

SUBJECT East Branch Reservoir
COMPUTATION Spillway Stability
COMPUTED BY BFW CHECKED BY R.N.W. DATE 7 Nov 1961



NAPPE PROPERTIES OF C4 PARABOLA

$y = 2.22 - .0661x^{1.836}$ $\qquad dA = y\,dx$

$dA = 2.22\,dx - .0661x^{1.836}\,dx$

$$A = \int_0^{6.80} 2.22\,dx - \int_0^{6.80} .0661x^{1.836}\,dx = \left[2.22x\right]_0^{6.80} - \left[\frac{.0661x^{2.836}}{2.836}\right]_0^{6.80}$$

$$A = 2.22(6.80) - \frac{.0661(6.80)^{2.836}}{2.836} = 15.10 - 5.35 = \underline{9.75'}$$

$dM_y = x\,dA = x\,y\,dx$

$$M_y = \int_0^{6.80} 2.22x\,dx - \int_0^{6.80} .0661x^{2.836} = \left[\frac{2.22x^2}{2}\right]_0^{6.80} - \left[\frac{.0661x^{3.836}}{3.836}\right]_0^{6.80}$$

$$M_y = 1.11(6.80)^2 - \frac{.0661(6.80)^{3.836}}{3.836} = 51.33 - 26.96 = 24.37\ ft^3$$

$$\bar{x} = \frac{M_y}{A} = \frac{24.37}{9.75} = \underline{2.50'}$$

$$M_x = \int \frac{y^2\,dx}{2} = \int_0^{6.80} \frac{(2.22 - .0661x^{1.836})^2}{2}\,dx$$

$$= \int_0^{6.80} \left[\frac{2.22^2}{2} - 2(2.22)(.0661x^{1.836}) + \frac{.0661^2}{2}x^{2(1.836)}\right]\frac{dx}{2}$$

SUBJECT East Branch Reservoir
COMPUTATION Spillway Stability
COMPUTED BY BRW CHECKED BY R.N.W. DATE 7 Nov. 1961

$$M_x = \int_0^{6.80} \frac{\overline{2.22}^2 dx}{2} - \int_0^{6.80} 2.22(.0661x^{1.836})dx + \int_0^{6.80} \frac{\overline{.0661}^2}{2} x^{3.672} dx$$

$$= \left[\frac{\overline{2.22}^2 x}{2}\right]_0^{6.80} - \left[\frac{2.22(.0661)x^{2.836}}{2.836}\right]_0^{6.80} + \left[\frac{\overline{.0661}^2 x^{4.672}}{2(4.672)}\right]_0^{6.80}$$

$$= \frac{\overline{2.22}^2}{2}(6.80) - \frac{2.22(.0661)(6.80)^{2.836}}{2.836} + \frac{\overline{.0661}^2(6.80)^{4.672}}{2(4.672)}$$

$$= 16.76 - 11.88 + 3.63 = 8.51$$

$$\bar{y} = \frac{M_x}{A} = \frac{8.51}{9.75} = \underline{0.87'}$$

PROPERTIES OF C7 CIRCULAR

$x^2 + y^2 = 100$
$y' = \sqrt{100 - x^2}$
$y = 10 - \sqrt{100 - x^2}$

$$A = \int_0^{5.15} y\,dx = \int_0^{5.15} (10 - \sqrt{100 - x^2})dx$$

$$= [10x]_0^{5.15} - \frac{1}{2}\left[x\sqrt{100 - x^2} + 100 \sin^{-1}\left(\frac{x}{10}\right)\right]_0^{5.15}$$

$$= 10(5.15) - \frac{1}{2}\left[5.15\overset{4.51}{\sqrt{100 - 26.5}} + 100(.541)\right] = 51.5 - 49.1 = \underline{2.4\ \square'}$$

$$M_y = \int xy\,dx = \int_0^{5.15} x(10 - \sqrt{100 - x^2})dx = \left[\frac{10x^2}{2}\right]_0^{5.15} + \frac{(100 - x^2)^{\frac{3}{2}}}{3} - \frac{(100)^{\frac{3}{2}}}{3}$$

$$= 132.61 + 209.94 - 333.33 = 9.22$$

$$\bar{x} = 5.15 - \frac{9.22}{2.4} = 5.15 - 3.84 = \underline{1.31'}$$

$$M_x = \int \frac{y^2}{2} dx = \int_0^{5.15} (10 - \sqrt{100 - x^2})^2 \frac{dx}{2} = \int_0^{5.15} (100 - 20\sqrt{100 - x^2} + 100 - x^2)\frac{dx}{2}$$

$$= \int_0^{5.15} 100\,dx - \int_0^{5.15} 10\sqrt{100 - x^2}\,dx - \frac{1}{2}\int_0^{5.15} x^2 dx = [100x]_0^{5.15} - 10(49.1) - \left[\frac{x^3}{6}\right]_0^{5.15}$$

$$= 515 - 491 - 22.76 = 1.24$$

$$\bar{y} = \frac{M_x}{A} = \frac{1.24}{2.4} = \underline{0.52'}$$

NED FORM 223
27 Sept 49

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS

SUBJECT East Branch Reservoir
COMPUTATION Spillway Stability
COMPUTED BY BJW CHECKED BY R.N.W. DATE 7 NOV. 1961

CONCRETE ONLY

ITEM		WGT.	H. ARM	H. MOM.	V. ARM	C.G. MOM.
C_1	$.15\,(1.13)(.67)\frac{1}{2}$	.06	.75	.05	6.42	.39
C_2	$.15\,(1.23)(.74)$	.14	1.75	.24	6.57	.92
C_3	$.15\,(2.36)(6.20)$	2.19	1.18	2.58	3.10	6.79
C_4	$.15\,(9.75)$	1.46	4.86	7.10	5.65	8.25
C_5	$.15\,(6.80)(4.78)$	4.88	5.76	28.11	2.39	11.66
C_6	$.15\,(.55)(4.60)$	.38	9.43	3.58	2.30	.87
C_7	$.15\,(2.4)$	.36	11.02	3.97	3.52	1.27
C_8	$.15\,(5.15)(3.0)$	2.32	12.29	28.51	1.50	3.48
	ΣV	= 11.79	ΣM_H	= 74.14	ΣM_{cg}	= 33.63

$$\frac{\Sigma M_H}{\Sigma V} = \frac{74.14^{'K}}{11.79^{K}} = 6.29' \qquad \frac{\Sigma M_{cg}}{\Sigma V} = \frac{33.63}{11.79} = 2.85' \qquad e = 7.43 - 6.29 = 1.14'$$

$$f = \frac{11.79}{14.86}\left(1 \pm \frac{6 \times 1.14}{14.86}\right) = 0.793(1 \pm 0.46)$$

