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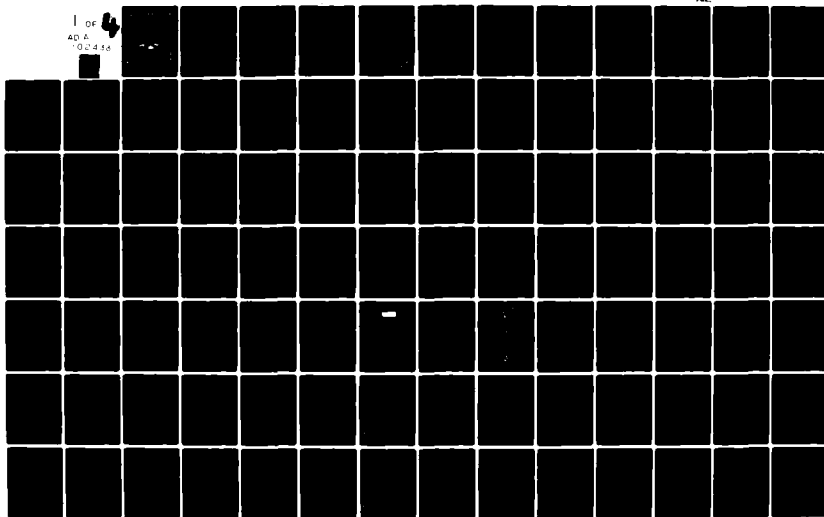
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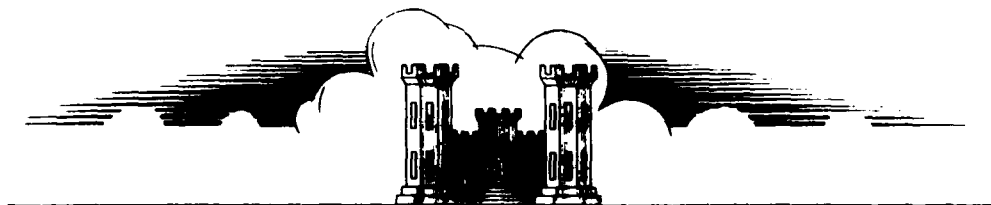
BIG CREEK FLOOD CONTROL PROJECT

CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D
DESIGN ANALYSIS

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Prepared by
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

Consulting Engineers

Harrisburg, Pennsylvania

For

U.S. ARMY ENGINEER DISTRICT, BUFFALO

Corps of Engineers

Buffalo, New York 14207

AUGUST 1979

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The purpose of this appendix is to present the design criteria procedures, and calculations associated with the design of the principal features of the Big Creek Flood Control Project. Preequissites to this appendix are appendix A: Soil, Geology, and Construction Materials; Appendix B; Alternative Studies; and Appendix C: Hydrology and Hydraulics. The results of the subsurface exploration program presented in Appendix A, established the general adequacy of the site for the flood control project. The field and laboratory testing		

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program determined the various engineering properties of the project soils and borrow material required for the design analysis. In appendix B, various alternatives for the principal features of the project were studied, and an alternative was selected for final design. The water surface profile presented in Appendix C was used for setting the tops of the various containment structures, and the channel velocities presented in Appendix C were used for sizing riprap and gabion protection.

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CLEVELAND, OHIO

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DESIGN ANALYSIS

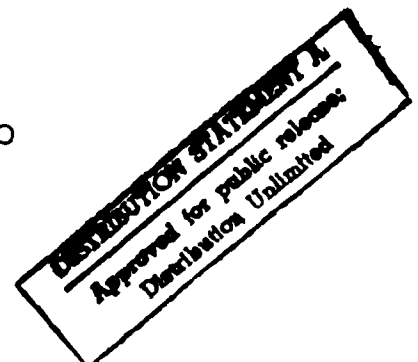
Prepared by

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
Consulting Engineers
Harrisburg, Pennsylvania 17105

For

U.S. ARMY ENGINEER DISTRICT, BUFFALO
Corps of Engineers
Buffalo, New York 14207

AUGUST 1979



BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
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DESIGN ANALYSIS

AUGUST 1979

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BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D

DESIGN ANALYSIS

SECTION A

INTRODUCTION

D1. Purpose. The purpose of this Appendix is to present the design criteria, procedures, and calculations associated with the design of the principal features of the Big Creek Flood Control Project.

D2. Previous Studies. Prerequisites to this Appendix are Appendix A: Soil, Geology, and Construction Materials; Appendix B: Alternative studies; and Appendix C: Hydrology and Hydraulics. The results of the sub-surface exploration program, presented in Appendix A, established the general adequacy of the site for the flood control project. The field and laboratory testing program determined the various engineering properties of the project soils and borrow material required for the design analysis. In Appendix B, various alternatives for the principal features of the project were studied, and an alternative was selected for final design. The water surface profile presented in Appendix C was used for setting the tops of the various containment structures, and the channel velocities presented in Appendix C were used for sizing riprap and gabion protection.

SECTION B
STRUCTURAL DESIGN

D3. General. This Section presents the basic data, design criteria, assumptions and loading conditions used in designing the various structures of the Big Creek Flood Control Project. Design computations for the hydraulic structures are presented in Subappendix D1. Design computations for the relocated Baltimore and Ohio Railroad mainline bridge, the Baltimore and Ohio Railroad spurline bridge, and the temporary trestle for the Norfolk and Western Railroad are presented in Subappendix D2.

D4. Design Criteria. Design stresses, design criteria, loading conditions, assumptions and methods were based on applicable Corps of Engineers' engineering and design manuals or on industry codes, supplemented where necessary by conservative judgment and experience. Publications used in establishing design criteria include the following:

Manuals - Corps of Engineers

- (1) EM 1110-2-2000, 1 November 1971, "Standard Practice of Concrete".
- (2) EM 1110-2-2101, 1 November 1963, "Working Stress for Structural Design".
- (3) EM 1110-2-2103, 21 May 1971, "Details of Reinforcement-Hydraulic Structures".
- (4) EM 1110-2-2400, 2 November 1964, "Structural Design of Spillway and Outlet Works".
- (5) EM 1110-2-2501, 18 June 1962, "Floodwalls".
- (6) EM 1110-2-2502, 29 May 1961, "Retaining Walls".

Engineering Technical Letters-Corps of Engineers

- (1) ETL 1110-2-184, 25 February 1974, "Gravity Dam Design-Stability".
- (2) ETL 1110-2-236, 30 June 1978, "Design Criteria-Paved Concrete Flood Control Channels".

Other Publications

- (1) ACI Building Code (ACI 318-77).
- (2) ACI Design Handbook (ACI SP-3).
- (3) ACI Design Handbook (ACI SP-17-73).
- (4) AISC Manual of Steel Construction, 1970, with supplement dated September 1978.
- (5) Manual for Railway Engineering, American Railway Engineering Association, 1975.
- (6) Stresses in Framed Structures, Hool and Kinne, 1942, McGraw Hill.
- (7) Standard Specifications for Highway Bridges, American Association of State Highway and Transportation Officials, 1977 and 1978 Interim.
- (8) Structural Welding Code, D1, 1-75 including Revision 1-76 and Revision 2-77, American Welding Society.

D5. Concrete. The reinforced concrete hydraulic structures were designed with working stresses given in the ACI Building Code and based on an ultimate compressive strength (f'_c) of 3,000 psi at 28 days. Working stress modifications for hydraulic structures are in accordance with EM 1110-2-2101. Reinforced concrete railroad structures were designed with working stresses given in the AREA Manual and based on an ultimate compressive strength (f'_c) of 3,000 psi at 28 days.

D6. Concrete Working Stresses. The following table lists the concrete and reinforced concrete working stresses used in design.

<u>Concrete Working Stresses</u> <u>Hydraulic Structures</u>		<u>Working Stress</u> <u>(psi)</u>
<u>Compressive Stress (f'_c)</u> $f'_c = 3,000$ psi		
<u>Flexure (f_c)</u>		
Extreme fiber stress in compression, $0.35 f'_c$ _____		1,050
Extreme fiber stress in tension (plain concrete for footings, walls, and on downstream toe of spillway weir, but not for other portions of gravity sections) $1.2 \sqrt{f'_c}$ _____		66
Extreme fiber stress in tension (for other portions of gravity sections, where permitted by pertinent engineering manual) $0.6 \sqrt{f'_c}$ _____		33
<u>Shear (v)</u> (As a measure of diagonal tension at a distance "d" from the face of the support).		
Beams with no web reinforcement, $1.1 \sqrt{f'_c}$ _____		60
Members with vertical or inclined web rein- forcement or properly combined bent bars and vertical stirrups, $5.5 \sqrt{f'_c}$ _____		300
Slabs and footings, $2 \sqrt{f'_c}$ _____		110
<u>Bond (u)</u>		
With "D" equal to the nominal bar diameter in inches, the bond stress shall not exceed the following:		
For tension bars with size and de- formation conforming to ASTM A 615, A 617:		

$$\begin{array}{ll} \text{Top Bars} & \frac{3.4 \sqrt{f'_c}}{D}, \text{ 350 Max.} \\ \text{Bars other than top bars} & \frac{4.8 \sqrt{f'_c}}{D}, \text{ 500 Max.} \end{array}$$

Bearing (f_c)

$$\begin{array}{ll} \text{On full area, } 0.25 f'_c & 750 \\ \text{On one-third area or less, } 0.375 f'_c & 1,125 \end{array}$$

When the loaded area is greater than one-third but less than the full area, the bearing stress will be interpolated between the values given.

Modular Ratio (n)

$$n = 9.2$$

Concrete Working Stresses
Railroad Structures
(AREA)

Working Stress
(psi)

Compressive Stress (f'_c)

$$f'_c = 3,000 \text{ psi}$$

Flexure (f_c)

$$\begin{array}{ll} \text{Extreme fiber stress in compression,} & \\ 0.45 f'_c & 1,350 \end{array}$$

Shear (v) (As a measure of diagonal tension at a distance "d" from the face of the support).

$$\begin{array}{ll} \text{Slabs and footings (peripheral shear,} & \\ \text{Sec. F, Art. 8) } 2 \sqrt{f'_c} & 110 \end{array}$$

Bond (u)

(1) Tension bars No. 3 - No. 11 with deformations conforming to ASTM A 615, A 617 ("D" is the nominal diameter of bar, inches):

$$\begin{array}{ll} \text{Top Bars} & \frac{3.4 \sqrt{f'_c}}{D}, \text{ 350 Max.} \end{array}$$

Top bars in reference to bond are horizontal bars so placed that more than 12 inches of concrete is cast in the member below the bar.

$$\begin{array}{ll} \text{Bars other than top bars} & \frac{4.8 \sqrt{f'_c}}{D}, \text{ 500 Max.} \end{array}$$

- (2) All compression bars with deformations conforming to ASTM A 615, A 617 _____ $6.5 \sqrt{f'_c}$, 400 Max.

Bearing (f_c)

Full area loaded, $0.25 f'_c$ _____ $\frac{D}{750}$

Modular Ratio (n)

The ratio of the modulus of elasticity of steel to that of concrete, E_s/E_c , equals "n" and shall be based upon the compressive strength of the concrete as follows:

For f'_c (psi) between 3,000 and 3,999 _____ $n = 10$

D7. Reinforcing Steel. All reinforcing steel bars for both the hydraulic structures and the railroad structures were designed for the working stresses of new billet steel, intermediate grade, deformed bars conforming to ASTM A 615 or A 617, Grade 40. Working stresses for hydraulic structures are in accordance with the requirements of the ACI Building Code, except as modified in EM 1110-2-2101. The flexural (f_s) working stress, with or without axial loads, is 20,000 psi for both the hydraulic structures and the railroad structures.

D8. Minimum embedment lengths and splice lengths for the hydraulic structures conform to ACI 318-77 and EM 1110-2-2103. Minimum embedment lengths and splice lengths for the railroad structures conform to the AREA Manual. Splices at points of maximum moments were avoided and, where possible, were staggered in adjacent bars. When the structural analysis indicated that bending and direct stress exists under the critical loading, reinforcing steel, if required, was computed for both bending moment and axial load.

D9. Temperature and shrinkage reinforcement for the hydraulic structures was in accordance with the applicable requirements of ACI 318-77, EM 1110-2-2103, and EM 1110-2-2400. Temperature and shrinkage reinforcement for the railroad structures was in accordance with the AREA Manual.

D10. Structural Steel. Structural steel was designed for ASTM A36, $F_y = 36,000$ psi. Bolted connections were designed for ASTM A325, H.S. Bolts.

D11. Basic Data and Assumptions. The following basic data and assumptions were used in design of the hydraulic structures:

(1) Dead loads (pounds per cubic foot).

compacted backfill, saturated _____	125
compacted backfill, moist _____	125
compacted backfill, submerged _____	62.5
concrete, plain and reinforced _____	150

- (2) Live loads.

water (pounds per cubic foot)	62.5
wind (pounds per square foot)	30.0
live load surcharge - equivalent to 2 feet of soil	
- (3) Water pressure.
Hydrostatic pressure as in submerged fill and free water, were applied to structures by conventional pressure distribution. Uplift pressures are treated in subsequent paragraphs where loading conditions are given.
- (4) Earth pressures.
Vertical earth loads were given unit weight in accordance with assigned loading conditions. In general, lateral earth pressures were determined in accordance with Corps of Engineers' manual EM 1110-2-2502.
- (5) Frost protection.
A minimum protective earth cover of 4 feet was used for frost protection.

D12. Joints in Concrete Construction. Joints in concrete construction will be provided as follows:

- (1) Horizontal and vertical contraction joints.
The concrete elements of the various structures will be separated by contraction joints to relieve restraint and minimize the development of cracks. Reinforcement will not extend across the joints, and concrete bond will be broken by the application of a bituminous coating. Rubber or polyvinyl-chloride waterstops will be used in contraction joints to prevent water flow and subsequent damage. For concrete structures that function similar to floodwalls and have a design water surface that is higher than the adjacent existing ground surface, waterstops will be used in horizontal and vertical contraction joints to prevent water flow from the channel side to the land side of the structure. For concrete structures that will act solely as retaining structures, waterstops will be used in vertical contraction joints to prevent piping of backfill material through the contraction joints. Waterstops will not be used in horizontal contraction joints of concrete structures founded on rock.
- (2) Horizontal and vertical construction joints.
These joints will be located to facilitate construction procedure and minimize shrinkage cracks. The reinforcement will be continuous through the construction joint.
- (3) Expansion joints.
Expansion joints will be provided for volume change of the concrete, prevention of spalling, and prevention of

serious effects from cracking. A premolded 1/2-inch joint filler will be installed in the joints.

D13. Railroad Bridges and Temporary Trestle. The Baltimore and Ohio Railroad mainline and spurline bridges and the temporary trestle for the Norfolk and Western Railroad were designed in accordance with the American Railway Engineering Association (AREA) Manual for Railway Engineering, Chapter 8 - Concrete Structures and Foundations and Chapter 15 - Steel Structures.

D14. The superstructures were designed for loads and forces as shown in AREA Chapter 15 with recommended live load Cooper E80 with diesel impact. AREA recommends Cooper E80 loading for steel structures (Page 15-1-6). Structural steel was designed for ASTM A36, Fy 36,000 psi. Bolted connections were designed for ASTM A325, H.S. Bolts. Fatigue design was in accordance with American Welding Society (AWS) Structural Welding Code D1.1, Revision 2-77. All welding was designed in accordance with AREA and AWS criteria.

D15. The substructures were designed for loads and forces as shown in AREA Chapter 8 with recommended live load Cooper E72 without impact. AREA recommends Cooper E72 loading for concrete structures (Page 8-2-3). Ice and stream flow loads were in accordance with the American Association of State Highway and Transportation Officials Standard Specifications for Highway Bridges, 1978 Interim. Abutments and wings were designed as semi-gravity type founded on rock with an allowable foundation pressure of 10 kips per square foot. Structural backfill shall be AREA Type 1 granular backfill.

D16. The temporary trestle was designed for the same loads and forces as the superstructures. Structural steel, bolted connections, and welding design were the same as for the superstructures. Piles were designed for HP12 x 74, ASTM A36, with maximum allowable design pile load equal to 100 tons based on 9,000 psi point pressure.

D17. Concrete Chute-Transition At Upstream End of Project. The chute-transition at the upstream end of the project was designed as two reinforced concrete L-walls with a reinforced concrete slab between. The same design was used for both the section of the zoo access road immediately adjacent to the chute-transition and for the section of road leading to the Brookside Park Drive underpass that is immediately adjacent to the chute-transition. Reinforced concrete keys will be provided at both the upstream and downstream ends of the chute-transition. There is no specific design requirement for these keys; however, based on engineering judgment it is felt that for a hydraulic structure of this type keys are desirable. The key at the upstream end of the structure will reduce underseepage, and it will lessen the possibility of undermining of the slab if erosion of the upstream soil occurs. The key at the downstream end of the structure will reduce underseepage, and it will help in preventing the underdrainage system from being overtaxed. A drainage system will be provided behind the walls, and a subdrainage system will be provided for the slabs. Design computations are presented in Subappendix D1.

D18. The L-walls were designed as retaining walls except for about a 50-foot reach at the right bank near the downstream end of the two-barrel conduit. Along this reach, the chute-transition will be close to the end of the two-barrel conduit, and the amount of backfill that can be placed is limited. The lowest point of the top of backfill is at about the chute-transition grade. This reach of wall was designed as a floodwall. The sudden drawdown condition was used for the retaining wall design. The design flood condition was used for the floodwall design. Loading conditions are as follows:

Case I - Sudden Drawdown Condition

- (a) Chute-transition empty.
- (b) Backfill at maximum elevation (6 inches below top of wall).
- (c) Backfill submerged to an elevation midway between the design water surface and bottom of slab (corresponds to the assumption of a 50 percent effective wall drainage system).
- (d) Backfill above the level of submergence naturally drained.
- (e) Lateral earth pressure from backfill based on an active pressure coefficient ($K_a = 0.33$).
- (f) Uplift across the base varies uniformly from reduced hydrostatic head at heel to 3-foot hydrostatic head at inside face of wall. Uniform 3-foot hydrostatic head from inside face of wall to toe of wall.

Case II - Design Flood Condition.

- (a) Water surface at design elevation.
- (b) Backfill at minimum elevation.
- (c) Backfill naturally drained.
- (d) Uplift varying uniformly across the base.

D19. Stability criteria for the L-walls is as follows:

- (1) Resultant shall be within the middle third of the base.
- (2) Sliding Factor $\Sigma H / \Sigma V$ shall not exceed 0.60.
- (3) Maximum foundation pressure shall not exceed 2 kips per square foot.

D20. The slab between the walls was designed with consideration given to its dual purpose. It will be used as both a floodway channel and a roadway. Although a subdrainage system will be provided, it is not assumed to be 100 percent effective. The slab at the downstream end of the chute-transition will have a zero percent slope. A head will have to develop in the subdrainage system in order to drain subsurface water. The slab was designed to resist a uniform uplift equal to a 3-foot hydrostatic head. The slab design and subdrainage system is presented in Subappendix D1.

D21. Concrete Transition at End of Three-Barrel Conduit. The transition at the end of the three-barrel conduit was designed as two reinforced concrete L-walls with a reinforced concrete slab between. The upstream end

of the transition will tie into the existing slab and wingwalls. A reinforced concrete key will be provided at the downstream end of the transition. A drainage system will be provided behind the walls; and weep holes, drilled 10 feet into rock, will be provided in the bases of the L-walls and in the middle slab. The drainage system is needed to reduce hydrostatic pressures that are expected to develop from the sudden drawdown condition. The 10-foot depth of the weep holes is based on engineering judgment. For similar hydraulic structures on other projects, this depth has been used for weep holes in rock. Design computations are presented in Sub-appendix D1.

D22. The L-shaped walls were designed for the sudden drawdown condition. Loading conditions are as follows:

Sudden Drawdown Condition.

- (a) Water in the transition at channel grade.
- (b) Backfill 6 inches below top of wall.
- (c) Backfill submerged to an elevation midway between the design water surface and channel grade (corresponds to the assumption of a 50 percent effective drainage system).
- (d) Backfill above the level of submergence naturally drained.
- (e) Lateral earth pressure from backfill based on an at-rest pressure coefficient ($K_r = 0.60$).
- (f) Uplift uniform across the base (pressure equal to reduced hydrostatic head in backfill).

D23. Since the L-walls will be founded on rock, an at-rest earth pressure coefficient was used. In accordance with EM 1110-2-2502, Paragraph 4e, when using at-rest pressures, resultants located outside the middle third are acceptable, provided that maximum foundation pressures are within safe values. The stability criteria is as follows:

- (1) Resultant shall be within the middle half of the base.
- (2) Shear-friction factor of safety shall not be less than 4.
- (3) Maximum foundation pressure shall not exceed 10 kips per square foot.

D24. The slab between the L-walls was designed to resist a uniform uplift based on the head from the sudden drawdown condition. This corresponds to the assumption of a 50 percent effective drainage system. Anchor bars will be provided as required to ensure stability of the slab.

D25. Concrete Flume and Retaining Walls at West 25th Street Bridge. The flume at the upstream end of the diversion channel was designed as a reinforced concrete U-frame. A reinforced concrete key will be provided at the downstream end of the flume. A drainage system will be provided behind the walls; and weep holes, drilled 10 feet into rock, will be provided in the slab. The right side of the flume that is adjacent to the West 25th Street bridge pier will require a special bracing system to resist surcharge loading from the bridge pier. The bracing system will consist of pre-cast

reinforced concrete lagging, vertical structural steel beams, and structural steel struts. The bracing system will become an integral part of flume. The flume was checked for stability against flotation, and it was found to be adequate. Design computations are presented in Subappendix D1.

D26. The flume was designed for the following loading condition:

Sudden Drawdown Condition

- (a) Flume empty.
- (b) Backfill 6 inches below top of wall.
- (c) Backfill submerged to elevation midway between the design water surface and flume grade (corresponding to the assumption of 50 percent effective drainage system).
- (d) Backfill above level of submergence naturally drained.
- (e) Lateral earth pressure from backfill based on an at-rest pressure coefficient ($K_r = 0.60$).
- (f) Uniform uplift across the base (pressure equal to the reduced head in the backfill).
- (g) Surcharge loading from Bridge Pier No. 14 where required.

D27. At the upstream end of the flume, the wingwalls at the right bank and the wall between the flume and the new Baltimore and Ohio Railroad mainline bridge abutment were designed as reinforced concrete T-walls. Reinforced concrete keys will be provided at the toes of the walls. A drainage system will be provided behind the walls. Design computations are presented in Subappendix D1.

D28. The T-walls were designed for the following loading condition:

Sudden Drawdown Condition

- (a) Channel empty.
- (b) Backfill 6 inches below top of wall.
- (c) Backfill submerged to elevation midway between the design water surface and the channel grade (corresponding to the assumption of 50 percent effective drainage system).
- (d) Backfill above level of submergence naturally drained.
- (e) Lateral earth pressure from backfill based on an at-rest pressure coefficient ($K_r = 0.60$).
- (f) Uniform uplift across the base (pressure equal to the reduced hydrostatic head in the backfill).

D29. Since the T-walls will be founded on rock, an at-rest earth pressure coefficient was used. Stability criteria is the same as outlined in Paragraph D23.

D29a. Foundation Conditions for Concrete Structures. Project soils consist principally of sandy, silty clay. Bedrock at the project site is predominately gray shale that is horizontally bedded. A detailed discussion on the soils and geology at the project site and the results of the subsurface exploration and testing programs are presented in Appendix A. Except

for the chute-transition at the upstream end of the project, all concrete structures will be founded on rock. As discussed in Appendix A, the shale has the characteristic of air-slaking. For the concrete structures founded on rock, the concrete will have to be placed on the foundation immediately after excavating to final grade, or the foundation surface will have to be protected, such as being kept continuously wet.

D29b. The chute-transition will be founded on natural overburden material consisting principally of sandy, silty clay, classified as CL. Based on computations presented in Subappendix D1, an allowable foundation pressure of 2.0 kips per square foot was selected for the soil foundation. The two-barrel conduit is located beneath a portion of the chute-transition. Care will have to be exercised during construction so as not to damage this conduit. Some dewatering is anticipated during construction at the downstream end of the chute-transition.

D29c. The concrete transition at the end of the three-barrel conduit will be founded on a gray, silty shale. Core borings indicate that the foundation is adequate for the structure. For design, the maximum allowable foundation pressure was set at 10 kips per square foot. As the structure will be constructed in existing Big Creek, diversion and dewatering will be required during construction.

D29d. The flume at the upstream end of the diversion channel and the associated walls at the upstream end of the flume will be founded on a gray shale. Core borings indicate that the foundation is adequate for these concrete structures. The maximum allowable foundation pressure was set at 10 kips per square foot for design. As the flume will be located between the existing piers of the West 25th Street bridge, care will have to be exercised during construction in order not to damage the existing piers. It is anticipated that some dewatering will be required during construction.

D29e. The two abutments of the Baltimore and Ohio Railroad mainline bridge and the two abutments and pier of the Baltimore and Ohio Railroad spurline bridge will be founded on a gray, silty shale. Bottoms of footings will be placed in the shale and a value of 10 kips per square foot was assigned for maximum allowable foundation pressure. As the concrete structures will be constructed in existing Big Creek, diversion and dewatering will be required during construction.

SECTION C

RIPRAP AND GABION DESIGN

D30. General. This Section presents the basic data, design criteria, and assumptions used in designing the channel bottom and side slope protection for the Big Creek Flood Control Project. Also included in this Section is the design of the protection required for the drop structures.

D31. Design Criteria. Design criteria, assumptions, and methods were based on applicable Corps of Engineers' engineering and design manuals, supplemented where necessary by conservative judgment and experience. Publications used in establishing design criteria include the following:

Manual - Corps of Engineers

- (1) EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", 1 July 1970

Engineering Technical Letter - Corps of Engineers

- (1) ETL 1110-2-120, "Additional Guidance for Riprap Channel Protection", 14 May 1971

Other Publication

- (1) Technical Report H-75-19, Fourmile Run Local Flood-Control Project, Alexandria and Arlington County, Virginia, Hydraulic Model Investigation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi 39180, December 1975

D32. Riprap Design. The riprap was designed in accordance with the method presented in EM 1110-2-1601 and ETL 1110-2-120. Average channel velocities were used to determine riprap size. Where the channel is curved, a bend-loss factor (BLF) was computed by the following formula from EM 1110-2-1601, Plate 34:

$$BLF = 3.10 \left(\frac{W}{R} \right)^{0.5}$$

R = Centerline radius of channel curve in feet.

W = Top width of channel in feet, computed by projecting the channel sideslopes to design water surface.

A nonuniform flow factor of 1.5 was used. If the BLF exceeded the nonuniform flow factor, the BLF was used in lieu of the nonuniform flow factor. Computations for riprap design are presented in Subappendix D3. The

gradation of 12-inch thick riprap and 18-inch thick riprap is presented in Appendix A.

D33. Gabion Design. As an alternative to the use of riprap, the use of gabions was considered in Appendix B, Alternative Studies. The results of the Alternative Studies showed that gabions are less expensive than riprap where required riprap protection is 24-inch thick or greater. The required gabion thickness is set equal to one-half the required riprap thickness. As discussed in Appendix B, this gabion-riprap relationship was established from model tests for the Fourmile Run Local Flood-Control Project.

Technical Report H-75-19, Fourmile Run Local
Flood-Control Project, Alexandria and Arlington
County, Virginia, Hydraulic Model Investigation,
U.S. Army Engineer Waterways Experiment Station,
Vicksburg, Mississippi 39180, December 1975.

If 24-inch thick riprap is required, then only a 12-inch thick gabion would be required. The gradation of stone used to fill gabion baskets is presented in Appendix A.

D34. Freeboard. The top of riprap and gabion protection was set 3.0 feet vertically above design water surface on the levee slope and 2.5 feet on all other channel slopes.

D35. Bedding Material. A 6-inch thick layer of bedding material will be provided beneath both riprap protection and gabion protection. The use of filter cloth in lieu of using bedding material was considered in Appendix B. However, the filter cloth was found not to be feasible for the project site. The gradation of the bedding material is presented in Appendix A.

D36. Protection of Air-Slaking Shale. The shale at the project site has the characteristic of air-slaking. The need to protect the air-slaking shale is discussed in Appendix A. Various alternatives for protecting the air-slaking shale were considered in Appendix B. Where the channel bottom is in bedrock and not continuously wet, riprap protection will be provided on the channel bottom where channel velocities are high.

D37. Summary of Riprap and Gabion Design. The riprap and gabion design resulted in the following:

<u>Station</u>	<u>Area</u>	<u>Protection</u>	<u>Remarks</u>
<u>Diversion Channel</u>			
67+ 74D- 61+00D	Banks and Bottom	12" Riprap	Diversion Channel Downstream end of diversion channel
61+ 00D- 58+00D	Banks and Bottom	18" Riprap	

<u>Station</u>	<u>Area</u>	<u>Protection</u>	<u>Remarks</u>
<u>Floodway.</u>			
112+ 80F-111+80F	Banks and Bottom	12" Riprap	Downstream end of concrete chute
110+ 20F-109+50F	Banks and Bottom	12" Gabions	Drop Structure No. 1
105+ 20F-104+50F	Banks and Bottom	12" Gabions	Drop Structure No. 2
100+ 20F- 99+50F	Banks and Bottom	12" Gabions	Drop Structure No. 3
95+ 20F- 94+50F	Banks and Bottom	12" Gabions	Drop Structure No. 4
92+ 00F- 91+30F	Banks and Bottom	12" Gabions	Drop Structure No. 5

Modified Channel.

115+22.5M-114+50M	Bottom	12" Riprap	Downstream of 2-barrel conduit
89+ 50M- 89+00M	Banks and Bottom	12" Gabions	Downstream of 3-barrel conduit
89+ 00M- 87+65M	Left Bank	12" Gabions	Confluence Area
89+ 00M- 87+00M	Right Bank	12" Gabions	Confluence Area
76+ 00M- 74+00M	Banks and Bottom*	12" Riprap	R.R. spur bridge
70+ 52D- 69+74D	Right Bank	12" Riprap	Approach to flume
71+ 00M- 70+00M	Left Bank	12" Riprap	Mainline B&O R.R. bridge

*except low flow channel.

D38. Discussion on Design. In general, the riprap and gabion design was in accordance with the methods noted. However, a certain amount of engineering judgment entered into the design where the hydraulic performance was uncertain. In areas of uncertain hydraulic performance, a conservative approach was taken in selecting the thicknesses of riprap and gabions and in determining the lengths of reaches requiring protection.

D39. In the floodway channel, except at the drop structures, the channel velocities vary between 5.4 and 6.3 feet per second (fps). Paragraph 13c of EM 1110-2-1601 recommends a maximum mean velocity in Bermuda grass-lined channels of 6.0 fps for sandy silt and 8.0 fps for silt clay. Although the maximum mean channel velocities are slightly above the recommended maximum, it is not felt that the deviations are sufficiently significant to warrant the expense of riprap protection. Furthermore, the channel will be dry most of the time; the floodway only carries flood discharge. This will provide good conditions for establishing and maintaining a good grass cover.

D40. At the downstream end of the concrete transition located at the downstream end of three-barrel conduit, the modified channel is narrow. Average channel velocities are high, and the centerline curves are relatively sharp. The left bank of the modified channel will be overtopped during the design flood by flows in the floodway channel. Twelve-inch thick gabions (24-inch riprap) was the computed requirement just downstream of the concrete transition. These gabions were extended to cover the nose where the floodway channel joins the modified channel. Although the 12-inch gabions selected will provide more protection than computations show are needed, the computations do not include the effects of the expected turbulence and eddies at the confluence. Because of the overtopping, the flow in this reach of the diversion channel may be greater than the discharges used in design. The riprap on the right bank of the modified channel was extended downstream until it was felt that the flows between the floodway channel and the modified channel would be fully combined.

D41. Along all of the diversion channel, the computed riprap thickness is 12 inches. At the downstream end, an 18-inch thickness is selected. This is a confluence area with flows joining at right angles. Turbulence and eddies can be expected. The conservative design is therefore believed to be warranted. The need for keys in riprap revetment is outlined in Paragraph 14K of EM 1110-2-1601. It is stated in this paragraph that "the upstream and downstream ends of riprap revetment should be protected against erosion by increasing the revetment thickness or extending the revetment to areas of noneroding velocities". Although this reference pertains to riprap revetment, it is believed to be equally applicable for gabion structures. Where riprap and gabions terminate, a change in roughness occurs and increased turbulence can be expected. Because of the increased turbulence, the erosion potential is greater; and, therefore, there is need for additional protection. Keys are, therefore, used along the edges of the riprap or gabions where they terminate. The key detail is a 3-foot by 3-foot gabion placed in a trench. Although this detail is not one of the standard riprap key details shown in EM 1110-2-1601, it has been used on Corps of Engineer Flood Control Projects. It is felt that gabion keys provide better protection than riprap keys because they extend further below the channel template than the standard keys and because they are firmly connected together.

SECTION D

SLOPE STABILITY ANALYSES

D42. General. A detailed discussion on the soils and geology at the project site is presented in Appendix A. Adopted design values for the project soils for the slope stability analyses are presented in Appendix A. The adopted design values include both shear strength parameters and the unit weights of soils involved.

D43. It is anticipated that the majority of fill used for constructing the embankment of the relocated Baltimore and Ohio Railroad mainline will come from an offsite borrow area. However, the results of the exploration and testing program for the offsite borrow area were not available at the time the slope stability analyses had to be run. In order not to delay the schedule for completion of the design of the project, it was assumed that the shear strength of the borrow material would be equal to or greater than the shear strengths of the project soils. This decision was made by the Buffalo District, Corps of Engineers during a meeting with Gannett Fleming Corddry and Carpenter, Inc., on December 14, 1978. The validity of this assumption will have to be checked when the results of the exploration and testing program for the offsite borrow area are available.

D44. References. Publications used in establishing design criteria and procedures include the following:

Manuals - Corps of Engineers

- (1) EM 1110-2-1902, 27 December 1960, "Stability of Earth and Rock-Fill Dams".
- (2) EM 1110-2-1902, 1 April 1970, "Stability of Earth and Rock-Fill Dams".

D45. Cross-Sections. Cross-sections were selected for detailed stability analyses for the floodway, modified, and diversion channels. Included in the floodway channel sections are the stability analyses of the embankment of the relocated Baltimore and Ohio Railroad mainline and the levee. In the diversion channel section, the stability of the cut in the trash pile was analyzed, as well as the stability of the cuts and fills of the relocated Baltimore and Ohio Railroad mainline. Cross-sections were selected to reflect various channel templates and the various soil classifications. Sections were selected where it was judged that the lowest factors of safety would result. The cross-sections were simplified as required for stability analysis purposes. The phreatic lines used and the lines between different soil materials were assumed based on available information and engineering judgment. For stability analyses purposes only, the assumed top of rock used for the sections was lowered about 3 feet. This is conservative and is believed to be warranted because of irregularities in the top of rock and because of weathering and decomposition in the top few feet of rock.

D46. Conditions Analyzed and Required Factors of Safety. Each cross-section selected was analyzed for the following conditions:

- (1) End of Construction (Case I, Paragraph 11a of EM 1110-2-1902, 1 April 1970)
- (2) Sudden Drawdown from Design Water Surface (Case III, Paragraph 11 of EM 1110-2-1902, 1 April 1970)

D47. In accordance with EM 1110-2-1902, 1 April 1970, the minimum factors of safety required are as follows:

- (1) End of Construction Condition _____ 1.3
- (2) Sudden Drawdown Condition _____ 1.2

D48. Adopted Design Values for Project Soils. The adopted design unit weights and shear strength parameters for the project soils for use in the slope stability analyses are presented in Appendix A. For convenience, they are presented below. The shear test envelopes and the adopted shear strength parameters for project soils are presented in Appendix A on Plate A13. Adopted shear strength parameters are needed for the stability analysis for end of construction condition and sudden drawdown condition. For the end of construction condition, only one shear test envelope is available for the existing Baltimore and Ohio Railroad embankment material, and it was adopted for design. Also, for the end of construction condition, only one shear test envelope is available for the existing Norfolk and Western Railroad embankment material, and it was selected for design. For the end of construction condition, two shear test envelopes are available for the natural foundation material. The adopted design envelope for the natural foundation material was selected by engineering judgment, and it lies between the two shear test envelopes. For the end of construction condition, two shear test envelopes are available on project soils to be used in the relocated Baltimore and Ohio Railroad embankment and levee. The shear strength envelope selected for design was based on engineering judgment. It lies between the two shear test envelopes and is conservative. It seemed advisable to be conservative because a considerable portion of the mainline embankment material will be obtained from an offsite borrow. If shear test results on borrow material prove to be lower than the adopted shear strength parameters, considerable redesign would be involved in the project. For the sudden drawdown condition, the adopted shear strength parameters are based on the results of the consolidated-drained (CD) and consolidated-undrained (CU) shear tests. Normally for the stability analysis of a sudden drawdown condition, a combined CD-CU shear strength envelope is adopted for design. This would be the procedure for a sudden drawdown stability analysis for the upstream slope of a dam. For the Big Creek Flood Control Project, however, a true sudden drawdown condition, as with a dam, cannot occur. It was therefore felt that the refinement of a combined envelope for design was not warranted, and a straight line envelope was selected. The shear strength parameters adopted

ADOPTED DESIGN VALUES FOR PROJECT SOILS

Material	Unit Weight, PCF		Shear Strength Parameters			
	Molst	Saturated	End of Construction ϕ , Degrees	C, TSF	Sudden Drawdown ϕ , Degrees	C, TSF
(1) Earthfill for Relocated RR Embankment and Levee	125.0	130.0	11.0	0.60	22.8	0.12
(2) Existing N&W RR Embankment	125.0	130.0	2.5	0.67	20.0	0.20
(3) Existing B&O RR Embankment	125.0	130.0	0.0	0.48	18.0	0.30
(4) Natural Foundation Material	125.0	130.0	0.0	0.60	19.0	0.25
(5) Trash Material	90.0	—	30.0	0.00	30.0	0.00
(6) Riprap, Stone Ballast, and Filter Material*	125.0	—	35.0	0.00	35.0	0.00

* Adopted design values for these materials were not presented in Appendix A. Values selected are conservative. These materials take up a small part of the sections and have little effect on the results of the stability analyses.

for design are based on engineering judgment and are believed to be conservative. As with the construction case, because material for the railroad embankment will be obtained from an offsite borrow, it was felt desirable to be conservative in selecting the adopted shear parameters for the railroad embankment material. For the cut slope through the trash pile, the adopted shear strength parameters for the trash material are based on the angle of repose of the trash pile. The angle of repose of the trash pile is shown in Appendix A on Plate A14. A discussion on the adopted shear strength parameters for the trash material is presented in Appendix A. For project soils, except at the trash pile, adopted unit weights are based on laboratory tests. As no laboratory tests were run on trash pile material for the purpose of determining a unit weight, the adopted unit weight was based on the assumed unit weights of the several types of material in the trash pile. Additional discussion on the adopted unit weights is presented in Appendix A.

D49. Surcharge Loadings. Surcharge loadings, equivalent to live loadings, were used in the stability analyses and are as follows:

- (1) Along the centerline of relocated Baltimore and Ohio Railroad mainline, the surcharge loading used was equivalent to 10,000 lbs./ft. distributed over a width of 10 feet.

- (2) Along the top of levee, the surcharge loading used was 2 feet of earthfill (equivalent truck loading).

D50. Computer and Manual Solutions. The slope stability analyses were run using a computer program. The computer program used is based on the Circular Arc Method as presented in EM 1110-2-1902, dated 27 December 1960. The cross-sections selected for the stability analyses and the results of the computer solution are presented in Subappendix D4 on Plates D4-1 through D4-7, inclusive. A manual check was run for both the End of Construction Condition and Sudden Drawdown Condition. The purpose of the manual computations was to verify the results of the computer solution. Arc No. 2 from Plate D4-4, Left Bank Floodway Channel at Station 89+50F, was selected for the manual check. The manual check computations for the Sudden Drawdown Condition are presented in Subappendix D4 on Plate D4-8, and the manual check computations for the End of Construction Condition are presented on Plate D4-9. The manual check computations were based on Modified Swedish Method as outlined in EM 1110-2-1902, dated 1 April 1970. Consideration was given to the affects of the relocated Baltimore and Ohio Railroad mainline embankment and loadings on the stability of the Norfolk and Western Railroad embankment. The relocated mainline embankment will be adjacent to and essentially parallel to the existing Norfolk and Western Railroad embankment. At the upstream end of the relocation, the grade of the relocated Baltimore and Ohio Railroad mainline will be about 20 feet below that of the Norfolk and Western Railroad. As the relocated mainline proceeds downstream, this differential decreases uniformly and the grades of the two tracks are about level at the mainline bridge. Where there is no differential or only

a small differential between the grades of the two tracks, it is apparent that the relocated mainline embankment and loadings will have no adverse affects on the stability of the Norfolk and Western Railroad embankment. Where there is a larger differential between the grades of the two tracks, the mainline embankment is essentially acting as a stabilizing fill at the toe of the Norfolk and Western Railroad embankment. Rather than having an adverse affect, the relocated mainline embankment would be improving the overall stability of the Norfolk and Western Railroad embankment. It is significant to note that the embankment slope of the Norfolk and Western Railroad embankment is as steep as 1V on 1.5H. Whereas the embankment slope of the relocated mainline is 1V on 2.5H. Dynamic train loadings could be comparable to the vertical component of an earthquake loading but of a smaller magnitude. Normally, it can be assumed that if an embankment has adequate factors of safety for static loadings, it would be stable for small earthquake loadings. Therefore, the Baltimore and Ohio Railroad dynamic train loadings are not expected to affect the stability of the Norfolk and Western Railroad embankment. The Norfolk and Western Railroad has experienced slope stability problems with the cut slope on the north side of the Norfolk and Western Railroad track. As the Norfolk and Western cut slope is farther away from the relocated Baltimore and Ohio Railroad track than the Norfolk and Western Railroad embankment, the relocated Baltimore and Ohio Railroad track has less effect on the Norfolk and Western cut slope than it does on the Norfolk and Western Railroad embankment. Therefore, the relocated Baltimore and Ohio Railroad embankment and train loadings will have no adverse effect on the Norfolk and Western cut slope. As outlined in Paragraph D49, surcharge loadings, equivalent to live loadings, were used in the stability analysis of the mainline embankment.

D51. Summary of Results. Results of the computer solutions and manual check computations for the slope stability analyses are as follows:

COMPUTER SOLUTION SUMMARY

Plate No.	Location	<u>Factor of Safety</u>	
		<u>Sudden Drawdown Condition</u>	<u>End of Construction Condition</u>
Subappendix D4			
D4-1	Right Bank, Diversion Channel, Sta. 64+00D	1.28	1.17
D4-2	Left Bank, Diversion Channel, Sta. 64+00D	1.76	3.69
D4-3	Left Bank, Modified Channel, Sta. 80+00M	1.64	2.32
D4-4	Left Bank, Floodway Channel, Sta. 89+50F	1.50	2.52
D4-5	Left Bank, Floodway Channel, Sta. 102+00F	1.78	2.80
D4-6	Left Bank, Floodway Channel, Sta. 108+25F	2.21	3.71
D4-7	Levee, Floodway Channel, Sta. 111+00F	2.58	6.30

MANUAL CHECK SUMMARY

		<u>Factor of Safety</u>	
		<u>Manual</u>	<u>Computer</u>
		<u>Check</u>	<u>Solution</u>
(1)	Sudden Drawdown Condition, Arc. No. 2, Left Bank, Floodway Channel, Sta. 89+50F (Subappendix D4, Plate D4-8)	1.58	1.50*
(2)	End of Construction Condition, Arc. No. 2, Left Bank, Floodway Channel, Sta. 89+50F (Subappendix D4, Plate D4-9)	3.44	3.49*

* Subappendix D4, Plate D4-4.

D52. Discussion on Stability Analyses. The number of arcs shown on the Plates in Subappendix D4 are representative of the arcs analyzed. In all cases the arc with the lowest factor of safety is presented.

D53. Except for the results of the stability analysis on the cut through the trash pile (Subappendix D4, Plate D4-1), the factors of safety obtained for both the End of Construction and Sudden Drawdown Conditions are considerably higher than the minimum required factor of safety. The high factors of safety obtained for the End of Construction Condition can generally be attributed to the relatively high adopted design values used for cohesion for the various soils involved.

D54. The high factors of safety obtained for the Sudden Drawdown Condition cannot be attributed to either the adopted design value for angle of internal friction or cohesion for the various soils involved. The high factors of safety obtained are believed to be attributed to a combination of factors; such as, assumed phreatic line, adopted shear parameters, and side slope.

D55. The channel side slopes used for the various sections analyzed were selected during the initial studies made in connection with the preparation of Appendix B. The side slopes selected were believed to be slightly flatter than would theoretically be required to satisfy slope stability criteria. A conservative approach was taken because if it were found that the slopes were too steep, flattening the slopes to satisfy stability criteria would result in major changes to the alignments of the floodway, modified, and diversion channels. This, in turn, would result in a delay in completion of the project design. Therefore, as expected, the side slopes are conservative, except for the diversion channel cut at the trash pile.

D56. For the diversion channel cut in the trash pile, the factor of safety for the End of Construction Condition was 1.17 compared with the minimum required value of 1.3. It is apparent that the low factor of safety is attributed to the shear strength parameters adopted for the trash pile material.

The adopted shear parameters for the trash material was 30° for angle of internal friction and zero for cohesion. A detailed discussion on how these parameters were selected is presented in Appendix A. It is believed that these parameters are on the conservative side for several reasons. The angle of inclination of the existing slope of the trash pile varies between 33° and 38° . The actual angle of internal friction is believed to be considerably more than the assumed 30° . Also, the trash material is believed to have some cohesion. A small amount of cohesion for the trash material would make the factor of safety higher. Because of these considerations, the factor of safety of 1.17 obtained is accepted. It is not believed that flattening the slope of the cut to obtain the 1.3 factor of safety is warranted.

D57. The difference in the results between the computer solution and manual check is relatively small and is considered acceptable. Since the manual check gave slightly greater factors of safety than the computer solution, the computer solution is slightly conservative. The difference can be attributed to the difference in method of analysis and also to the normal inaccuracies expected in the graphical procedure used for the manual check.

D57a. Engineering Data Required for Levee, Earthfill in Zoo Floodplain, and Railroad Embankments. Earthen material required for the levee and earthfill in Zoo floodplain will be obtained from required common excavation. Earthen material required for the railroad embankments will be obtained from both required common excavation and from the designated offsite borrow area. A detailed description of these materials along with laboratory test data is presented in Appendix A.

D57b. Material for the levee and earthfill in Zoo floodplain will consist primarily of the impervious project soils consisting of sandy, silty clay, classified as CL. The material shall contain a minimum of 20 percent passing the No. 200 sieve, and it shall have a minimum plasticity index of 3. The moisture content after compaction shall be within the limits of 2 percentage points above optimum and 2 percentage points below optimum. Material shall be compacted to 95 percent of Standard Proctor Density. The levee and earthfill in Zoo floodplain shall not have stones, rocks, and rock fragments larger than $2/3$ the placement lift thickness.

D57c. Material for the railroad embankments shall consist of earth materials obtained from required excavation and designated borrow area which are suitable for use in the railroad embankments. The moisture content after compaction shall be within the limits of 2 percentage points above optimum and 2 percentage points below optimum. Material shall be compacted to 95 percent of Standard Proctor Density. The embankment shall not have stones, rocks, and rock fragments larger than $2/3$ the placement lift thickness.

SECTION E
RAILROAD RELOCATIONS

D58. General. Several alignments of the relocated Baltimore and Ohio Railroad mainline and spurline were presented in Appendix B, Alternative Studies, and one alignment of the mainline and spurline was selected for final design. Since completion of the Alternative Studies, detailed field surveys of selected portions of the existing railroad facilities at the project site were performed. Accurate horizontal and vertical survey data of the existing railroad facilities was needed for finalizing the design of mainline and spurline alignments.

D59. The selected mainline and spurline alignments have been refined and coordinated to accommodate all constraints of the floodway channel, modified channel, diversion channel, Baltimore and Ohio Railroad mainline and spurline, and the Norfolk and Western Railroad.

D60. Design Criteria and Procedures. The horizontal and vertical geometry was located and coordinated in the final position using the standard design criteria furnished by the Chessie System. The horizontal criteria is based on Engineering Bulletin No. R-13, dated April 18, 1977. The vertical criteria is based on the Pamphlet package from the Chessie System, dated June 19, 1978. The track roadbed typical sections were taken from the "Roadbed and Ballast Sections for New Construction", dated January 23, 1964. The roadbed drainage for pipe locations and sizes is based on the U.S. Department of Transportation "Hydraulic Engineering Circular No. 12" and "Hydraulic Design Series No. 3". The slope stability analyses of the relocated railroad embankment sections are presented in Section D and Subappendix D4. A listing of design criteria and design calculations for the final location of the relocated mainline and the spurline alignments are presented in Subappendix D5.

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D
DESIGN ANALYSIS

AUGUST 1979

SUBAPPENDIX D1
COMPUTATIONS FOR STRUCTURAL DESIGN
OF
HYDRAULIC STRUCTURES

SUBAPPENDIX D1

COMPUTATIONS FOR STRUCTURAL DESIGN
OF
HYDRAULIC STRUCTURES

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Concrete Flume and Retaining Walls at West 25th Street Bridge	D1-57 to D1-105

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT _____ FILE NO. _____
SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____

BIG CREEK FLOOD CONTROL PROJECT

STRUCTURAL DESIGN

CHUTE-TRANSITION AT UPSTREAM END
OF PROJECT

(INCLUDING ZOO ACCESS ROAD AND
ACCESS TO BROOKSIDE PARK DRIVE UNDERPASS)

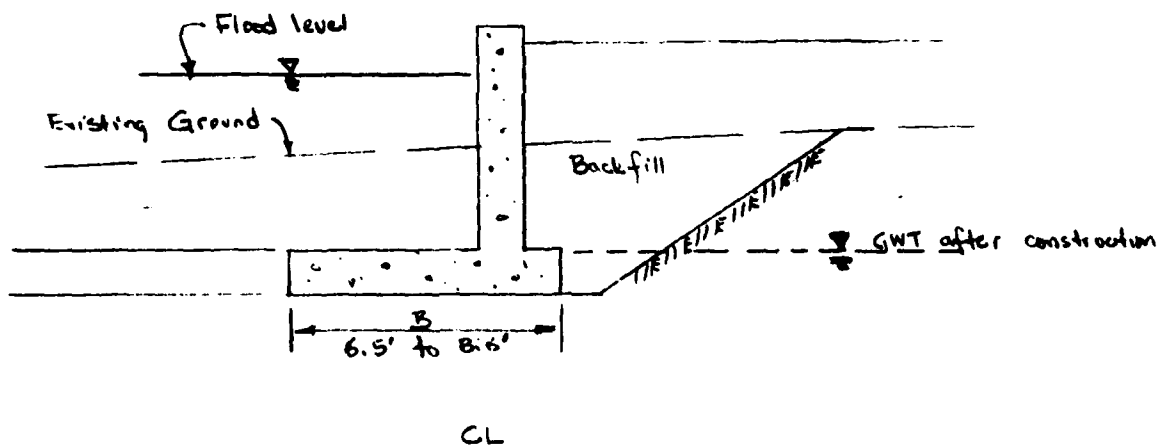
Purpose: Determine maximum allowable pressures for walls on earth foundations.

Applicability: Walls on earth foundations will be constructed at the following locations:

1. Chute-transition at upstream end of project

Preliminary Design Data:

1. Walls will be founded on CL soils.
2. Wall base will be essentially a continuous strip.



Note: The effects of overburden has been neglected

Soil Test Data: Ref.: Phase II GDM, Appendix A
For Foundation Material:

Construction Case : $C = 0.60$ TSF $\phi = 0^\circ$
Sudden Drawdown : $C = 0.25$ TSF $\phi = 19^\circ$
 $\gamma_t = 125$ pcf $D1-4$

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Design Criteria - Allowable FILE NO. 7622.00
Resources for Walls on Earth SHEET NO. 2 OF 2 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PDW DATE 2/28/79 CHECKED BY FFM DATE 3-3-79

Using the general bearing capacity developed by Hansen for cohesive soils (Ref.: "Foundation Analysis and Design", J.E. Bowles, 1968):

$$q_{ult} = c N_c S_c d_c i_c + W q N_q S_q d_q i_q + W' \frac{1}{2} \gamma B N_\gamma S_\gamma d_\gamma i_\gamma$$

Construction Case

$$\gamma_E = 0.125 \text{ KSF} \quad c = 0.60 \text{ TSF} = 1120 \text{ KSF} \quad \phi = 0^\circ$$

From Tables:

$N_c = 5.14$	$N_q = 1.00$	$N_\gamma = 0.0$
$S_c = 1.00$	$S_q = 1.00$	$S_\gamma = 1.00$
$i_c = 1.00$	$i_q = 1.00$	$i_\gamma = 1.00$
$d_c = 1.00$	$d_q = 1.00$	$d_\gamma = 1.00$

$$q = (1.5)(0.15 - 0.0625) = 0.13 \text{ KSF} \quad \leftarrow \text{Considering only the wt of the conc. slab.}$$

$W = 0.5 \quad W' = 0.5$

$$q_{ult} = (1.2 \text{ KSF})(5.14)(1)(1.00)(1) + (0.5)(0.13 \text{ KSF})(1)(1)(1)(1) + 0$$

$$q_{ult} = 6.23 \text{ KSF}$$

Use Factor of Safety = 3.0

$$q_a = 6.23/3.0 = 2.08 \text{ KSF} \quad \text{Use } 2.0 \text{ KSF}$$

$\therefore$ ALLOWABLE PRESSURE = 2.0 KSF for Construction Case

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Design Criteria - Allowable FILE NO. 7622.00
Pressures for Walls on Earth SHEET NO. 3 OF 3 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PJW DATE 2/28/79 CHECKED BY FFM DATE 3-2-79

Flood Case (Assume water has receded in flume)

$$\gamma_t = 0.125 \text{ KSF} \quad C = 0.25 \text{ TSF} = 0.5 \text{ KSF} \quad \phi = 19^\circ$$

From Tables:

$$N_c = 13.93$$

$$N_g = 5.8$$

$$N_y = 4.68$$

$$S_c = 1.00$$

$$S_g = 1.00$$

$$S_y = 1.00$$

$$i_c = 1.00$$

$$i_g = 1.00$$

$$i_y = 1.00$$

$$d_c = 1.00$$

$$d_g = 1.00$$

$$d_y = 1.00$$

* Foundation

Engineering

Hand book

by Foundation Analysis

I-E. Bowles.

$$q = 0.13 \text{ KSF}$$

$$W = 0.5$$

$$W' = 0.5$$

$$q_{ult} = (0.5 \text{ KSF})(13.93)(1)(1)(1) + (0.5)(0.13 \text{ KSF})(5.80)(1)(1)(1)$$

$$+ (0.5)(0.5)(0.0625)(4.68)(1)(1)(1) = 7.817 \text{ KSF}$$

$$q_a = 7.817 / 3.0 = 2.606 \text{ KSF} \quad (> 2.0 \text{ KSF}, \therefore \text{not critical})$$

ADOPTED DESIGN VALUE
FOR
ALLOWABLE PRESSURE

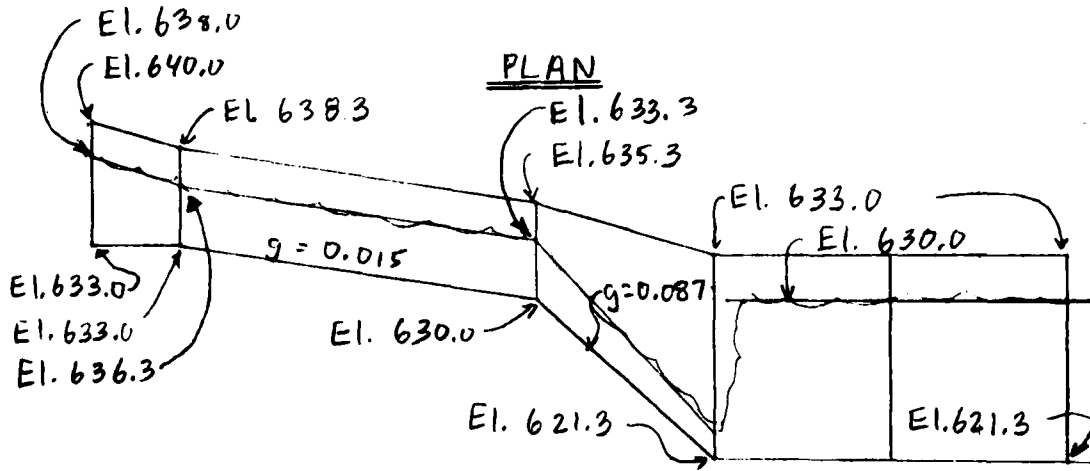
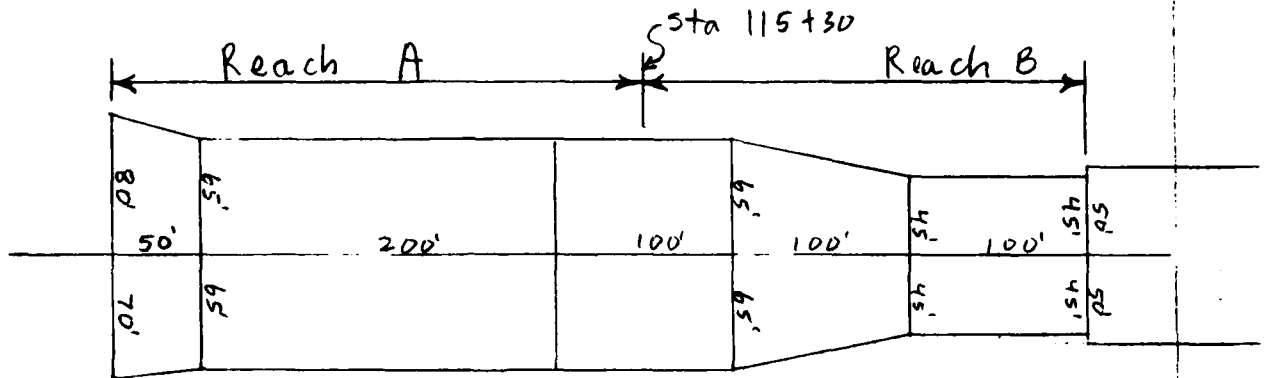
$$= 2.0 \text{ KSF}$$

GANNETT FLEMING CORDRY
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SUBJECT CHUTE - TRANSITION FILE NO. 7622.00
BIG CREEK FLOOD SHEET NO. 1 OF 1 SHEETS
FOR CONTROL PROJECT
COMPUTED BY Pyd C. DATE 11/28/78 CHECKED BY FFH DATE 3-2-79

PLAN & PROFILE

Scale 1" = 100' H
1" = 10' V



PROFILE

Scale: H: 1" = 100'
V: 1" = 10'
01-7

LOADING CONDITIONS.

CASE I. Sudden Drawdown.

- (a) Chute - Transition empty.
- (b) Backfill at max. elevation.
- (c) Backfill submerged to an elev. midway betn design water surface and bottom of slab.
- (d) Backfill above the level of submergence naturally drained.
- (e) Lateral earth pressure based on $K_{active} = 0.33$.
- (f) Uplift across the base varies from reduced hydrostatic head at the heel to 3-foot at inside face of wall,
Uniform 3.0' Uplift on the rest of the base.

CASE II. Design Flood.

- (a) Water surface at design elev. (2.0' below top of wall)
- (b) Backfill at min. elev.
- (c) Back fill naturally drained.
- (d) Uplift varying uniformly across the base.

+ Reaches A & B will be designed for case (I)

+ Betn Sta. 115+55^F and Sta. 116+05^F in Reach A
CASE II is considered for right bank.

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SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 7622
CHUTE TRANSITION AT UPSTREAM END SHEET NO. 29 OF 30 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY _____ DATE _____ CHECKED BY D/aw DATE 3/3/79

TEMPERATURE AND SHRINKAGE REINFORCEMENT

Reference EM 1110-2-2103, Para. 10 b (1)

$A_s = 0.20\%$ of gross cross-sectional area,
half in each face.

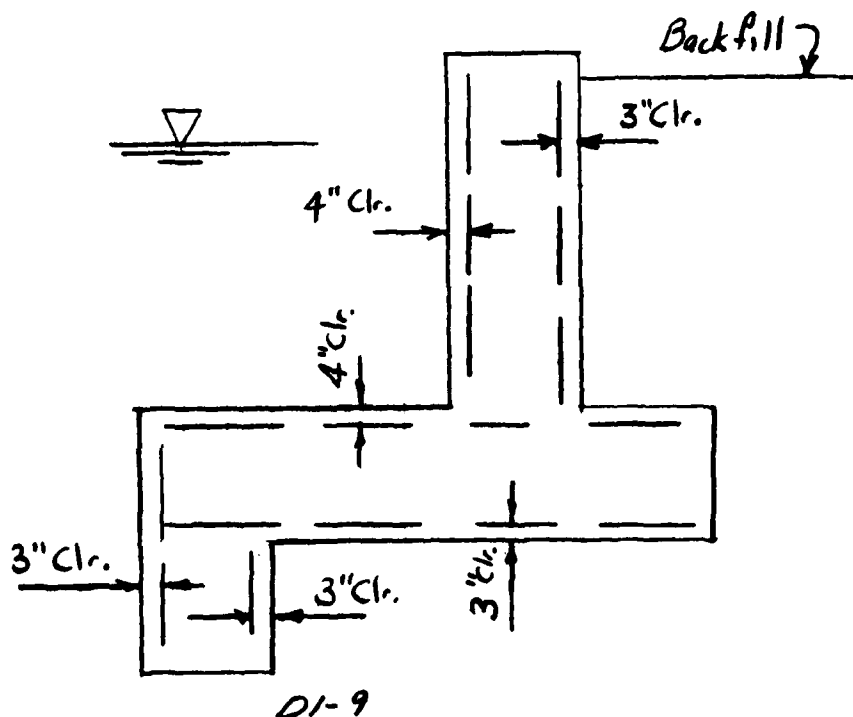
Considering Cleveland is in a region
of severe climatic temperature conditions,
add 25%.

$$\therefore A_s = 0.20 + 0.05 = 0.25\%$$

$A_s = 0.125\%$ of gross cross-sectional
area in each face

CLEARANCES

Reference EM 1110-2-2103, Para. 8



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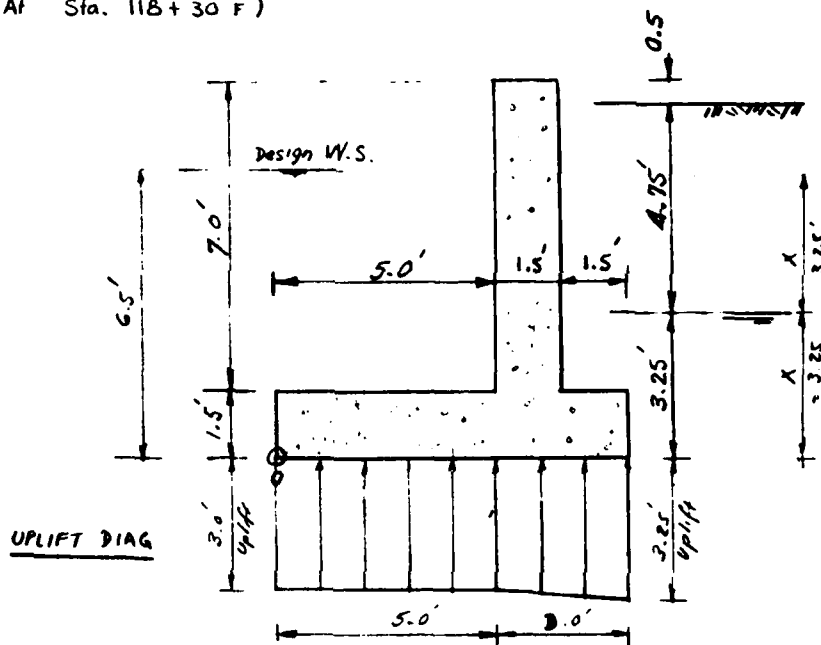
SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 7622
CHUTE - TRANSITION AT UPSTREAM END SHEET NO. 3 OF 3 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFM DATE 3-1-79 CHECKED BY D/SM DATE 3-3-79

I. REACH "A"

A. SUDDEN DRAWDOWN CONDITION.

1. Critical Section Dimensions.

(At Sta. 118+30 F)



2. Adopted Design Values:

$$\gamma_{sat} = 125.0 \text{ pcf}$$

$$\gamma_{conc} = 150.0 \text{ pcf}$$

$$\gamma_w = 62.5 \text{ pcf}$$

$$f_c = 20,000 \text{ psi}$$

$$f_c = 1,050$$

$$K_{active} = 0.33$$

$$n = 9.2$$

$$K_{act} \gamma_{sat} = .0417 \text{ K/ft}^2$$

$$K_{act} \gamma_{conc} = .021 \text{ " "}$$

$$\gamma_w + K_{act} \gamma_{soil} = .083 \text{ " "}$$

DI-10

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SUBJECT STRUCTURAL DESIGN - L-WALL FILE NO. 7622
CHIEF - TRANSITION AT UP-STREAM SHEET NO. 4 OF 4 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFM DATE 3-1-79 CHECKED BY D/SW DATE 3-3-79

3. Stability Table

Item	Computations		Horz ←	Vertical		Arm	Moment	
				↓	↑		→	←
Conc.	7.0 X 1.5 X .150	stem		1.575		5.75	9.056	
	8.0 X 1.5 X .150	base		1.800		4.00	7.200	
Soil	1.5 X 6.5 X .125	wt		1.219		7.25	8.836	
"	$4.75^2 \times .0417/2$		.470			4.83		2.272
	$4.75 \times 3.25 \times .0417$		.643			1.62 ^s		1.046
	$3.25^2 \times .0833/2$		.440			1.08 ^s		0.477
Uplift	3.0 X .0625 X 8.0				1.500	4.0		6.000
	0.25 X .0625 X 3/2				.023	7.0		0.164
			1.553	4.594	1.523		25.092	9.959
	Total		1.553	3.071		4.928	15.133	

$$e = .928' < \frac{l}{6} \quad \text{O.K.}$$

Check Sliding

$$\frac{\sum H}{\sum V} = \frac{1.553}{3.071} = 0.506 < 0.60 \quad \text{O.K.}$$

4. Stresses on the foundation

$$f_x = \frac{V}{l^3} (l - 6e) + \frac{V}{l^3} (12e) x$$

$$= 0.1167 + .0668 x$$

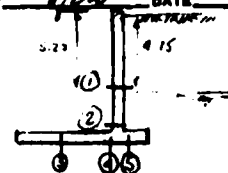
$f_0 = 0.1167$	K/ft ²	@ pt. 0
$f_{2.5} = 0.2837$	"	2.5' from 0
$f_{5.0} = 0.4507$	"	5.0' "
$f_{6.5} = 0.5509$	"	6.5' "
$f_{8.0} = 0.6511$	"	8.0' "

$$\text{All} < 2.0 \text{ K/ft}^2 \quad \text{OK}$$

DI-11

GANNETT FLEMING CORDRY
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SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 7622
CHUTE TRANSITION AT UP-STREAM END SHEET NO. 5 OF 5 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFM DATE 3-1-79 CHECKED BY R/SW DATE 3-3-79



5- STRESS ANALYSIS

PT.	(N) Normal Force		(Q) Shearing Force		Arm	(M) Moment	
	Comps	Value (K)	Comps	Value (K)		Comps	Value (K-FT)
①	5.23 X 1.5 X .15	1.180	$4.75^2 \times .0417/2$	0.470	1.583	0.470×1.583	0.745
②	7.0 X 1.5 X .15	1.575	$4.75^2 \times .0417/2$ + $4.75 \times 1.75 \times .0417$ + $1.75^2 \times .0833/2$	0.470 0.347 0.128 0.945	3.333 0.875 0.583	0.470×3.333 0.347×0.875 0.128×0.583	1.567 0.303 0.074 1.944
③	$\frac{1.523}{8} \times 2.5$	0.476	$(0.1167 + 3 \times .0625 - 1.5 \times .15) \times 2.5$ $(2.837 - .1167) \times \frac{2.5}{2}$	0.1950 0.2088 0.4068	1.25 0.833	0.198×1.25 0.2088×0.833	0.2475 0.1739 0.4214
④	$\frac{1.523}{8} \times 5$	0.952	$0.1167 + 3 \times .0625 - 1.5 \times .15) \times 5$ $(.4307 - .1167) \times \frac{5}{2}$	0.3960 0.8350 1.2310	2.50 1.667	0.396×2.50 0.835×1.667	0.9900 1.3945 2.3845
⑤	$\frac{1.523}{8} \times 6.5$	1.237	$(.125 \times 6.5 + .150 \times 1.5) \times 1.5$ $[(.5509 + .150) \times \frac{1.5}{2} + 3.25 \times .0625] \times 1.5$	1.556 -1.206 0.350	0.75 0.75	1.556×0.75 -1.206×0.75	1.167 -0.904 0.263

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SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. _____
CHUTE - TRANSITION SHEET NO. _____ OF _____ SHEETS
FOR BIG CREEK
COMPUTED BY FFM DATE 7-13-79 CHECKED BY _____ DATE _____

6. Reinforcement.

Reference: ACI Publication SP-3,
Reinforced Concrete Design - Working
Stress Method.

Since moments are small consider max.

$$A_s = M / a d$$

$$M = \text{Moment} = 2.3845 \text{ K-Ft.}$$

d = Effective depth in flexural members

$$d = 14.5", \quad t = 18"$$

$$a = \text{Coefficient} = f_s j / 12000 = 1.48$$

$$A_{s@} = 2.3845 / 1.48 \times 14.5 = 0.11 \text{ in}^2/\text{ft}$$

Temperature & Shrinkage Steel:

$$A_s = 0.125 \times 12 \times 18 / 100 = 0.27 \text{ in}^2/\text{ft.}$$

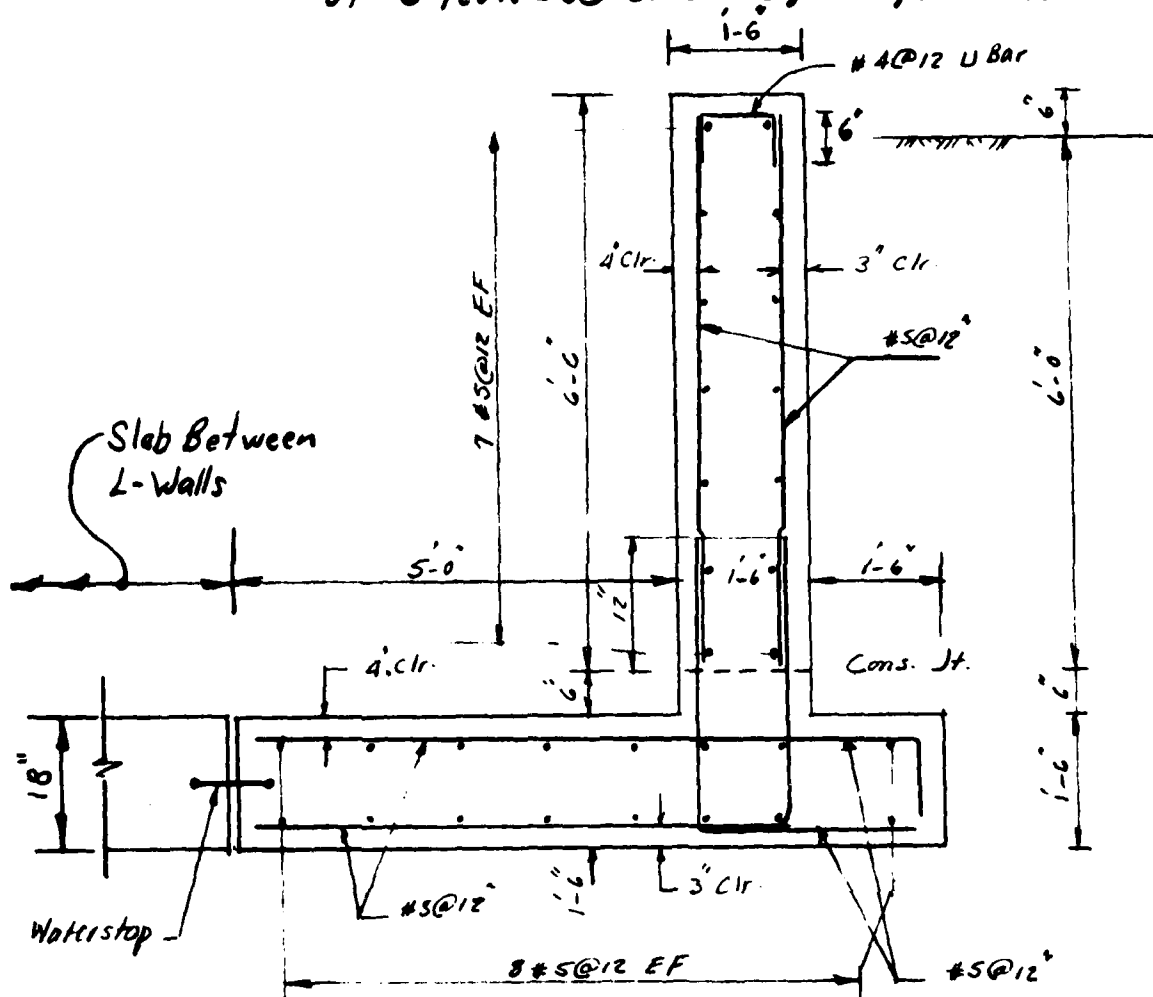
Use #5 @ 12 EW, EF (0.31 in²/ft)

D1-12a

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SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 7622
CHUTE - TRANSITION AT UP-STREAM END SHEET NO. 6 OF 6 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY EFM DATE 3-1-79 CHECKED BY RFW DATE 3-3-79

NOTE: The base of the L-Wall is designed to match the slabs between the two L-Walls. The slabs are designed to resist an uplift of 3 feet. See slab design Page D1-31.



Reinforcement Details.

scale $1" = 2.0'$

D1-13

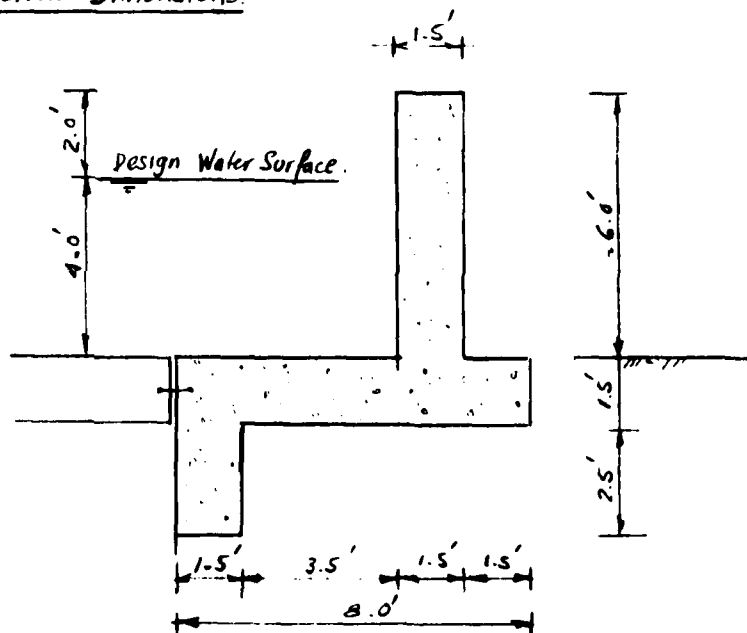
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SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 1622
CHUTE-TRANSITION AT UP-STREAM END SHEET NO. 7 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFM DATE 3-1-79 CHECKED BY DPW DATE 3-2-79

B. DESIGN FLOOD CONDITION.

Around Sta 115+80 F there is no backfill behind the wall.
Consequently, The wall should design as a floodwall betn.
Sta. 115+55 F and Sta. 116+05 F.

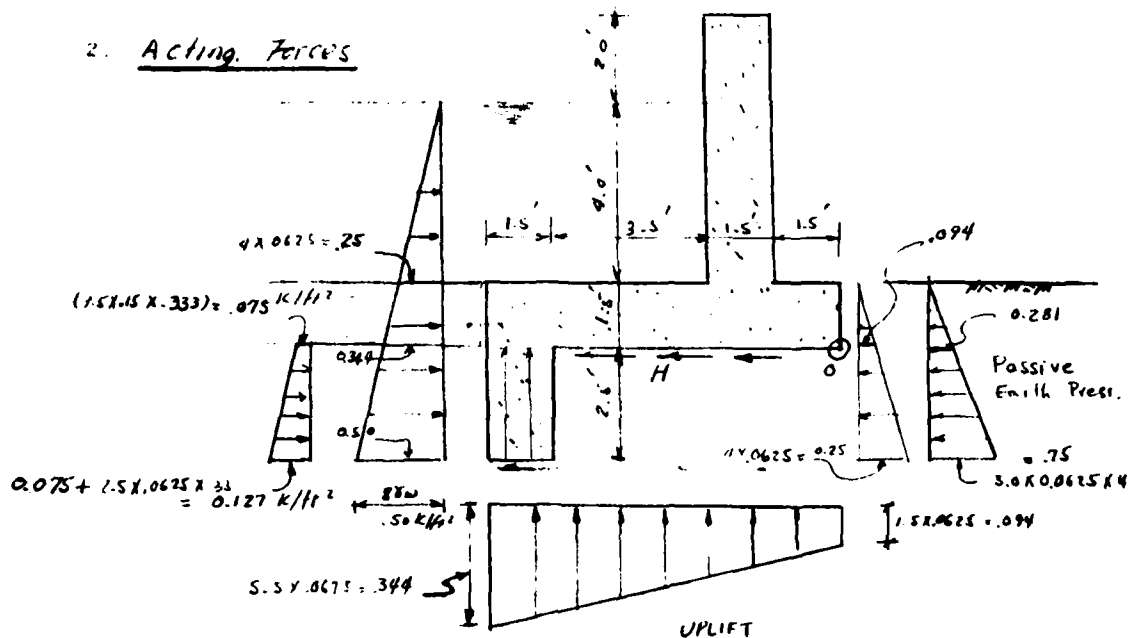
1. Critical Section Dimensions.



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SUBJECT STRUCTURAL DESIGN, L. WALL FILE NO. 7622
CHUTE - TRANSITION AT UP-STREAM END SHEET NO. 8 OF 8 SHEETS
FOR HIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FEM DATE 3-1-79 CHECKED BY D/SUP DATE 3-3-79

2. Acting Forces



3. STABILITY TABLE

Item	Computations	Horizontal		Vertical		Arm	Moment	
		→	←	↓	↑		7	f
Conc.	6.0 x 1.5 x .15			1.350		2.25		3.038
	8.0 x 1.5 x .15			1.800		4.00		7.200
	2.5 x 1.5 x (.15 - .0625)			0.328		7.25		2.378
Water	5 x 4 x .0625			1.25		5.50		6.875
	1.5 x 0.0625 x 8 1/2				0.875	2.67	1.000	
	5.5 x 0.0625 x 8 1/2				1.375	5.333	7.333	
	8 1/2 x 0.0625 / 2	2.000				0.167	0.334	
Soil	4 1/2 x 0.0625 / 2		0.50			- 1.167	0.584	
	0.075 x 2.5 / 2	0.094				- .833		0.079
	0.127 x 2.5 / 2	0.159				- 1.667		0.265
Passive	3.0 x .0625 x 4 1/2		1.50			- 1.167	1.750	
	Subtotal	2.254	2.000	4.728	1.750		11.001	19.835
	TOTAL	.254 = H		2.978		2.967	8.834	

D1-15

$e = 1.033 < 1/6$ O.K.

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SUBJECT STRUCTURAL DESIGN, I - WALL FILE NO. 7622
CHUTE-TRANSITION AT UP-STREAM END SHEET NO. 9 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFM DATE 3-1-79 CHECKED BY D. GUP DATE 3-3-79

Sliding Coefficient.

$$\frac{\Sigma H}{\Sigma V} = \frac{0.254}{2.978} = 0.085 < 0.60 \text{ O.K.}$$

4. Stresses on Foundation

$$e = x' - \frac{l}{2} = 2.967 - 4.0 = -1.033 < \frac{l}{6}$$

(Resultant within Middlethird)

$$f_x = \frac{V}{l^2} (l - 6e) + \frac{V}{l^3} (12e)x$$

$$= 0.6607 - .0721 x$$

$$f_0 = 0.6607 \quad \text{K/ft}^2$$

$$f_{1.5} = 0.5525$$

$$f_{3.0} = 0.4444$$

$$f_{4.5} = 0.1920$$

$$f_{8.0} = 0.0839$$

All < 2.0 $\therefore$ O.K.

Uplift

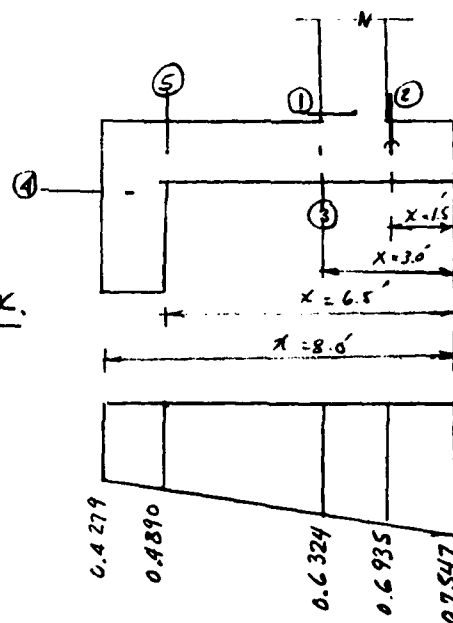
$$U_0 = 1.5 \times 0.0625 = 0.094 \quad \text{K/ft}$$

$$U_{1.5} = (1.5 + \frac{1.5}{2}) \times 0.0625 = 0.141$$

$$U_{3.0} = (1.5 + \frac{3.0}{2}) \times 0.0625 = 0.1875$$

$$U_{4.5} = (1.5 + \frac{4.5}{2}) \times 0.0625 = 0.297$$

$$U_{8.0} = (1.5 + \frac{8.0}{2}) \times 0.0625 = 0.344$$



Total Stress.