f_{max} = 1158 PSF
f_{min} = 428 PSF

CASE I CONSTRUCTION CONDITION

C		11.79 ↓		+ 74.14	
WIND	0.03 (5.0)	.15 ←	4.5	− .68	

ΣM = 73.46

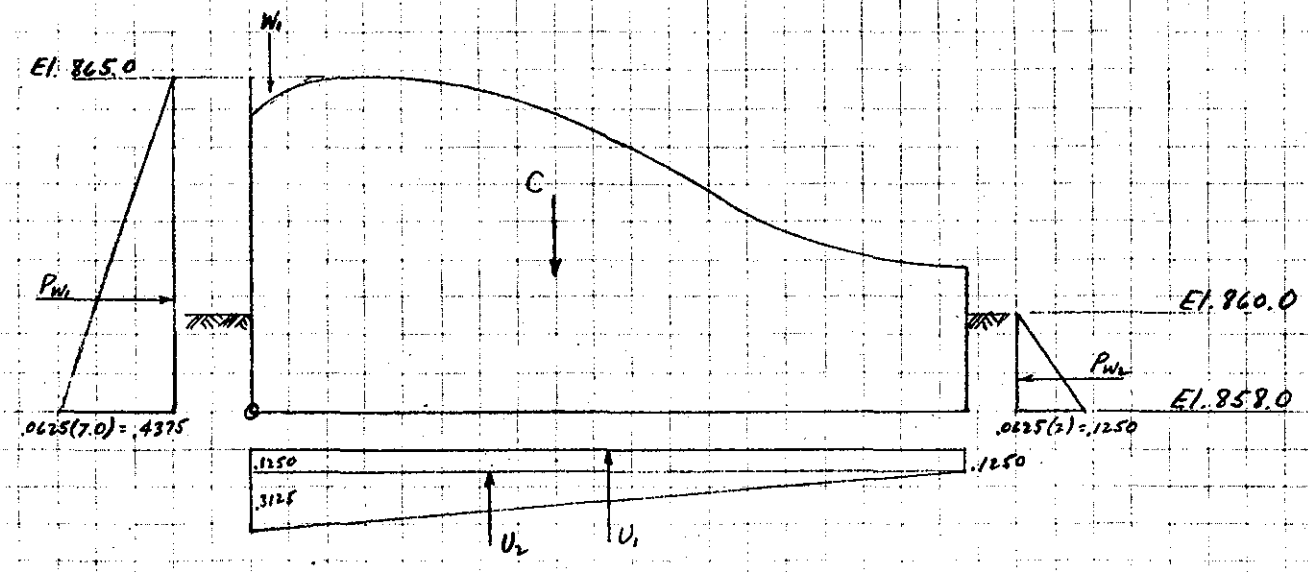
$$\frac{\Sigma M}{\Sigma V} = \frac{73.46}{11.79} = 6.23' > 4.95' < 9.91' \quad \text{O.K.} \qquad e = 7.43 - 6.23 = 1.20'$$

$$f = 0.79\left(1 \pm \frac{6 \times 1.20}{14.86}\right) = 0.793(1 \pm 0.48)$$

f_{max} = 1174 PSF
f_{min} = 412 PSF

SUBJECT East Branch Reservoir
COMPUTATION Spillway Stability
COMPUTED BY BJW CHECKED BY RNW DATE 7 Nov. 1961

CASE II NORMAL OPERATING CONDITION



C		11.79 ↓		+ 74.14
W_1	.0625 (.80)(1.25) ½	.03 ↓	.42	+ .01
U_1	.1250 (14.86)	1.86 ↑	7.43	- 13.82
U_2	.3125 (14.86) ½	2.32 ↑	4.95	- 11.48
	ΣV =	7.64 ↓		
P_{W1}	.4375 (7.0) ½	1.53 →	2.33	+ 3.56
P_{W2}	.1250 (2.0) ½	.13 ←	.67	- .09
	ΣH =	1.40 →	ΣM =	+ 52.32

$$\frac{\Sigma H}{\Sigma V} = \frac{1.40}{7.64} = 0.23 < 0.65 \quad \text{O.K.}$$

$$\frac{\Sigma M}{\Sigma V} = \frac{52.32}{7.64} = 6.85' > 4.95' < 9.91' \quad \text{O.K.} \qquad e = 7.43 - 6.85 = 0.58'$$

$$f = \frac{7.64}{14.86}\left(1 \pm \frac{6 \times 0.58}{14.86}\right) = 0.514\,(1 \pm 0.234)$$

f_{max} = 634 PSF

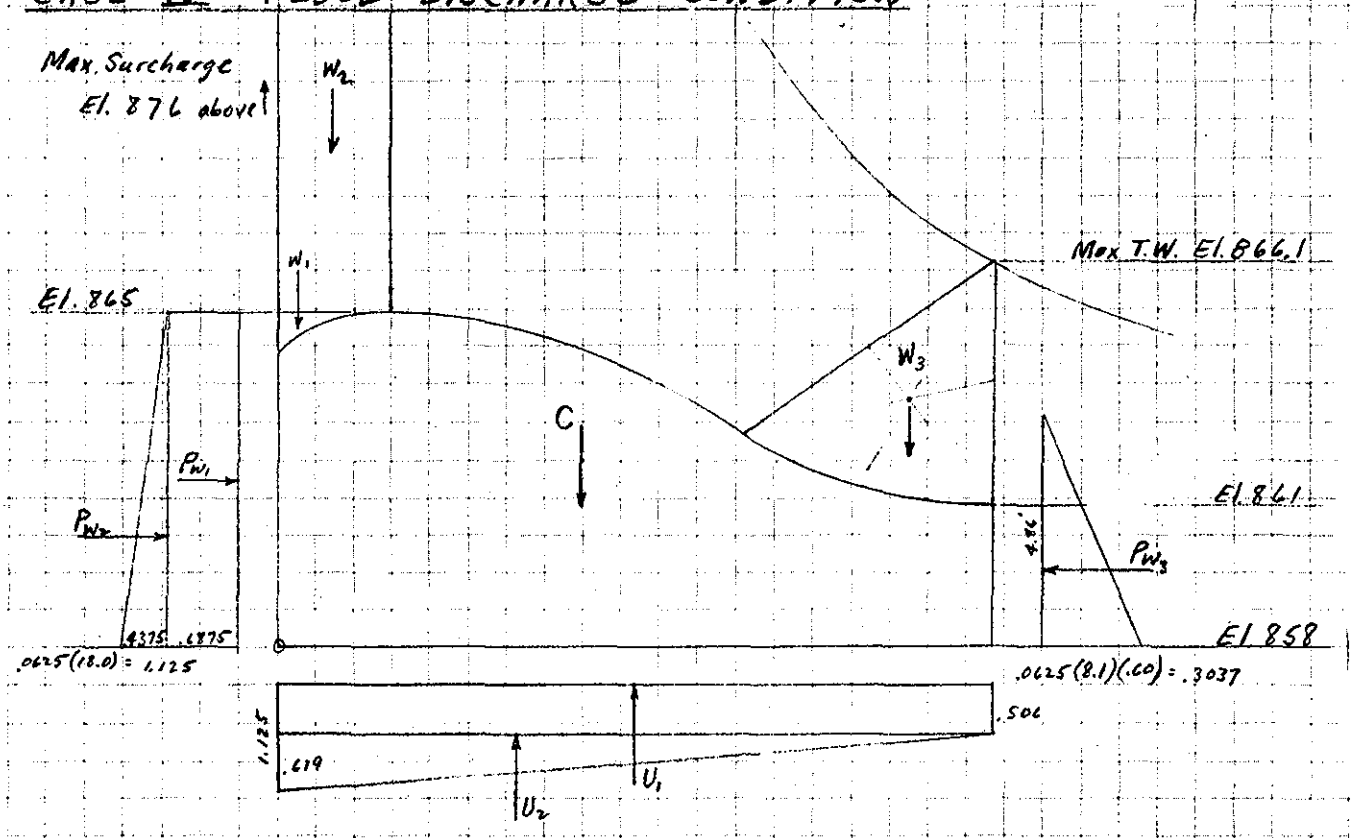
f_{min} = 394 PSF

NED FORM 223
27 Sept 49

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS

SUBJECT: East Branch Reservoir
COMPUTATION: Spillway Stability
COMPUTED BY: BFW CHECKED BY: RNW DATE: 8 Nov. 1961

CASE IV FLOOD DISCHARGE CONDITION



C		11.79	↓		+ 74.14
W_1		.03	↓		+ .01
W_2	.0625 (2.36)(11)	1.62	↓	1.18	+ 1.91
W_3	.0625 (5.15)(5.1) 1/2	.82	↓	13.2	+ 10.82
U_1	.506 (14.86)	7.52	↑	7.43	- 55.87
U_2	.619 (14.86) 1/2 (0.67)	3.08	↑	4.95	- 15.25
	ΣV	3.66	↓		
P_{W_1}	.6875 (7.0)	4.81	→	3.5	+ 16.84
P_{W_2}	.4375 (7.0) 1/2	1.53	→	2.33	+ 3.56
P_{W_3}	.3037 (4.86) 1/2	.74	←	1.62	- 1.20
	ΣH	5.60	→	ΣM	+ 34.96

$\frac{\Sigma H}{\Sigma V} = \frac{5.60}{3.66} = 1.53 > 0.65$ Check Shear-Friction F.S.