@ x = 0	0.6607 + 0.094	=	0.7547	K/ft ²
x = 1.5	0.5525 + 0.141	=	0.6935	"
x = 3.0	0.4444 + 0.188	=	0.6324	"
x = 4.5	0.1920 + 0.297	=	0.4890	"
x = 8.0	0.0839 + 0.344	=	0.4279	"

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SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 7622
CHUTE - TRANSITION AT UPSTREAM END SHEET NO. 10 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY LFM DATE 3-1-79 CHECKED BY qbur DATE 3-3-79

5. STRESS ANALYSIS.

PT	(N) Normal Force		(A) Shearing Force		Arm	(M) Moment	
	Comps	Values	Comps	Value		Comps	Value
①	$1.5 \times 6.0 \times 1.15$	1.350	$.3625 \times 4^{3/2}$	0.500	1.33	0.500×1.333	0.667
②	$(0.094 + 0.281) \frac{1.5}{2}$	0.231	$(0.7547 + 0.6935) \frac{1.5}{2}$	1.086	0.75	0.748×0.75	0.561
	$\frac{0.254}{8} \times 1.5$ comp.	0.048 0.329	$-(1.5 \times 1.5) 1.5$	-0.338 .748	0.75		
③	$-0.0625 \times 4^{3/2}$	-0.500	$6 \times 1.5 \times 1.5$	+1.350	0.75	$+1.350 \times 0.75$	+1.013
	$+ (0.094 + 0.281) \frac{1.5}{2}$	+0.281	$+ 3 \times 1.5 \times 1.5$	+0.675	1.50	$+ 0.675 \times 1.50$	+1.013
	$+ \frac{0.254}{8} \times 3$	+0.095	$-(.7547 + .6324) \frac{3}{2}$	-2.081	1.5	-2.081×1.5	-3.121
	Tens.	-0.124		-0.056		(W) 0.5×2.08	+1.042 -0.050
④	$-2.5 \times 1.5 (.15 - .0625)$	-0.328	$(.094 + .281) \frac{2.5}{2}$	+0.469	0.833	$+ 0.469 \times .833$	+0.390
	$+ (.4890 + .4279) \frac{1.5}{2}$	+0.688	$+ (.025 + 0.76) \frac{2.5}{2}$	+1.250	1.667	$+ 1.250 \times 1.667$	+2.084
			$-(.075 + .344) \frac{2.5}{2}$	-0.524	0.833	$- 0.524 \times .833$	-0.436
			$-(.127 + 0.50) \frac{2.5}{2}$	-0.784	1.667	$- 0.784 \times 1.667$	-1.306
	Comp.	0.360		0.411			0.732
⑤	$+ 0.25 \times 4^{1/2}$	+0.500	$1 \times .0625 \times 1.5$	+0.375	.583	$0.500 \times .583$	-.292
	$+ 0.500 \times 4^{1/2}$	+1.000	$+ 4 \times .15 \times 1.5$	+0.900	1.917	1.000×1.917	-1.917
	$+ 0.075 \times 2.5^{1/2}$	+0.094	$- 2.5 \times .462 \times 1.5$	-0.234	1.583	0.094×1.583	-0.149
	$+ 0.127 \times 2.5^{1/2}$	+0.159	$-(.4279 + .489) \frac{1.5}{2}$	-0.688	2.417	0.159×2.417	-0.384
	$-(0.094 + .281) \frac{2.5}{2}$	-0.469			1.583	0.469×1.583	+0.743
	$-(0.25 + 0.76) \frac{2.5}{2}$	-1.250			2.417	1.250×2.417	+3.021
	$- \frac{0.254}{8} \times 1.5$	-0.048			3.25	0.048×3.25	+0.155
				+0.353	0.75	$0.353 \times .75$	-0.264
							+0.913

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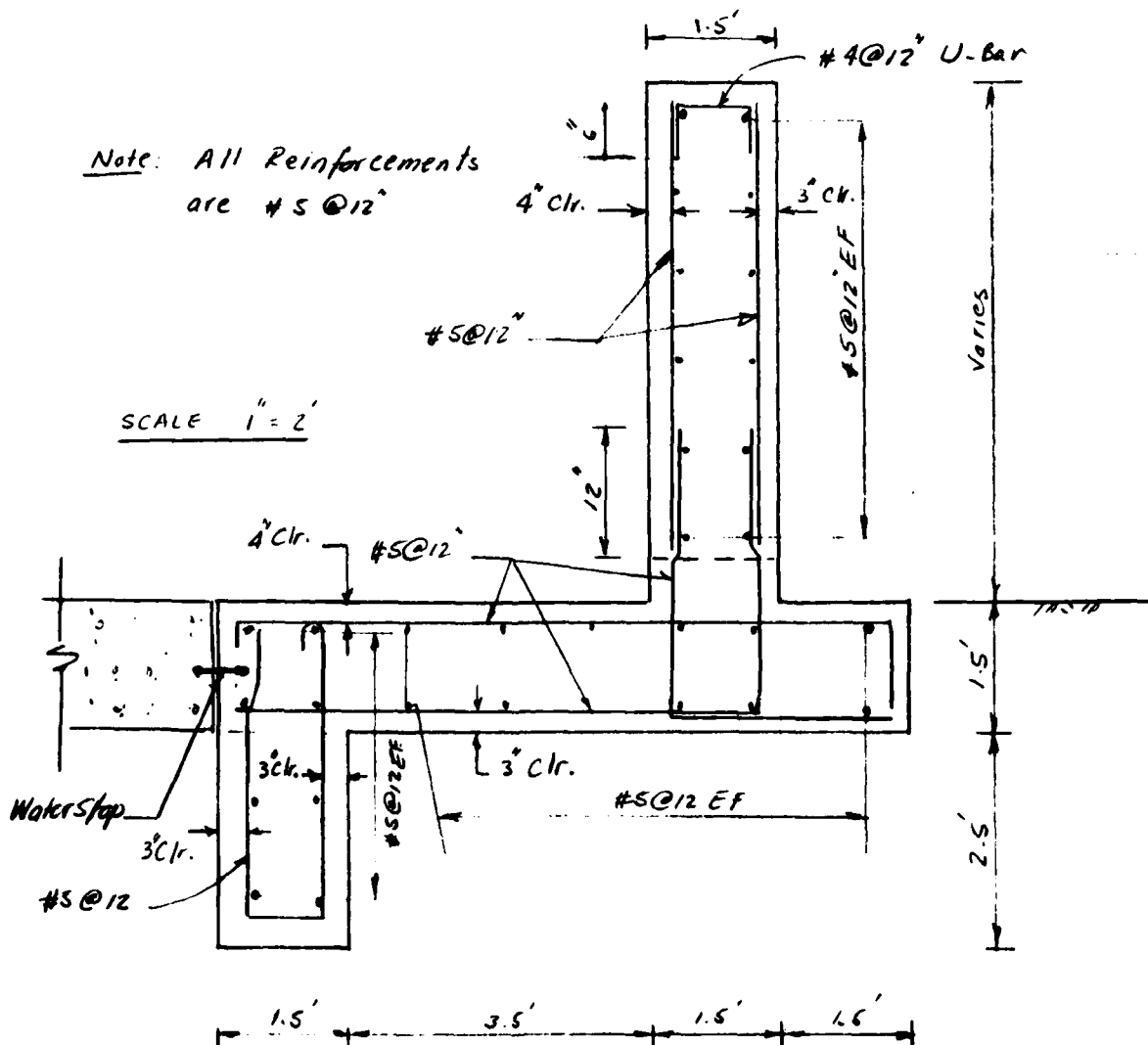
SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 7622
CHUTE - TRANSITION AT UPSTREAM SHEET NO. 11 OF 11 SHEETS
FOR PIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFM DATE 3-2-79 CHECKED BY DBW DATE 3-3-79

Maso Moment = 0.913 K.Ft. , $t = 18'$, $d = 13.5''$

$$A_s_{req} = \frac{M}{\phi A} = \frac{0.913}{1.48 \times 13.5} = .046 \square'$$

$$\text{Temp. Reinf} = \frac{0.125 \times 18 \times 12}{100} = 0.270 \square'$$

USE # 5 @ 12" E.W. E.F.
(.310')



D1-18

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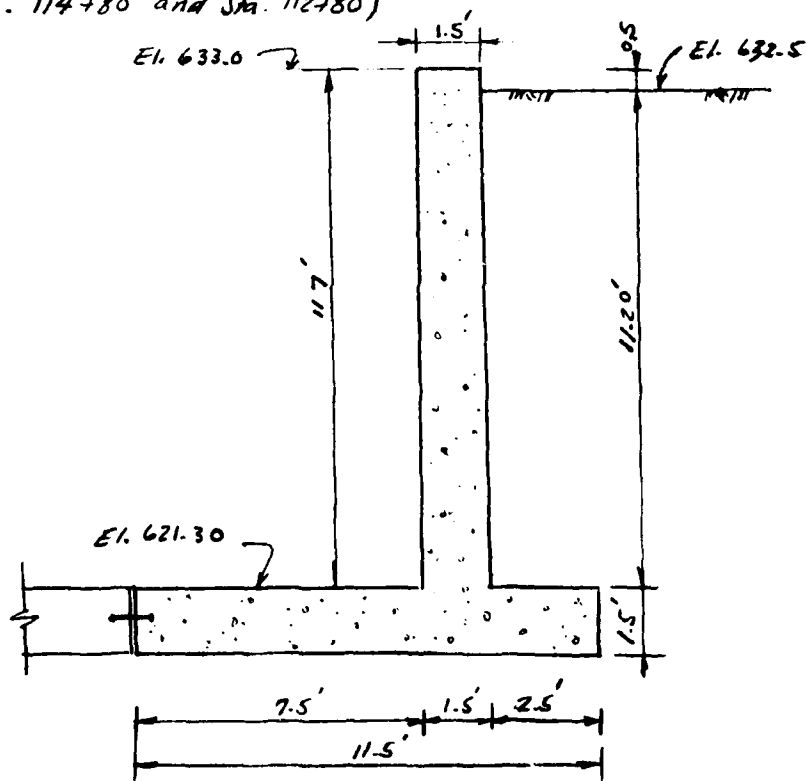
SUBJECT STRUCTURAL DESIGN, L WALL FILE NO. 7622
CHUTE-TRANSITION AT UPSTREAM END SHEET NO. 12 OF 12 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFM DATE 3-2-79 CHECKED BY D/SW DATE 3-2-79

II. REACH "B"

SUDDEN DRAWDOWN CONDITION

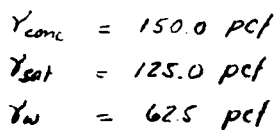
(1) Critical Section Dimension.

(Betn. Sta. 114+80 and Sta. 112+80)



D1-19

SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 7622
CHUTE - TRANSITION AT UPSTREAM END SHEET NO. 13 OF SHEETS
 FOR BIG CREEK FLOOD CONTROL PROJECT
 COMPUTED BY FFLI DATE 3-2-79 CHECKED BY DSW DATE 3-3-79



$$K_{act} Y_{sat} = 0.0417 \text{ K/ft}^2$$

$$K_{ac} Y_{sub} + Y_w = 0.833 \text{ "}$$

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SUBJECT STRUCTURAL DESIG, L. WALL FILE NO. 7622
CHUTE TRANSITION AT UPSIDEAL END SHEET NO. 14 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFM DATE 3-2-79 CHECKED BY DJW DATE 3-2-79

3. Stability Table.

Item	Computations	Horiz ←	VERTICAL		Arm	Moment @ 0	
			↓	↑		↷	↶
Conc.	11.7 X 1.5 X 0.150		2.633		8.25	21.722	
	11.5 X 1.5 X 0.150		2.588		5.75	14.878	
Soil	11.2 X 2.5 X 0.125 (wt)		3.500		10.25	35.875	
	$7.6^2 \times 0.0417 / 2$	1.204			7.63		9.191
	$7.60 \times 5.10 \times 0.0417$	1.616			2.55		4.120
	$5.1^2 \times 0.0833 / 2$	1.083			1.70		1.842
uplift	3.0 X .0625 X 11.5			2.156	5.75		12.398
	(5.1-3.0) .0625 X 4/2			0.263	10.162		2.674
		3.903	8.721	2.419		72.475	30.225
Total.		3.903	6.302		6.704	42.250	

$$e = .954 < \ell/6 \text{ OK.}$$

Sliding factor. $\frac{\sum H}{\sum V} = \frac{3.903}{6.302} = .619 \approx 0.6 \text{ Assume OK.}$

4. Stresses on the foundation.

$$f_x = \frac{V}{\ell} (1 - 6e) + \frac{V}{\ell^2} (12e) x$$

$$= 0.275 + .0474 x$$

		Uplift.	Total.
$f_0 = 0.275$	K/ft ²	0.1875	0.4625
$f_{2.5} = 0.465$	"	0.1875	0.6522
$f_{7.5} = 0.631$	"	0.1875	0.8183
$f_{9.0} = 0.702$	"	$[(5.1-3.0) \frac{1.5}{4} + 3] .0625$	0.9383
$f_{11.5} = 0.821$	"	$\frac{0.2367}{5.1 \times .0625} = .3188$	1.1398

All < 2.0 ~ O.K.

$$\sum H/\ell = 3.903/11.5 = 0.339 \text{ K/A}^2$$

DI-21

**GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.**

SUBJECT STRUCTURAL DESIGN, L. WALL FILE NO. 1612
SHUTE TRANSITION AT UPSTREAM END SHEET NO. 15 OF SHEETS
 FOR EIG CREEK FLOOD CONTROL PROJECT
 COMPUTED BY FFM DATE 3-2-79 CHECKED BY QHR DATE 3-2-79

S. Stress Analysis

PT.	(N) Normal Force		(Q) Shearing Force		Arm	(M) Moment	
	Comps	Value	Comps	Value		Comps	Values
①	8.1 x 1.5 x .15	1.823	7.6 ² x .0417/2	1.204	2.533	1.204 x 2.533	3.051
②	11.7 x 1.5 x .15	2.633	7.6 ² x .0417/2	1.204	6.133	1.204 x 6.133	7.384
			7.6 x 3.6 x .0417	1.141	1.800	1.141 x 1.800	2.054
			3.6 ² x .0833/2	0.540	1.200	0.540 x 1.20	0.648
		2.633		2.885			10.086
③	0.6169 x 1.5/2	0.4627	11.2 x 2.5 x .125	+ 3.500	1.25	3.5 x 1.25	+ 4.375
	+ 0.7418 x 1.5/2	+ 0.5564	1.5 x 2.5 x .15	+ 0.563	1.25	0.563 x 1.25	+ 0.703
	- 0.339 x 2.5	- 0.848	- 0.9383 x 2.5/2	- 1.173	0.833	1.177 x 0.833	- 0.977
			- 1.1398 x 2.5/2	- 1.425	1.667	1.425 x 1.667	- 2.375
		0.1711		+ 1.961			+ 1.726
④	0.339 x 4.0	1.356	0.4625 x 4/2	0.925	2.667	0.925 x 2.667	2.467
			0.6522 x 4/2	1.304	1.333	1.304 x 1.333	1.739
			- 1.5 x .15 x 4	- 0.900	2.00	0.900 x 2.00	- 1.800
		1.356		1.329			2.406
⑤	0.339 x 7.5	2.543	0.4625 x 7.5/2	1.734	5.00	1.734 x 5.00	8.672
			0.8182 x 7.5/2	3.069	2.50	3.069 x 2.50	7.672
			- 1.5 x .15 x 7.5	- 1.688	3.75	1.688 x 3.75	- 6.328
		2.543		3.115			10.016

DI-22

5a. Reinforcement Design.

Reference: ACI Publication SP-3, Reinforced
Concrete Design Handbook, Working
Stress Method.

Terminology of Non-Standard Terms

N = Axial load normal to cross section (kips)

E = Eccentricity measured from tensile
steel axis (ft.)

K = Coefficient; $K = \frac{fcj k}{2}$

F = Coefficient used to determine the
ability of section to resist moment
 $F = bd^2 / 12000$

NE = Moment at the axis of tensile
steel for section subject to bending
combined with normal load.

KF = The resisting moment of the section
by the tensile reinforcement only
(without compression steel)

a = coefficient in $A_s = \frac{M}{ad}$ and in $A_s = \frac{NE}{adi}$

A_s = Area of tensile reinforcement

M = External moment (ft.-kips)

d = Effective depth of flexural members (in.)

$i = \frac{1}{1 - \frac{jd}{e}}$; e = eccentricity in inches

DI-22a

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 7622
CHUTE-TRANSITION AT UPSTREAM END SHEET NO. 16 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFM DATE 3-2-79 CHECKED BY D/BW DATE 3-3-79

6. Reinforcement Requirements.

At pt ①
=====

$$M = 3.051^K, \quad N = 1.823^K \text{ comp.}$$

$$Q = 2.533^K$$

$$t = 18', \quad b = 12', \quad d = 14.5', \quad d' = 5.5'$$

$$e = \frac{12(M)}{N} + d' = \frac{12(3.051)}{1.823} + 5.5 = 25.58'$$

$$E = e/12 = 25.58/12 = 2.13'$$

$$e/d = 25.58/14.5 = 1.76 \rightarrow \bar{e} = 1.99$$

$$NE = 1.823 \times 2.13 = 3.886 \text{ K.Ft}$$

$$KF = 152 \times 0.21 = 31.920 \quad \text{(No Comp. Reinf. Req.)}$$

$$A_s = \frac{NE}{adi} = \frac{3.886}{1.44 \times 14.5 \times 1.99} = 0.0935 \text{ sq. in.}$$

Use #5 @ 12' (.31 sq')

At pt ②
=====

$$M = 10.086^K, \quad N = 2.633^K \text{ comp.}, \quad Q = 2.885^K.$$

$$\text{try } t = 18', \quad b = 12', \quad d = 14.5', \quad d' = 5.5'$$

$$e = \frac{12(10.086)}{2.633} + 5.5' = 51.47' \rightarrow E = 4.29', \quad \bar{e} = 3.55$$

$$NE = 2.633 \times 4.29 = 11.296 \text{ K.Ft} \quad \bar{e} = 1.33$$

$$KF = 152 \times 0.21 = 31.920 \quad \text{(No Comp Reinf Req.)}$$

$$A_s = \frac{NE}{adi} = \frac{11.296}{1.44 \times 14.5 \times 1.33} = 0.407 \text{ sq in}$$

#5 @ 6' (.62 sq')

$$g = \frac{2.885 \times 1000}{12 \times 14.5} = 16.28 \text{ psi} \quad \text{O.K.}$$

< 60

DI-23

GANNETT FLEMING CORDRY
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HARRISBURG, PA.

SUBJECT STRUCTURAL DESIGN, L-WALL FILE NO. 7622
CHUTE TRANSITION AT UPSTREAM END SHEET NO. 17 OF SHEETS
FOR RIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FFB DATE 3-2-79 CHECKED BY dur DATE 3-2-79

At pt ③ $M = 1.726^{'K}$, $N = 1711^K$ $Q = 1.461^K$

(moment , Normal force are smaller than at pt ①.
∴ Use #5 @ 12" (Min Temp. Reinf.)

At pt ④ $M = 2.406^{'K}$, $N = 1.356^K$ $Q = 1.329^K$

(moment , normal force are smaller than at pt ①
∴ Use #5 @ 12" (Min Temp. Reinf.)

At pt ⑤ $M = 10.016^{'K}$ $N = -2.543^K$, $Q = 3.115^K$

Moment & Normal force are compatible

to those at pt ②

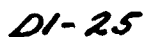
USE #5 @ 6"

$$q = \frac{3115}{14.5 \times 12} = 17.9 < 60 \text{ psi}$$

O.K.

DI-24

SUBJECT STRUCTURAL DESIGN, L- WALL FILE NO. 7622
CHUTE- TRANSITION AT UPSTREAM END SHEET NO. 18 OF SHEETS
 FOR BIG CREEK FLOOD CONTROL PROJECT
 COMPUTED BY FFM DATE 3-2-79 CHECKED BY D/BW DATE 3-3-79



SUBJECT CONCRETE CHUTE-TRANSITION AT FILE NO. _____
UPSTREAM END OF PROJECT SHEET NO. _____ OF _____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-18-79 CHECKED BY AM DATE 3/2/79

SLAB AND SUBDRAINAGE SYSTEM

References

- (1) ETL 1110-2-236, "Design Criteria - Paved Concrete Flood Control Channels", 30 June 1978.
- (2) EM 1110-2-2103, "Details of Reinforcement-Hydraulic Structures", 21 May 1971.
- (3) EM 1110-2-2502, "Retaining Walls", 29 May 61.

Discussion on Design

ETL 1110-2-236 outlines the procedure for design of a paved concrete slab for flood control projects. Although the chute-transition is not exactly a paved channel, some of the design criteria in the ETL is believed to be applicable. An important feature of the design is the subdrainage system. An excerpt from the ETL is as follows: "Selection of locations for soil plugs and drain outlets needs to consider the profile for maximum ground water surface. For cases where the water table will not be above the channel invert, a subdrainage system will not be required."

The chute-transition for the Big Creek Flood Control Project is different from a channel for an ordinary Flood Control Project in that it is not located in the main stream. The present water table at the downstream end of the chute-transition is about 1 foot above slab grade. After completion of the project, it is expected that the normal water table will be below the slab grade. The upstream end of the chute-transition is above the two-barrel conduit.

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SUBJECT CONCRETE CHUTE-TRANSITION AT FILE NO. _____
UPSTREAM END OF PROJECT SHEET NO. _____ OF _____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-14-79 CHECKED BY QHW DATE 3/2/79

SLAB AND SUBDRAINAGE SYSTEM

Discussion on Design (Cont'd.)

The normal water table along this reach is expected to be below the slab grade.

The above factors must be taken into consideration in design. Also, consideration must be given to the fact that the chute-transition will be used as a roadway for John Nagy Boulevard.

Subdrainage System

The subdrainage system will generally consist of 6" gravel drain material on filter material with 6" Dia. perforated pipes placed longitudinally. Outlets will be provided. A plan and section are shown on the following sheets.

Although a subdrainage system may not be required to relieve uplift from the normal water table, a system is needed to relieve uplift from a sudden drawdown condition.

BY FF DATE 2-14-79
CHKD. BY gim DATE 3/2/79

SUBJECT. CONCRETE CHUTE-TRANSITION

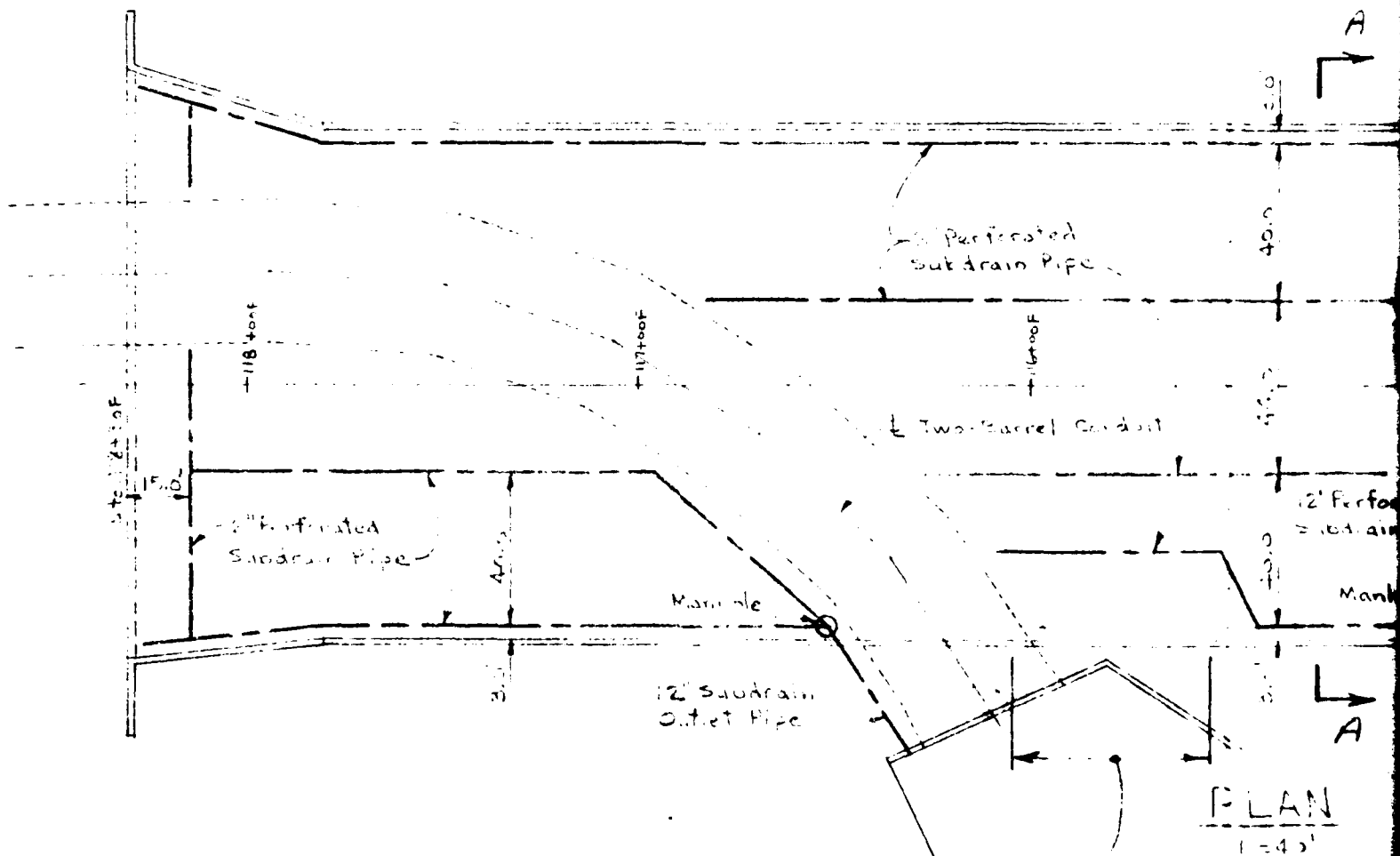
SHEET NO. OF

CHKD. BY *441* DATE *3/2/79*

AT UPSTREAM END OF PROJECT

JOB NO.

BIG CASH FLOW CONTROL PROJECT

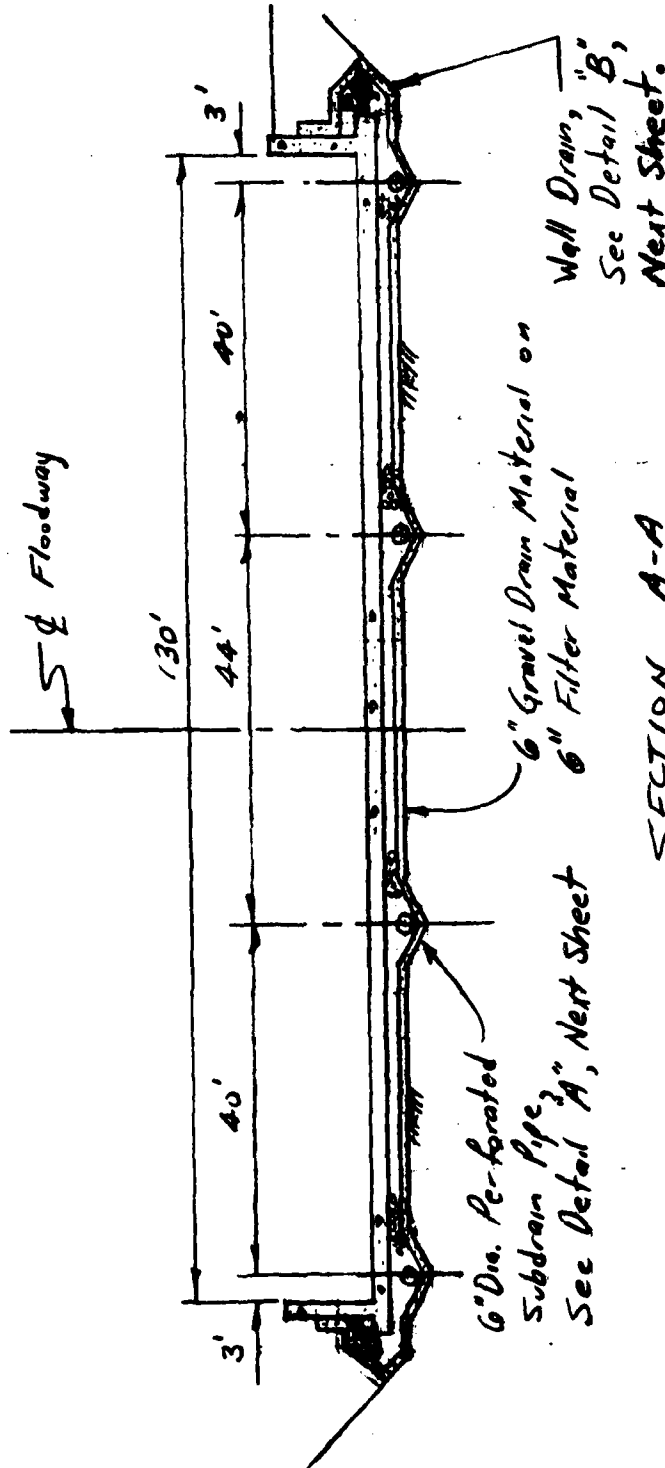


Floodwall Design for
1- Wall Along This Reach

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SUBJECT CHUTE-TRANSITION AT FILE NO. _____
UPSTREAM END OF PROJECT SHEET NO. _____ OF _____ SHEETS
FOR BIG CREEK ROAD CONTROL PROJECT
COMPUTED BY FF DATE 2-14-79 CHECKED BY CHW DATE 3/2/79

SLAB AND SUBDRAINAGE SYSTEM



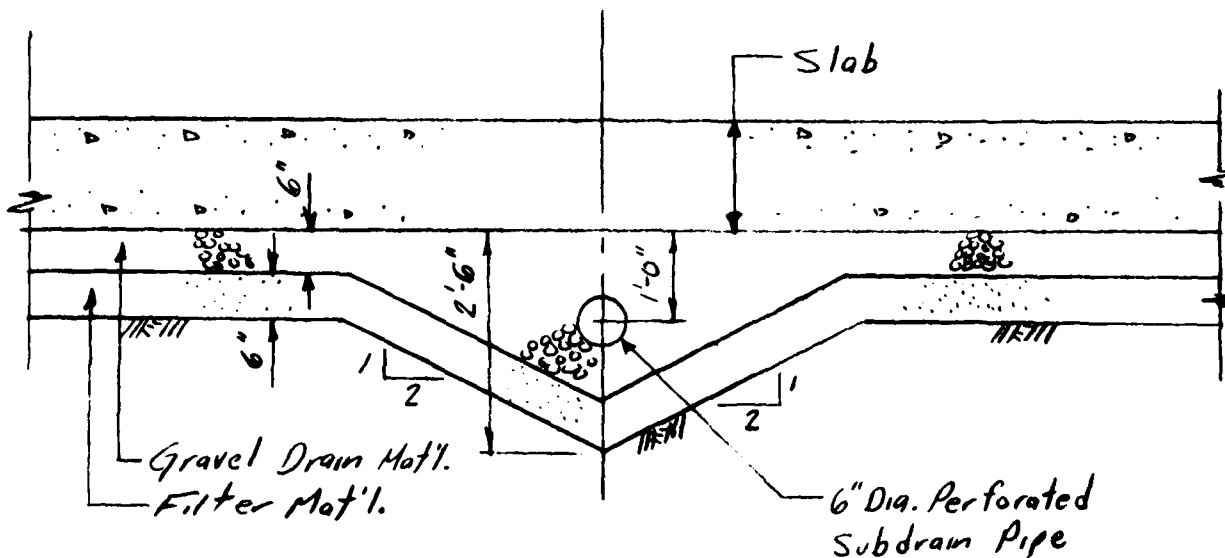
NOTE: Section A-A cut on previous sheet.

DI-29

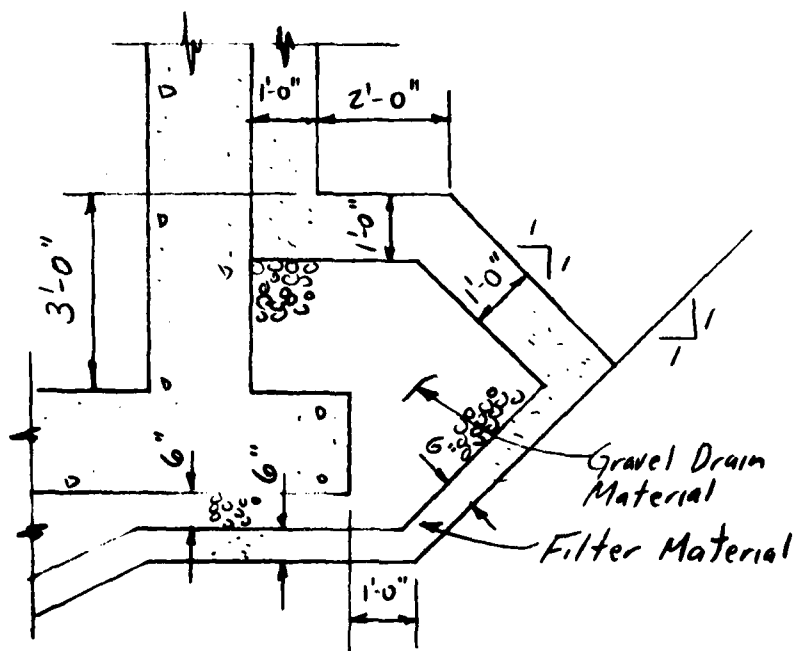
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SUBJECT CHUTE - TRANSITION AT
UPSTREAM END OF PROJECT
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-14-79 CHECKED BY CHW DATE 3/2/79

SLAB AND SUBDRAIN SYSTEM



DETAIL "A"
NOT TO SCALE



DETAIL "B"
NOT TO SCALE

DI-30

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SUBJECT CHUTE-TRANSITION AT FILE NO. _____
UPSTREAM END OF PROJECT SHEET NO. _____ OF _____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-14-79 CHECKED BY QHW DATE 3/2/79

SLAB AND SUBDRAINAGE SYSTEM

Slab Design

1. Compressive strength of concrete = 3,000 psi @ 28 days.
2. Grade 40 reinforcing steel.
3. An excerpt from ETL H10-2-236 is as follows:

"For U-channels, the minimum thickness of the wall and invert slab should not be less than 10" and preferably 12". Other rectangular shaped channels should also have a minimum thickness of wall and footing of 12". "

Base on this, the absolute minimum thickness of the slab is 12".

4. Consideration should be given to the following:
 - a. The chute/transition will be used as a roadway for John Nagy Boulevard.
 - b. A reach of the chute has an 8.7% slope with supercritical velocities.
 - c. The downstream end of the chute acts as a combination transition & stilling basin.
 - d. Although a subdrainage system is provided, the downstream end of the chute/transition has a zero percent slope which could possibly make the subdrainage system less than 100% effective; that is, there could possibly be uplift on the slab after a flood. Because of this, a design criteria established for the slab is that it should be able to resist a uniform uplift equal to a 3-foot hydrostatic head.

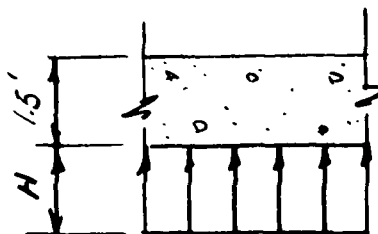
SUBJECT CHUTE-TRANSITION AT UPSTREAM FILE NO. _____
END OF PROJECT SHEET NO. _____ OF _____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-14-79 CHECKED BY AKW DATE 3/2/79

Slab Design - Cont'd.

- e. Because of the openings in the walls at Brookside Park Drive and the Access to the Zoo, the hydraulic performance is uncertain at this part of the chute / transition.
- f. Salt and cinders will probably be placed on John Nagy Boulevard in the winter.
5. Considering the items outlined above, it is believed that a conservative design is warranted, and an 18" thick slab is selected.

6. Uplift.

$$\begin{aligned} 62.5 H &= 1.5 \times 150 \\ H &= 1.5 \times 150 / 62.5 \\ H &= 3.6' \end{aligned}$$



The slab can take an uplift of 3.6'.
This is greater than 3.0 $\therefore$ O.K.

7. Steel Reinforcement for Temperature & Shrinkage

From EM 1110-2-2103, Paragraph 10b (1),
temperature and shrinkage reinforcement = 0.20 % +
0.25 % for slabs exposed to weather = 0.25 %.
This is 0.25 % of gross cross-sectional area
with half in each face.

$$\begin{aligned} .0025 \times 1.5 \times 144 &= 0.54 \text{ IN}^2/\text{FOOT} \\ \frac{1}{2} \times 0.54 &= 0.27 \text{ IN}^2/\text{FOOT TOP \& BOTTOM.} \end{aligned}$$

Use #5 @ 12 Top & Bottom ($A_s = 0.31 \text{ IN}^2/\text{FT.}$)

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HARRISBURG, PA.

SUBJECT CHUTE - TRANSITION AT FILE NO. _____
UPSTREAM END OF PROJECT SHEET NO. _____ OF _____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-14-79 CHECKED BY CLW DATE 3/2/79

Slab Design - Cont'd.

B. Joints

ETL 1110-2-236, Paragraph 6b, recommends continuously reinforced concrete. This would be practical for a long paved concrete channel, but it is not believed to be practical for the chute / transition structure on the Big Creek Project. Generally, the transverse joints (normal to flow) in the slab will be the same as the joints in the walls. EM 1110-2-2502, Paragraph 9b, states that "It has been demonstrated that, to be most effective, the contraction joints generally should be spaced not more than 30 feet apart.

A transverse joint spacing of 25 feet will be used for walls and slab. Longitudinal joints (parallel to flow) will have to vary to fit the geometry but will not be greater than 30 feet.

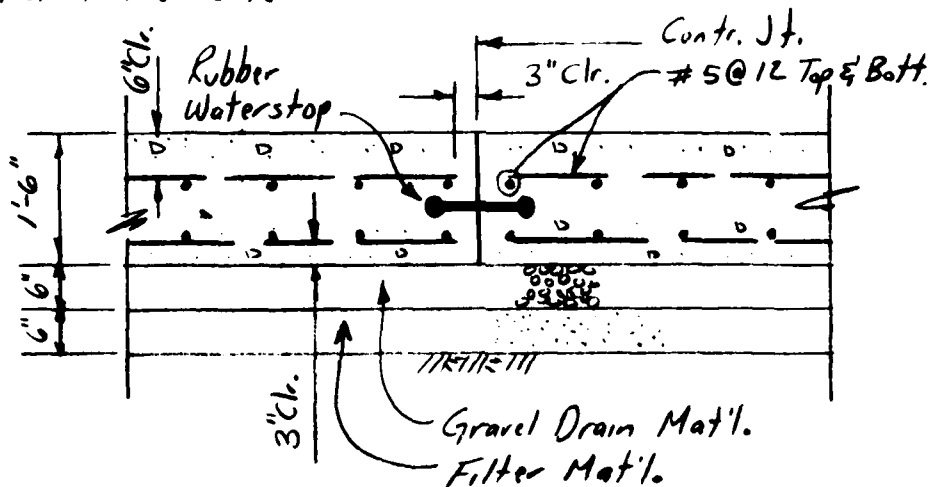
Slab Design - Cont'd.

9. Reinforcing Steel Clearance

From EM 1110-2-2103, Paragraph B, a 6" clear cover is required for formed or screeded surfaces subject to high velocity flows such as ogee weirs and stilling basin slabs.

Because of supercritical velocities on the chute and because it will be used as a roadway for John Nagy Boulevard, a 6" cover is warranted for the top reinforcement.

A 3" clear cover is selected for bottom reinforcement.



CHUTE/TRANSITION SLAB

GANNETT FLEMING CORDRY
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HARRISBURG, PA.

SUBJECT CHUTE-TRANSITION AT FILE NO. _____
UPSTREAM END OF PROJECT SHEET NO. _____ OF _____ SHEETS
FOR BG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-14-79 CHECKED BY QHW DATE 3/2/79

SLAB FOR ACCESS TO UNDERPASS AT BROOKSIDE
PARK DRIVE

The slab section used for the chute/transition will also be used for the slab leading to the underpass. This is believed warranted because of the potential for uplift and because it is part of John Nagy Blvd.

SLAB FOR ZOO ACCESS ROAD

A reduction in slab thickness is believed to be warranted for the Zoo Access Road. The road will not be used frequently, and because it is on a 12% grade the potential for uplift is not great—the subdrainage system should function properly. Clearance requirements for reinforcement is not as great as for the chute/transition and 4" Clr. will be used for top steel.

A 15" slab is selected.

$$\text{Uplift: } H = 1.25 \times 150 / 62.5 = 3.0'$$

The slab can resist an uplift of 3.0' $\therefore$ O.K.

$$\text{Steel Reinforcement: } .0025 \times 1.25 \times 144 = A_s$$

$$A_s = 0.45 \text{ IN}^2/\text{FOOT}$$

$$0.225 \text{ IN}^2/\text{FOOT Top \& Bottom}$$

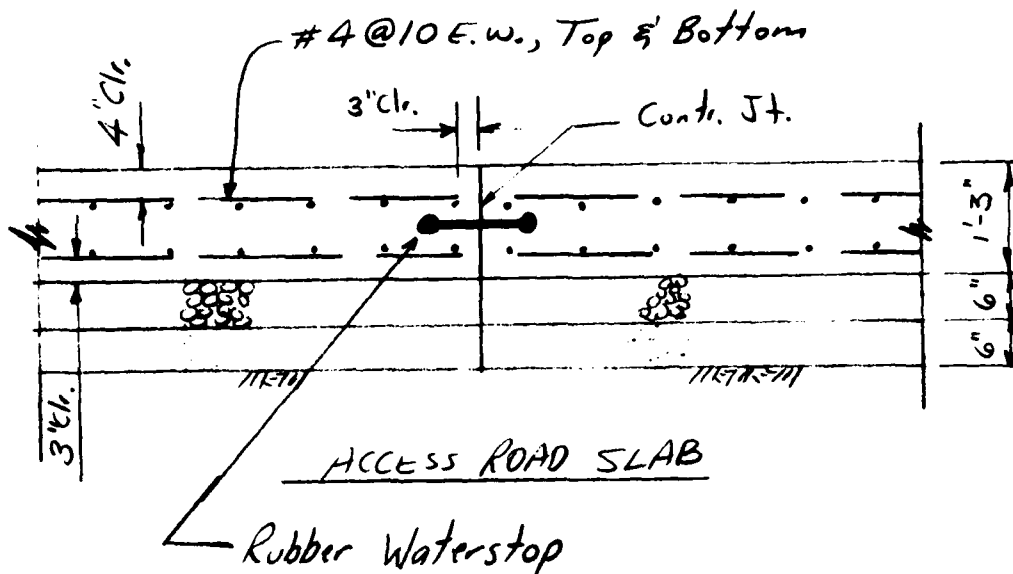
Use #4 @ 10 Top \& Bottom

$$(A_s = 0.24 \text{ IN}^2/\text{FOOT})$$

DI-35

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AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT CHUTE-TRANSITION AT FILE NO. _____
UPSTREAM END OF PROJECT SHEET NO. _____ OF _____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-14-79 CHECKED BY AMW DATE 3/2/79



D1-36

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT _____ FILE NO. _____
SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____

BIG CREEK FLOOD CONTROL PROJECT

STRUCTURAL DESIGN

*CONCRETE TRANSITION AT END
OF THREE-BARREL CONDUIT*

D1-37

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622
OF THREE BARREL CONDUIT SHEET NO. 1 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-26-79 CHECKED BY FFM DATE 3-4-79

LOADING CONDITION FOR L-WALLS

Sudden Drawdown Condition

1. Water in transition at channel grade.
2. Backfill 6 inches below top of wall.
3. Backfill submerged to an elevation midway between the design water surface and channel grade (corresponds to the assumption of a 50% effective drainage system).
4. Backfill above the level of submergence naturally drained.
5. Lateral earth pressure from backfill based on an at-rest pressure coefficient ($K_r = 0.60$).
6. Uplift uniform across the base (pressure equal to reduced hydrostatic head in back fill).

UPLIFT CONDITION FOR MIDDLE SLAB

Slab designed to resist a uniform uplift based on the head from the sudden drawdown condition. (Uplift same as 6, above).

GANNETT FLEMING CORDRY
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SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622
OF THREE-BARREL CONDUIT SHEET NO. 2 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-26-79 CHECKED BY FFM DATE 3-4-79

STABILITY CRITERIA FOR L-WALLS

1. Resultant shall be within the middle half of the base.
2. Shear-friction factor of safety shall not be less than 4.
3. Maximum foundation pressure shall not exceed 10 kips per square foot.

SHEAR-FRICTION FACTOR OF SAFETY

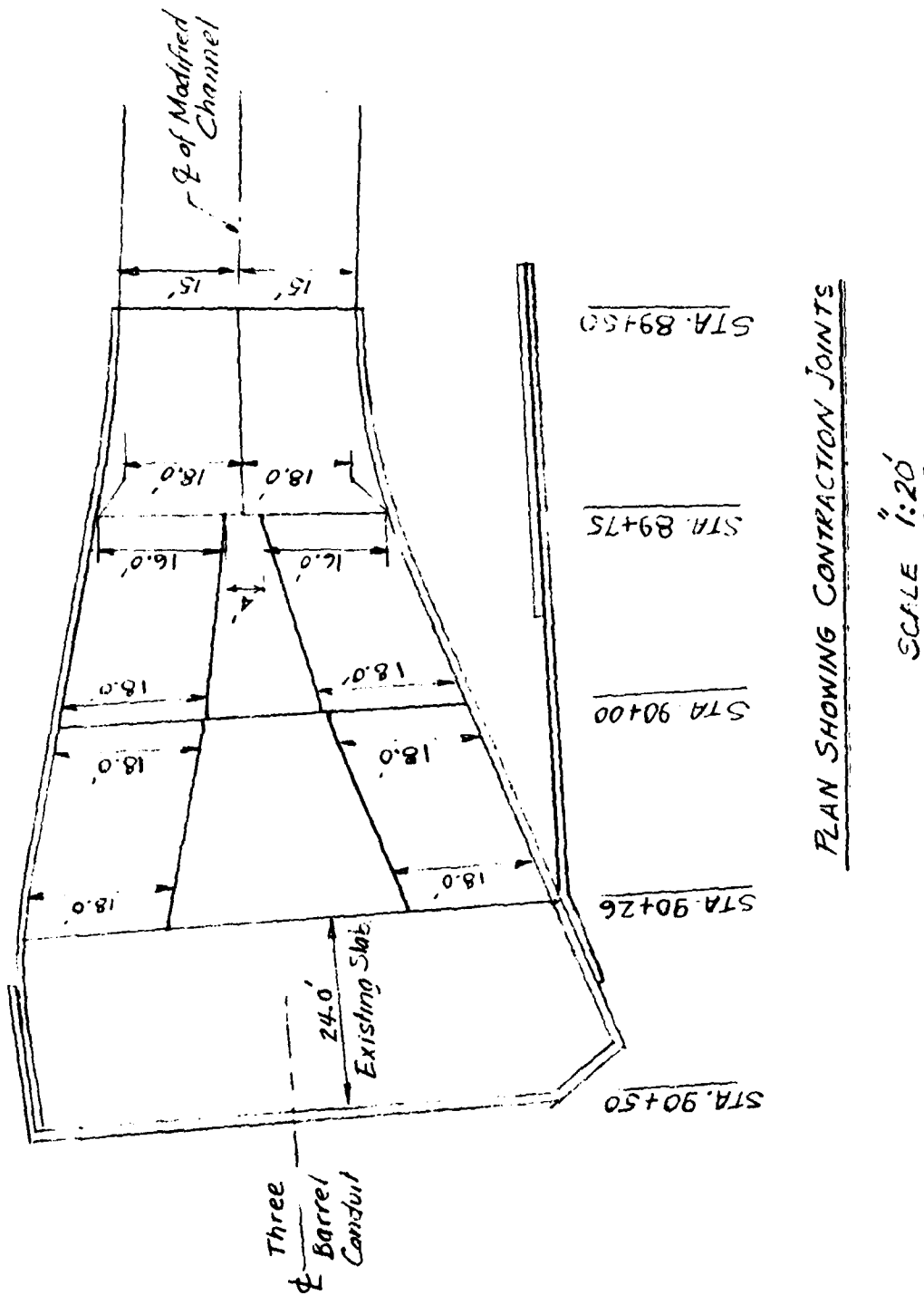
Reference: ETL 1110-2-184, 25 February 1974,
"Gravity Dam Design - Stability".

$$Ss-f = \frac{SA}{\Sigma H}$$

$Ss-f$ = Shear-friction safety factor
 S = Unit shearing strength at zero normal load along failure plane (Use 200 psi)
 ΣH = Sumation of horizontal forces.
 A = Area of resistance.

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SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622
OF THREE BARREL CONDUIT SHEET NO. 3 OF 3 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY FFM DATE 3-4-74 CHECKED BY DATE



DI-40

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SUBJECT CONCRETE TRANSITION AT END FILE NO. _____
OF THREE BARREL CONDUIT SHEET NO. 4 OF _____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 2-27-79 CHECKED BY FEM DATE 3-4-79

UNIT WEIGHTS

Compacted Backfill, moist & saturated — 125 lb/ft^3
Compacted Backfill, submerged — 62.5
Concrete, Plain & Reinforced — 150
Water — 62.5

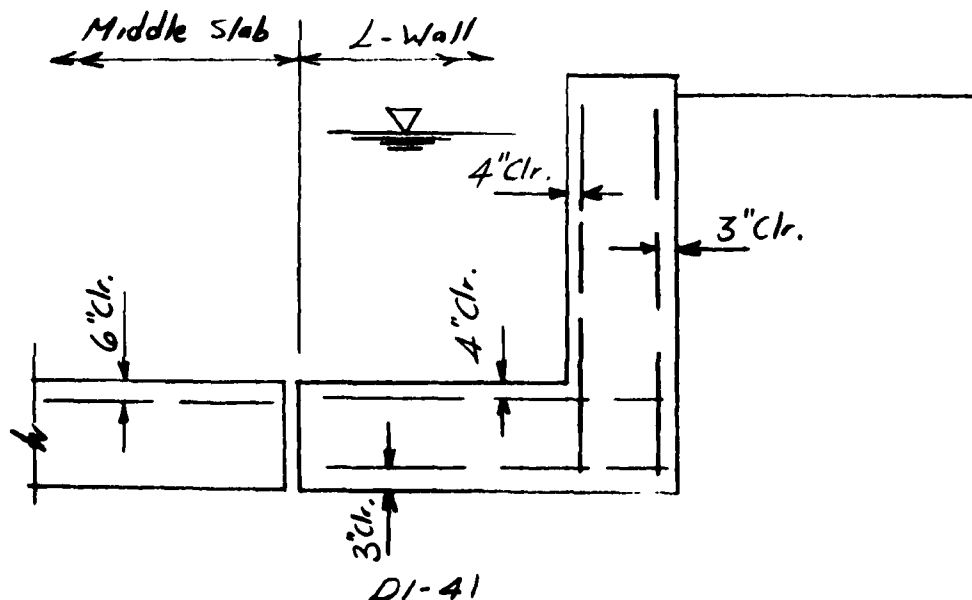
ALLOWABLE STRESSES

Reference: EM 1110-1-2102

$f_c = 1,050 \text{ psi}$
 $f_s = 20,000 \text{ psi}$
 $n = 9.2$

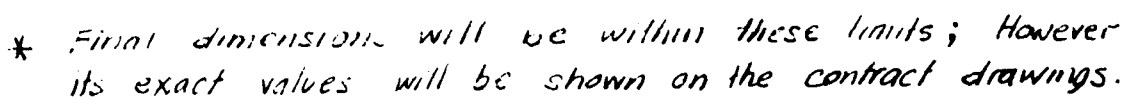
REINFORCING STEEL CLEARANCES

Reference: EM 1110-2-2103



SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622.00
OF THREE BARREL CONDUIT SHEET NO. 5 OF SHEETS
 FOR BIG CREEK FLOOD CONTROL PROJECT
 COMPUTED BY WS DATE 2/29/79 CHECKED BY FFM DATE 3-4-79

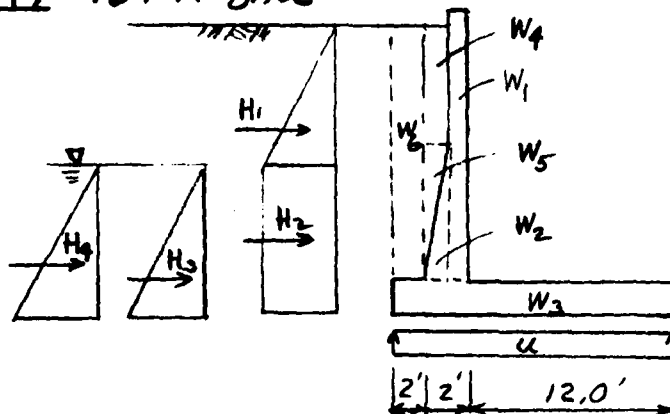
STATION	90+26M	90+00M	89+81.5M	89+75M	89+50M
GRADE	604.95	603.0	601.8	601.4	601.4
TOP OF WALL	616.5	616.5	616.5	616.5	616.5
WATER	613.4	613.4	613.4	613.4	613.4
BACKFILL	616.0	616.0	616.0	607.0	602.0



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HARRISBURG, PA.

SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622.00
OF THREE BARREL CONDUIT SHEET NO. 6 OF 6 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 2/27/79 CHECKED BY EFM DATE 3-4-79

STABILITY - 16 FT. BASE



	VERT.	HORIZ.	ARM	M ₀ (-)	M _R (+)
W ₁ 15.1 X 1.5 X .15	3.40		12.75		43.35
W ₂ 1/2 X 6 X .5 X .15	.23		13.67		3.14
W ₃ 2 X 16 X .15	4.8		8.0		38.40
W ₄ 8.6 X .5 X .125	.54		13.75		7.42
W ₅ 1/2 X .5 X 6 X .125	.19		13.83		2.63
W ₆ 14.6 X 2 X .125	3.65		15.0		54.75
H ₁ 1/2 X .125 X .6 X 8.6 ²		2.77	11.27	31.22	
H ₂ .125 X .6 X 8.6 X 8		5.16	4.0	20.64	
H ₃ 1/2 X .0625 X 8 ²		2.00	2.67	5.34	
H ₄ 1/2 X .0625 X .6 X 8 ²		1.20	3.04	3.65	
U 16 X 8.0 X .0625	- 8.0		8.0	64.0	

4.81 11.13 124.85 149.69
ΣM = 24.84

$$\frac{L}{4} = \frac{16}{4} = 4 \quad e_T = \frac{24.84}{4.81} = 5.16 > 4'$$

Resultant within middle half, ∴ O.K.

$$S_{s-f} = \frac{SA}{\Sigma H} = \frac{.200 \times 16 \times 144}{11.13} = 41.4 > 4, \therefore \text{O.K.}$$

$$f_p = \frac{2 \Sigma V}{3 e_T} = \frac{2}{3} \times \frac{4.81}{5.16} = .62 < 10 \text{ KSF}, \therefore \text{O.K.}$$

* See Page D1-43a

D1-43

Discussion and Reference of Formula: $f_p = \frac{2 \Sigma V}{3 e_t}$

References:

- (1) Foundation Analysis and Design by Joseph E. Bowles, McGraw-Hill, 1972, Page 257.
- (2) Foundation Engineering by Peck, Hanson and Thornburn, John Wiley, 1953, Page 327.
- (3) Design of Concrete Structures by G. Winter and A.H. Nilson, McGraw-Hill, 1972, Page 307.

The formula f_p or $f = \frac{2 \Sigma V}{3 e_t}$ is only

applicable when the resultant falls outside the middle third, i.e. stress distribution is triangular.

ΣV = Total vertical force

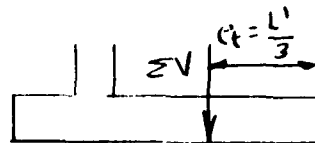
e_t = Distance of resultant from toe = $L'/3$

$$\therefore 3e_t = L'$$

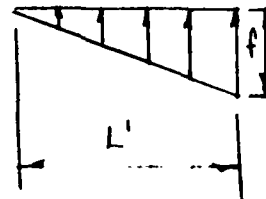
$$\Sigma V = \frac{1}{2} f L'$$

$$2 \Sigma V = f L' = f \times 3e_t$$

$$\therefore f = \frac{2}{3} \frac{\Sigma V}{e_t}$$



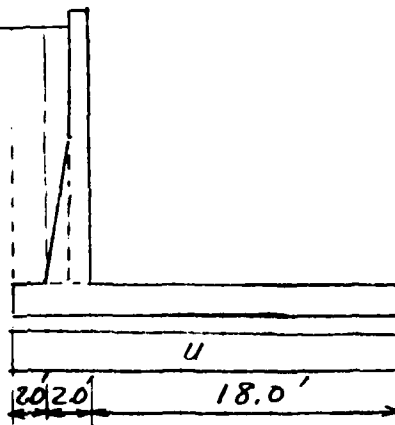
NOTE: The formula used on Page D1-11 and D1-44 is used for trapezoidal stress distribution i.e. when resultant within middle third.



GANNETT FLEMING CORDORY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622.00
OF THREE BARREL CONDUIT SHEET NO. 2 OF 2 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WES DATE CHECKED BY FFM DATE 3-4-79

STABILITY - 22 FT BASE



	VERT.	HORIZ.	ARM	M _o (-)	M _R (+)
W ₁	3.40		18.75		63.75
W ₂	.23		19.67		4.52
W ₃ 22X2X.150	6.6		11.0		72.60
W ₄	.54		19.75		10.67
W ₅	.19		19.83		3.77
W ₆	3.65		21.0		76.65
H ₁				31.22	
H ₂				20.64	
H ₃				5.34	
H ₄				3.65	
U 22X8X.0625	-11.0		11	121.0	
	3.61	11.13		181.85	231.96
				ΣM = 50.11	

$$\frac{L}{4} = 5.50 \quad e_T = \frac{\Sigma M}{\Sigma V} = \frac{50.11}{3.61} = 13.88 < 16.50$$

$$\frac{3}{4}L = 16.50$$

Resultant within middle half, ∴ O.K.

$$S_{s-f} = \frac{\Sigma A}{\Sigma H} = \frac{200 \times 22 \times 144}{11.13} = 56.93 > 4, \therefore \text{O.K.}$$

$$f_p = \frac{\Sigma V}{L} \left[1 \pm \frac{6(L/2 - e_T)}{L} \right] = \frac{361}{22} \left[1 - \frac{6(11 - 13.88)}{22} \right] = .29 \text{ KSF}$$

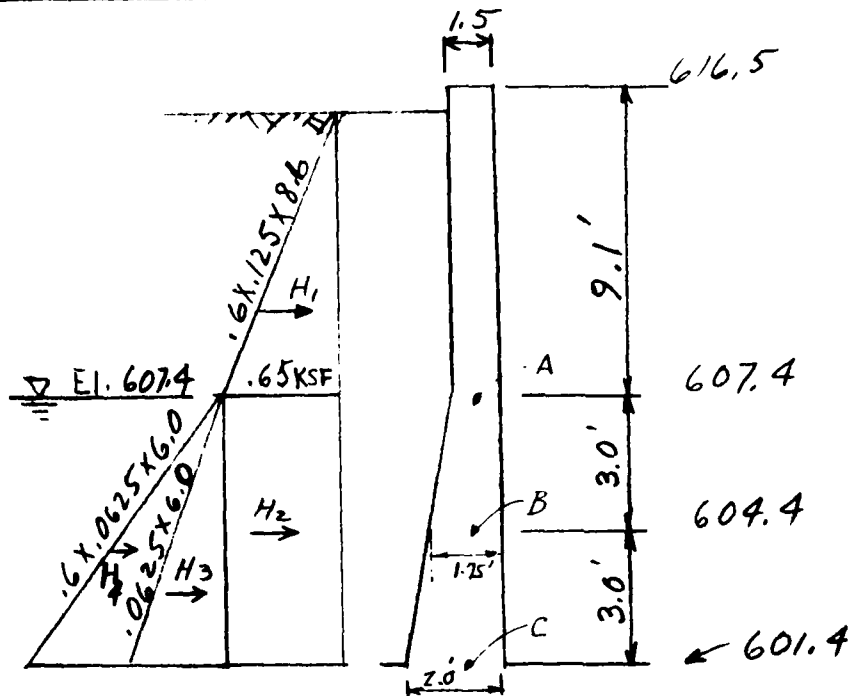
$$f_p < 10 \text{ KSF}, \therefore \text{O.K.}$$

D1-44

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622.00
OF THREE BARREL CONDUIT SHEET NO. 8 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 2/26/79 CHECKED BY FFM DATE 3-4-79

WALL DESIGN



$$M_A = \frac{1}{2} (.6) .125 (8.6)^3 .38 = 9.06 \text{ 'K/1}$$

$$N_A = 1.5 \times 9.1 \times .150 = 2.05 \text{ 'K}$$

$$M_B = \frac{1}{2} (.65) 8.6 (3 + .38 \times 8.6) + .65 \times \frac{3^2}{2} + \frac{.0625 \times 3^2}{2} + \frac{.6 \times .0625 \times 3^3 \times .38}{2}$$

$$M_B = 20.91 \text{ 'K/1}$$

$$N_B = (12.1 \times 1.5 + \frac{.25 \times 3}{2}) .15 + (\frac{.25 \times 3}{2} + .25 \times 8.6) .125 = 3.09$$

$$M_C = \frac{.65 \times 8.6}{2} (6 + .38 \times 8.6) + .65 \times \frac{6^2}{2} + \frac{.0625 \times 6^3}{2 \times 3} + \frac{.6 \times .0625 \times 6^3 \times .38}{2}$$

$$M_C = 41.39 \text{ 'K/1}$$

$$N_C = (15.1 \times 1.5 + .5 \times \frac{6}{2}) .15 + (.5 \times \frac{6}{2} + .5 \times 8.6) .125 = 4.35 \text{ 'K}$$

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SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622.00
OF THREE BARREL CONDUIT SHEET NO. 9 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WJS DATE 3/1/79 CHECKED BY FFM DATE 3-4-79

WALL DESIGN *

POINT A

$$M = 9.06 \quad N = 2.05$$

$$F = \frac{bd^2}{12000} = \frac{12(14.5)^2}{12,000} = 0.21$$

$$M = 9.06$$

$$KF = 152 \times .21 = \underline{31.96}$$

— No A_s'

$$e = \frac{12 \times 9.06}{2.05} + 5.5 = 58.53 \quad E = 4.88$$

$$\frac{e}{d} = \frac{58.53}{14.5} = 4.03 \quad j = .89 \quad i = 1.29$$

$$a = 1.48$$

$$A_s = \frac{NE}{a d^2} = 0.36$$

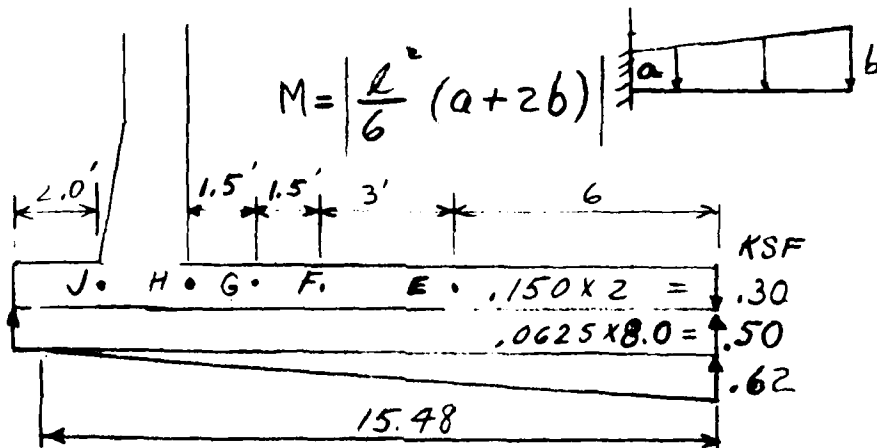
POINT	A	B	C
M K-FT.	9.06	20.09	41.39
N K	2.05	3.09	4.35
t IN.	18	21	24
d IN.	14.5	17.5	20.5
KF	31.96	46.51	63.84
e	58.53	85.53	122.68
NE	10.00	21.88	44.47
i	1.29	1.22	1.17
A_s	.36	.69	1.25

* Design based on use of ACI SP-3, Reinforced Concrete Design Handbook - Working Stress Design. For terminology see Page D1-22a.

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SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622.00
OF THREE BARREL CONDUIT SHEET NO. 10 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 2/27/79 CHECKED BY FEM DATE 3-4-79

FOOTING DESIGN - 16 FT. BASE



$$M_E = \frac{6^2}{6} (.580 + 2 \times .82) = 13.32 \quad \text{Mom. } \frac{\text{K-FT}}{\text{FT.}} \quad A_s^* = \frac{11}{1.48 \times 20.5} = .44 \text{ IN}^2$$

$$M_F = \frac{2^2}{6} (.460 + 2 \times .82) = 28.36 \quad .93$$

$$M_G = \frac{10.5^2}{6} (.399 + 2 \times .82) = 37.50 \quad 1.24$$

$$M_H = \frac{12^2}{6} (.339 + 2 \times .82) = 47.54 \quad 1.57$$

$$M_J = (-3.65 + 2 \times 2.0) + \left(\frac{1}{2} \times .059 \times 1.48 \right) \frac{1.48}{3} = -3.22 \frac{\text{K-FT}}{\text{FT}}$$

$$V = \frac{.82 + .339}{2} \times 12 = 6.954 \text{ K}$$

$$V = \frac{6.954}{12 \times 20.5} = 28 \text{ PSI} < 60 \text{ PSI}$$

O.K. @ Face $\therefore$ O.K. @ $d/2$

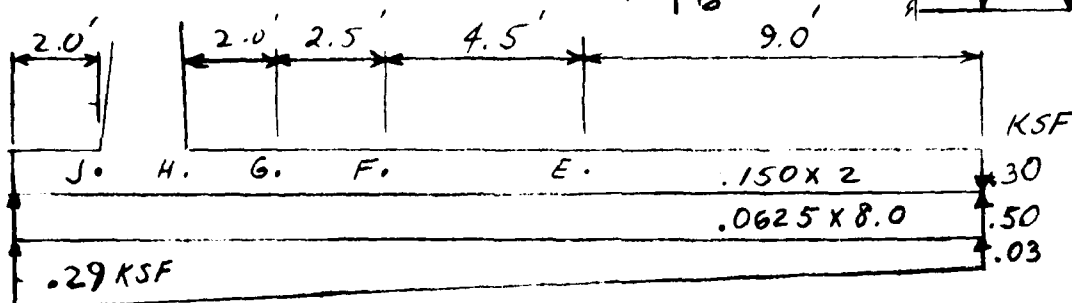
* The effect of normal forces is neglected in computing "A_s"

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SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622.00
OF THREE BARREL CONDUIT SHEET NO. 11 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 2/27/79 CHECKED BY FFM DATE 3-4-79

FOOTING DESIGN - 22 FT. BASE

$$M = \frac{l^2}{6} (2a + b)$$



$$K\text{-FT./FT.} \quad A_s^* = \frac{M}{1.48 \times 20.5}$$

$$M_E = \frac{9^2}{6} (2 \times .336 + .23) = 12.18 \quad .40$$

$$M_F = \frac{13.5^2}{6} (2 \times .389 + .23) = 30.62 \quad 1.00$$

$$M_G = \frac{16^2}{6} (2 \times .419 + .23) = 45.57 \quad 1.50$$

$$M_H = \frac{18^2}{6} (2 \times .442 + .23) = 60.16 \quad 1.98$$

$$M_J = -3.65 + \frac{2^2}{6} (.436 + 2 \times .49) = -2.71 \quad K\text{-FT./FT.}$$

$$V = \frac{.442 + .23}{2} \times 18 = 6.048 \text{ K}$$

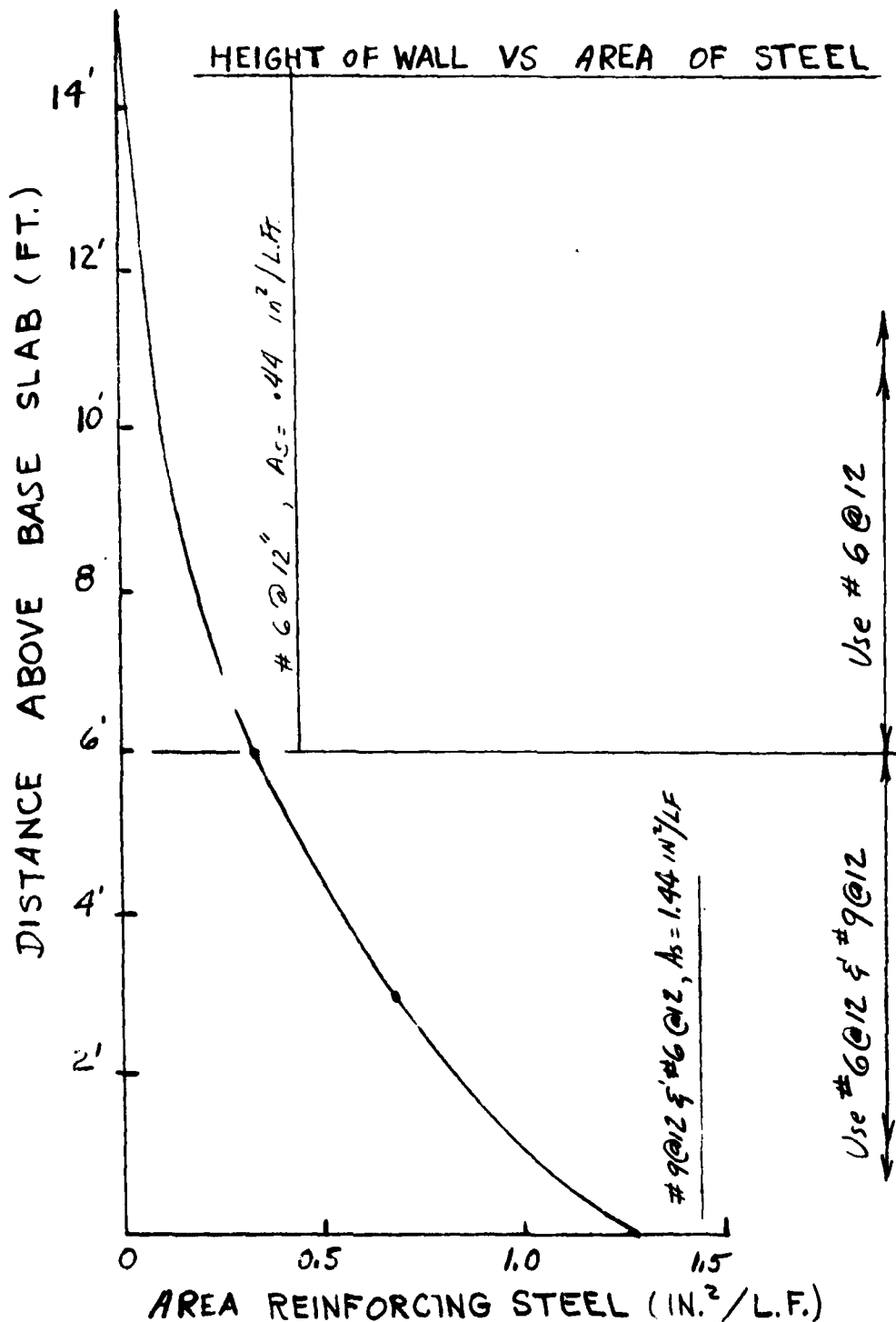
$$V = \frac{6048}{12 \times 20.5} = 24.6 \text{ psi} < 60 \text{ psi}$$

O.K @ Face $\therefore$ O.K @ $d/2$

* The effect of normal forces is neglected in computing A_s

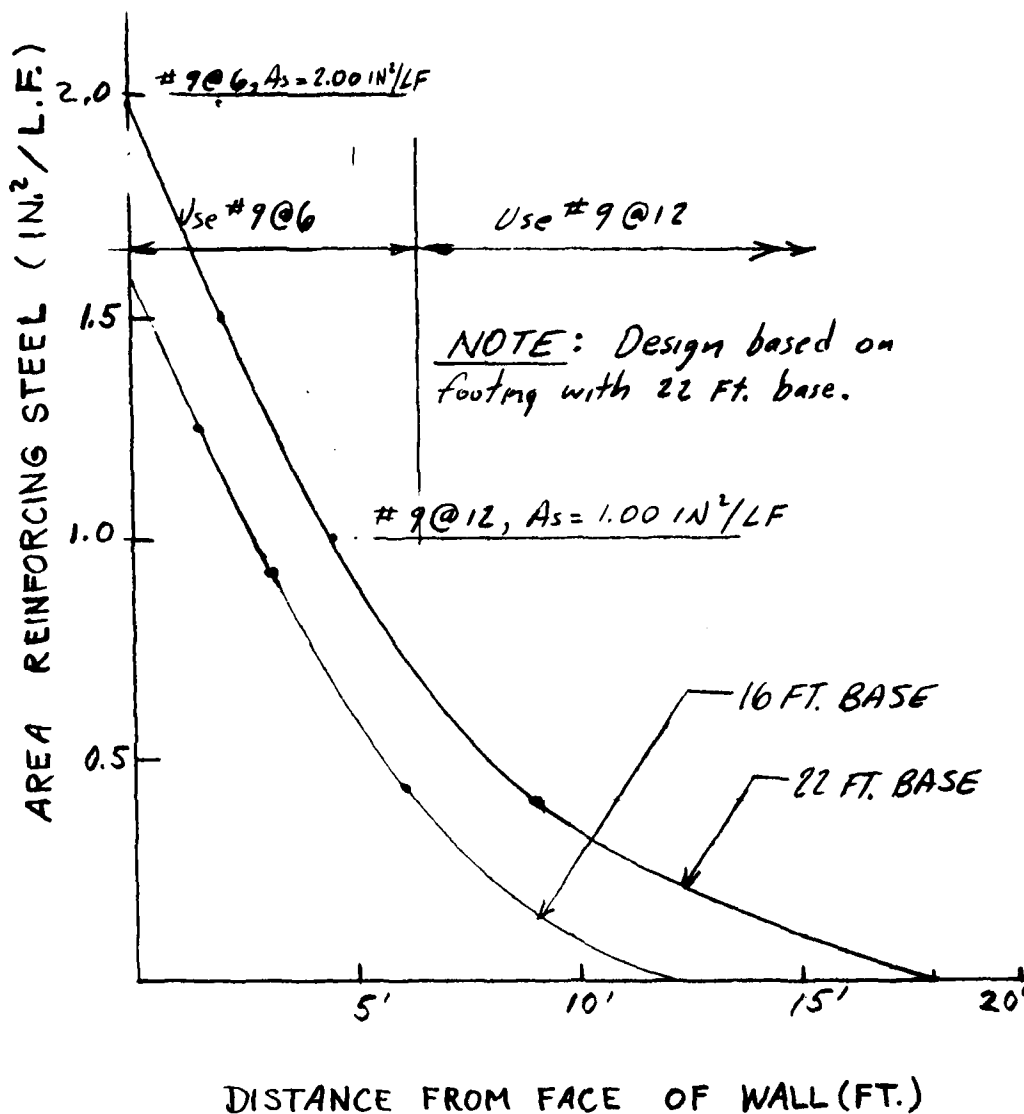
GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622.00
OF THREE BARREL CONDUIT SHEET NO. 12 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 2/28/79 CHECKED BY FFM DATE 3-4-79



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SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622.00
OF THREE BARREL CONDUIT SHEET NO. 13 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 2/28/79 CHECKED BY FFM DATE 3-4-79



AREA OF FOOTING REINFORCING STEEL
VS
DISTANCE FROM FACE OF WALL

SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622
OF THREE-BARREL CONDUIT SHEET NO. 14 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-26-79 CHECKED BY FFM DATE 3-4-79

Temperature & Shrinkage Reinforcement for L-Walls

Reference: EM 1110-2-2103 21 May 1971,
"Details of Reinforcement-Hydraulic
Structures".

For the stem, Paragraph 10 b (1) is applicable.
Cleveland is considered to be in a region with
severe climatic temperature conditions and
25% will be added to the 0.20% of gross area.

$$0.20\% \times 1.25 = 0.25\%$$

$A_s = 0.0025 \times$ gross cross-sectional area,
half in each face, with a maximum
of #6 @ 12.

For Stem thickness (t) = 1.5'

$$A_s = 0.0025 \times 1.5 \times 144 = 0.54 \text{ IN}^2/\text{FT.}$$

$$A_s = 0.27 \text{ IN}^2/\text{FT. in each face.}$$

Use #5 @ 12 ($A_s = 0.31 \text{ IN}^2/\text{FT.}$) (Horiz. & Vert.)

For Stem thickness (t) = 2.0'

$$A_s = 0.0025 \times 2.0 \times 144 = 0.72 \text{ IN}^2/\text{FT.}$$

$$A_s = 0.36 \text{ IN}^2/\text{FT. in each face}$$

Use #5 @ 10 ($A_s = 0.37 \text{ IN}^2/\text{FT.}$) (Horiz.)

Use #6 @ 12 ($A_s = 0.44$) (Vertical)

For the slab of the L-wall, Paragraph 10 b (2)
is applicable. As above, add 25%.

$$A_s = 0.20\% \times 1.25 = 0.25\% \text{ of gross area}$$

$A_s = 0.0025 \times$ gross cross-sectional area,
half in each direction in the opposite face (top),
with a maximum of #6 @ 12. No reinforcement is
required in the restrained face (bottom); however,
#4 @ 24 spacer bars will be provided (See Note
Page 01-52).

01-51

GANNETT FLEMING CORDRY
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SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622
OF THREE BARREL CONDUIT SHEET NO. 15 OF 15 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-26-79 CHECKED BY FFM DATE 3-4-79

Slab of the L-wall - Cont'd.

$$A_s = 0.0025 \times 2.0 \times 144 = 0.72 \text{ IN}^2/\text{FT}$$

$$A_s = 0.36 \text{ IN}^2/\text{FT} \text{ in each direction}$$

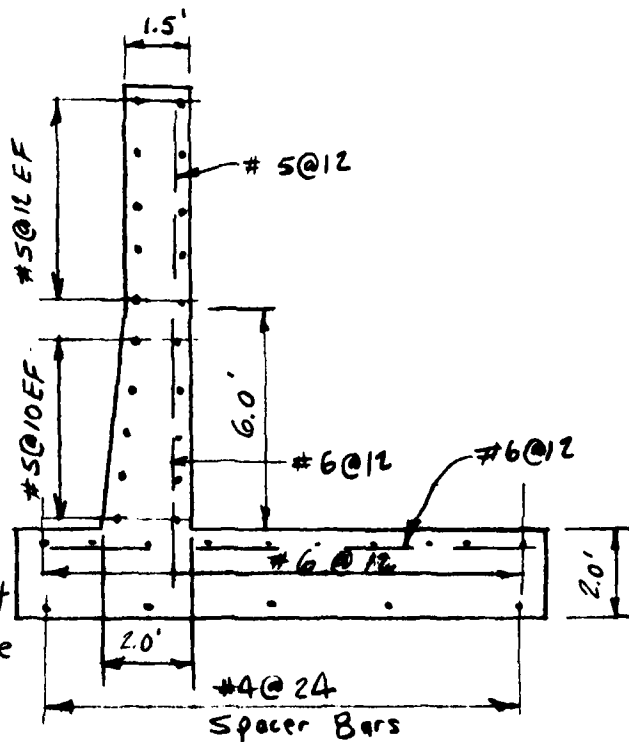
$$\text{Use } \#6 @ 12 \text{ (} A_s = 0.44 \text{ IN}^2/\text{FT.} \text{)} *$$

Main steel will govern for steel normal to wall but shall not be less than $\#6 @ 12$.

* $\#5 @ 10$ ($A_s = 0.37$) would satisfy requirement; however, $\#6 @ 12$ is selected as a conservative design since no reinforcement in bottom (other than spacer bars).

NOTE:

Spacer bars are needed for the main reinforcement at bottom of slab. Size and spacing selected based on engineering judgement. Size and spacing is not considered to be excessive. This size and spacing has been used on similar hydraulic structures.

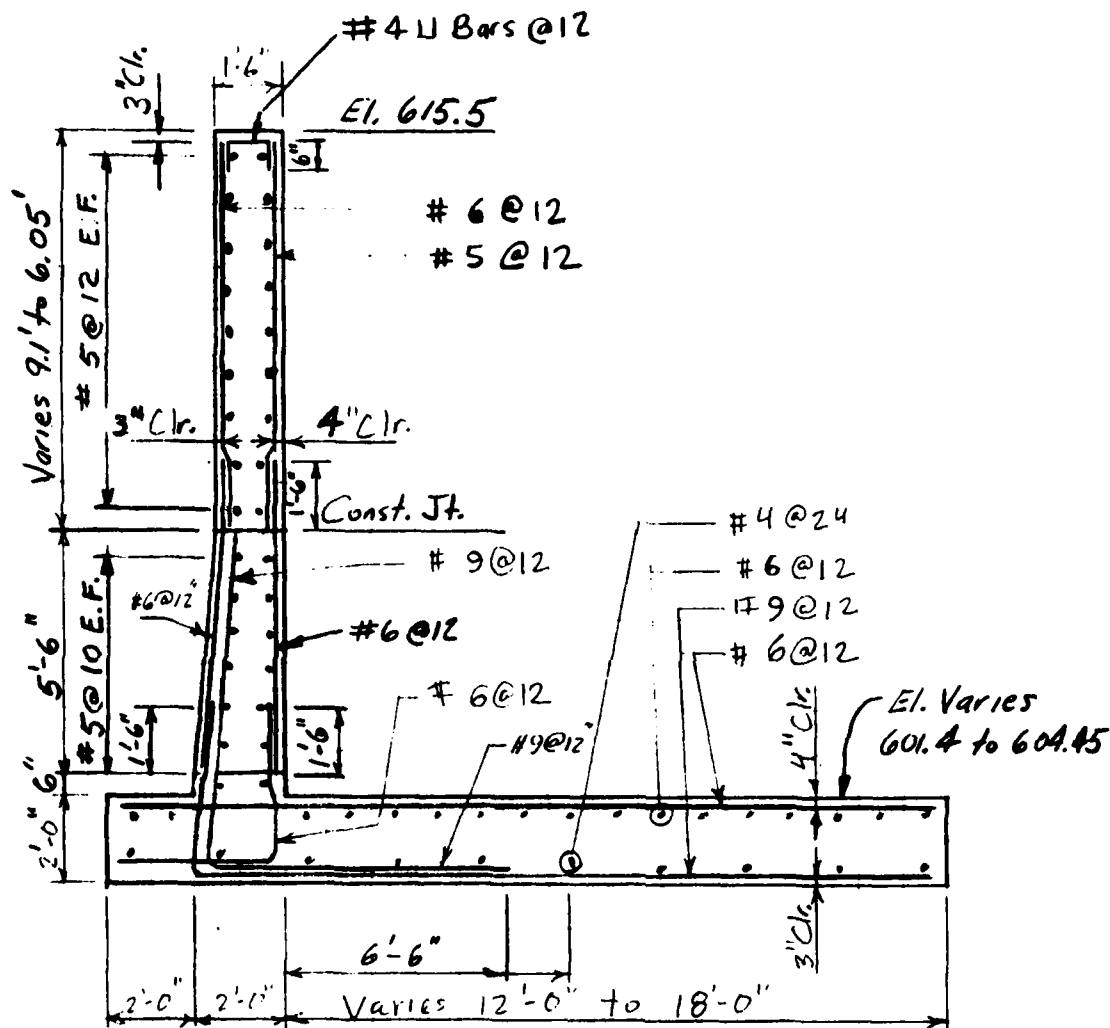


L-Wall

Temperature & Shrinkage Reinforcement

GANNETT FLEMING CORDDRY
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HARRISBURG, PA.

SUBJECT CONCRETE TRANSITION AT END OF FILE NO. 1622.012
THREE-BARREL CONDUIT SHEET NO. 16 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WES DATE CHECKED BY FFM DATE 3-4-79

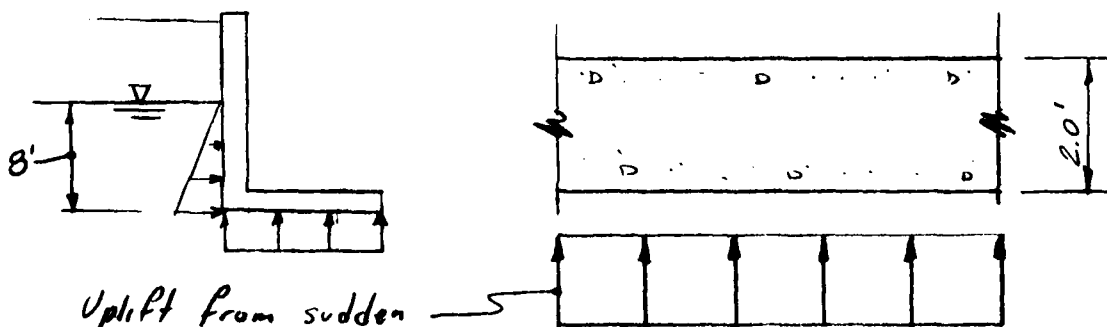


TYPICAL WALL SECTION

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

D1-53

Middle Slab Design



Uplift from sudden
drawdown equal to 8.0' head

$$\begin{aligned} \text{Wt. Concrete} &= 2.0' \times 1.0' \times 10' \times 150 \text{ LB/FT}^3 \\ &= 300 \text{ LB/FT}^2 \end{aligned}$$

$$\text{Uplift} = 8.0 \times 62.5 = 500 \text{ LB/FT}^2$$

$$\text{Uplift} - \text{Wt. Concrete} = 500 - 300 = 200 \text{ LB/FT}^2$$

Anchor Bars needed to resist 200 LB/FT^2 uplift.
Use #11 Hooked Anchor Bar grouted in 3" Dia. drilled
hole. Anchor Bars will extend 10' into rock. Check
anchor bar strength for the following types of failures:

1. Bar failing in tension (Use $f_s = 20,000 \text{ psi}$)
2. Bar & grout pulling out; that is bond failure between grout and rock (Use $\mu = 90 \text{ psi}$)
3. Bar pulls out; that is bond failure between grout and bar (Use $\mu = 140 \text{ psi}$)
4. Hook pulling out.

$$\begin{aligned} \text{Anchor Bar Strength for 1} &= f_s A_s = 20,000 \times 1.56 \\ &= 31,200 \text{ * } \end{aligned}$$

$$\begin{aligned} \text{Anchor Bar Strength for 2} &= L \times C \times \mu \\ &= (10 \times 12) \times D \pi \times 90 = 120 \times 3.0 \pi \times 90 \\ &= 101,790 \text{ * } \end{aligned}$$

Middle Slab Design - Cont'd.

$$\begin{aligned}\text{Bar strength for 3} &= L \times P \times U \\ &= 10 \times 12 \times 4.430 \times 140 \\ &= 74,420 \# \quad \leftarrow\end{aligned}$$

Bar strength for 4
From ACI-318-77, Para. 12.5

$$\begin{aligned}f_h &= \xi \sqrt{f'_c} = 360 \sqrt{3000} = 19,718 \text{ psi} \\ \text{Strength} &= 19,718 \times 1.56 = 30,760 \# \quad \leftarrow\end{aligned}$$

Hook of anchor bar will be hooked over slab reinforcing steel so strength actually more.

For design purposes, use Anchor Bar Strength
 $= 30,000 \#$

$$\begin{aligned}\text{Anchor Bar Spacing: Area} &= 30000 / 200 \# / \text{FT}^2 \\ &= 150 \text{ FT}^2\end{aligned}$$

$\therefore$ One anchor bar needed per 150 ft² of slab.

As a minimum, place anchor bars @
about 10' cc or one per 100 ft².

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SUBJECT CONCRETE TRANSITION AT END FILE NO. 7622
OF THREE-BARREL CONDUIT SHEET NO. 19 OF SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY FF DATE 2-26-79 CHECKED BY FFM DATE 3-4-79

Middle Slab Design - Cont'd.

Temperature & Shrinkage Reinforcement

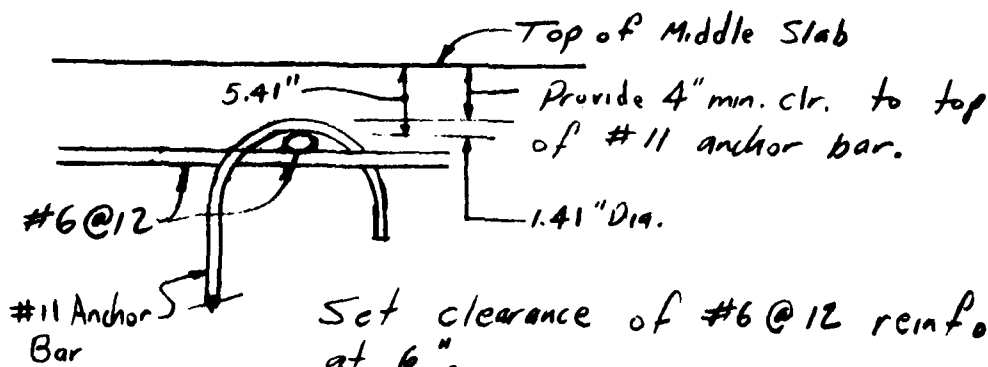
Para. 106(2) of EM 1110-2-2103 is applicable for the slab. Same as for slab of L-wall.

$$A_s = 0.0025 \times 2.0 \times 144 = 0.72 \text{ IN}^2/\text{FT}$$

$A_s = 0.36 \text{ IN}^2/\text{FT}$ in each direction top of slab only.

No reinforcement is required in restrained face (bottom).

Use #6 @ 12 EW ($A_s = 0.44 \text{ IN}^2/\text{FT}$).



GANNETT FLEMING CORDRY
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HARRISBURG, PA.

SUBJECT _____ FILE NO. _____
SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____

BIG CREEK FLOOD CONTROL PROJECT

STRUCTURAL DESIGN

*CONCRETE FLUME AND RETAINING
WALLS AT WEST 25TH ST. BRIDGE*

D1 - 57

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel Flume FILE NO. 7627
SHEET NO. 1 OF 12 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY EFM DATE 3-5-79 CHECKED BY PvdG DATE 2/2/79

The diversion channel flume is designed as an integral U-shape frame. Since the heights of its walls are not constant. The flume has been designed for two different cross-section. For economy and convenience, the whole flume will consist of the following:

1- Reach "A":

from Sta. 69+72 to Sta. 68+54

Section "A" for Left half & Right half.

2- Reach "B":

from Sta. 68+54 to Sta. 68+02

Section "B" for Left half, Sec. "A" for Right half.