$\frac{\Sigma M}{\Sigma V} = \frac{34.96}{3.66} = 9.55'$ Within Mid 1/3 O.K. $e = 9.55 - 7.43 = 2.12'$ RT.

$f = \frac{3.66}{14.86}\left(1 \pm \frac{6 \times 2.12}{14.86}\right) = 0.246(1 \pm .856)$ $f_{max} = 457$ PSF @ TOE
$f_{min} = 35$ PSF @ HEEL

$S_{S-F} = \frac{0.65(3.66) + 1.0(.075)(14.86)(144)}{5.60} = 29.1 > 4.0$ O.K.

SUBJECT East Branch Reservoir
COMPUTATION Spillway Stability
COMPUTED BY BJW CHECKED BY R.N.W. DATE 8 Nov. 1961

CASE V CONSTRUCTION CONDITION WITH EARTHQUAKE

C		11.79 ↓		+ 74.14
P_{e_1}	0.05 (11.79)	.59 ←	2.85	− 1.68
			ΣM =	+ 72.46

$\frac{\Sigma M}{\Sigma V} = \frac{72.46}{11.79} = 6.15' > 4.95' < 9.91'$ o.k.

$e = 7.43 - 6.15 = 1.28'$

$f = 0.793\left(1 \pm \frac{6 \times 1.28}{14.86}\right) = 0.793(1 \pm .517)$ $f_{max} = 1203$ PSF
$f_{min} = 383$ PSF

CASE VI NORMAL OPERATING CONDITION WITH EARTHQUAKE

$C_e = \frac{51}{\sqrt{1 - 0.72\left(\frac{7}{1000 \times 1}\right)^2}} = \frac{51}{\sqrt{.99996472}} = \frac{51}{.9999} = 51$

$P_{e_2} = \frac{2}{3}(51)(.05)(5.0)\sqrt{(7)(5)}\left(\frac{1}{1000}\right) = 0.0503$ Mom. Arm $= \frac{2}{3}y + d = \frac{2}{3}(5) + 2 = 4.0'$

P_{e_1}		.59 →		+ 1.68
P_{e_2}		.05 →	4.0	+ .20
Σ CASE II		1.40 →		+ 52.32
		7.64 ↓		
	ΣV	7.64 ↓	ΣM	+ 54.20
	ΣH	2.04 →		

$\frac{\Sigma H}{\Sigma V} = \frac{2.04}{7.64} = 0.27 < 0.85$ o.k.

$\frac{\Sigma M}{\Sigma V} = \frac{54.20}{7.64} = 7.09'$ o.k. Within Mid 1/3

$e = 7.43 - 7.09 = 0.34'$

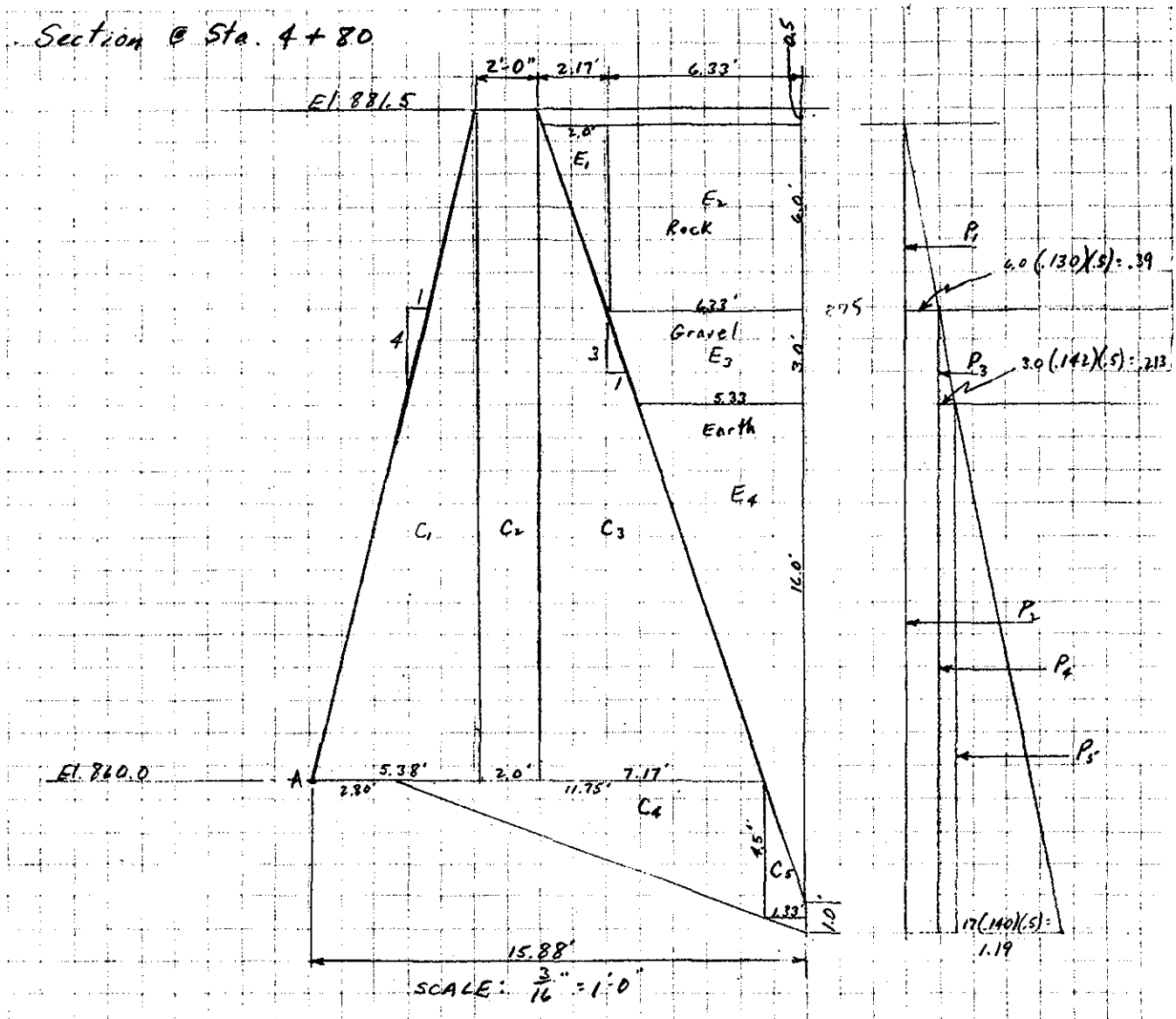
$f = 0.514\left(1 \pm \frac{6 \times 0.34}{14.86}\right) = 0.514(1 \pm .137)$

$f_{max} = 584$ PSF

$f_{min} = 444$ PSF

SUBJECT East Branch Reservoir
COMPUTATION Retaining Wall @ Spillway - East Wall
COMPUTED BY BJW CHECKED BY R.N.W. DATE 14 NOV. 1961

Section @ Sta. 4+80



LOADING CONDITION:-

Rapid drawdown, moist soil, no uplift

wts. of moist matls:-

Rock	130 PCF
Gravel	142
Earth	140

Earth Pressure : At rest K = 0.5

NED FORM 223
27 Sept 49

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS

SUBJECT: East Branch Reservoir
COMPUTATION: Retaining Wall @ Spillway - East Wall
COMPUTED BY: BJW CHECKED BY: RNW DATE: 17 Nov. 1961

		W	ARM	M
C_1	.150 (21.5)(5.38)(.5)	8.68	3.59	31.16
C_2	.150 (21.5)(2.0)	6.45	6.38	41.15
C_3	.150 (21.5)(7.17)(.5)	11.56	9.77	112.94
C_4	.150 (4.50)(11.75)(.5)	3.97	10.63	42.20
C_5	.150 (4.50)(1.33)(.5)	.45	14.99	7.98 6.73
E_1	.130 (6.0)(2.0)(.5)	.78	8.88	6.75
E_2	.130 (6.0)(6.33)	4.94	12.72	62.84
E_3	.142 (3.0)(5.83)	2.48	12.97	32.17
E_4	.140 (16.0)(5.33)(.5)	5.97	14.10	84.18
	ΣV	45.28		
P_1	.39 (6.0)(.5)	1.17	17.0	- 19.89
P_2	.39 (20.0)	7.80	5.0	- 39.0
P_3	.213 (3.0)(.5)	.32	13.0	- 4.16
P_4	.213 (17.0)	3.62	3.5	- 12.67
P_5	1.19 (17.0)(.5)	10.12	.67	- 6.78
	ΣH	23.03	ΣM	338.87

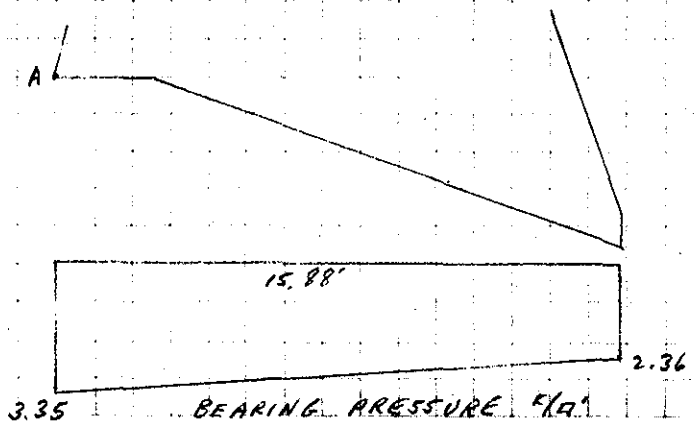
$\frac{\Sigma H}{\Sigma V} = \frac{23.03}{45.28} = .51$ O.K. Shape of base provides additional resistance to sliding

$\frac{\Sigma M}{\Sigma V} = \frac{338.87}{45.28} = 7.48'$ O.K. within Mid 1/3 $e = \frac{15.88}{2} - 7.48 = 0.46'$

$f = \frac{45.28}{15.88}\left(1 \pm \frac{6 \times 0.46}{15.88}\right) = 2.85(1 \pm .174)$

$f_{max} = 3.35$ K/□' @ Channel Side

$f_{min} = 2.36$ K/□' @ Land Side

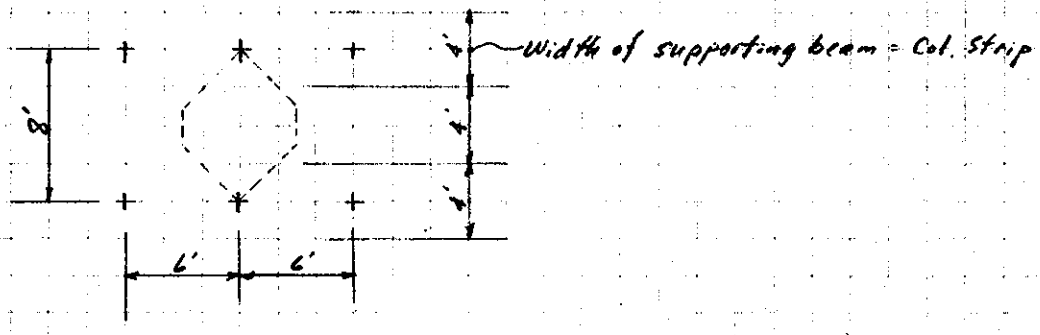


SUBJECT East Branch Reservoir
COMPUTATION Spillway Lining
COMPUTED BY BPW CHECKED BY R.N.W. DATE 28 Nov. 1961

Top of Lining El 876.0 Thickness of Lining 1'-0", d = 6"
Channel El. 859.45
Head = 16.55'

Due to drains reduce head 50% ∴ Max Head = .5 (16.55) = 8.28'

$w = 8.28\,(62.5) = 517$ PSF



Design as two-way slab $m = \frac{6.0}{8.0} = 0.75$

Long Span $M = C_w S^2$

Middle Strip (3' wide)
$-M = 0.033\,(517)(6.0)^2 = 614$ '#
$+M = 0.05\,(517)(6.0)^2 = 930$ '#

Supporting Beams - Assume width = col. strip = 4'-0"

Long Span Equiv. $w = \frac{wS}{3}\,\frac{(3-m^2)}{2}$

$= \frac{517\,(6.0)}{3}\,\frac{(3-\overline{0.75}^2)}{2} = 1260$ PLF

$-M = \frac{wl^2}{10} = \frac{1260\,(8.0)^2}{10} = 8070$ '# (Governs)

$d = \sqrt{\frac{8070 \times 12}{160 \times 48}} = \sqrt{12.6} = 3.54"$ O.K. $d_{turn} = 6.0"$

$A_s = \frac{8070\,(12)}{20{,}000\,(.885)(6.0)} = 0.91$ □" for 4' width

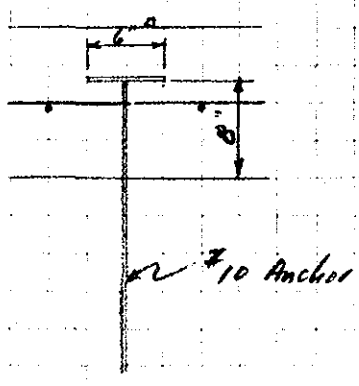
$= \frac{0.91}{4} = 0.23$ □"/' Use #5 @ 12" each way.