3- Reach "C":

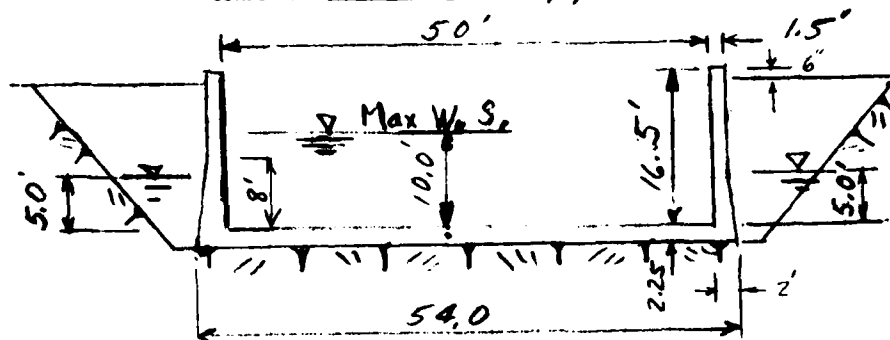
from Sta. 68+02 to Sta. 67+74.

Sec "B" for Left half & Right half.

D1-58

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel Flume FILE NO. 7622.00
SHEET NO. 1-4 OF 15 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY W.S. DATE 3/1/79 CHECKED BY FFM DATE 3-1-79



SECTION "A"

Loading Criteria - Sudden drawdown

Flume Empty

Hydrostatic head in backfill at elevation
midway between flume grade and
maximum water surface elevation.

$$K_r = 0.6$$

Backfill within .5 feet of top of wall

No surcharge loading

$$\begin{aligned} * &\rightarrow 1.5 \times 16.5 \times .15 = 3.713 \\ &+ 0.5 \times 8.0 \times .15 = 0.300 \\ &+ 0.5 \times 8.0 \times .125 = 0.250 \\ &+ 0.5 \times 8.0 \times .125 = 0.500 \\ &\hline &4.763 \end{aligned}$$

Stability

Conc & Soil

$$(2.25 \times 54) \cdot 15 + 2 \times 4.763 = 27.75 \text{ K} \downarrow$$

Uplift

$$54 \times .0625 (5 + 2.25) = \frac{24.47}{3.28} \text{ K} \uparrow \downarrow > 0.0$$

Pressure on foundation

$\therefore$ No Flotation

$$P = \frac{3.28}{54} = .060764 \text{ K SF.}$$

$$\therefore P_s = .060764 + \frac{24.47}{54} = .513889 \text{ KSF}$$

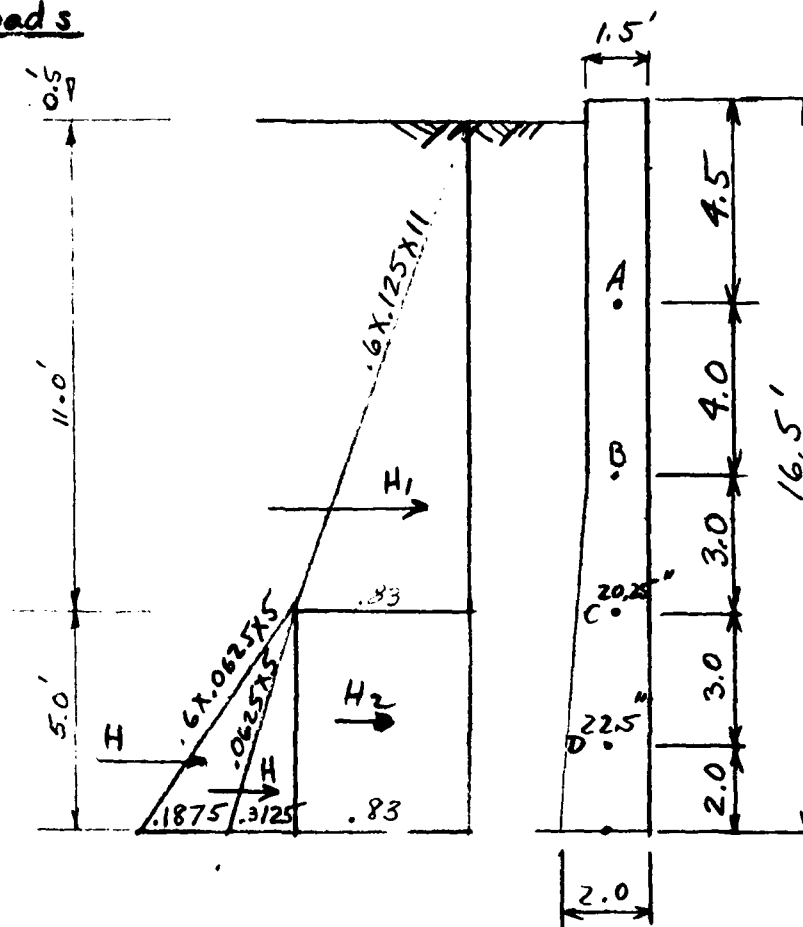
Reaction on slab.

D1-59

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT DIVERSION CHANNEL FLUME FILE NO. 7622.00
SHEET NO. 2 OF 11 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 3/1/79 CHECKED BY FFM DATE 3-5-79

Moments & Loads



$$M_A = \frac{.6 \times .125 \times 4.0^3}{2} \times .38 = .91' K_1$$

$$M_B = \frac{.6 \times .125 \times 8^3}{2} \times .38 = 7.3' K_1$$

$$M_C = \frac{.6 \times .125 \times 11^3}{2} \times .38 = 18.97' K_1$$

$$M_D = \frac{.6 \times .125 \times 11^2}{2} \times 7.18 + \frac{.83 \times 3^2}{2} + \frac{.6 \times .0625 \times 3^3 \times .38}{2} + \frac{.0625 \times 3^2}{2}$$

$$M_D = 36.79' K_1$$

$$M_E = \frac{.6 \times .125 \times 11^2}{2} \times 9.18 + \frac{.83 \times 5^2}{2} + \frac{.6 \times .0625 \times 5^3 \times .38}{2} + \frac{.0625 \times 5^3}{2 \times 3} = 54.22' K_1$$

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT DIVERSION CHANNEL FLUME FILE NO. 7622.00
SHEET NO. 3 OF 15 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY WS DATE 3/1/79 CHECKED BY FEM DATE 3-5-79

Moments & Loads (Contd.)

POINT F

ITEM	DESCRIPTION	VERT	HORIZ.	ARM	MOM.
CONC.	1.5 X 16.5 X .15	3.71		.75	+ 2.78
	.5 X 8.0 X .15	.30		1.67	+ .50
	2.0 X 2.25 X .15	.68		1.00	+ .68
SOIL	.5 X 8 X .125	.5		1.75	+ .88
	.5 X 8/2 X .125	.25		1.83	+ .46
H ₁	11 ² / ₂ X 0.075		4.54	10.305	- 46.78
H ₂	11 X 7.25 X .075		5.98	2.5	- 14.95
H ₃	7.25 ³ / ₂ X .0375		.99	1.63	- 1.61
H ₄	7.25 ³ / ₂ X .0625		1.64	1.297	- 2.12
Found+U	0.513889 X 2.0	- 1.03		1.00	- 1.03
		4.41	13.15		- 61.19

$$N_A = 4.5 \times 1.5 \times .15 = 1.01 \text{ K}$$

$$N_B = 8.5 \times 1.5 \times .15 = 1.91$$

$$N_C = 11.5 \times 1.5 \times .15 + \frac{3.0 \times 2.25}{2} (.15 + .125) + \frac{2.25 \times 8 \times .125}{12}$$

$$N_C = 2.85 \text{ K}$$

$$N_D = 14.5 \times 1.5 \times .15 + \frac{6 \times 4.5}{2 \times 12} (.15 + .125) + \frac{4.5 \times 8 \times .125}{12} = 3.95 \text{ K}$$

$$N_E = (16.5 \times 1.5 + \frac{8 \times 4.5}{2}) .15 + (8 \times .5 + \frac{8 \times 4.5}{2}) .125 = 4.76 \text{ K}$$

AD-A102 433

CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT
BIG CREEK FLOOD CONTROL PROJECT, CLEVELAND, OHIO. PHASE II. GEN--ETC(U)
AUG 79

F/6 13/2

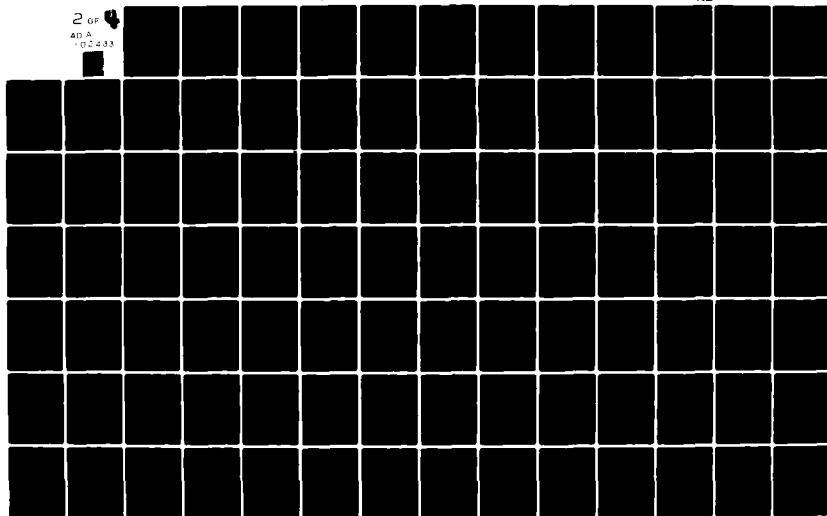
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2 OF 4

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GANNETT FLEMING CORDROY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel Flume FILE NO. 7622.00
SHEET NO. 7 OF 13 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 11/15/78 CHECKED BY WS DATE 1/23/79

Moments & Loads

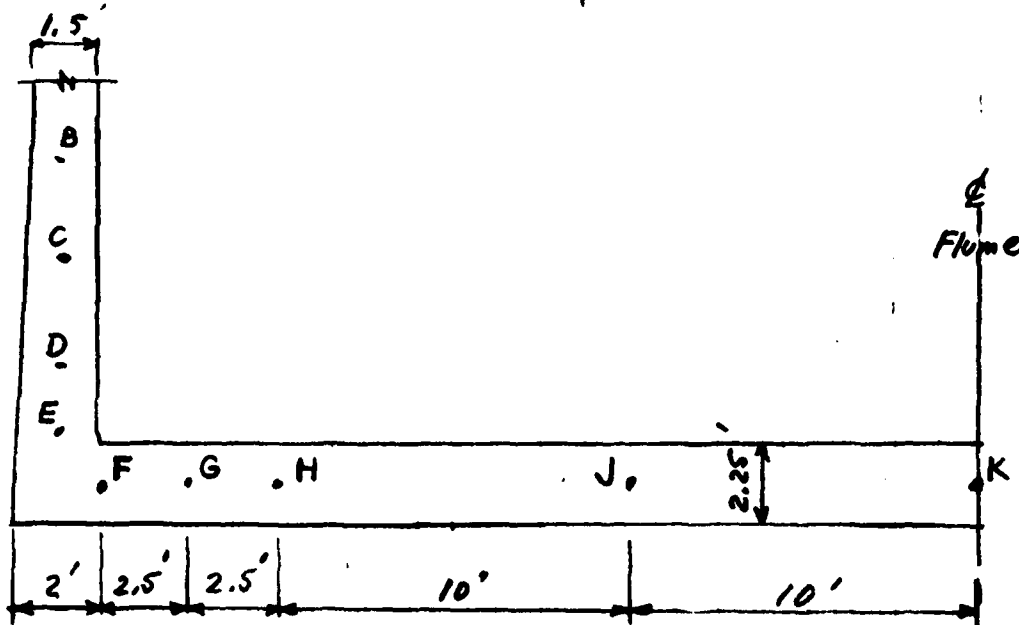
Point G $M = M_F + [w(\text{found. & upl. ft}) - w(\text{concrete})] l^2/2$
 $- V_F l$
 $M = 61.19 + (0.513889 - 2.25 \times 0.150) \times 2.5^2/2$
 $- 4.41 \times 2.5 = 50.72 \text{ kip-ft}$

Point H $M = 61.19 + 0.176389 \times 5.0^2/2 - 4.41 \times 5.0$
 $M = 41.35 \text{ K-ft}$

Point J $M = 61.19 + 0.176389 \times 15^2/2 - 4.41 \times 15.0$
 $M = 14.89 \text{ K-ft}$

Point K $M = 61.19 + 0.176389 \times 25.0^2/2 - 4.41 \times 25.0$
 $M = 6.07 \text{ K-ft}$

Points G to K $N = 13.15 \text{ kips}$



GANNETT FLEMING CORDDRY
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SUBJECT Diversion Channel Flume FILE NO. 7622.00
SHEET NO. 5 OF 12 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 11/10/78 CHECKED BY WS DATE 1/19/79

Concrete Design *

$$f_y = 20.0 \text{ ksi}$$

$$f'_c = 3.0 \text{ ksi}$$

$$n = 9.2$$

$$K = 152 \text{ ①}$$

$$\alpha = 1.48 \text{ ②}$$

$$f_c = 1.05 \text{ ksi}$$

Concrete cover of reinforcing bars

Wall - soil side : 3"

water side : 3"

Slab - soil side : 4"

water side : 4"

* Design based on use of ACI SP-3 Handbook.
For terminology see Page D1-22a

$$\text{① } K = \frac{f_c k j}{2}, \text{ Where } k = \frac{1}{1 + f_y/nf_c}, j = 1 - \frac{1}{3}K$$

K is used in equations :

$$M \leq KF \quad ; \quad F = \frac{bd^2}{12000}$$

$$\text{or } NE \leq KF$$

$$\text{② } a = \frac{f_y j}{12000}, \text{ a is used in equations :}$$

$$A_s = \frac{M}{ad} \quad \text{or} \quad A_s = \frac{NE}{adi}$$

$$\text{Where } i = \frac{1}{1 - j d/e}$$

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SUBJECT Diversions Channel Flume FILE NO. 7622.0D
SHEET NO. 6 OF 13 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 11/14/78 CHECKED BY WS DATE 1/23/79

Concrete Design, Point E, Base of Wall *

$M = 54.22 \text{ k-ft}$	$f_s = 20.0 \text{ ksi}$	$a = 1.48$
$N = 4.76 \text{ kips}$	$f_c = 3.0 \text{ ksi}$	$K = 152$
$t = 24 \text{ inches}$	$f_c = 1.05 \text{ ksi}$	$j = 0.89$
$d = 20.5 \text{ inches}$	$n = 9.2$	$k = 0.326$
$d'' = 8.5 \text{ inches}$		

$$e = \frac{12M}{N} + d'' = \frac{12 \times 54.22}{4.76} + 8.5 = 145.2$$

$$E = e/12 = 12.1$$

$$NE = 4.76 \times 11.99 = 57.60$$

$$KF = 152 \times \frac{20.5^2}{1000} = 63.88$$

$$NE - KF =$$

$$e/d = \frac{145.20}{20.5} = 7.08$$

$$i = \frac{1}{1 - jd/e} = \frac{1}{1 - 0.89/7.02} = 1.15$$

$$A_s = \frac{NE}{adi} = \frac{57.60}{1.48 \times 20.5 \times 1.15} = 1.66 \text{ in}^2/\text{ft}$$

CHECK SHEAR: $V = 1.325 \text{ Kips}$ at base of wall.
 $v = V \times 1000 / bd$

$$v = \frac{1.325 \times 1000}{12 \times 20.5} = 58 \text{ psi} < 60 \text{ psi}$$

O.K. @ edge $\therefore$ O.K. @ $d/2$
from slab.

* Design based on use of ACI SP-3 Handbook.
See Page D1-22a. Also, see Page D1-63.

D1-64

GANNETT FLEMING CORDRY
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SUBJECT Diversions Channel Hume FILE NO. 16-22-00
SHEET NO. 7 OF 13 SHEETS
FOR City Creek Flood Control Project
COMPUTED BY FvdG DATE 11/20/78 CHECKED BY W3 DATE 1/23/79

Concrete Design

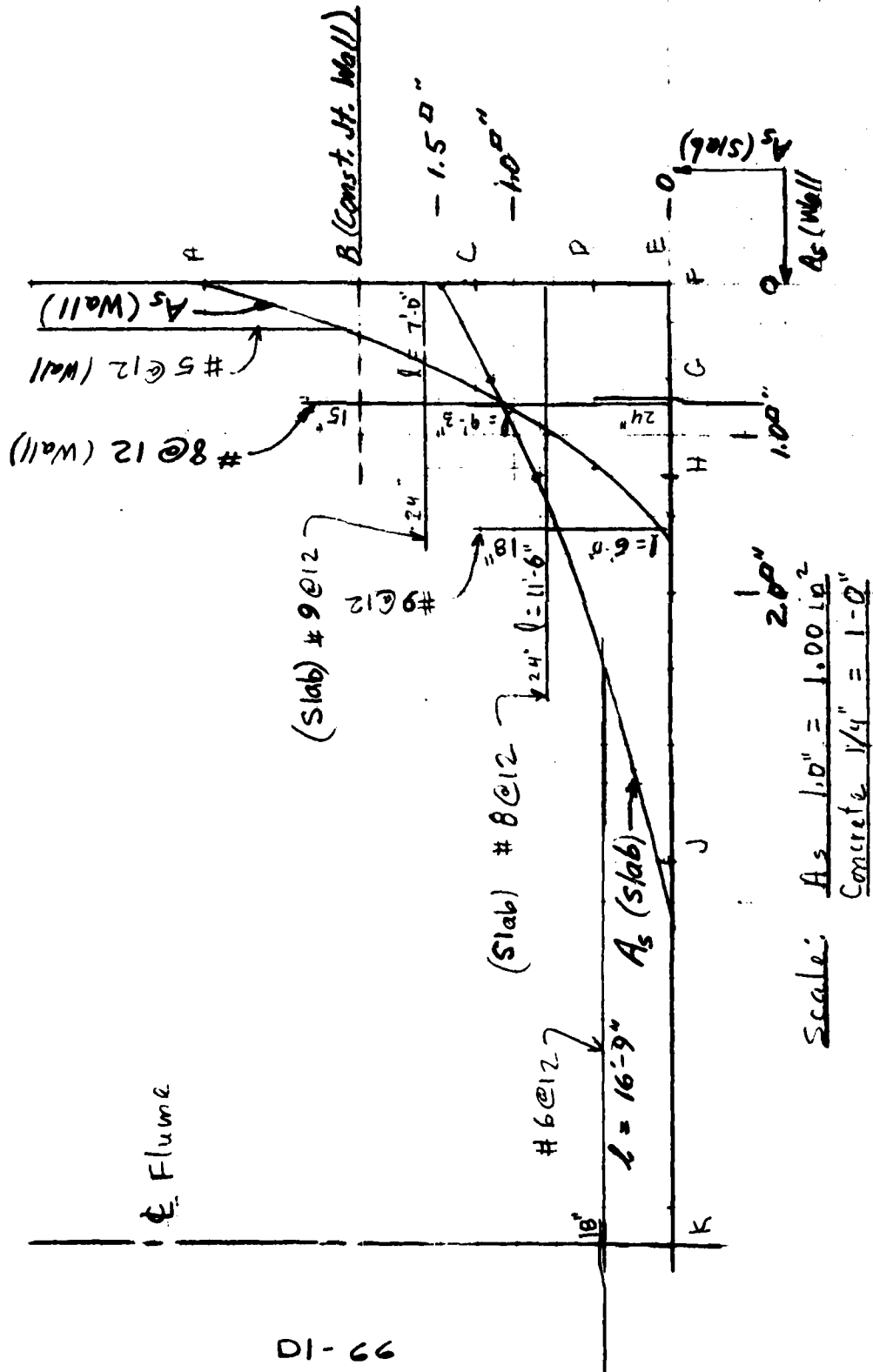
$K = 152$ 4
 $f_c = 20.0 \text{ ksi}$ $a = 1.48$ 5
 $f_c = 1.05 \text{ ksi}$ $j = 0.87$ 6
 $m = 9.2$

Point		A	B	C	D
Moment K-ft	0	0.91	7.30	18.97	36.79
Normal Kips	1	1.01	1.91	2.85	3.95
x inches	2	18.0	19.0	20.25	22.5
d inches	3	14.5	14.5	16.75	19.0
KF		31.96	31.96	42.64	54.87
c		16.3	51.36	86.50	119.52
NE		1.37	8.18	20.54	39.34
i		4.79	1.33	1.21	1.16
H_s		0.013	0.28	0.68	1.20

Point	F	G	H	J	K
Moment	61.19	50.72	41.35	14.89	6.07
Normal	13.15	13.15	13.15	13.15	13.15
x	27.0	27.0	27.0	27.0	27.0
d	22.5	22.5	22.5	22.5	22.5
KF	76.95	76.95	76.95	76.95	76.95
c	64.88	55.28	48.73	22.59	14.54
NE	71.05	69.00	51.21	29.75	15.93
i	1.45	1.56	1.75	8.8	+
H_s	1.47	1.16	0.88	0.08	+

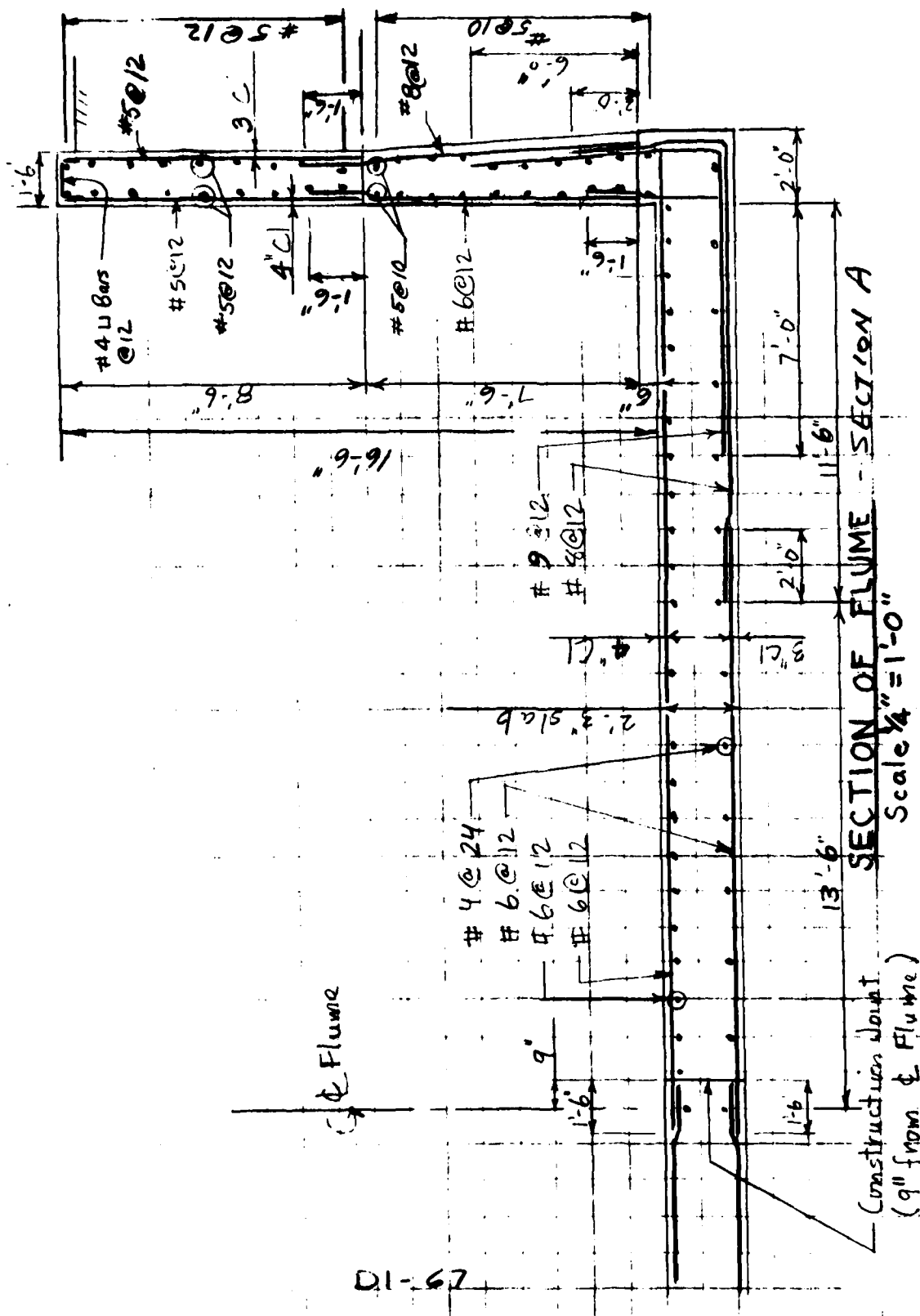
GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diverging Channel Flume FILE NO. 7622.00
SHEET NO. 8 OF 13 SHEETS
FOR Big Creaks
COMPUTED BY PvdG DATE 11/20/79 CHECKED BY WJS DATE 1/23/79



DI-66

SUBJECT Diver: 100 Channel Flume FILE NO. 16210
SHEET NO. 9 OF 13 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY FDG DATE 11/21 CHECKED BY FFM DATE 3-5-79



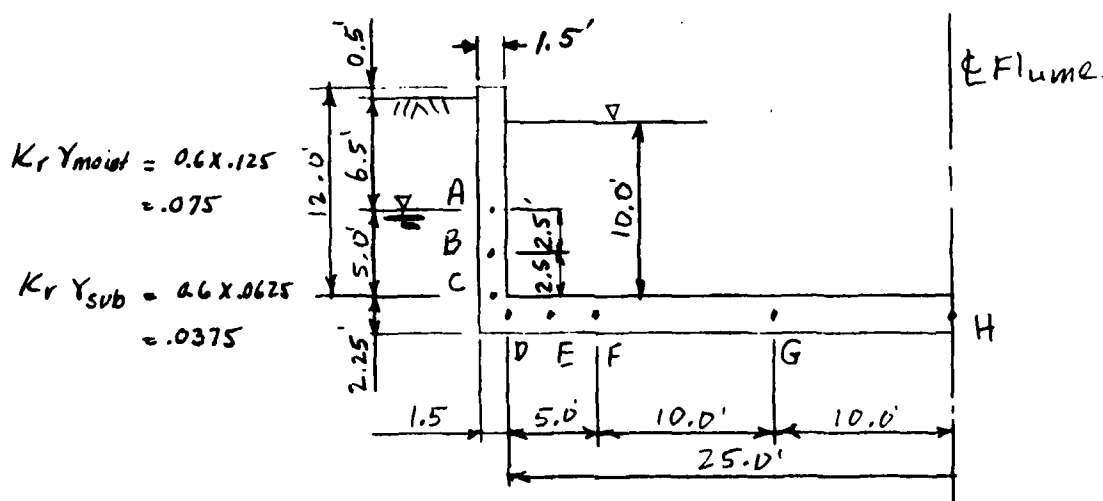
DI-67

GANNETT FLEMING CORDRY
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HARRISBURG, PA.

SUBJECT Diversion Channel Flume FILE NO. 7622.00
SHEET NO. 10 OF 13 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 12/29/79 CHECKED BY WS DATE 1/23/79

Flume Design

SECTION 'B'



For Loading Condition, etc, see sheets 1 and 2

Point A $M = w l^3 / 6 = 0.075 \times 6.5^3 / 2 \times 38 = 3.91 \text{ k-ft}$
 $N = h \times \gamma = 1.0 \times 1.5 \times 0.150 = 1.58 \text{ kips}$

Point B $M = 0.075 \times 6.5^2 / 2 (4.97) + \frac{0.0625 \times 2.5^3}{6} + \frac{0.0375 \times 2.5^3 \times 38}{2} + 4.875 (2.5)^2 \times 5$
 $M = 7.87 + 1.63 + 0.11 + 1.52 = 9.67 \text{ k-ft}$
 $N = 9.5 \times 1.5 \times 0.150 = 2.14 \text{ kips}$

Point C $M = 0.075 \times 6.5^2 / 2 \times (2.47 + 5.0) + 0.0625 \times \frac{5^3}{6} + 0.0375 \times 5^3 \times \frac{38}{2} + \frac{4.875}{2} \times 5^2$
 $M = 11.83 + 1.3 + 8.9 + 6.09 = 20.11 \text{ k-ft}$
 $N = 12.0 \times 1.50 \times 0.150 = 2.70 \text{ kips}$

Total WT = $2.25 \times (25 + 1.5) \times 0.150 + 2.70 = 11.64375$

Total pressure = $\frac{11.64}{26.5} = 0.439387 \text{ k/ft}$ } uplift F.S. = 97
 51.0

Uplift pressure = $(5.0 + 2.25) \times 0.0625 = 0.453125 \text{ k/ft}$ } Consider it OK

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SUBJECT Diversion Channel Flume FILE NO. 7622.00
SHEET NO. 11 OF 13 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 12/29/78 CHECKED BY MS DATE 1/23/79

Moments and Loads

Point D

Item	Mom. at D	Vert ↓	Horiz →	arm	Mom ↑
Conc	$1.5 \times 14.25 \times 0.150$	+ 3.21		0.75	- 2.40
Soil →	$6.5^2/2 \times 0.075$		+ 1.58	8.595	+ 13.58
	$6.5 \times 7.25 \times 0.075$		+ 3.53	2.50	+ 8.84
	$7.25^2/2 \times 0.0625$		+ 1.64	1.2917	+ 2.12
	$7.25^2/2 \times 0.0375$		+ 0.98	1.63	+ 1.61
Found	0.453125×1.50	- 0.68		0.75	+ 0.51
		2.53	7.75		24.26

Point E $M = M_D + [w(\text{uplift}) - w(\text{concrete})] l^2/2 - V_D l$

$M = 24.26 + (0.453125 - 0.150 \times 2.25) \times 2.5^2/2 - 2.53 \times 2.5$
 $M = 18.31$

Point F $M = 24.26 + 0.115625 \times 5.0^2/2 - 2.53 \times 5.0$
 $M = 13.08$

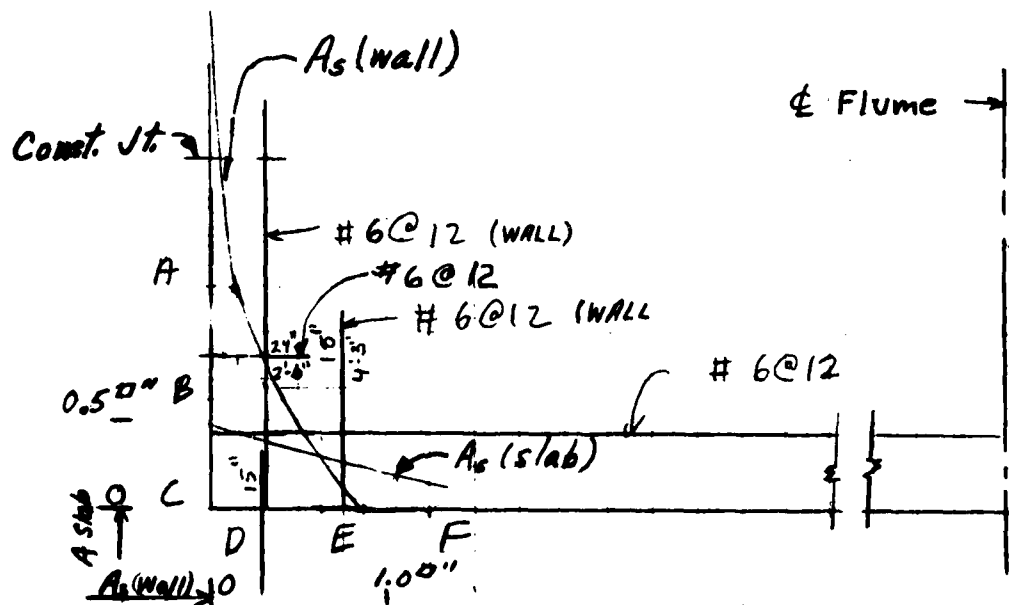
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HARRISBURG, PA.

SUBJECT Diversion Channel Flume FILE NO. 7622.00
SHEET NO. 12 OF 13 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY Pvd G DATE 12/27/78 CHECKED BY WS DATE 1/23/79

Concrete Design

$$\begin{aligned} f_s &= 20.0 \text{ ksi} & K &= 152 \\ f_c &= 1.05 \text{ ksi} & a &= 1.48 \\ n &= 9.2 & j &= 0.891 \end{aligned}$$

Point	A	B	C	D	E	F
Moment K-ft	3.91	9.76	20.11	24.26	18.31	13.08
Normal Kips	1.58	2.14	2.70	7.75	7.75	7.75
t inches	18.0	18.0	18.0	27.0	27.0	27.0
d inches	14.5	14.5	14.5	23.5	23.5	23.5
KF	31.96	31.96	31.96	84.18	84.18	84.18
e	25.20	60.56	94.88	47.56	38.35	30.25
NE	4.63	10.60	21.35	30.72	24.76	19.54
i	1.58	1.27	1.15	1.78	2.20	3.29
A _s	0.14	0.39	0.86	0.49	0.32	0.17

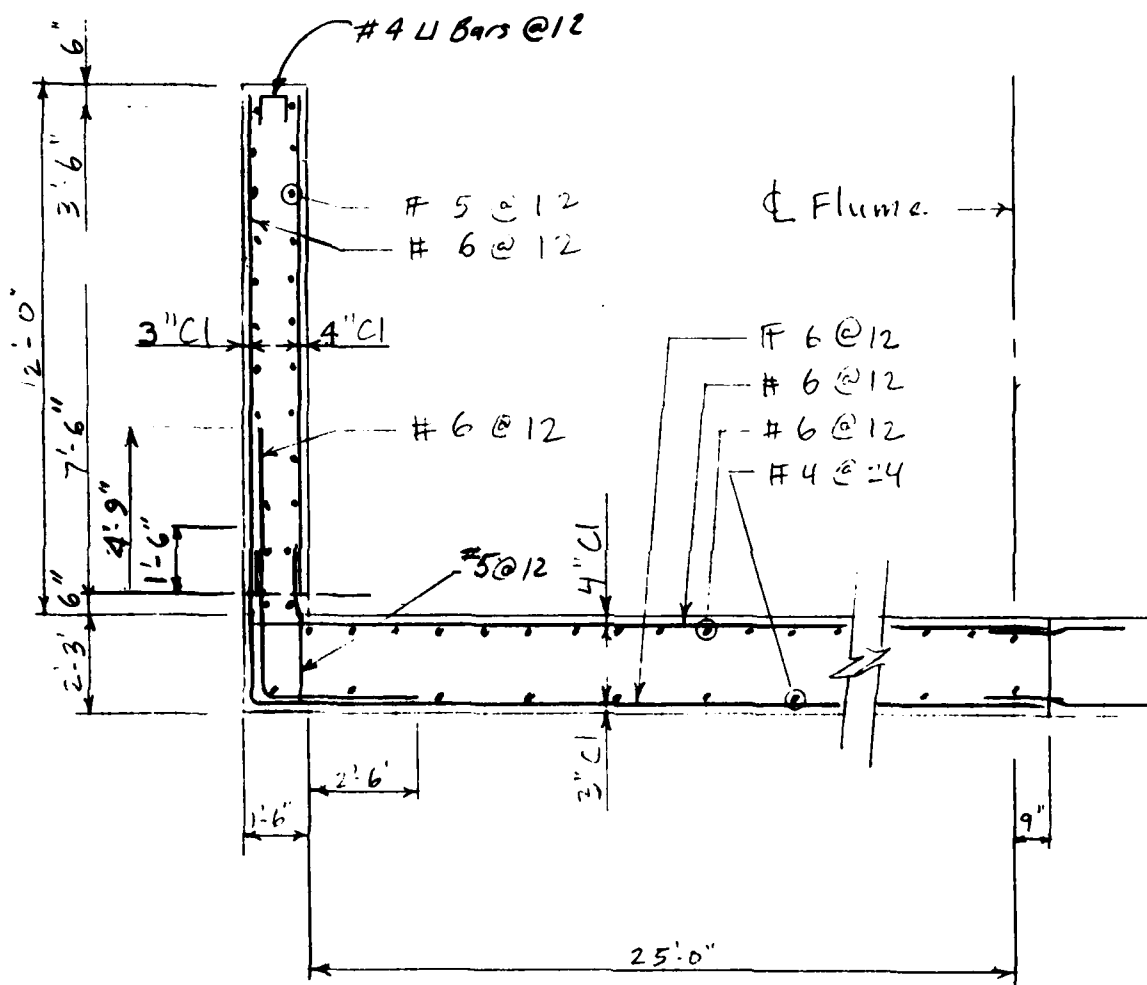


Scale Concrete 1/4" = 1'-0"
A_s 1.0" = 1.00 ft
DI-70

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SUBJECT Divergence Channel Flume FILE NO. 7622.00
SHEET NO. 13 OF 13 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY FvdG DATE 12/29/78 CHECKED BY WS DATE 1/29/79

Summary



SECTION OF FLUME
SECTION 8

Scale 1/4" = 1'-0"

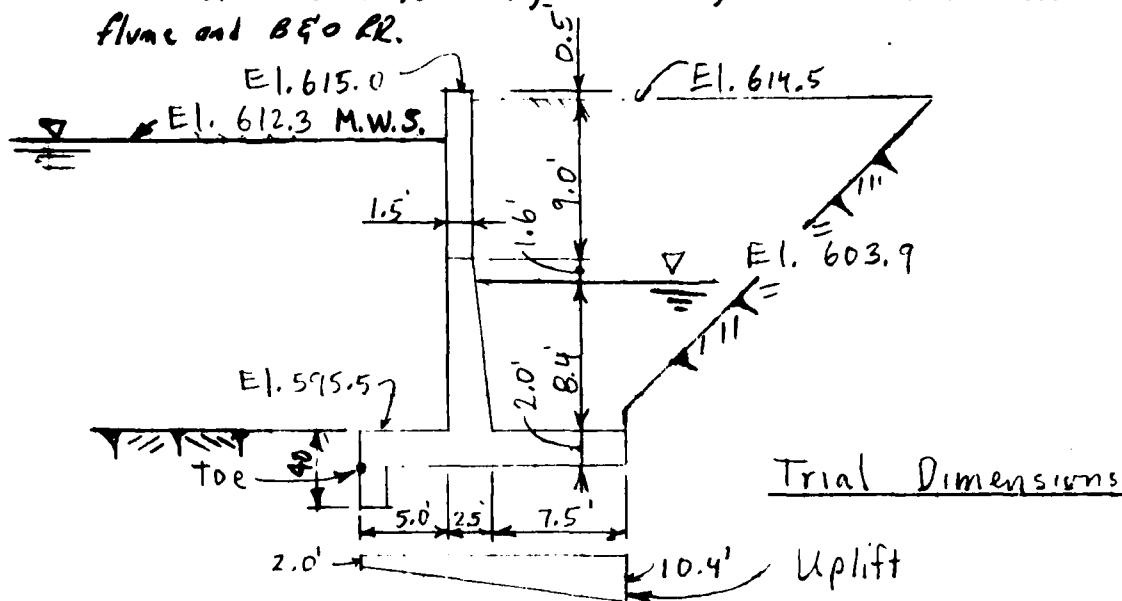
D1-71

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel Retaining Wall FILE NO. 7622.0
SHEET NO. 1 OF 1 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY Pvd/G DATE 11/21/78 CHECKED BY WS DATE 1/23/79

Retaining Wall Design

Located Upstream the Diversion Channel Flume. Same wall section used for wingwall at right bank and wall between flume and B&O RR.



Loading Condition - Sudden Drawdown

1. Channel Empty.
2. Soil submerged to an elevation midway between flood elevations and channel grade (50% drawdown)
3. R at rest = 0.60 for soil pressure for silt
4. Soil to within 6 inches
5. No surcharge loading.

Soil pressure

$$\gamma_{\text{soil}} = 0.125 \text{ k/ft}^3$$

$$\gamma_{\text{water}} = 0.0625 \text{ k/ft}^3$$

$$K \gamma_{\text{soil}} = 0.075 \text{ k/ft}^3$$

$$K \gamma_{\text{submerged soil}} = 0.0375 \text{ k/ft}^3$$

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SUBJECT Diversion Channel Retaining FILE NO. 7622.00
SHEET NO. 2 OF 2 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY W.S. DATE 11/22/78 CHECKED BY EFM DATE 3-6-79

Stability

In stability analysis, the key will be ignored
and footing shall be assumed flat across
bottom

Item	Description	Horiz.	Vert.	arm	M _O	M _R
SOIL	10.6 ² x .5 x 0.075	4.21		14.428	60.74	
	10.6 x .075 x 10.4	8.27		5.2	42.99	
	10.4 ² x .5 x .0625	3.38		3.467	11.72	
	10.4 ² x .5 x .0375	2.03		3.952	8.01	
CONC	1.5 x 19.5 x .15		4.39	5.75		25.23
	10 x .5 x .15		.75	6.833		5.12
	2 x 15 x .15		4.50	7.50		33.75
SOIL	1 x 9 x .125		1.13	7.00		7.88
	1 x 10 x .5 x .125		.63	7.1667		4.48
	7.5 x 19.0 x .125		17.81	11.250		200.39
U	2 x 15 x .0625		-1.88	7.50	14.06	
	8.4 x 15 x .5 x .0625		-3.94	10.00	39.38	
		17.89	23.39		176.90	276.85

$$\frac{L}{4} = 3.75'$$

$$e_r = \frac{276.85 - 176.90}{23.39} = 4.27' > 3.75'$$

$$\frac{L}{3} = 5.0'$$

Resultant within middle half

$$S_{s-f} = \frac{SA}{\Sigma H} = \frac{.200 \times 15 \times 144}{17.89} = 24.15 > 4 \therefore O.K$$

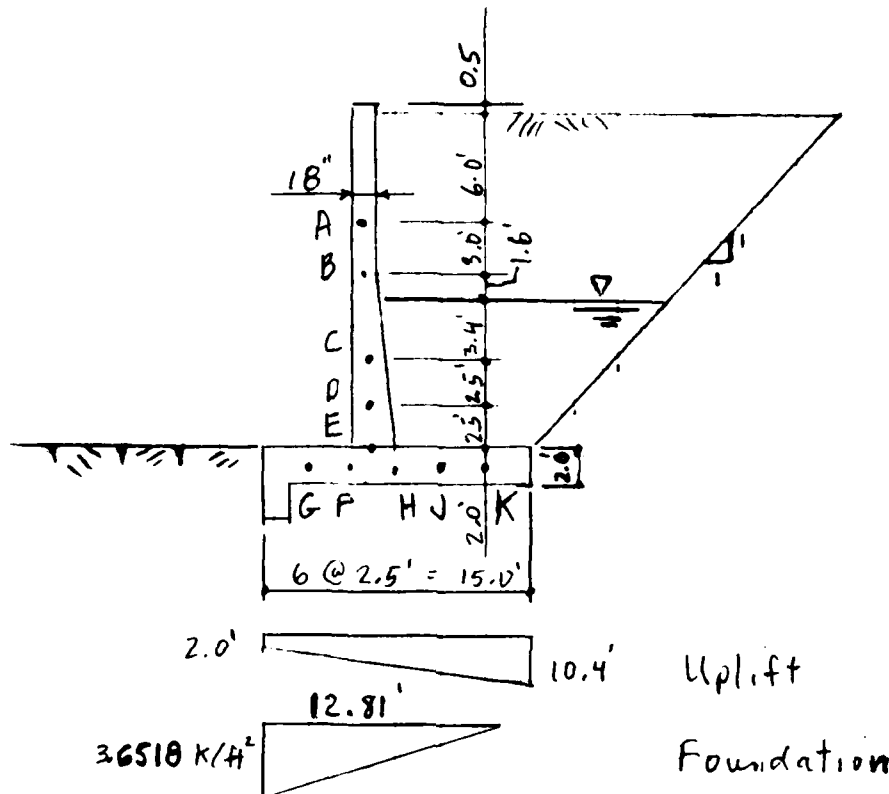
$$\frac{\Sigma H}{\Sigma V} = \frac{17.89}{23.39} = .765$$

$$P = \frac{\Sigma V}{e_r} = \frac{23.39 \times 2}{4.27 \times 3} = 3.65 < 10 \text{ KSF}$$

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SUBJECT Diversions Channel Retaining Wall FILE NO. 7622.012
SHEET NO. 3 OF 3 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY Pyd G DATE 1/24/79 CHECKED BY WS DATE 1/23/79

Design Moments



Point A

$$M = w \left\{ \frac{1}{2} \times 38 \right\} 0.075 \times 6.0 \frac{1}{2} \times 38 = 3.08 \text{ K-ft}$$

$$N = 1.5 \times 6.5 \times 0.150 = 1.46 \text{ Kips}$$

Point B

$$M = 0.075 \times 9.0 \frac{1}{2} \times 38 = 10.38 \text{ K-ft}$$

$$N = 1.5 \times 9.5 \times 0.150 = 2.14 \text{ Kips}$$

Point C

$$M = 0.075 \times 10.6^2 / 2 \times (10.6 \times 38 + 3.4) + 10.6 \times 3.4 \frac{1}{2} \times 38$$

$$+ 0.075 \times 3.4^2 \times 38 \times 0.075 + 3.4 \frac{1}{2} \times 38 \times 0.075 = 39.10 \text{ K-ft}$$

$$N = 1.5 \times 14.5 \times 0.150 + 5 \times 0.5 / 2 \times (0.150 + 0.125)$$

$$+ 0.5 \times 9.0 \times 0.125 = 4.17 \text{ Kips}$$

GANNETT FLEMING CORDRY
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HARRISBURG, PA.

SUBJECT Diversin. Channel Retaining Wall FILE NO. 7622-00
SHEET NO. 4 OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 11/24/78 CHECKED BY WS DATE 1/23/79

Design Moments

Point D

$$M = 0.075 \times 10.6^2 / 2 \times (10.6 \times 38 + 5.9) + 10.6 \times 5.9^2 / 2 \times 0.075 + 0.075 \times 5.9 \times \frac{38}{2} + 5.9^3 / 6 \times 0.0625 = 59.27 \text{ K-ft}$$

$$N = 1.5 \times 17.0 \times 0.150 + 7.5 \times 0.75 / 2 (0.150 + 0.125) + 0.75 \times 9.0 \times 0.125 = 5.44 \text{ kips}$$

Point E

$$M = 0.075 \times 10.6^2 / 2 \times (10.6 \times 38 + 8.4) + 10.6 \times 8.4^2 / 2 \times 0.075 + 0.075 \times 8.4 \times \frac{38}{2} + 8.4^3 / 6 \times 0.0625 = 90.81 \text{ K-ft}$$

$$N = 1.5 \times 19.5 \times 0.150 + 10.0 \times 1.0 / 2 (0.150 + 0.125) + 1.0 \times 9.0 \times 0.125 = 6.87 \text{ K-ft}$$

Pressures

$$\text{Toe } 3.6518 + 2 \times 0.0625 - 2 \times 0.150 = 3.4768 \text{ K/ft}^2$$

$$\text{G } \frac{3.6518 \times 10.31}{12.81} + \frac{0.0625}{15} (2 \times 12.5 + 10.4 \times 2.5) - 2 \times 0.150 = 2.8516 \text{ K/ft}^2$$

$$\text{F } \frac{3.6518 \times 7.81}{12.81} + \frac{0.0625}{15} (2 \times 10.0 + 10.4 \times 5.0) - 2 \times 0.150 = 2.2264 \text{ K/ft}^2$$

$$\text{Heel } 19.0 \times 0.125 + 2 \times 0.150 - 10.4 \times 0.0625 = 2.0250 \text{ K/ft}^2$$

$$\text{K } 19.0 \times 0.125 + 2 \times 0.150 - (2.0 \times 2.5 + 10.4 \times 12.5) \times \frac{0.0625}{15} - \frac{0.31}{12.81} \times 3.6518 = 2.0245 \text{ K/ft}^2$$

$$\text{J } 2.675 - (2 \times 5.0 + 10.4 \times 10.0) \times \frac{0.0625}{15} - \frac{2.81}{12.71} \times 3.6518 = 1.398$$

$$\text{H } 2.675 - (2 \times 7.5 + 10.4 \times 7.5) \times \frac{0.0625}{15} - \frac{5.31}{12.71} \times 3.5416 = 0.819$$

GANNETT FLEMING CORDRY
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SUBJECT Diversions Channel Retaining Wall FILE NO. 7622-DR
SHEET NO. 5 OF 5 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 11/27/78 CHECKED BY W/S DATE 1/23/79

Design Moments

Point F $M = 3.6518 \times 5.0^2/3 + 2.2264 \times 5.0^2/6 = 39.71 \text{ k-ft}$

$$N_x = \frac{(f_x + f_{+oe})}{2} \times x \times \mu$$

$$N = \frac{(3.6518 \times 7.81 + 3.6518)}{12.81} \times \frac{5.0}{2} \times 0.765 = 11.24 \text{ kips}$$

Point G $M = 3.6518 \times 2.5^2/3 + 2.8516 \times 2.5^2/6 = 10.58 \text{ k-ft}$
 $N = \frac{(3.6518 \times 10.31 + 3.6518)}{12.81} \times \frac{2.5}{2} \times 0.765 = 6.30 \text{ kips}$

Point H $M = 0.808 \times 7.5^2/6 + 2.0250 \times 7.5^2/3 = 45.65 \text{ k-ft}$
 $N = - \frac{(3.6518 \times 5.31^2/2)}{12.81} \times 0.765 = -3.07 \text{ kips}$

Point J $M = 1.3926 \times 5.0^2/6 + 2.0250 \times 5.0^2/3 = 22.68 \text{ k-ft}$
 $N = - \frac{(3.6518 \times 3.21^2/2)}{12.81} \times 0.765 = -1.124 \text{ kips}$

Point K $M = 2.1125 \times 2.5^2/6 + 2.0250 \times 2.5^2/3 = 6.328 \text{ k-ft}$
 $N = 0.$

GANNETT FLEMING CORDRY
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HARRISBURG, PA.

SUBJECT Diversion Channel Retaining Wall FILE NO. 7622-012
SHEET NO. 6 OF 6 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 11/27/78 CHECKED BY WS DATE 1/23/79

Concrete Design

$K = 152.$
 $f_s = 20.0 \text{ ksi}$
 $f_c = 1.05 \text{ ksi}$
 $n = 9.2$
 $\alpha = 1.45$
 $j = 0.871$

Point	A	B	C	D	E
Mom k-ft	3.08	10.38	39.10	59.27	90.81
N kips	1.46	2.14	4.17	5.44	6.89
t in.	18.0	18.0	24.0	27.0	30.0
d in.	14.5	14.5	20.5	23.5	26.5
KF	31.96	31.96	63.88	83.94	106.74
e	30.82	64.21	121.0	140.74	169.66
NE	3.75	11.36	42.05	63.80	97.41
i	1.72	1.27	1.19	1.17	1.16
As	0.10	0.42	1.15	1.56	2.14
Point	F	G	H	J	K
Mom. k-ft	39.71	10.58	45.65	22.68	6.33
N kips	11.24	6.30	-3.07	-1.124	0
t in.	24.0	24.0	24.0	24.0	24.0
d in	20.5	20.5	19.5	19.5	19.5
KF	63.88	63.88	57.96	57.96	57.96
e	50.9	28.85	-170.51	-234.6	-
NE	47.67	15.04	43.62	21.97	6.41
i	1.56	2.75	0.91	0.93	1.00
As	1.01	0.18	1.67	0.82	0.22
As(N=0)	1.31	0.35			

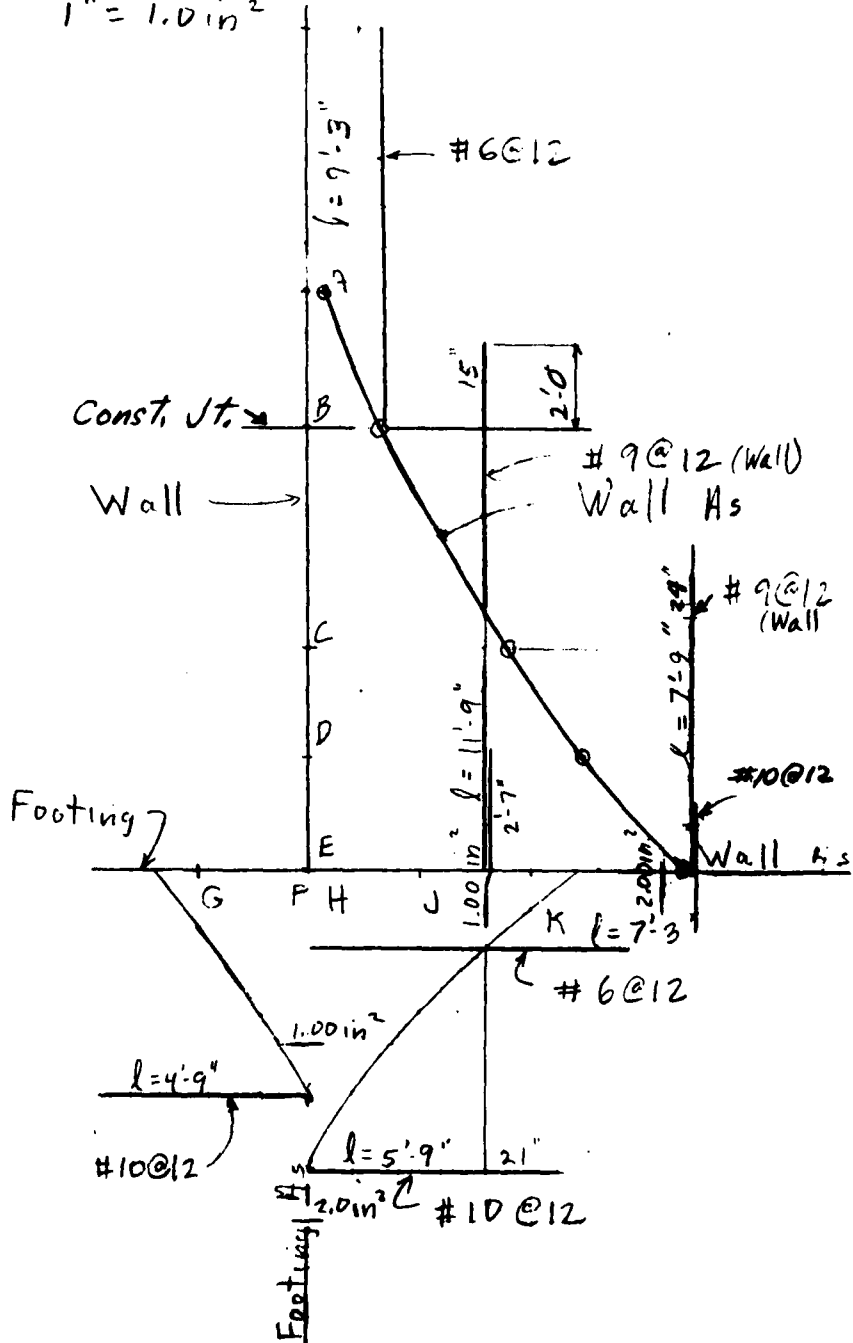
D1-77

**GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.**

SUBJECT Diversions Channel Retaining Wall FILE NO. 7622.00
SHEET NO. 7 OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 11/27/78 CHECKED BY W/S DATE 1/23/79

Concrete Design

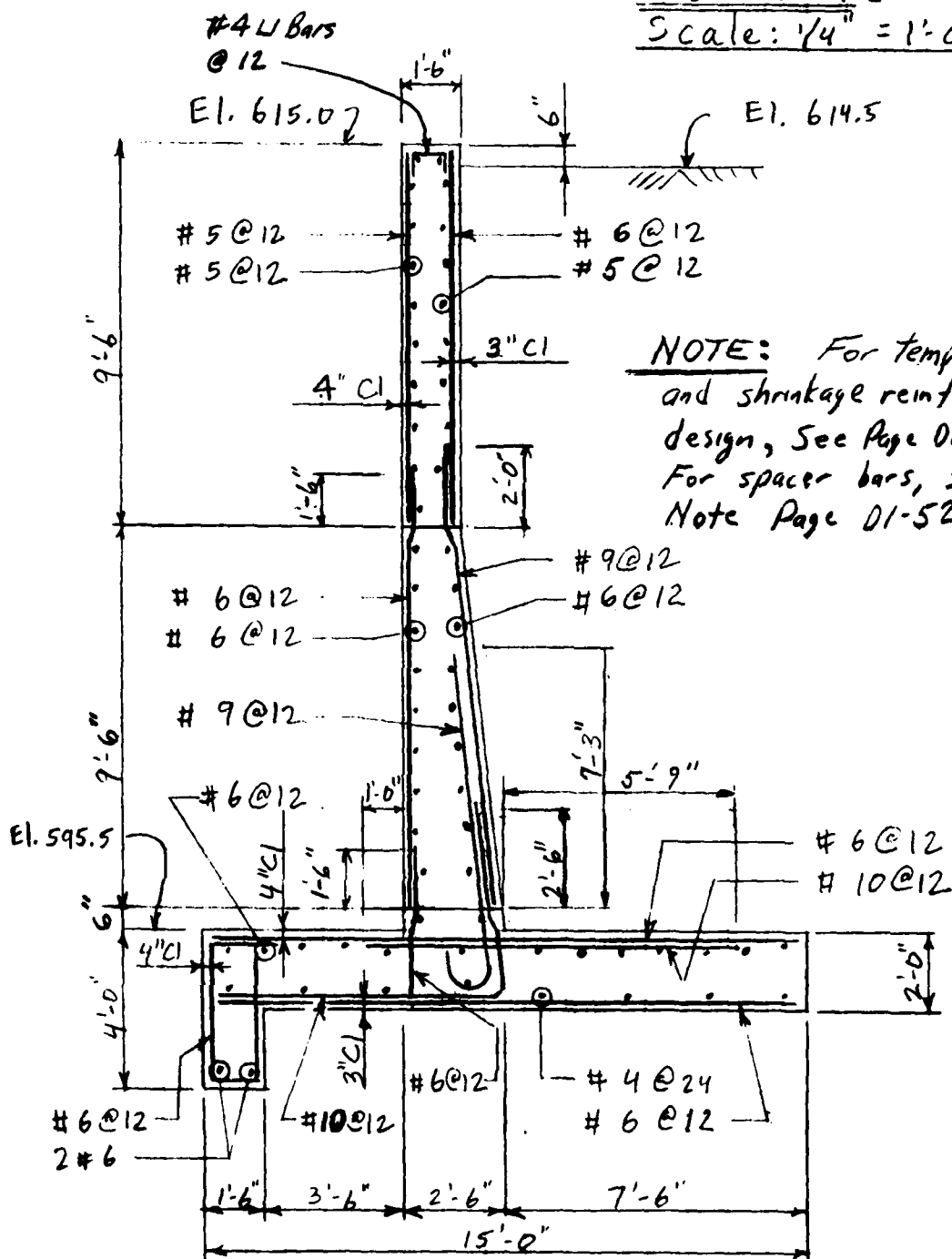
Scale: Concrete $\frac{1}{4}'' = 1' - 0''$
As $1'' = 1.0 \text{ in}^2$ ↓



GANNETT FLEMING CORDDRY
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HARRISBURG, PA.

SUBJECT Diversion Channel Retaining Wall FILE NO. 7622.00
SHEET NO. 8 OF 8 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PdG DATE 11/28/78 CHECKED BY W/S DATE 1/23/79

SECTION C
Scale: 1/4" = 1'-0"



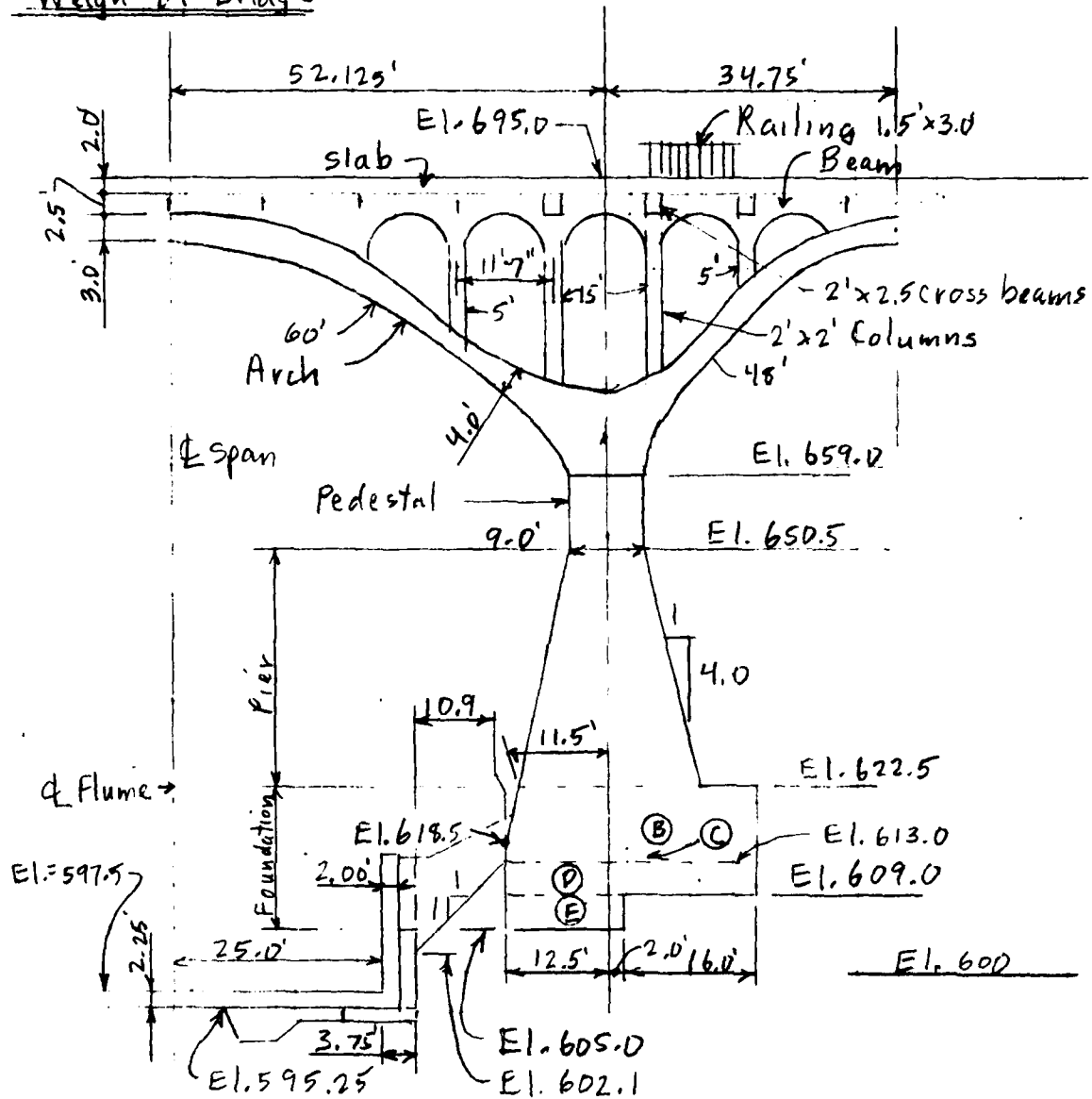
NOTE: For temperature and shrinkage reinforcement design, See Page 01-51.
For spacer bars, see Note Page 01-52

D1-79

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
25th Street Bridge SHEET NO. 1 OF ONE SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY FvdG DATE 2/14/79 CHECKED BY WS DATE 3-2-79

Weight of Bridge

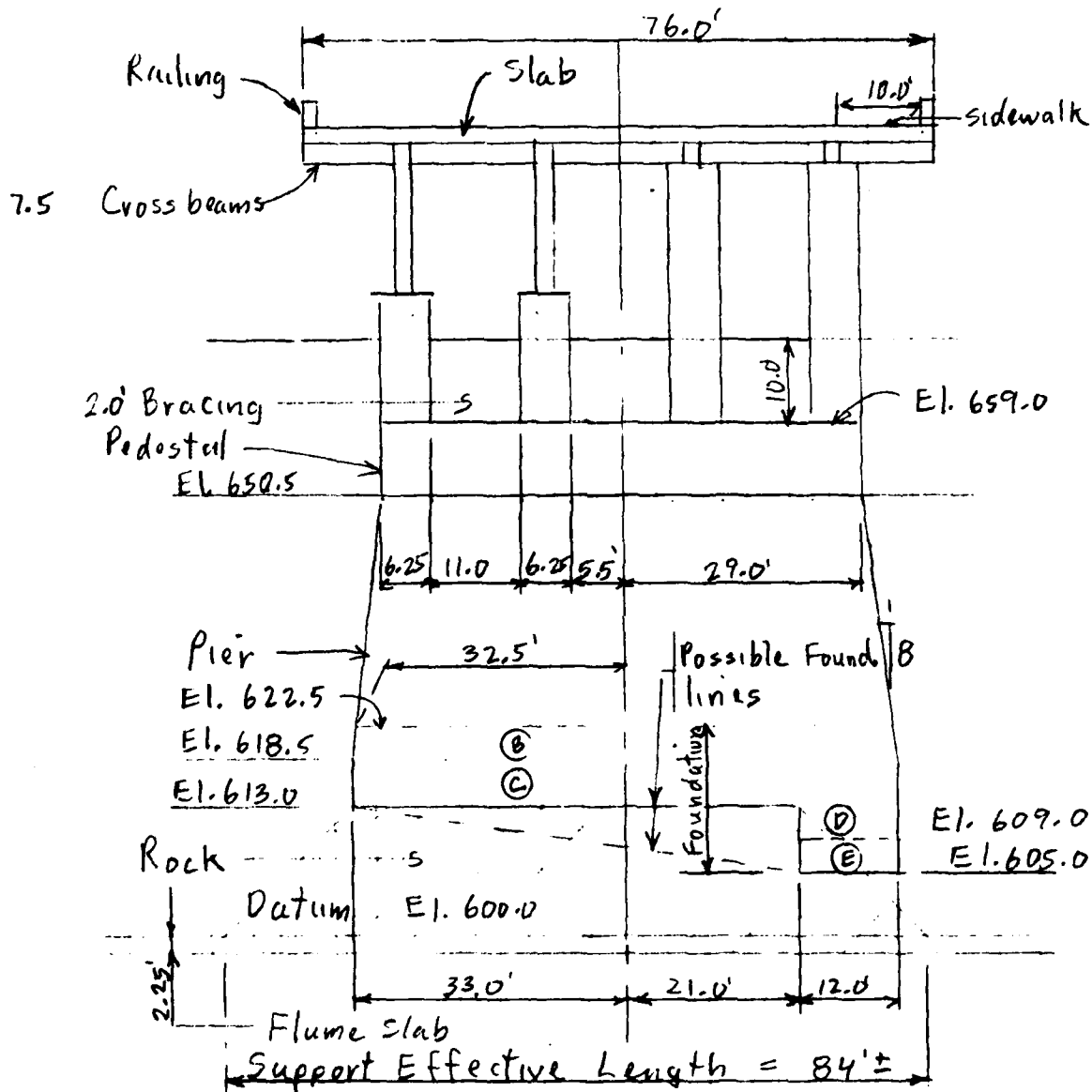


Section at Pier
Scale 1" = 20'

DI-80

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622-00
Twenty fifth Street Bridge SHEET NO. 2 OF 2 SHEETS
 FOR Big Creek Flood Control Project
 COMPUTED BY PvdG DATE 2/13/79 CHECKED BY WS DATE 3-2-79



Scale 1" = 20'

DI-81

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
Twenty Fifth Street Bridge SHEET NO. 3 OF 3 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/13/79 CHECKED BY WS DATE 2-2-79

Weight of Bridge - Dead Load

$$\begin{aligned} \text{Slab } 2.0 \times 76.0 \times (52.125 + 34.75) \times 0.150 &= 1981 \\ \text{Cross beam } 7.5 \times 2 \times 2.5 \times (76 - 4 \times 2.0) \times 0.150 &= 383 \\ \text{Beam } 4 \times 4.0 \text{ } \textcircled{1} \times 2.0 \times (52.125 + 34.75) \times 0.150 &= 417 \\ \text{Columns } 8 \times 5.0 \text{ } \textcircled{1} \times 2.0 \times 2.0 \times 0.150 &= 24 \\ &8 \times 15.0 \text{ } \textcircled{1} \times 2.0 \times 2.0 \times 0.150 = 72 \\ \text{Railing } 2 \times 1.5 \times 3.0 \times (52.125 + 34.75) \times 0.150 &= 117 \\ \text{Arch } 4 \times 48.0' \times 4.0 \times 6.25 \times 0.150 &= 720 \\ &4 \times 60.0' \times 4.0 \times 6.25 \times 0.150 = 900 \\ \text{Bracing } 3 \times 10.0 \times 2.0 \times 11.0 \times 0.150 &= 99 \\ \text{Pedestal } 8.5 \times 9.0 \times 58.0 \times 0.150 &= 666 \end{aligned}$$

$$\begin{aligned} \text{Pier; } A_1 &= \text{Area top} = 9 \times 58 = 522 \\ A_2 &= \text{Area bottom} = 23 \times 65 = 1495 \\ A_3 &= \text{Area mid. section} = 16 \times 61.5 = 984 \\ \text{WT.} &= 1/6 \times 28 (522 + 4 \times 984 + 1495) \times 0.150 = 4167. \end{aligned}$$

$$\begin{aligned} \text{Found. B } [(65.0 \times 29.5) + (66 \times 30.5)] / 2 \times 4.0 \times 0.15 &= 1179 \\ \text{C. } 66.0 \times 30.5 \times 5.5 \times 0.15 &= 1661 \\ \text{D. } 12.0 \times 30.5 \times 4.0 \times 0.15 &= 220 \\ \text{E. } 12.0 \times 14.5 \times 4.0 \times 0.15 &= 104 \end{aligned} \quad \textcircled{2}$$

Total Dead Load 12709 kips

① Estimated average dimensions

② Exclude Found D. + E.: Dead Load = 12385 kips ← USE
D1-82

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
W. 25th Street Bridge SHEET NO. 4 OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/14/79 CHECKED BY WS DATE 3-2-79

Live Load *

$$\text{Lane Loading } (0.640 \times 86.875 + 26.) \times 4 \times 0.75 = 245$$

$$\text{Side walk } 10.0 \times 86.875 \times 2 \times 0.060 = \underline{104}$$

Live Load 349 kips

Rock between El. 613.0 and El. 602.1

$$\text{Base Area El. 613.0} = 30.5 \times 66.0 = 2013 \text{ ft}^2$$

$$\text{Base Area El. 602.1} = (30.5 + 2 \times 10.9) \times 66.0 = 3452 \text{ ft}^2$$

$$\text{WT Rock @ El. 602.1} = 10.9 \times 3452 \times 0.165 = 6208 \text{ kips}$$

$$\text{WT Rock @ El. 595.25} = 6.85 \times 3452 \times 0.165 = 3901 \text{ kips}$$

Total Loads & Pressures

$$\text{Total Load} = 1.10 \text{ Dead} + \text{Live (+ Rock)}$$

$$\text{Pressure} = \frac{\text{Total Load}}{\text{Area}}$$

$$\text{El. 613.0} \quad \text{Total Load} = 13973 \text{ kips}$$
$$\text{Pressure} = 6.94 \text{ k/ft}^2$$

$$\text{El. 602.1} \quad \text{Total Load} = 20181 \text{ kips}$$
$$\text{Pressure} = 5.846 \text{ k/ft}^2$$

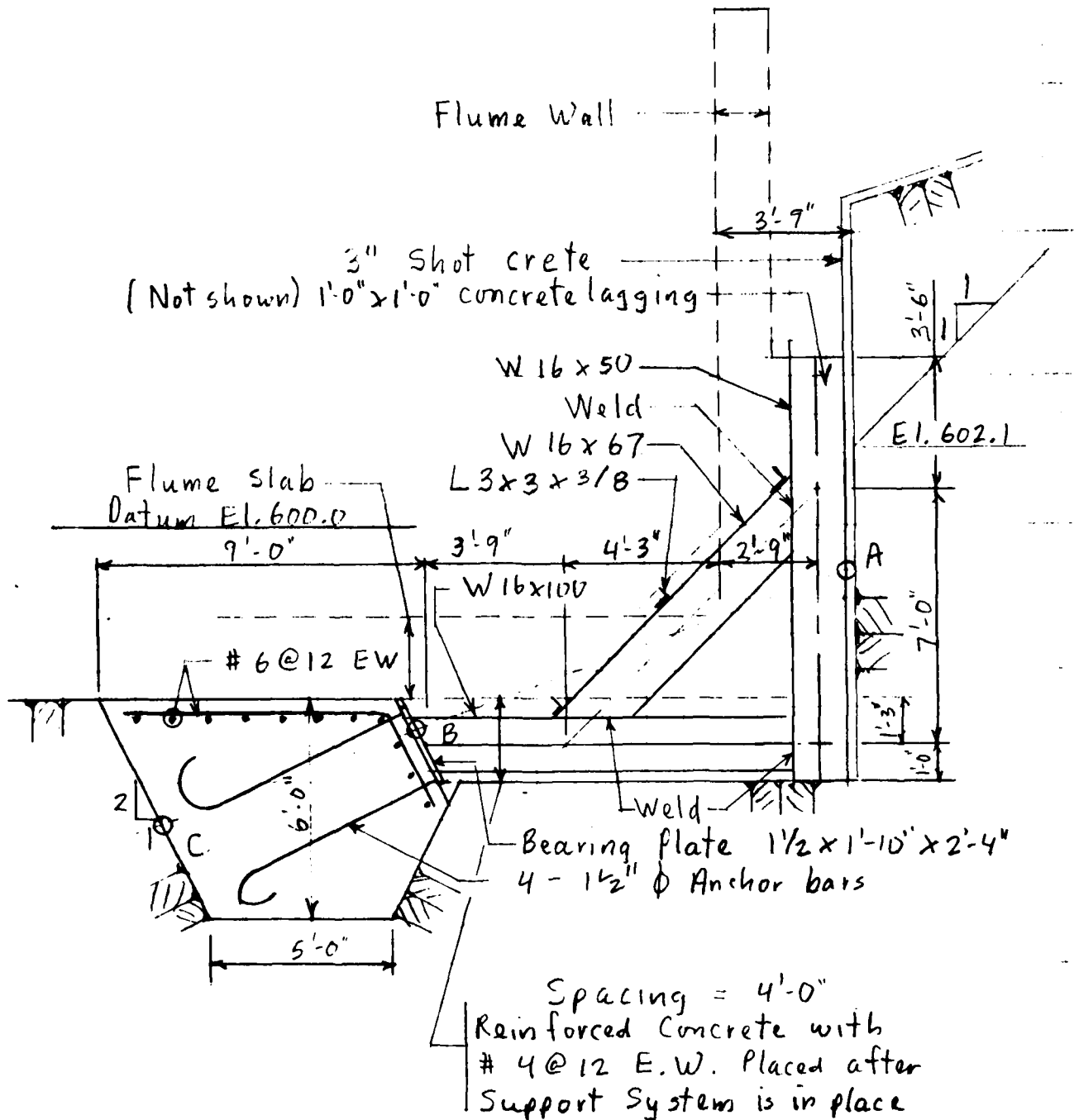
$$\text{El. 595.25} \quad \text{Total Load} = 24082 \text{ kips}$$
$$\text{Pressure} = 6.987 \text{ k/ft}^2$$

* AASHTO, Standard Specifications for Highway Bridges, 1977. Art. 1.2. The W. 25th St. Bridge is assumed to have a roadway width of 48' and two sidewalks of 10' each. DI-83

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Division Channel FILE NO. 7622-00
Pier Protection SHEET NO. 5 OF 5 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/26/77 CHECKED BY WS DATE 3-2-79

Design Cross Section and Summary



GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
SHEET NO. 6 OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdC DATE 2/21/79 CHECKED BY WS DATE 3-2-79

Design Loads and Assumptions

Assume uniform horizontal load equal to average of pressures at El. 602.1 and 595.25 times K equal to 0.6 (at rest).

$$w = 0.6 (5.846 + 6.787) / 2 = \underline{3.85 \text{ k/ft}^2}$$

Coefficient of Friction = $\mu = 0.45$.

This coefficient of friction acts on the vertical wall of rock against the support.

Allowable Rock Bearing Press = 10.0 k/ft^2

$F_y = 36.0 \text{ ksi}$ (A36 steel)

$f'_c = 3000 \text{ ksi}$

Use High Early Concrete for the foundation so that $f'_c = 3000$ at 7 days.

$F_y = 36.0 \text{ ksi}$

DI-85

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
SHEET NO. 7 OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/22/79 CHECKED BY ws DATE 3-2-79

Lagging

$$w = 3.85$$

Assume support spacing = 4.0 ft

$$V = \frac{4 \times 3.85}{2} = 7.7 \text{ kips}, \quad b = 12 \text{ inches}$$

$$r_{\text{max}} (\text{concrete}) = 60 \text{ psi}$$

$$d = \frac{1000 V}{b \times r} = \frac{1000 \times 7.7}{12 \times 60} = 10.69 \text{ in}$$

$$t = d + 1.5 = \text{say } 12 \text{ inches} \quad (\text{set } d = 10.5")$$

$$M = \frac{w l^2}{8} = \frac{3.85 \times 4.0^2}{8} = 7.7 \text{ k-ft}$$

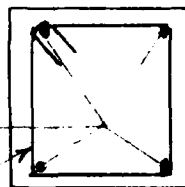
$$F = \frac{b d^2}{12000} = \frac{12 \times 10.5^2}{12000} = 0.110$$

$$KF = 152.4 \times 0.110 = 16.8 > 7.7 \quad \text{O.K.}$$

$$A_s = \frac{M}{a d} = \frac{7.7}{1.486 \times 10.5} = 0.493$$

USE 2 #5 bars each Face

4 #5
#2 ties @ 5"



DI-86

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. _____
Pier Protection SHEET NO. _____ OF _____ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY pdg DATE 7-13-79 CHECKED BY FF DATE 7-13-79

Discussion on Lagging

The lagging is an essential element of the support system. The lagging transfers the loading to the vertical structural member (W16x50).

The concrete lagging consists of individual elements of reinforced concrete block 12"x12"x3'-10". The blocks are laid horizontally, one on top of the other to form a wall. The ends of the blocks are wedged between the flanges of the vertical wide flange member of the steel support system. Shotcrete lining will be placed on the rock surface before the lagging is placed.

Details of the Support System are shown on Sheets D1-84 and D1-98

D1-86a

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
Pier Protection SHEET NO. 8 OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY pvdG DATE 2/26/79 CHECKED BY WS DATE 3-2-79

Steel Design Procedure

Ref: Manual of Steel Construction, Seventh Edition, AISC.

Dimensions and Properties New W, HP and WT Shapes, Sept. 1978, AISC.

AISC, Part 5, Specifications and Codes

$F_y = 36.0 \text{ Ksi}$ for A36 steel.

Section 1.5.1.2 $F_v = 0.40 F_y = 14.5 \text{ Ksi}$

Sect. 1.5.1.3.1 F_a from Table 1-36
 $K=1$ Try $F_a = 20.0 \text{ Ksi}$, $Kl/r \leq 29$

Sect. 1.5.1.4. $F_b = 0.60 F_y = 22.0 \text{ Ksi}$ (non-compact)

Sect. 1.6.1 $\frac{f_a}{0.60 F_y} + \frac{f_b}{F_b} \leq 1.0$

Ref: Structural Steel Designer's Handbook, Merritt, 1972, Artical 5-32.

$F_p = 0.25 f'_c = 0.750 \text{ Ksi}$

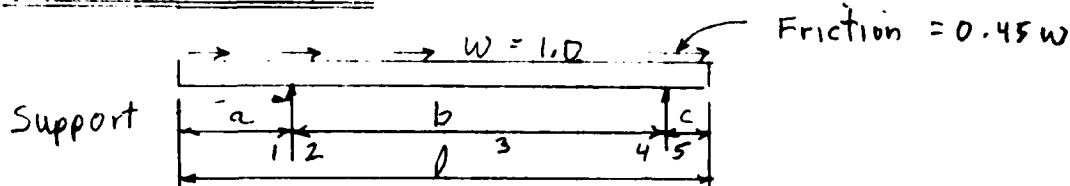
Sect. 1.17 Use E70xx weld
 $F_v = 21.0 \text{ Ksi}$

D1-87

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversions Channel FILE NO. 7622.00
Pier Protection SHEET NO. 9 OF 9 SHEETS
FOR Big Cress Flood Protection
COMPUTED BY PvdG DATE 2/26/77 CHECKED BY WS DATE 3-2-79

Vertical Member



$$R_{12} = \frac{wl(l-2c)}{2b}; \quad V_1 = wa; \quad V_2 = R_{12} - V_1$$

$$R_{45} = \frac{wl(l-2a)}{2b}; \quad V_5 = wc; \quad V_4 = R_{45} - V_5$$

$$M_1 = M_2 = wa^2/2 \quad M_4 = M_5 = wc^2/2$$

$$M_3 = \frac{w}{8}(b^2 - 2a^2 - 2c^2)$$

V_1 a	b	V_5 c	l	R_{12}	V_2	R_{45}	V_4	M_1 M_2	M_4 M_5	M_3
3.0	7.5	1.0	11.5	7.28	4.28	4.22	3.22	-4.50	-0.50	4.53
3.25	7.25	↓	↓	7.53	4.28	3.97	2.97	-5.28	↓	3.68
3.50	7.00	↓	↓	7.80	4.30	3.70	2.70	-6.13	↓	2.81
3.75	6.75	↓	↓	8.09	4.34	3.41	2.41	-7.03	↓	1.93
4.00	6.50	↓	↓	8.40	4.40	3.10	2.10	-8.00	↓	1.03

D/-88

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
Pier Protection SHEET NO. 10 OF 10 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY pxdG DATE 2/26/77 CHECKED BY WS DATE 3-2-77

Vertical Member

Set $a = 3.5$, $b = 7.0$, $c = 1.0$, $\mu = 0.45$, spacing = 4.0 ft.

$$R_{12} = 3.85 \times 7.80 \times 4.0 = 120.2 \text{ kips}$$

@ a slope of 1 on 1 $R = 170.7 \text{ kips}$

$$V_1 = 3.85 \times 3.50 \times 4.0 = 53.9 \text{ kips}$$

$$V_2 = 3.85 \times 4.30 \times 4.0 = 66.3 \text{ kips}$$

$$R_{4-5} = 3.85 \times 3.70 \times 4.0 = 56.9 \text{ kips}$$

$$V_4 = 3.85 \times 2.70 \times 4.0 = 41.5 \text{ kips}$$

$$V_5 = 3.85 \times 1.0 \times 4.0 = 15.4 \text{ kips}$$

$$M_1 = 3.85 \times -6.13 \times 4.0 = 94.3 \text{ kip-ft}$$

$$M_3 = 3.85 \times -2.81 \times 4.0 = 43.3 \text{ kip-ft}$$

$$M_5 = 3.85 \times -0.50 \times 4.0 = 7.7 \text{ kip-ft}$$

$$\text{Horizontal shear} = 3.85 \times 0.45 \times 3.5 \times 4.0 = 24.3 \text{ kips}$$

$$\text{Comp. above support} = 24.3 \text{ kips}$$

$$\text{Tension below support} = 95.9 \text{ kips}$$

Design for: $M = 94.3 \text{ K-ft}$
 $V = 66.3 \text{ kips}$
 $N = 95.9 \text{ kips Tens.}$

$$S = \frac{M}{F_b} = \frac{94.3 \times 12}{22.0} = 51.44 \text{ in}^3$$

$$A_w = \frac{V}{F_v} = \frac{66.3}{14.5} = 4.57 \text{ in}^2$$

$$A = \frac{N}{F_a} = \frac{95.9}{20.0} = 4.80 \text{ in}^2$$

01-89

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
Pier Protection SHEET NO. 11 OF 11 SHEETS
 FOR Big Creek Flood Control Project
 COMPUTED BY PVAC DATE 2/26/77 CHECKED BY WS DATE 3-2-79

Vertical Member

$$f_a = \frac{N}{A} \quad f_b = \frac{M \times 12}{S} \quad A_w \geq 4.57 \text{ in}^2$$

$$\frac{f_a}{0.60 F_y} + \frac{f_b}{F_b} \leq 1.0$$

W Shape	A	d	t _w	(Shear) A _w	S _{xx}	$\frac{f_a}{.6 F_y}$	$\frac{f_b}{F_b}$	sum
W 18 x 46	13.5	18.06	0.360	6.50	78.8	.329	.653	.982
W 16 x 50	14.7	16.26	.380	6.18	81.0	.302	.635	.937
W 16 x 45	13.3	16.13	.345	5.56	72.7	.334	.708	1.041
W 14 x 53	15.6	13.92	.370	5.15	77.8	.285	.661	.946

TRY W 16 x 50

DI-90

GANNETT FLEMING CORDRY
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HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622-00
Pier Protection SHEET NO. 12 OF 12 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/26/79 CHECKED BY WS DATE 3-2-79

Diagonal Member

$N = 170.7$ kips: (sh. 10)

Pick a member with twice the necessary area to compensate for END Moments

$$A = \left(\frac{170.7}{20} \right) \times 2 = 17.07$$

r (radius of gyration) ^{*} is limited such that
 $KL/r < 29$ and $F_s = 20.0$ Ksi

$$l = 8.0 \quad k = 1.0$$

$$r = \frac{1.0 \times 8.0 \times 12}{29} = 3.3 \quad \text{Not practical.}$$

W Shape	A	r	$\frac{KL}{r}$	F_a Table 1-36	ϕf_a	$\frac{f_a}{F_a}$
W 16 x 50	14.7	1.59	60.4	17.33	11.61	0.67
W 14 x 53	15.6	1.92	50.0	18.35	10.94	0.60
W 16 x 50	14.7	1.59	30.2	19.90	11.61	0.58
W 16 x 67	19.7	2.46	39.0	19.27	8.66	0.45
			19.5	20.60	8.66	0.42

①

①

① Assume bracing at mid point, $l = 4.0'$

TRY W 16 x 67

Bracing @ 2% $N = 3.41$ kips, $l = 6.0$ ft

USE L 3 x 3 x 3/8

* See NOTE, Sheet D1-91a.

D1-91

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. _____
Pier Protection
FOR Big Creek Flood Control Project SHEET NO. _____ OF _____ SHEETS
COMPUTED BY PvdG DATE 7-13-79 CHECKED BY _____ DATE _____

NOTE REGARDING RADII OF GYRATION

The design reference is Manual of Steel Construction, AISC, Seventh Edition, Part 5, Table 1-36. For a trial design, F_a is limited to 20.0 ksi and therefore $KL/r \leq 29$. In the final analysis, $KL/r = 39.0$ and $F_a = 19.27$ ksi.

D1-91a

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AND CARPENTER, INC.
HARRISBURG, PA.