SUBJECT East Branch Reservoir
COMPUTATION Spillway Lining
COMPUTED BY BFW CHECKED BY RNW DATE 28 Nov. 1961

Anchors for Spillway Lining

Pull on Anchors = 517 (6.0)(8.0) = 24,800 #

$A = \frac{24,800}{20,000} = 1.24 \square''$ Use #10 Anchors $A_s = 1.27 \square''$



Check Punching Shear:-

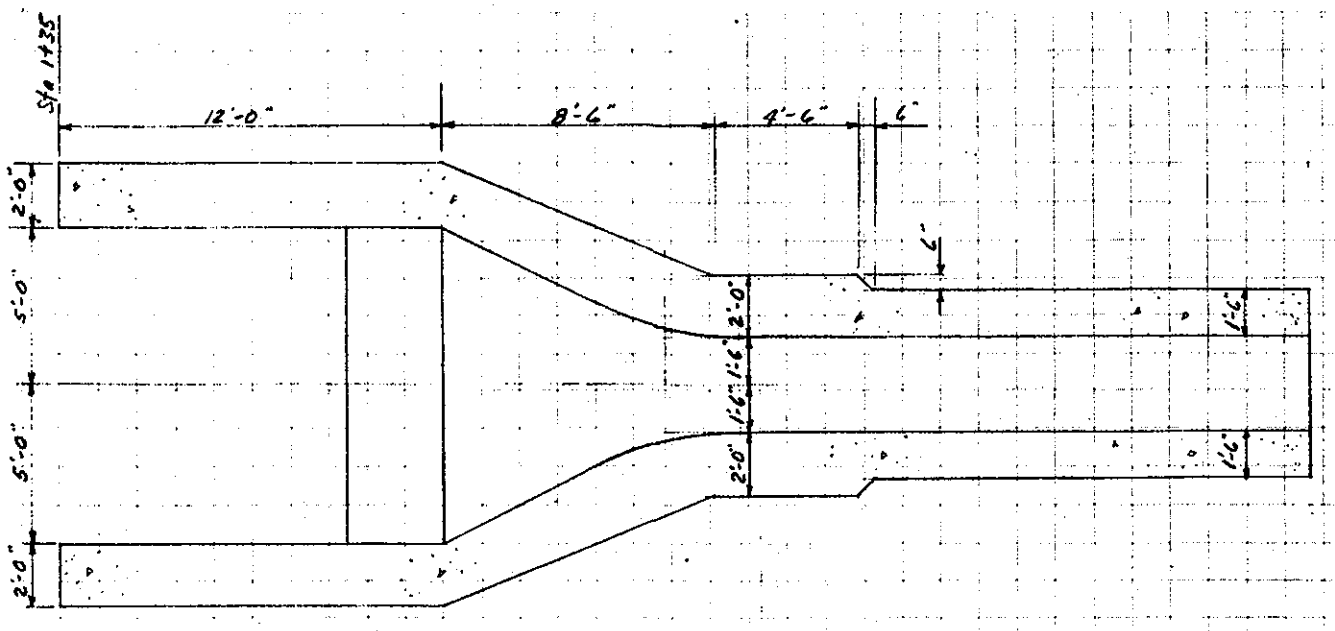
$v_T = \frac{V}{bKd} = \frac{24,800}{24(.344)(8.0)} = 376$ psi o.k.

Allowable $v_T = 0.2 f'_c = 0.2(3000) = 600$ psi

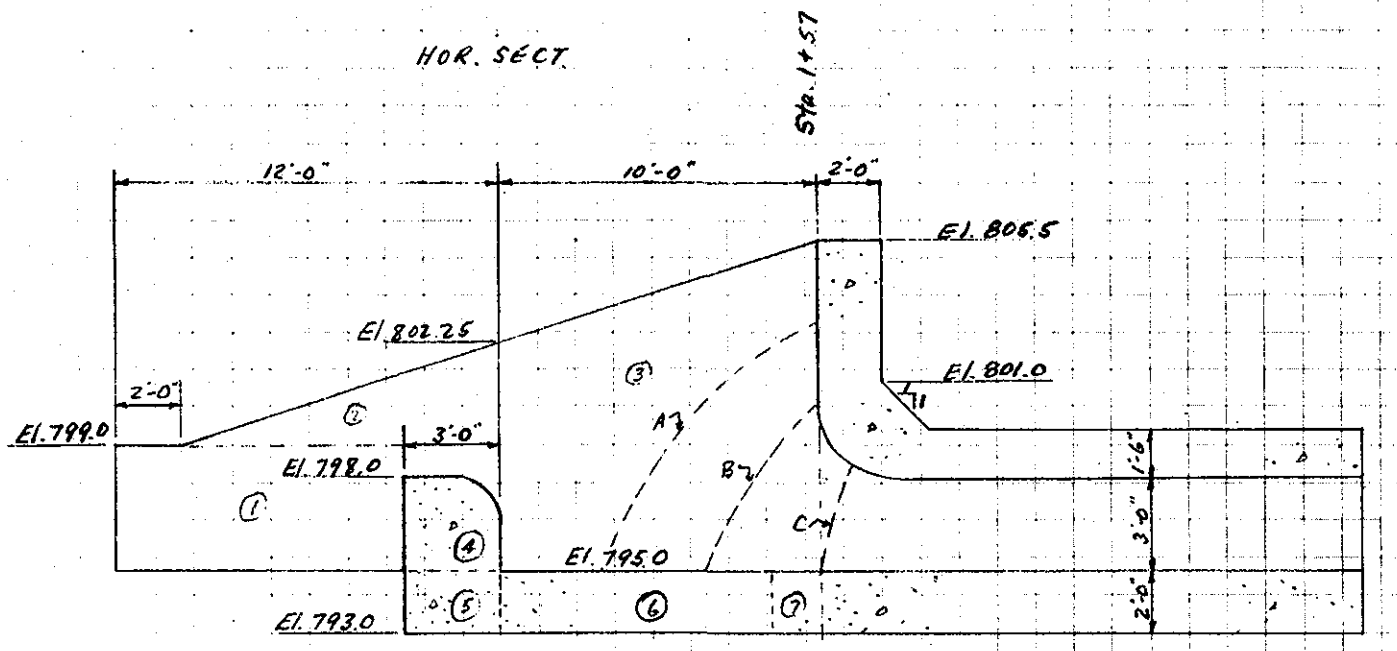
NED FORM 223
27 Sept 49

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS

SUBJECT East Branch
COMPUTATION Inlet Structure
COMPUTED BY RPW CHECKED BY R.N.W. DATE 19 Dec 1961



HOR. SECT.



VERT. SECT.

SCALE: 1" = 6'-0"