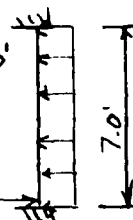
SUBJECT Diversions Channel FILE NO. 7622-00
Fier Protection SHEET NO. 13 OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdC DATE 2/27/79 CHECKED BY WS DATE 3-2-79

Horizontal Member

$$N = 56.9 \text{ Kips (sh. 10.)}$$

$$w = 3.85 \times 4.0'$$

Assume Vertical Member to be
fixed ended, with $1/2$ moment N
going into this Horizontal Member



$$M = \frac{wl^2}{12} = \frac{3.85 \times 4.0 \times 7.0^2}{12} = 62.88 \text{ K-ft}$$

$$M = \frac{1}{2} M = \underline{31.44 \text{ K-ft}}$$

Calculate Moments, Shears, Loads, 7.0' to the left
of $\perp$ Vert. Mem. at intersection of Diagonal Member

Item	Computations	← Horiz	↓ Vert	arm	↺ Mom	↻ Mom.
Horiz	$3.85 \times 4.0 \times 11.5$	+177.1		4.75	+841.2	
Vert	$3.85 \times 4.0 \times 11.5 \times 0.45$		+79.7	7.75		617.6

$$\Sigma M = 223.6 \text{ K-ft}$$

$$\bar{x} = -2.8056 \text{ ft}$$

$$\bar{y} = -1.2625 \text{ ft}$$

01-92

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622-00
Pier Protection SHEET NO. 14 OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/27/79 CHECKED BY WS DATE 3-2-79

Horizontal Member

$N = 177.1$ Kips Assume fully braced.
 $M = 223.6$ Kip-ft
 $V = 79.7$ Kips

$$f_a = \frac{N}{A} \quad A_w \geq \frac{V}{14.5} = \frac{79.7}{14.5} = 5.50 \text{ in}^2$$

$$f_b = \frac{12 M}{5}$$

$$\frac{f_a}{0.6 F_y} + \frac{f_b}{F_b} \leq 1.0$$

$$F_b = 22.0 \text{ Ksi}$$

$$F_y = 36.0 \text{ Ksi}$$

W Shape	A	d	t _w	(Shear) A _w	S _{xx}	$\frac{f_a}{.6 F_y}$	$\frac{f_b}{F_b}$	sum
W 18 x 86	25.3	19.39	0.480	8.83	166	.324	.735	1.059
W 18 x 77	28.5	18.59	0.535	9.95	188	.288	.649	.936
W 16 x 89	26.2	16.75	0.525	8.79	155	0.313	.787	1.100
W 16 x 100	29.4	16.77	0.585	9.93	175	0.277	.697	.976
W 14 x 99	29.1	14.16	0.485	6.87	157	0.282	.777	1.059

TRY W 16 x 100

D1-93

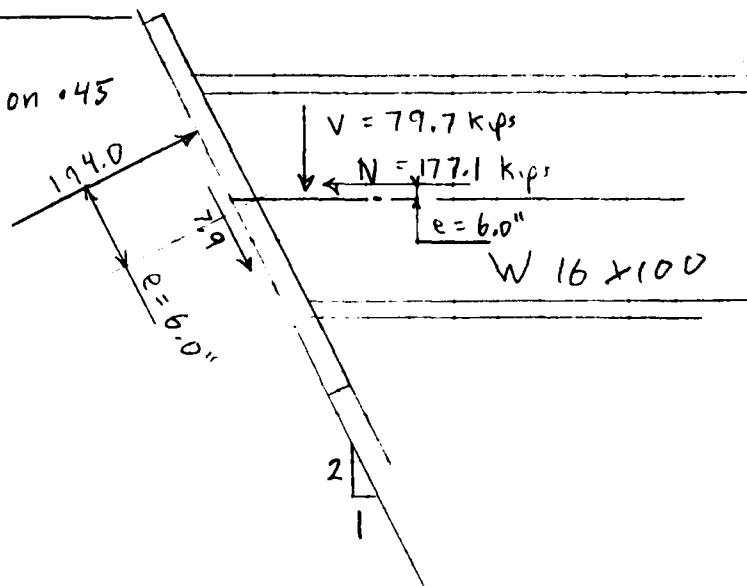
GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622-00
Pier Protection SHEET NO. 15 OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 2/27/79 CHECKED BY WS DATE 3-2-79

Bearing Plate

$$\begin{aligned} N &= 177.1 \text{ kips} \\ V &= 79.7 \text{ kips} \\ R &= 194.2 \text{ kips at } 1 \text{ on } .45 \end{aligned}$$

$$\begin{aligned} R &= 194.0 \} \text{ at } 2 \text{ on } 1 \\ V &= 7.9 \} \end{aligned}$$



Assume eccentricity = 6"
 $M = \frac{6}{12} \times 194.0 = 97 \text{ k-ft}$

$$F_p = 0.25 f'_c = 0.25 \times 3.00 = 0.750$$

$$A = \frac{194.0}{(0.750/2)} = 517.3 \text{ in}^2$$

Try 28" x 20"

$$F_b (\text{base plate}) = 27.0 \text{ ksi}$$

$$d = 16.97$$

$$d (\text{slope}) = 16.97 \times 1.0966 = 18.61$$

$$bf = 10.425$$

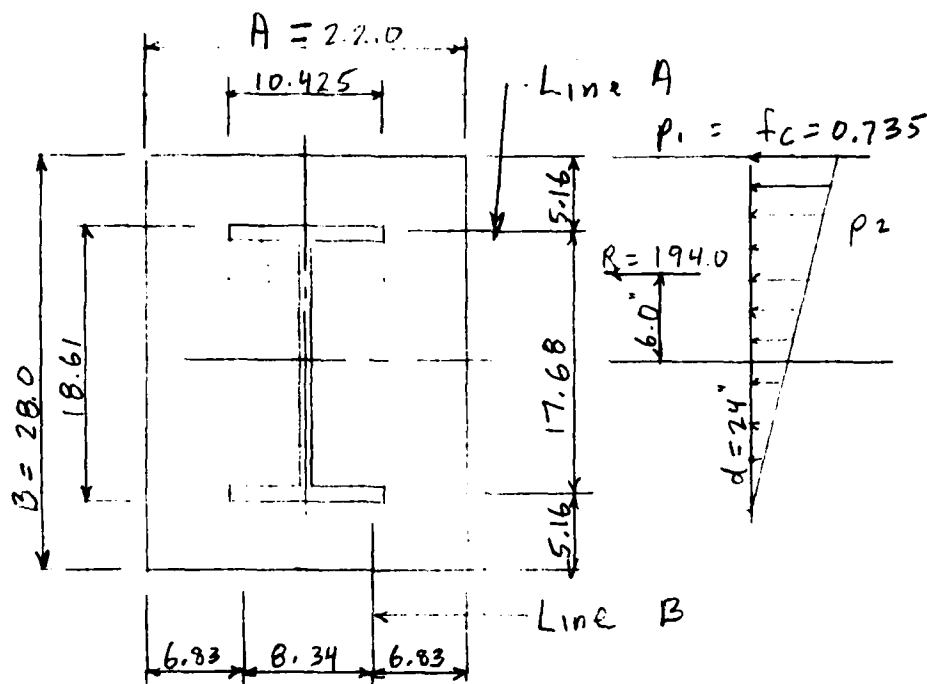
R is resolved into components normal to the slope of 2 on 1 then: $R = 194.0 \text{ kips}$
 $V = 7.9 \text{ kips}$

DI-94

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
fill Protection SHEET NO. 16 OF SHEETS
 FOR Big Creek Flood Control Project
 COMPUTED BY Pvdc DATE 2/27/79 CHECKED BY WS DATE 3-2-79

Bearing Plate



$$d = \left(\frac{B - e}{2} \right) 3 = \left(\frac{28 - 6}{2} \right) 3 = 24"$$

$$f_c = \frac{R \cdot 2}{A d} = \frac{194.0 \times 2}{22 \times 24} = 0.735 \text{ ksi}$$

$$p_1 = 0.735$$

$$p_2 = \frac{0.735}{24} (24 - 5.16) = 0.577 \text{ ksi}$$

Moment about Line A

$$M = A \frac{d^2}{6} (w_1 + 2 w_2)$$

$$M = \frac{22}{6} (5.16)^2 (0.577 + 2 \times 0.735) = 199.8 \text{ k-in.}$$

$$t = \sqrt{\frac{6 M}{A F_b}} = \sqrt{\frac{6 \times 199.8}{22 \times 27.0}} = \sqrt{2.0192}$$

$$t = 1.42 \text{ say } 1\frac{1}{2} \text{ in.}$$

D1-95

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
Pier Protection SHEET NO. 17 OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PxdG DATE 2/27/79 CHECKED BY WS DATE 3-2-79

Bearing Plate

Moment about Line B

$$M = d \times f_c / 2 \times l^2 / 2$$

$$M = 24 \times 0.735 / 2 \times 6.93^2 / 2 = 205.7 \text{ K-in}$$

$$t = \sqrt{\frac{6M}{B F_b}} = \sqrt{\frac{6 \times 205.7}{28 \times 27.0}} = \sqrt{1.6324} = 1.28 \text{ in}$$

Use 1 1/2 inches

Use 4 - 1 1/2" Φ Anchor bars

Foundation

R = 194.2 kips at a slope of 1 on 0.45
for 4.0 ft

R = 48.55 kips / ft

F_R = 10.0 ksf

Graphically, draw a Reaction line from
mid point of Vertical Member on rock
side (A), through bearing plate (B) such
that e = 6.0 inches, to Foundation (C). *
*

Bottom of flume to C measured on a
slope of 2 on 1 shall be at least:

$$a > \frac{2R}{3 F} = \frac{2 \times 48.55}{3 \times 10.0} = 3.24'$$

Total depth of trench (l) shall be less
than 3a = 9.7'

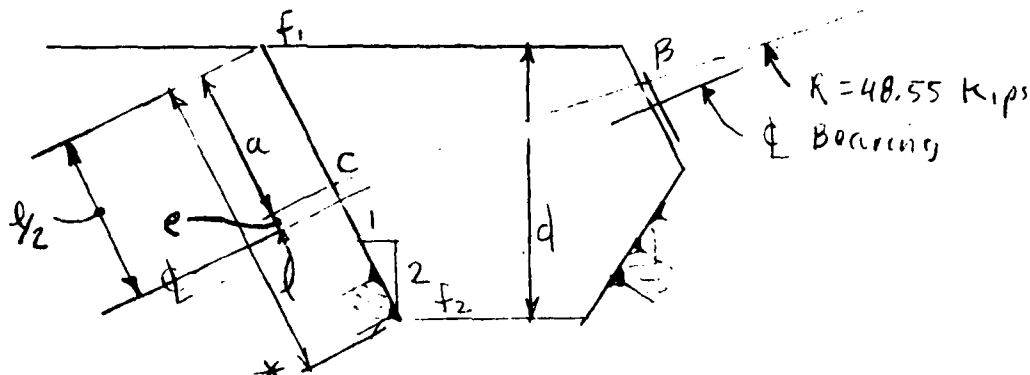
DI-96

* see sheet 5, 18

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
Pier Protection SHEET NO. 18 OF SHEETS
 FOR Big Creek Flood Control Project
 COMPUTED BY PvdG DATE 2/27/77 CHECKED BY WS DATE 3/5/79

Foundation



FORMULAS *

$f_1 = 10.0 \text{ k/ft}^2$ max. found. pressure.

$$f_1 = \frac{R}{l^2} (l + 6e) \leq 10 \quad \& \quad f_2 = \frac{R}{l^2} (l - 6e) \geq 0.0$$

$$a + e = l/2 \quad \text{or} \quad e = l/2 - a$$

Substituting $(l/2 - a)$ for e gives the following:

$$f_1 = \frac{R}{l^2} (4l - 6a) \leq 10 \quad f_2 = \frac{R}{l^2} (6a - 2l) > 0$$

l	a	f_1	f_2	d
8.94	3.75	6.06	2.80	8.0
8.94	3.08	15.50	0.36	8.0
10.06	3.08	10.44	-0.79	9.0
7.53	3.75	6.95	5.43	7.0
6.71	3.75	4.67	9.80	6.0

USE

* For Note regarding Formulas,
See Sheet D1-97a

D1-97

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. _____
Pier Protection SHEET NO. _____ OF _____ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY Prdy DATE 7-13-79 CHECKED BY _____ DATE _____

NOTE REGARDING FORMULAS ON SHEET D1-97

The first two equations, $f_1 = R(1 + 6e)/l^2 \leq 10$
and $f_2 = R(1 - 6e)/l^2 \geq 0$ are basic foundation
pressure equations.

f_1 and f_2 are the foundation pressures at
each end of the foundation;
 R is the applied load, normal to the foundation;
 l is the length of the foundation; and
 e is the eccentricity of the applied load.
 $a + e = l/2$ or $e = l/2 - a$

The second two equations are the same
except $(l/2 - a)$ has been substituted for e .

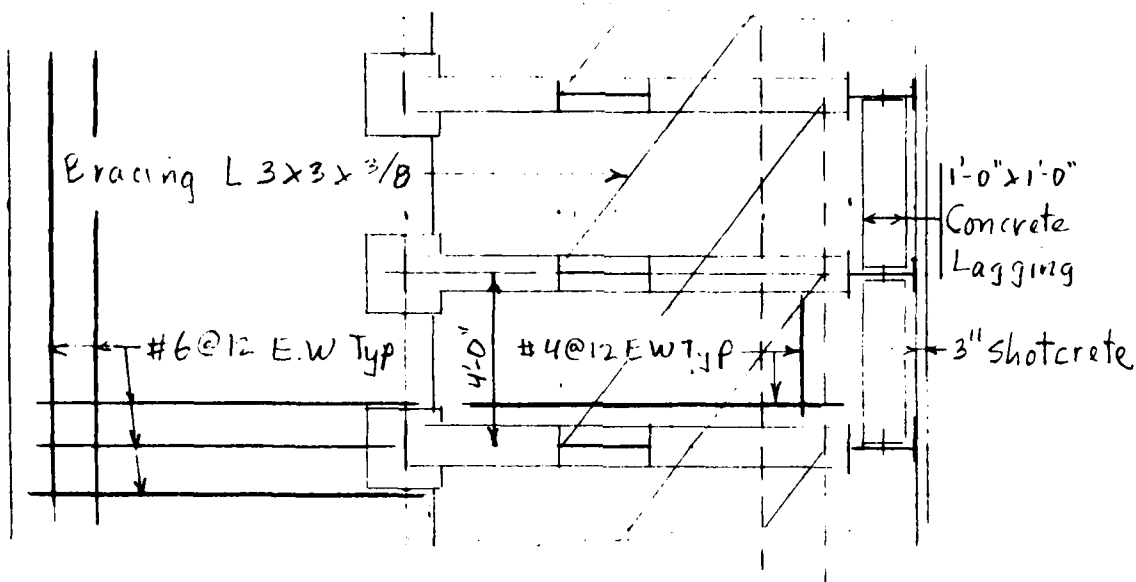
The foundation in this case is assumed
to consist of only the sloping portion of
the trench.

D1-97a

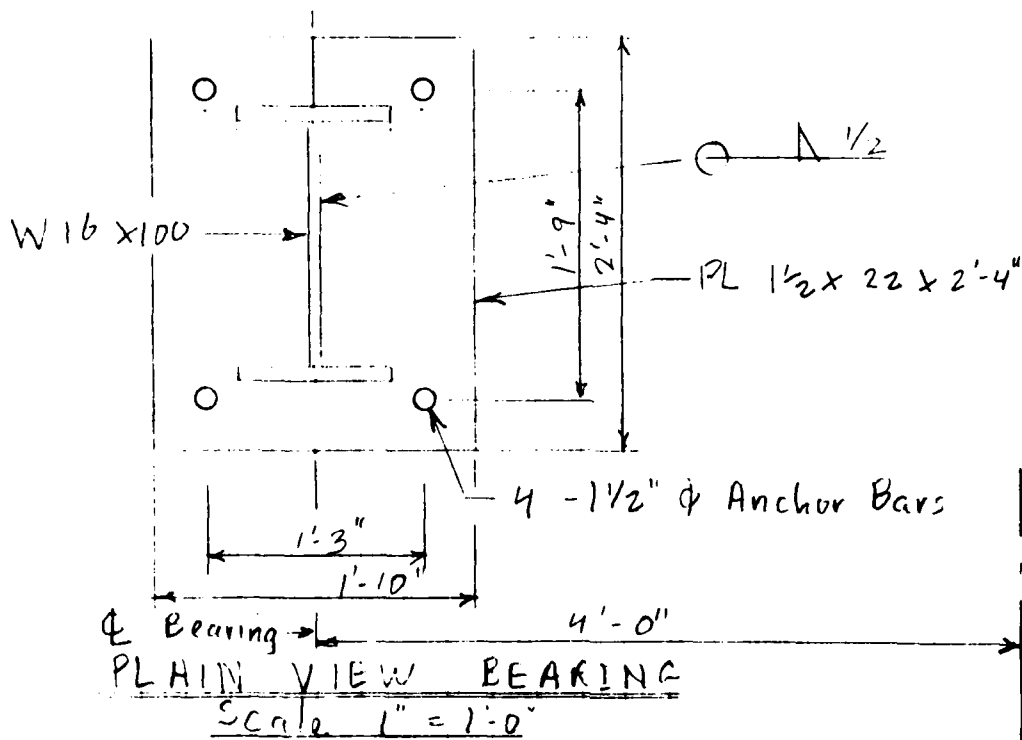
GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Division Channel FILE NO. 7622.00
river protection SHEET NO. 19 OF SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY Pydg DATE 2-27-79 CHECKED BY WS DATE 3-5-79

Summary



--- #6@12 E.W Typ
PLAN VIEW. SUPPORT SYSTEM
Scale 1/4" = 1'-0"



DI-98

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
Pier Protection SHEET NO. 20 OF 20 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 3/1/79 CHECKED BY WS DATE 3-5-79

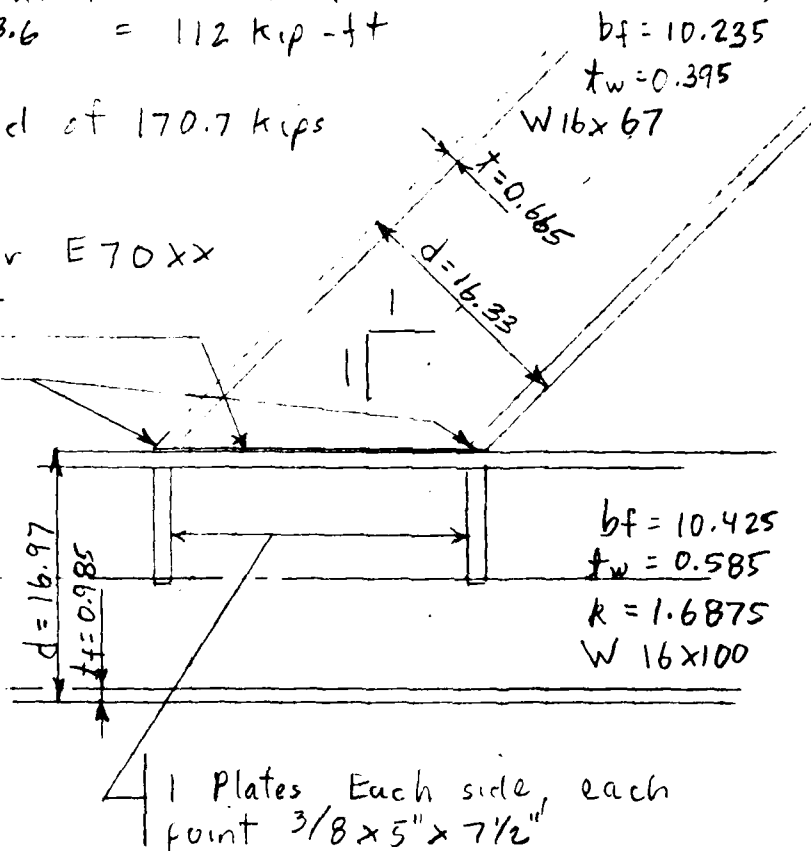
Weld Design

Use $\frac{1}{2}$ of Moment from sheet 13
 $= \frac{1}{2} 223.6 = 112 \text{ kip-ft}$

Use Normal Load of 170.7 kips
(ch. 10)

$f_v = 21 \text{ ksi}$ for E70XX
or similar

$\frac{1}{2}$
 $\frac{1}{2}$



1 Plates Each side, each
point $\frac{3}{8} \times 5 \times 7\frac{1}{2}$

Ref: AISC, p. 4-88

$$T = \frac{12M}{d} = \frac{12 \times 112}{16.33} = 82.3 \text{ kips per Flange}$$

$$N = \frac{170.7}{2} = 85.4 \text{ kips per Flange}$$

$$\text{Total} = 167.7 \text{ kips}$$

$$\text{Shear} = 167.7 \times \sqrt{.5} = 118.5 \text{ kips} \leftarrow$$

$$\text{Reaction} = 120 \text{ k} \downarrow \text{ say } 120 \text{ kips}$$

PI-99

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7622.00
Pier Protection SHEET NO. 21 OF 21 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 3/1/79 CHECKED BY WS DATE 3-5-79

Weld Design

Load: 120 kips

USE Complete penetration TC-L46 Weld
Single Bevel Groove

$$t = 0.665 \quad F_v = 21.0, \quad b = 10.235$$

$$f_w = \frac{120}{0.665 \times 10.235} = 17.63 < 21.0 \quad \text{O.K.}$$

Stiffener Design

$$A_{st} = A_p - t(t_b + 5R)$$

$$R = 120$$

$$A_p = 0.665 \times 10.235$$

$$t = 10.235$$

$$t = 0.585$$

$$t_b = 0.665$$

$$R = 1.6875$$

$$A_{st} = 0.665 \times 10.235 - 0.585(0.665 + 5 \times 1.6875)$$

$$A_{st} = 1.481 \text{ in}^2 \quad l/t_{\max} = 15.8$$

$$\text{set } l = 5.0$$

$$t = \frac{5.0}{15.8} = 0.316 \quad \text{say } 3/8"$$

$$\text{Min weld size} = \frac{t_w \times F_{vw}}{2 \sqrt{0.5} F_{vw}} = \frac{0.585 \times 14.5}{2 \times \sqrt{0.5} \times 21.0} = 0.286$$

size = 5/16" weld.

$$\text{Length of weld} = A_{st} \times F_y = \frac{5 \times 3/8 \times 36}{0.7280 \times 1.65} = 8.62"$$

$$\text{Weld around, Length} = 2(4 + 6.5) = 21" \quad \text{O.K.}$$

DI-100

Weld Design

Vertical and Diagonal Connection

Ref: AISC, page 4-88

Item 5

A: Add Flange Cover Plate
 $\frac{1}{4} \times 7 \times 2'-6"$

B: Add 2 Web Cover Plates
 $\frac{1}{4} \times 14 \times 2'-6"$
grind to fit beam fillet

t_w = web thickness or t . Reference is Manual of Steel Construction, AISC, 7th Ed., Pg. 4-88 and Part 5, Sec. 1.15; t and t_w both refer to web thickness.

$$t_w < \frac{A_p}{t_b + 5k} = \frac{0.665 \times 10.235 \times \sqrt{0.5}}{0.665 + 5 \times 1.3125}$$

$$\begin{aligned} t_w &= 0.380 \\ b_f &= 7.070 \\ k &= 1.3125 \\ d_c &= 13.635 \end{aligned}$$

$t_w = 0.380 < 0.666 \therefore$ Need Stiffeners

$$t_w < \frac{d_c}{5\sqrt{F_y}} = \frac{13.635}{5 \times \sqrt{36}} = 0.4545 \therefore \text{Need Stiffeners}$$

$$t_f < 0.4 \sqrt{A_p} = 0.4 \times \sqrt{10.235 \times 0.665 \times \sqrt{0.5}} = 0.738$$

Add Flange cover plate thickness equal to
 $0.738 - 0.630 = 0.108 = \frac{1}{8}"$

Add 2 Web cover plates $\frac{0.666 - 0.380}{2} = 0.143 = \frac{3}{16}$

USE $\frac{1}{4}"$ plates for Flange and web.

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. 7822.00
Flood Protection SHEET NO. 23 OF 23 SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY PvdG DATE 3/2/79 CHECKED BY WS DATE 3-5-79

Connections - Vertical & Horizontal

Horizontal Member W 16 x 100 $t_f = 0.985$
 $bf = 10.425$

Vertical Member W 16 x 50 $t_f = 0.630$
 $bf = 7.070$
 $R = 1.3125$
 $d_c = 13.635$

$$t_w < \frac{0.985 \times 10.425}{0.985 + 5 \times 1.3125} = 1.361 \quad \text{Need stiffeners}$$

$$t_w < \frac{13.635}{\sqrt{36}} = 0.4545 \quad \text{Need Stiffeners}$$

$$t_f < 0.4 \sqrt{10.235 \times 0.665} = 1.044"$$

Add Flange Cover Plate of 0.414" or 1/2"

$$R \text{ now becomes } 1.3125 + 0.5 = 1.8125$$

$$t_w < \frac{0.985 \times 10.425}{0.985 + 5 \times 1.8125} = 1.022"$$

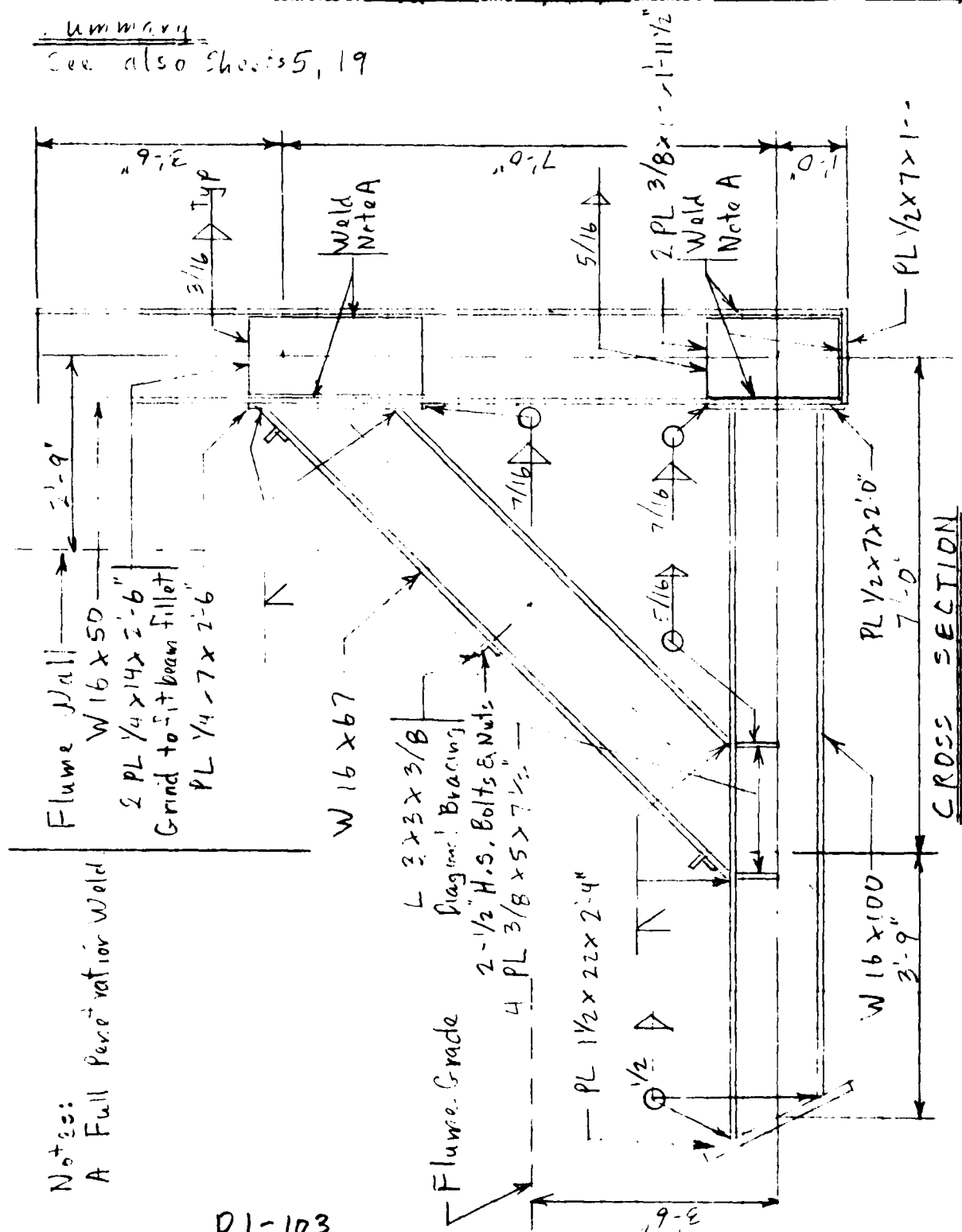
$$\text{Add 2 Web Plates of } \frac{1.022 - 0.380}{2} = 0.321 = 3/8"$$

USE 1 Flange Cover Plate, PL 1/2 x 7 x 2'-0"

USE 2 Web Cover Plates, PL 3/8 x 14 x 2'-0"
(grind to fit beam fillet)

SUBJECT Divergence Channel FILE NO. 7622-00
Flow Protection SHEET NO. 24 OF SHEETS
 FOR Big Creek Level Control Project
 COMPUTED BY Lvd/c DATE 1-13-79 CHECKED BY WS DATE 3-5-79

See also sheets 5, 19

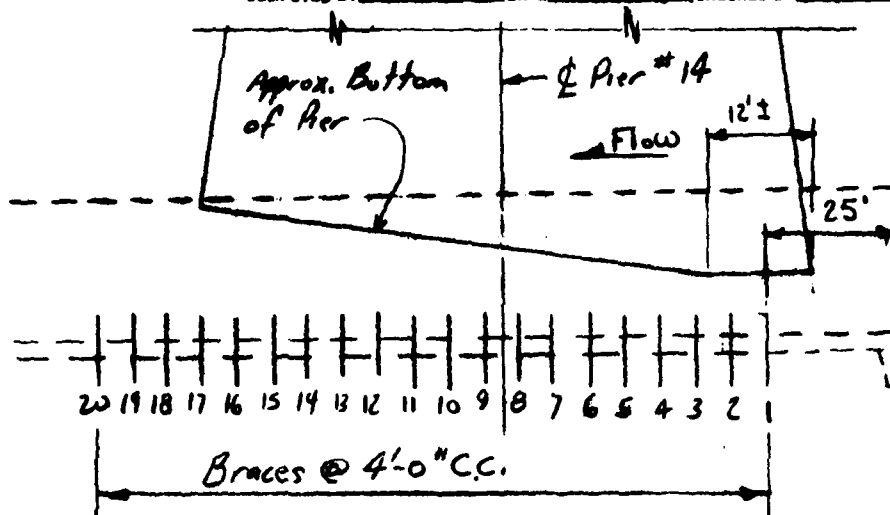

$$N_0 + \frac{1}{2} \frac{1}{N_0}$$

A Full Perse⁺ration World

D1-103

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel FILE NO. _____
Pier Protection SHEET NO. _____ OF _____ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY FF DATE 3-5-79 CHECKED BY _____ DATE _____



GENERAL CONSTRUCTION PROCEDURE

1. Excavate overburden along reach of bracing system.
2. Place shotcrete on rock surface along pier (area between vertical rock cut and pier).
3. Start rock excavation at upstream end of pier and work in a downstream direction.
4. Excavate as required for brace ① and ②. Shotcrete vertical face after each 5-foot lift of rock excavation.
5. Place concrete anchor blocks. Let set for 7 days before proceeding with step 6.
6. Install braces ① and ②.
7. Install lagging (Place mortar between lagging and shotcrete, wedge lagging at braces).
8. Excavate rock for braces ③ & ④ → continue sequence. Concrete between concrete anchor block and lagging placed at Contractor's option.

D1-104

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Diversion Channel - Pier Protection FILE NO. _____
SHEET NO. _____ OF _____ SHEETS
FOR Big Creek Flood Control Project
COMPUTED BY FF DATE 3-5-79 CHECKED BY _____ DATE _____

Comment on Design

Assumptions and procedures are believed to be on the conservative side. It was felt that this was necessary because of the importance of the bridge. Also, the bridge is old and not in good condition. The fillet at the bottom of the wall is not believed to have any significant affect on the hydraulics. Pier #14 takes the load from unequal spans. The actual loading on the pier is angled into the abutment. For design purposes, it was assumed that the load was vertical.

D1-105

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D
DESIGN ANALYSIS

AUGUST 1979

SUBAPPENDIX D2
COMPUTATIONS FOR DESIGN
OF
RAILROAD BRIDGES AND TEMPORARY TRESTLE

SUBAPPENDIX D2

COMPUTATIONS FOR DESIGN OF RAILROAD BRIDGES AND TEMPORARY TRESTLE

CONTENTS

<u>Item</u>	<u>Page No.</u>
Geometry Computations	D2- 3 to D2-19
Superstructure Design-Mainline and Spurline	D2-20 to D2-31
Abutment and Wingwall Design-Mainline	D2-32 to D2-54
Abutment and Wingwall Design-Spurline	D2-55 to D2-61
Pier Design-Spurline	D2-62 to D2-72
Trestle Bent Design-Temporary N&W Structure.	D2-73 to D2-84
Beam Deflection Program	D2-85
Retaining Wall-Abutment Program	D2-86 to D2-91
Program for Load and Moment Points for Interactive Curve	D2-92

NOTE:

The Beam Deflection Program, the Retaining Wall-Abutment Program, and the Program for Load and Moment Points for Interactive Curve have been verified by hand computations.

**GANNETT FLEMING CORDRY
AND CARPENTER, INC.**
HARRISBURG, PA.

SUBJECT Cleveland Flood Control Project
Spur Line Bridge

FILE NO. _____

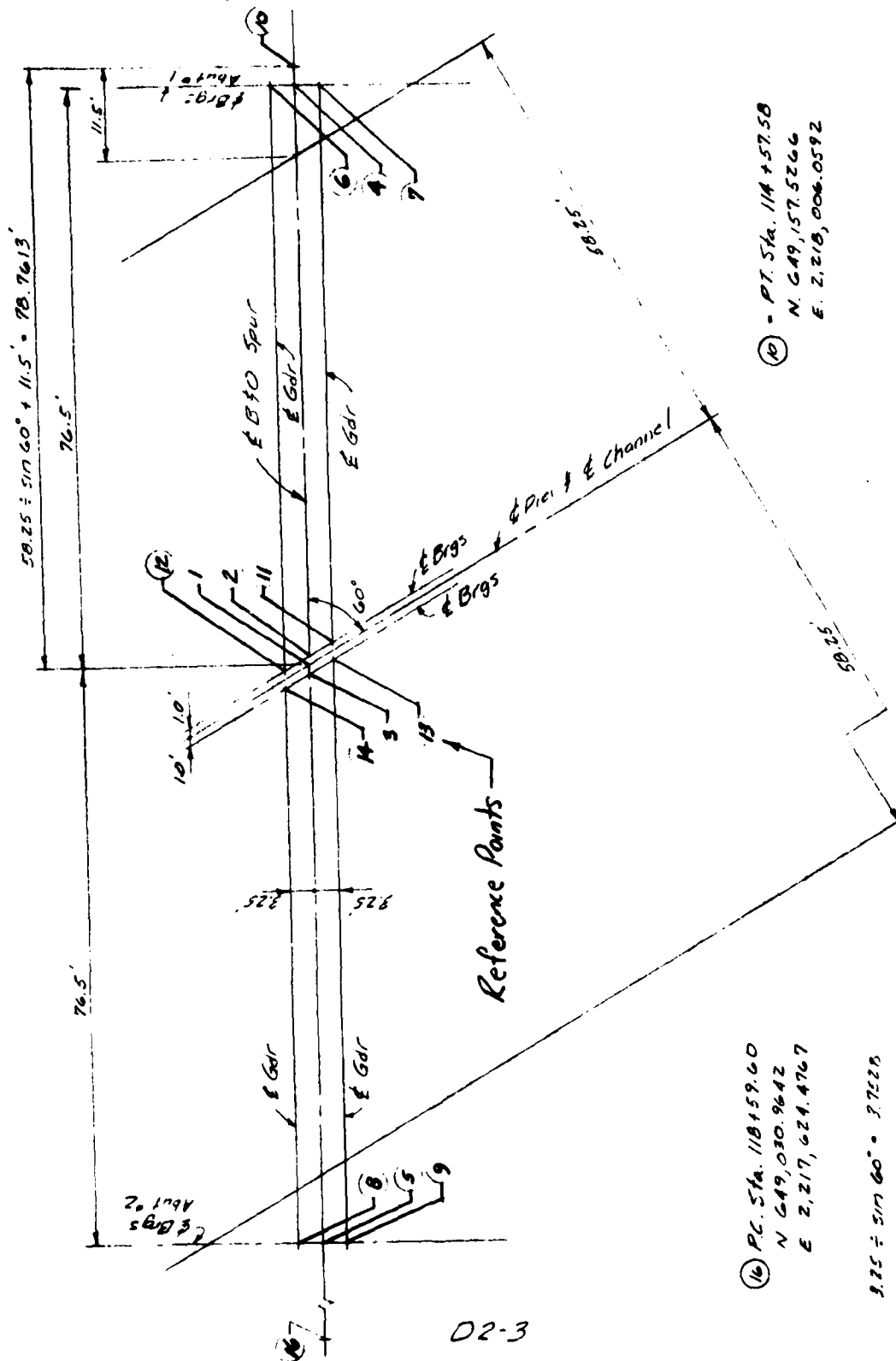
SHEET NO. _____ OF _____ SHEETS

FOR _____

COMPUTED BY RSM DATE 2-1-79

CHECKED BY DLH DATE 2-8-79

GEOMETRY - Spur Line Bridge



(10) - PT Sta. 114+57.58
N. 64.9, 157.5266
E. 2.218, 004.0592

(16) PL Sta. 118+59.60
N. 64.9, 030.9642
E. 2.217, 624.4767

3.75 ÷ sin 60° = 3.7228

02-3

Geometry - Spur Line Bridge

by: RSM (2-1-75)

cnfld: D.I.T (2-8-73)

edit c1(coq) ip11
EDIT run

COMMAND:

? CLR
? 1 29 1
? 0 0 0

COMMAND:

? str
? 10 649157.5266 2218006.0592 PT Sta. 114+57.58
? 16 649030.9642 2217624.4767 PC Sta. 118+59.60
? 0 0 0

COMMAND:

? 117
? 10 16 1 78.7613
1 649132.7315 2217931.3026 $\neq$ Pier
? 10 16 2 77.7613
2 649133.0463 2217932.2518
? 10 16 3 79.7613
3 649132.4167 2217930.3535
? 1 10 4 76.5
4 649156.8147 2218003.9129 $\neq$ Orgs. Abut. #1
? 1 16 5 76.5
5 649108.6483 2217858.6924 $\neq$ Orgs. Abut. #2
? 1 0 0 0

COMMAND:

? 4 5 3 25 6 0
~~COMMAND NOT FOUND~~

~~COMMAND:~~

NOTE:

Sheets 02-4 thru 02-6, 02-8 thru 02-14,
and 02-16 thru 02-19 are the output
from a COGO Program. For writeup
of program, see Subappendix 05.

Reference Points,
See Sheet 02-3.

? 4 5 3.25 6 8
 6 649159.8995 2218002.8897
 8 649111.7331 2217857.6692
 ? 5 4 3.25 9 7
 9 649105.5636 2217859.7155
 7 649153.7300 2218004.9360
 ? 0 0 0 0 0

COMMAND:

? 16 3 14 3.7528 60 00 00
 14 649134.9108 2217927.5493
 ? 10 3 13 3.7528 60 00 00
 13 649129.9226 2217933.1576
 ? 16 2 12 3.7528 60 00 00
 12 649135.5404 2217929.4476
 ? 10 2 11 3.7528 60 00 00
 11 649130.5523 2217935.0559
 ? 0 0 0 0 0 0

COMMAND:

? ibr
 ? 10 16
 SW 71- 39- 1.69 DIST= 402.0239
 ? 10 4
 SW 71- 39- 1.69 DIST= 2.2613
 ? 10 2
 SW 71- 39- 1.69 DIST= 77.7613
 ? 10 1
 SW 71- 39- 1.69 DIST= 78.7613
 ? 10 3
 SW 71- 39- 1.69 DIST= 79.7613
 ?

Geometry - Spur Line Bridge

by: RSM (2-1-79)

Chgo: DLT (2-8-72)

Geometry - Four Line Bridge

L1: RSM 2.12
 Chord: Dist 13-5-3

PT Sta 114+57.58
 (+) 2.26

Orgs About #1 Sta 114+59.84
 (+) 76.50

2 Pier Sta 115+36.34
 (+) 76.50

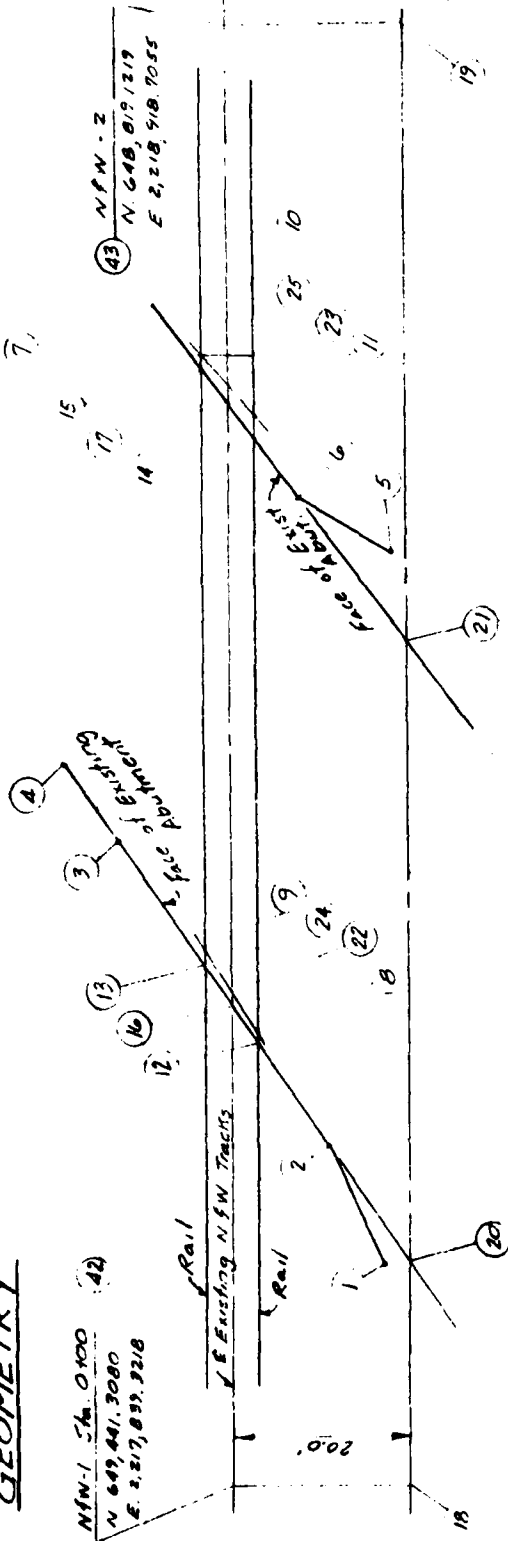
Orgs About #2 Sta 116+12.84

10 5	SW 71- 39-	1.69	DIST=	155.2613
6 12	SW 71- 39-	1.74	DIST=	77.2764
7 11	SW 71- 39-	1.63	DIST=	73.6236
14 8	SW 71- 39-	1.63	DIST=	73.6236
13 9	SW 71- 39-	1.74	DIST=	77.3764
12 14	SW 71- 39-	1.69	DIST=	2.0000
2 3	SW 71- 39-	1.69	DIST=	2.0000
11 13	SW 71- 39-	1.69	DIST=	2.0000
11 12	NW 48- 20-	58.31	DIST=	7.5056
13 14	NW 48- 20-	58.31	DIST=	7.5056
6 8	SW 71- 39-	1.69	DIST=	153.0000
7 9	SW 71- 39-	1.69	DIST=	153.0000
4 2	SW 71- 39-	1.69	DIST=	75.5000
4 1	SW 71- 39-	1.69	DIST=	76.5000
1 5	SW 71- 39-	1.69	DIST=	76.5000
3 5	SW 71- 39-	1.69	DIST=	75.5000
0 0	SW 71- 39-	1.69	DIST=	75.5000

**GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.**

SUBJECT Cleveland Flood Control Project FILE NO. _____
Mainline Bridge SHEET NO. _____ OF _____ SHEETS
 FOR _____
 COMPUTED BY ASM DATE 2-2-79 CHECKED BY 2-2-79 DATE -8-79

GEOMETRY



Turn To	Clockwise &	Distance
(1)	348°-10'-40"	89.01
(2)	10°-46'-20"	102.06
(3)	24°-36'-58"	132.83
(4)	27°-53'-40"	144.70
(5)	44°-55'-35"	110.60
(6)	43°-23'-15"	133.34
(7)	45°-53'-37"	159.85
(8)	16°-59'-50"	112.67
(9)	20°-29'-04"	119.68
(10)	45°-35'-58"	151.97
(11)	45°-03'-40"	143.60

From Survey:

T at Mon. 110 (40)

N 649,008.78
E 2,218,363.99

Backsight to Mon. 121 (41)

N 649,106.18
E 2,218,409.23

Case: 17-00000

111

5 649046.8972 2218467.8141

Existing N & W Bridge
 by: RSM (2-2-79)
 SHAD: DH (2-8-79)

41 40 6 133.34 43 23 15
 6 649058.0793 2218487.8816
 ? 41 40 7 159.85 45 53 37
 7 649061.3299 2218514.9553
 ? 41 40 8 112.67 16 59 50
 8 649092.6272 2218439.2508
 ? 41 40 9 119.68 20 29 04
 9 649092.8164 2218449.2026
 ? 41 40 10 151.97 45 35 58
 10 649059.4756 2218507.2549
 ? 41 40 11 143.60 45 03 40
 11 649057.9533 2218498.9083
 ? 0 0 0 0 0 0

COMMAND:

? Fin
 ? 12 8 11 2 3
 12 649092.8956 2218438.7889
 ? 13 9 10 2 3
 13 649093.6165 2218447.8094
 ? 14 8 11 6 7
 14 649059.1550 2218496.8407
 ? 15 9 10 6 7
 15 649060.2446 2218505.9160
 ? 16 42 43 2 3
 16 649093.2442 2218443.1513
 ? 17 42 43 6 7
 17 649059.6965 2218501.3508
 ? 22 42 43 8 9
 22 649092.7186 2218444.0632
 ? 23 42 43 10 11
 23 649058.7107 2218503.0610
 ? 0 0 0 0 0

COMMAND:

?

Existing N & W Bridge

by: RSM (2-2-79)
CHD: DCH (2-2-79)

pin
42 43 20.0 18.19
18 649423.9966 2217829.3338
19 648801.7945 2218908.7175
2 0 0 0 0 0

COMMAND:
? tot
24 9 8 11
24 649088.3513 2218446.6075
25 10 8 11
25 649054.7115 2218504.4859
2 0 0 0 0

COMMAND:
? pin
20 18 19 2 3
20 649090.4334 2218407.9796
21 18 19 6 7
21 649055.7170 2218468.2064
2 0 0 0 0 0

COMMAND:
? lbr
2 3
NE 85- 25- 50.65 DIST= 41.6461
NE 83- 9- 12.78 DIST= 27.2681
NE 88- 54- 39.26 DIST= 9.9537
NE 79- 39- 48.26 DIST= 8.4843
SE 60- 7- 49.00 DIST= 66.9453
SE 8 11
SE 59- 50- 3.07 DIST= 69.0022
?

SE 60- 7- 49.00	DIST=	67.0070
SE 60- 2- 22.86	DIST=	67.1761
SE 59- 50- 3.07	DIST=	67.1449
NW 60- 7- 49.00	DIST=	1.6066
NW 60- 2- 22.86	DIST=	1.0525
NW 59- 50- 3.07	DIST=	0.5342
SE 60- 7- 49.00	DIST=	1.5441
SE 60- 2- 22.86	DIST=	1.9740
SE 59- 50- 3.07	DIST=	2.3914
SW 85- 25- 50.65	DIST=	15.5959
SW 83- 9- 12.78	DIST=	19.8165
SE 60- 2- 22.86	DIST=	696.9638
SE 60- 2- 22.86	DIST=	764.1399
SE 60- 2- 22.86	DIST=	667.8957
SE 60- 2- 22.86	DIST=	737.4119
SE 60- 2- 22.86	DIST=	69.5161
SW 85- 25- 50.65	DIST=	35.2838
SW 85- 25- 50.65	DIST=	19.6880

Existing N & W Bridge
 by: REM (2-2-79)
 chMo: DJT (2-8-79)

SW 85-	17 21	9-	12.78	DIST=	33.3824
SW 85-	17 6	9-	12.78	DIST=	13.5659
SW 85-	9 24	9-	56.93	DIST=	5.1644
SW 85-	10 25	9-	56.93	DIST=	5.5104
SW 88-	9 22	54-	39.26	DIST=	5.1404
SW 88-	22 9	54-	39.26	DIST=	4.8133
SW 85-	13 16	25-	50.65	DIST=	4.6729
SW 85-	16 12	25-	50.65	DIST=	4.3763
SW 85-	13 12	25-	50.65	DIST=	9.0493
SW 85-	15 17	9-	12.78	DIST=	4.5980
SW 83-	17 14	9-	12.78	DIST=	4.5425
SW 83-	15 14	9-	12.78	DIST=	9.1404
SW 79-	10 23	39-	48.26	DIST=	4.2631
SW 79-	23 11	39-	48.26	DIST=	4.2212
SE 62-	2 6	26-	0.46	DIST=	72.5974
	0 0				

Existing N + W Bridge
 by: RSM (2-2-79)
 chro: JCH (2-2-79)

02-12

COMMAND

? ang
 ? 9 8 11
 ? 31- 15- 17.67
 ? 9 22 43
 ? 31- 2- 57.88
 ? 3 13 10
 ? 34- 26- 20.35
 ? 3 16 43
 ? 34- 31- 46.49
 ? 3 12 11
 ? 34- 44- 6.28
 ? 7 15 10
 ? 36- 42- 58.22
 ? 7 17 43
 ? 36- 48- 24.36
 ? 7 14 11
 ? 37- 0- 44.15
 ? 10 23 43
 ? 40- 17- 48.88
 ? 10 11 25
 ? 40- 30- 8.67
 ? 3 20 19
 ? 34- 31- 46.49
 ? 7 21 19
 ? 36- 48- 24.36
 ? 20 2 1
 ? 10- 4- 58.29
 ? 5 6 21
 ? 22- 16- 51.74
 ? 0 0 0

Existing 1 1/2 W Bridge

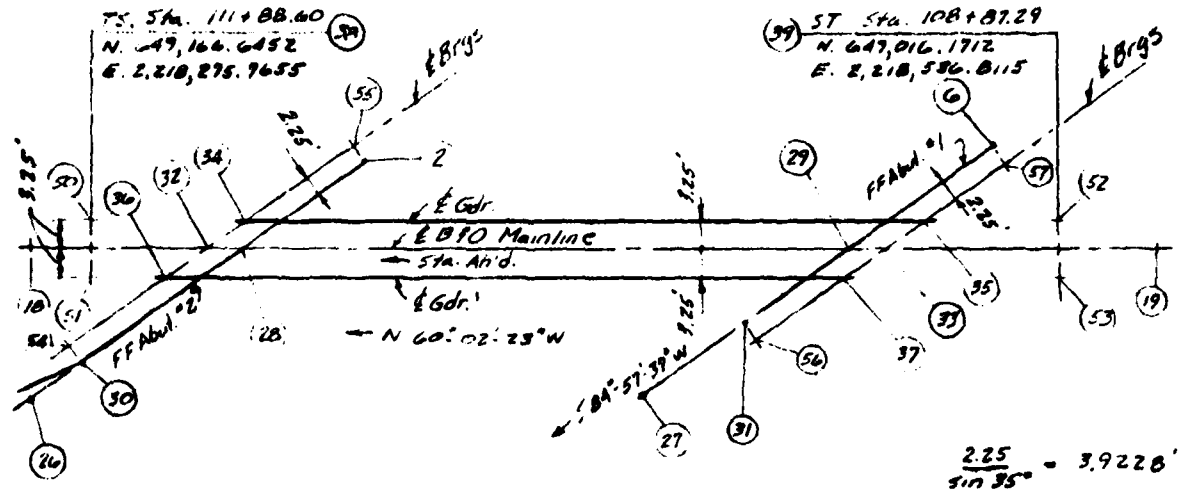
by: RSM (2-2-79)
 chks: DJT (2-5-79)

DIST 8 TO 11= 69.0022
 DIST 22 TO 43= 547.8508
 DIST 13 TO 10= 68.5519
 DIST 16 TO 43= 548.9033
 DIST 12 TO 11= 69.5364
 DIST 15 TO 10= 1.5441
 DIST 17 TO 43= 481.7272
 DIST 14 TO 11= 2.3914
 DIST 23 TO 43= 479.7532
 DIST 11 TO 25= 6.4513
 DIST 20 TO 19= 577.9713
 DIST 21 TO 19= 508.4552
 DIST 2 TO 1= 39.5575
 DIST 6 TO 21= 19.8165

**GANNETT FLEMING CORDRY
AND CARPENTER, INC.**
HARRISBURG, PA.

SUBJECT Cleveland Flood Control Project FILE NO. _____
Manning Bridge SHEET NO. _____ OF _____ SHEETS
 FOR _____
 COMPUTED BY KSM DATE 2-2-79 CHECKED BY DLT DATE 2-5-79

GEOMETRY



SKew Δ - $35^{\circ}-00'-00''$
 Pt (30) - Bend Pt. of Wing
 Pt (31) - $\frac{1}{2}''$ Jt.
 From Abut. Dwgs:
 Dist. 32 to 54 = $24'-11''$
 do 33 to 56 = $13'-46''$

edit c:\p099) (p1)

EDIV run

COMMAND

?
? 1 0 0 0
? 0 0 0

COMMAND

?
? 2 649091.6758 2218423.5259
? 5 649058.0703 2218487.0016
? 10 649473.9806 2217829.3330
? 19 648801.7945 2218908.7175
? 26 649078.4989 2218274.1058
? 27 649044.9024 2218338.4615
? 28 649090.3219 2218408.1731 (Call OK)
? 29 649056.2610 2218467.2627
? 30 649166.6452 2218275.7655
? 39 649016.1712 2218536.8115
? 0 0 0

COMMAND

?
? 19 18
? NW 60- 2- 22.86 DIST= 1245.8671
? 39 38
? NW 60- 2- 22.86 DIST= 301.3095
? 0 0

COMMAND

?
? 19 39
? NW 60- 2- 22.87 DIST= 429.2685
? 0 0

COMMAND

?

lan
 28 2 55 2.25 90 00 00
 55 649093.9171 2218423.3283
 29 6 57 2.25 270 00 00
 57 649055.8380 2218488.0793
 ? 0 0 0 0 0 0

COMMAND:

? lin
 28 38 32 3.9228
 32 649092.2810 2218404.7727 ← ← Brgs, Abut = 2
 29 39 33 3.9228
 33 649054.3020 2218470.6613 ← ← Brgs, Abut = 1
 32 55 54 -24.9167
 54 649090.0924 2218379.9523
 33 57 56 -13.3438
 56 649053.1297 2218457.3691
 ? 0 0 0 0

COMMAND:

? lan
 55 54 30 2.25 90 00 00
 30 649087.8511 2218380.1499
 57 56 31 2.25 270 00 00
 31 649055.3710 2218457.1714
 ? 0 0 0 0 0 0

COMMAND:

? pln
 39 38 3.25 52 50
 52 649018.9869 2218538.4346
 50 649169.4609 2218277.3886
 38 39 3.25 51 53
 51 649163.8295 2218274.1424
 53 649013.3555 2218535.1884
 ? 0 0 0 0

Mainline P & O Bridge
 by: RSM (2-2-77)
 chmd: DLH (2-8-77)

3

Marine 3400

by: REM: 2-2-79)

chro: 22-1

COMPANY	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895	2896	2897	2898	2899	2900	2901	2902	2903	2904	2905	2906	2907	29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[illegible]

02-18

Span length = 76'-0.5"

?	32 36				
	SW 84- 57-	39.50	DIST=	5.6648	
?	34 36				
	SW 84- 57-	39.50	DIST=	11.3326	
?	35 33				
	SW 84- 57-	36.97	DIST=	5.6662	
?	33 37				
	SW 84- 57-	36.97	DIST=	5.6662	
?	35 37				
	SW 84- 57-	36.97	DIST=	11.3324	
?	29 31				
	SW 84- 57-	36.41	DIST=	10.1304	
?	28 30				
	SW 84- 57-	39.55	DIST=	28.1301	
?	0 0				

COMMAND:

? eo i

END OF PROGRAM COG

EDIT end

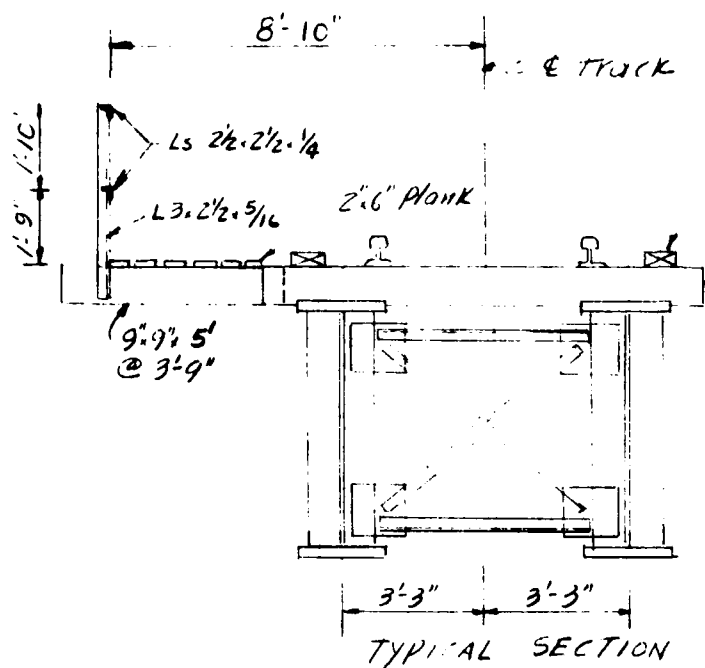
Mainline B+O Bridge

by: RSM (2-2-79)

chrd: JH (2-8-79)

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT BIG CREEK R.R. BRIDGE FILE NO. _____
Main Line SHEET NO. _____ OF _____ SHEETS
FOR U.S. Army Engineer District - Buffalo
COMPUTED BY JKS DATE 12-13-78 CHECKED BY REM DATE 1-2-79



SPAN LENGTH = 78'
(4c Bearings)

4" x 8" timber guard rail

9" x 9" x 10' tie @ 15'

Design specifications:
AREA (1975)
Structural Welding Code:
AWS D1.1 Rev. 2-77

DEAD LOAD:

1) Track and sidewalk:

WT OF TRACK rails, guard rails, etc	= 200 #/l
Timber guard rail = $0.33 \times 0.67 \times 60 \times 2$	= 27
TIES = $0.75 \times 0.75 \times 10' \times 60 \div 1.25$	= 270
$0.75 \times 0.75 \times 5' \times 60 \div 3.75$	= 45
Planks = $0.17 \times 0.5 \times 6 \times 60$	= 64
railing = $L 2 1/2 \times 2 1/2 \times 1/4 = 4.1 \times 2$	= 8
$L 3 \times 2 1/2 \times 5/16 = 5.6 \times 4.33 \div 3.75$	= 6
	<u>620 #/l</u>

2) Steel:

* For DL Computations only.

Web: $61 \times 1/2" = 109 \times 2$	= 218
Flanges: $24 \times 2 5/8 = 214 \times 4$	= 856
Transv. Stiff: $8 \times 1/2 @ 4' (1) = 13.6 \times 5.33 \times 4 \div 4$	= 72
Diaphragms: $L 3 1/2 \times 3 1/2 \times 1/2 = 11.1 \times 4.75 \times 2 = 105$	
$L 3 1/2 \times 3 1/2 \times 1/2 = 11.1 \times 5.75 \times 2 = 128$	
Ch. Rs: $15 \times 1/2 \times 12 = 25.5 \times 4 = 102$	
	<u>335</u> $\div 15.6 = 21$
	Total DL = 1815 #/l

Per Girder = 0.91 #/l

Lateral bracing = $L 2 1/2 \times 3 1/2 \times 1/2 = 11.1 \times 10 \times 2 \div 2 = 15.6$
28
1195 #/l

D2-20

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek R.R. Bridge FILE NO. _____
Main Line SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 12-13-78 CHECKED BY RSM DATE 1-3-79

Live Load: Cooper E-80

Impact: Diesel impact and open-deck bridge

$$I = \frac{100}{5} + 40 - \frac{3L^2}{1600}$$

$$S = 6.5' \quad L = 78' \quad I = 44\%$$

Moments and shears for Cooper's E-80: Table 3 Page 144
(Stresses in framed structures)
Hool & Kunne (McGraw Hill)

Max Moments:

$$\begin{aligned} DL &= 0.910 \times 78^2 \div 8 = 692 \\ LL &= 2581 \times \frac{80}{50} = 4130 \\ I &= 4130 \times 0.44 = 1817 \\ &= 6639 \text{ K-ft} \end{aligned}$$

Max. Shears:

$$\begin{aligned} 0.910 \times 78 + 2 &= 35 \\ 152 \times \frac{80}{50} &= 243 \\ 243 \times 0.44 &= 107 \\ &= 385 \text{ K} \end{aligned}$$

USE A36 Steel.

Allow Shear in Web = 12.5 ksi

$$\text{Max shear stress} = 385 \div (64 \times \frac{1}{2}) = 12.0 \text{ ksi}$$

$$I = I_w + d^2 A \times 2 \quad \leftarrow (2 \text{ Flanges})$$

$$\begin{aligned} \text{Max bending stress: } I &= \frac{64 \times 0.5^3}{12} + 33.25 \times 24 \times 2 = 142,591 \text{ in}^4 \\ S &= 4162 \quad f_s = \frac{6639 \times 12}{4162} = 19.14 \text{ ksi} \quad (\text{increase flange size}) \\ &\quad \text{See LL+I deflections} \end{aligned}$$

Allow. Compressive stress: Diaphragm spacing = 17.5'

$$A_1 = \frac{64}{2} \times 0.5 + 24 \times 2.5 = 76 \text{ in}^2$$

$$I_1 = \frac{24 \times 2.5^3}{12} + \frac{64 \times 0.5^3}{12} = 2880 \text{ in}^4 \quad r_y = 6.16"$$

$$\frac{L}{r} = \frac{17.5 \times 12}{6.16} = 34 < 157$$

$$F_0 = 20000 - 0.4(34)^2 = 19535 \text{ psi}$$

$$\text{OR } \frac{10500000}{17.5 \times 12 \times 69/24 \times 2.5} = 43478 \text{ psi}$$

USE 20.0 ksi

* For Detailed Breakdown,
See Sheet D2-21a

Deflection: Use Live load + Impact

$$\text{allow} = \frac{L}{640} = 1.46"$$

D2-21

MOMENT OF INERTIA OF GIRDER

Reference Sheet D2-21 where Moment of Inertia of Girder computed at 143,591 IN^3 . The following is a detailed breakdown for determining this value.

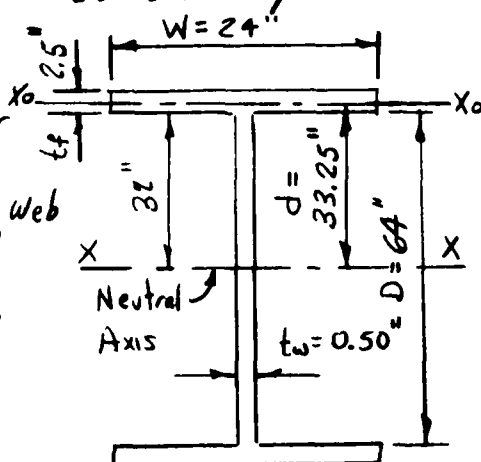
I = Moment of Inertia of Girder

$$I = I_W + I_{FT} + I_{FB}$$

I_W = Moment of Inertia of Web

I_{FT} = Moment of Inertia of Top Flange

I_{FB} = Moment of Inertia of Bottom Flange



$$I_W = \frac{1}{12} \times t_w \times D^3$$

$$= \frac{1}{12} \times 0.50 \times 64^3 = 10,922.67 \text{ IN}^3$$

$$I_{FT} = I_{FB} = A \times d^2$$

$$A = 2.5 \times 24 = 60.0 \text{ IN}^2$$

$$d = 32.00 + \frac{1}{2} t_f = 32.00 + \frac{1}{2} \times 2.5$$

$$d = 32.00 + 1.25 = 33.25$$

$$I_{FT} = I_{FB} = 60 \times 33.25^2 = 66,333.75 \text{ IN}^3$$

$$\therefore I = 10,922.67 + 66,333.75 + 66,333.75$$

$$I = 143,590.17 \text{ IN}^3$$

NOTE: Theoretically, $I_{FT} \& I_{FB} = I_{X_0} + A d^2$

I_{X_0} = The moment of inertia of the flange with respect to its parallel centroidal axis (X_0)

$$I_{X_0} = \frac{1}{12} \times W \times t_f^3 = \frac{1}{12} \times 24 \times 2.5^3 = 31.25 \text{ IN}^3$$

$$\therefore I = 143,590.17 + 31.25 + 31.25 = 143,652.67 \text{ IN}^3$$

% Error in neglecting $I_{X_0} = 0.04\%$

I_{X_0} is neglected because it is negligible.

D2-21 a

```

edit dfl jeli
EDIT  run
SPAN(FT).WL(KIP/FT).WR(KIP/FT).ML(FT-KIP).MR(FT-KIP)
? 78 5.76 5.76 0 0

```

```

START & END OF UNIFORM LD?
? 74.54 78

```

```

NO. OF "I" VALUES?
? 1

```

```

DISTANCE & "I"?
? 78 143594

```

```

NO. OF CONC. LDS.?
? 12

```

```

LOAD & DISTANCE?
? 37.44 2.54 37.44 8.54

```

```

? 37.44 13.54 28.8 21.54

```

```

? 57.6 29.54 57.6 34.54

```

```

? 57.6 39.54 57.6 44.54

```

```

? 37.44 53.54 37.44 58.54

```

```

? 37.44 64.54 37.44 69.54

```

```

DEFLECTION (INCHES)
.10 PT .20 PT .30 PT .40 PT .50 PT
0.4663 0.8847 1.2164 1.4309 1.5053

```

```

.60 PT .70 PT .80 PT .90 PT
1.4316 1.2190 0.8880 0.4682

```

```

ROTATIONS(RAD.)
LEFT= 0.0050741 RIGHT= -0.0050917

```

```

DIST. TO SPECIAL POINT?
? 0

```

```

END OF PROGRAM DFL
EDIT end

```

Live Load Deflection

B&O Mainline

BY: JRS (12-13-78)

CHKD: RSM (1-3-79)

NOTE:

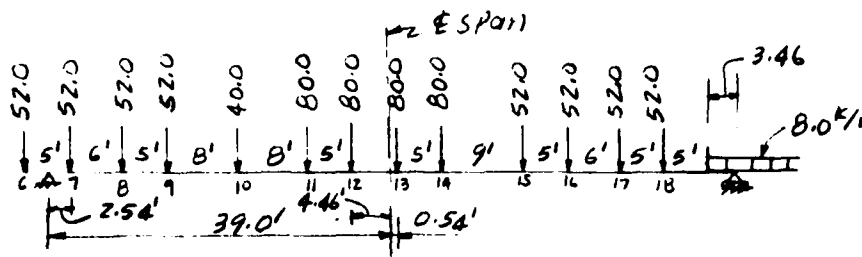
This sheet is the output from
a Deflection Program. Writeup
of this program at end of this
Subappendix.

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SUBJECT BIS Creek R.R. Bridge FILE NO. _____
Main Line SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 12-13-78 CHECKED BY RSM DATE 1-4-79

Deflection (cont.)

Locate Wheel 13 at 0.54' Rt of E span:



Load per Girder: (include impact)

$$\begin{aligned} \frac{52}{2} \times 1.44 &= 37.44^k & \frac{80}{2} \times 1.44 &= 57.60^k \\ \frac{40}{2} \times 1.44 &= 28.80^k & \frac{8}{2} \times 1.44 &= 5.76^k/ft \end{aligned}$$

Run program DFL

Max deflection 1.51 > Δ_{allow}

increase flange R_s by $\frac{1}{8}$:

$$I = \frac{64^3 \times 0.5}{12} + 33.31 \times 24 \times 2.625 \times 2 = 150727 \text{ in}^4$$

$$S = 4353$$

$$\text{Max deflection}_1 = 1.51 \times \frac{143591}{150727} = 1.44" < \frac{L}{640} \text{ ok}$$

$$\text{Max. stresses} = \frac{6639 \times 12 + 4353}{150727} = 183$$

Use 64" $\frac{1}{2}$ Web and 24" $2\frac{5}{8}$ Flanges.

Intermediate stiffeners:

$$\frac{D}{t} = \frac{64}{0.5} = 128 > 60 \text{ use stiffeners}$$

$$\text{Max } S = 12.5 \text{ ksi} \quad \text{spacing} = \frac{10500 \times 0.5}{\sqrt{12500}} = 47"$$

Max shear at $\frac{1}{4}$ Point:

$$V_{DL} = 35.0 - 19.5 \times 0.91 = 17^k$$

$$V_{LL} = 88.2 \times \frac{80}{50} \times 1.44 = 203 \quad V_{total} = 220^k$$

$$S = 6.83 \text{ ksi} \quad d = \frac{10500 \times 0.5}{\sqrt{6880}} = 63"$$

$$\text{Stiffener Size: } 0.5 \times \frac{1}{2} \text{ Max width} = 16 \times \frac{1}{2} = 8" \text{ say } 8 \times \frac{1}{2} \text{ (pairs)}$$

$$\text{or } 2" \times \frac{69.25}{32} = 4.3$$

$$\text{Stiffener on one side only: } I \text{ of 2 stiff} \times \frac{16^3 \times 0.5}{12} = 171$$

$$I \text{ of one stiff} = \frac{1}{3} \times \frac{1}{16} = 171 \quad h \approx 9.5" \quad t = \frac{1}{8} \text{ say } 9 \times \frac{1}{2} \times \frac{1}{8} \text{ (one side)}$$

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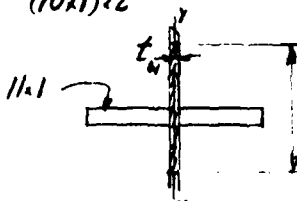
SUBJECT BIG Creek R.R. Bridge FILE NO. _____
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FOR _____
COMPUTED BY JRS DATE 12-14-78 CHECKED BY RSM DATE 1-4-79

Bearing Stiffeners: Max reaction = 385 k

try 11" Rs: Min $t = W/12 = 1"$

check bearing: $\frac{385}{(10 \times 1) \times 2} = 19.25 < 30.0$ OK

Compressive stress:



$A = 11.1 \times 2 + 12.5 \times 0.5 = 28.25$

$I_y = \frac{11.1^3}{12} \times 2 + 11.1 \times 2 \times 5.75^2$
 $+ \frac{12.5^3}{12} = 949.3$

$r = 5.8$

$\frac{KL}{r} = \frac{0.75 \times 64}{5.8} = 8.3 < 15$ use $F_u = 20.0$ ksi

Max stress = $\frac{385}{28.25} = 13.63$ ksi OK

Stiffener to web connection:

allow. shear in fillet welds = 12.5 ksi

thickness = $\frac{385}{2 \times 64 \times 2 \times 0.707 \times 12.5} = 0.17$ use $5/16"$ (Min. size)

Fatigue: use 500,000 cycles use AWS criteria

Attachment for lateral bracing: use category E

(see Fig 9.4b AWS D.1) stress range $F_{sr} = 12.5$ ksi (*)

assume welding @ 5" from bot. of web: $S = \frac{150727}{27} = 5582$

Max stresses = $\frac{6639 \times 12}{5582} = 14.22$

Min stress (DL on 1/2) = $\frac{692 \times 12}{5582} = 1.49$ * By AASHTO $F_{sr} = 8.0$ ksi

stress range = 12.78

use bolted connection

transverse stiffeners: $F_{sr} = 20.0$ ksi

Lateral bracing and diaphragms:

Wind load: 1) on loaded bridge = 300 #/ft (8' above top of rail)
2) on bridge = $20 \text{ #/ft} \times \frac{69}{12} = 172 \text{ #/ft} \times 1.5 = 258 \text{ #/ft}$

Lateral force from equipment: $\frac{1}{4} \times 80 \times 20.0$

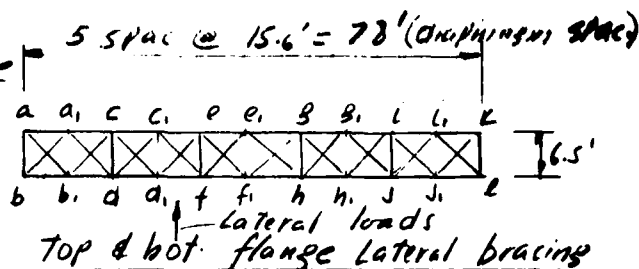
Bracing between compression members: $0.025 \times 20.0 \times 24 \times 245 = 31.5$

D2-24

Assume Max stresses

a) Lateral bracing:

assume 90° skew bridge



Use a lateral truss placed in the plane of the top flange in order to resist all the lateral loads. Assume that diagonals take both Tension and Compression and that they are both in action, each taking $\frac{1}{2}$ the shear on the section.

$$\text{Wind load per panel} = (300 + \frac{258}{2}) \times \frac{15.6}{2} = 3.35K$$

$$V_{ab} = 3.35 \times \frac{10}{2} = 16.7K$$

Lateral load from equipment: applied at panel bd

$$V_{ab} = 20K$$

$$\text{Max } V_{ab} = 37K \quad b a_1 (\text{length}) = (6.5^2 + 7.8^2)^{\frac{1}{2}} = 10.2'$$

$$\text{Force on } b a_1 = \frac{37}{2} \times \frac{10.2}{6.5} = 29K \quad (\#) \text{ Note: Use } L 3\frac{1}{2} \times 3\frac{1}{2} \times \frac{3}{8} \quad (\text{Min Size Material} = 0.425")$$

$$\text{Try } L 3\frac{1}{2} \times 3\frac{1}{2} \times \frac{5}{16} \quad A = 2.09 \text{ in}^2 \quad r = 0.69$$

$$\text{allow stresses: Use } L = 4.2' \quad K = \frac{3}{4} \quad \frac{KL}{r} = \frac{4.2 \times 12 \times 0.75}{0.69} = 55.75$$

$$F_a = 21500 - 100 \times 55 = 16000 \text{ psi}$$

$$f_a = 29 \div 2.09 = 13.8 \text{ KSI OK}$$

bolts connection: Use $\frac{7}{8}" \phi$ H.S. Bolts

$$\text{neglect fatigue: load per bolt} = 0.875 \times 3.14 \times 20 = 12.0K$$

$$\# \text{ of bolts required} = 29 \div 12 = 2.4 \text{ Use } 3 (\#)$$

$$\# \text{ Weld required} = 29 \div (12.5 \times \frac{1}{2} \times 0.707) = 13"$$

b) Intermediate diaphragms: Use cross frames to brace top flange and stiffen the bot. flange.

Each diagonal is assumed to take $\frac{1}{2}$ of the horizontal shear (Tension and Compression at the same time)

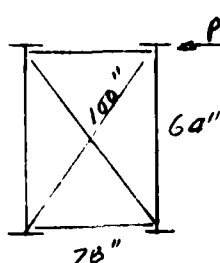
D2-25

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Diaphragms (cont.)

$$F(\text{diagonal}) = \frac{31.5 \times 100}{78 \times 2} = 19^k$$



$$F(\text{Horizontal}) = 15.75$$

$$L \approx 68" \quad \frac{KL}{r} = 74$$

$$F_c = 21500 - 100 \times 74 = 14100$$

$$\text{try } L3\frac{1}{2} \times 3\frac{1}{2} \times 5/16 : A = 2.09 \quad r = 0.69 \quad L = 50" \quad \frac{KL}{r} = 54 \text{ (diagonal)}$$

$$F_c = 21500 - 100 \times 54 = 16100$$

$$f_c = 19 \div 2.09 = 9.1^k \quad \text{ok. Use } L3\frac{1}{2} \times 3\frac{1}{2} \times 3/8$$

$$\# \text{ of bolts} = 19 \div 12 = 1.6 \text{ say } 3 \text{ Min Weld} = 19 \div 12.5 \times 0.707 \times \frac{1}{4} = 9"$$

End diaphragms: provide end cross frames to carry all lateral forces to the supports on the Abutments.

$$\text{Wind load} = 16.7^k$$

$$\text{Lateral load} = \frac{200^k}{2}$$

$$36.7^k \text{ (Applied } \perp \text{ to } \& \text{ Girder)}$$

For end diaphragm design see next sh.

Check stability:

$$LL = 1200 \#/11$$

$$\text{Vertical reaction per Girder: } DL = 35^k$$

$$LL = \frac{1.2 \times 78}{2} = 2 \text{ (No impact)} = 24^k$$

Horizontal Reactions:

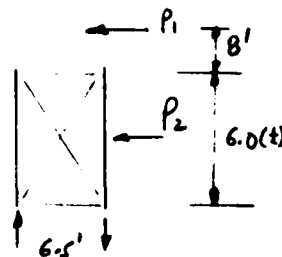
$$\text{Wind on } LL = 0.3 \times 78 \div 2 = P_1 = 11.7^k \text{ (@ 8' above top of rail)}$$

$$\text{Wind on structure} = 0.25 \times 78 = P_2 = 10.0^k$$

$$\text{Overturning Moment} = \frac{71.7}{2} \times 14.0 + 10.0 \times 3 = 194^k \cdot 1$$

$$\text{Vertical reaction} = \frac{+194}{6.5} = 30.0^k$$

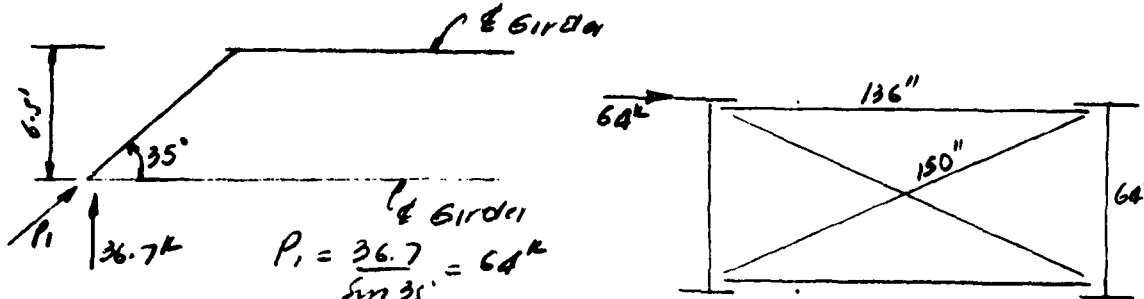
$$\text{Min reaction} = 35 + 24 - 30 = 29^k \text{ No uplift}$$



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COMPUTED BY JRS DATE 12-15-78 CHECKED BY REM DATE 1-8-79

End diaphragm (cont.)



$$\text{Force Diagonal} = 32 \times \frac{150}{136} = 35.3 \text{ k}$$

STRUT:

$$\text{Max } \frac{KL}{r} = 120 \quad l = 136 - 12 = 124"$$

$$\text{try } L 4 \times 4 \times \frac{1}{2}: \quad r = 0.782" \quad A = 3.75 \text{ in}^2$$

$$\frac{KL}{r} = \frac{0.75 \times 124}{0.782} = 119 \text{ OK}$$

$$F_u = 21500 - 100 \times 119 = 9.6 \text{ kN}$$

$$f_c = 32 \div 3.75 = 8.53$$

$$\text{Weld. length} = \frac{9.6 \times 3.75}{12.5 \times 0.707 \times \frac{1}{8}} = 16.3"$$

USE $L 4 \times 4 \times \frac{1}{2}$

Diagonal:

$$\text{try } L 3 \frac{1}{2} \times 3 \frac{1}{2} \times \frac{3}{8} \quad A = 2.48 \quad r = 0.687$$

$$\frac{KL}{r} = \frac{0.75 \times (75 - 12)}{0.687} = 68.8 < 120$$

$$F_u = 14.62 \text{ kN}$$

$$f_c = \frac{35.3}{2.48} = 14.23 \text{ kN OK}$$

USE $L 3 \frac{1}{2} \times 3 \frac{1}{2} \times \frac{3}{8}$

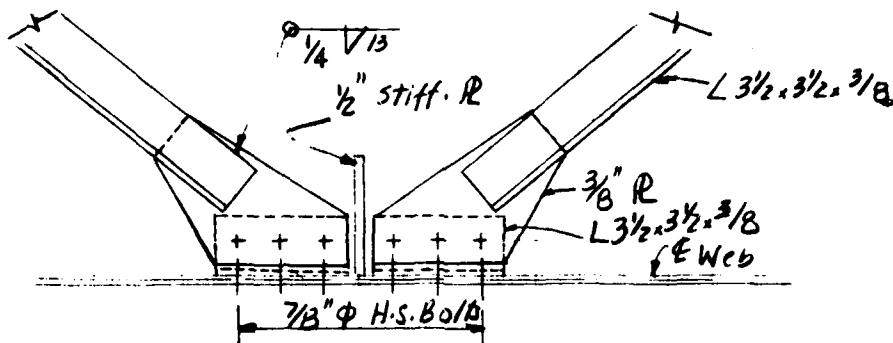
$$l_{\text{weld}} = \frac{14.5 \times 35.3}{32} = 16"$$

$$\text{No of bolts} = \frac{35.3}{12} = 3 \text{ bolts}$$

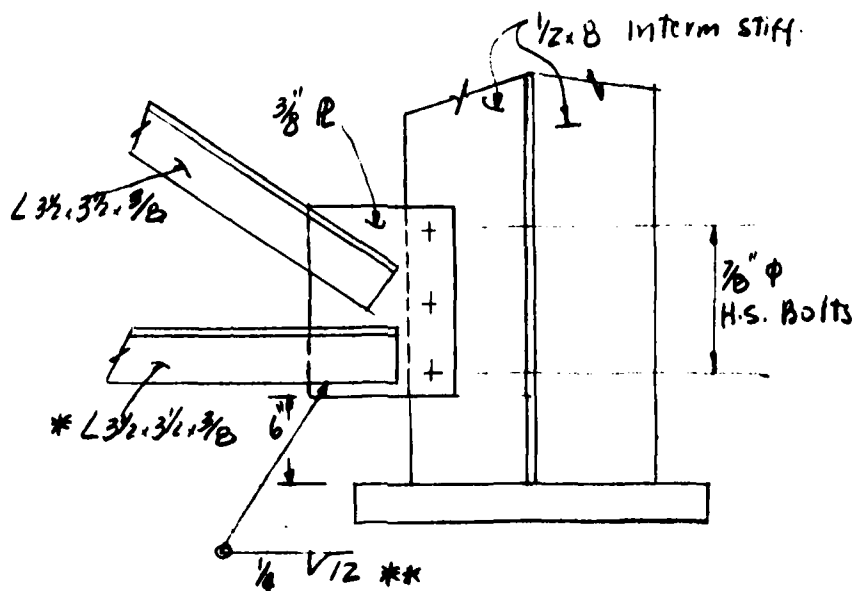
02-27

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SUBJECT BIG CREEK R.R. Bridge FILE NO. _____
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Lateral Bracing Connection
Scale 1"=1'-0"



Typ. Diaphragm Connection
Scale 1"=1'-0"

* Use L4 x 4 x 1/2 End diaphragm.

** UK 16" at 1/4" fillet weld for end diaphragm.

D2-28

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SUBJECT Big Creek R.R. Bridge
Main Line

FILE NO. _____
SHEET NO. _____ OF _____ SHEETS

FOR _____
COMPUTED BY JRS DATE 12-18-78 CHECKED BY RSM DATE 1-8-79

Bearing shoes:

Max Reaction = 385^k Flange Width = 24"

Allow bearing between rockers and rocker pin = 13.5 ksi

Allow bearing on rockers = 640 d for d < 25"

1) Expansion shoe: = 3450 $\sqrt{d}$ 25" < d < 125"

Min length (pin) = $\frac{385}{3.13.5} = 9.5"$ Use 3" ϕ < 28"
(try 3" diameter) 3.13.5

Allow bearing on steel parts in contact = 30.0 ksi

Min size of Web R = $\frac{385}{3.120} = 4.3"$ Use 28" x 3"

Bearing on rocker: Use R = 15"

d = 30" Allow. bearing = 3450 $\sqrt{30} = 18900 \text{ psi}$

Min length = $\frac{385}{18.9} = 20.3"$ Use 30"

Max effective length = 28 + (15 - 1.5) = 41.5" < 20.3"

$W_{top} - W_{bot} \leq 2h$ 12 - 1.5 = 10.5 < 2.15" radius

Masonry R:

Expansion: Use 1" per 100' or $\epsilon_{cc} = \frac{1.0 \times 79}{100} = 0.79\%$

$M = 0.79 \times 385 = 304 \text{ k-in.}$

Max effective length = 41.5

effective width = 4t

Allow bearing pressure = 0.25 f_{c'} Use f_{c'} = 3000 psi
= 0.25 x 3000 = 750 psi

try t = 4" : b = 4.4.0 = 16

$p_{max} = \frac{385}{41.5 \times 16} \pm \frac{304}{41.5 \times \frac{16}{6}} = 0.580 \pm 0.171 = 0.751 < 0.75 \text{ ok}$

check thickness: $p_{max} = 0.751$ $R_e = 0.580$
 $p_{min} = 0.409$

$M = 0.580 \times \frac{b^2}{2} + 0.171 \times \frac{b}{2} \times \frac{3.8}{3} = 22.2 \text{ k-in/in}$ $t = \left(\frac{22.2 \times 6}{20} \right)^{1/2} = 2.6$

Use 44" x 16" x 4" Masonry R.

check bearing on pintles: $F_{lateral} = 11.7 + 10.0 + 20.0 = 41.7 = 2.2 \text{ k}$

bearing = $\frac{2.1}{2 \times 1.1} = 10.5 \text{ k/in}^2$ Per shoe
Use 2 pintles (1 1/2" ϕ)

Shear = $\frac{21.0}{1.48 \times 73 \frac{1}{2}} = 11.9 < 15.0$ (allow. shear on pins) D2-29

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COMPUTED BY JKS DATE 12-18-78 CHECKED BY RSM DATE 1-7-79

Bearing Stiffeners (cont.)