Spillway Crest		865.0
Press. Grad.	A	863.7
" "	B	862.6
" "	C	856.6

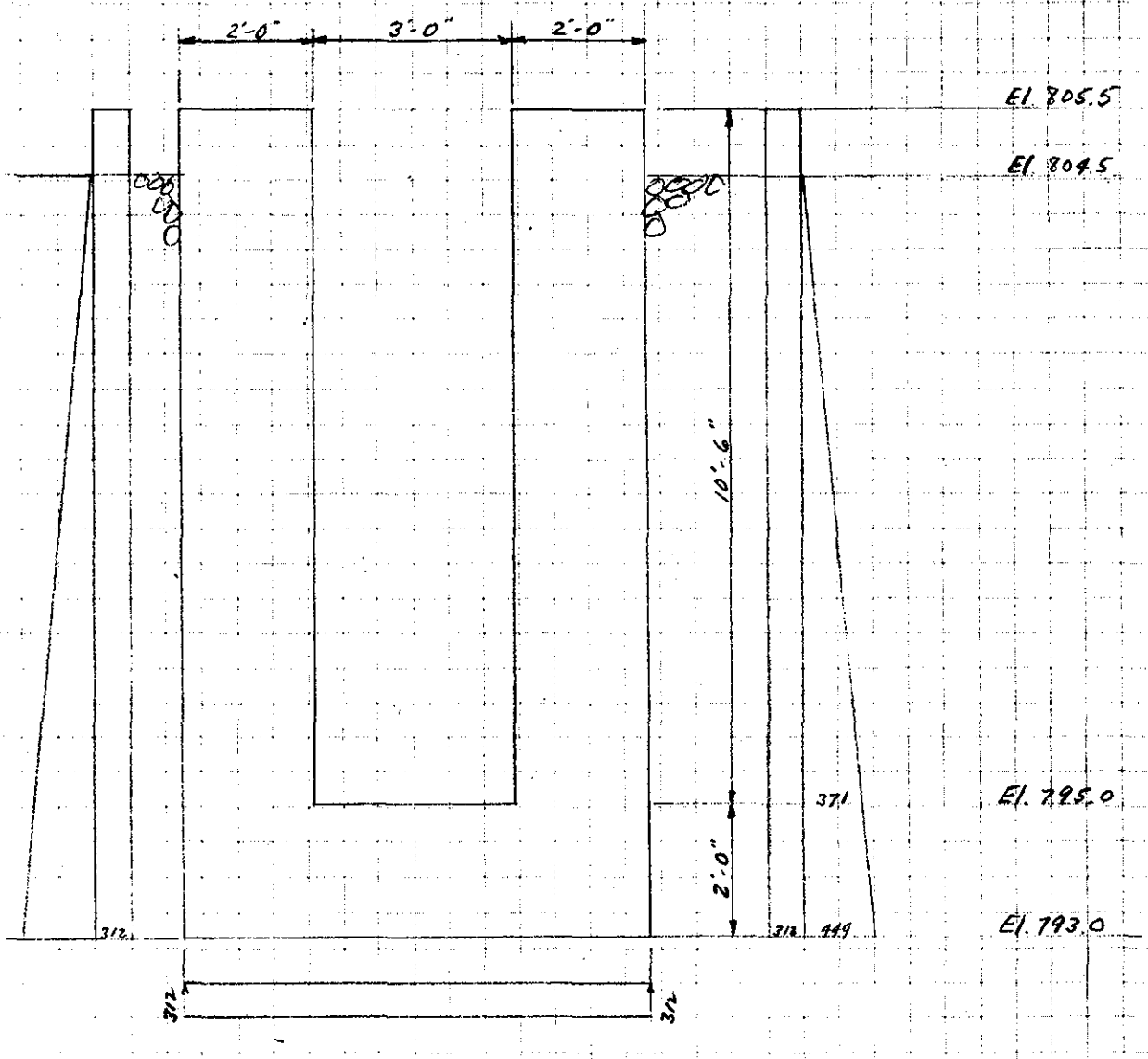
NED FORM 223
27 Sept 49

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS

SUBJECT East Branch
COMPUTATION Inlet Structure
COMPUTED BY BPW CHECKED BY RNW DATE 26 Dec 1961

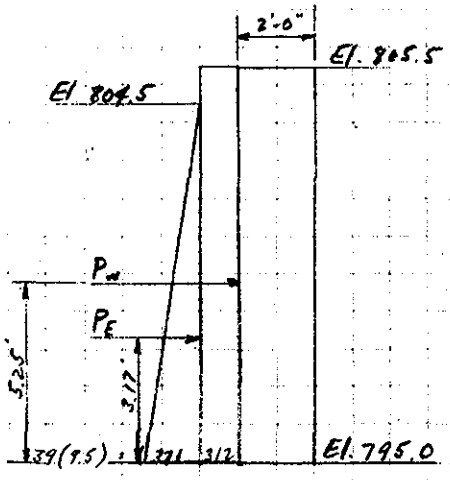
Assumption for Design: The pressure gradient curves indicate differentials in head of less than 5'. The structure will be designed for a 5' differential in head.

Section taken at Sta. 1+57



Lat. Press. for 5' Differential of Head = 5 x 62.5 = 312 #/□'
Equiv. Fl. Press. for $\delta_{sub.}$ = 0.5 (78) = 39 PCF

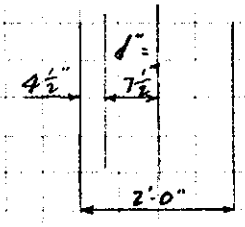
SUBJECT East Branch
COMPUTATION Inlet Structure
COMPUTED BY BFW CHECKED BY RNW DATE 26 Dec 1961



Sect. C Sta. 1+57

Design Wall as Cantilever off Base Slab

$N = .15(10.5)(2.0) = 3.15^k$



	Force	L.A.	Mast. Base
P_w .312 x 10.5	3.28	5.25'	17.2 'k
P_E .371 x 9.5 x ½	1.76	3.17	5.59
	5.04		22.79 'k

$M_s = 22.79 + \frac{7.5}{12}(3.15) = 24.76^{'k}$ (1.97)

$d = \sqrt{\frac{24760 \times 12}{160 \times 12}} = \sqrt{154.8} = 12.4''$ o.k. $d_{from} = 19.5''$

$A_s = \frac{24.76 \times 12}{20.0 \times .885 \times 19.5} - \frac{3.15}{20.0} = 0.86 - 0.16 = 0.70^{\square''}$

$v = \frac{5040}{12 \times .885 \times 19.5} = 24$ psi o.k.

Use #6 @ 7½" outside face

#6 @ 12" inside face

NED FORM 223
27 Sept 49

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS

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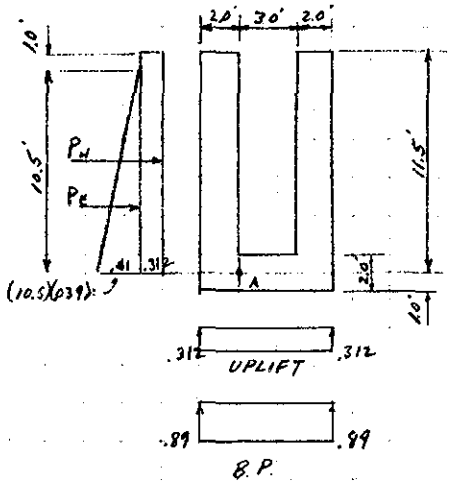
SUBJECT East Branch
COMPUTATION Inlet Structure
COMPUTED BY BJW CHECKED BY RNW DATE 26 Dec. 1961

Base Slab - Take Section at Inside Face of Wall



$$B.P. = \frac{.15\left[(10.5)(2.0)(2) + (2.0)(7.0)\right]}{7.0} - .312$$

$$= 1.20 - .31 = 0.89^{KLF}$$

			L.A.	M
.15(12.5)(2.0)	3.75 ↓		1.0'	-3.75 ^ik
.312(2.0)	.62 ↑		1.0	.62
.89 (2.0)	1.78 ↑		1.0	1.78
.312 (11.5)		3.59 →	5.75	20.6
.41 (10.5) ½		2.15 →	3.5	7.52
	1.35 ↓	5.74 →		26.77 ^ik

$$d = \sqrt{\frac{26{,}770 \times 12}{160 \times 12}} = \sqrt{167.2} = 12.9'' \quad \text{O.K.} \quad d_{furn} = 19.5''$$

$$A_s = \frac{26.77 \times 12}{20.0 \times .885 \times 19.5} = 0.93^{\square''} \qquad \text{Use } \#7 \text{ @ } 7\tfrac{1}{2}'' \text{ bot. slab}$$

$$\text{Max MC \& Top Slab} = \frac{1.20\,(5.0)^2}{8} = 3.75^{ik}$$

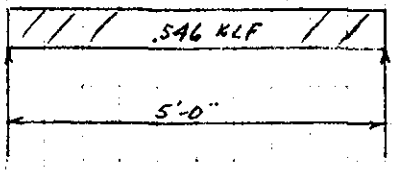
$$A_s = \frac{3.75 \times 12}{20.0 \times .885 \times 19.5} = 0.13^{\square''} \qquad \text{Use } \#6 \text{ @ } 12'' \text{ top slab}$$