Bearing Stiffener: $\frac{385}{3} = 128.3 \text{ k/rib} \div 30.0 = 4.3 \text{ in}^2$
allow bearing

Use $4\frac{1}{2} \times 1$ stiff: area = $4.12 = 8.0$ ok.

Weld Size = $\frac{128.3}{2 \times (0.2) \times 12.5 \times 0.707} = 0.45$ Use $\frac{1}{2}$ "

Fixed Shoe:

Longitudinal Force = 15% LL

assume continuous rail and the effective $LF = \frac{L}{1200}$
 $= \frac{79}{1200} = 0.066$

$LF = 243.0 \times 0.15 \times 0.066 = 2.4 \text{ k}$ negligible.

try 28×3 " at top - bearing = $\frac{385}{28 \times 3} = 4.58 \text{ ksi} < 13.5$

Max dim. at top of Masonry R: 28×3

Effect. L: $L_B - L_T < 2H$ $L_B = 2 \times 15 + 28 = 58"$

Effect. W: $W_B - W_T < 2H$ $W_B = 2 \times 15 + 3 = 33"$

Masonry R: use 4" thick, $L = 44"$, $W = 16"$

bearing = $\frac{385}{44 \times 16} = 0.547 \text{ ksi}$

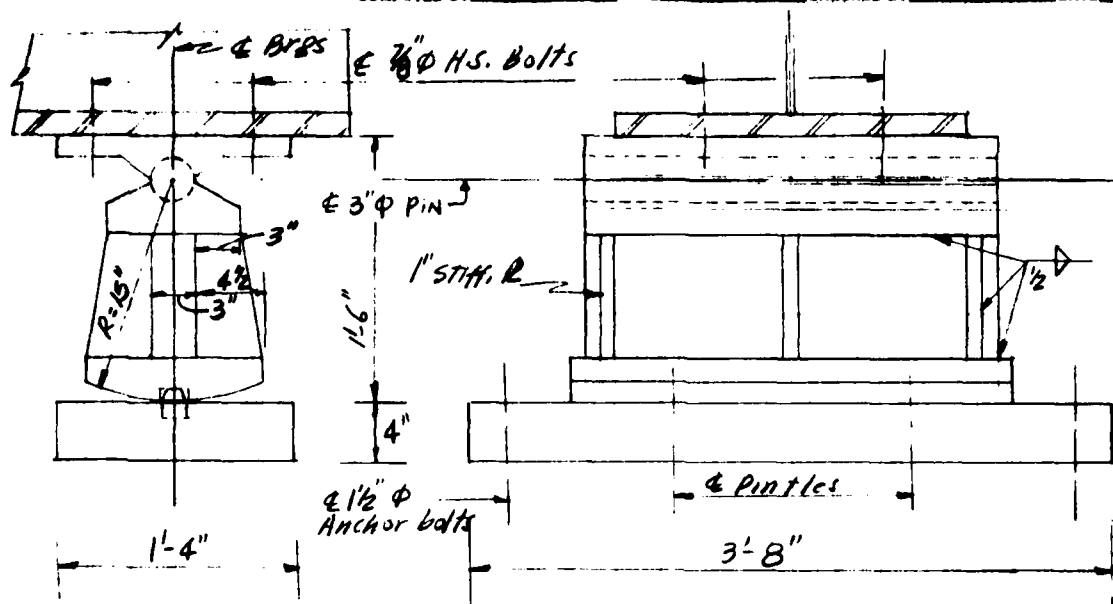
Anchor bolts: Max horizontal force = 21 k/shoe (see exp shoe)

Use 4- $\frac{3}{8}$ " ϕ H.S. bolt for shoe to Girder connection

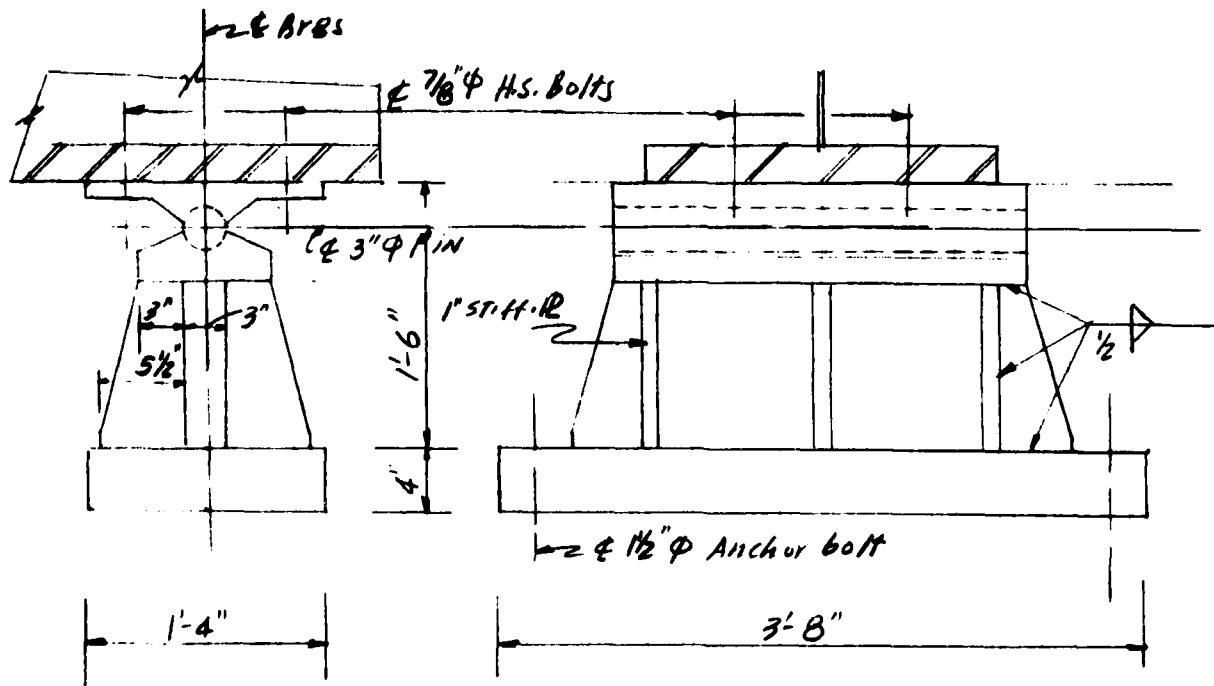
4- $1\frac{1}{2}$ " ϕ Anchor bolts for shoe to Abut. "

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EXPANSION SHOE
Scale 1"=1'-0"



FIXED SHOE
Scale 1"=1'-0"

D2-31

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SUBJECT Big Creek Flood Control FILE NO. _____
Project - Severnino, Ohio SHEET NO. _____ OF _____ SHEETS
FOR U.S. Army Eng. Dist - Fort L. Collins of Engr.
COMPUTED BY RSM DATE 12-14-78 CHECKED BY JRS DATE 12-21-78

Relocated B&O Railroad Bridge-Mainline-Abut. Design

Design Criteria: AREA

Concrete - $f'_c = 3,000 \text{ psi}$, $n = 10$

Reinf. - $f_s = 40,000 \text{ psi}$, $f_s = 20,000 \text{ psi}$

Fdn on Rock - Allow Brg. Pressure = 5 tons/s.f. ($\frac{\text{min}}{\% \text{ tests}}$)

Resultant within middle half (p. 8-5-4)

F.S. against sliding = 1.5, $f = 0.60$ ($\frac{\text{min}}{\% \text{ tests}}$)

* Concrete on sound rock with rough surface (p. 8-5-5) *

Backfill - Use Type 1 Granular Backfill

Unit Wt. = 105 lbs/cu. ft. (p. 8-5-4)

$\phi = 30^\circ$ (do)

$$K_a = \frac{1 - \sin \phi}{1 + \sin \phi} = \frac{1 - .5}{1 + .5} = .333$$

$$\text{Equiv. Fluid Pressure} = .105 \times .333 = .035 \text{ }^{\text{K/1.}}$$

Surcharge: (p. 8-5-3)

For E72 Loading

$$\text{Equiv. Ht. of Fill} = \frac{72^{\text{K}}}{5 \times 14 \times .105} = 9.8'$$

Use Semi-Gravity Wall:

Width of Stem at top of Fig. = $\frac{1}{4} \text{ Ht}$ (8-5-8)

Superstructure Reactions: See Gdr Design

Width of Abut. = $28' (\pm)$

$$DL = \frac{70^{\text{K}}}{128'} = 2.50 \text{ }^{\text{K/1.}}$$

$$LL = \frac{186^{\text{K}}}{20' \times 80} = \frac{15.62^{\text{K/1.}}}{18.12^{\text{K/1.}}} \text{ (without impact)}$$

Longit. Force:

For continuous rail:

$$LF = 15\% \times 15.62 \times \frac{70'}{1200} = .15 \text{ }^{\text{K/1.}} \text{ (p. 8-2-5)}$$

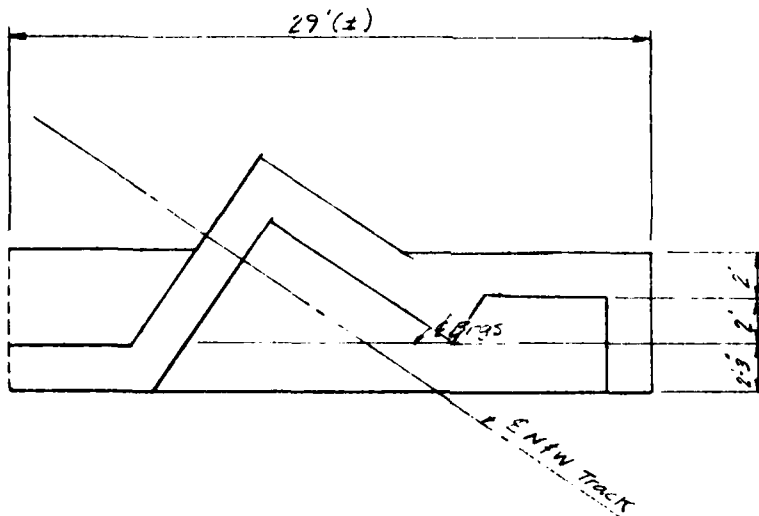
Ignore

D2-32

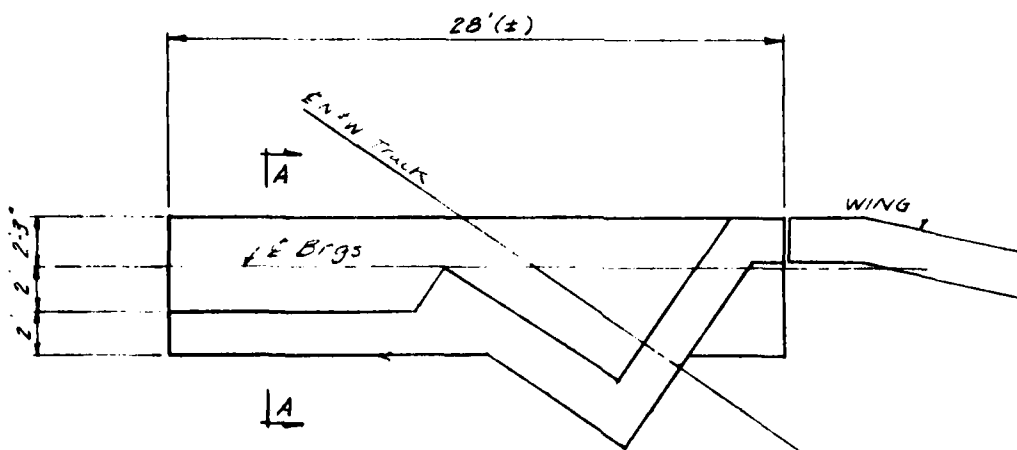
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SUBJECT Big Creek Flood Control FILE NO. _____
Project - Cleveland Ohio SHEET NO. _____ OF _____ SHEETS
FOR U.S. Army Eng. Dist. - Buffalo - Corps of Eng.
COMPUTED BY RSM DATE 12-15-78 CHECKED BY JRS DATE 12-21-78

Abut Design (cont'd)



PLAN - ABUT. NO. 1



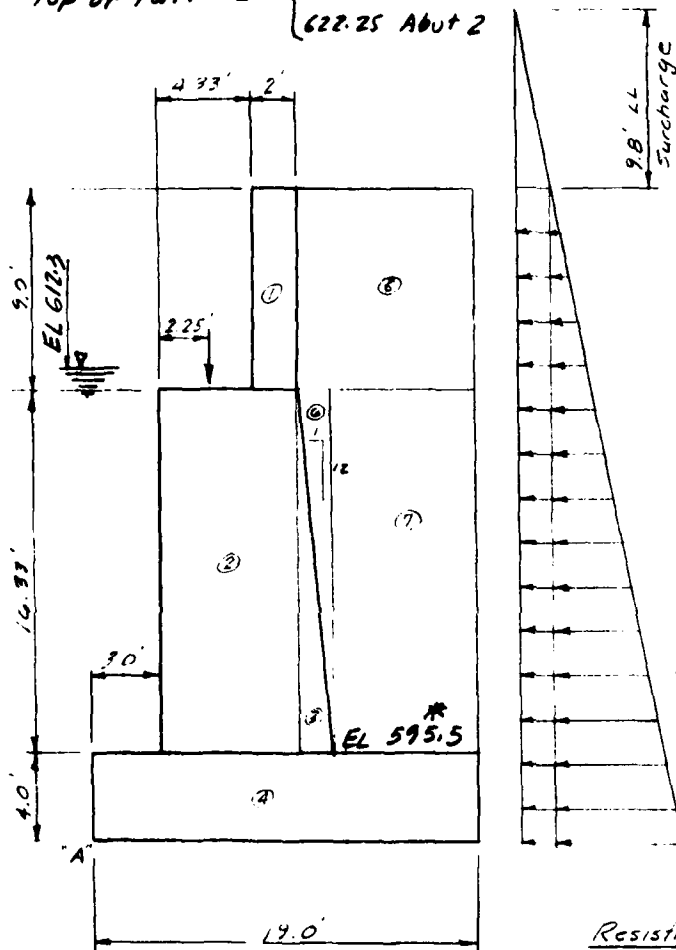
PLAN - ABUT. NO. 2

Note: Design abutment section at 'A-A' for all loads
including LL Surcharge. (Conservative)

D2-33

SUBJECT Fig - 55A Flood Control FILE NO. _____
Project - Cleveland Ohio SHEET NO. _____ OF _____ SHEETS
FOR U S Army Engr Dist - Buffalo - Corps of Engr.
COMPUTED BY RSM DATE 12-18-78 CHECKED BY JRS DATE 12-21-78

Top of rail EL = $\begin{cases} 621.5 \text{ Abut 1} \\ 622.25 \text{ Abut 2} \end{cases}$



* bot. of Channel
Bot. of footing shall be
located below frost line

Rail & Tie = 1'-5"
Gar. = 5'-9"
Shoe = 1'-10"

9'-0"

Abut. Ht. = 29.33
Stem Width = $25.33/4 = 6.33$
Use 1.12 Batter
Stem Width = $6.33 + 16.33/12$
= 7.69' > 6.33'

$$9.8 \times 0.035 \times 29.73 = 10.06 \times 14.66 = 147.5$$

$$\frac{1}{2} \times 0.035 \times 29.73^2 = \underline{15.05} \times 9.70 = \underline{147.2}$$

$$H = 25.11^{\text{K}} \quad M_{\text{OT}} = 294.9^{\text{K}}$$
$$\begin{array}{ll} \textcircled{1} & 2.0 \times 9.0 \times .15 = 2.70 \times 8.33 = 22.5 \\ \textcircled{2} & 6.33 \times 16.33 \times .15 = 15.51 \times 6.17 = 95.7 \\ \textcircled{3} & \frac{1}{2} \times 1.36 \times 16.33 \times .15 = 1.67 \times 9.78 = 16.3 \\ \textcircled{4} & 19.0 \times 4.0 \times .15 = 11.40 \times 9.5 = 108.3 \\ \textcircled{5} & 9.67 \times 9.0 \times .105 = 9.14 \times 14.17 = 129.5 \\ \textcircled{6} & \frac{1}{2} \times 1.36 \times 16.33 \times .105 = 1.16 \times 10.24 = 11.9 \\ \textcircled{7} & 8.31 \times 16.33 \times .105 = \underline{14.25} \times 14.05 = \underline{211.6} \end{array}$$

58.33 608.9

$$= 15.62 \times 5.25 = 82.0$$
$$V = 73.95^\circ \quad M_0 = 690.9^\circ$$

D2-34

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SUBJECT Logan Tunnel - 1000' - 271.01 FILE NO. _____
Cleveland SHEET NO. _____ OF _____ SHEETS
FOR Army Engr. Dist. - Buffalo - Corps of Engr.
COMPUTED BY RSN DATE 12-8-78 CHECKED BY JRS DATE 12-26-78

Resultant of (640.9 - 271.7) / 73.95 = 5.35' > $\frac{B}{4} = 4.75'$ (OK)

Resultant of (640.9 - 271.7) / 73.95 = 5.35' > $\frac{B}{4} = 4.75'$ (OK)

Resultant of (640.9 - 271.7) / 73.95 = 5.35' > $\frac{B}{4} = 4.75'$ (OK)

$$e = \frac{B}{2} - 5.35 = 4.15'$$

$$Z_{max} = \frac{2 \times 73.95}{3(9.5 - 4.15)} = 9.43 \text{ "/sf} < 10 \text{ (OK)}$$

$$FS \text{ Sliding} = \frac{73.95 \times 0.60}{25.11} = 1.77 > 1.5 \text{ (OK)}$$

CL + Surcharge

$$\text{Resultant at } (600.9 - 274.7) / 58.33 = 5.39' > \frac{B}{4} = 4.75'$$

$$e = 9.5 - 5.39 = 4.11'$$

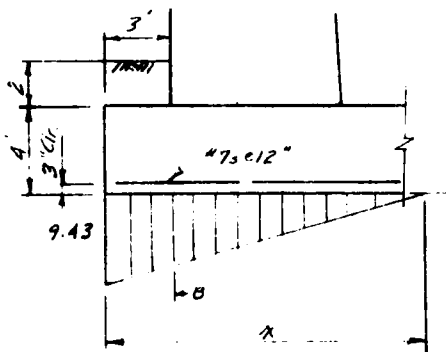
$$Z_{max} = \frac{2 \times 58.33}{3(9.5 - 4.11)} = 7.22 \text{ "/sf}$$

Four footing against
rock (OK as a key)

$$FS \text{ Sliding} = 58.33 \times 0.6 / 25.11 = 1.39 \text{ (Call OK)}$$

$$\text{Bearing Pressure (Toe)} = 25.11 / 4 = 6.3 \text{ "/sf (Neglect friction)}$$

Tee Design



$$x = 3 \left(\frac{B}{2} - e \right)$$

$$= 3(9.5 - 4.15) = 16.05'$$

$$Z_o = 9.43 \times \frac{13.05}{16.05} = 7.68 \text{ "/sf}$$

$$\frac{V_u}{B} \quad \frac{M_u}{B}$$

$$- 4 \times 3 \times 1.5 = 18.0 \times 1.5 = 27.0$$

$$7.68 \times 3 = 23.04 \times 1.5 = 34.56$$

$$\frac{1}{2} \times 1.75 \times 3 = 2.63 \times 2.0 = 5.25$$

$$23.87 \text{ " } \quad 37.11 \text{ "}$$

$$\text{Reqd } A_s = \frac{37.11}{1.44 \times 44.5} = 0.58 \text{ "}$$

$$\text{Try } = 7 \text{ # } 12"$$

$$A_s = 0.60$$

$$\text{reqd } Z_o = \frac{23.87}{1.300 \times 8 \times 44.5} = 2.04 \text{ " OK}$$

$$Z_o = 2.80$$

$$M = 300 \text{ psi}$$

1" from face (p. 8-2-12 f 8-2-10)

$$d > 3.0'$$

C2-35

SUBJECT Big Creek Flood Control FILE NO. _____
Project - Cleveland, Ohio SHEET NO. _____ OF _____ SHEETS
 FOR U.S. Army Engr Corps - Buffalo - Corps of Engrs
 COMPUTED BY RSM DATE 12-19-78 CHECKED BY JRS DATE 12-26-78

0212

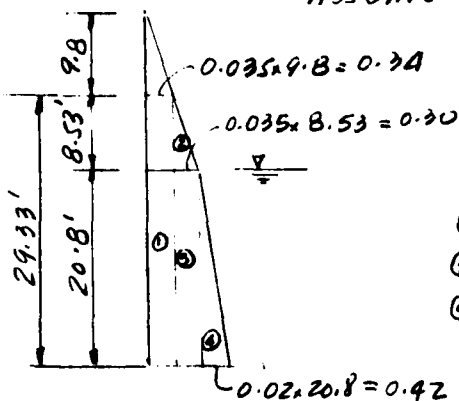
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HARRISBURG, PA.

SUBJECT BIG Creek R.R. Bridge FILE NO. _____
Main Line SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 12-28-78 CHECKED BY RSM DATE 1-10-79

Abutment stability (cont.)

DL + LL surcharge + Buoyancy :

Assume $\gamma' = 60 \text{ pcf}$ and $P_a = 0.06 \times 0.333 = 0.02 \frac{1}{2} \text{ f}$



Earth pressure :

$$\begin{aligned} \textcircled{1} &= 0.34 \times 29.33 = 9.97 \times 14.67 = 146.3 \\ \textcircled{2} &= 0.3 \times 8.53 \times 0.5 = 1.28 \times 23.64 = 30.2 \\ \textcircled{3} &= 0.3 \times 20.8 = 6.24 \times 10.4 = 64.9 \\ \textcircled{4} &= 0.42 \times 20.8 \times 0.5 = 4.37 \times 6.43 = 28.3 \end{aligned}$$

21.86 271.7

Resisting moment : About 'A' : See section A-A :

$$\begin{aligned} \textcircled{1} \text{ thru } \textcircled{5} &= 40.42 \quad = 372.3 \quad * \frac{9.67}{2} \times 9.33 = 44.17 \\ \textcircled{6} : 1.16 \times 0.06 \div 0.105 &= 0.66 \times 10.24 = 6.8 \\ \textcircled{7} : 14.25 \times 0.06 \div 0.105 &= 8.14 \times 14.85 = 120.9 \\ \text{DL} &= 2.50 \times 5.25 = 13.1 \\ \text{LL Surcharge} &= 72 \times 9.67 / 4.5 = 9.95 \times 14.17 = 140.9 \\ \textcircled{2} : 15.5 \times 62.4 / 150 &= -6.45 \times 6.17 = -39.8 \\ \textcircled{3} : 1.67 \times 62.4 / 150 &= -0.70 \times 9.78 = -6.8 \\ \textcircled{4} : 11.40 \times 62.4 / 150 &= -4.74 \times 9.50 = -45.1 \end{aligned}$$

49.78 562.3

Resultant at $(562.3 - 271.7) \div 49.78 = 5.84 > 0.4$

F.S. (sliding) $= 49.78 \times 0.6 \div 21.86 = 1.36 < 1.5$

Note. Pour footing against rock and use as a key to resist horizontal loads.

DL + LL + Surcharge + Buoyancy :

F.S. (sliding) $= (49.78 + 15.62) \times 0.6 \div 21.86 = 1.80$

Resultant at: $(562.3 + 82 - 271.7) \div (49.78 + 15.62) = 5.70 > 0.4$

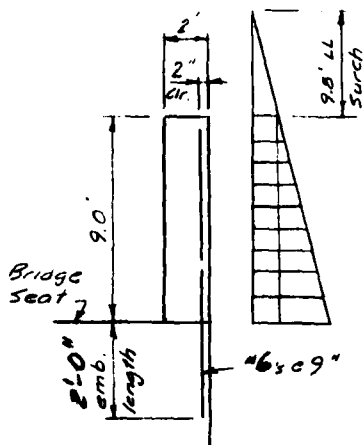
D2-37

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SUBJECT Big Creek Flood Control FILE NO. _____
Project - Cleveland Ohio SHEET NO. _____ OF _____ SHEETS
FOR U.S. Army Eng. District - Buffalo - Corps of Eng.
COMPUTED BY RSM DATE 12-19-78 CHECKED BY JRS DATE 1-3-79

Abutment Design (cont'd)

Backwall



Earth Pressure:

$$9.0 \times 0.35 \times 9 = 3.09 \times 4.5 = 13.89$$

$$\frac{1}{2} \times 0.35 \times 9^2 = 1.42 \times 3.0 = 4.25$$

$$H = 4.51' \quad M = 18.14'$$

Design for pure bending:

$$\text{Req'd } A_s = \frac{18.14}{1.44 \times 21.5} = .59'$$

$$\mu = \frac{4.8 \times \sqrt{3000}}{0.75} = 0.35 \quad \text{Use "6's @ 9" } A_s = 0.59' \quad \Sigma_0 = 3.1$$

$$\text{Emb. Length} = \frac{20 \times .59}{3.1 \times .350} = 10.9' \text{ min}$$

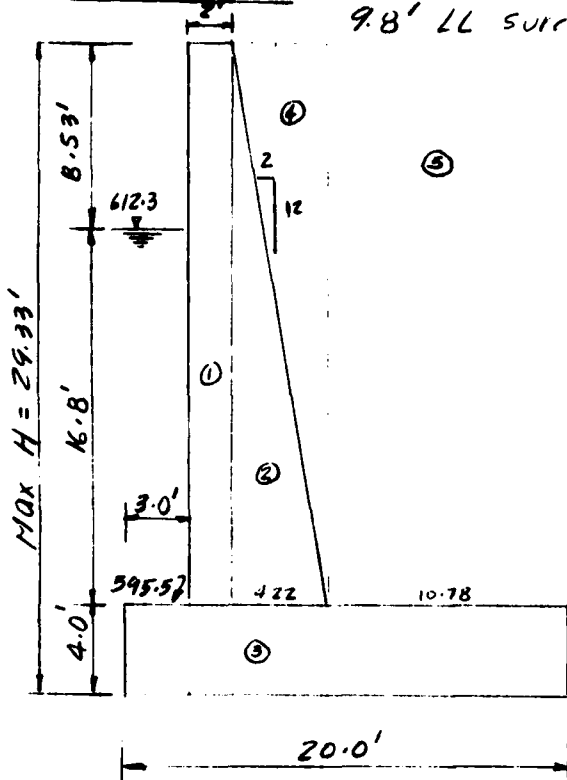
Use Eff Depth = 1'10" (p. 8-2-14)

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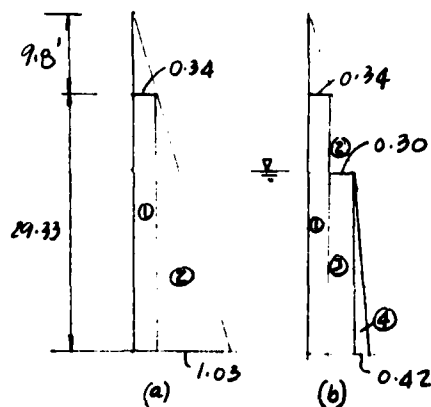
SUBJECT BIG CREEK R.R. BRIDGE FILE NO. _____
Main Line SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 12-28-78 CHECKED BY RSM DATE 1-10-79

Wing Wall Design:

1) Max Height: assume horizontal fill behind wall ($\beta=0$) but use 9.8' LL surcharge.



Min Width at top of footing
 $= 25.33/4 = 6.33$
Use 2:12 batter



a) DL + LL Surcharge:

Earth pressure:

$$\begin{aligned} \textcircled{1} \quad 0.34 \times 29.33 &= 9.97 \times 14.67 = 146.3 \\ \textcircled{2} \quad 1.03 \times 29.33 \times 0.5 &= \frac{15.10}{25.07} \times 9.78 = \frac{147.7}{294.0} \end{aligned}$$

Resisting moment:

$$\begin{aligned} \textcircled{1} \quad 2.0 \times 25.33 \times 0.15 &= 7.60 \times 4.0 = 30.4 \\ \textcircled{2} \quad 4.22 \times 25.33 \times 0.15 &= 8.02 \times 6.41 = 51.4 \\ \textcircled{3} \quad 4.0 \times 20.0 \times 0.15 &= 12.0 \times 10.0 = 120.0 \\ \textcircled{4} \quad 4.22 \times 25.33 \times 0.5 \times 0.105 &= 5.61 \times 7.81 = 43.8 \\ \textcircled{5} \quad 10.78 \times 25.33 \times 0.105 &= \frac{28.67}{61.90} \times 14.61 = \frac{418.9}{664.5} \end{aligned}$$

F.S. (sliding)

$$= 61.90.6 \div 25.07 = 1.49 \approx 1.5$$

Resultant at:

$$(664.5 - 294.0) \div 61.9 = 5.92 > 8/4$$

$$ecc = 10.0 - 5.92 = 4.08$$

* Without w/o LL surcharge (conservative for stability)

$$p_{max} = 2 \times 61.9 \div [8 \times (\frac{20}{2} - 4.08)] = 7.0 \text{ ksf}$$

D2-39

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SUBJECT Big creek R.R. Bridge FILE NO. _____
Main Line SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 12-29-78 CHECKED BY RSM DATE 1-10-79

Wing Wall (Cont.)

b) DL + LL Surcharge + Buoyancy

Earth pressure:

$$\begin{aligned} ① &= 0.34 \times 29.33 = 9.97 \times 14.68 = 146.4 \\ ② &= 0.30 \times 8.53 \times 0.5 = 1.28 \times 23.64 = 30.2 \\ ③ &= 0.30 \times 20.8 = 6.24 \times 10.4 = 64.9 \\ ④ &= 0.42 \times 20.8 \times 0.5 = 4.37 \times 6.93 = 30.3 \\ &\quad \quad \quad 21.86 \quad \quad \quad 271.8 \end{aligned}$$

Resisting moment:

$$\begin{aligned} ① \text{ Hriv } ② &= 27.62 = 201.8 \\ - 27.62 \times \frac{62.9}{150} &= -11.49 \quad 201.8 \times \frac{62.9}{150} = -83.9 \quad * = \frac{15.0}{2} + 20 + 3.0 = 12.5 \\ 8.53 \times 2.0 \times 0.0624 &= 1.06 \times 4.0 = 4.3 \\ 1.42 \times 8.53 \times 0.5 \times 0.0624 &= 0.38 \times 5.47 = 2.1 \\ 1.42 \times 8.53 \times 0.5 \times 0.105 &= 0.64 \times 5.95 = 3.8 \\ 2.8 \times 8.53 \times 0.105 &= 2.51 \times 7.82 = 19.6 \\ 2.8 \times 16.8 \times 0.5 \times 0.06 &= 1.41 \times 8.29 = 11.7 \\ 10.78 \times 8.53 \times 0.105 &= 9.66 \times 14.61 = 141.1 \\ 10.78 \times 16.8 \times 0.06 &= 10.87 \times 14.61 = 158.8 \\ \text{Wt LL Surcharge} &= \frac{72.15}{14 \times 5} = 15.43 \times 12.5 * = 192.9 \\ &\quad \quad \quad 58.09 \quad \quad \quad 652.2 \end{aligned}$$

F.S. (Sliding)

$$\begin{aligned} &= 58.09 \times 0.6 \div 21.86 \\ &= 1.59 \end{aligned}$$

Resultant at $(652.2 - 271.8) \div 58.09 = 6.54 < B/4$

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SUBJECT BIG creek R.R. Bridge FILE NO. _____
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FOR _____
COMPUTED BY JKS DATE 12-29-78 CHECKED BY KSM DATE 1-10-79

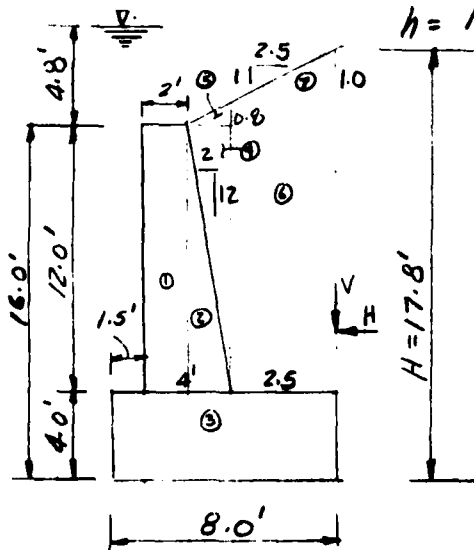
Wing Wall (cont.)

2) Min Height:

Top of Wing Wall $EL = 607.5$

Top of footing $EL = 595.5$

$h = 12.0'$



$$V = \frac{1}{2} K_v H^2$$

$$H = \frac{1}{2} K_h H^2$$

Use 2.5:1 slope

Backfill material Type 1

From AREA B-5-17:

$$K_v = 0.012 \text{ k/sf}$$

$$K_h = 0.032 \text{ k/sf}$$

$$V = \frac{1}{2} \times 0.012 \times 17.8^2 = 1.90$$

$$H = \frac{1}{2} \times 0.032 \times 17.8^2 = 5.07$$

$$H_H^2 = 5.07 \times 5.93 = 30.1$$

Resisting Moment:

$$① = 2.0 \times 12.0 \times 0.15 = 3.60 \times 2.5 = 9.0$$

$$② = 2.0 \times 12.0 \times 0.5 \times 0.15 = 1.80 \times 4.17 = 7.5$$

$$③ = 8.0 \times 4.0 \times 0.15 = 4.80 \times 4.0 = 19.2$$

$$④ = 2.0 \times 12.0 \times 0.5 \times 0.105 = 1.26 \times 4.83 = 6.1$$

$$⑤ = 0.8 \times 2.0 \times 0.5 \times 0.105 = 0.08 \times 4.83 = 0.4$$

$$⑥ = 2.5 \times 12.8 \times 0.105 = 3.36 \times 6.75 = 22.7$$

$$⑦ = 2.5 \times 1.0 \times 0.5 \times 0.105 = 0.13 \times 7.17 = 0.9$$

$$V = 1.90 \times 8.0 = 15.2$$

$$16.93 \quad 81.0$$

F.S. (sliding)

$$= \frac{16.93 \times 0.6}{5.07} = 2.0$$

Resultant at:

$$(81.0 - 30.1) \div 16.93$$

$$= 3.0 > 0.4$$

$$e = \frac{B}{2} - 3 = 1.0$$

Buoyancy:

$$① \text{ thru } ③: 10.2 \times \frac{62.4}{150} = -4.24 \quad 35.7 \times \frac{62.4}{150} = -14.9$$

$$④ \text{ thru } ⑦: 4.83 \times \frac{0.04}{0.105} = 2.76 \quad = 17.2$$

$$V = 1.90 \times \frac{0.06}{0.105} = 1.09 \quad = 8.7$$

$$\Sigma H = 5.07 \times \frac{0.06}{0.105} = 2.90 \quad H = 17.2$$

F.S. (sliding) = 2.02

$$\text{Resultant at: } (46.7 - 17.2) \div 9.81 = 3.0 > 0.4$$

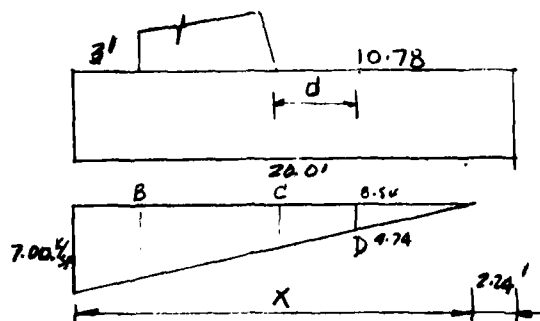
02-41

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SUBJECT BIG creek R.R. Bridge FILE NO. _____
Main Line SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 1-2-79 CHECKED BY RSM DATE 1-11-79

(Wing Wall Cont.)
(Max h)

Toe design: Neglect foot cover.



$$X = 3\left(\frac{28}{3} - 4.00\right) = 17.76$$

$$q_b = \frac{7.00 \times 14.76}{17.76} = 5.82$$

M_b

$$V_b = -3 \times 0.15 \times 4 = -1.8 \times 1.5 = -2.7$$

$$5.82 \times 3.0 = 17.5 \times 1.5 = 26.2$$

$$\frac{1.8 \times 3.0 \times 0.5}{17.5} = \frac{1.8 \times 2.0}{27.1} = \frac{3.6}{27.1}$$

V @ "d" from face = 0

$$A_s = 27.1 \div (1.44 \times 44.5) = 0.42 \text{ in}^2/\text{ft}$$

$$Z_o = \frac{17.5}{0.35 \times 0.875 \times 44.5} = 1.28 \text{ in}^2/\text{ft}$$

$$\text{USE } \#6 @ 12" (H) \left\{ \begin{array}{l} A_s = 0.44 \\ Z_o = 2.4 \end{array} \right.$$

Heel design:

$$q_c = 7.00 \times 8.54 / 17.76 = 3.37$$

(neglect Wt of surcharge)

M_c

$$V_c = -3.37 \times 8.54 \times 0.5 = -14.4 \times 2.85 = -41.0$$

$$25.33 \times 0.105 \times 10.78 = 28.7 \times 5.39 = 154.5$$

$$\frac{4.0 \times 0.15 \times 10.78}{20.8} = \frac{6.5}{148.4} \times 5.39 = \frac{34.9}{148.4}$$

$$A_s = 148.4 \div (1.44 \times 45.5) = 2.30 \text{ in}^2/\text{ft}$$

$$Z_o = \frac{20.8}{0.146 \times 0.875 \times 45.5} = 3.60 \text{ in}^2/\text{ft}$$

$$\text{USE } \#10 @ 6" (H) \left\{ \begin{array}{l} A_s = 2.54 \\ Z_o = 8.0 \end{array} \right.$$

Shear @ "d" from C:

$$q_d = 7.00 - 4.74 / 17.76 = 1.87$$

$$V_d = -1.87 \times 4.74 \times 0.5 + (25.33 \times 0.105 + 4.0 \times 0.15) \times 6.99 = 18.6$$

$$V = 18.6 \div (12 \times 45.5) = 0.034 \text{ K/in}^2$$

$$\text{allow } V_c = 0.06$$

D2-42

SUBJECT Big Creek R.R. Bridge FILE NO. _____
Main Line SHEET NO. _____ OF _____ SHEETS
 FOR _____
 COMPUTED BY JRS DATE 1-2-79 CHECKED BY RSM DATE 1-12-79

Wing wall (cont.)

check reinforcement @ 32' from Exp. Joint. ($\frac{1}{3}$ pt of tapered section)
assume min. length 66'

Assume Wing length = 66'

Total wing height from 29.33' to 16'

Footings Width from 20' to 8'

Wing Section @ 32':

$$h = 40 + 12.0 + (25.33 - 12.0) \times \frac{36}{54} = 24.9'$$

$$Toe = 1.5 + (3.0 - 1.5) \times \frac{3\frac{1}{4}}{54} = 2.50'$$

Footings width = $8.0 + (20.0 - 8.0) \times \frac{3}{54} = 16'$

Resisting Moments: Moments about "A"

$$\textcircled{1}: 2.0 \times 20.9 \times 0.15 = 6.27 \times 3.50 = 21.9$$

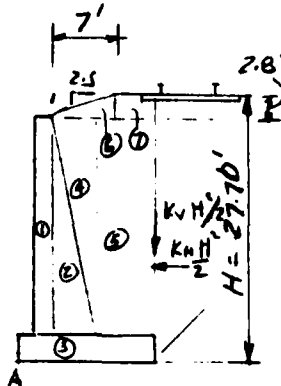
②: $20.9 \times \frac{2}{17} \times 20.9 \times 0.15 \times 0.5 = 5.46 \times 5.66 = 30.9$

$$\textcircled{3} = 4.0 \times 16.0 \times 0.15 = 9.60 \times 8.0 = 76.8$$

$$\textcircled{2}: 3.48 \times 20.9 \div 0.105 \times 0.5 = 3.82 \times 6.82 = 26.0$$

(5): $8.02 \times 20.9 \times 0.105 : 17.60 \times 12.01 = 211.2$

42.75 366.8



Faith pressure : distance from footing to edge of tie is less than height of wall.

assume full live load surcharge $h' = 9.8'$

$$H = 27.7$$

For 2.5:1 slope and $\frac{H_1}{H} = 0$ $K_v = 0$ and $K_H = 0.032$

$$\frac{1}{2} K_H H^2 = 0.5 \times 0.032 \times 27.7^2 = 12.27 \quad M_A = 12.27 \times \frac{27.7}{3} = 113.4$$

$$\text{Surcharge} = 9.8 \times 0.035 \times 24.9 = 8.50 \text{ MN} \quad 8.5 \times 24.9 = 105.8$$

$$\textcircled{6}: \frac{7.0}{2.1} \times 7.0 \times 0.5 = 0.105 \quad = 1.03 \times 9.17 = 9.4$$

$$\textcircled{7} : 2.8 \times 4.50 \times 0.105 = 1.32 \times 13.75 = 18.2$$

$$\Sigma (Q+D) = 2.15 \quad 27.6$$

$$F_{is}(\text{sliding}) = (42.75 + 2.35) \times 0.6 \div (12.27 + 8.5) = 1.20$$

Resultant at: $(366.8 + 27.1 - 113.4 - 105.8) \div 45.1 = 3.88$

$$\text{Max bearing pressure} = \frac{45.1 \times 2}{3 \times 3.88} = 7.72 \text{ ksf}$$

for design: $X = 3.388 = 11.64$

$$g_B = 7.74 \cdot \frac{9.14}{11.64} = 6.08$$

$$V_g = -4.0 \times 0.15 \times 2.50 = -1.5 \times 1.25 = -1.9$$

$$6.08 \times 2.5 = 15.2 \quad + 1.25 = 16.0$$

$$1.66 \times 2.5 = 0.5 = \frac{2.08}{15.78} \quad \times 1.67 = \frac{3.5}{20.6}$$

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SUBJECT BIG CREEK R.R. BRIDGE FILE NO. _____
Main Line SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 1-2-79 CHECKED BY RSM DATE 1-12-79

Section @ 32' (Cont.)

$$A_s = 20.6 \div (1.44 \times 44.5) = 0.32$$

$$\Sigma_o = 15.78 \div (0.35 \times 0.875 \times 44.5) = 1.16$$

$$\text{Use } A_6 @ 12" \left\{ \begin{array}{l} A_s = 0.44 \\ \Sigma_o = 2.4 \end{array} \right.$$

Heel design:

$$q_c = 7.74 \times \frac{3.66}{11.60} = 2.43$$

$$V_c = -2.43 \times 3.66 = -4.45 \times 1.22 = 5.43$$

$$4.802 \times 0.15 = 4.81 \times 4.0 = 19.2$$

$$24.7 \times 0.105 = 19.96 \times 4.0 = 79.8$$

$$20.32 \quad 93.57$$

$$A_s = 93.57 \div (1.44 \times 45.5) = 1.43$$

$$\Sigma_o = 20.32 \div (0.152 \times 0.875 \times 45.5) = 3.8$$

$$\text{Use } \#11 @ 12" (1)$$

$$A_s = 1.56$$

$$\Sigma_o = 4.4$$

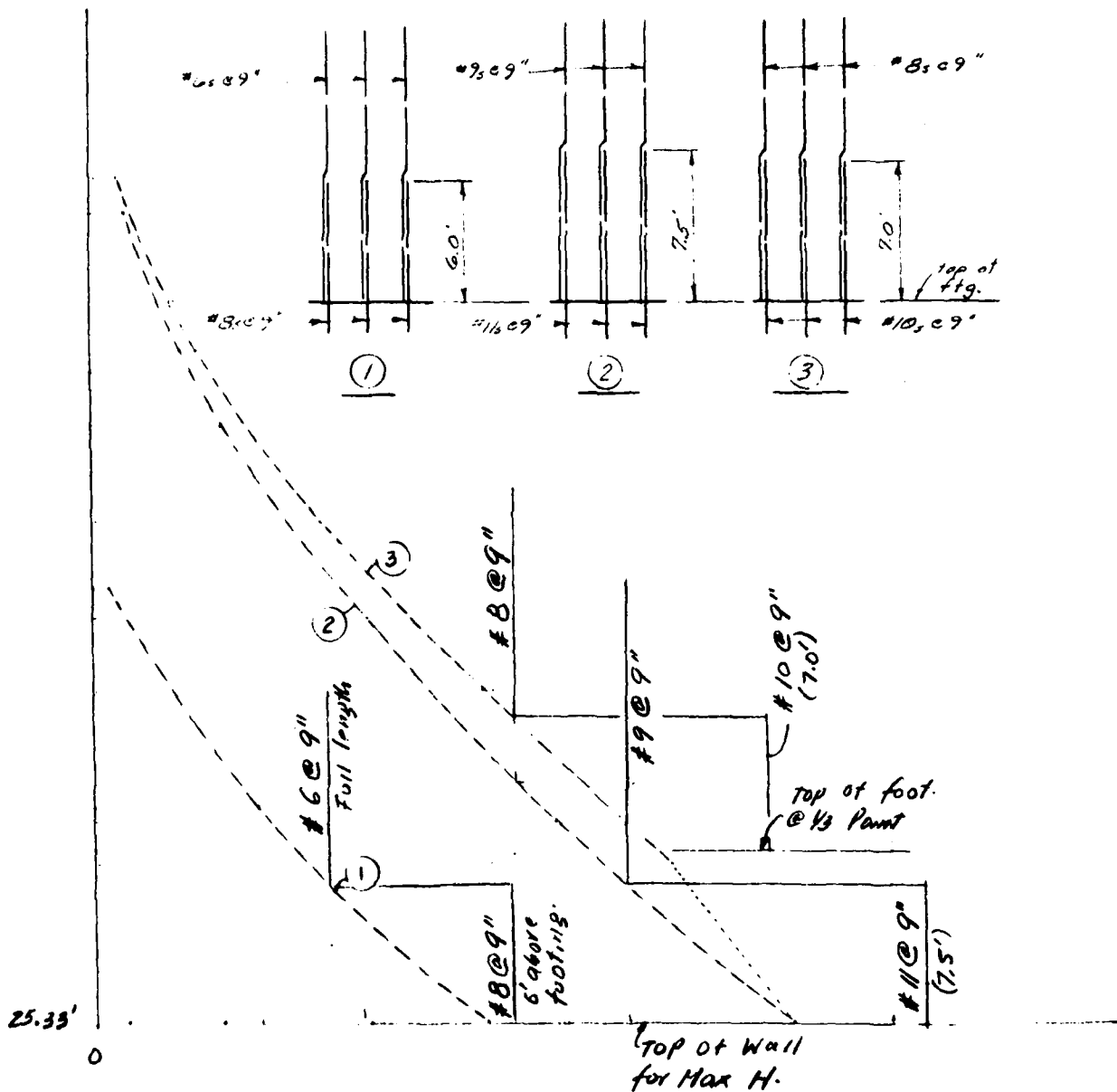
Shrinkage and Temperature steel will be detailed in accordance with AREA Specs.

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SUBJECT BIG CREEK R.R. BRIDGE FILE NO. _____
Main Line SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 1-3-79 CHECKED BY REM DATE 1-12-79

As shown (cont.)

Steel Design: see program PWW



Scale: V: 1" = 4'
H: 1" = 0.4'

- ①: Abutment
- ②: Wing With LL surcharge only but near Wall
- ③: Wing With LL surcharge and inclined DL surcharge. D2-45

READY (edit run) (F1)
EDIT run

RETAINING WALL(0), OR ABUTMENT(1)
1
WT. OF CONC. & BACKFILL(KCF) EQUIV. FLUID PRES. (KSF/FT. DEPTH)
2 15 .035
PAVEMENT THICKNESS(FT)
2 0

ABUTMENT - Mainline

Use for Stem Steel On-y

CHTD: RSM (1-12-79)

NOTE:

Results from Retaining Wall -
Abutment Design Program. Only
wall design portion of program
was needed. However, total
program had to be run. Computer
program output not applicable
to stem design is crossed out.

Writeup for this program at
end of this Subappendix.

FOOTING WIDTH, DEPTH & TOE LENGTH (FT)
2 12 4 3
DIST. OF 1ST ROW OF PILES FROM THE TOE(FT)
2 1.5
MAX. DESIGN PILE LOAD(KIPS)
2 150
CONC. ALLOW. FC & SHEAR STRESS (KSI) OF FOOTING
2 1.35 .06
ALLOW. FS (KSI) & ELAS. MODULUS RATIO OF FOOTING
2 20 10
CONC. COVER TO C.L. OF BOT. & TOP STEEL - INCHES
2 3.5 2.5

WALL HEIGHT(FT)
2 25.33
CONC. ALLOW. FC & SHEAR STRESS (KSI) OF STEM
2 1.35 .06
ALLOW. FS (KSI) & ELAS. MODULUS RATIO OF STEM
2 20 10
CONC. COVER TO C. L. OF STEM STEEL - INCHES
2 2.5
BEAM SEAT HEIGHT & WIDTH(FT)
2 9 4.33
BACKWALL HEIGHT & WIDTH(FT)
2 9 2
BACKWALL BATTER HEIGHT & WIDTH(FT)
2 0 0

ABUTMENT BATTER(N/12)

? 1

DIST. WALL F.F. TO PRG. C.L. (FT)

? 2.25

DEAD LOAD & LIVE LOAD REACTIONS(K/FT)

? 2.5 15.62

ADDITIONAL VERT. & HORIZ. FORCES(K/FT) APPL. AT C.L. BRGS.

? 0 0

GROUP FACTOR

? 1

LIVE LOAD SURCHARGE(FT)

? 9.8

ABUTMENT

USE FOR STAM DESIGN ONLY

CHRG : RSM (1-12-79)

MOM & FORCES CAUSED BY SUBSTRUC. EARTH PRESS & LL SURCH

VERT FORCE(K/FT) 55.824 RESISTING MOMENT(K-FT/FT) 511.843

HORI FORCE(K/FT) 25.115 OVERTURN MOMENT(K-FT/FT) 294.714

OF PILE ROWS(MAX. 6)

? 3

DIST. FROM 1ST ROW(FT) & BATTER(N/12) OF EACH ROW

? 0 3 3 16 0

EACH ROW PILE SPACING(FT)

? 3 3 6

TOTAL PILE AREA(PILE/FT)

ROW 0.833

VERT. LOAD

1 94.733

2 90.642

3 72.914

TOTAL LOAD

97.649

93.432

72.914

HORI(BATT)

23.683

22.661

0.000

HORI(BEND)

11.600

11.600

11.600

KIPS/PILE

KIPS/PILE

KIPS/PILE

(NOTE: ALL PILE LOADS INCLUDE LIVE LOAD SURCHARGE)

ANOTHER TRIAL? YES=1, NO=0

? 0

CHANGE FOOTING? YES=1, NO=0

? 0

ABUTMENT (Cont.)

CHTO: RCM (1-12-79)

FOOTING DESIGN		RECD. DEPTH (IN)	ACTUAL DEPTH (IN)	RECD. STEEL (SQ. IN/FT)	SHEAR STRESS (KSI)
HEEL		20.740	45.500	0.454	0.027
TOE		13.773	45.500	0.696	0.001
THE FOOTING DESIGN IS O.K.					
CHANGE FOOTING? YES=1, NO=0					
?					

STEM DESIGN

HEIGHT (FEET)	COMP STEEL REQD?	ACTUAL DEPTH (INCHES)	RECD AS (SQ IN/FT)	SHEAR (KSI)
9.000	NO	21.500	0.528	0.017
9.000	NO	73.460	0.000	0.005
14.443	NO	78.903	0.033	0.009
19.887	NO	84.347	0.419	0.014
25.330	NO	89.790	0.984	0.018

NEW DESIGN? YES=1, NO=0

?

END OF PROGRAM

EDIT end

Embedment length for #8 bar = $\frac{0.79 \times 20.0}{3/42 \times 0.263} = 19"$

AD-A102 433

CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT

F/6 13/2

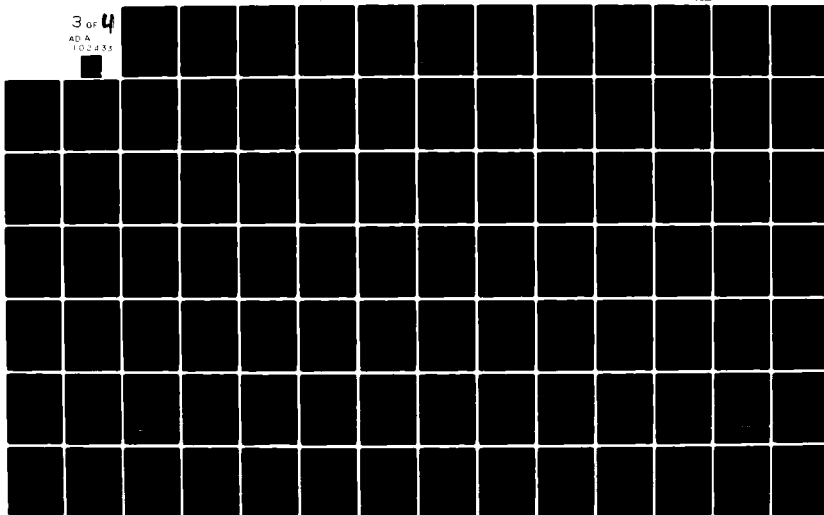
BIG CREEK FLOOD CONTROL PROJECT, CLEVELAND, OHIO. PHASE II. GEN--ETC(U)

AUG 79

UNCLASSIFIED

NL

3 of 4
AD A
102433



edit rwm ieli
EDIT run

RETAINING WALL(0), OR ABUTMENT(1)

? 0

WT. OF CONC. & BACKFILL(KCF) EQUIV. FLUID PRES. (KSF/FT. DEPTH)

? .15 .105 .035

PAVEMENT THICKNESS(FT)

? 0

WING (MAX H.)

OK for stem design only

FOOTING WIDTH, DEPTH & TOE LENGTH (FT)
? 21 4 4
DIST. OF 1ST ROW OF PILES FROM THE TOE(FT)
? 1.5
MAX. DESIGN PILE LOAD(KIPS)
? 150
CONC. ALLOW. FC & SHEAR STRESS (KSI) OF FOOTING
? 1.35 .06
ALLOW. FS (KSI) & ELAS. MODULUS RATIO OF FOOTING
? 20 10
CONC. COVER TO C.L. OF BOT. & TOP STEEL - INCHES
? 3.5 2.5

CHRG: REM (1-12-79)

WALL HEIGHT(FT)

? 25.33

CONC. ALLOW. FC & SHEAR STRESS (KSI) OF STEM

? 1.35 .06

ALLOW. FS (KSI) & ELAS. MODULUS RATIO OF STEM

? 20 10

CONC. COVER TO C. L. OF STEM STEEL - INCHES

? 2.5

PARAPET HEIGHT & WIDTH(FT)

? 0 0

STEM WIDTH(FT) & BATTER(N/12)

? 2 2

SURCHARGE SLOPE & SLOPE DIST.(FT)

? 0 0

LIVE LOAD SURCHARGE(FT)

? 9.8

MOM & FORCES CAUSED BY SUBSTRUC.EARTH PRESS & LL SURCH
 VERT FORCE(K/FT) 62.500 RESISTING MOMENT(K-FT/FT) 632.945
 HORI FORCE(K/FT) 25.115 OVERTURN MOMENT(K-FT/FT) 294.714

PRESSURE= 0.035K/SF/F PRESSURE SLOPE= 0.00

WING (MAX H.)

CHRD: RSM (1-12-79)

OF PILE ROWS(MAX. 6)

DIST. FROM 1ST ROW(FT) & BATTER(N/12) OF EACH ROW

EACH ROW PILE SPACING(FT)

TOTAL PILE AREA(PILE/FT) 0.833

ROW VERT. LOAD TOTAL LOAD

1 70.145 17.536

2 73.179 18.295

3 88.351 0.000

(NOTE: ALL PILE LOADS INCLUDE LIVE LOAD SURCHARGE)

ANOTHER TRIAL? YES=1.NO=0

CHANGE FOOTING? YES=1.NO=0

FOOTING DESIGN

REDD. DEPTH (IN) ACTUAL DEPTH (IN)

HEEL 28.345 45.500

TOE 30.686 44.500

THE FOOTING DESIGN IS O.K.

CHANGE FOOTING? YES=1.NO=0

REDD. STEEL (SQ. IN/FT)

0.803

0.836

SHEAR STRESS (KSI)

0.037

0.041

HORI(BEND)

15.805

15.805

15.805

KIPS/PILE
KIPS/PILE
KIPS/PILE

WINE (HAR H)

CR. 10: RCM (1-2-73)

STEM DESIGN

HEIGHT (FEET)	COMP STEEL REQD?	ACTUAL DEPTH (INCHES)	REQD AS (30 IN/FT)	SHEAR (KSI)
5.066	NO	31.632	0.078	0.006
10.132	NO	41.764	0.321	0.011
15.198	NO	51.896	0.690	0.015
20.264	NO	62.028	1.169	0.019
25.330	NO	72.160	1.753	0.023

NEW DESIGN? YES=1, NO=0

?

END OF PROGRAM

EDIT end

READY

Embed. length for #11 bar = $\frac{156 \times 20.0}{4.4 \times 0.186} = 38"$

edit run ipli

EDIT run

RETAINING WALL(0). OR ABUTMENT(1)

? 0

WT. OF CONC. & BACKFILL(KCF) EQUIV. FLUID PRES. (KSF/FT. DEPTH)

? .15 .105 .035

PAVEMENT THICKNESS(FT)

? 0

FOOTING WIDTH,DEPTH & TOE LENGTH (FT)

? 17 4 3.25

DIST. OF 1ST ROW OF PILES FROM THE TOE(FT)

? 1.5

MAX. DESIGN PILE LOAD(KIPS)

? 150

CONC. ALLOW. FC & SHEAR STRESS (KSI) OF FOOTING

? 1.35 .06

ALLOW. FS (KSI) & ELAS. MODULUS RATIO OF FOOTING

? 20 10

CONC. COVER TO C.L. OF BOT. & TOP STEEL - INCHES

? 3.5 2.5

WALL HEIGHT(FT)

? 21.3

CONC. ALLOW. FC & SHEAR STRESS (KSI) OF STEM

? 1.35 .06

ALLOW. FS (KSI) & ELAS. MODULUS RATIO OF STEM

? 20 10

CONC. COVER TO C. L. OF STEM STEEL - INCHES

? 2.5

PARAPET HEIGHT & WIDTH(FT)

? 0 0

STEM WIDTH(FT) & BATTER(N/12)

? 2 2

SURCHARGE SLOPE & SLOPE DIST.(FT)

? .4 7

LIVE LOAD SURCHARGE(FT)

? 9.8

WING AT 1/3 PT OF Tapered Section
Use for stem design only

CHFD: RSM (1-12-79)

MOM & FORCES CAUSED BY SUBSTRUC. EARTH PRESS & LL SURCH
 VERT FORCE(K/FT) 46.513 RESISTING MOMENT(K-FT/FT) 376.081
 HORI FORCE(K/FT) 22.406 OVERTURN MOMENT(K-FT/FT) 246.504
 PRESSURE = 0.035K/CT/F PRESSURE SLOPE = 0.00

Wing at 1/3 (Cont.)

CHRD: RSM (1-2.7%)

OF PILE ROWS(MAX. 6)
 3
 DIST. FROM 1ST ROW(FT) & BATTER(N/12) OF EACH ROW

0 3 3 14 0
 EACH ROW PILE SPACING(FT)

3 3 6

TOTAL PILE AREA(PILE/FT) 0.833

ROW VERT. LOAD TOTAL LOAD

1 65.930 67.959

2 58.344 60.139

3 30.529 30.529

(NOTE: ALL PILE LOADS INCLUDE LIVE LOAD SURCHARGE)

ANOTHER TRIAL? YES=1, NO=0

0

CHANGE FOOTING? YES=1, NO=0

0

HORI(BEND)
 14.460
 14.460
 14.460
 KIPS/PILE
 KIPS/PILE
 KIPS/PILE

FOOTING DESIGN

RECD. DEPTH (IN) ACTUAL DEPTH (IN) RECD. STEEL (SQ. IN/FT) SHEAR STRESS (KSI)
 28.897 45.500 1.127 0.038
 12.242 44.500 0.550 0.002

HEEL

TOE

THE FOOTING DESIGN IS O.K.

CHANGE FOOTING? YES=1, NO=0

0

Wing at 1/3 pt (Cont.)

Chrd: RSM (1-12-75)

STEM DESIGN

HEIGHT (FEET)	COMP STEEL REDD?	ACTUAL DEPTH (INCHES)	REDD AS (SQ IN/FT)	SHEAR (KSI)
4.260	NO	30.020	0.067	0.005
8.520	NO	38.540	0.275	0.010
12.780	NO	47.060	0.584	0.013
17.040	NO	55.580	0.978	0.017
21.300	NO	64.100	1.452	0.020

NEW DESIGN? YES=1, NO=0

?

END OF PROGRAM

EDIT end

READY logoff

LOGGED OFF AT 10.33.21 01/03/79

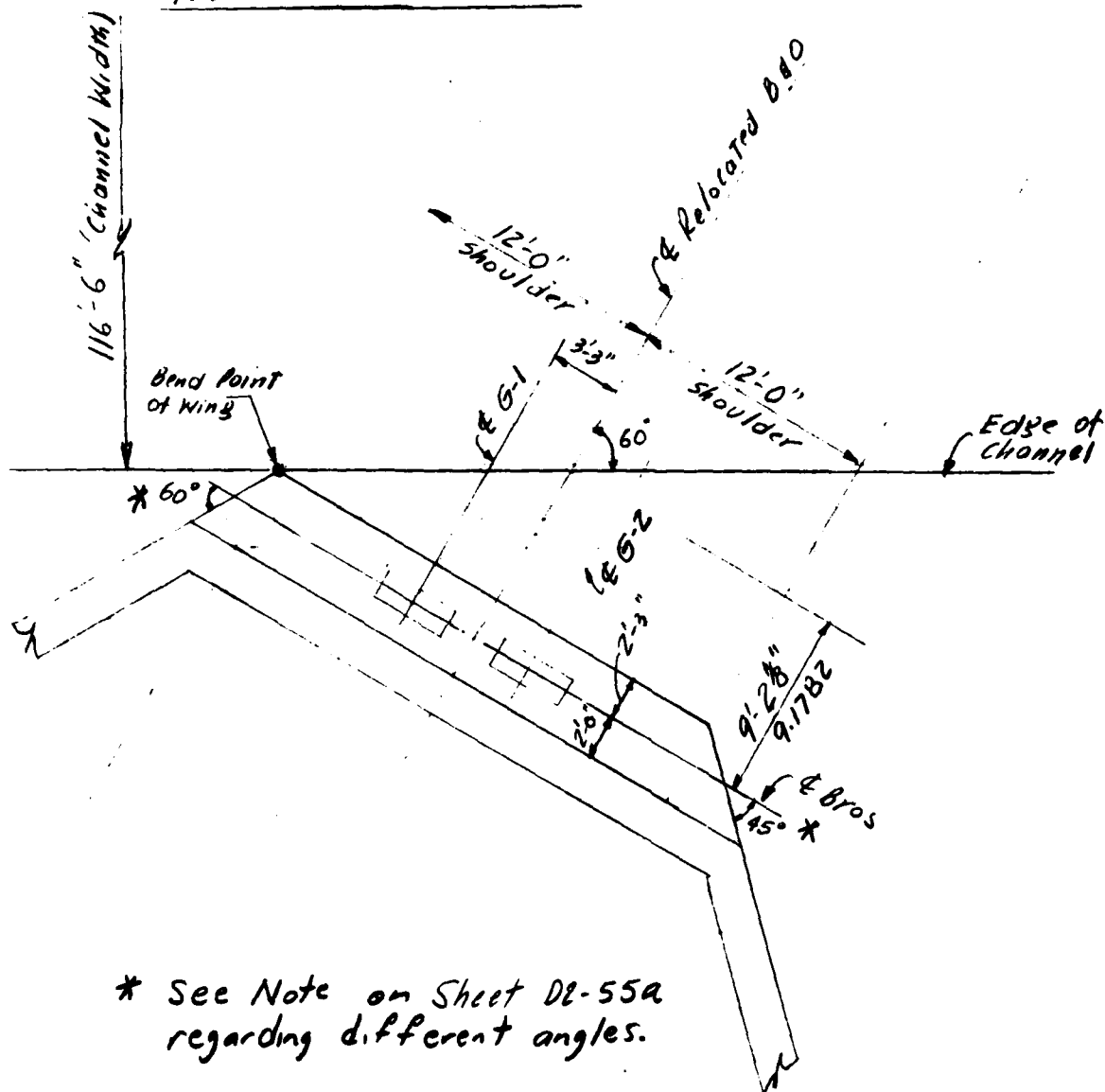
SESSION DURATION 00.32.36 CPU TIME USED 46299/300THS SEC.

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GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT BIG CREEK R.R. BRIDGE FILE NO. _____
SPUR LINE SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 1-8-79 CHECKED BY JM DATE 1 10 79

ADJACENT LOCATION:



* See Note on Sheet D2-55a
regarding different angles.

Scale: 1/8" = 1'-0"

D2-55

GANNETT FLEMING CORDRY
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SUBJECT BIG CREEK R.R. BRIDGE FILE NO. _____
SPURLINE SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY RSM DATE 7/30/79 CHECKED BY _____ DATE _____

NOTE REGARDING ABUTMENT ANGLES

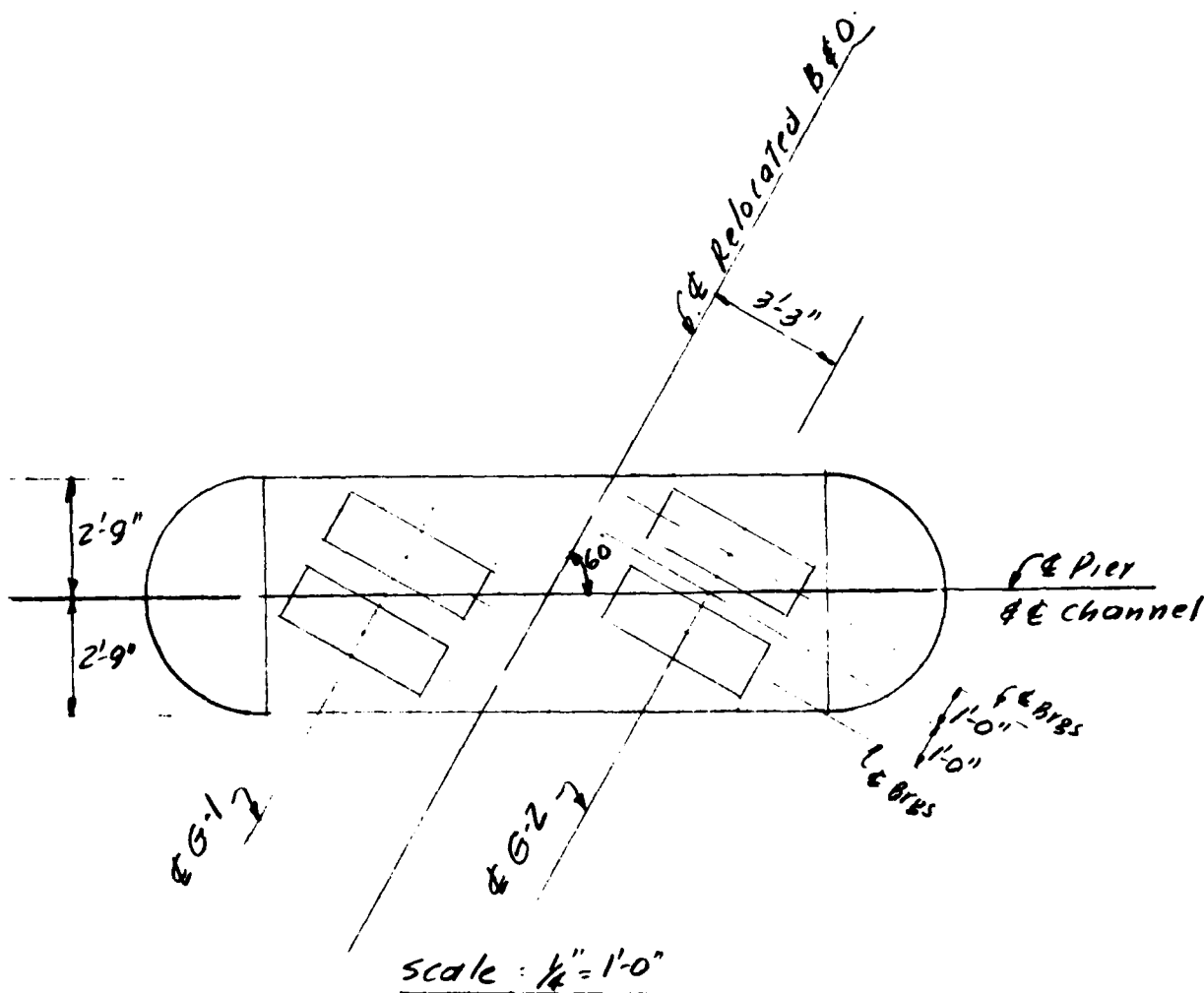
Normally both abutment walls would have 45° angles. However, for the abutment wall that is closest to the edge of the channel, it was felt desirable to pull the abutment wall closer to the abutment, or a 60° angle instead of a 45° angle. The 15° difference would not affect the cost appreciably. As the top of the abutment wall slopes down from the bridge, pulling the abutment wall in towards the abutment would be exposing less of the riprap behind the wall to channel flow. Although the riprap is designed for the expected channel velocities, the channel slope behind the wall is an area of expected turbulence. Although the footing for the abutment wall is below channel grade, it was felt desirable not to have the footing close to the edge of the channel for the entire length of the abutment wall. A 45° abutment deflection is standard when a bridge is normal to the channel centerline. When there is a substantial skew, the geometry at the abutments sometimes makes different wall skews desirable. The selection of the 60° angle instead of the 45° angle was basically an engineering judgment decision.

02-55a

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HARRISBURG, PA.

SUBJECT BIG creek R.R. BRIDGE FILE NO. _____
SPUR LINE SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 1-9-79 CHECKED BY RSM DATE 1-10-79

PIER LOCATION:



Span length = (along Relocated B&O):

E Brgs Abutment 1 to E Brg Abutment 2:

$$L = (116.5 + \sin 60^\circ) + 9.1782 \times 2 = 152.8790 \approx 152'-10\frac{1}{2}"$$

E Brgs Abutment to E Pier = 76.4395'

$$\text{Max span length} = 76.4395 + 3.25 \tan 30^\circ - 1.0 = 77.3159'$$

$$\text{Min span length} = 76.4395 - 3.25 \tan 30^\circ - 1.0 = 73.5631'$$

NOTE: For SUPERSTRUCTURE design see Main Line.

D2-56

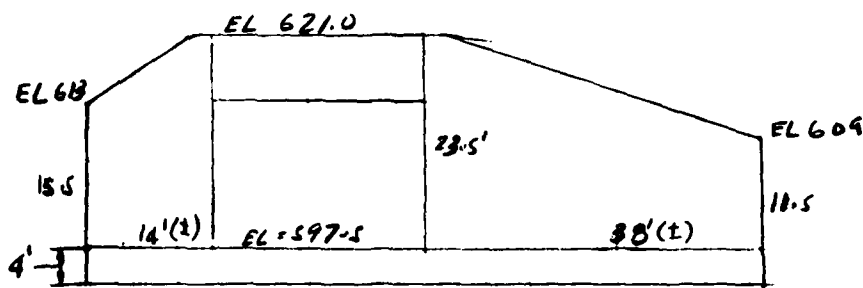
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SUBJECT BIG CREEK R.L. Bridge FILE NO. _____
SPUR LINE SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 1-17-79 CHECKED BY RSM DATE 1-18-79

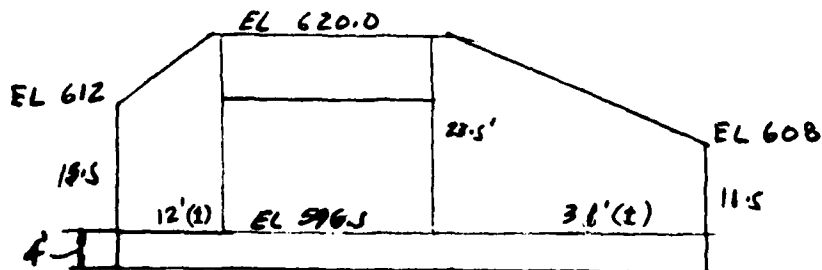
ABUTMENT DESIGN:

ABUTMENT #2: Top of rail EL = 621.5 (±)
ABUTMENT #1: Top of rail EL = 621.5 + 153 × 0.00043 = 622.5 (±)
Top of footing EL: Abutment #2 = 596.5 (±)
Abutment #1 = 597.5 (±)
Abutment #2 height = 621.5 - 596.5 - 1.5 = 23.5'
(top of backwall to top of foot)
Abutment #1 = 622.5 - 597.5 - 1.5 = 23.5'

Max height water EL = 612.5



ABUTMENT 1 : STA 114+60 (±)



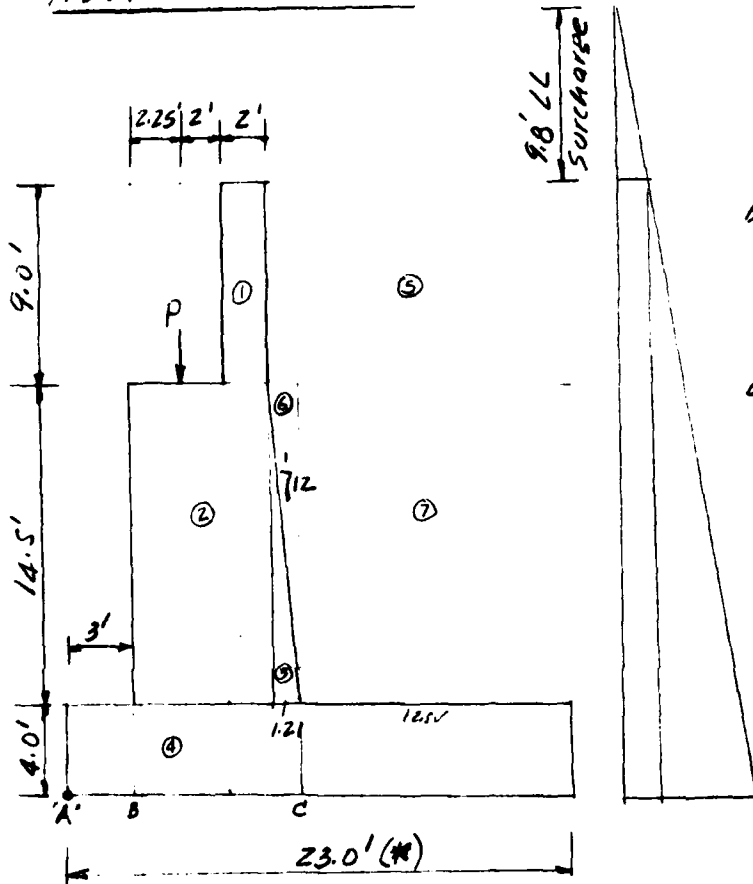
ABUTMENT 2 : STA 116+13 (±)

D2-57

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SUBJECT BIG ROCK R.R. BRIDGE FILE NO. _____
SPUR LINE SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 1-23-79 CHECKED BY SEM DATE 1-21-78

Abutment design:



Backwall height = 9'

$$DL \text{ Reaction} = \frac{70}{24} = 2.92 \text{ K/1}$$

$$LL \text{ Reaction} = \frac{486}{24} \times \frac{72}{80} = 18.23 \text{ K/1}$$

* larger than required in order to fit wingwall footings.

Earth pressure:

$$\begin{aligned} 9.8 \times 0.035 \times 27.5 &= 9.83 \times 13.75 = 129.7 \\ \frac{27.5^2}{2} \times 0.035 \times 0.5 &= \frac{13.23}{22.66} \times 9.17 = \frac{121.4}{251.1} \end{aligned}$$

Resisting Moment about "A"

$$\begin{aligned} ①: 2.90 \times 0.15 &= 2.70 \times 8.25 = 22.8 \\ ②: 6.75 \times 14.5 \times 0.15 &= 13.59 \times 6.125 = 83.3 \\ ③: 1.21 \times 14.5 \times 0.5 \times 0.15 &= 1.31 \times 9.65 = 12.7 \\ ④: 23.0 \times 4.0 \times 0.15 &= 13.80 \times 11.5 = 158.7 \\ ⑤: 13.75 \times 9.0 \times 0.105 &= 12.99 \times 16.125 = 209.5 \\ ⑥: 1.21 \times 16.5 \times 0.5 \times 0.105 &= 0.92 \times 10.06 = 9.3 \\ ⑦: 12.54 \times 14.5 \times 0.105 &= 19.09 \times 16.73 = 319.4 \\ DL &= 2.92 \times 5.25 = 15.3 \end{aligned}$$

Total DL = 67.32

831.0

DL+LL:

$$67.32 \quad 831.0$$

$$LL = \frac{18.23}{85.55} \times 5.25 = \frac{95.7}{926.7}$$

$$85.55 \quad 926.7$$

D2-58

GANNETT FLEMING CORDRY
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HARRISBURG, PA.

SUBJECT BIG CREEK R.R. BRIDGE FILE NO. _____
SPUR LINE SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 1-23-79 CHECKED BY RSM DATE 1-24-79

ABUT. design (cont.)

$$F.S. (sliding) = 67.32 \div 0.6 = 22.66 = 1.78$$

$$\text{Resultant at: } (831 - 251.1) + 67.32 = 8.61 > 8 \text{ DL only}$$

$$(926.7 - 251.1) \div 45.55 = 7.94 > 4 \text{ DL+LL}$$

$$e_x = \frac{23.0}{2} - 8.61 = 2.88$$

$$e_{x,LL} = \frac{23.0}{2} - 7.94 = 3.56$$

$$q_{max} = \frac{67.32}{23} \left(1 + \frac{6 \times 2.88}{23} \right) = 5.12 \text{ k/sf} < 10 \text{ OK}$$

$$q_{max} = \frac{85.55}{23} \left(1 + \frac{6 \times 3.56}{23} \right) = 7.17 \text{ k/sf} < 10 \text{ OK}$$

$$q_{min} = 0.73 \text{ k/sf}$$

$$q_{min} = 0.27 \text{ k/sf}$$

Toe design: Soil pressure at face of abutment = $0.27 + 6.9 \times \frac{23}{23} = 6.27$

	V_B	M_B		
$-4.0 \times 0.15 \times 3.0$	$= -1.8 \times 1.5$	$= -2.7$	$A_s = \frac{28.2}{1.44 \times 45.5}$	$= 0.44 \text{ USE } \#6 @ 12$
6.27×3.0	$= 18.8 \times 1.5$	$= 28.2$		$A_s = 0.44$
$0.9 \times 3.0 \times 0.5$	$= \frac{1.3}{18.3} \times 2.0$	$= \frac{2.7}{28.2}$	$\Sigma_o = \frac{18.3}{0.165 \times 78.445}$	$= 1.34 \quad \Sigma_o = 2.4$

Heel design: soil pressure at "c": $0.73 + 4.39 \times \frac{12.54}{23.0} = 3.12 \text{ DL only}$
 $= 0.27 + 6.9 \times \frac{12.54}{23.0} = 4.03 \text{ DL+LL}$

	V_c	M_c		
$4.0 \times 0.15 \times 12.54$	$= 7.5 \times 6.27$	$= 47.2$		
$23.5 \times 0.105 \times 12.54$	$= 30.9 \times 6.27$	$= 194.0$	$A_s = \frac{121.2}{1.44 \times 45.5}$	$= 1.85$
-0.73×12.54	$= -9.2 \times 6.27$	$= -57.4$		
$-2.39 \times 12.54 \times 0.5$	$= \frac{-15.0}{14.2} \times 4.18$	$= \frac{-62.6}{121.2}$	$\Sigma_o = \frac{14.2}{0.165 \times 78.445}$	$= 2.16$

#9 bar $u = 0.165$

USE #9 @ 6"

$V @ "d" \text{ from } "c": d = 3.79$

$A_s = 2.0$

$$q = 0.73 + 4.39 \times \frac{8.75}{23.0} = 2.40$$

$\Sigma_o = 7.1$

$$V = (4.0 \times 0.15 + 23.5 \times 0.105) \times 8.75 - 0.73 \times 8.75 - 1.67 \times 8.75 \times 0.5 = 13.1$$

$$V_c = \frac{13.1}{12 \times 45.5} = 0.024 < 0.06$$

stem design: see Main Line Abutment

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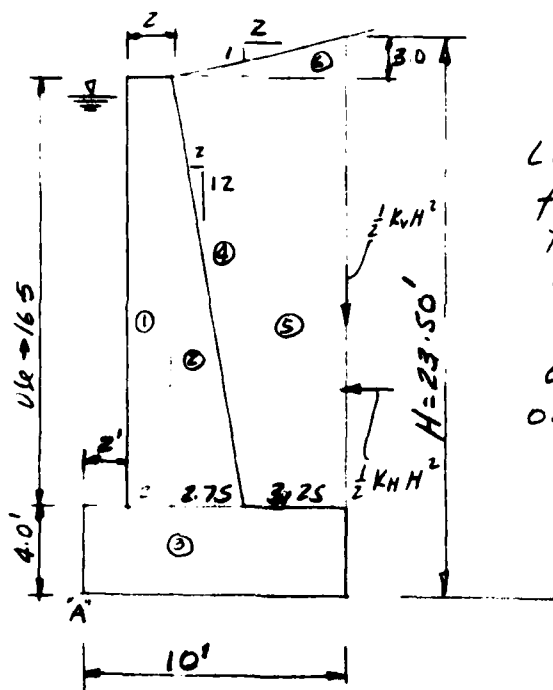
SUBJECT BIG CROCK R.R. BRIDGE FILE NO. _____
SPUR LINE SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JKS DATE 1-16-79 CHECKED BY R-M DATE 1-18-79

Abutment design (cont.)

Wing Wall design:

1) Max Height: see Main Line Wing walls

2) Min. Height: For 45° skew angle use backfill slope 2:1
use backfill material type 1



$$K_v = 0.018 \text{ (From AREA)}$$

$$K_H = 0.04 \text{ (B-5-17)}$$

Live load surcharge: distance from footing to edge of tie is greater than height of wall. (neglect LL surcharge)

Overturning Moment:

$$0.04 \times 28.5 \times 0.5 = 11.0 \times 7.83 = 86.2$$

$$F.S. \text{ (sliding)} = \frac{28 \times 28 \times 0.6}{11.0} = 1.54$$

Resisting Moments:

$$\begin{aligned} ① &= 2 \times 16.5 \times 0.15 = 4.95 \times 3.0 = 14.9 \\ ② &= 2.75 \times 16.5 \times 0.5 \times 0.15 = 3.40 \times 4.92 = 16.7 \\ ③ &= 10.0 \times 4.0 \times 0.15 = 6.00 \times 5.0 = 30.0 \\ ④ &= 2.75 \times 16.5 \times 0.5 \times 0.105 = 2.38 \times 5.83 = 13.9 \\ ⑤ &= 3.25 \times 16.5 \times 0.105 = 5.63 \times 8.38 = 47.2 \\ ⑥ &= 8.0 \times 6.0 \times 0.5 \times 0.105 = 0.95 \times 8.9 = 7.6 \\ \frac{1}{2} K_v H^2 &= 0.5 \times 0.018 \times 28.5^2 = 4.97 \times 10.0 = 49.7 \\ \hline &28.28 \qquad 180.0 \end{aligned}$$

Resultant at:

$$x = \frac{180.0 - 86.2}{28.28} = 3.32$$

$28.28 > 8\frac{1}{4} \text{ ok.}$

D2-60

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SUBJECT BIG CREEK R.R. BRIDGE FILE NO. _____
SPUR LINE SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 1-18-79 CHECKED BY RSM DATE 1-18-79

Wing wall (Cont)

Check Buoyancy: assume High Water at top of wing
 $\gamma = 0.06$

① thru ③	= 14.35	= 61.6
① thru ③ = $14.35 \times \frac{62.4}{150}$	= -5.97	= -25.6
④ & ⑤: $8.01 \times \frac{0.06}{0.105}$	= 4.58	= 34.9
⑥:	= 0.95	= 7.6
$V = 4.97 \times \frac{0.06}{0.105}$	= 2.84	= 28.4
	16.75	106.9

Overturning: $0.04 \times 23.5 \times 0.5 \times \frac{0.06}{0.105} = 6.31 \times 7.83 = 49.4$

F.S. (sliding) = $\frac{16.75 \times 0.6}{6.31} = 1.59$ OK

Resultant at = $(106.9 - 49.4) \div 16.75 = 3.43$
 $> 8/4$

Max Soil pressure:

$x = 3.32$ $e = 5.0 - 3.32 = 1.68$

$p = \frac{28.28}{10} \pm \frac{28.28 \times 1.68 \times 6}{10^2} = 2.83 \pm 2.85 = 5.68 \text{ KSF} < 10.0$
Min p = 0

For stem and footing reinforcement See Main Line.

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HARRISBURG, PA.

SUBJECT BIG CREEK R.R. BRIDGE FILE NO. _____
SPRINT SHEET NO. _____ OF _____ SHEETS
FOR _____
COMPUTED BY JRS DATE 1-9-79 CHECKED BY REM DATE 1-15-79

PIER DESIGN: USE FIXED BEARINGS.

TOP OF YO. 1 EL = 627.0 Max. H.W. EL = 612.5
BOT. OF Channel EL = 546.5 (at Abut. #2) and EL = 600.0 (at Pier)
beam drop = rail and tie = 1'-5"
Girder = 5'-9"
slab = 1'-10"
EL 546.5 9'-0"

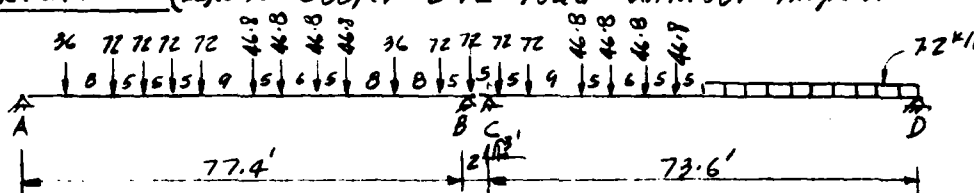
TOP OF footing to TOP of pier = 16.5'
Assume 4' Footing

DL REACTIONS (DL):

$$R = 0.91 \times 153.0 \div 2 = 69.6 \text{ k} \times 2 = 139.2 \text{ k}$$

* per girder

LL REACTIONS (LL): USE COOPER E72 load WITHOUT IMPACT.



$$R_B = [72(77.4 + 72.4) + 36 \times 64.4 + 46.8(56.4 + 51.4 + 45.4 + 40.4) + 72(31.4 + 26.4 + 21.4 + 16.4) + 36 \times 8.4] + 77.4 = 379.2 \text{ k}$$

$$R_C = [72(70.6 + 65.6) + 46.8(56.6 + 51.6 + 45.6 + 40.6) + 72 \times 35.6 + 17.8] + 73.6 = 318.8 \text{ k}$$

$$\text{TOTAL REACTIONS} = 698.0 \text{ k}$$

$$\text{For stability use } R_{\text{total}} = 1.2 \times 153.0 \div 2 = 91.8 \text{ k}$$

WIND FORCE (W & WL):

1) Wind from structure (W): 30 #/SF (Perpendicular to E of the Track)

Vertical Projection = 8.0 (ft)

$$R = 0.03 \times 8.0 \times 153.0 \div 2 = 18.4 \text{ k}$$

2) Wind on train (WL): 300 #/ft (assume both spans loaded)

$$R = 0.3 \times 153.0 \div 2 = 23.0 \text{ k}$$

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Pier design (cont.)