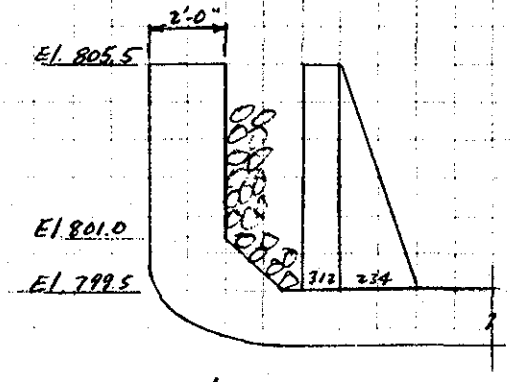
SUBJECT East Branch
COMPUTATION Inlet Structure
COMPUTED BY BPW CHECKED BY RNW DATE 27 Dec 1961

Vert. Wall @ Front of Intake Structure (Sta. 1+57)

Design as Beam Spanning Cantilevered Side Walls

5' Differential Head = 5(62.5) = 312 PSF





$M = \frac{wl^2}{8} = \frac{.546\,(5.0)^2}{8} = 1.71^{'k}$

Max. Load = 546 PSF

$A_s = \frac{1.71 \times 12}{20 \times .885 \times 19.5} = .06^{\square''}$ Use Min Steel #6 @ 12" each face

Trash Beams

Main Longit. Members @ 2'-6" o.c.

w for 5' Diff. Head = 5(62.5)(2.5) = 780 #/'

Member Fixed at Both Ends

$M = \frac{780\,(13.0)^2}{12} = 11{,}000^{'\#}$

$Z = \frac{11000 \times 12}{20{,}000} = 6.6\ in^3$ Use 6 I 12.5

Transverse Members @ 2'-0" o.c. w = 5(62.5)(2.0) = 625 #/'

$M = \frac{625\,(2.5)^2}{8} = 488^{'\#}$

$Z = \frac{488 \times 12}{20000} = 0.29\ in^3$ Use 4 [5.4

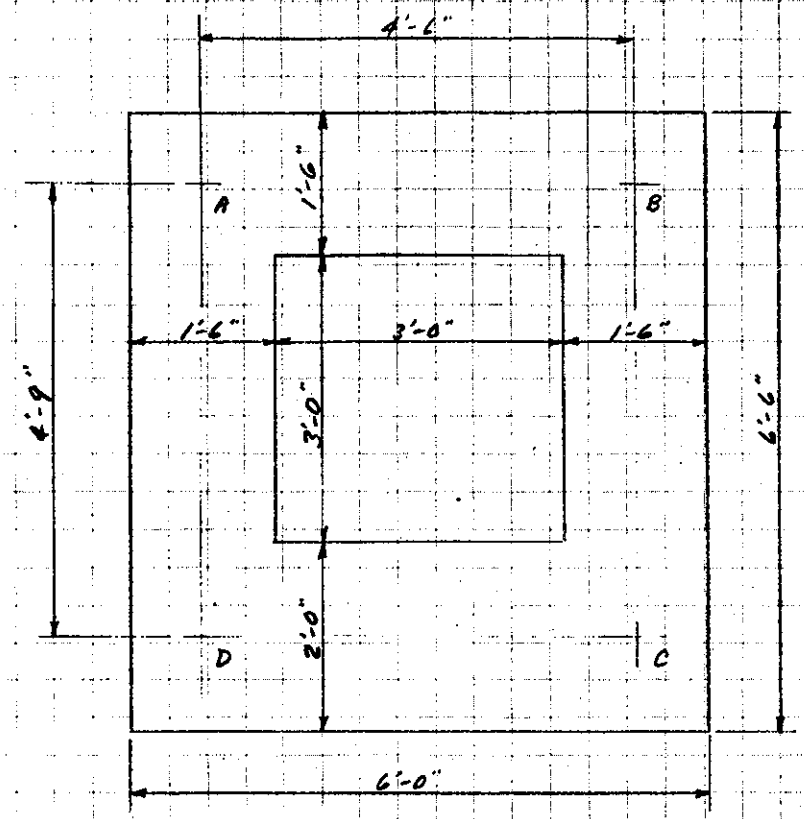
For Main Member $V = \frac{780 \times 13.0}{2} = 5070^{\#}$

Using 6 I 12.5 $v = \frac{5070}{6 \times 1/4} = 3380$ psi O.K.

NED FORM 223
27 Sept 49

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS

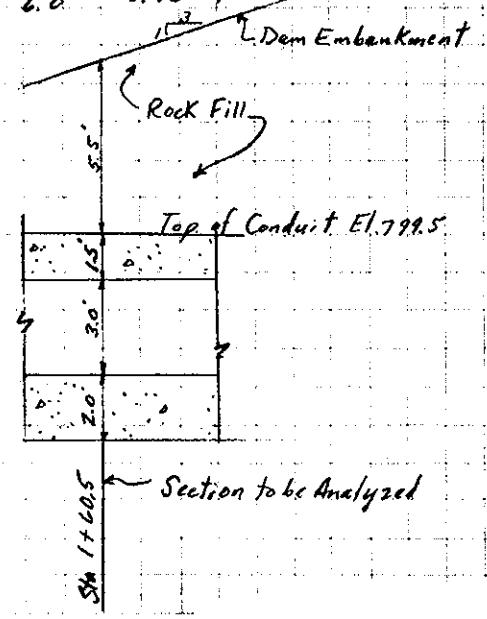
SUBJECT: East Branch
COMPUTATION: Conduit Transition Section
COMPUTED BY: BHW CHECKED BY: R.A.W. DATE: 20 Dec 1961



Area = (6.0)(6.5) - 3.0 = 30.0 □'

Wt. of concrete = .15 (30.0) = 4.5 k for 1' section

$\frac{4.5}{6.0}$ = 0.75 k/LF



Load Factors: - Vert. 1.0 Hor. 0.5

Loading: - Top of Rock Fill El. 805.0
" " Conduit El. 799.5
5.5'

CASE I Rapid drawdown from spillway crest El. 865.0
Vert. Load = (1.0)(140)(5.5) = 770 PSF
Hor. " = (0.5)(140)(5.5) = 385 PSF

CASE II Water at spillway crest El. 865.0
Vert. Load = (1.0)(78)(5.5) + (62.5)(15.5) = 4523 PSF
Hor. " = (0.5)(78)(5.5) + (62.5)(15.5) = 4309 PSF

Design for CASE II

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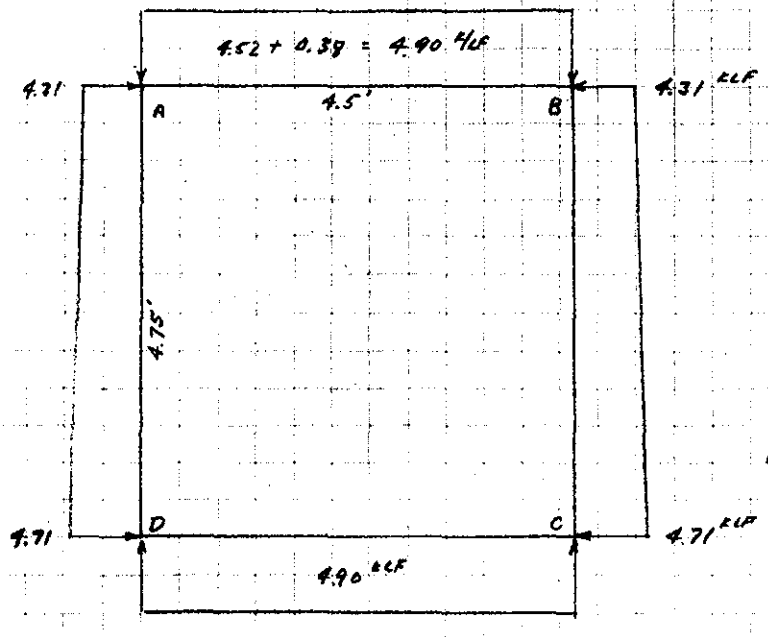
Addit. Hor. Load at Bot. of Sect. = 6.5 (62.5) = 406 PSF