Stream Current (SF): (UK AASHTO 1978 Interim)

$$Q = 12000 \text{ CFS}$$

Channel Area:

$$(30 + 43.5) \times \frac{1}{2} \times 3 = 110.25$$

$$116.5 \times 12.5 = 1456.25$$

$$31.25 \times 12.5 \times \frac{1}{2} \times 2 = 390.6$$

$$1957.1 \text{ SF}$$

$$V = 12000 \div 1957.1 = 6.1 \text{ ft/sec.}$$

$$P = KV^2 \quad K = \frac{2}{3} \text{ (circular piers)}$$

$$P = (6.1)^2 \times \frac{2}{3} = 25 \text{ #/SF}$$

$$F = 25 \times 12.5 \times 5.5 = 1.8 \text{ K} \quad M_0 = 1.8 \times 13.25 = 24 \text{ K-ft}$$

Effect of Ice: (UK AASHTO 1978 Interim)

Thickness of Ice in contact = 6" = t

$$F = C_n p t W \times C_1$$

$$C_n = 1.0 \text{ (Inclination of nose to vertical = } 0^\circ)$$

$p = 200 \text{ psi}$ (break-up at melting temperature and
Ice moves in large pieces)

$$W = 66' \quad C_1 = 0.8 \left(\frac{W}{L} = \frac{66}{6} = 11.0 > 4 \right)$$

$$F_L = 1.0 \times 200 \times 6 \times 66 \times 0.8 = 63.4 \text{ K (longitudinal direction)}$$

$$F_0 = 63.4 \times 0.15 = 9.5 \text{ K (overturning direction)}$$

Moments at bot. of pier: applied forces at EL 612.0

$$M_B = 19.5 \times 63.4 = 1236 \text{ K-ft}$$

$$M_0 = 19.5 \times 9.5 = 185 \text{ K-ft}$$

Pier design (cont.)

Longitudinal Force (LF): assume continuous rail and full long
force resisted by fixed bearings.

$$R_B = (36 + 72 \times 4 + 46.8 \times 4 + 36 + 72 \times 2) \times 0.15 \times \frac{77.4}{1200} = 6.7$$

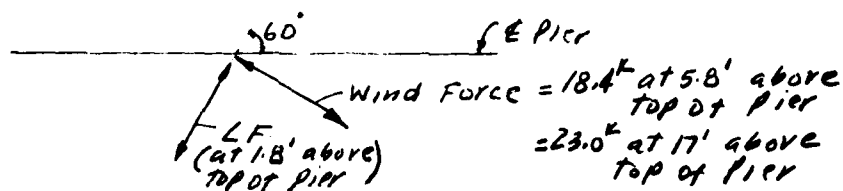
$$R_C = (72 \times 2 + 46.8 \times 4 + 7.2 \times 35.6) \times 0.15 \times \frac{73.6}{1200} = 5.4$$

$$\text{TOTAL LF} = 12.1^k$$

Footing Design:

set footing on sound rock $\approx 2 \in$ Track

Allow bearing pressure = $5 \frac{\text{ton}}{\text{SF}}$



Wind from Pier: assume: $\begin{cases} \text{length} = 19.5' \\ \text{width} = 5.5' \end{cases}$ and Wind $\perp$ to Track

$$\text{Wind } \parallel \text{ to } \in \text{ pier} = 0.03 \times \cos 30^\circ \times 5.5 \times 13.0 = 1.9^k \quad M_0 = 1.9 \times 14.0 = 27^k$$

$$\text{Wind } \perp \text{ to } \in \text{ pier} = 0.03 \times \sin 30^\circ \times 18.5 \times 13.0 = 3.6^k \quad M_0 = 3.6 \times 14.0 = 50^k$$

Forces and Moments at bot. of footing:

Max Forces in overturning direction:

$$F_0(W) = 18.4 \sin 30^\circ = 9.2^k \quad F_0(WL) = 23.0 \sin 30^\circ = 11.5^k \quad F_0(LF) = 12.1 \sin 60^\circ = 10.5^k$$

$$M_0 = 9.2 \times 26.3 + 11.5 \times 37.5 + 10.5 \times 22.3 = 907^k \cdot \text{ft} \quad F_0(\text{total}) = 31.2^k$$

$$F_0(W) = 18.4 \sin 60^\circ = 15.9^k \quad F_0(WL) = 23.0 \sin 60^\circ = 19.9^k \quad F_0(LF) = 12.1 \sin 30^\circ = 6.1^k$$

$$M_0 = 15.9 \times 26.3 + 19.9 \times 37.5 + 6.1 \times 22.3 = 1028^k \cdot \text{ft} \quad F_0(\text{total}) = 29.7^k$$

Max Forces in Bent direction: $F_0 = 9.2 + 11.5 - 10.5 = 10.2^k$

$$M_0 = 9.2 \times 26.3 + 11.5 \times 37.5 - 10.5 \times 22.3 = 439^k \cdot \text{ft}$$

$$F_0 = 15.9 + 19.9 + 6.1 = 41.9^k \quad M_0 = 15.9 \times 26.3 + 19.9 \times 37.5 + 6.1 \times 22.3 = 1300^k \cdot \text{ft}$$

Axial load: assume $20 \times 9.5 \times 4$ Footing.

$$\text{Wt of shaft} = 13.0 \times 16.5 \times 5.5 \times 0.15 + 3 \times 14.5 \times 5.5 \times 16.5 \times 0.15 = 235.7^k$$

$$\text{Wt of footing} = 20 \times 9.5 \times 4 \times 0.15 = 114.0^k$$

$$\text{Total axial load: 1) DL only} = 139.7 + 235.7 + 114.0 = 488.9$$

$$2) \text{ DL + LL} = 488.9 + 698.0 = 1186.9^k$$

$$\text{Wt of cover} = (20 \times 9.5 - 13.0 \times 5.5 - 3 \times 14.5 \times 5.5) \times 0.12 = 40^k \quad \text{D2-64}$$

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Foot. design (cont.): Use the following loading conditions:

Group I: DL + LL + B + SF

$$P_{DL} = 488.9 + 40 - (235.7 + 114.0) \times 0.062 - 40 \times 0.062 = 364.2^k$$

$$\text{Total } P = 364.2 + 698.0 = 1062.2^k$$

$$M_0 = 0 \quad M_B = 24^{k \cdot 1}$$

$$\text{Group Ia: } DL + LL \quad P = 1226.9^k \quad M_0 = M_B = 0$$

Group II: DL + B + SF + W:

$$P = 364.2^k + 1.25 = 291^k$$

$$M_B = 24 + 418 = 442 - 1.25 = 354^{k \cdot 1}$$

$$M_0 = 242 + 1.25 = 194^{k \cdot 1}$$

$$e_0/9.5 = 0.07$$

$$e_0/20 = 0.06 \quad \text{Case I}$$

Group III: DL + LL + B + SF + 0.3W + WL + LF

$$P = 1062.2 + 1.25 = 850^k$$

$$M_B = 24 + 418 \times 0.3 + 746 - 136 = 759 + 1.25 = 608^{k \cdot 1}$$

$$M_0 = 242 \times 0.3 + 431 + 239 = 738 + 1.25 = 590^{k \cdot 1}$$

$$e_0/9.5 = 0.07$$

$$e_0/20.0 = 0.04 \quad \text{Case I}$$

Group IIIa: DL + LL + 0.3W + WL + LF

$$P = 488.9 + 40 + 698.0 = 1226.9 + 1.25 = 982^k$$

$$M_B = (759 - 24 + 27 \times 0.3) + 1.25 = 592^{k \cdot 1}$$

$$M_0 = 738 + 50 \times 0.3 = 753 + 1.25 = 602^{k \cdot 1}$$

$$e_0/9.5 = 0.06$$

$$e_0/20.0 = 0.03 \quad \text{Case I}$$

Group VIII: DL + LL + B + SF + Ice

$$P = 1062.2 + 1.4 = 759^k$$

$$M_0 = 185 + 1.4 = 132^{k \cdot 1}$$

$$M_B = (1236 + 24) + 1.4 = 900^{k \cdot 1}$$

$$e_0/9.5 = 0.02$$

$$e_0/20.0 = 0.06 \quad \text{Case I}$$

Group IX: DL + B + SF + W + Ice

$$P = 364.2 + 1.5 = 243^k$$

$$M_B = (442 + 1236) + 1.50 = 1119^{k \cdot 1}$$

$$M_0 = (242 + 185) + 1.50 = 285^{k \cdot 1}$$

$$e_0/9.5 = 0.12$$

$$e_0/20.0 = 0.23 \quad \text{Case II}$$

For soil pressures of footings under doubly eccentric loads see AREA fig 6, p B-3-12

* B = Boyancy

D2-65

FOR NOTE ON
LOADING CONDITIONS
SEE SHEET 02-66

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Foot. design (cont.)

Max. bearing pressure:

$$A = 9.5 \times 20 = 190 \quad S_0 = \frac{9.5^2 \times 20}{6} = 301 \quad S_8 = \frac{20^2 \times 9.5}{6} = 633$$

$$\text{GROUP IA: } p = \frac{1226.9}{190} = 6.46 \text{ K/SF}$$

$$\text{GROUP IIIc: } p = \frac{982}{190} + \frac{594}{633} + \frac{602}{301} = 5.17 + 0.94 + 2.00 = 8.11 \text{ K/SF} < 10.0$$

$$\text{GROUP IX: } K = 3.75$$

$$p = \frac{3.75 \times 243}{190} = 4.80 \text{ K/SF}$$

USE 20' x 9.5' x 2' FOOTING.

footing depth: try 2': USE $\begin{cases} f'_c = 3000 \text{ psi} \\ f_s = 20000 \text{ psi} \end{cases}$

$$\text{OVERTURNING: } 8.11 \times 2.0 = 16.2 \times 1.0 = 16.2$$

$$- 2.0 \times 0.15 \times 2.0 = -0.6 \times 1.0 = -0.6$$

$$- 3.0 \times 0.12 \times 2.0 = -0.7 \times 1.0 = -0.7$$

$$V = 14.9 \text{ K} \quad M = 14.9 \text{ K-FT}$$

$$A_s = \frac{14.9}{1.44 \times 20.5} = 0.50\%$$

$$\text{USE } \# 6 @ 9" \quad \begin{cases} A_s = 0.59 \\ Z_0 = 3.1 \end{cases}$$

$$Z_0 = \frac{14.9}{0.35 \times 0.875 \times 20.5} = 2.40\%$$

$$u = \frac{4.8 \sqrt{3000}}{0.75} = 0.35$$

* OK 2' footing

v_e at distance "d" is negligible

NOTE:

Group I, II, etc. refer to Loading Conditions. Loading Conditions are from the AASHTO Specification for highway bridges. In the past, this design procedure has been acceptable to the railroads. A copy of Paragraph 1.2.22, LOADING CONDITIONS from AASHTO is on Sheet 66a. This is from "Standard Specifications for Highway Bridges," 11th Edition, 1973.

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COMPUTED BY FF DATE 9-20-79 CHECKED BY _____ DATE _____

Refer to Note on Sheet D2-66. The following
is from AASHTO:

1.2.22 — LOADING COMBINATIONS

The following Groups represent various combinations of loads and forces to which a structure may be subjected. Each part of such structure, or the foundation on which it rests, shall be proportioned for all combinations of such of these forces as are applicable to the particular site or type, and at the percentage of the basic unit stress indicated for the various groups except that no increase in allowable unit stresses shall be permitted for members or connections carrying wind loads only. See Articles 1. 2. 1 to 1. 2. 21 for loads and forces.

The maximum section required shall be used.

		Percentage of Unit Stress
Group I	= D + L + I + E + B + SF	100%
Group II	= D + E + B + SF + W	125%
Group III	= Group I + LF + F + 30% W + WL + CF	125%
Group IV	= Group I + R + S + T	125%
Group V	= Group II + R + S + T	140%
Group VI	= Group III + R + S + T	140%
Group VII	= D + E + B + SF + EQ	133 1/3%
Group VIII	= Group I + ICE	140%
Group IX	= Group II + ICE	150%
D	= Dead Load	
L	= Live Load	
I	= Live Load Impact	
E	= Earth Pressure	
B	= Buoyancy	
W	= Wind Load on Structure	
WL	= Wind Load on Live Load—100 pounds per linear foot	
LF	= Longitudinal Force from Live Load	
CF	= Centrifugal Force	
F	= Longitudinal force due to friction or shear resistance (elastomeric bearings).	
R	= Rib Shortening	
S	= Shrinkage	
T	= Temperature	
EQ	= Earthquake	
SF	= Stream Flow Pressure	
ICE	= Ice Pressure	

D2-66a

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Column Design:

Group IA: $P = 235.7 + 139.2 + 698 = 1073^k$ $M_0 = M_0 = 0$

Group I: $P = 235.7 + 139.2 + 648 - 235.7 \times \frac{0.062}{0.15} = 975.4^k$
 $M_0 = 0$ $M_B = 1.8 \times 9.25 = 17^k$

Group II: $P = 277.9 - 1.25 = 222^k$

$M_0 = 17 + 15 \times \frac{9.25}{22.3} = 371 + 1.25 = 297^k$ $e = 134$ $e/18.5 = 0.07$

$M_0 = 9.2 \times 22.3 = 205 - 1.25 = 164^k$ $e = 0.74$ $e/5.5 = 0.13$

Group III: $P = 139.2 + 648 + 235.7 - 235.7 \times \frac{0.062}{0.15} = 975 + 1.25 = 786.7^k$

$M_0 = 17 + 0.3 \times 354 + 19.9 \times 33.5 - 6.1 \times 18.3 = 678 + 1.25 = 542$ $e/18.5 = 0.04$

$M_0 = 0.3 \times 205 + 11.5 \times 33.5 + 10.5 \times 18.3 = 639 + 1.25 = 511$ $e/5.5 = 0.12$

Group IIIa: $P = 235.7 + 139.2 + 698 = 1072.9 + 1.25 = 858.3^k$

$M_0 = 0.3(354 + 1.9 \times 10) + 667 - 112 = 667 + 1.25 = 533$ $e/18.5 = 0.03$

$M_0 = 0.3(205 + 3.6 \times 10) + 385 + 192 = 649 + 1.25 = 519$ $e/5.5 = 0.11$

Group VIII: $P = 975.4 + 1.40 = 697.0^k$

$M_0 = 17 + 63.4 \times \frac{9.25}{15.5} = 1000 + 1.40 = 714$ $e/18.5 = 0.06$

$M_0 = 9.5 \times 15.5 = 147 + 1.4 = 105$ $e/5.5 = 0.03$

Group IX: $P = 277.9 + 1.5 = 185.3$

$M_0 = 371 + 983 = 1354 + 1.5 = 902$ $e = 487$ $e/18.5 = 0.26$

$M_0 = 205 + 147 = 352 + 1.5 = 235$ $e = 1.26$ $e/5.5 = 0.23$

For Note on
Loadings,
See D2-66

Min concrete section with 1% of reinforce steel:

Actual column dimensions: $5.5' \times 13' (*)$

* Without circular portions.

ratio $W/T = 13.0/5.5 = 2.4$

try $34" \times 82"$ section $A = 2788 \text{ in}^2$

$A_s = 0.01 \times 2788 = 27.88 \text{ in}^2$ try 36 #8 bars $A_s = 28.44 \text{ in}^2$ say $\rho = 0.01$

use $f'_c = 3000 \text{ psi}$ and $f_s = 20000 \text{ psi}$ $F_y = 40000 \text{ psi}$

in all groups (except IX) $\sum e/f_c < 0.5$

$f_c = \frac{N}{A_g} \left[\frac{1 + \sum \frac{De}{E}}{1 + (n-1)\rho} \right] = \text{combined fiber stress}$
in compression.

assume $D=5$

Max. allowable compressive stress $= f_p = f_c \left[\frac{1 + \sum \frac{De}{E}}{1 + C \sum \frac{De}{E}} \right]$

$f_a = \frac{0.225 f'_c + f_s \rho \times 0.8}{1 + (n-1)\rho}$ and $C = \frac{f_a}{0.4 f'_c}$

D2-67

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Column design (cont.)

$$f_a = \frac{0.225 \times 3.0 + 20.0 \times 0.01}{1 + 11 \times 0.01} \times 0.8 = 0.63$$

$$C = \frac{0.63}{0.4 \times 3.0} = 0.525$$

$$\text{Group IA} = \sum \frac{D_e}{t} = 0$$

$$f_c = \frac{1073}{34 \times 82} \left(\frac{1}{1 + 11 \times 0.01} \right) = 0.343$$

$$f_p = f_a = 0.63 > f_c \text{ ok.}$$

$$\text{Group IIIa: } \sum \frac{D_e}{t} = 5(0.09 + 0.21) = 1.5 \quad f_c = \frac{858.3}{34 \times 82} \left(\frac{1 + 1.4}{1.11} \right) = 0.693$$

$$e/1.83 = 0.09 \quad t$$

$$e/1.83 = 0.21$$

$$f_p = 0.63 \left[\frac{1 + 1.5}{1 + 0.525 \times 1.5} \right] = 0.881 > f_c \text{ ok.}$$

$$\text{Group II: } \sum \frac{D_e}{t} = 5(0.20 + 0.26) = 2.30 \quad f_c = \frac{222}{34 \times 82} \left(\frac{1 + 2.30}{1.11} \right) = 0.237$$

$$e/1.83 = 0.20 \quad t$$

$$e/1.83 = \frac{0.36}{0.46}$$

$$f_p = 0.63 \left[\frac{2.30}{1 + 0.525 \times 2.30} \right] = 0.943 > f_c \text{ ok.}$$

$$\text{Group IX: } \sum \frac{e}{t} > 0.5$$

neglect tensile strength of the concrete and use 0.03 max. strain at the extreme compression fiber.

Assume strain in reinforcement and concrete directly proportional to the distance from the N.A.

run program UCD: Load-Moment interaction curve and use 35% of the combined flexural and axial load capacity.

$$0.1 f'_c A_g \times 0.35 = 836 \times 0.35 = 293^k > P \quad \frac{M_x}{M_{nx}} + \frac{M_y}{M_{ny}} \leq 1$$

$$\text{Group IX: } \frac{902}{2182} + \frac{235}{1198} = 0.41 + 0.20 = 0.61 < 1.0$$

Lateral ties: use #4 bars.

$$\text{Spacing} = 16 \times 1.0 = 16.0$$

$$48 \times \frac{1}{2} = 24.0$$

$$\text{Min. column dimension} = 66$$

} use 16"

D2-68

edit and print

EDIT RUN

WIDTH, THICKNESS, FC CONC, FY STEEL, NO. BAR LOC, NA INCR
 ? 34 67 3 40 6 6
 INPUT 6 PAIRS OF DISTANCES AND AS (MAX. 4 PAIRS PER LINE)
 ? 3 4.74 18.20 4.74 33.4 4.74 48.4 4.74
 ? 63.8 4.74 79 4.74

CHECK: RCM 1-1-77

POINTS ON LOAD-MOMENT INTERACTION CURVE
 COLUMN W= 34.0 IN CONC FC= 3.00 KSI
 T= 82.0 IN REINF FY= 40.00 KSI

Big Creek R.R. Bridge SPUR LINE

REINFORCEMENT DISTANCE (IN) AND AS (SQ IN)		Ant direction	
DIS	AS	DIS	AS
3.00	4.74	18.20	4.74
63.80	4.74	79.00	4.74
		33.40	48.60
		4.74	4.74

NOTE: PHI=1 COMPRESSION IS PLUS
 I(CONC)= 75.338 FT4 I(REINF)= 0.9242 FT4
 EI(CONC)/5+EI(STEEL)= 10633517 K-FT2
 0.1*FC*AG= 836.4 K AS/AG= 0.0102

NOTE:

This is an analysis program that analyzes a concrete section for axial load and moment. Program generates the interaction diagram. Writeup of program at end of this Subappendix.

N-AXIS (IN)	FORCE (K)	MOMENT (KF)	ECCEN (FT)
	8174.5	0.0	
109.000	8079.8	276.3	0.034
103.000	8048.3	358.2	0.045
97.000	8012.9	450.1	0.056
91.000	7581.8	1815.3	0.239
85.000	7081.0	3187.8	0.450
79.000	6568.3	4393.5	0.669
73.000	6056.1	5412.7	0.894
67.000	5517.1	6297.8	1.142
61.000	4956.0	7033.1	1.419
55.000	4360.2	7612.3	1.746

Best direction (cont.)

$e_{II} = 4.87$ $M = 6230 \times 0.35 = 2182$ *

CHG.: REM (1-17-79)

49.000	3774.5	7880.9	2.088
43.000	3171.0	7945.8	2.506
37.000	2613.4	7710.5	2.950
31.000	2019.5	7220.4	3.575
25.000	1412.6	6408.7	4.537
19.000	836.7	5397.6	6.451
13.000	212.2	4041.5	19.046
10.456	0.1	3509.9	
BALANCED DESIGN POINT			
54.118	4267.7	7687.9	1.801
END OF PROGRAM UCD			
EDIT			

* Program based on ultimate strength design and requires longhand check for working stress design required by AREA.

e_{II} = actual eccentricity

By interpolation Ultimate Moment = 6230

.35 Factor converts moment to allowable working stress moment.

$\therefore M_{all} = 2182 > M_{actual}$ of 902 (see Sheet D2-67)

WIDTH, THICKNESS, FC CONC, FY STEEL, NO. BAR 100, MA INCH
 82 34 3 40 4 6
 INPUT 4 PAIRS OF DISTANCES AND AS (MAX. 4 PAIRS PER LINE
 3 11.06 12.33 3.16 21.67 3.16 39 11.06

POINTS ON LOAD-MOMENT INTERACTION CURVE
 COLUMN W= 32.0 IN CONC FC= 3.00 KSI
 (= 34.0 IN REINF FY= 40.00 KSI

Overtuning direction

REINFORCEMENT DISTANCE(IN) AND AS(SO IN)
 DIS AS DIS AS DIS AS
 3.00 11.06 12.33 3.16 21.67 3.16 31.00 11.06

Chrd: RSM (1-17-79)

NOTE PHI=1 COMPRESSION IS PLUS
 I(CONC)= 12.952 FT4 I(REINF)= 0.2157 FT4
 EI(CONC)/5+EI(STEEL)= 2065469 K-FT2
 0.1*FC*AG= 836.4 K. AS/AG= 0.0102

N-AXIS(IN)	FORCE(K)	MOMENT(KF)	ECCEN(FT)
8174.5	0.0		
37.000	7342.4	1037.7	0.141
31.000	6117.0	2256.5	0.369
25.000	4781.6	3145.0	0.658
19.000	3398.6	3560.4	1.048
13.000	2170.1	3263.5	1.504
7.000	963.1	2453.5	2.547
3.352	1.6	1407.3	

*ED=126 M= 3422*0.35= 1198**

BALANCED DESIGN POINT
 21.236 3847.8 3551.6 0.923

** See explanation Sheet DL-70.*

END OF PROGRAM UCD

EDIT end

READY logoff

LOGGED OFF AT 09.11.51 01/15/79

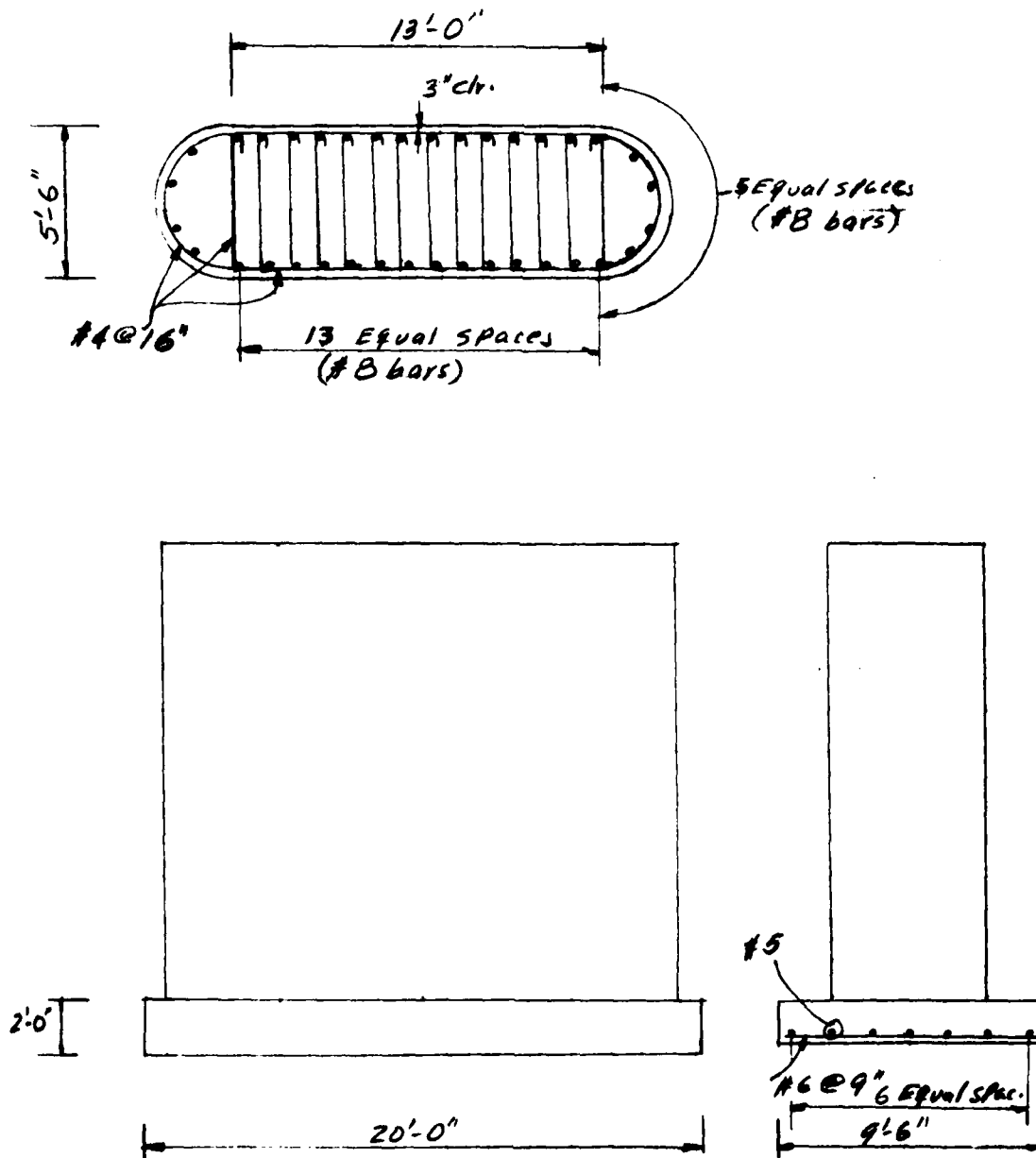
SESSION DURATION 00.05.25 CPU TIME USED 2766/300THS SEC.

=====

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Pier design (Cont.)

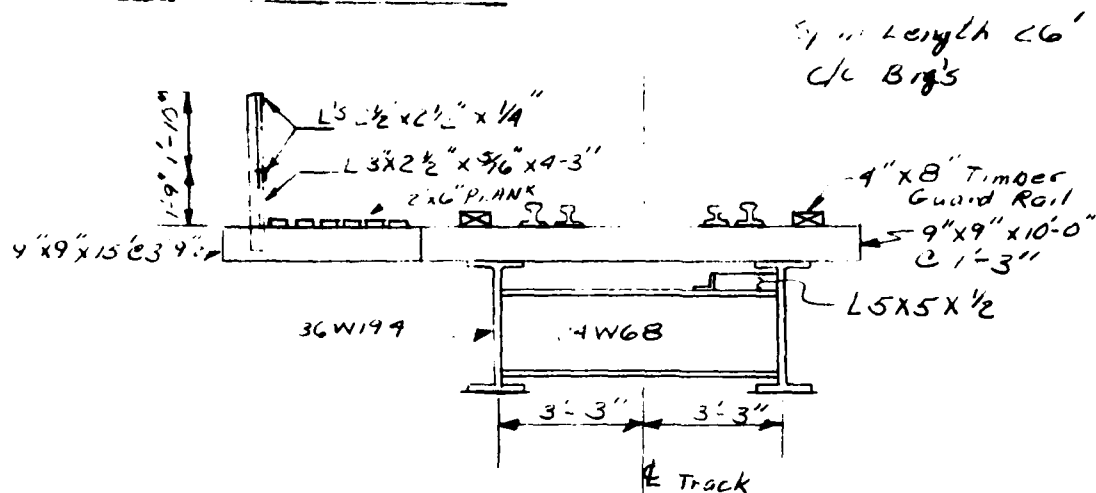


D2-72

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SUBJECT Big Creek A.A. Bridge FILE NO. _____
Trussing Structure SHEET NO. _____ OF _____ SHEETS
FOR Wm. Henry Engineer District Buffalo
COMPUTED BY RNP DATE 1/29/79 CHECKED BY JRS DATE 2-5-79

TRESTLE BENTS DESIGN:



TYPICAL SECTION

DEAD LOADS

- 1) Weight of Track Rails, Inside Guard Rails,
fastenings $= 200 \text{ #/ft}$
 " Timber Guard Rails $0.33(0.6)(60)(2) = 27$
 " Walk way $(6)(0.12)(0.5)(60) = 31$
 " Railing $2(9.1) + 8(4.25)(5.6)/26 = 15.5$
 " Ties $(0.75)(0.75)(10)(60)/1.25 = 270$
 " Ties $(0.75)(0.75)(5)(60)/3.75 = 45$
 588.5 #/ft
- 2) 36 W 194 Girders $2(194) = 388 \text{ #/ft}$
 29 W 68 Diaphragm $(65)(68)/26 = 17 \text{ #/ft}$
 5 x 5 x 1/2" Lateral Bracing $4(8.93)(6.2)/26 = 22.3 \text{ #/ft}$
 427.3 #/ft

Total Dead Load 1 + 2 = 1015.8 #/ft

D.L. per girder = 0.52 K/ft

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LIVE LOAD: COOPER E-80

Impact: Open Deck without Hammer Blow

$$I = \frac{100}{S} + 40 - \frac{3L^2}{1600} = \frac{100}{6.5} + 40 - \frac{3(26)^2}{1600} = 54\%$$

From "Stresses in Framed Structures" Hoof & Kinnie
table 3 page 144

Max. Mom	Max Shear
$D.L. = 0.52(26)^2/8 = 43.9 \text{ K-ft}$	$0.52(26)/2 = 6.76 \text{ K}$
$L.L. = 406 \times 80/50 = 649.6 \text{ K-ft}$	$72.6 \times 80/50 = 116.2 \text{ K}$
$I = 649.6 \times 0.54 = 350.8 \text{ K-ft}$	$116.2 \times .54 = 62.7 \text{ K}$
1041 K-ft	185.7 K

Max. Shear Stress

$$f_v = 185.7 / (36.48 \times 0.77) = 6.61 \text{ KSI} < 12.5 \text{ Allow.}$$

Max. Bending Stress

$$f_b = 1041 (12) / 665 = 18.8 \text{ KSI}$$

Allow. Compressive Stress w/ Diaph. Sp. = 13'
(f_{rc}) $(12)13/2.56 = 60.94$

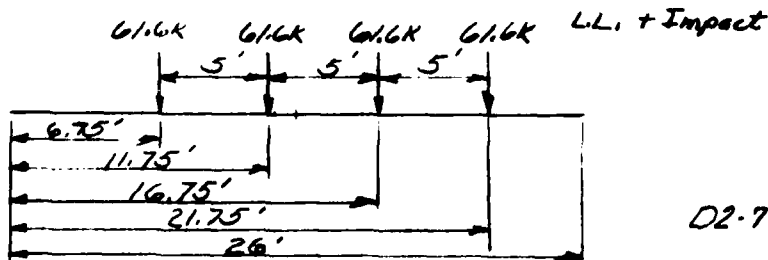
$$F_b = 20,000 - 0.4(60.94)^2 = 18.5 \text{ KSI } \phi_{AP} = 2.39$$

$$F_b = 10500000 / (12 \times 13)(2.39) = 28.2 \text{ KSI } \therefore \text{USE } 20 \text{ KSI}$$

Deflection

$$\Delta_{\text{Allow.}} = \frac{L}{640} = \frac{12(26)}{640} = 0.49"$$

Loading for Max. Deflection wheels 1.25' left of center



D2-74

Big Creek A.R. Bridge
 Temporary Structure
 U.S. Army Engineer District - Buffalo
 By: RNR 1/30/79
 CHKD BY: JRS 2-5-79

```

END * d44 04
EDIT 044
TRANSIT WL (KIP/FT), MR (KIP/FT), AL (FT-KIP), MR (FT-KIP)
1 26.0 0 0 0 0
NO. OF "P" VALUES
2 4
DISTANCE A "P"
2 26.0 12169
NO. OF CONC. LBS.
2 4
LOAD & DISTANCE
2 61.7 51.75
2 61.6 44.75
2 61.5 36.75
2 61.6 21.75
DEFLECTION (INCHES)
.10 FT .20 FT .30 FT .40 FT .50 FT
0.1039 0.1981 0.2732 0.3217 0.3392
.60 FT .70 FT .80 FT .90 FT
0.3241 0.2773 0.2029 0.1073
ROTATIONS (RAD.)
LEFT= 0.0033913 RIGHT= -0.0034994
DIST. TO SPECIAL POINT?
2 0
END OF PROGRAM DEF
EDIT end

```

Max Deflection = 0.34" < Allowable 0.49"
 ∴ Use W 36 x 191

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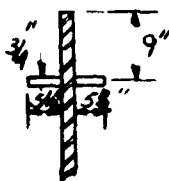
SUBJECT Big Creek R.R. Bridge FILE NO. _____
Temporary Structure SHEET NO. _____ OF _____ SHEETS
FOR U.S. Army Engineer District - Buffalo
COMPUTED BY RVP DATE 1/30/79 CHECKED BY JRS DATE 2-5-79

Bearing Stiffeners: @ Abutments

$$\text{Max Reaction} = 185.7K$$

Try $3/4" \times 5 1/2"$ stiffener PL

$$\text{check Bearing } 185.7 / 5(.75)(2) = 24.76 \text{ KSI} < 30 \text{ KSI}$$



$$A = 18(.77) + 5.5(.75)(2) = 22.11 \text{ in}^2$$

$$I_y = \frac{(.75)(5.5)^3}{12} \times 2 + 5.5(.75)(2)(3.13)^2 + \frac{(18)(.77)^3}{12} = 102.3 \text{ in}^4 \quad r_y = 2.151 \text{ in}$$

$$\frac{A}{r} = (.75)(33.96) / 2.151 = 11.84 < 15 \quad F_a = 20 \text{ KSI}$$

$$f_a = 185.7 / 22.11 = 8.4 \text{ KSI} < 20 \text{ KSI} \quad \text{OK}$$

USE $5 1/2" \times 3/4"$ Plate Bearing Stiffeners

$$\text{Allowable shear in fillet welds} = 12.5 \text{ KSI}$$

$$\text{Thickness} = 185.7 / (2)(33.96)(2)(0.707)(12.5) = 0.15 \text{ in}$$

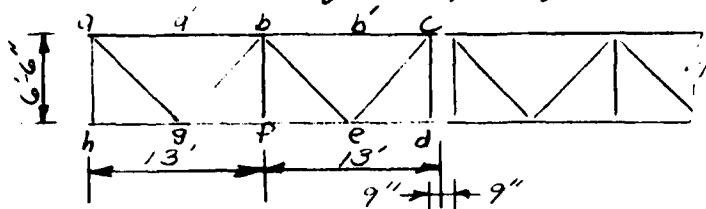
D2-76

USE $5/16"$ (min size)

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Lateral Bracing & Diaphragms



Diaphragms: Assume wind load is carried by
Lateral Bracing

$$\text{Wind load on a-h} = (300 + 30(1.5)(\frac{52}{12}))13 = 6435^*$$

$$\text{Lateral Load from equipment} = \frac{1}{4}(80) = 20K$$

$$\text{Max. Load to ah} = 6.4 + 20 = 26.4K$$

try W24x68

$$Kl/r = (75)(6.5)(12)/1.87 = 31.28$$

$$F_a = 21,500 - 100(31.28) = 18372 \text{ psi}$$

$$f_a = 26.4/20 = 1.32 \text{ ksi} \quad \text{OK USE W24x68}$$

Load c-g or e-c

$$\text{Axial load} = (6.4)(8.93)/6.5 = 8.8K$$

try 5x5x1/2

$$Kl/r = (75)(8.93)(12)/(983) = 81.76$$

$$F_a = 21,500 - 100(81.76) = 13324$$

$$f_a = 8.8/4.75 = 1.85 \text{ ksi} < 13.3 \text{ ksi} \quad \text{OK}$$

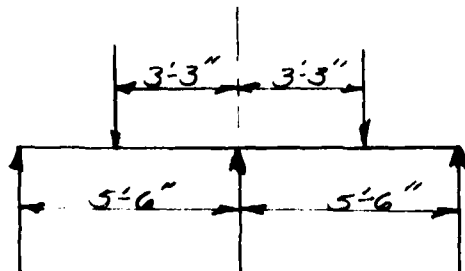
USE 5x5x1/2 Diagonals

$$\text{weld length} = 8.8/(2)(12.5)(.707)(.25) = 2" < 6.9" \text{ avail.}$$

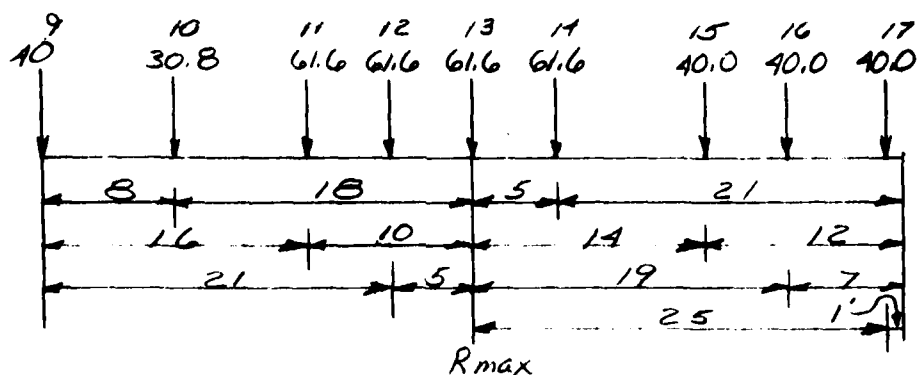
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Bridge supported by 3 Pile Steel Bent
Bent Cap



Position of Loads for Max. Reaction on
Bent Cap Place Wheel 13 over $\frac{1}{2}$ of Bent



$$R_{max} = [30.8(8) + 61.6(16) + 61.6(21) + (61.6)(21) + (40)(12) + 40(7) + 40(1)] \div 26 + 61.6 = 239.26K$$

(L.L. + Impact)
per rail

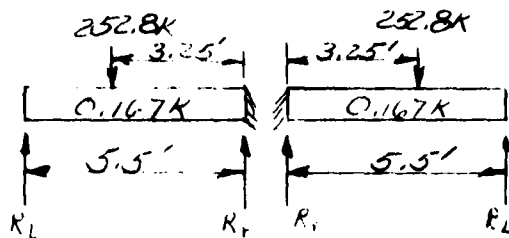
$$R_{max} = 0.52(26) = 13.5K$$

(D.L.)

$$\text{Total per Girder} = 252.8K$$

Assume W 14 x 167

D2-78



$$-mom = (0.167)(5.5)^2/8 + \frac{252.8(2.25)(3.25)(2.25+5.5)}{2(5.5)^2} = 234.72 \text{ K-ft}$$

$$R_L = [(0.167)(5.5)(2.75) + 252.8(3.25) - 234.72] \div 5.5 = 105.15 \text{ K}$$

$$R_T = [(0.167)(5.5)(2.75) + 252.8(2.25) + 234.72] \div 5.5 = 145.37 \text{ K}$$

$$R_{\text{Total}} = 145.37(2) = 290.74 \text{ K}$$

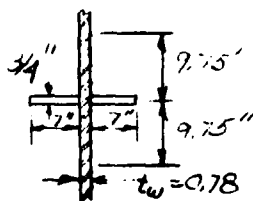
$$+mom = (0.167)(2.25)^2/2 - 105.15(2.25) = 236.89 \text{ K-ft}$$

$$\text{Max. Bending Stress} = \frac{M}{S} = 236.89(12)/207 = 10.64 \text{ KSI}$$

$$\text{Max. Shear Stress} = \frac{V}{A} = 145.37/(15.12(0.78)) = 12.3 \text{ KSI}$$

$$d/t = 19.4 < 60 \text{ No stiff. Req.} \quad < 12.5 \text{ Allowable}$$

Bearing: $\frac{3}{4}$ " x 7" Plate bearing stiffeners
@ E of Piles & Under long. beams



Effective length of web

$$25(t_w) = 19.5"$$

$$\text{Bearing} = 290.7/6.5(7.75)(2) = 29.8 \text{ KSI} < 30$$

$$H = 19.5(0.78) + 2(7)(7.75) = 25.71"$$

$$r_y = \frac{(7.75)(7)^3}{12} (2) + (7)(7.75)(2)(3.89)^2 + \frac{(19.5)(0.78)^3}{12} = 202.5 \text{ in}^4$$

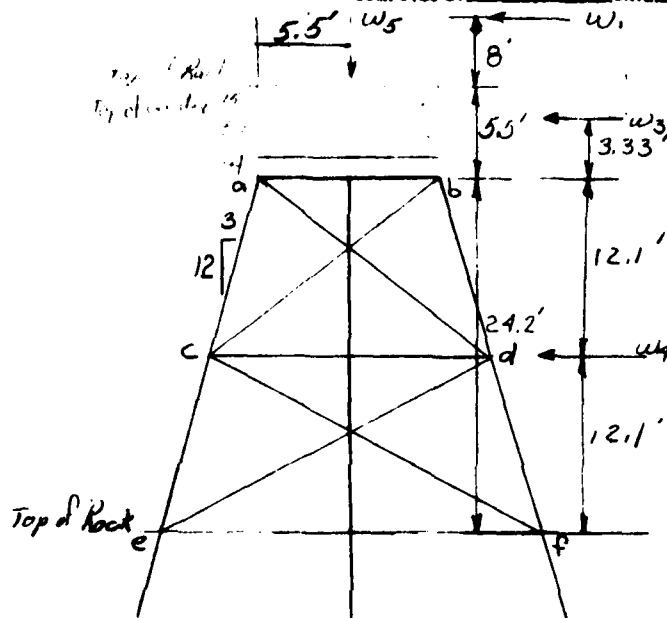
$$r_y = 2.8" \quad K/L = 0.75(12.62)/2.8 = 3.38 < 15 \quad F_a = 20 \text{ KSI}$$

$$F_a = 290.7(2)/25.71 = 11.3 \text{ KSI} < 20 \text{ KSI} \therefore \text{OK}$$

Use $\frac{3}{4}$ " x 7" Plate bearing stiffeners
D2-79

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$$w_1 = (0.3)(26) = 7.8 K$$

$$w_3 = (0.03)(1.5)(\frac{52}{12})(26) = 5.07 K$$

$$w_4 = (0.03)(21.5)(\frac{16.12}{12} + 26) = 1.30 K$$

$$w_5 = (1.2)(26) = 31.2 K$$

Bents (Transverse direction)

Load Per Pile: Assume each pile carries $\frac{1}{3}$ of Full (D.L. + L.L. + I.). Allowable Point Bearing Stress = 9 KSI

Try HP 12 x 74

Pile load Capacity = $21.8 \times 9 = 196 K$ say 100 Ton

Load per Pile = $2(252.8 + 167(1)) \div 3 = 170 K < 196 K$

USE HP 12 x 74

Assume piles only subjected to Axial compression. Longitudinal & Transverse Forces Carried by Diagonal Bracing. Assume $K = 0.8$

$$K \frac{L}{r} = 0.8(22)(12) / 5.1 = 41.4 > 15$$

$$F_a = 21500 - 100(41.4) = 17360 \text{ psi } f_a = \frac{166.6}{21.8} = 7.64 KSI \text{ OK}$$

Use HP 12 x 74 Piles
D2-80

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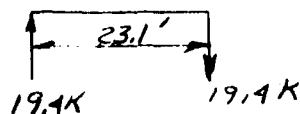
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COMPUTED BY RNF DATE 2/1/79 CHECKED BY JRS DATE 2-6-79

check stability of vent

Overturning moment

$$(7.8)(37.7) + 5.07(27.53) + 1.3(12.) = 449$$

couple



$$449/23.1 = 19.4 \text{ K}$$

$$\text{Uplift} = 19.4 - (1.05)(26)/3 - (0.074)(34) - (1.67)(3)/3 \\ - 31.2/3 = -3.3 \text{ K}$$

No Uplift

check diag. ad:

$$\text{Take mom. @ C } (7.8)(25.6) + 5.07(15.13) = 277.91 \text{ K-ft}$$

$$\text{Vert. component of ad} = 277.91/17.05 = 16.3 \text{ K}$$

$$\text{Axial Force in ad} = 16.3(18.52)/12.1 = 25 \text{ K} \\ \text{try } 6 \times 6 \times 1/2$$

$$f_a = 25/5.75 = 4.35 \text{ KSI} < 20 \text{ OK}$$

$$1/r = 23.4(12)/1.17(2) = 118 < 200$$

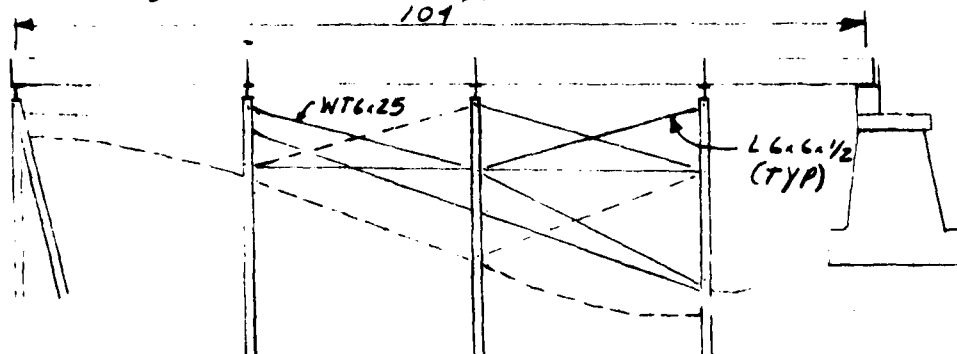
weld length req. to develop capacity of member

$$(5.75/2)(20)/(12.5)(.375)(.707) = 17.4''$$

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Bents (Longitudinal direction)



_____ = Approximate North Limit of Cut & Piers & N. Bracing
----- = " South " & South Bracing

All three intermediate bents have fixed bearings. Girders are bolted together end to end. Assume Long. force is distributed equally to 2 bents at a time i.e. bracing is not effective in comp. Worst condition occurs when load applied west to east since load is transmitted by only 3 Bracing Angles.

Longitudinal Force = 15% of L.L.

$$L_t = 2 \text{ Locomotives \& tenders} = 2(40 + 4(80) + 4(52)) = 1136 \text{ K}$$

$$\text{Long. Force} = (0.15)(1136) = 170.4 \text{ K} \quad \text{Force/Angle} = 170.4/3 = 56.8 \text{ K}$$

Tension in single angle bent

$$T = 56.8 \frac{\sqrt{725}}{26} = 58.8 \text{ K}$$

$$\text{try } 6 \times 6 \times 1/2 \quad \phi_r = (12 \sqrt{725}) / 1.18 = 274.7200$$

$$r_{req.} = 12 \sqrt{725} / 200 = 1.62 \quad \text{Use WT } 6 \times 25$$

$$f_a = 58.8 / 7.36 = 8.0 \text{ KSI OK.}$$

D2-B2

Max. Unsupported length of double bracing

$$= 16^{(\pm)} \text{ min } r_{eq} = 12(16)/200 = 0.96"$$

Use Single $6 \times 6 \times 1/2$ L's

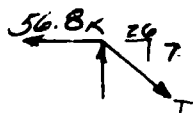
Use welded connections

Allowable Shear in fillet welds = 12.5 KSI

Use $1/4"$ min thickness

$$req. \text{ length} = 58.8 / (0.35)(.707)(12.5) = 27"$$

Max tension in double braced bent



$$T = \frac{56.8}{2} \frac{1}{\cos 26.8} = 29.4 \text{ K}$$

$$\text{single } 6 \times 6 \times 1/2 \text{ L } f_a = 29.4 / 5.75 = 5.2 \text{ KSI OK}$$

$$\text{Brace to R: length of weld req.} = 57.5 / 0.25(.707)(12.5) = 26"$$

Use $1/2" \times 10"$ PL

PL to Pile: length of weld req.

$$T_x = 29.4(\frac{26}{27.8}) = 27.4 \text{ K} \quad T_y = 29.4(7/27.8) = 7.4 \text{ K}$$

$$\text{M/c face of Pile} = 7.4(5/12) = 3.1 \text{ K-ft}$$

$$\text{Assume } 1/4" \text{ weld } 15" \text{ long } S = \frac{(.25)(.707)(5)^2(2)}{6} = 13.2 \text{ in}^3$$

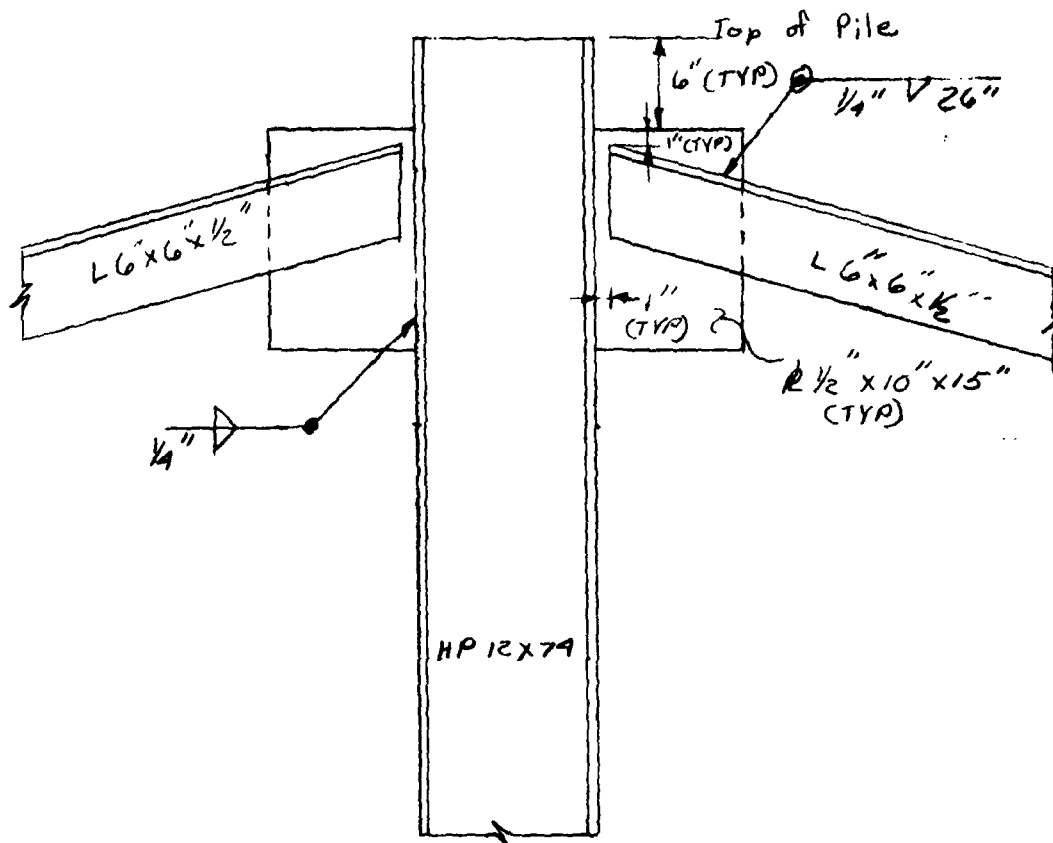
$$f = (3.1 \times 12) / 13.2 = 2.8 \text{ KSI} \quad \sigma_x = 27.4 / (.25)(.707)(15) + 2.8 = 7.96 \text{ KSI}$$

Use $1/2" \times 10" \times 15"$ PL

D2-83

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Longitudinal Bent Bracing
Scale: 1"=1'-0"

D2-84

ITF PROGRAM FILE

PROGRAM Call Name DFL GFC&C FILE 216K

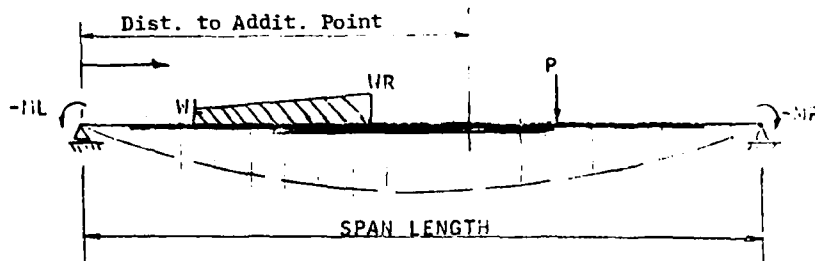
DESCRIPTION Calculates deflections due to uniform and/or concentrated loads on a simple beam with end moments.

INPUT Span Length (ft), Uniform Load (left, right value)
 Dist. Left Reaction to start of Uniform Load.
 Dist. Left Reaction to end of Uniform Load.
 Left end moment (Ft-Kips) and right end moment (Ft-Kips) (minus for tension on top)
 Moment of Inertia values (in^4) and corresponding end distances (ft) from left support.
 Concentrated load values (kips) and corresponding distances (ft) from left support.
 Distances to special points (not at 10th points of span).

OUTPUT Deflections (inches) at 10th points of span.
 Deflections at additional requested points

FEATURES Rotations (plus = clockwise; minus = counterclockwise)
 Maximum Number of moments of Inertia = 20
 Maximum Number of Concentrated Loads = 25
 Input No. of concentrated Loads as 0 for no concentrated loads.

SAMPLE RUN See Next Sheet...



REV1 (051073)

1/2

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ITF PROGRAM FILE

PROGRAM Call Name RWM GFC6C FILE 216AN

DESCRIPTION This program is for analyzing Retaining Walls or Abutments on Pile Foundations. Computes (1) Moments and Forces caused by Substructure, Earth Pressure and Live Load Surcharge, (2) Footing Design and (3) Stem Design.

INPUT For detailed information of input see Figures 1, 2, 3 and Sample Runs.

Retaining Wall and/or Abutment Input

1. Weight of Concrete and Backfill (kips/cu.ft.) and Equivalent Fluid Pressure (kips/sq.ft./ft.depth)
2. Pavement Thickness (Ft.)
3. Width and Thickness of Footing and Toe Length (Ft.)
4. Distance of 1st row of piles from the toe (Ft.)
5. Maximum Design Pile Load (kips)
6. Concrete allowable Flexure and Shear Stresses for Footing (ksi)
7. Allowable Steel Stress (ksi) and Ratio of Modulus of Elasticity for Footing.
8. Concrete cover to C_L of bottom steel and top steel.
9. Height of wall (Ft.)
10. Concrete allowable Flexure and Shear Stresses for Stem (ksi).
11. Allowable Steel Stress (ksi) and Ratio of Modulus of Elasticity for Stem.
12. Concrete cover to C_L Reinforcing Steel of Stem (in.)
13. Items "a" and "b" for Retaining Walls only.
Items "c" thru "g" for Abutments only.

Retaining Walls only:

- a. Parapet Height and Width (Ft.)
- b. Stem Top Width (Ft.) and Rear Face Batter (N/12)
- c. Soil Slope (n1/1), Slope Distance

(102076)

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D2-86

Abutments Only:

- d. Height and Width of Beam Seat (Ft.)
- e. Height and Width of Backwall (Ft.)
- f. Height and Width of Backwall Batter (Ft.)
- g. Abutment Batter (N/12)
- h. Distance from the Front Face of Wall to C_L of Bearing (Ft.)
- 14. Live Load Surcharge (Ft.)
- 15. Abutment Only
 - a. Dead Load and Live Load Reactions (kips/Ft.)
 - b. Additional Vertical and Horizontal Forces (kips/Ft.)
applied at Bearing Support.
 - c. Group Factor
- 16. Number of Rows of Piles (Max. 4)
- 17. Distance (Ft. from 1st row) and Batter (N/12) of each Pile.
- 18. Pile Spacing of each Row (Ft.)

OUTPUT Moments and Forces caused by Substructure
Earth Pressure and Live Load Surcharge
Total Pile Area (Piles/Ft)
Vertical Pile Load
Total Pile Load
Horizontal Load Due to Batter
Horizontal Load taken by pile in Bending

For Footing Design (Heel and Toe)

Required Depth
Actual Depth
Required Steel

Shear Stress

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For Stem Design

Wall Height
Compression Steel
Actual Depth
Required Steel (Tension)

Shear Stress

FEATURES

1. Pile configuration input may be repeated as many times as desired until the best design is obtained.
2. Size of footing may be changed following each pile analysis.
3. Batter may be input for the Front Face or the Rear Face - program will not handle both F.F. and R.F. Batter at the same time.

(102076)

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D2-88

GEOMETRY OF RETAINING WALL

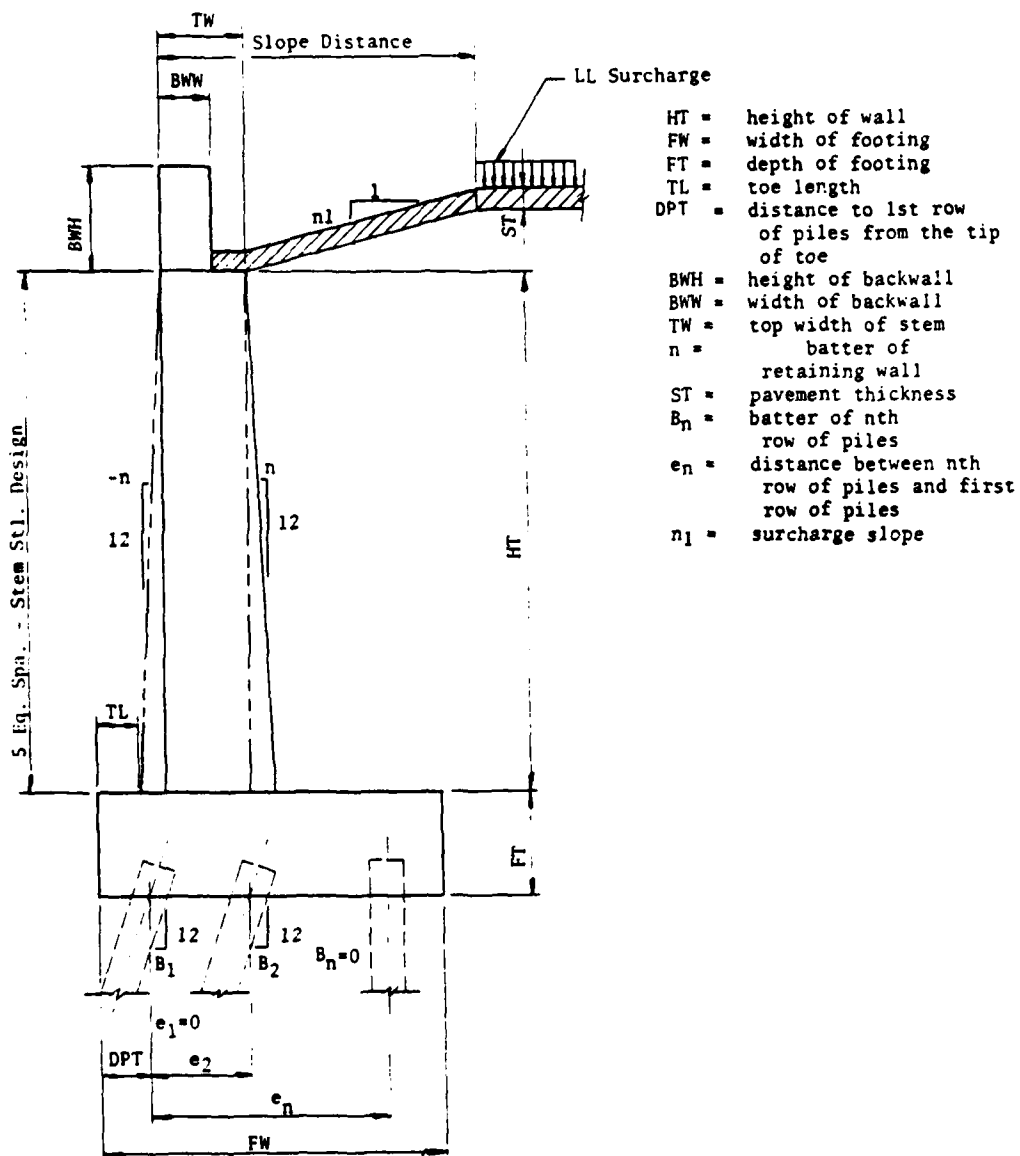


FIGURE 1. RETAINING WALL

(102076)

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D2-89

GEOMETRY OF ABUTMENT

- HT = height of wall
 FW = width of footing
 FT = depth of footing
 DPT = distance to 1st row of
 piles from the tip
 of toe
 ST = pavement thickness
 BH = height of beam seat
 BW = width of beam seat
 BWB = width of backwall
 BWH = height of backwall
 BBH = height of backwall batter
 BBW = width of backwall batter
 n = batter of abutment
 BFL = dist. from the F.F.
 of abutment to C.L.
 of bearing
 TL = toe length
 B_n = batter of nth row of piles
 e_n = distance between first
 row of piles and nth
 row of piles

All the loadings are applied
at Pt. A

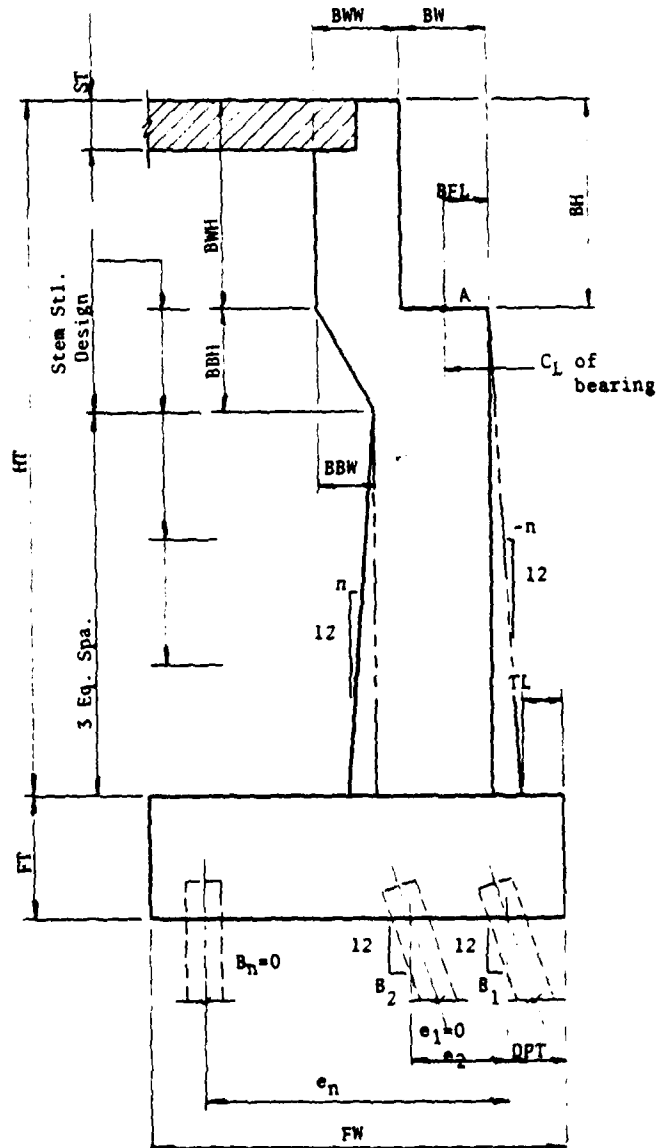


FIGURE 2. ABUTMENT

(102076)

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D2-90

PILE ARRANGEMENT

- PMA = pile capacity
 n = No. of rows of piles
 e_1 = 0.0
 e_n = distance between nth row of piles and 1st row of piles
 P_n = pile spacing of nth row of piles

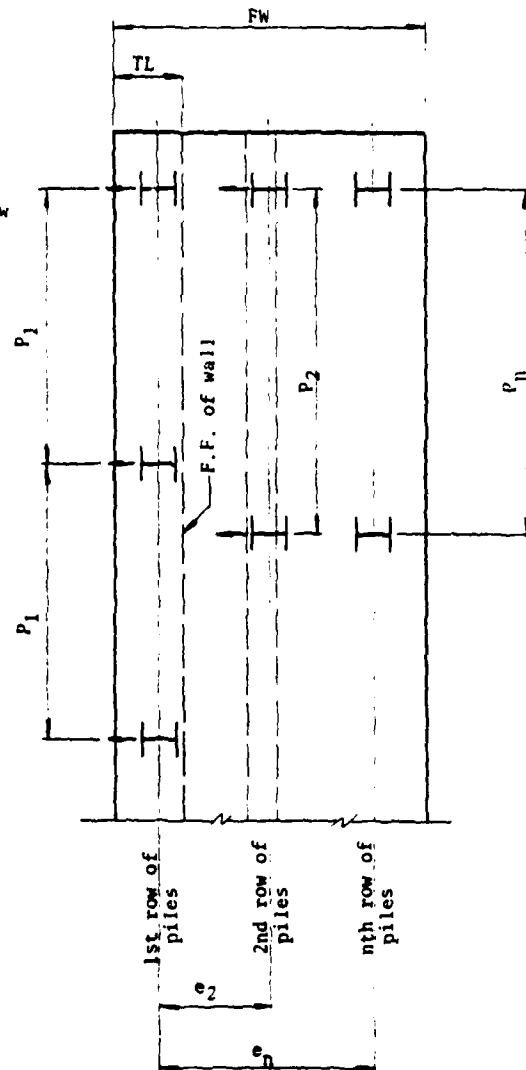


FIGURE 3. PILE ARRANGEMENT

(090575)

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D2-91

ITF PROGRAM FILE

PROGRAM Call Name UCD GFC&C FILE 216AS

DESCRIPTION This program computes Load and Moment points for the interaction curve. ϕ has not been included (ie $\phi = 1.0$). Points are based on increments to neutral axis location. The section must be rectangular and all reinf. bars are included. The first value is P_0 and the last is at $P = 0$. Finally, the balanced design case is output.

INPUT W = Column width - In
 T = Column thickness - In
 FC = Concrete f'_c - Ksi
 FY = Reinf. f_y - Ksi
 N = No. of Reinf. Locations - (32 max.)
 X = N.A. Increment - In
 D_n = Dist. to Reinf. - In
 A_n = A_s at each Dist. - In^2] 4 pair of values per line

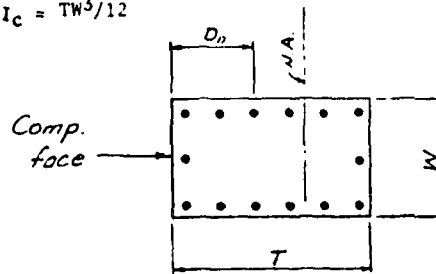
OUTPUT All Input
 I_c - ft^4 & I_s - ft^4
 $E_c I_c / 5 \cdot E_s I_s$ - K- ft^2
 $0.1 f'_c A_g$ - K & A_s / A_g -
 Neutral Axis Location - In
 Axial Force - K } At P_0 , each increment, $P = 0$
 Moment - K-ft } and lastly at Balanced
 Eccentricity - Ft } Design

FEATURES The program conforms to 1974 AASHTO Interim Specifications.
 For ACI code applications, use Program ULT.

Note: To plot $0.1 f'_c A_g$ on this output where $\phi = 1$, divide
 $0.1 f'_c A_g$ by $\phi = 0.7$

$$E_c = 57.00 \sqrt{f'_c} \text{ \& } E_s = 29000 \text{ ksi}$$

$$I_c = TW^3/12$$



(121675)

1/2

125/

D2-92

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D
DESIGN ANALYSIS

AUGUST 1979

SUBAPPENDIX D3
COMPUTATIONS FOR RIPRAP AND GABION DESIGN

SUBAPPENDIX D3

COMPUTATIONS FOR RIPRAP
AND
GABION DESIGN

CONTENTS

<u>Item</u>	<u>Page No.</u>
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Diversion Channel	D3- 5 to D3- 8
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Drop Structures	D3-12
Railroad Spurline Bridge	D3-13
Approach to Diversion Channel Flume	D3-14
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End of Three-Barrel Conduit and Confluence Area	D3-16 to D3-19
Riprap Design	D3-20 to D3-22

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 1 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY CWA DATE 1/23/79 CHECKED BY FEM DATE 2-23-79

METHODOLOGY

y = depth of flow γ = unit wt water = 62.5 pcf

1. DETERMINE AVERAGE VELOCITY (V)

$$= \text{TOTAL DISCHARGE} / \text{TOTAL AREA (W/A)}$$

2. DETERMINE LEFT AND RIGHT CHANNEL
SIDE SLOPES (SL & SR)

3. FROM EM-1110-2-1601 PAGE 36
AND PLATE 29, DETERMINE IF
RIPRAP IS NEEDED

4. DETERMINE RADIUS OF CHANNEL ϕ (R)

5. DETERMINE TOPWIDTH (T) OF WATER SURFACE

* 6. DETERMINE BEND FACTOR (BF)

$$\text{WHERE } BF = 3.1 \left(T/R \right)^{0.5} \quad (\text{EM 1110-2-1601} \\ \text{PLATE 34})$$

7. DETERMINE NON UNIFORM FLOW FACTOR (NU)

$$NU = 1.5 \quad \text{IF } BF < 1.5 \quad (\text{ETL 1110-2-120 Pd4})$$

$$NU = BF \quad \text{IF } BF \geq 1.5$$

8. ASSUME D_{50} (MIN)

8a DETERMINE LOCAL BOUNDARY SHEAR $T_0 =$

$$\gamma \left[\frac{V}{32.6 \log_{10} \frac{30Y}{D_{50 \text{ min}}}} \right]^2 \quad (\text{ETL 1110-2-120 Pd3})$$

* Referring to Plate 34, EM 1110-2-1601, the
curve "Rough Channel (Extrapolated)" is used.
Where the abscissa value is 1.0 the ordinate
value is 3.1 - which is the coefficient for the
curve. D3-3

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 2 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY AMW DATE 1/23/79 CHECKED BY FFM DATE 2-23-79

9. DETERMINE DESIGN SHEAR $T =$
 $d (\gamma_s - \gamma) D_{50 \min}$

$d = 0.04$ $\gamma_s =$ DRY UNIT WT. OF STONE
ASSUMED 155 pcf

10. MULTIPLY T BY K , FOR REVISED
DESIGN SHEAR (T') WHERE $K =$
 $(1 - \frac{\sin^2 \phi}{\sin^2 \delta})^{0.5}$ $\delta = 40^\circ$
 $\phi = \tan^{-1}(\frac{1}{5_1} \text{ OR } \frac{1}{5_2})$
EM 1110-2-1601 PLATE 36

11. DETERMINE RATIO (Z)
 $\frac{T'}{T_0}$

12. IF $Z = NU$ OR
IF NOT, CHANGE $D_{50 \min}$ AND GO TO 8

13. DETERMINE RIPRAP THICKNESS
FROM $D_{50 \min}$

D_{50} USED ABOVE IS $D_{50 \min}$ IN FEET
PER ETL 1110-2-120

$D_{50 \max} = 1.5 D_{50 \min}$
(REF ETL 1110-2-120 INCL. 1)

T (RIPRAP THICKNESS) = 12 IN/FT $\times 1.5 \times D_{50 \max}$
(REF ETL 1110-2-120 INCL. 1)

D3-4

GANNETT FLEMING CORDRY
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HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN

FILE NO. 7622

SHEET NO. 3 OF 17 SHEETS

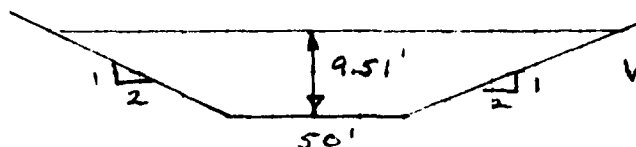
FOR BIG CREEK FLOOD CONTROL PROJECT

COMPUTED BY AWW DATE 1/23/79 CHECKED BY FFM DATE 2-23-79

DIVERSION CHANNEL

USED AS SAMPLE FOR TABLE
ON PAGES 6-8

STATION 8.00, COMPUTER = 67+72.0 - DIVERSION CHANNEL



$V_{AVE} = 10.66 \text{ FPS}$

K_1 (SIDE SLOPE FACTOR) = 0.718

TOPWIDTH = 89.04' R = ∞

BUILD LOSS FACTOR = 1.00

NONUNIFORM FLOW FACTOR = 1.5

USE 1.5

FOR BOTTOM $K_1 = 1.00$

$T_0 = 0.761$ $D_{50} = 0.31'$

$T = 1.147$

$T \times K_1 = 1.147$

$\frac{T \times K_1}{T_0} = \frac{1.147}{0.761} = 1.51$

6.4" RIPRAP

FOR SIDES $K_1 = 0.718$

$T_0 = 0.879$ $D_{50} = 0.50$

$T = 1.85$

$T \times K_1 = 1.330$

$\frac{T \times K_1}{T_0} = \frac{1.33}{0.879} = 1.51$

10.4" RIPRAP

USE 12" RIPRAP

D3-5

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 4 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY JMA DATE 1/23/79 CHECKED BY FFM DATE 2-23-79

LINE	STATION	LOCATION	COMPUTED FUNCTION - STATION	CL	SK	DEPTH Y FT.	VAVG FPS	RADIUS R FT.
1	59+72.0	SIDES	0.00	2	2	12.2	7.7	
2		BOTTOM		-	-	"	"	
3	61+72.0	SIDES	2.00	2	2	11.4	8.44	
4		BOTTOM		-	-	"	"	
5	62+72.0	SIDES	4.00	2	2	10.67	9.20	
6		BOTTOM		-	-	"	"	
7	65+72.0	SIDES	6.00	2	2	10.53	9.96	
8		BOTTOM		-	-	"	"	
9	67+72.0	SIDES	8.00	2	2	9.51	10.66	
10		BOTTOM		-	-	"	"	

$R = 572.42$
STA. 61+05.0
TO
62+22.0

DIVERSION CHANNEL

CONCRETE
STRUCTURE
STARTS
AT
67+72.0

STA 10.00 (component) = 69+72.20 (ALIGNMENT)

D3-6

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 5 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY W.H. DATE 1/23/79 CHECKED BY FFM DATE 2-23-79

DIVERSION CHANNEL

LINE	K ₁	T FT	BF	NU	COMMENTS
1	.718	98.8	1.28	1.5	VELOCITY GREATER THAN 6 FPS. RIPRAP NEEDED
2	1.00	98.8	1.28	1.5	
3	.718	95.6	1.27	1.5	
4	1.00	95.6	1.27	1.5	
5	.718	92.67	1.25	1.5	
6	1.00	92.67	1.25	1.5	
7	.718	90.12	1.00	1.5	
8	1.00	90.12	1.00	1.5	
9	.718	88.04	1.00	1.5	
10	1.00	88.04	1.00	1.5	

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 6 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY CMM DATE 1/23/79 CHECKED BY FFM DATE 2-23-79

DIVERSION CHANNEL

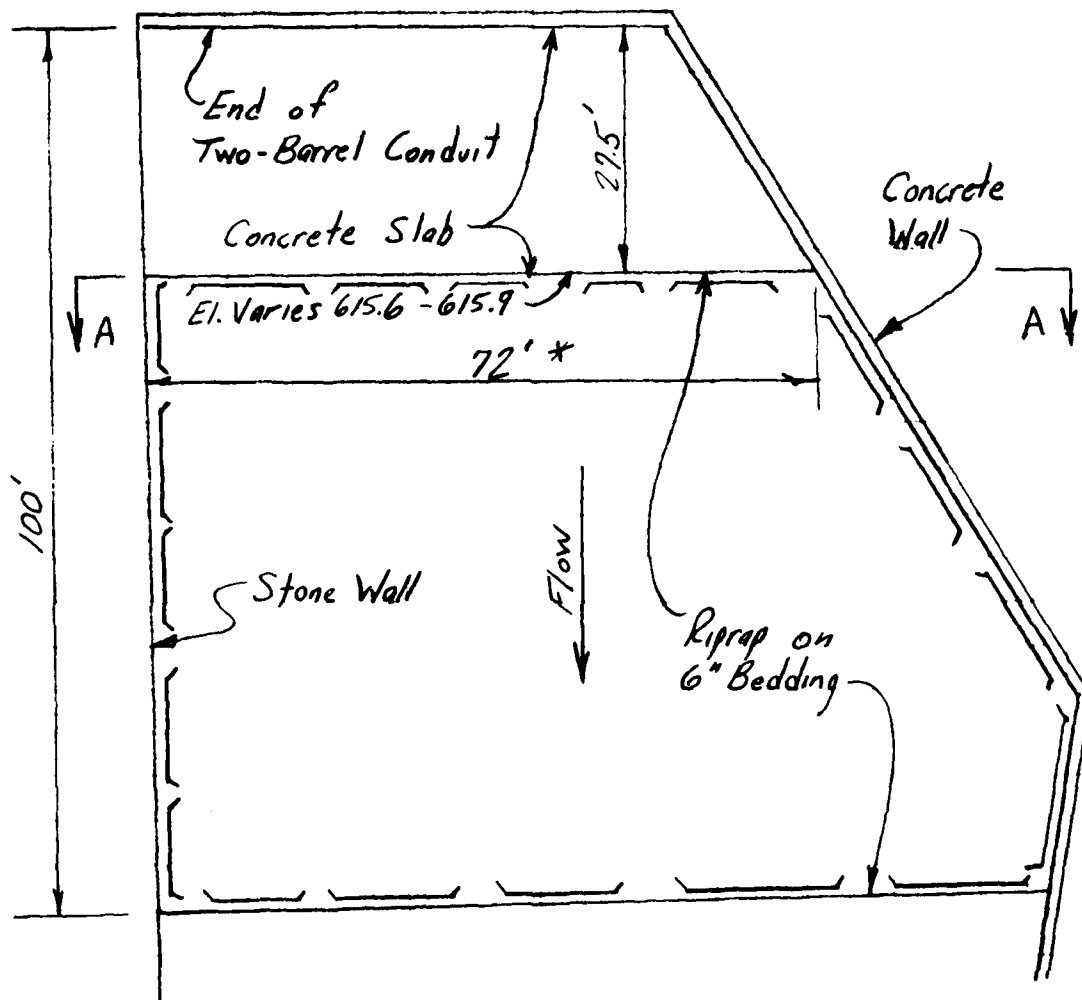
LINE	D ₅₀	T ₀	T	T'	Z	DESIGN RIPRAP THICKNESS	SELECTED RIPRAP THICKNESS
1	.19	.324	.703	.505	1.56	3.9"	12"
2	.12	.288	.444	.444	1.54	2.5"	12"
3	.24	.421	.888	.638	1.51	5.0"	12"
4	.16	.378	.592	.592	1.57	3.3"	12"
5	.31	.548	1.147	.824	1.50	6.4"	12"
6	.20	.485	.974	.974	1.53	4.1"	12"
7	.40	.705	1.48	1.063	1.51	8.3"	12"
8	.25	.615	.925	.925	1.50	5.2"	12"
9	.50	.879	1.85	1.33	1.51	10.4"	12"
10	.31	.761	1.147	1.147	1.51	6.4"	12"

D3-8

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 7 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY QW DATE 1/23/79 CHECKED BY FFM DATE 2-23-79

END OF TWO-BARREL CONDUIT



PLAN

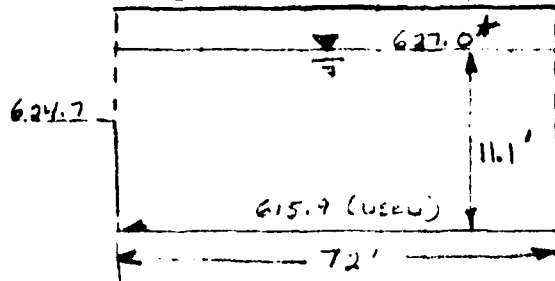
CHANNEL AT END OF TWO-BARREL CONDUIT

* Dimension from survey notes.

D3-9

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 8 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY QUANT DATE 1/23/79 CHECKED BY FFM DATE 2-23-79
END OF TWO-BARREL CONDUIT



$Q = 6900 \text{ CFS}$

Section at End of
Existing Slab, Section A-A,
Sheet 7 of 17.