406 PSF
4309
Tot = 4715 PSF



FEM:-

$M^F_{AB} = \frac{1}{12}(4.90)(4.5)^2 = 8.26^{1k}$

$M^F_{BC} = \frac{1}{12}(\overset{8.1}{4.31})(4.75)^2 + \frac{1}{15}(\overset{.30}{0.40})(4.75)^2(\frac{1}{2}) = 8.40^{1k}$

$M^F_{CB} = \frac{1}{12}(\overset{8.1}{4.31})(4.75)^2 + \frac{1}{10}(\overset{.45}{0.40})(4.75)^2(\frac{1}{2}) = 8.55^{1k}$

Stiffness Factors:-

$K_{AB} = \frac{1.5^3}{4.5} = 0.75$

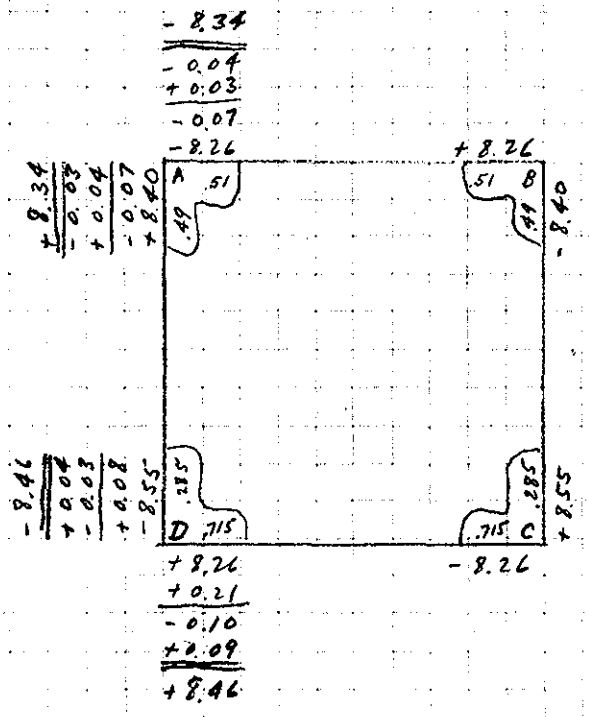
$K_{AD} = \frac{1.5^3}{4.75} = 0.71$

$K_{DC} = \frac{2.0^3}{4.5} = 1.78$

Dist. Factors:-

Jt A AB $\frac{0.75}{1.46} = .51$
AD $\frac{0.71}{1.46} = .49$

Jt D DA $\frac{0.71}{2.49} = .285$
DC $\frac{1.78}{2.49} = .715$



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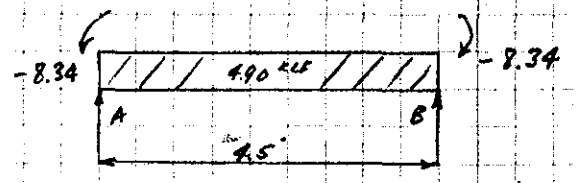
Member A-B



$R_A = R_B = \frac{490(4.5)}{2} = 11.0^k$

$+M = \frac{490(4.5)^2}{8} - 8.34 = 12.4 - 8.34 = 4.06^{'k}$

$+A_s = \frac{4.06 \times 12}{20.0 \times .866 \times 13.5} = 0.21''$ Use #6 @ 1'-0"

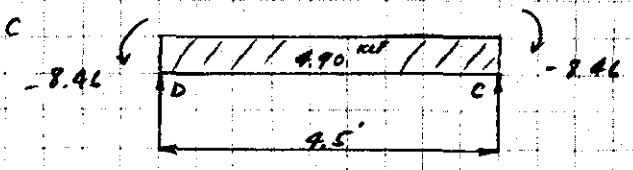
$-A_s = \frac{8.34 \times 12}{20.0 \times .866 \times 13.5} = 0.43''$ Use #6 @ 1'-0"

$v = \frac{11000}{12 \times .866 \times 13.5} = 78$ psi < 90 O.K.

V at Face Col $= \frac{1.50}{2.25}(11.0) = 7.34^k$

$u = \frac{7340}{2.4 \times .866 \times 13.5} = 261$ psi

Member D-C



$+M = 12.4 - 8.46 = 3.94^{'k}$

$+A_s = \frac{3.94 \times 12}{20.0 \times .866 \times 19.5} = 0.14''$ Use #6 @ 1'-0"

$-A_s = \frac{8.46 \times 12}{20.0 \times .866 \times 19.5} = 0.30''$ Use #6 @ 1'-0"

$u = \frac{7340}{2.4 \times .866 \times 19.5} = 181$ psi

Vert. Members A-D & B-C :- By inspection - use min. steel #6 @ 1'-0"

NED FORM 223
27 Sept 49

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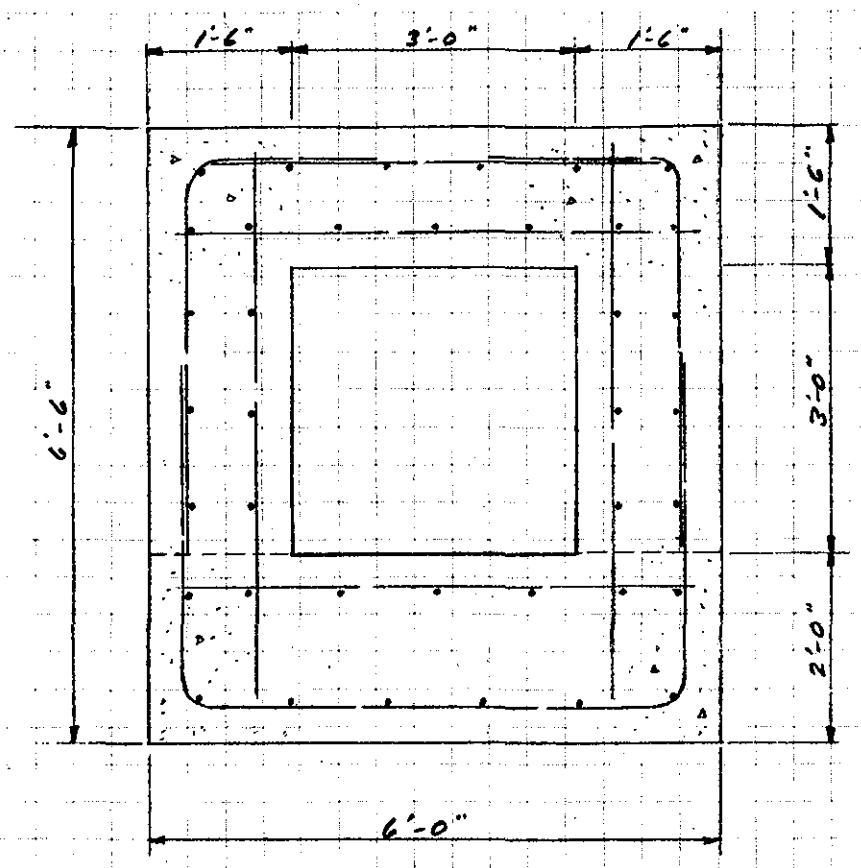

REINF. STEEL

SCALE: ½" = 1'-0"

Note: all reinf. #6 @ 1'-0"