*FROM PLATE 15, PHASE I GDM

$$A = 72 \times 11.1 = 799.2$$

$$V = Q/A = 7.51 \text{ FPS}$$

$$D_{50} = .12$$

$$\tau_0 = .280$$

$$\tau = \tau' = .444$$

$$\frac{\tau_0}{\tau'} = z = 1.59$$

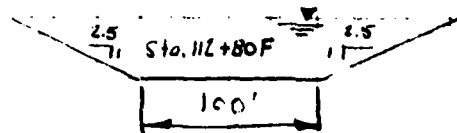
Riprap size = 2.5"
USE 12"

D3-10

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 9 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY aw DATE 1/23/79 CHECKED BY FFH DATE 2-23-79

DOWNSTREAM END OF CHUTE - TRANSITION



NOTE: Riprap needed
per PHASE I GDM

	SIDES	BOTTOM
SL	2.5	—
SR	2.5	—
Y	8.11	8.11
VAVC	6.16	6.16
R	∞	∞
K _i	.816	1.00
T	140.55	140.55
BF	1.00	1.10
NU	1.5	1.5
D ₅₀	.10'	.08'
T ₀	.195	.184
T	.37	.296
T'	.30	.296
Z	1.55	1.61
DESIGN THICKNESS	2.1"	1.7"
SELECTED THICKNESS	12"	12"

D3-11

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN

FILE NO. 7622

SHEET NO. 10 OF 17 SHEETS

FOR BIG CREEK FLOOD CONTROL PROJECT

COMPUTED BY AM DATE 1/23/79 CHECKED BY FFM DATE 2-13-79

STATION	91+80F		95+00F		100+00F		125+00F		110+00F	
	SIDE	BOT	SIDE	BOT	SIDE	BOT	SIDE	BOT	SIDE	BOT
SL	2.5	-	2.5	-	2.5	-	2.5	-	2.5	-
SR	2.5	-	2.5	-	2.5	-	2.5	-	2.5	-
Y	8.42		6.44		6.46		5.91		5.67	
V _{AVG}	9.37		13.09		13.05		12.74		12.58	
R	-		-		818.5		-		716.2	
K ₁	.816	-	.816	-	.816	-	.816	-	.816	-
T	N/A		N/A		87.3		N/A		98.34	
BF	1.0		1.0		1.01		1.0		1.15	
NU	1.5		1.5		1.5		1.5		1.5	
D ₅₀	.30	.23	.94	.68	.93	.68	.91	.66	.89	.65
T ₀	.603	.558	1.884	1.674	1.863	1.662	1.821	1.617	1.788	1.592
T	1.11	.851	3.478	2.516	3.441	2.516	3.367	2.442	3.293	2.405
T'	.906	.851	2.838	2.516	2.808	2.516	2.747	2.442	2.687	2.405
E	1.50	1.52	1.51	1.50	1.51	1.51	1.51	1.51	1.50	1.51
DESIGN THICK	6.2"	4.8"	19.5"	14.1"	19.3"	14.1"	18.8"	13.7"	18.4"	13.5"
SCOUR THICK	12" GABION = 24" RIPRAP									

No. 5

No. 4

No. 3

No. 2

No. 1

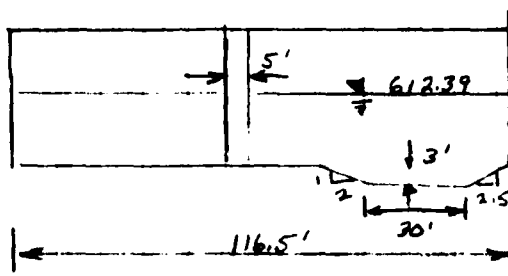
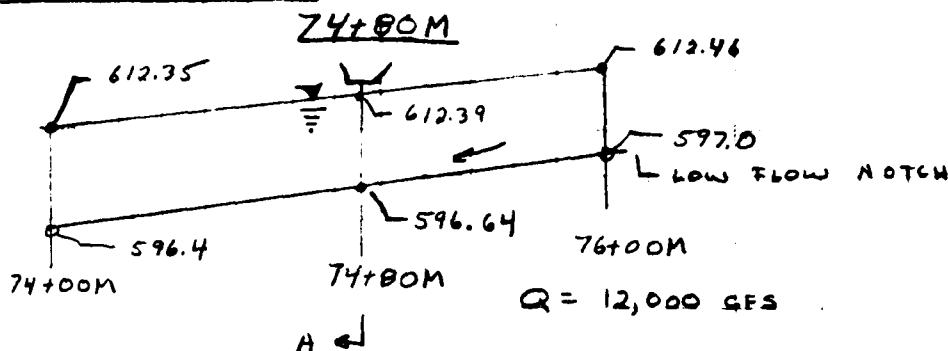
DROP STRUCTURES

D3-12

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 11 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY AAW DATE 1/25/79 CHECKED BY EFM DATE 2-23-79

RAILROAD SPURLINE BRIDGE



$$A = (116.5 - 5) \times (612.39 - 596.64 - 3) + 3(30 + 2.25 \times 3) = 1531.88$$

$$V = \frac{12,000}{1531.88} = 7.83 \quad y = 612.39 - 596.64 = 15.75$$

$$\begin{aligned} D_{50} &= 0.12' \\ \tau_0 &= .278 \\ \tau = \tau' &= 0.444 \\ \tau_0 / \tau' &= 1.60 \\ (\text{FLAT BOTTOM}) \\ D_{50} &= 0.15 \\ \tau_0 &= .295 \\ \tau &= 0.535 \\ \tau' &= 0.453 \\ \tau_0 / \tau' &= 1.54 \end{aligned}$$

2.5" RIPRAP USE 12"
(FLAT BOTTOM)

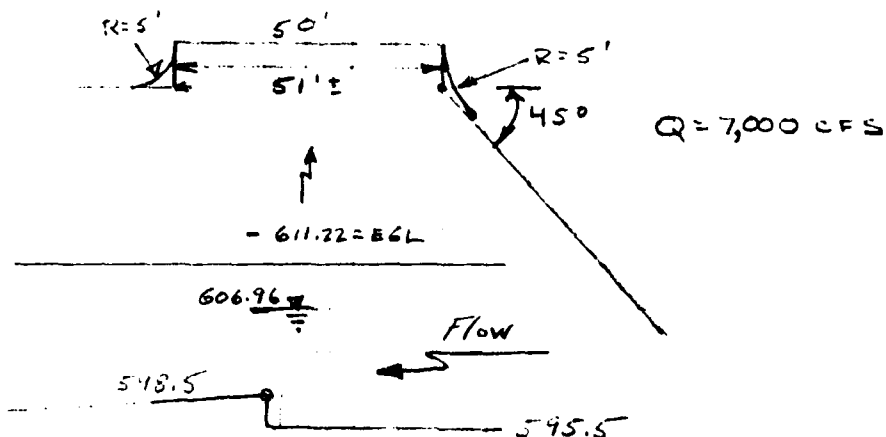
3.1" RIPRAP USE 12"
(1V ON 2.5H SLOPES)

D3-13

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

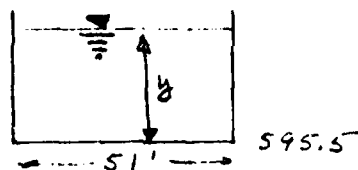
SUBJECT RIPPAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 17 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY QWANT DATE 1/25/79 CHECKED BY LEH DATE 2/25/79

APPROACH TO DIVERSION CHANNEL FLUME



USING E.G.L. AND ASSUMING NO LOSSES

— 611.22



$$y + \frac{Q^2}{2g \cdot 51^2 y^2} = 611.22 - 595.5 = 15.72$$

$$y + \frac{7000^2}{64.36 \times 51^2 \times y^2} = 15.72$$

$$y = 14.29'$$

$$A = 728.79$$

$$V = Q/A = 9.60 \text{ fps}$$

FOR IV ON 2.5H SIDE SLOPES

$$D_{50} = 0.27'$$

$$\tau_0 = 0.529$$

$$\tau = 0.999$$

$$\tau' = 0.815$$

$$\tau_0/\tau' = 1.54$$

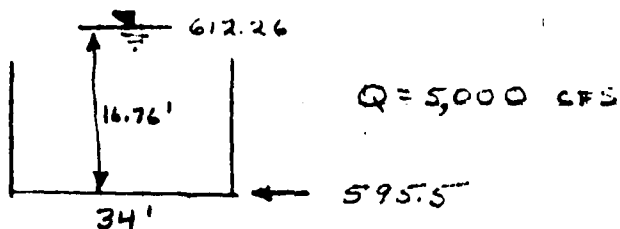
5.6" OF RIPPAP
USE 12" RIPPAP

D3-14

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 13 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY A.H.J. DATE 4/25/79 CHECKED BY FEM DATE 2-23-79

NEW B & O RAILROAD BRIDGE



$$A = 569.84 \text{ ft}^2$$

$$V = 8.77'$$

FOR IV ON 2.5H SLOPE

$$D_{50} = .20'$$

$$T_0 = .391$$

$$T = 0.74$$

$$T' = .60$$

$$T_0/T' = 1.54$$

4.6" RIPRAP

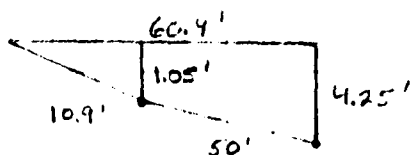
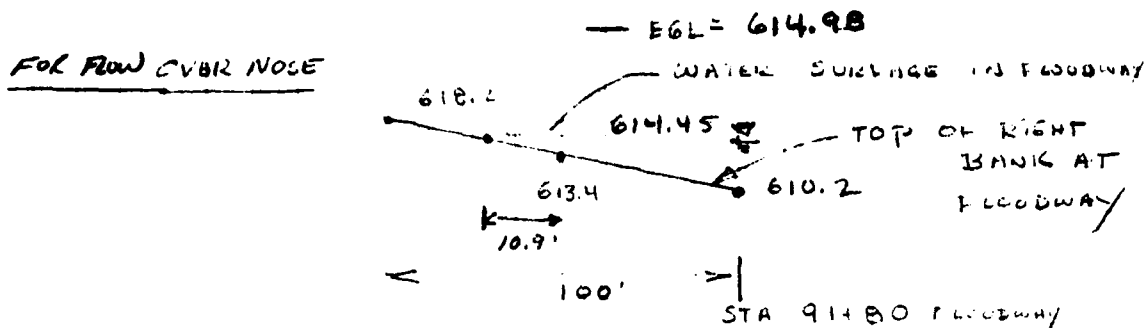
USE 12" RIPRAP

D3-15

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 14 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY QWANT DATE 1/26/79 CHECKED BY FFM DATE 2-23-79

END OF THREE-BARREL CONDUIT AND CONFLUENCE AREA



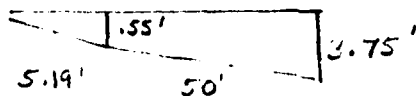
$$A = 1.05 \times 10.9 / 2 + \frac{(1.05 + 4.25)}{2} \times 50 = 138.22$$

$$T = 60.9'$$

$$Q = \sqrt{\frac{A^3 g}{T}} = 1181.3$$

$$V_{AVG} = 8.5 \text{ FPS} \quad h_v = 1.13'$$

THIS IS EXCESSIVE $EGL > AVG$ THE ENERGY
drop 0.5'



$$A = 108.92$$

$$T = 55.19$$

$$Q = 868 \sim 870 \text{ CFS}$$

$$V = 7.97 \text{ FPS} \quad h_v = 0.99'$$

$$EGL = 614.93 \quad \underline{\underline{O.K.}}$$

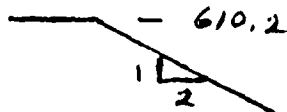
GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 15 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY Q.A.J. DATE 1/26/79 CHECKED BY FFM DATE 2-23-79

END OF THREE-BARREL CONDUIT AND CONFLUENCE AREA

$$EGL = 614.93$$

FOR FLOW OVER NOSE



$$H = 4.73$$

$$H_V = \frac{1}{3} H \quad (\text{A* CRITICAL depth})$$
$$= 1.57'$$

$$V = \sqrt{1.57 \times 64.36} = 10.07'$$

$$d = \frac{4}{3} H_V = 3.14'$$

FOR 1V ON 2H SLOPE

$$D_{50} = 0.70'$$

$$T_0 = 1.376$$

$$T = 2.886$$

$$T' = 2.072$$

$$T_0/T_1 = 1.51$$

16.1" RIPRAP

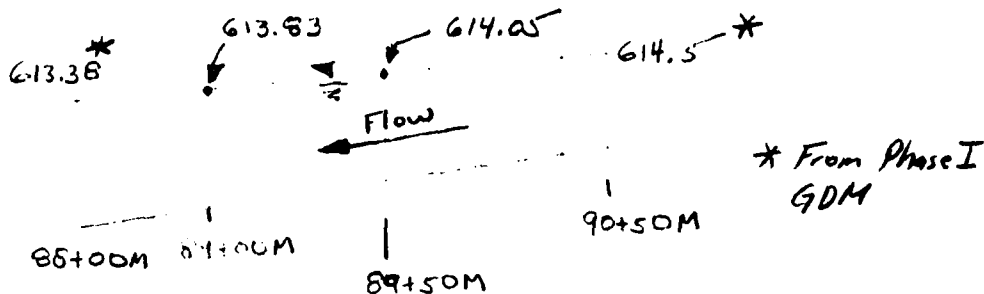
18" Riprap Required

However, 12" Gabions Selected

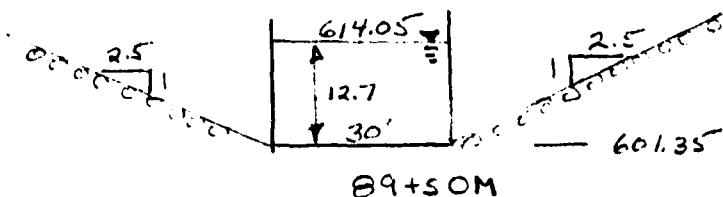
GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 16 OF 17 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY A.H.W. DATE 1/26/79 CHECKED BY FFM DATE 2-23-79

END OF THREE-BARREL CONDUIT AND CONFLUENCE AREA



$$Q = 6,000 \text{ cfs}$$



$$A = 12.7 \times 30 = 381 \text{ sq ft}$$

$$V = \frac{6000}{381} = 15.74 \text{ fps}$$

1V on 2.5H slope (.816)

$$D_{50} = 1.14'$$

$$T_0 = 2.287$$

$$T = 4.218$$

$$T' = 3.442$$

$$T_0/T' = 1.50$$

$$K_{\text{ripRap}} = 23.6''$$

24" Riprap Required

Use Equivalent 12" Gabions

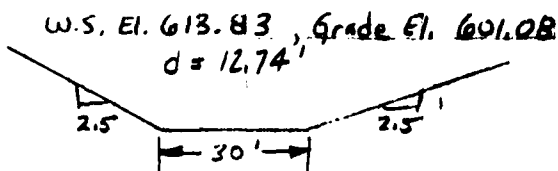
D3-18

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. 7622
SHEET NO. 17 OF 19 SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY AHW DATE 1/26/79 CHECKED BY EFM DATE 2-23-79

END OF THREE-BARREL CONDUIT AND CONFLUENCE AREA

STA. 89+00M



$$A = 12.74 (30 + 2.5 \times 12.74) = 787.97$$

$$T = 2.5 \times 2 \times 12.74 + 30 = 93.72$$

$$V = Q/A = 7.61$$

$$R = 301.55'$$

$$3.1 \left(\frac{T}{R} \right)^{0.5} = 1.728 > 1.5 \text{ USE } 1.728$$

$$D_{50} = .19$$

$$T_0 = .312$$

$$T = .703$$

$$T' = .574$$

$$T_0/T' = 1.838$$

$$\text{Riprap} = 3.9''$$

$$\text{USE} = 12''$$

MODIFIED TO 24" RIPRAP (12" GABIONS)
BECAUSE OF VERY UNCERTAIN FLOW
CONDITIONS

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. _____
SHEET NO. 17a OF _____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY CHW DATE 7/30/79 CHECKED BY DFW DATE 7/30/79

IN APPENDIX A, "SOILS AND GEOLOGY REPORT", A RIPRAP AND BEDDING MATERIAL GRADATION IS GIVEN. AFTER APPENDIX A WAS PREPARED, IT WAS DETERMINED THAT MOST OF THE STONE AVAILABLE HAD A UNIT WEIGHT OF 10 PCF LESS, OR 155 PCF. REVISED GRADATIONS FOR RIPRAP AND BEDDING ARE GIVEN BELOW:

STONE FOR 12-INCH RIPRAP THICKNESS

<u>Percent Lighter by Weight</u>	<u>Stone Weight in Pounds*</u>
100	81(12.0")
62-100	32(8.8")
50- 72	24(8.0")
30- 50	16(7.0")
15- 38	12(6.3")
0- 15	5(4.7")

STONE FOR 18-INCH RIPRAP THICKNESS

<u>Percent Lighter by Weight</u>	<u>Stone Weight in Pounds*</u>
100	274(18.0")
62-100	110(13.3")
50- 72	81(12.0")
30- 50	55(10.5")
15- 38	41(9.6")
0- 15	17(7.1")

*Numbers in parentheses are approximate stone diameters in inches corresponding to the weights given, assuming a spherical shape and a unit weight of 155 pounds per cubic foot.

03-20

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. _____
SHEET NO. 176 OF _____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY CHW DATE 7/30/79 CHECKED BY gsw DATE 7/30/79

BEDDING MATERIAL

<u>Sieve Size</u> <u>(U.S. Standard)</u>	<u>Percent Passing</u> <u>by Dry Weight</u>
3"	100
2"	85-100
1 1/2"	78--90
3/4"	68--78
1/2"	60--73
No. 4	43--60
No. 10	26--43
No. 20	12--26
No. 40	0--12
No. 200	0--03

CRITERIA FROM EM 1110-2-1901, "SOIL
MECHANICS DESIGN, SEEPAGE CONTROL"
STATE THAT

$$\frac{D_{15} \text{ RIPRAP}}{D_{15} \text{ BEDDING}} > 5 \text{ (PERMEABILITY)}$$

$$\frac{D_{15} \text{ RIPRAP}}{D_{85} \text{ bedding}} < 5 \text{ (PIPING PREVENTION)}$$

THE FOLLOWING, FROM THE GRADATIONS,
APPLY

	<u>MIN</u>	<u>MAX</u>
D ₁₅ 18" RIPRAP	7.1"	9.6"
D ₁₅ 12" RIPRAP	4.7"	6.3"
D ₁₅ bedding	.02"	.04"
D ₈₅ bedding	1.18"	1.97"

D3-21

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT RIPRAP AND GABION DESIGN FILE NO. _____
SHEET NO. 17c OF _____ SHEETS
FOR BIG CREEK FLOOD CONTROL PROJECT
COMPUTED BY AHW DATE 7/30/79 CHECKED BY gsw DATE 7/30/79

THE CRITICAL RELATIONSHIP FOR
PERMEABILITY USES DIS RIPRAP MIN
AND DIS bedding MAX, WHILE FOR
PIPING PREVENTION DIS RIPRAP MAX
AND DIS bedding MIN ARE USED

	<u>12" RIPRAP</u>	<u>18" RIPRAP</u>	<u>CRITERIA</u>
<u>DIS RIPRAP MIN</u> <u>DIS bedding MAX</u>	$\frac{4.7"}{.04"} = 117.5$	$\frac{7.1"}{.04"} = 177.5$	> 5
<u>DIS RIPRAP MAX</u> <u>DIS bedding MIN</u>	$\frac{6.3"}{1.18"} = 5.3 *$	$\frac{9.6"}{1.18"} = 8.1 **$	< 5

* NOT deemed A SIGNIFICANT
deviation

** NOT WITHIN CRITERIA; HOWEVER, TO
develop piping THROUGH RIPRAP, IT
IS NECESSARY TO HAVE A HEAD
DIFFERENTIAL, SUCH THAT FLOW OCCURS
FROM THE GROUNDWATER THROUGH
THE bedding AND RIPRAP. The only
18" RIPRAP AT THE SITE IS AT THE
DOWNSTREAM END OF THE DIVERSION CHANNEL,
WHERE SUCH HEAD DIFFERENTIALS WILL NOT
EXIST. THEREFORE, FOR ECONOMY, ONLY ONE
bedding MATERIAL IS SELECTED FOR
USE ON THE PROJECT.

D3-22

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D
DESIGN ANALYSIS

AUGUST 1979

SUBAPPENDIX D4
COMPUTER SOLUTION AND MANUAL CHECK
FOR
SLOPE STABILITY ANALYSES

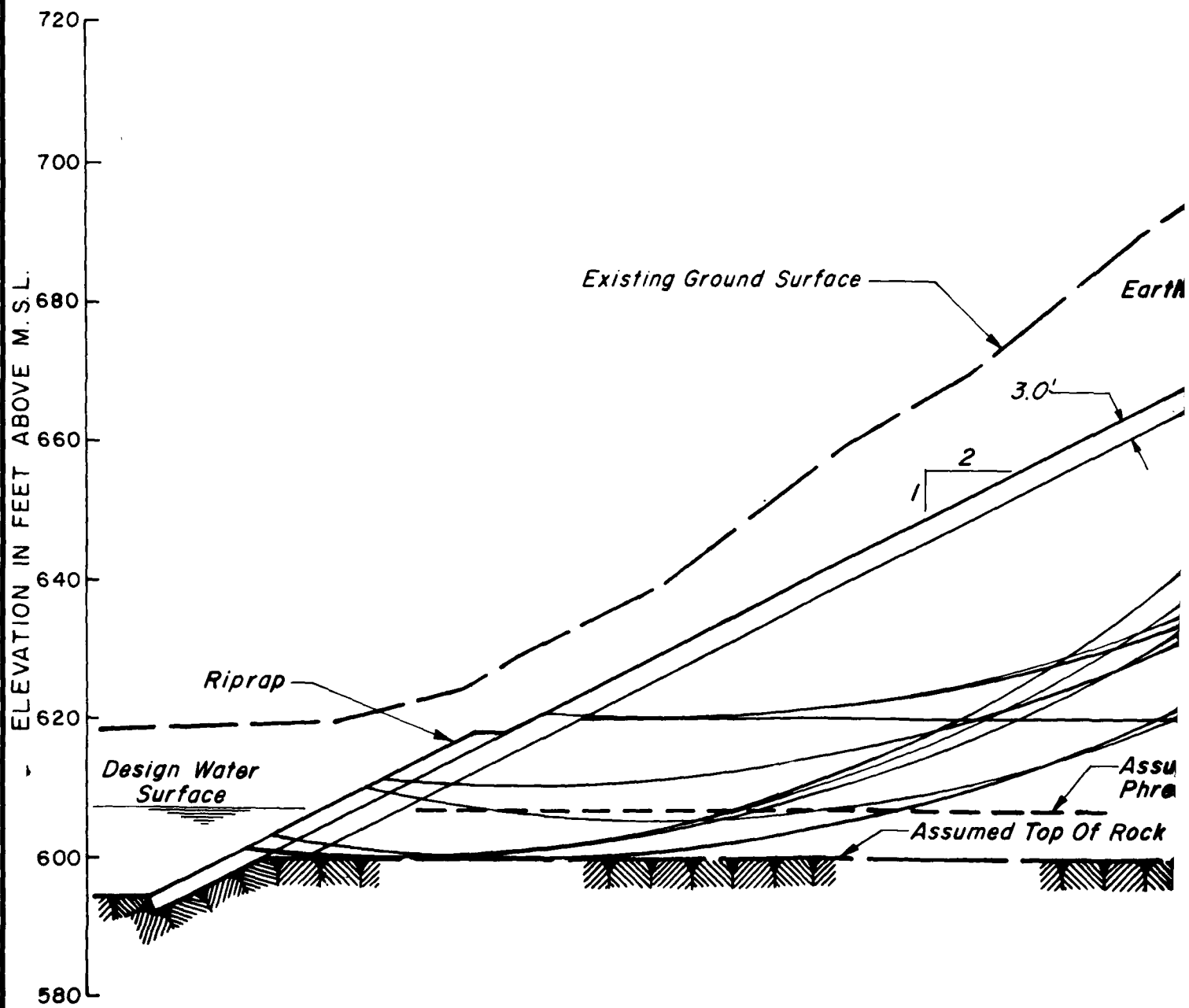
SUBAPPENDIX D4

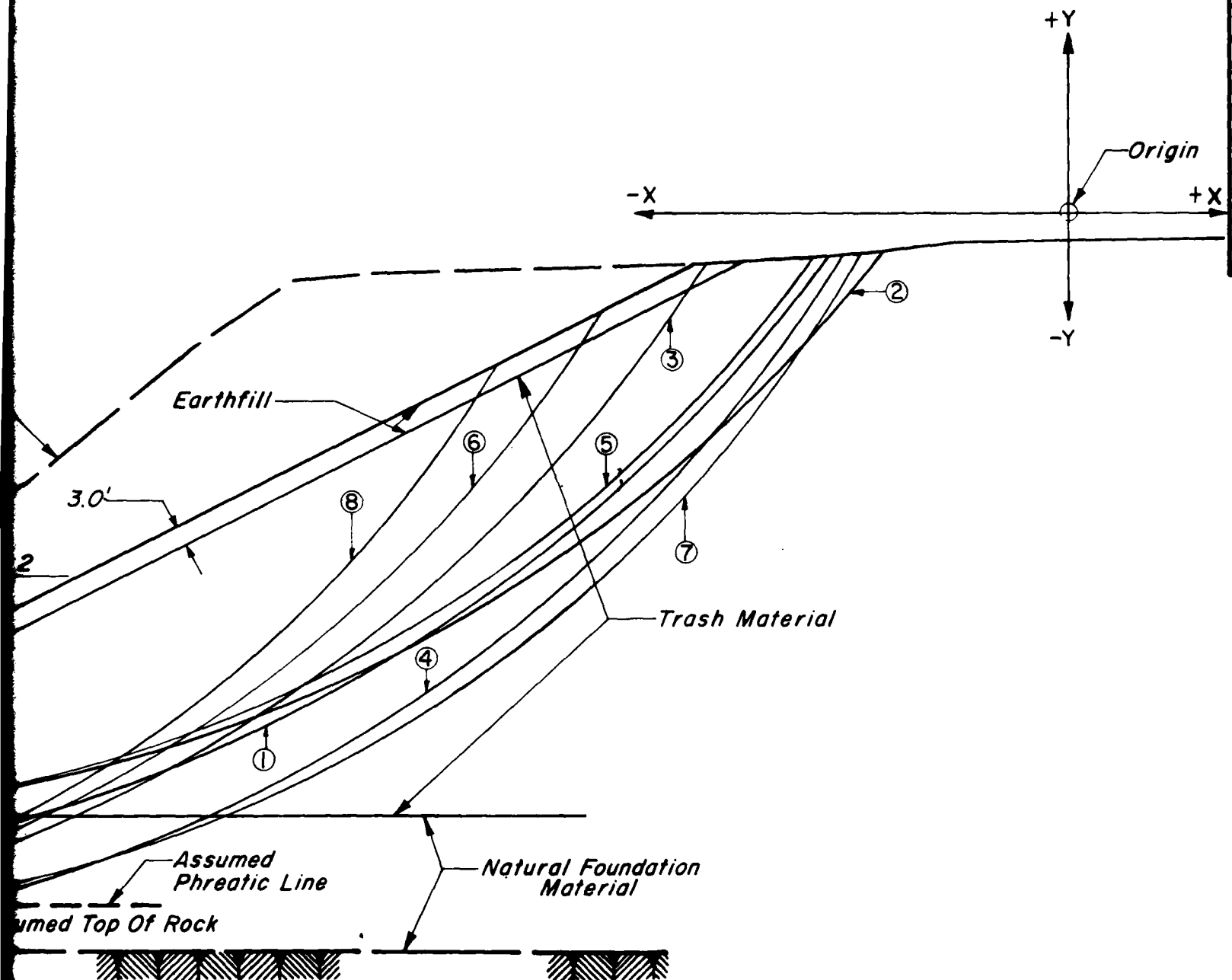
COMPUTER SOLUTION AND MANUAL CHECK
FOR
SLOPE STABILITY ANALYSES

CONTENTS

PLATES

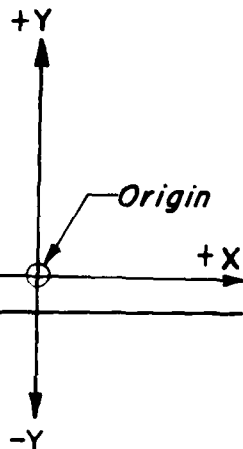
<u>Plate No.</u>	<u>Title</u>
D4-1	Summary of Slope Stability Analysis- Right Bank - Diversion Channel-Sta. 64+00D.
D4-2	Summary of Slope Stability Analysis- Left Bank - Diversion Channel-Sta. 64+00D.
D4-3	Summary of Slope Stability Analysis- Left Bank - Modified Channel-Sta. 80+00M.
D4-4	Summary of Slope Stability Analysis- Left Bank - Floodway Channel-Sta. 89+50F.
D4-5	Summary of Slope Stability Analysis- Left Bank - Floodway Channel-Sta. 102+00F.
D4-6	Summary of Slope Stability Analysis- Left Bank - Floodway Channel-Sta. 108+25F.
D4-7	Summary of Slope Stability Analysis- Levee-Floodway Channel-Sta. 111+00F.
D4-8	Manual Check Computations-Left Bank- Floodway Channel-Sta. 89+50F. Sudden Drawdown Condition.
D4-9	Manual Check Computations-Left Bank- Floodway Channel-Sta. 89+50F- End of Construction Case.





STA. 64+00 D

SCALE: 1 IN. = 20 FT.



RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	230.0	-220.0	130.0	1.38	1.34
2	220.0	-200.0	130.0	1.53	1.37
3	220.0	-240.0	110.0	1.28 *	1.28
4	220.0	-220.0	110.0	1.34	1.17 *
5	200.0	-200.0	110.0	1.49	1.33
6	200.0	-240.0	90.0	1.29	1.32
7	195.0	-200.0	90.0	1.39	1.20
8	180.0	-240.0	70.0	1.29	1.39

* Critical Arc

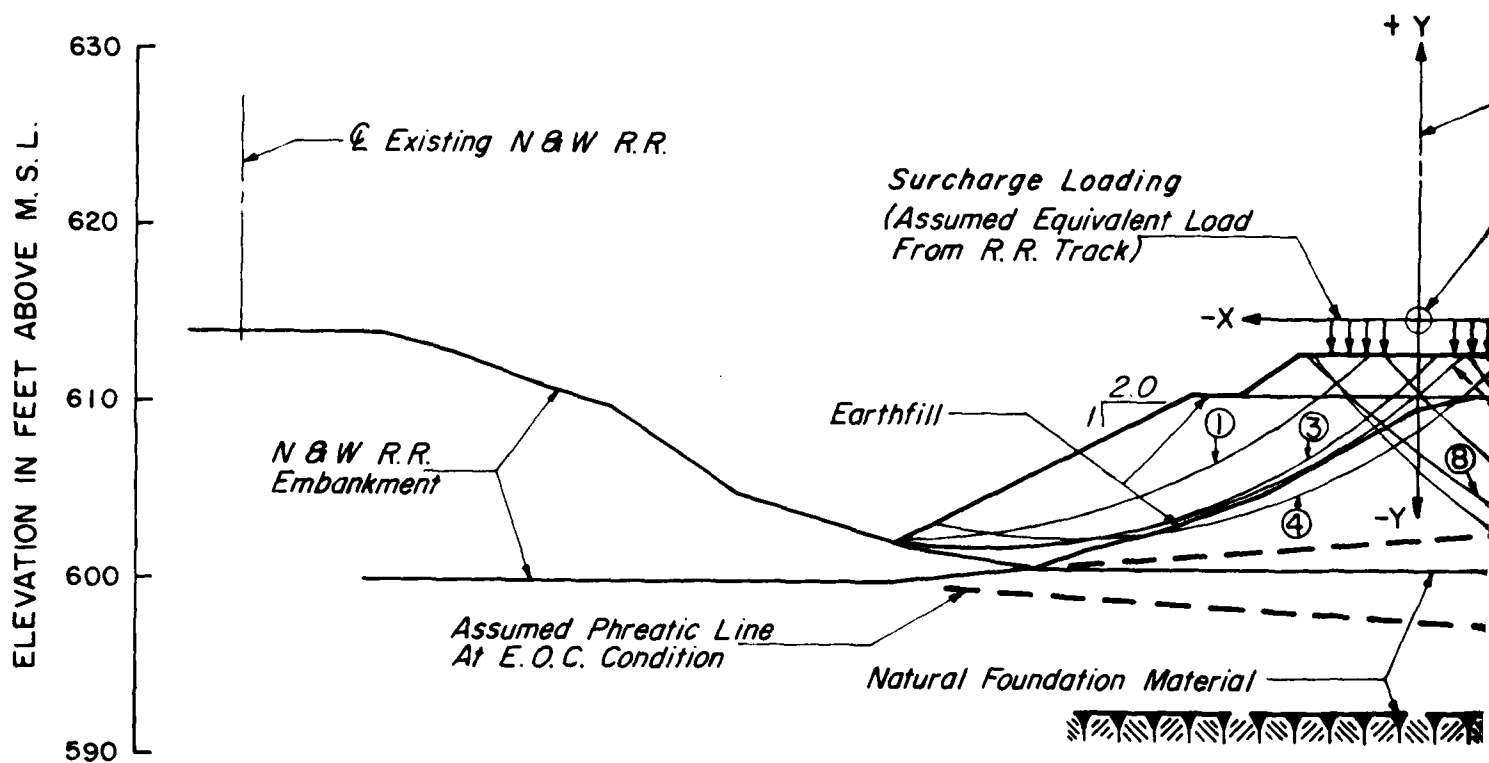
BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

SUMMARY OF
SLOPE STABILITY ANALYSIS
RIGHT BANK-DIVERSION CHANNEL
STA. 64+00 D

U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

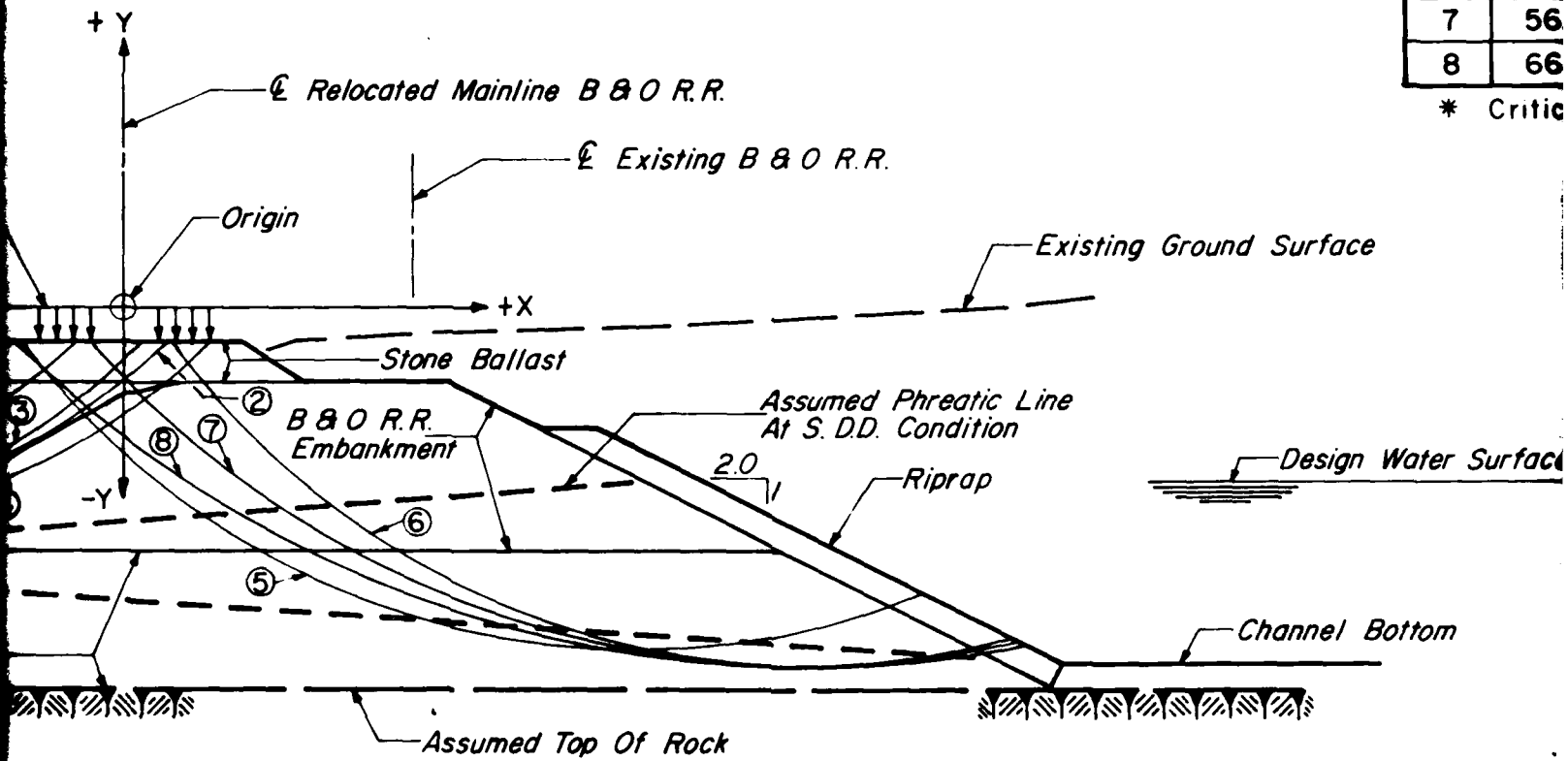
GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979
PLATE NO. D4-1



ARC NO.	RAD
1	40
2	40
3	36
4	35
5	45
6	46
7	56
8	66

* Critic



STA. 64+00D

SCALE: 1 IN. = 10 FT.

12

RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	40.0	-30.0	27.5	2.11	8.58
2	40.0	-25.0	27.5	1.76 *	5.86
3	36.0	-25.0	22.5	1.84	4.81
4	35.0	-20.0	22.5	2.25	4.44
5	45.0	30.0	25.0	2.36	4.88
6	46.0	40.0	25.0	2.71	3.94
7	56.0	40.0	35.0	2.31	3.85
8	66.0	40.0	45.0	2.42	3.69 *

* Critical Arc

Surface

Design Water Surface

Channel Bottom

E. O. C. = End Of Construction

S. D. D. = Sudden Drawdown

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

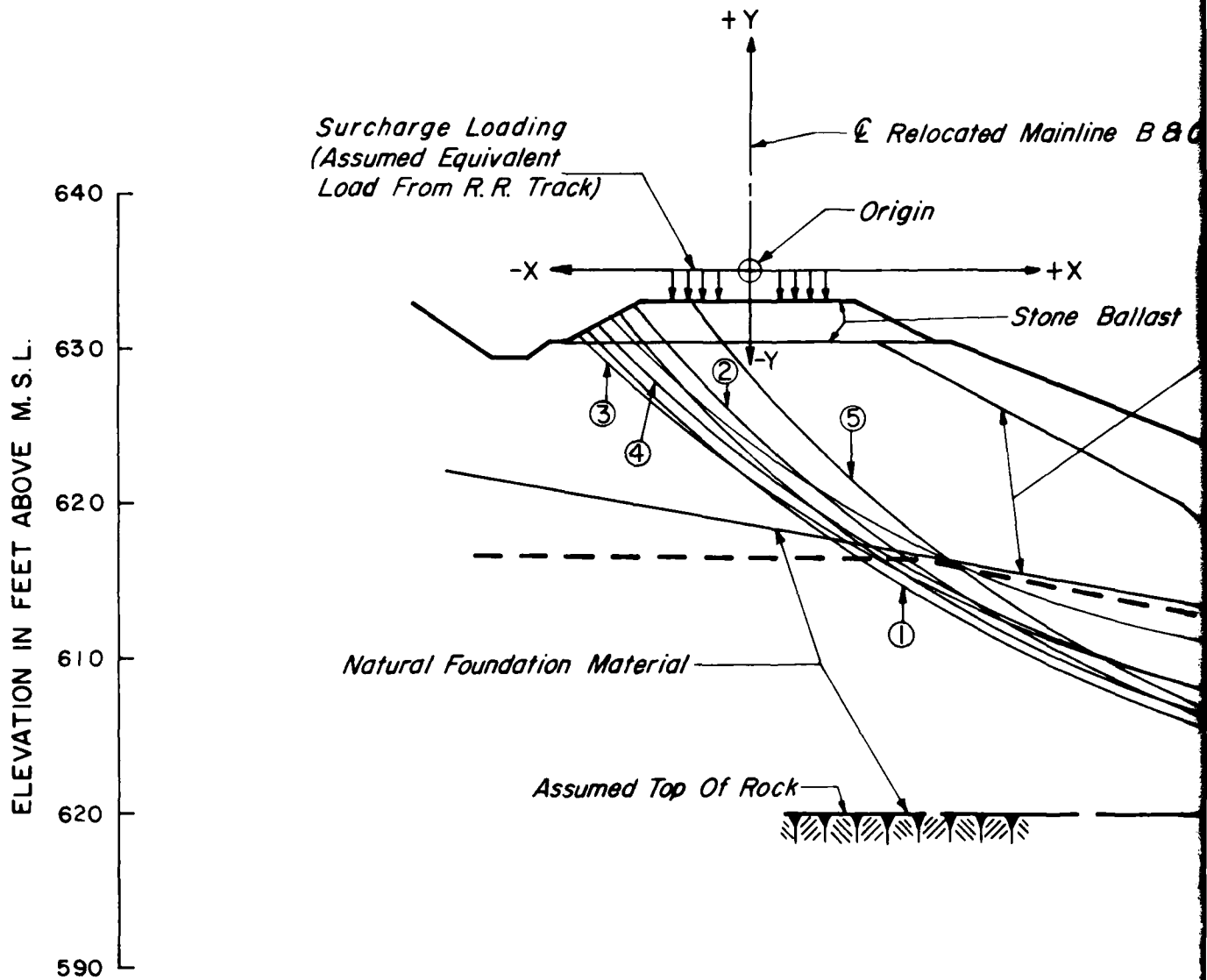
SUMMARY OF
SLOPE STABILITY ANALYSIS
LEFT BANK-DIVERSION CHANNEL
STA. 64+00D

U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

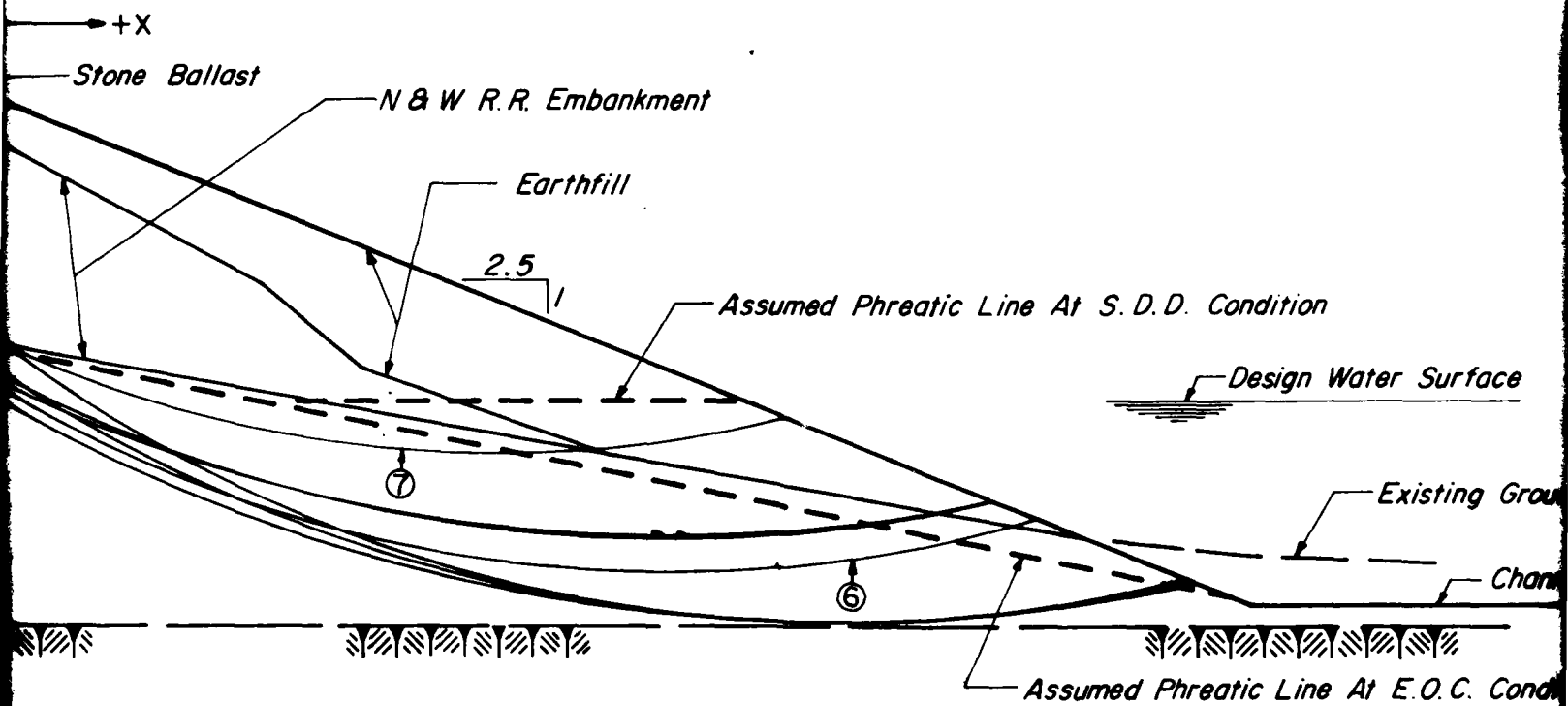
MARCH 1979

PLATE NO. D4-2



STA. 8
SCALE 1

ated Mainline B & O R.R.



STA. 80 + 00 M
SCALE 1 IN. = 10 FT.

RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	100.0	62.0	65.0	1.70	2.57
2	90.0	62.0	55.0	1.64 *	2.32 *
3	90.0	52.0	60.0	1.99	2.98
4	85.0	52.0	55.0	1.89	2.85
5	82.0	62.0	47.0	1.69	2.49
6	77.0	52.0	45.0	1.74	2.59
7	70.0	42.0	45.0	1.93	3.21

* Critical Arc

ition

ign Water Surface

Existing Ground Surface

Channel Bottom



Line At E.O.C. Condition

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

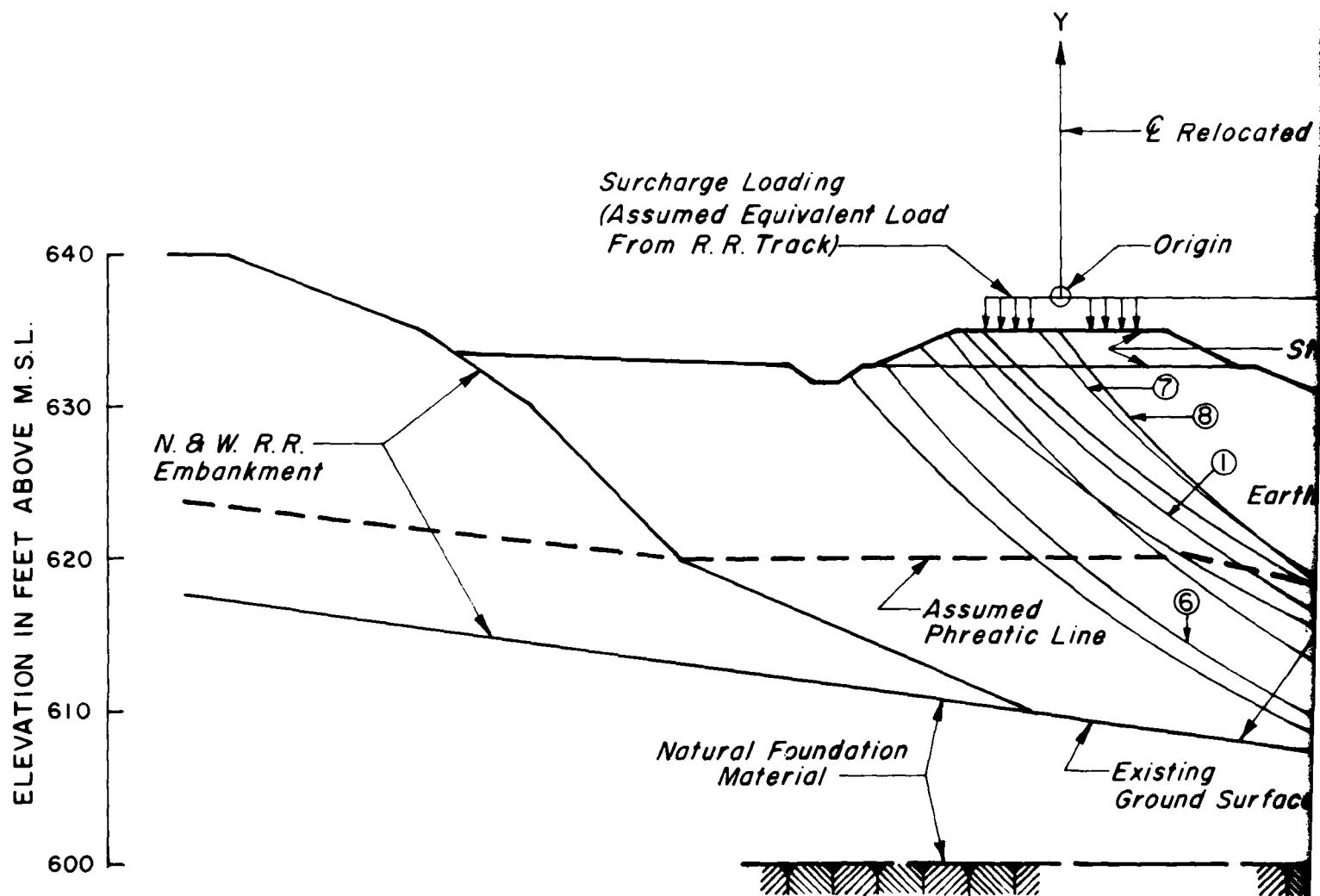
SUMMARY OF
SLOPE STABILITY ANALYSIS
LEFT BANK-MODIFIED CHANNEL
STA. 80+00M

U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979

PLATE NO. D4-3



ARC
NO.

1
2
3
4
5
6
7
8

*
NOTE

Relocated Mainline B & O R.R.

Origin

X

Stone Ballast

7
8

1
Earthfill

2.5
1

Assumed Phreatic Line For S.D.D. Condition

Assumed Phreatic Line For E.O.C.

Design Water Surface

Existing
Ground Surface

6

4

2

5

3

Assume

STA. 89 +50 F

SCALE: 1 IN. = 10 FT.

2

RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	105.0	70.0	70.0	1.61	2.85
2	90.0	60.0	60.0	1.50 *	3.49
3	90.0	55.0	53.0	1.66	2.52 *
4	90.0	55.0	60.0	1.61	3.18
5	85.0	60.0	49.0	1.60	2.67
6	85.0	55.0	48.0	1.57	2.58
7	80.0	60.0	49.0	1.58	3.46
8	75.0	60.0	43.0	1.57	3.27

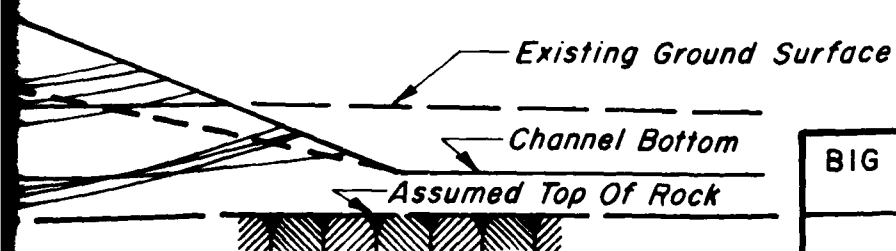
* Critical Arc

NOTE: Arc No. 2 was run by manual check, see Plate D4-8 and D4-9.

Phreatic Line For S.D.D. Condition

Assumed Phreatic Line For E.O.C. Condition

Design Water Surface



BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

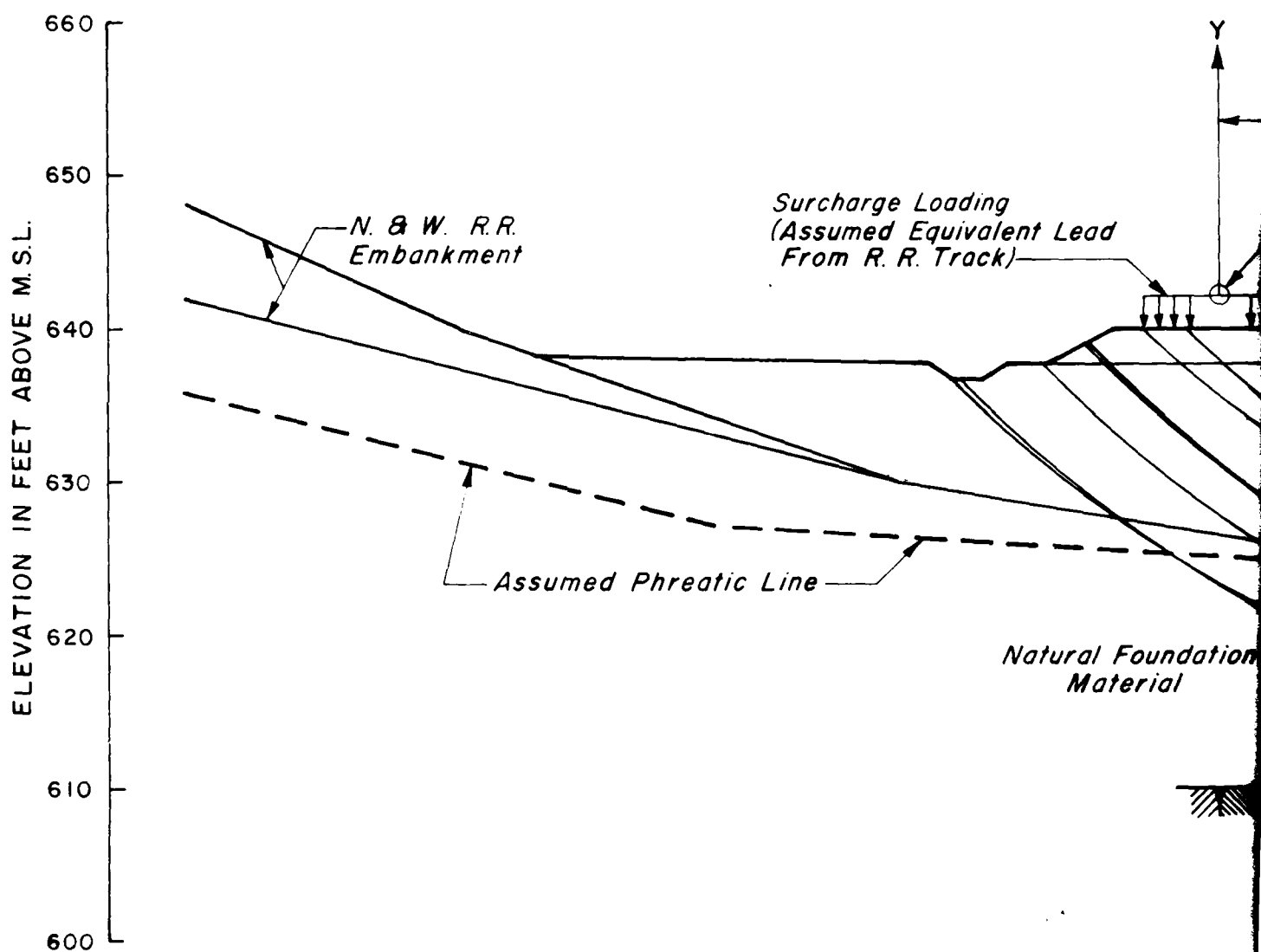
SUMMARY OF
SLOPE STABILITY ANALYSIS
LEFT BANK-FLOODWAY CHANNEL
STA. 89+50 F

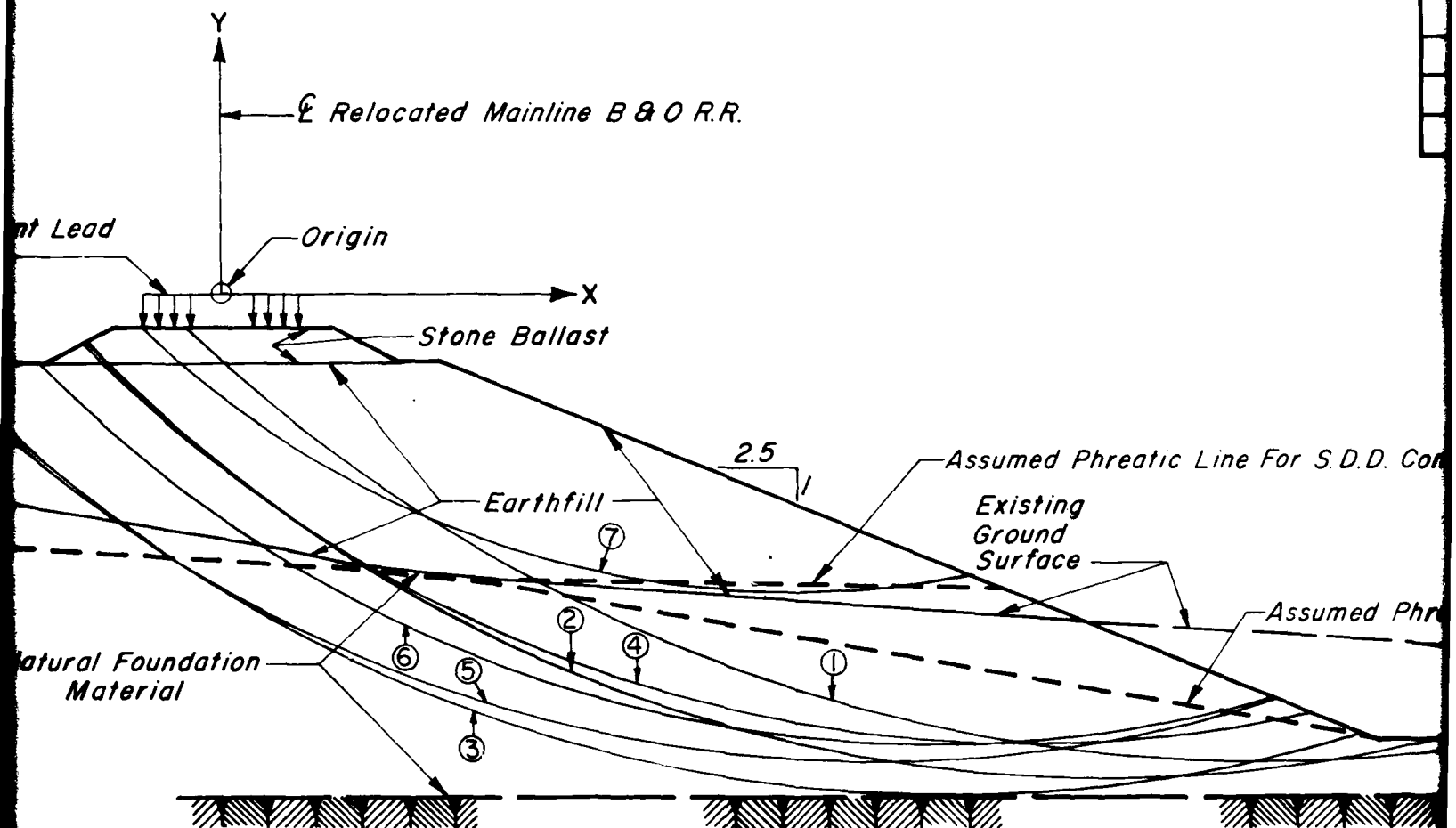
U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979

PLATE NO. D4-4





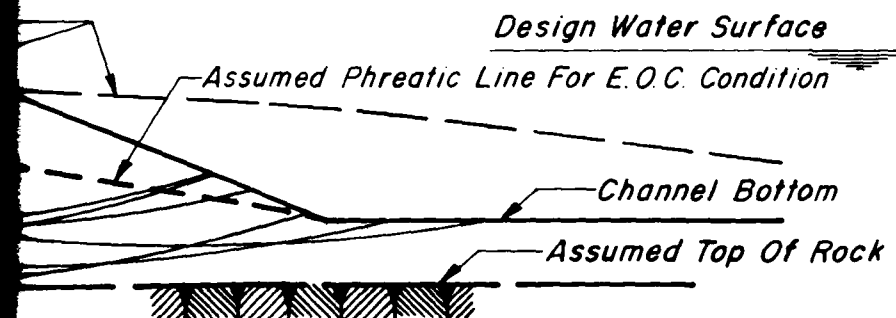
STA. 102 + 00 F

SCALE: 1 IN. = 10 FT.

RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	100.0	67.0	70.0	2.11	3.82
2	91.0	57.0	60.0	1.87	2.99
3	90.0	47.0	58.0	2.06	2.73
4	85.0	52.0	56.0	1.86	3.08
5	85.0	42.0	55.0	2.21	3.45
6	80.0	47.0	51.0	1.99	2.80 *
7	60.0	37.0	41.0	1.78 *	4.05

* Critical Arc

Phreatic Line For S.D.D. Condition



BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

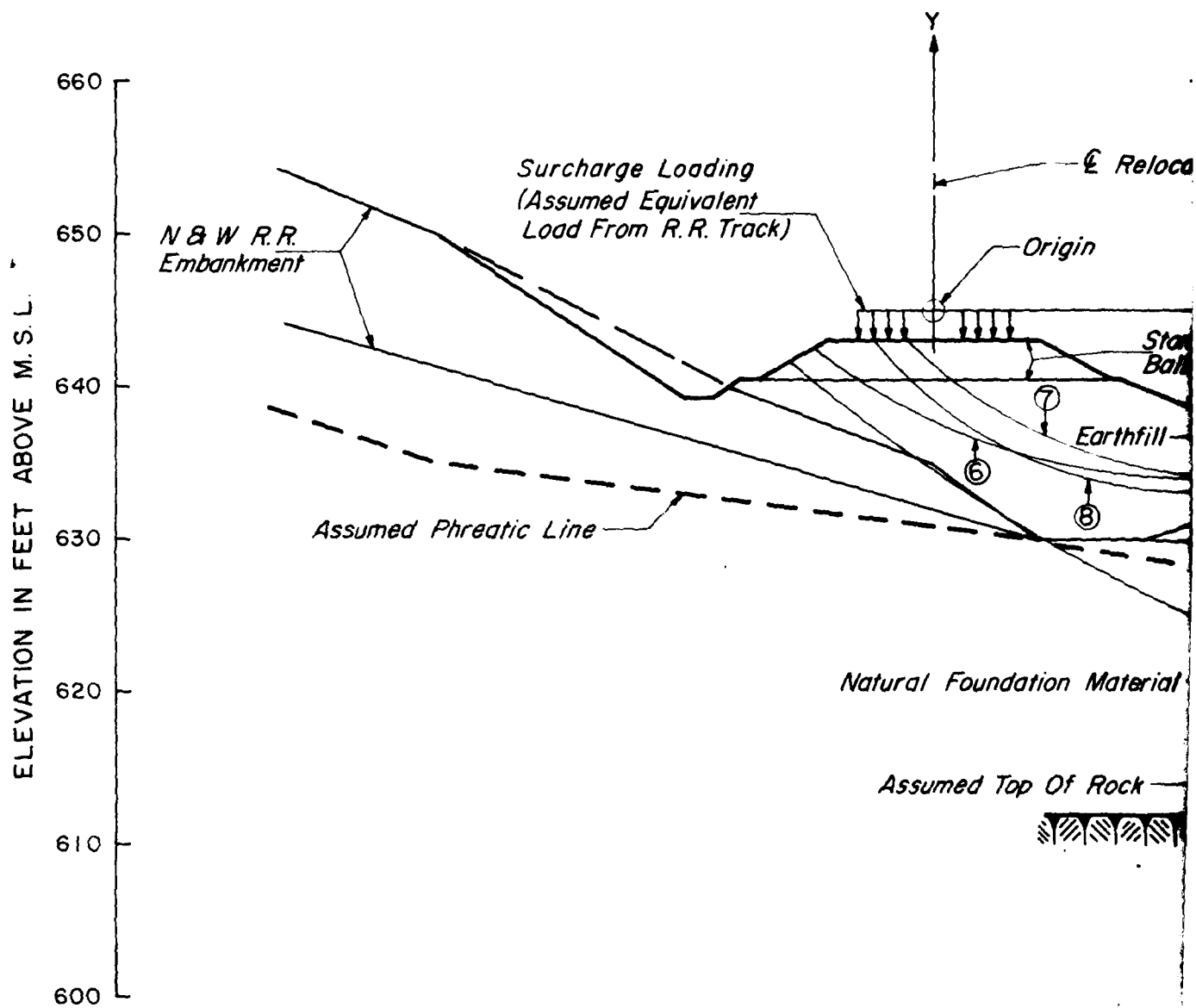
SUMMARY OF
SLOPE STABILITY ANALYSIS
LEFT BANK-FLOODWAY CHANNEL
STA. 102+00F

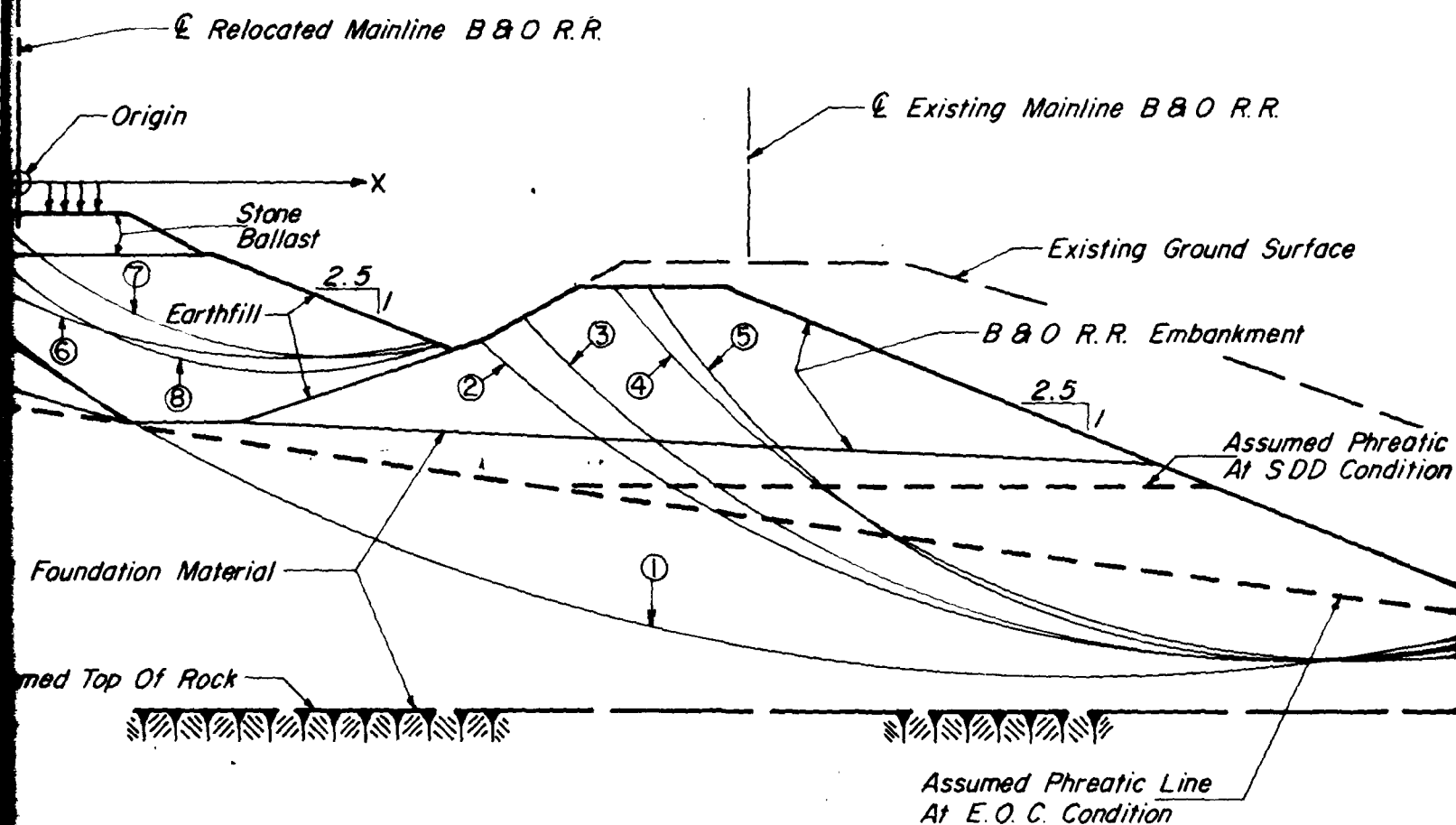
U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979

PLATE NO. D4-5





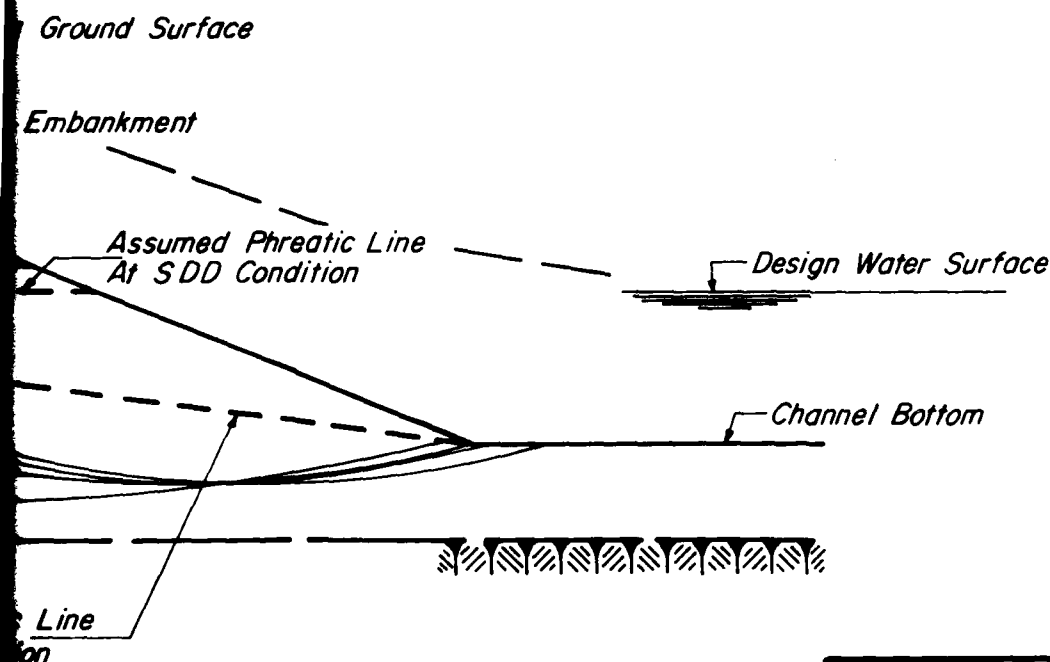
STA. 108+25F

SCALE: 1 IN. = 10 FT.

RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	120.0	67.0	89.0	2.67	3.71 *
2	75.0	80.0	45.0	3.00	4.12
3	65.0	80.0	35.0	2.98	4.08
4	60.0	85.0	30.0	2.90	5.00
5	50.0	82.0	20.0	2.79	4.80
6	41.0	17.0	30.0	2.57	6.10
7	31.0	20.0	20.0	2.27	5.71
8	27.0	17.0	15.0	2.21 *	5.65

* Critical Arc

B&O R.R.



BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

**SUMMARY OF
SLOPE STABILITY ANALYSIS
LEFT BANK-FLOODWAY CHANNEL
STA. 108+25F**

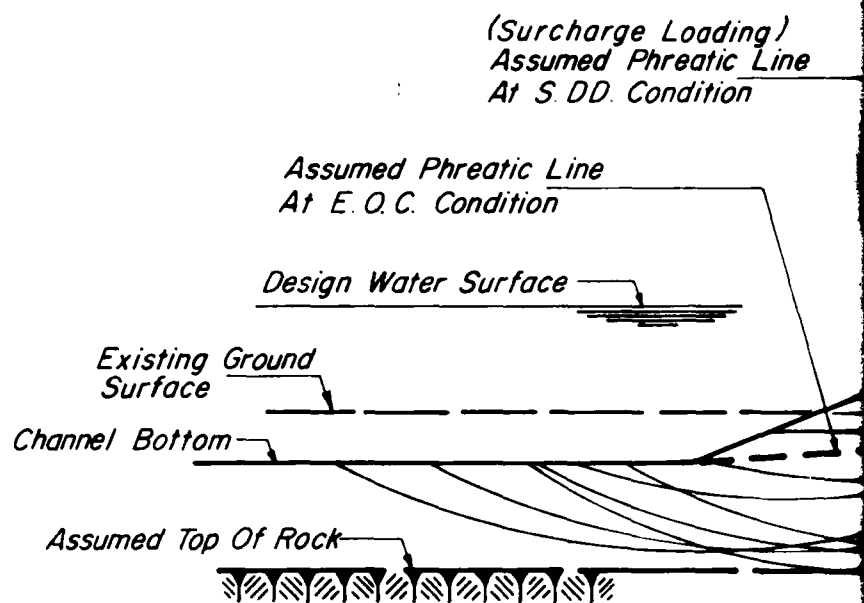
U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

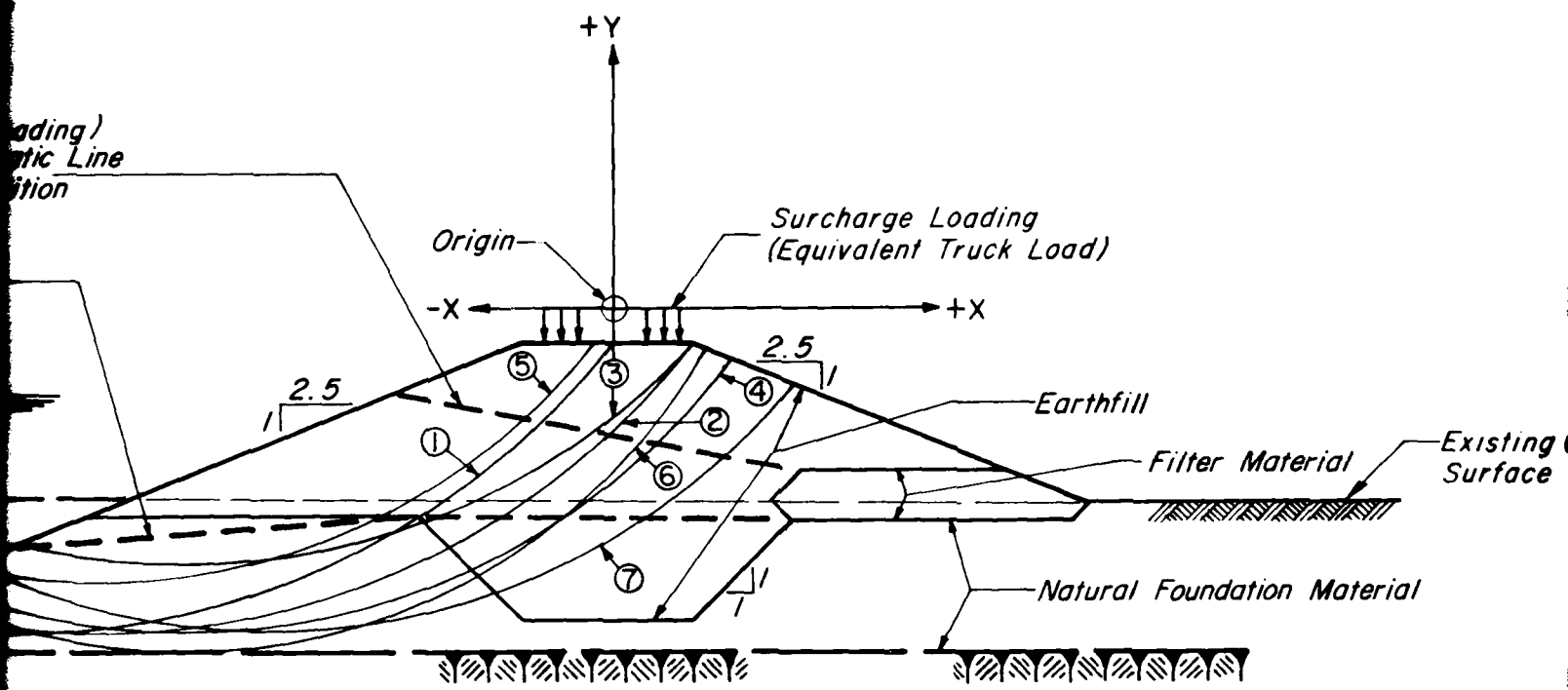
GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979

PLATE NO. D4-6

ELEVATION IN FEET ABOVE M.S.L.
640
630
620
610





STA. 111+00F
 SCALE 1 IN. = 10 FT.

RESULTS					
ARC NO.	RADIUS	CENTER COORDINATES		FACTOR OF SAFETY	
		X	Y	SUDDEN DRAWDOWN	END OF CONSTRUCTION
1	45.0	-35.0	26.0	3.69	7.12
2	44.0	-30.0	25.0	3.31	6.30 *
3	41.0	-25.0	26.0	2.58 *	6.79
4	40.0	-25.0	21.0	2.81	6.57
5	37.0	-30.0	21.0	3.50	7.67
6	35.0	-25.0	15.0	3.06	6.60
7	40.0	-20.0	21.0	3.22	7.33

* Critical Arc

Material Existing Ground Surface

tion Material

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

SUMMARY OF
SLOPE STABILITY ANALYSIS
LEVEE-FLOODWAY CHANNEL
STA. 111+00F

U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

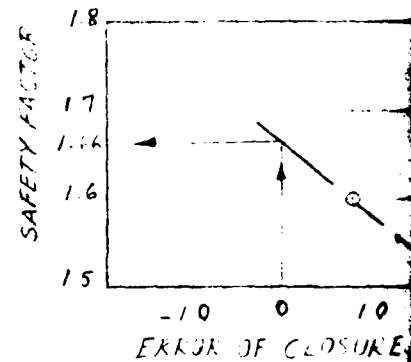
MARCH 1979

PLATE NO. D4-7

COMPUTATION OF FACTOR OF SAFETY - SUDDEN DE

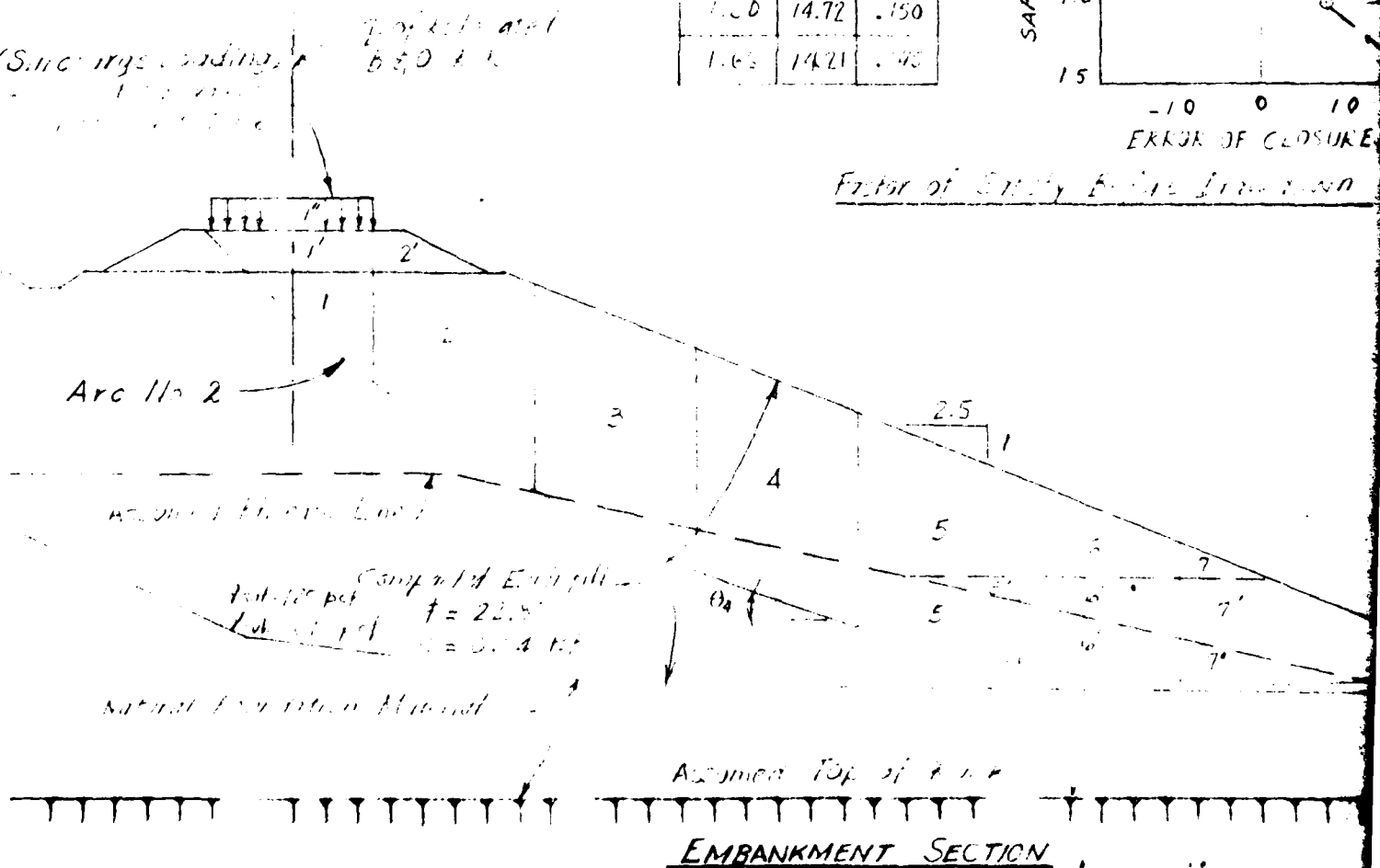
SLICE	No RIPS	ϕ	$N_b \tan \phi$	L	ΔL	W	θ	SM
1	14.1	22.5		10.40	1.5	12.26	42.5	.61
2	12.0			11.80	2.30	13.00	34.0	.55
3	14.1			12.00	2.64	12.85	26.1	.44
4	14.0			12.50	2.62	14.00	19.9	.31
5	12.0			12.20	2.44	13.02	13.2	.21
6	9.9			10.00	2.40	10.15	6.7	.11
7	5.6			7.00	2.10	7.02	0.0	.00
8	2.0			4.00	1.0	2.42	-6.0	-.11
Σ	84.2		35.36		19.89			

E_c	ϕ_D	C_D
10.1	22.8	.240
15.7	15.65	.160
12.0	14.72	.150
1.65	14.21	.140



Factor of Safety $F = 1.64$ (from graph)

(Since no loading is shown, the weight of the slice is assumed to be 100% of the weight of the slice.)



FETY - SUDDEN DRAWDOWN

W KIPS	θ	sin θ	W sin θ
16.26	42.5	.676	10.99
13.91	34.0	.555	7.78
12.82	26.7	.449	7.11
14.91	19.8	.339	5.05
13.02	13.2	.228	2.97
10.75	6.7	.117	1.25
7.02	0.0	.000	0.0
2.48	-6.0	-.105	-0.26
			34.92

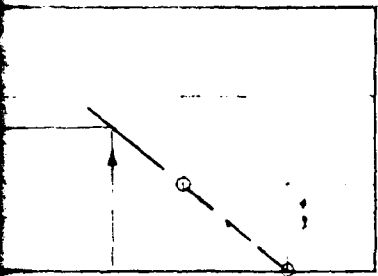
$$F.S. = \frac{\sum N_e \tan \phi + C \Delta L}{W \sin \theta}$$

Where N_e = Normal Effective Force Before Drawdown.

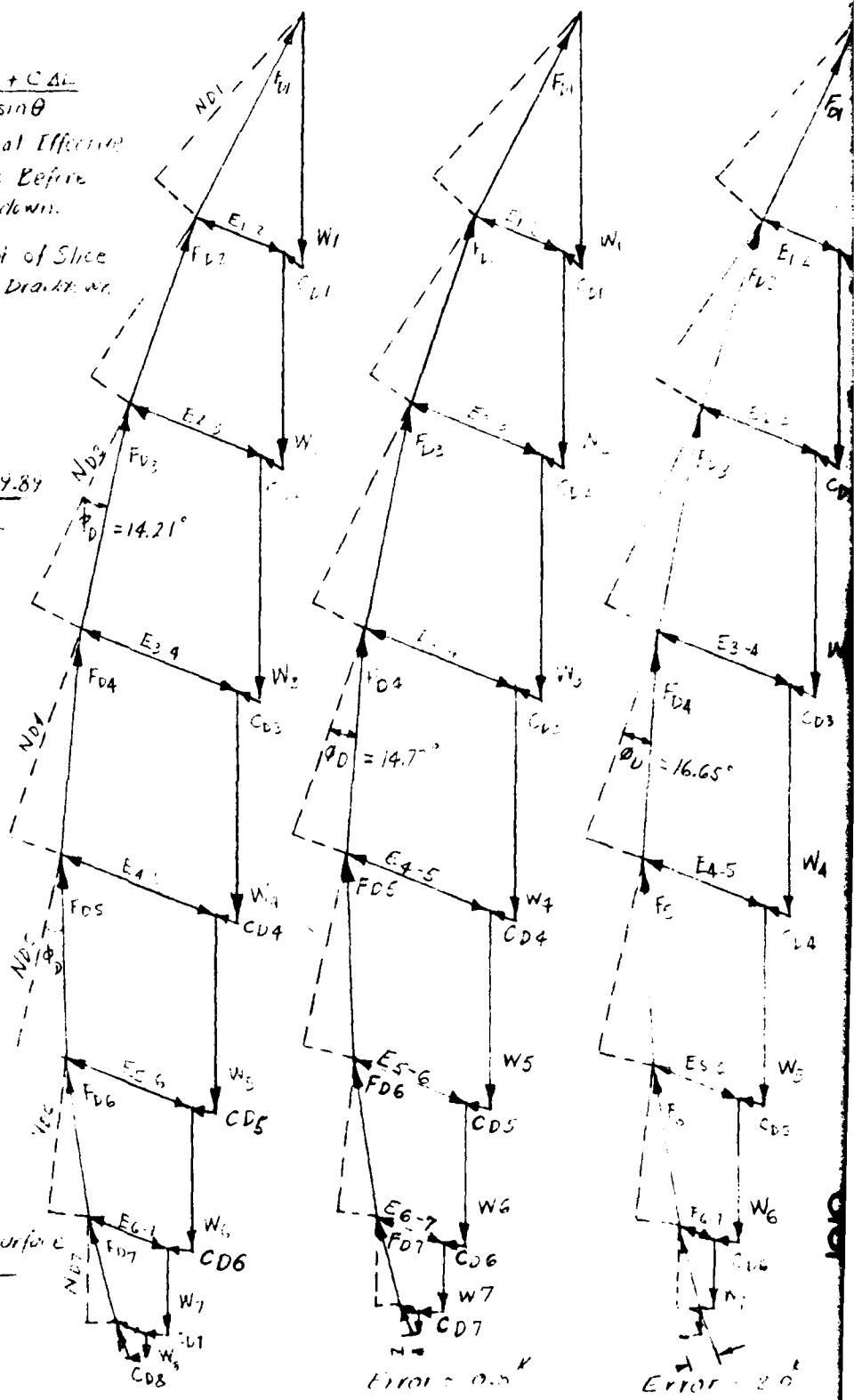
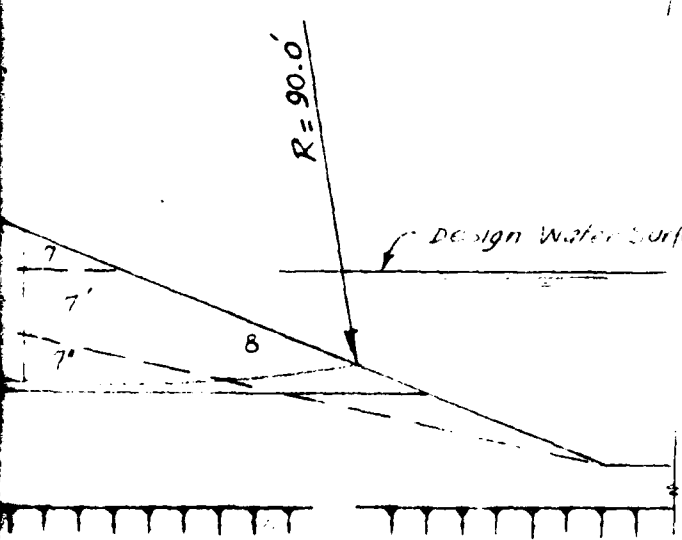
W = Weight of Slice After Drawdown.

$$F.S. = \frac{35.36 + 19.89}{34.92}$$

$$F.S. = 1.58$$



10 0 10 2.0
ERROR OF CLOSURE, KIPS
e 11.11111



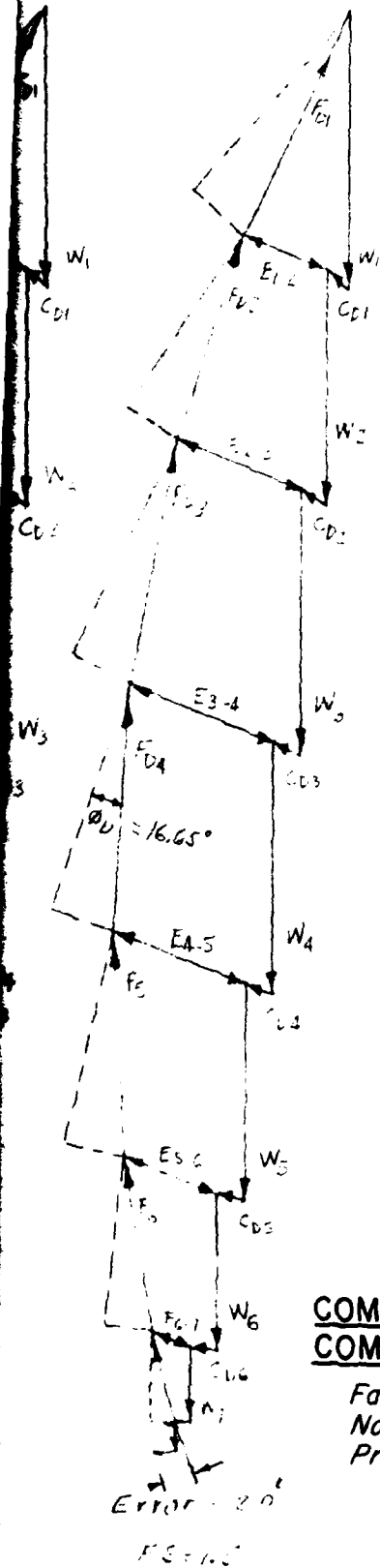
$$F.S. = 1.66$$

$$F.S. = 1.6$$

$$F.S. = 1.5$$

Composite Force Polygons Before Drawdown

Scale 1 IN = 10 KIPS



MANUAL CHECK COMPUTATIONS										
SLICE	HORIZONTAL WIDTH, FT	SLICE LENGTH OF SLICE, FT	SLICE HEIGHT, FT				WEIGHT, KIP			
			LEFT	RIGHT	TOP	BOTTOM	SLICE	INTER-SLICE	INTER-SLICE	INTER-SLICE
1	6.0	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
2	4.5	1.8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
3	10.0	11.0	12.0	11.0	12.0	12.0	15.00	15.00	15.00	15.00
4	10.0	10.5	11.0	10.5	11.0	11.0	15.00	15.00	15.00	15.00
5	10.0	10.0	11.0	10.0	11.0	11.0	15.00	15.00	15.00	15.00
6	10.0	10.0	11.0	10.0	11.0	11.0	15.00	15.00	15.00	15.00
7	10.0	10.0	11.0	10.0	11.0	11.0	15.00	15.00	15.00	15.00
8	9.0	9.0	10.0	9.0	10.0	10.0	15.00	15.00	15.00	15.00

COMPARISON WITH COMPUTER RESULTS

Factor of Safety for Arc.
No. 2 is 1.50 by Computer
Program (See Plate D4-4)

**BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO**

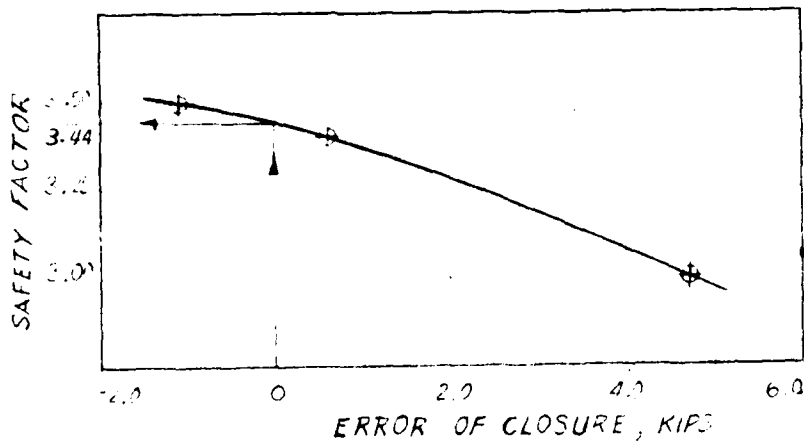
**MANUAL CHECK COMPUTATIONS
LEFT BANK-FLOODWAY CHANNEL
STA. 89+50F
SUDDEN DRAWDOWN CONDITION**

**U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM**

**GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA**

**MARCH 1979
PLATE NO. D4-8**

10. KIP

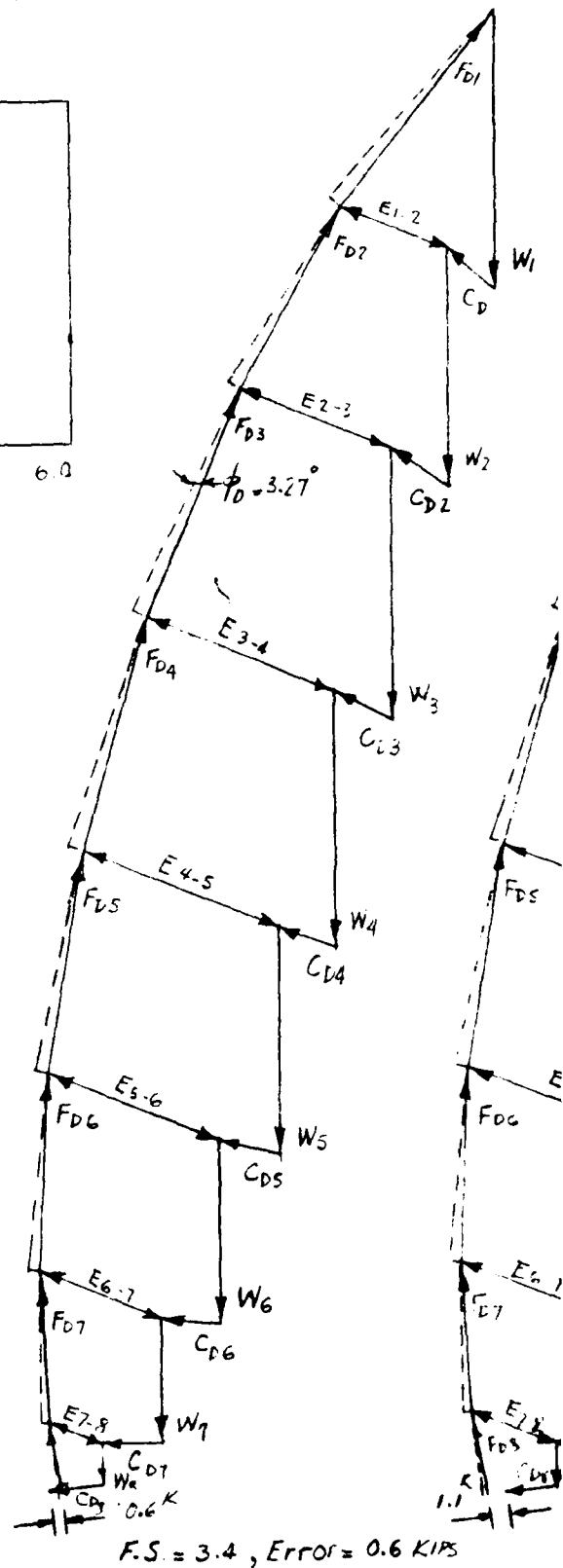
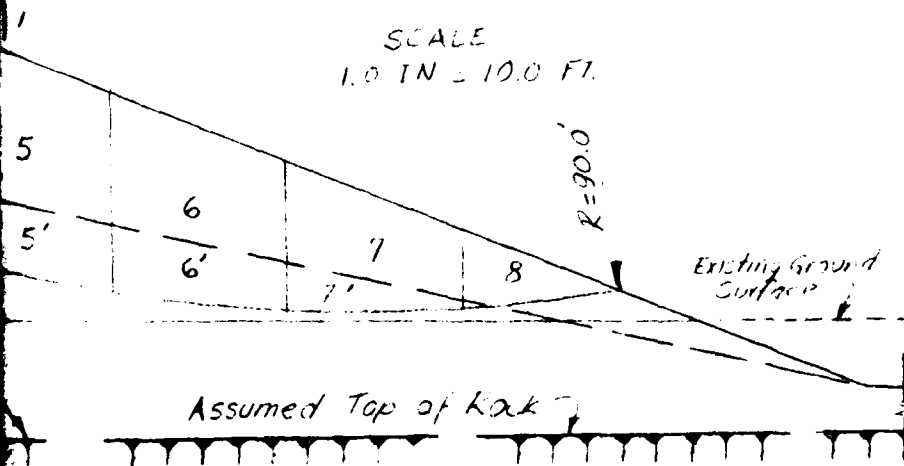


F.S.	ϕ_D degrees	C_D FS
3.00	3.707°	0.400
3.40	3.272°	0.353
3.50	3.179	0.343

Factor of Safety Obtained = 3.44

EMBANKMENT SECTION

SCALE
1.0 IN = 10.0 FT.



COMPOSITE FORCE POLYGONS

Scale 1.0 in =

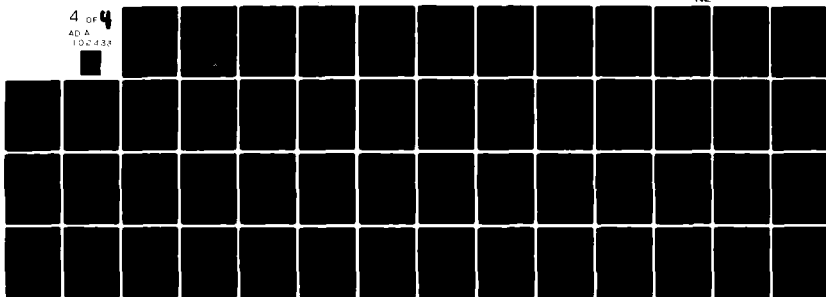
AD-A102 433

CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT
BIG CREEK FLOOD CONTROL PROJECT, CLEVELAND, OHIO. PHASE II. F/6 13/2
AUG 79 GEN-ETC(U)

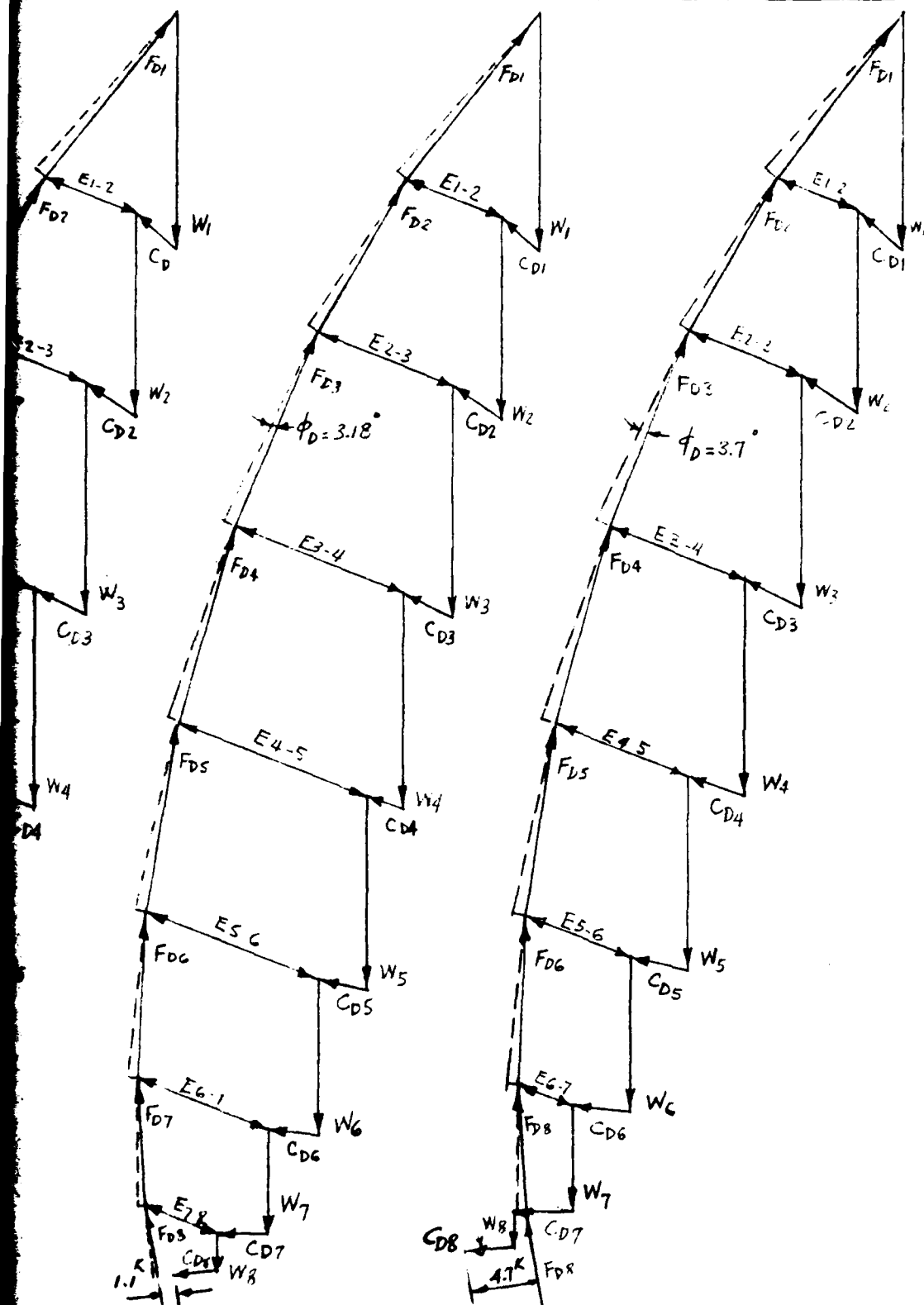
UNCLASSIFIED

NL

4 OF 4
AD A
10 2 1 8 8



END
DATE
FILMED
9-81
DTIC



SLICE No	Trial 1			
	Weight (KIPS)	Factor of Safety	Reaction (KIPS)	Resultant (KIPS)
1	2.0	3.5	5.0	3.45
2	11.0	2.5	10.0	2.50
3	10.0	2.0	11.0	2.00
4	10.0	11.0	9.4	10.2
5	10.0	2.6	3.8	3.2
6	10.0	9.4	7.8	3.6
7	10.0	3.8	3.8	3.8
8	10.0	7.8	3.8	6.8
9	10.0	3.8	3.8	3.3
10	10.0	5.8	4.0	4.9
11	10.0	2.8	0.2	1.5
12	9.0	1.4	1.0	7.2

COMPARISON COMPUTER RESULTS

Factor of Safety
No. 2 is 3.49 by
Program. (See Plot)

F.S. = 3.5, Error = 1.1 KIPS

F.S. = 3.0, Error = 4.7 KIPS

THE POLYGONS FOR THREE TRIALS

Scale 1.0 IN = 10.0 KIPS

MEASUREMENTS & WEIGHTS													
SLICE No	TOTAL WIDTH	HEIGHT, FT			AREA OF SLICE	WEIGHT, KIPS			EAST LENGTH, AL, FT	C.G. (AL) KIPS	TOTAL AL, FT (4.37)	C.G. (AL) KIPS	F.S. (4.37)
		LEFT SLIT	RIGHT SLIT	AVERAGE		DATUM	ADJ. SLIT	TOTAL					
1	8.0	1.5	1.5	2.50	12.0	2.50	-	16.26	10.4	12.45	4.16	3.57	3.67
2	10.0	2.5	2.5	2.50	12.0	1.41	-	13.91	11.8	14.16	4.72	4.05	4.16
3	10.0	1.0	1.0	1.00	10.0	15.00	-	15.88	11.0	13.20	4.40	3.77	3.88
4	10.0	11.0	9.4	10.2	102.0	12.75	-	14.91	10.5	12.60	4.20	3.60	3.71
5	10.0	9.1	7.8	8.6	86.0	10.10	-	13.32	10.2	12.21	4.08	3.50	3.60
6	10.0	7.8	5.8	6.8	68.0	8.50	-	10.73	10.0	12.00	4.00	3.43	3.53
7	10.0	5.8	4.0	4.9	49.0	6.12	-	7.14	10.0	12.00	4.00	3.43	3.53
8	9.0	4.4	3.0	3.2	32.0	2.41	-	1.45	9.0	10.80	3.60	3.09	3.15

COMPARISON WITH COMPUTER RESULTS

Factor of Safety for Arc
No. 2 is 3.49 by Computer
Program. (See Plate D4-4)

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

MANUAL CHECK COMPUTATIONS
LEFT BANK - FLOODWAY CHANNEL
STA. 89+50F
END OF CONSTRUCTION CONDITION

U. S. ARMY ENGINEER DISTRICT, BUFFALO
PHASE II GENERAL DESIGN MEMORANDUM

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.
CONSULTING ENGINEERS
HARRISBURG, PENNSYLVANIA

MARCH 1979

PLATE NO. D4-9

BIG CREEK FLOOD CONTROL PROJECT
CLEVELAND, OHIO

PHASE II
GENERAL DESIGN MEMORANDUM

APPENDIX D
DESIGN ANALYSIS

AUGUST 1979

SUBAPPENDIX D5
COMPUTATIONS FOR RAILROAD RELOCATIONS

SUBAPPENDIX D5

COMPUTATIONS FOR RAILROAD RELOCATIONS

CONTENTS

<u>Item</u>	<u>Page No.</u>
<u>Baltimore and Ohio Railroad Mainline</u>	
Design Criteria	D5- 3
Spiral Lengths	D5- 3 to D5- 4
Chessie System Bulletin No. R-13	D5- 5 to D5- 6
<u>Baltimore and Ohio Railroad Spurline</u>	
Design Criteria	D5- 7 to D5- 8
<u>Horizontal and Vertical Alignment and Miscellaneous Design</u>	
Index Sheet	D5- 9
Mainline Horizontal Alignment	D5-10 to D5-22
Spurline Horizontal Alignment	D5-23 to D5-26
Mainline Vertical Alignment	D5-27 to D5-33
Spurline Vertical Alignment	D5-34 to D5-37
Drainage	D5-38 to D5-41
Coordinated Survey Points	D5-42 to D5-43
Clearances	D5-44 to D5-45
COGO Program	D5-46 to D5-52

NOTE: The alignment geometry for the railroad relocations was obtained by using a computer program. The computer printout sheets in this Subappendix are from this program. A description of the program, general information, general rules, and index of commands for the program are at the end of this Subappendix on Pages D5-46 through D5-52, inclusive.

NOTE: The COGO Program has been verified by hand computations.

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek Flood Control Project FILE NO. 7622
B & O Railroad Relocation SHEET NO. _____ OF _____ SHEETS
FOR U.S. Army Corp of Engineers
COMPUTED BY RLH DATE 1/5/79 CHECKED BY WMTL DATE 1/5/78
B. & O MAIN LINE

NOTE:

All horizontal and vertical curvature has been established by use of coordinated survey points. These coordinated survey points have been computed from U.S. Army Corp of Engineers survey of the project area. Horizontal curvature has been computed by ARC definition.

Design Criteria:

Chessie System Engineering Bulletin Number R-13
Dated - April 18, 1977

Governing Constraints:

- (1) Mainline Design Speed — 30 M.P.H.
- (2) Mainline Gradient — +1.50% Max.
- (3) Mainline Curvature — $4^{\circ}00'00''$ Max (Spiraled)

Spiral Lengths:

Curve No. 1

Curvature = $6^{\circ}00'$ Existing
Superelevation = $3\frac{1}{2}''$ (by R-13) or match existing elevation.

Length of Spiral = 62 Ea.
= 62 (3.5)
= 217'

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek Flood Control Project FILE NO. 7622
B.O. Railroad Relocation SHEET NO. _____ OF _____ SHEETS
FOR U.S. Army Corp of Engineers
COMPUTED BY RLH DATE 1/5/79 CHECKED BY WMH DATE 1/5/79

Curve No. $\diamond 2$

Curvature = $4^{\circ}00'$
Superelevation = $2\frac{1}{2}"$ (by R-13)

Length of Spiral = 62 E.S.
= $62(2.5)$
= $155'$

Curve No. $\diamond 3$

Curvature = $1^{\circ}00'$
Superelevation = $\frac{1}{2}"$ (by R-13)

Length of Spiral = 62 E.S.
= $62(.5)$
= $31'$

Curve No. $\diamond 4$

Curvature = $4^{\circ}00'$
Superelevation = $2\frac{1}{2}"$ (by R-13)

Length of Spiral = 62 E.S.
= $62(2.5)$
= $155'$

Curve No. $\diamond 5$

Curvature = $4^{\circ}00'$
Superelevation = $2\frac{1}{2}"$ (by R-13)
Length of Spiral = Same as Curve No. 4 = $155'$
D5-4



BULLETIN NUMBER R-13
EFFECTIVE DATE April 20, 1970
REVISED DATE April 19, 1977

ENGINEERING DEPARTMENT PROCEDURE BULLETIN

INSTRUCTIONS GOVERNING THE SUPERELEVATION OF THE OUTER
RAIL AND THE SPEED OF TRAINS ON CURVES

Degree of Curve	SPEED IN MILES PER HOUR											
	20	25	30	35	40	45	50	55	60	65	70	75
0-15	0	0	1/4	1/4	1/4	1/2	1/2	1/2	3/4	3/4	1	1
0-30	1/4	1/4	1/4	1/2	1/2	3/4	3/4	1	1-1/4	1-1/2	1-3/4	2
0-45	1/4	1/2	1/2	3/4	3/4	1	1-1/4	1-1/2	1-3/4	2	2-1/2	3
1-00	1/4	1/2	1/2	3/4	1	1-1/4	1-1/2	2	2-1/4	2-3/4	3-1/4	3-3/4
1-15	1/2	1/2	3/4	1	1-1/4	1-3/4	2	2-1/2	3	3-1/2	4	4-3/4
1-30	1/2	1/2	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4-1/4	5	5-1/2
1-45	1/2	3/4	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	4-3/4	5-3/4	
2-00	1/2	3/4	1-1/4	1-3/4	2-1/4	2-3/4	3-1/4	4	4-3/4	5-1/2		
2-15	3/4	1	1-1/2	2	2-1/2	3	3-3/4	4-1/2	5-1/4			
2-30	3/4	1	1-1/2	2	2-3/4	3-1/2	4-1/4	5	6			
2-45	3/4	1-1/4	1-3/4	2-1/4	3	3-3/4	4-3/4	5-1/2				
3-00	3/4	1-1/4	1-3/4	2-1/2	3-1/4	4	5	6				
3-15	1	1-1/2	2	2-3/4	3-1/2	4-1/2	5-1/2					
3-30	1	1-1/2	2-1/4	2-3/4	3-3/4	4-3/4	5-3/4					
3-45	1	1-3/4	2-1/4	3	4	5	6					
4-00	1	1-3/4	2-1/2	3-1/4	4-1/4	5-1/4						
4-30	1-1/4	2	2-3/4	3-3/4	4-3/4	6						
5-00	1-1/4	2	3	4	5-1/4							
5-30	1-1/2	2-1/4	3-1/4	4-1/2	5-3/4							
6-00	1-1/2	2-1/2	3-1/2	4-3/4								
6-30	1-3/4	2-3/4	3-3/4	5-1/4								
7-00	1-3/4	3	4-1/4	5-1/2								
7-30	2	3	4-1/2	6								
8-00	2-1/4	3-1/4	4-3/4									
8-30	2-1/4	3-1/2	5									
9-00	2-1/4	3-3/4	5-1/4									
9-30	2-1/2	3-3/4	5-1/2									
10-00	2-3/4	4	5-3/4									
10-30	2-3/4	4-1/4										
11-00	2-3/4	4-1/2										
11-30	3	4-3/4										
12-00	3	4-3/4										
14-00	3-3/4	5-3/4										
16-00	4-1/4											
18-00	4-3/4											
20-00	5-1/4											

$E = -0.00066DV^2$
E = Superelevation
in Inches
D = Degree of Curve
V = Speed in Miles
Per Hour

TABLE A
EQUILIBRIUM ELEVATION



BULLETIN NUMBER R-13
EFFECTIVE DATE April 20, 1970
REVISED DATE April 18, 1977

ENGINEERING DEPARTMENT PROCEDURE BULLETIN

INSTRUCTIONS GOVERNING THE SUPERELEVATION OF THE OUTER
RAIL AND THE SPEED OF TRAINS ON CURVES

Degree of Curve	Elevation in Inches										
	0	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
0-30	76	84	93	100							
0-45	62	69	76	82	87	93	97	102			
1-00	53	60	65	71	76	80	85	89	93	96	100
1-15	48	52	59	63	68	72	76	79	83	86	89
1-30	44	49	53	58	62	65	69	72	76	79	82
1-45	40	45	50	54	57	61	64	67	70	73	76
2-00	38	42	46	50	53	57	60	63	65	68	71
2-15	36	40	44	47	50	54	56	59	62	64	67
2-30	34	38	41	45	48	51	53	56	59	61	63
2-45	32	36	40	43	46	48	51	54	56	58	60
3-00	31	35	38	41	44	46	49	51	53	56	58
3-15	30	33	36	39	42	45	47	49	51	54	56
3-30	29	32	35	38	40	43	45	47	49	52	53
3-45	28	31	34	37	39	41	44	46	48	50	52
4-00	27	30	33	35	38	40	42	44	46	48	50
4-30	25	28	31	33	36	38	40	42	44	45	47
5-00	24	27	29	32	34	36	38	40	41	43	45
5-30	23	25	28	30	32	34	36	38	40	41	43
6-00	22	24	27	29	31	33	35	36	38	39	41
6-30	21	23	26	28	30	31	33	35	36	38	39
7-00	20	23	25	27	29	30	32	34	35	36	38
7-30	20	22	24	26	28	29	31	32	34	36	37
8-00	19	21	23	25	27	28	30	31	33	34	36
8-30	18	20	22	24	26	28	29	30	32	33	34
9-00	18	20	22	24	25	27	28	30	31	32	33
9-30	17	19	21	23	25	26	27	29	30	31	32
10-00	17	19	21	22	24	25	27	28	29	30	32
10-30	16	18	20	22	23	25	26	27	29	30	31
11-00	16	18	20	21	23	24	26	27	28	29	30
11-30	16	18	19	21	22	24	25	26	27	28	29
12-00	15	17	19	20	22	23	24	26	27	28	29
14-00	14	16	17	19	20	21	23	24	25	26	27
16-00	13	15	16	18	19	20	21	22	23	24	25
18-00	13	14	15	17	18	19	20	21	22	22	23
20-00	12	13	15	16	17	18	19	19	20	21	22

TABLE C
MAXIMUM ALLOWABLE SPEED FOR FREIGHT TRAINS

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek Flood Control Project FILE NO. 7622
B&O Railroad Relocation SHEET NO. _____ OF _____ SHEETS
FOR U.S. Army Corp of Engineers
COMPUTED BY RLH DATE 1/8/79 CHECKED BY WM III DATE 1/12/79

B. & O. Spur to Industrial Park

NOTE: All horizontal and vertical curvature has been established by use of coordinated survey points. These coordinated survey points have been computed from U.S. Army Corp of Engineers survey of the project area. Horizontal curvature has been computed by Arc definition.

Design Criteria:

Chessie System Engineering Bulletin Number R-13
Dated April 18, 1977

Governing Constraints:

- 1) Spurline Curvature _____ 14°00' Max (No Spirals)
- 2) Turnout Size _____ Number 8

Description:

The Spurline alignment is basically as per preliminary design with the following exceptions. The use of a Number 6 Turnout has been done away with and a Number 8 Turnout used in its place. The C.T. which was located on the northern end of the proposed bridge carrying the siding to the industrial park, has been moved back off the bridge. To accomplish this, a minor alignment change was necessary. With the use of 14°00' curves and the number 8 turnout, we now have a satisfactory alignment both crossing the bridge

05-7 (continued next sheet)

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek Flood Control Project FILE NO. 7622
B. & O. Railroad Relocation SHEET NO. OF SHEETS
FOR U.S. Army Corps of Engineers
COMPUTED BY RLH DATE 1/8/79 CHECKED BY W.M. III DATE 1/12/79

and tying into the existing trackage in the industrial park. This will however, create additional work beyond the preliminary design limit. This additional work will consist of placement of approximately 250 feet of additional new trackage plus the adjustment of an existing turnout and, therefor, also the adjustment of the trackage connected to this turnout.

D5-8

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek Flood Control Project FILE NO. 7622
B & O Railroad Relocation SHEET NO. 1 OF SHEETS
FOR U.S. Army Corp of Engineers
COMPUTED BY RLH DATE 1/8/79 CHECKED BY W.M. III DATE 1/12/79

INDEX SHEET FOR
HORIZONTAL & VERTICAL ALIGNMENT and
MISCELLANEOUS DESIGN
For
B.O. RAILROAD MAINLINE and SPURLINE

	<u>SHEETS</u>
B. & O. R.R. Mainline Horizontal Alignment	2-14
B. & O. R.R. Spurline Horizontal Alignment	15-18
B. & O. R.R. Mainline Vertical Alignment	19-25
B. & O. R.R. Spurline Vertical Alignment	26-29
Drainage	30-33
Coordinated Survey Points	34-35
Clearance	36-37

BY RLH DATE 1/5/79
CHKD. BY RLH DATE 1/12/79

SUBJECT HORIZ. ALIGN.

SHEET NO. 2 OF 2
JOB. NO. 7622

TABULATION OF CURVE DATA

71

CURVE

NO.

1

EXIST = $6^{\circ} 00' 00''$

R = 954.93'

LS = 217.00'

OUT

LT = 144.76'

SZ = 72.42'

E = $3\frac{1}{2}''$ or match exist

Throw = 2.054'

CURVE

NO.

2

$\Delta = 6^{\circ} 55' 38.33''$

R = 1433.00'

D = $4^{\circ} 00' 00''$

Lc = 18.26'

LS = 155.00'

E = $2\frac{1}{2}''$

Throw = 0.70'

CURVE

NO.

3

$\Delta = 1^{\circ} 46' 41.41''$

R = 5730.00'

D = $1^{\circ} 00' 00''$

Lc = 146.83'

LS = 31.00'

E = $\frac{1}{2}''$

Throw = 0.007'

D5-10

BY RLH DATE 1/5/79
CHKD. BY W.M. DATE 1/12/79

SUBJECT HORIZ. ALIGN.

SHEET NO 3 OF
JOB NO 7622

M TAB. CONTINUED

CURVE

NO.

4

$$\Delta = 21^{\circ} 54' 38.77''$$

$$R = 1433.00'$$

$$D = 4^{\circ} 00' 00''$$

$$LC = 393.00'$$

$$LS = 155.00'$$

$$E = 2\frac{1}{2}''$$

$$Throw = 0.70'$$

CURVE

NO.

5

$$\Delta = 20^{\circ} 48' 49.35''$$

$$R = 1433.00'$$

$$D = 4^{\circ} 00' 00''$$

$$LC = 365.56$$

$$LS = 155.00'$$

$$E = 2\frac{1}{2}''$$

$$Throw = 0.70'$$

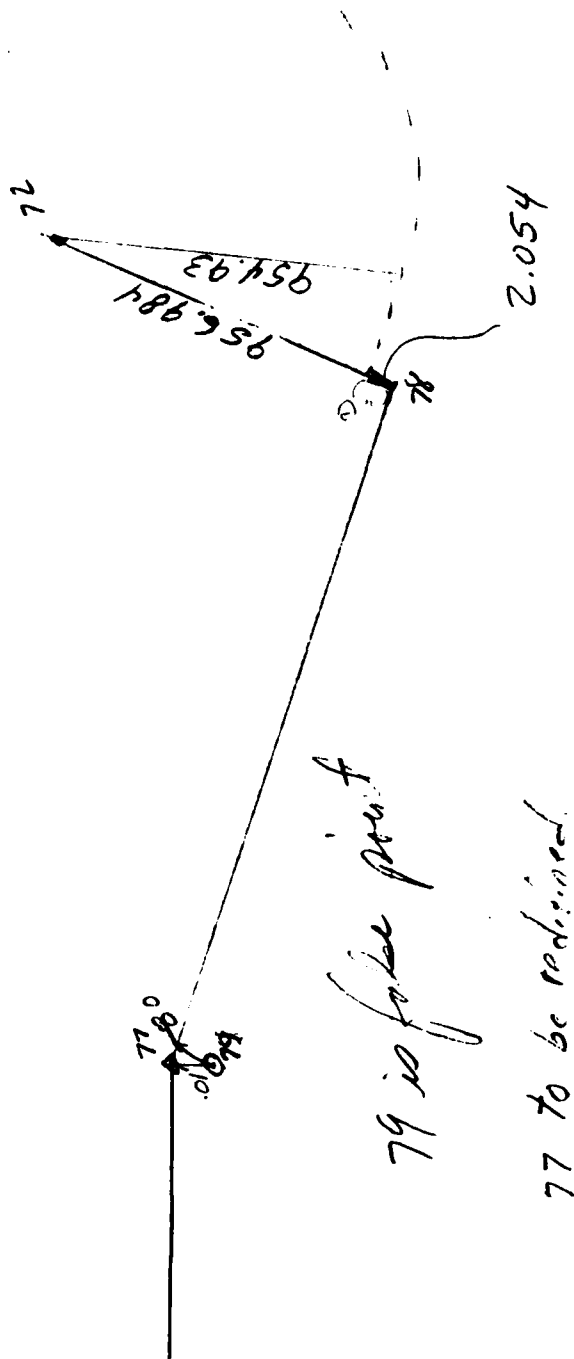
Job No. 7622 Sht. 4 of
 By RLH Date 11/4/79
 Subject Encl. Horiz. Align.

COMMAND:
 89 77 648234.1354 2218672.1291
 89 648729.5727 2218951.7035
 92 649218.7935 2218185.2974
 91 650438.333 2215909.1639
 93 650521.8818 2215148.9075
 40 650809.1256 2214587.2236
 31 648522.0199 2219317.0641
 87 648606.0543 2219129.9679
 0 0 0

COMMAND: seq 31 87 954.93 1 0 CHORD= 205.1018
 ARC LENGTH= 205.4981
 0 0 0 0

COMMAND:
 1br 89 77 DIST= 340.7972
 NW 53- 6- 44.50 DIST= 570.0000
 NW 60- 2- 22.83 DIST= 2582.2588
 NW 92 91 DIST= 764.8334
 NW 61- 49- 4.24 DIST= 630.8707
 NW 91 93
 NW 83- 43- 43.01
 NW 93 40
 NW 62- 54- 53.66
 0 0

Job No. 7622 Sht. 5 of 8
 By RLH Date 1/4/79 Ckd
 Subject Final Horiz Align
East 6° Curve Thru To
New Tangent for Spiral



$$O = 0.1454 \Delta \sum$$

$$.1454 (65095) (2.17) = 2.054$$

* Δ taken from spiral as previously

05-13

 JOB NO

 CHKD BY DATE

? 1 2 4 500
 4 648446.5711 2219908.8077
 ? 0 0 0 0

COMMAND:

? ang

? 4 2 3

* 6- 30- 34.25

? 0 0 0

DIST 2 TO 3=

72.4225

COMMAND:

? eo.j

END OF PROGRAM COG

EDIT end

READY

Job No. 7622 Sht. 6 of
 By RLH Date 1/4/78 Cnd
 Subject Final Horiz Blga

logon afcc2
 THANK YOU.
 READY edit cl(cog) ifli
 EDIT run

DATE 12/27/78

TIME 12.18.03

Job No. 7622 Sht. 7 of
 By ELH Date 12-27-78
 Subject FILE MFG. Flight

COMMAND:
 ? SOS
 ? 90
 00140 SOS 0443 END OF FILE
 EDIT run

COMMAND:
 ? str
 ? 10 649008.78 2218363.99
 ? 11 648554.50 2219251.42
 ? 21 649106.18 2218409.23
 ? 22 648599.40 2219319.79
 ? 6 650528.78 2215124.76
 ? 5 650855.32 2214515.40
 ? 9 649343.48 2217661.34
 ? 91 650438.333 2215909.1639- P1 138+75.27
 ? 8 650476.8864 2215558.3454
 ? 0 0 0

COMMAND:
 ? lan 10 9 99 470.21 107 54 03.9
 ? 99 649001.6761 2217338.4352
 ? 10
 ? ~~648522.319732219879.03+03.5~~
 ? 0 0 0 0 0 0

COMMAND:
 ? lan
 ? 10 11 31 73.24 179 13 03.8
 ? 31 648522.9199 2219317.0641
 ? 22 21 52 584.78 00 18 00.3
 ? 52 648819.1219 2218918.7055
 ? 22 21 51 661.14 181 21 31.2
 ? 51 ~~64941.3080~~ 2217838.3218
 ? 10 11 32 10.18 228 10 37.7
 ? 32 648544.6539 2219254.0058
 ? 10 11 33 26.80 339 11 25.1
 ? 33 648557.4402 2219224.7818
 ? 10 11 34 126.64 354 58 38.5
 ? 34 648602.1153 2219134.0724
 ? 10 11 35 425.31 359 57 27.5
 ? 35 648748.0216 2218872.6879
 ? 10 11 36 575.00 00 15 03.2

36 648818.7498 2218740.7371
 ? 5 6 37 295.62 175 32 44.6
 37 650409.8078 2215395.3830
 ? 5 6 38 80.90 02 55 20.7
 38 650570.5773 2215055.4939
 ? 5 6 39 206.90 00 14 36.4
 39 650627.2792 2214942.8108
 ? 5 6 40 606.25 359 21 29
 40 650809.1256 2214587.2236
 ? 0 0 0 0 0 0

COMMAND:

?

lan 9 99 61 353.96 255 10 02.2
 61 649170.7811 2217027.4832
 ? 9 99 62 155.32 258 58 23
 62 649084.7735 2217207.2136
 ? 9 99 63 96.07 261 02 28.5
 63 649055.9699 2217259.1785
 ? 9 99 64 40.86 29 30 18.9
 64 649013.7065 2217377.4840
 ? 9 99 65 97.1 47 54 49.8
 65 648999.4981 2217435.5108
 ? 9 99 66 250.06 57 25 58.2
 66 648954.8014 2217584.0625
 ? 9 99 67 11.35 165 25 55.2
 67 648991.7303 2217332.9667
 ? 9 99 68 64.82 103 52 02.4
 68 648947.1668 2217373.5119
 ? 9 99 69 161.77 48 11 30.7
 69 648997.2629 2217500.1450
 ? 9 99 70 321.61 46 35 13
 70 649001.9099 2217660.0451
 ? 9 99 71 402.15 47 00 37.4
 71 648998.9964 2217740.5763
 ?

Job No. 7622 Sht. 8 of
 By RHH Date 11/4/77 Ckd
 Subject Final Holog. Align

Job No. 7622 Sht. 2 of
 By RLH Date 1/4/78
 Subject F-701 Hong Kong

0 0 0 0 0 0 0
 COMMAND:
 ? ai 72 33 954.93 31 954.93 22
 72 649430.0509 2219612.6501
 ? 0 0 0 0 0 0

COMMAND:
 ? lan 51 52 73 20.00 -90 00 00
 73 648801.7945 2218908.7175
 ? 52 51 74 20.00 90 00 00
 74 649423.9805 2217829.3338
 ? 0 0 0 0 0 0

COMMAND:
 ? tof 98 72 34 35
 98 648595.1274 2219146.5910
 ? 0 0 0 0

COMMAND:
 ? lin 98 35 75 -761.17
 75 648224.1253 2219811.2242
 ? 0 0 0 0

COMMAND:
 ? lan 98 75 76 762.17 102 53 00
 76 648789.3060 2220321.0776
 ? 0 0 0 0 0 0

COMMAND:
 ? lin 73 74 77 265
 77 ~~648934.1355~~ 2218679.1291 Pt Redefine
 ? 0 0 0 0

COMMAND:
 ? lan 73 77 79 -001 90 00 00
 79 648934.1346 2218679.1286
 ? 75 76 4 2.054 -90 00 00
 4 648787.9302 2220322.6027
 ? 0 0 0 0 0 0

COMMAND:
 ? tan 78 72 956.984 80 70 .001 1 -1
 78 648664.6415 2219038.2227
 80 648934.1354 2218679.1292

Job No. 7622 Sht. 10 of
 By RLH Date 11/4/79 Ckd
 Subject Final Horiz. Align

0 0 0 0 0 0 0 0
 COMMAND:
 ? Pin 77 74 73 78 80
 77 648934.1354 2218679.1291 P STA 107+23.30
 ? 81 76 75 78 77
 81 648140.8769 2219736.1252
 ? 0 0 0 0 0

COMMAND:
 ? Lin 81 78 1 -2.054
 1 648139.6440 2219737.7680
 ? 1 4 3 1000.000
 3 648882.1533 2220407.6037
 ? 1 4 90 -50.00
 90 648102.5185 2219704.2762
 ? 0 0 0 0

COMMAND:
 ? ang 90 1 78
 84- 49- 59.70 DIST 1 10 78= 874.6348

0 0 0
 COMMAND:
 ? fit
 ? 82 3 1 954.93 217 217 84 49 59.70 1.0

LT= 144.7646 ST= 72.4224
 NTS 82 648869.3887 2220396.0885
 NPI 83 648761.8997 2220299.1200
 NSC 84 648713.9721 2220244.8249
 SIMPLE CURVE
 NPI 85 648256.4040 2219726.4657
 NC 86 649429.8830 2219612.8733

SPIRAL OUT ST= 72.4224
 LT= 144.7646
 NCS 87 648606.0543 2219129.9679—STA. 101+65.50
 NPI 88 648642.6781 2219067.4883
 NST 89 648729.5727 2218951.7035—STA. 103+82.50

11n 77 74 92 570
 92 649218.7935 2218185.2974 PI 112+302
 ? 0 0 0 0

COMMAND:
 ? ang 73 77 78
 ? 6- 55- 38.36 DIST 77 TO 78= 448.9713
 ? 0 0 0

COMMAND:
 ? fit 53 1 77 1433.00 155 155 6 55 38.36
 ? -1.0

SPIRAL IN ST= 51.6811
 LT= 103.3492
 NTS 53 648835.5336 2218810.5134 - STA. 105+59.03
 NPI 54 648897.5687 2218727.8533
 NSC 55 648926.3104 2218684.9016 - STA. 107+14.03

SIMPLE CURVE
 NPI 56 648931.3869 2218677.3152
 NC 57 647735.3559 2217887.9597

SPIRAL OUT ST= 51.6811
 LT= 103.3492
 NCS 58 648936.3664 2218669.6647 - STA. 107+32.29
 NPI 59 648964.5586 2218626.3503
 NST 60 649016.1712 2218536.8115 - STA. 108+87.29

COMMAND:
 ? ang 91 92 74
 ? 1- 46- 41.38 DIST 92 TO 74= 410.8671
 ? 0 0 0

COMMAND:
 ? fit 41 77 92 5730 31 31 1 46 41.38 -1.0

Job No. 7622 Sht. 11 of
 By RLH Date 11/4/79 Cld
 Subject Encl Horiz Align

Job No. 1622 Sht. 12 of
 By RLH Date 11/12/72 Sld
 Subject Fiscal Hwyg Align

LT= 20.6667 SPIRAL IN ST= 10.3333
 NTS 41 649166.6452 2218275.7655 - STA. 111+88.60
 NPI 42 649176.9661 2218257.8604
 NSC 43 649182.1024 2218248.8940 - STA 112+19.60

SIMPLE CURVE
 NPI 44 649218.5954 2218185.1873
 NC 45 644210.0712 2215400.7708

SPIRAL OUT ST= 10.3333
 LT= 20.6667
 NCS 46 649253.4442 2218120.5664 - STA. 113+66.43
 NPI 47 649258.3491 2218111.4713
 NST 48 649268.1094 2218093.2547 - STA. 113+97.43

COMMAND:
 ? Fin 93 40 39 91 8
 ? 93 650521.8818 2215148.9075 ~~SA~~ PI 143+29.49
 ? 0 0 0 0 0

COMMAND:
 ? 11n 91 92 94 -100.00
 ? 94 650485.5606 2215821.0188
 ? 93 40 95 -100.00
 ? 95 650476.3505 2215237.9407
 ? 0 0 0 0

COMMAND:
 ? ang 8 91 94
 ? 21- 54- 38.77 DIST 91 TO 94= 100.0000
 ? 8 93 95
 ? 20- 48- 49.32 DIST 93 TO 95= 100.0000
 ? 0 0 0

COMMAND:
 ?

fit 13 92 91 1433 155 155 21 54 38.77 -1.0

Job No. 7622 Sta. 13 of
 By RLH Date 11-22-73
 Subject E.C. Hwy Align.

LT= 103.3492 SPIRAL IN ST= 51.6811
 NTS 13 650270.6670 2216222.0937 - STA 135+20.25
 NPI 14 650319.4764 2216130.9965
 NSC 15 650341.3859 2216084.1894 - STA 136+75.25

SIMPLE CURVE

NPI 16 650425.2160 2215905.0968
 NC 17 649043.5305 2215476.6861

SPIRAL OUT ST= 51.6811
 LT= 103.3492
 NCS 18 650457.4104 2215709.9938 - STA 140+68.25
 NPI 19 650465.8246 2215659.0023
 NST 20 650477.1143 2215556.2717 - STA 142+23.25

COMMAND:

? fit 23 91 93 1433 155 155 20 48 49.32 1.0

LT= 103.3492 SPIRAL IN ST= 51.6811
 NTS 23 650484.6532 2215487.6706 - STA. 142+92.26
 NPI 24 650495.9429 2215384.9399
 NSC 25 650504.3571 2215333.9484 - STA. 144+47.26

SIMPLE CURVE

NPI 26 650534.2783 2215152.6215
 NC 27 651918.2371 2215567.2561

SPIRAL OUT ST= 51.6811
 LT= 103.3492
 NCS 28 650608.9881 2214984.7134 - STA. 148+12.83
 NPI 29 650629.9975 2214937.4954
 NST 30 650677.0537 2214845.4804 - STA. 149+67.83

COMMAND:

? arc 55 58 1433 1 0

55 ~~647647.9249 2218476.7724~~

0 0 0

COMMAND:

? str 55 648926.3104 2218684.9016
 ? 0 0 0

COMMAND:

CONTINUED

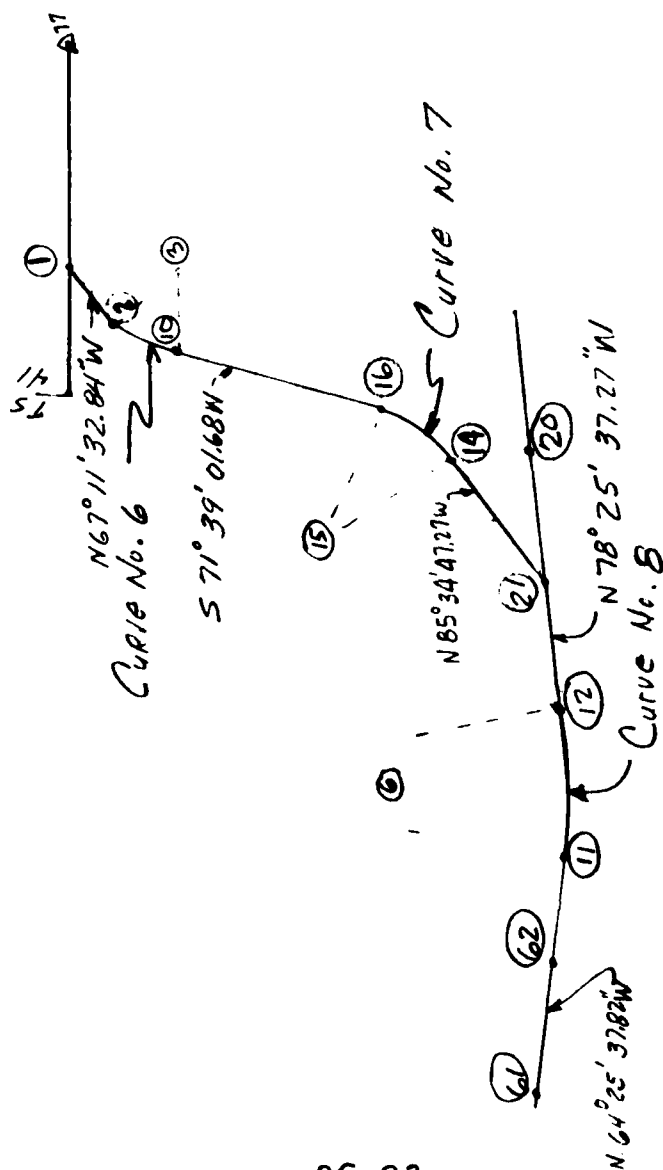
Job No. 2622 Sht. 14 of
By RLH Date 11/17/92 Chd
Subject Equal Horiz. Ht. 92

seq 55 58 1433 1 0		
ARC LENGTH=	18.2563	CHORD=
43 46 5730 1 0		
ARC LENGTH=	146.8252	CHORD=
15 18 1433 1 0		
ARC LENGTH=	393.0008	CHORD=
25 28 1433 1 0		
ARC LENGTH=	365.5625	CHORD=
0 0 000 0		

COMMAND:

Job No. 7622 SM. 15 0'
 By RLH 4/4/79
 Subject Final Horiz. Align.
Points.

② = Siding Numbers



PT 1.	STA. 110 + 93.60
PC 2.	STA. 111 + 63.60
PT 10.	STA. 114 + 57.58
PC 16	STA. 118 + 59.60
PT 14	STA. 120 + 22.24
PI 21	STA. 120 + 92.24
PC 12	STA. 121 + 22.24
PT 11	STA. 122 + 22.24
Point 62	STA. 122 + 92.24
Point 61	STA. 124 + 91.49

BY RLH DATE 1/5/79 SUBJECT HORIZ. ALIGN
CHKD BY _____ DATE _____

SHEET NO 16 OF _____
JOB NO 7622

TABULATION OF CURVE DATA

(Siding - No Spirals)

Curve
No. 6. $\left\{ \begin{array}{l} \Delta = 41^{\circ} 09' 25.48'' \\ R = 409.26' \\ D = 14^{\circ} 00' 00'' \\ LC = 293.98 \\ E = 0 \end{array} \right.$

Curve
No. 7 $\left\{ \begin{array}{l} \Delta = 22^{\circ} 46' 11.05'' \\ R = 409.26' \\ D = 14^{\circ} 00' 00'' \\ LC = 162.64' \\ E = 0 \end{array} \right.$

PI @ Point 21 $\Delta = 7^{\circ} 09' 10''$ - PI of No. 8 T.O.

Curve
No. 8 $\left\{ \begin{array}{l} \Delta = 13^{\circ} 59' 59.45'' \\ R = 409.26' \\ D = 14^{\circ} 00' 00'' \\ LC = 100.00' \\ E = 0 \end{array} \right.$

Job No. 7622 Sht. 17 of
 By RH Date 11/4/79 Ckd
 Subject Final Horiz Align
(Siding)

COMMAND:
 ? str 41 649166.6452 2218275.7655
 ? 61 649170.7811 2217027.4832 - SURVEY POINT-STA. 124+91.41
 ? 77 648934.1354 2218679.1291
 ? 62 649084.7735 2217207.2136- SURVEY POINT-STA. 122+92.24
 ? 0 0 0

COMMAND:
 ? lin 41 77 1 95.00
 ? 1 649119.2022 2218358.0708 - STA. 110+93.60 PI OF NO. 8 TURNOUT.
 ? 0 0 0 0

COMMAND:
 ? lan 41 2
 ? 1 2 70 -7 09 10
 ? 2 649146.3368 2218293.5439 - PC STA 111+63.60
 ? 1 2 3 409.26 90 00 00
 ? 3 648769.0759 2218134.8996
 ? 0 0 0 0 0 0

COMMAND:
 ? lin 62 61 11 -70.00
 ? 11 649054.5574 2217270.3562 - PT STA. 122+22.24
 ? 0 0 0 0

COMMAND:
 ? lan 62 11 13 409.26 90 00 00
 ? 13 649423.7252 2217447.0166
 ? 0 0 0 0 0 0

COMMAND:
 ? arc 12 13 -100.00 11
 ? 12 649022.7855 2217364.9125 - PC STA. 121+22.24
 ? 0 0 0 0

COMMAND:
 ? lan 13 12 20 100.00 90 00 00

Job No. 7622 Sta. 18 of 1
 By RLH Date 11/4/73
 Subject Final Horiz. Adj.
(Siding)

20 649002.7239 2217462.8795
 ? 13 12 22
 ? 30.00 00 00 00
 21 649016.7070 2217394.3024 -PI STA 120+92.24
 ? 20 24 14 70.00 -7 09 10
 14 649011.3321 2217464.0944 - PT. STA. 120+22.24
 ? 21 14 15 409.26 90 00 00
 15 649419.4148 2217495.6363
 ? 0 0 0 0 0 0

COMMAND:
 ? tan 16 15 409.26 -1 -1
 ? 0 0 0 0 0
 00180 TAN 0402 INV ARPY SUBSC
 EDIT run

COMMAND:
 ? tan
 ? 16 15 409.26 10 3 409.26 -1 -1
 16 649030.9642 2217624.4767 - PC STA. 118+59.60
 10 649157.5266 2218006.0592 PT STA 114+57.58
 ?

0 0 0 0 0 0 0

COMMAND:
 ? ibr
 ? 1 2
 ? NW 67- 1- 32.84 DIST= 70.0000
 ? 10 16
 ? SW 71- 39- 1.68 DIST= 402.0239
 ? 14 21
 ? NW 85- 34- 47.27 DIST= 70.0000
 ? 21 12
 ? NW 78- 25- 37.27 DIST= 30.0000
 ? 62 61
 ? NW 64- 25- 37.82 DIST= 199.2494
 ? 0 0

COMMAND:
 ? seq 2 10 409.26 1 0
 ? ARC LENGTH= 293.9823 CHORD= 287.7024
 ? 16 14 409.26 1 0
 ? ARC LENGTH= 162.6427 CHORD= 161.5746
 ? 0 0 0 0

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT _____ FILE NO. _____
SHEET NO. 19 OF _____ SHEETS
FOR _____
COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____

*B & O RAILROAD MAINLINE
VERTICAL ALIGNMENT*

D5-27

Job No. 7622 Est. 20 of ---
 By ELM Date 4/4/77 Ctd ---
 Subject Engl. Vert. Align.
M

PVI STA. & EL.: NEAR & FAR GRADES (%), VC LENGTH?
 ? 10343.55 613.888 0.62 1.18 280

PVC STA= 102+03.550 PVT STA= 104+83.550
 PVC ELEV= 613.020 PVT ELEV= 615.540

M.O.= 0.196

START STA., INC., END STA.
 ? 10200.00 25 11900.00

STATION	ELEVATION	TANGENT SLOPE (%)
102+00.000	612.998	0.6200
102+25.000	613.157	0.6629
102+50.000	613.329	0.7129
102+75.000	613.514	0.7629
103+00.000	613.711	0.8129
103+25.000	613.920	0.8629
103+50.000	614.142	0.9129
103+75.000	614.377	0.9629
104+00.000	614.624	1.0129
104+25.000	614.883	1.0629
104+50.000	615.155	1.1129
104+75.000	615.440	1.1629
105+00.000	615.734	1.1800
105+25.000	616.029	1.1800
105+50.000	616.324	1.1800
105+75.000	616.619	1.1800
106+00.000	616.914	1.1800
106+25.000	617.209	1.1800
106+50.000	617.504	1.1800
106+75.000	617.799	1.1800
107+00.000	618.094	1.1800
107+25.000	618.389	1.1800
107+50.000	618.684	1.1800
107+75.000	618.979	1.1800
108+00.000	619.274	1.1800
108+25.000	619.569	1.1800
108+50.000	619.864	1.1800
108+75.000	620.159	1.1800
109+00.000	620.454	1.1800
109+25.000	620.749	1.1800
109+50.000	621.044	1.1800
109+75.000	621.339	1.1800

(

110+00.000	621.634	1.1800
110+25.000	621.929	1.1800
110+50.000	622.224	1.1800
110+75.000	622.519	1.1800
111+00.000	622.814	1.1800
111+25.000	623.109	1.1800
111+50.000	623.404	1.1800
111+75.000	623.699	1.1800
112+00.000	623.994	1.1800
112+25.000	624.289	1.1800
112+50.000	624.584	1.1800
112+75.000	624.879	1.1800
113+00.000	625.174	1.1800
113+25.000	625.469	1.1800
113+50.000	625.764	1.1800
113+75.000	626.059	1.1800
114+00.000	626.354	1.1800
114+25.000	626.649	1.1800
114+50.000	626.944	1.1800
114+75.000	627.239	1.1800
115+00.000	627.534	1.1800
115+25.000	627.829	1.1800
115+50.000	628.124	1.1800
115+75.000	628.419	1.1800
116+00.000	628.714	1.1800
116+25.000	629.009	1.1800
116+50.000	629.304	1.1800
116+75.000	629.599	1.1800
117+00.000	629.894	1.1800
117+25.000	630.189	1.1800
117+50.000	630.484	1.1800
117+75.000	630.779	1.1800
118+00.000	631.074	1.1800
118+25.000	631.369	1.1800
118+50.000	631.664	1.1800
118+75.000	631.959	1.1800
119+00.000	632.254	1.1800

ODD STATION?
? 10160.00
ELEV= 612.750
? 0

TAN. SLOPE= 0.6200%

Job No. 7622 Sht. 21 of ---
By RLH Date 1/4/79
Subject Final Vert. Align.
RM

EDIT TWO
 PVI STA. & ELEV. NEAR & FAR GRADES (%), VC LENGTH?
 ? 12000.00 633.43 1.18 0.4 200.00
 PVI STA= 119+00.000 PVI STA= 121+00.000
 PVI ELEV= 632.250 PVI ELEV= 633.830
 M.O.= 0.195

START STA., INC., END STA.
 ? 11950.00 25 14400.00

STATION	ELEVATION	TANGENT SLOPE (%)
119+50.000	632.791	0.9850
119+75.000	633.025	0.8875
120+00.000	633.235	0.7900
120+25.000	633.420	0.6925
120+50.000	633.581	0.5950
120+75.000	633.717	0.4975
121+00.000	633.830	0.4000
121+25.000	633.930	0.4000
121+50.000	634.030	0.4000
121+75.000	634.130	0.4000
122+00.000	634.230	0.4000
122+25.000	634.330	0.4000
122+50.000	634.430	0.4000
122+75.000	634.530	0.4000
123+00.000	634.630	0.4000
123+25.000	634.730	0.4000
123+50.000	634.830	0.4000
123+75.000	634.930	0.4000
124+00.000	635.030	0.4000
124+25.000	635.130	0.4000
124+50.000	635.230	0.4000
124+75.000	635.330	0.4000
125+00.000	635.430	0.4000
125+25.000	635.530	0.4000
125+50.000	635.630	0.4000
125+75.000	635.730	0.4000
126+00.000	635.830	0.4000
126+25.000	635.930	0.4000
126+50.000	636.030	0.4000
126+75.000	636.130	0.4000
127+00.000	636.230	0.4000

Job No. 7622 - 22 of -
 S. RLH - 79 CRD
 Subject Elev. Adj. Align
Q

Job No. 7622 Site 23 of
By RLH Date 11/4/79
Subject Final Vert. Align.
NY

127+25.000	636.330	0.4000
127+50.000	636.430	0.4000
127+75.000	636.530	0.4000
128+00.000	636.630	0.4000
128+25.000	636.730	0.4000
128+50.000	636.830	0.4000
128+75.000	636.930	0.4000
129+00.000	637.030	0.4000
129+25.000	637.130	0.4000
129+50.000	637.230	0.4000
129+75.000	637.330	0.4000
130+00.000	637.430	0.4000
130+25.000	637.530	0.4000
130+50.000	637.630	0.4000
130+75.000	637.730	0.4000
131+00.000	637.830	0.4000
131+25.000	637.930	0.4000
131+50.000	638.030	0.4000
131+75.000	638.130	0.4000
132+00.000	638.230	0.4000
132+25.000	638.330	0.4000
132+50.000	638.430	0.4000
132+75.000	638.530	0.4000
133+00.000	638.630	0.4000
133+25.000	638.730	0.4000
133+50.000	638.830	0.4000
133+75.000	638.930	0.4000
134+00.000	639.030	0.4000
134+25.000	639.130	0.4000
134+50.000	639.230	0.4000
134+75.000	639.330	0.4000
135+00.000	639.430	0.4000
135+25.000	639.530	0.4000
135+50.000	639.630	0.4000
135+75.000	639.730	0.4000
136+00.000	639.830	0.4000
136+25.000	639.930	0.4000
136+50.000	640.030	0.4000
136+75.000	640.130	0.4000
137+00.000	640.230	0.4000
137+25.000	640.330	0.4000
137+50.000	640.430	0.4000
137+75.000	640.530	0.4000

138+00.000
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643.030

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Job No. 7622 of 24
By RLH Date 11/11/77 CWD
Subject Engg/Vert. Align.
NY

ODD STATION?

? 0

END OF PROGRAM VC

EDIT run
PVI STA. & EL. NEAR & FAR GRADES(%). VC LENGTH?
? 14546.14 643.61 0.4 0.74 200

PVC STA= 144+46.140 PVT STA= 146+46.140
PVC ELEV= 643.210 PVT ELEV= 644.350
M.O.= 0.085

START STA. INC. END STA.?
? 14425.00 25 14850.00

STATION	ELEVATION	TANGENT SLOPE(%)
144+25.000	643.125	0.4000
144+50.000	643.225	0.4066
144+75.000	643.332	0.4491
145+00.000	643.450	0.4916
145+25.000	643.578	0.5341
145+50.000	643.717	0.5766
145+75.000	643.866	0.6191
146+00.000	644.026	0.6616
146+25.000	644.197	0.7041
146+50.000	644.378	0.7400
146+75.000	644.563	0.7400
147+00.000	644.748	0.7400
147+25.000	644.933	0.7400
147+50.000	645.118	0.7400
147+75.000	645.303	0.7400
148+00.000	645.488	0.7400
148+25.000	645.673	0.7400
148+50.000	645.858	0.7400

ODD STATION?
? 14857.90
ELEV= 645.917
? 0
TAN. SLOPE= 0.7400%

END OF PROGRAM VC

EDIT

Job No. 7622 Sht. 25 of
By RCH Date 11/4/79 Cld
Subject Final Vert. Align
MY

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT _____ FILE NO. _____
SHEET NO. 26 OF _____ SHEETS
FOR _____
COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____

*B & O RAILROAD SPURLINE
VERTICAL ALIGNMENT*

05-34

Job No. 7622 Date 11/4/79
 By RLH Eng. 11/4/79
 Subject Final Vert Align
SIDING

run
 PVI STA. & EL. NEAR & FAR GRADES(%), VC LENGTH?
 ? 11211.27 624.13 1.18 -0.643 100
 PVC STA= 111+61.270 PVI STA= 112+61.270
 PVC ELEV= 623.540 PVI ELEV= 623.808
 M.O.= 0.228
 CURVE HIGH POINT= 623.922 STATION= 112+25.998
 START STA., INC., END STA.?
 ? 11125.00 25 11650.00

STATION	ELEVATION	TANGENT SLOPE(%)
111+25.000	623.112	1.1800
111+50.000	623.407	1.1800
111+75.000	623.685	0.9297
112+00.000	623.860	0.4740
112+25.000	623.921	0.0182
112+50.000	623.869	-0.4375
112+75.000	623.720	-0.6430
113+00.000	623.559	-0.6430
113+25.000	623.398	-0.6430
113+50.000	623.238	-0.6430
113+75.000	623.077	-0.6430
114+00.000	622.916	-0.6430
114+25.000	622.755	-0.6430
114+50.000	622.595	-0.6430
114+75.000	622.434	-0.6430
115+00.000	622.273	-0.6430
115+25.000	622.113	-0.6430
115+50.000	621.952	-0.6430
115+75.000	621.791	-0.6430
116+00.000	621.630	-0.6430
116+25.000	621.469	-0.6430
116+50.000	621.309	-0.6430

ODD STATION?
 ?
 ? 0
 END OF PROGRAM VC

EDIT Run
PVI STA. & EL. NEAR & FAR GRADES(%), VC LENGTH?
? 11670.00 25

621.18 -0.643 -1.3281 100

PVC STA= 116+20.000 PVT STA= 117+20.000
PVC ELEV= 621.501 PVT ELEV= 620.516
M.O.= 0.086

START STA., INC., END STA.
? 11675.00 25 12100.00

STATION	ELEVATION	TANGENT SLOPE(%)
116+75.000	621.044	-1.0193
117+00.000	620.768	-1.1911
117+25.000	620.449	-1.3281
117+50.000	620.117	-1.3281
117+75.000	619.785	-1.3281
118+00.000	619.453	-1.3281
118+25.000	619.121	-1.3281
118+50.000	618.789	-1.3281
118+75.000	618.457	-1.3281
119+00.000	618.125	-1.3281
119+25.000	617.793	-1.3281
119+50.000	617.461	-1.3281
119+75.000	617.129	-1.3281
120+00.000	616.797	-1.3281
120+25.000	616.465	-1.3281
120+50.000	616.133	-1.3281
120+75.000	615.801	-1.3281
121+00.000	615.469	-1.3281

ODD STATION?

0

END OF PROGRAM UC

Job No. 7622 Sta. 28 of
By RLH Date 11-7-78 Ckd.
Subject Eng. for Road
Swing

```

EDIT RUN
PVI STA. & EL.. NEAR & FAR GRADES(%), VC LENGTH?
? 12172.24 614.51 -1.3281 0.74 100

```

```

PVC STA= 121+22.240 PVI STA= 122+22.240
PVC ELEV= 615.174 PVI ELEV= 614.880
M.O.= 0.259
CURVE LOW POINT= 614.747 STATION= 121+86.458

```

```

START STA.. INC.. END STA.?
? 12125.00 25 12200.00

```

STATION	ELEVATION	TANGENT SLOPE(%)
121+25.000	615.138	-1.2710
121+50.000	614.885	-0.7540
121+75.000	614.760	-0.2370
122+00.000	614.766	0.2801

```

ODD STATION?
? 12291.49
ELEV= 615.392 TAN. SLOPE= 0.7400%
? 0

```

END OF PROGRAM VC

```

EDIT end
READY logoff
LOGGED OFF AT 13.59.55 01/04/79
#SESSION DURATION 00.24.34 CPU TIME USED 60153/300THS SEC.
#####

```

Job No. 7622 Sht. 29 of
 By R.H. Date 11/4/79 Ckd
 Subject Encl. Vert. Align
Siding

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek Flood Control Project FILE NO. 7622
B&O Railroad Relocation SHEET NO. 10 OF SHEETS
FOR U.S. Army Corp of Engineers
COMPUTED BY RLH DATE 1/8/79 CHECKED BY W.M DATE 1/16/79

DRAINAGE OF TRAIL AREAS

The Drainage has been studied with the following results:

- 1). The drainage area between the Norfolk & Western Railroad and the Relocated B&O R.R. from Fulton Road to Sta. 147[±] is considered not to have been disturbed or altered and will drain as present conditions allow.
- 2). The drainage area between the N&W R.R. and the Relocated B.&O. R.R. from Sta. 118+50[±] to Sta. 147[±] is approximately 4 Acres in size. This area will be drained with the use of a one(1) foot deep ditch below subgrade between the tracks and on a percent of grade equal to that of the top of rail. This will be outletted through a 18" Reinforced Cement Concrete Pipe Class IV, under the B.&O. Railroad and to the top of slope. A paved slope ditch will carry the discharge from the 18" RCP down the slope to the channel.
- 3) The drainage area between the N&W R.R. and the B.&O. R.R. from Pearl Road to 118+50[±] is approx. 1/2 acre in size. This area will drain by use of the normal swale between tracks (45" deep) and on a grade equal to that of the top of rail. This will be intercepted by a small headwall 10 feet west of the proposed Mainline B.O. R.R. Bridge abutment. This will be outletted through a 15" Reinforced Cement Concrete Pipe, Class IV placed through the abutment allowing water to free fall into channel.

D5-38

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek Flood Control Project FILE NO. 7622
B. & O. Railroad Relocation SHEET NO. 31 OF SHEETS
FOR U.S. Army Corp of Engineers
COMPUTED BY RLH DATE 1/8/79 CHECKED BY W.M. DATE 1/16/79

- 4) The drainage area east of Pearl Road between N&W and B.&O. tracks will be drained by one (1) foot deep ditch located as shown on plans and outletted directly to Big Creek.
- 5) The drainage area on the north side of the B.&O. Spur line between the tracks and the channel will drain as existing conditions permit.
- 6) The drainage area on the south side of the Spurline will be drained by use of a one (1) foot deep ditch located at the toe of Slope and graded to drain directly toward the channel.

Drainage Ref. - U.S Dept of Transportation
Hydraulic Eng. Circular No 12
Hydraulic Design Series No. 3

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Drainage between tracks FILE NO. _____
SHEET NO. 32 OF _____ SHEETS
FOR _____
COMPUTED BY RLH DATE 1/8/79 CHECKED BY W.M. DATE 1/25/79

Area Between Tracks (Sta. 118+50 Rt to Pearl)

Avg. Length 800' x Avg. Width 26' $\div$ 43560 = .48 Ac.

Use: 10 year storm, $C = .6$ (n)_{ditch} = .025

El. 633

- 620

$$S = 13 \div 800 = .016 \quad K = \frac{60.9}{1.016} = 6275.7 \div 1000 = 6.3$$

From chart: Time = 5 min

$T_{conc} = T_{duration}$

$$intensity = 2(2.22)(1.6) = 7.1 \text{"/in.}$$

$$Q = (.6)(7.1)(.48) = 2.04 \text{ cfs.} \quad V = 2.6 \text{ fps}$$

This will drain with swale between tracks carried to bridge abut & outlet pipe through abut.

Use 15" RCCP

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Drainage between tracks FILE NO. _____
SHEET NO. 33 OF _____ SHEETS
FOR _____
COMPUTED BY ELH DATE 1/8/79 CHECKED BY W.M. DATE 1/25/79

Area Between Tracks (Fulton to Sta. 118+50 RT)

$$\text{Avg. Length } 2850' \times \text{Avg. Width } 63' \div 43,560' = 4.12 \text{ Ac.}$$

Use: 10 year storm $C = .6$ $n(\text{ditch}) = .025$

El. 650

- 633

$$S = 17 \div 2850 = .00596 \quad K = \frac{2850}{\sqrt{.00596}} = 36916.6 \div 1000 = 36.92$$

From Chart: TIME = 21 min.

$T_{\text{conc}} = T_{\text{duration}}$

$$\text{intensity} = (2) (1.25)^{\frac{2 \text{ min.}}{1 \text{ hr.}}} (1.6) = 4''/\text{hr.}$$

$$Q = (.6)(4'')(4.12) = 9.9 \text{ c.f.s.} \quad v = 2.72 \text{ f.p.s.}$$

Ditch 1' deep 2:1 sides = depth in ditch of 0.95'

Use 18" CL. IV

Use 3'-0" min. cover

From Concrete Design Manual Loading on pipe = 3955 #/ft
(E72 Design Loading - Impact Included)

Assume CL. C Bedding $L_f = 1.5$

Factor of Safety 1.0

$$D_{.001} = \frac{3955}{1.5 \times 1.5 \times 1.0} = 1758 \text{ #/Lin ft inside dia.}$$

From AASHTO M170 - Use CL III RCCP

D5-41

Job No. 7622 Sht. 24 of
 By R.H. Date 4-21 Ckd
 Subject Controlled Survey
Point

COMMAND:

? str 10 649008.78 2218363.99
 ? 11 648554.50 2219251.42
 ? 21 649106.18 2218409.23
 ? 22 648599.40 2219319.79
 ? 6 650528.78 2215124.76
 ? 5 650855.32 2214515.40
 ? 9 649343.48 2217661.34
 ? 91 650438.3333 2215909.1639
 ? 8 650476.8864 2215558.3454
 ? 0 0 0

COMMAND:

? lan 10 9 99 470.21 107 54 03.9
 ? 99 649001.6761 2217338.4352
 ? 10 11 31 73.24 179 13 03.5
 ? 31 648522.0199 2219317.0641
 ? 22 21 52 584.78 00 18 0.3
 ? 52 648819.1219 2218918.7055
 ? 22 21 51 661.14 181 21 31.2
 ? 51 649441.3080 2217839.3218
 ? 10 11 32 10.18 228 10 37.7
 ? 32 648544.6539 2219254.0058
 ? 10 11 33 26.80 339 11 25.1
 ? 33 648557.4402 2219224.7818
 ? 10 11 34 126.64 354 58 38.5
 ? 34 648602.1153 2219134.0724
 ? 10 11 35 425.31 359 57 27.5
 ? 35 648748.0216 2218872.6879
 ? 10 11 36 575.00 00 15 03.2
 ? 36 648818.7498 2218740.7371
 ? 5 6 37 295.62 175 32 44.6
 ? 37 650409.8078 2215395.3830
 ? 5 6 38 80.9 02 55 20.7
 ? 38 650570.5773 2215055.4939
 ? 5 6 39 206.90 00 14 36.4
 ? 39 650627.2792 2214942.8108
 ? 5 6 40 606.25 359 21 29
 ? 40 650809.1256 2214587.2236
 ? 0 0 0 0 0 0

COMMAND:

? lan 9 99 61 353.96 255 10 02.2
 ? 61 649170.7811 2217027.4832
 ? 9 99 62 155.32 258 58 23
 ? 62 649084.7735 2217207.2136

? 9 99 63 96.07 261 02 28.5
 ? 63 649055.9699 2217259.1785
 ? 9 99 64 40.86 29 30 18.9
 ? 64 649013.7065 2217377.4240
 ? 9 99 65 97.10 47 54 49.8
 ? 65 648999.4981 2217435.5108
 ? 9 99 66 250.06 57 25 58.2
 ? 66 648954.8014 2217584.0625
 ? 9 99 67 11.35 165 25 55.2
 ? 67 648991.7303 2217332.9667
 ? 9 99 68 64.82 103 52 02.4
 ? 68 648947.1668 2217373.5119
 ? 9 99 69 161.77 48 11 30.7
 ? 69 648997.2629 2217500.1450
 ? 9 99 70 321.61 46 35 13
 ? 70 649001.9099 2217660.0451
 ? 9 99 71 402.15 47 00 37.4
 ? 71 648998.9964 2217740.5763
 ? 0 0 0 0 0 0

CONTROL POINT	CORR. CHAINED DIST.	CORR. EDM DIST.
MON. 121 to 122		1042.10'
121 to B&O-1	31	661.14'
121 to B&O-2	52	584.78'
MON. 111 to 110		—
111 to B&O-1	31	73.24'
111 to B&O-2	32	10.18'
111 to B&O-3	33	26.80'
111 to B&O-4	34	126.64'
111 to B&O-5	35	425.31'
111 to B&O-6	36	575.00'
MON. 106 to 105		691.35'
106 to B&O-7	37	295.62'
106 to B&O-8	38	80.90'
106 to B&O-9	39	206.90'
106 to B&O-10	40	606.25'
MON. 109 to 109A		470.21'
109A to B&O S1	41	353.96'
109A to B&O S2	42	155.32'
109A to B&O S3	43	96.07'
109A to B&O S4	44	40.86'

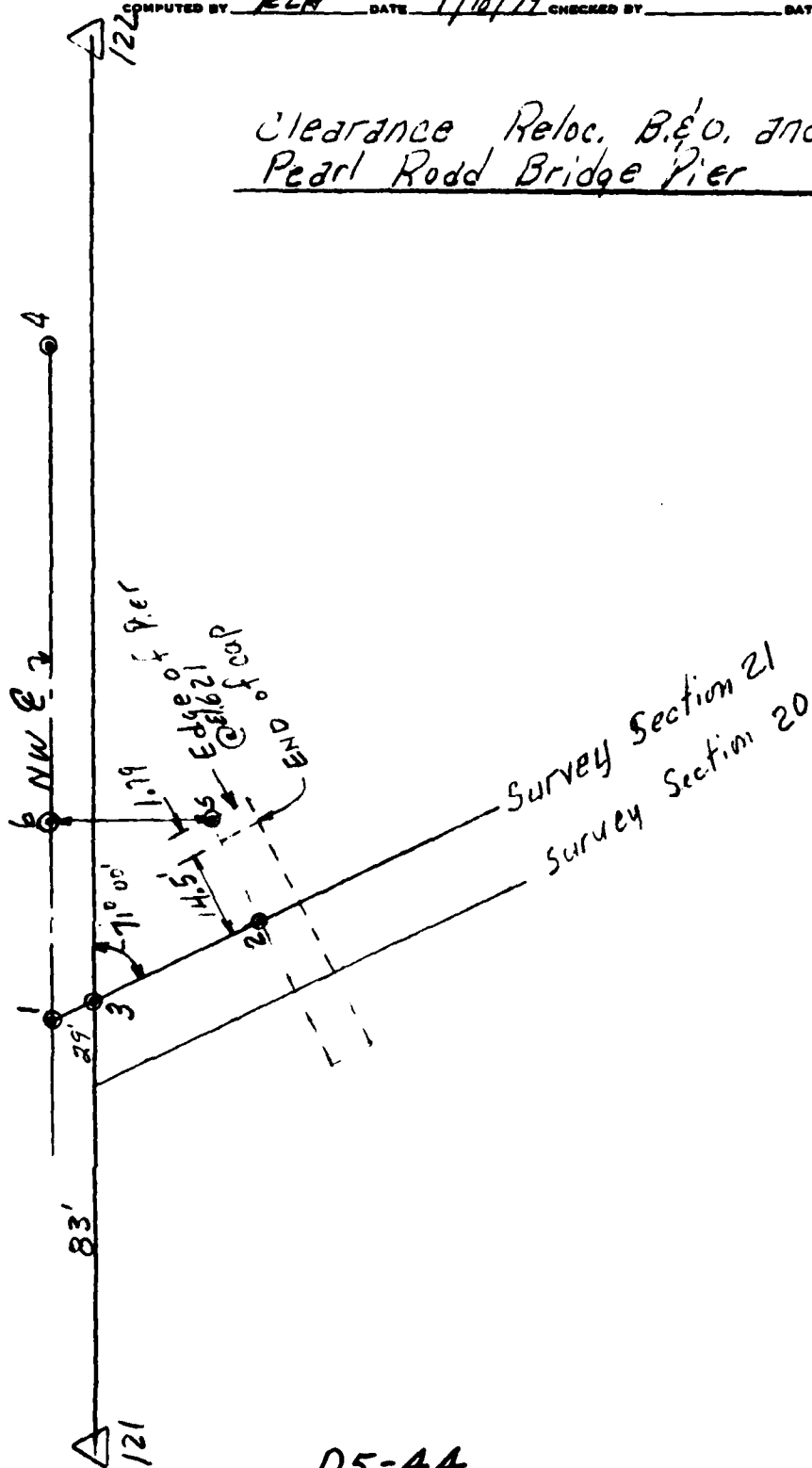
CONT. 'D on PG. 2A

CONTROL POINT	CORR. CHAINED DIST.	CORR. EDM DIST.
109A to B&O S5	45	97.10'
109A to B&O S6	46	250.06'
109A to B&O S7	47	11.35'
109A to B&O S8	48	64.82'
109A to B&O S9	49	161.77'
109A to B&O S10	50	321.61'
109A to B&O S11	51	402.15'

GANNETT FLEMING CORDRY
AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT Big Creek Flood Control Project FILE NO. 7622
B.&O. Railroad Relocation SHEET NO. 36 OF SHEETS
FOR U.S. Army Corp of Engineers
COMPUTED BY RLH DATE 1/10/79 CHECKED BY DATE

Clearance Reloc. B.&O. and
Pearl Rodd Bridge Pier



D5-44

Job No. 7622 Sht. 37 of
 by RLH Date 11/9/79 CMAA
 Subject Clearance Reloc B & O.
2nd Pearl Road Bridge *
Pier

* West 25th Street Bridge

? str 3 1000.000 1000.000
 ? 0 0 0

COMMAND:
 ? 1az 3 1 4.0 0 00 00
 ? 1 1004.0000 1000.0000
 ? 0 0 0 0 0 0

COMMAND:
 ? 1ln 3 1 2 -50.00
 ? 2 950.0000 1000.0000
 ? 0 0 0 0

COMMAND:
 ? 1an 3 2 5 16.29 90 00 00
 ? 5 950.0000 1016.2900
 ? 2 1 4 50.00 -71 00 00
 ? 4 987.7216 1047.2759
 ? 0 0 0 0 0 0

COMMAND:
 ? tof 6 5 1 4
 ? 6 993.2617 1031.1862
 ? 0 0 0 0

COMMAND:
 ? dis 6 5
 ? 45.754498
 ? 0 0

CLR = 45.75
-20.00
 25.75' @ Tracks
 @ To Face of pier

COMMAND:
 ? eoi
 END OF PROGRAM COG
 EDIT end
 READY logoff

GANNETT FLEMING CORDDRY & CARPENTER, INC.

Program No. 175

IBM SYSTEM/360

COGO

April, 1975

D5-46

DESCRIPTION OF PROGRAM

General Concept

The COGO programming system is designed specifically for civil engineering geometry problems. It may, however, be used in other application areas; in fact, there is almost no limit to the applicability of the system concept.

COGO is based on a vocabulary used by the engineer to state his problem. The statement of the problem in this familiar vocabulary and the input of these statements to the computer are all that is necessary to generate the solution to the problem. No programming, in the usual sense of the word, is necessary.

For example, an engineer interested in determining the area of the enclosed plat 7-5-3-8 states the problem as shown in Figure 1. The information in Figure 1 (with the exception of the diagram) is entered into the computer and the area is typed out automatically. One begins by giving the known information to the computer and then commanding it to perform specific functions on the known or previously calculated data. In this case the command AREA is used. It asks the computer to find the AREA of the enclosed polygon. Appearing right after the command is the result, so that the engineer can follow the sequence of calculation and keep a high degree of familiarity with the problem.

If the engineer wants the distance between points 5 and 8, he enters the command DISTANCE 5-8. The distance between points 5 and 8 is then typed out by the computer.

In practice, the engineer, using a sketch of his problem, writes the description of his problem and how to solve it as if he were solving it by hand. As a guide he follows the command descriptions shown later in this manual. Once he has written the commands on paper, he has a "computer program" for his problem. He then punches these on cards for entry into the 360. No intermediate programming is necessary.

Basis of System

The COGO Programming system is based on the repetitive use, by many different programs, of common data storage. This common data storage area is known as the "coordinate table". The engineer uses the COGO vocabulary to locate points on a traverse, subdivision, or along some alignment, etc. The points may be used in later calculations by other COGO commands and may be printed for immediate use. The engineer gives each point an identification number and refers to that point by number whenever it is needed.

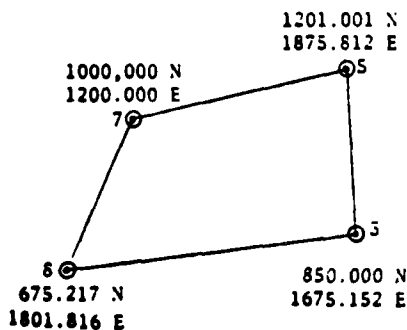


FIGURE 1

STORE	7	1000.000	1200.000
	3	850.000	1675.152
	8	675.217	1801.816
	5	1201.001	1875.812

AREA 7 5 3 8 7

AREA = 184463.3598 sq ft. = 4.25 ACRES

DISTANCE 5 8

From PT 5 to PT 8 DIST = 952.5016

GENERAL INFORMATION

Operators. In 360 COGO, distances, angles, and azimuths can be specified by using an operator (a single character) and the required number of identifying points. For example, if two points of a line are known but the unknown distance is required as part of a command, the operator D may be used as follows to input the distance:

D 21 22

(where points 21 and 22 are the two known points of the line). In this case, if the operator were not used, the distance would have to be calculated either manually or by a previous run.

The following operators will be used to denote values to be calculated from known points:

<u>Operator</u>	<u>Points</u>	<u>Description</u>
D	XXX YYY	Denotes a straight-line distance from point XXX to point YYY.
A	XXX YYY	Denotes the Azimuth from point XXX to point YYY.
G	XXX YYY ZZZ	Denotes the angle at point YYY, clockwise from XXX to ZZZ.

At least one blank must be used before an operator but is optional after the operator. A blank must appear between the point numbers.

Bearings. Bearings are entered into command cards by either the quadrant method or the N,S,E,W delimiter method. In the former, a bearing is entered as quadrant, degrees, minutes, and seconds. The quadrant is coded as follows: NE=1, SE=2, SW=3, NW=4. For example, 1 30 05 58.0 is the code for N 30° 5'58.0"E.

In the delimiter method, the angle must be bracketed by the characters S or N (on the left) and E or W (on the right). At least one blank must precede each delimiter; blanks following a delimiter are optional. Looking at the same example as above, N 30 05 58.0 E is the code for N 30° 5'58.0" E.

Angles and azimuths. Angles and azimuths are entered as degrees, minutes, and seconds. For example 75 0 5.0 is the code for 75° 0' 5.0". (However, degree of curvature is given in decimal degrees.)

Note that at least one blank column separates degrees from minutes, and minutes from seconds. Degrees and minutes should be entered as integer quantities; the seconds must contain a decimal point and can contain decimal digits as well. Only the degrees portion carries a sign. To conform with practice, azimuths must be entered as positive quantities, measured clockwise from the north.

Zeros and small negative angles. Zeros must be included in the data. For example, an angle of zero degrees, zero minutes, and zero seconds must be entered as 0 0 0.0.

With counterclockwise angles (negative angles) of less than one degree (for example, -0 12 27.0), use the 360° complement of the angle as the clockwise angle, since minus zero is not distinguishable from plus zero. In the example given, -0 12 27.0 must be entered as 359 47 33.0.

Coordinate System

360 COGO uses a Y (North), X (East) coordinate system. Therefore coordinates must be entered in this order. The output is also given in this order.

Legal Numbers

For input to any COGO command, the user is permitted a maximum of 16 numerical characters plus a decimal and a minus sign. (Leading and trailing zeros are counted as numeric characters.)

COGO Output

The output of a COGO job is printed out on the printer. The output format has answers interspersed with the listing of the input commands. The one exception to this is the LOTS/COMP command which has the listing of the input command suppressed to improve the output format.

When cards are punched as output to the Dump Command, the cards are punched in the Store Command format in order that these same cards may be used for a future run as store command input.

Coordinates and Curves

Up to 2000 points can be stored in 360 COGO. Number points from 1 to 2000.
Up to 50 curves can be stored and referenced. Number curves from 1 to 50.

GENERAL RULES

There are some general rules which should be followed when writing COGO Input. Following the rules listed below can amount to a considerable saving of both time and computer costs by eliminating unnecessary reruns due to carelessly written input.

1. Write clearly on input forms.
2. Supply all necessary data for each command.
3. Use the CLEAR Command at the start of a new job.
4. Use the END/OF/JOB Command at the end of each run.
5. Numerical input must not begin before column 12 when using Long Form Command.
6. Numerical Input must not begin before column 5 when using Short Form Command.
7. The first column of a Comment Card shall contain an Asterisk (*) - the comment itself shall not start before column 5 and must end before column 73.
8. An Asterisk (*) after the last input data on each card allows a comment to be written in the remaining portion of the card. This comment must end before column 73.
NOTE: Allow at least one blank space between the last piece of data and the Asterisk.
9. Angles are input in degrees, minutes, and seconds.
10. Minus angles must be signed for degrees only.
11. The LOTS/COMP Command cannot be used once Plotting has been initiated by the SCALE Command (#65) and until Plotting has been completed by the SCALE Command (#75).

INDEX OF COMMANDS

<u>Number</u>	<u>Long Form</u>	<u>Short Form</u>
1	END/OF/JOB	EOJ
2	STORE	STR
3	CLEAR	CLR
4	DUMP	DMP
5	*	*
6	REDEFINE	RED
7	EJECT	EJT
8	DISTANCE	DIS
9	LOCATE/AZIMUTH	LAZ
10	LOCATE/BEARING	LBR
11	LOCATE/ANGLE	LAN
12	LOCATE/LINE	LLN
13	LOCATE/DEFLECTION	LDF
14	INVERSE/AZIMUTH	IAZ
15	INVERSE/BEARING	IBR
16	PARALLEL/LINE	PLN
17	TANGENT/OFFSET	TOF
18	RT/TRI/HYP	RTH
19	RT/TRI/LEG	RTL
20	ANGLE	ANG
21	ARC/POINT	ARC
22	POINTS/INTERSECT	PIN
23	AZ/INTERSECT	AIN
24	BR/INTERSECT	BIN
25	DIVIDE/LINE	DLE
26	ARC/LINE/POINTS	ALP
27	ARC/ARC/INTERSECT	AA
28	ARC/LINE/AZ	ALA
29	ARC/LINE/BR	ALB
30	DIVIDE/ARC	DAE
31	SEGMENT	SEG
32	SEGMENT/PLUS	SPL
33	SEGMENT/MINUS	SNI
34	TANGENT	TAN
35	SIMPLE/CURVE	SC
36	DEFINE/CURVE	DC
37	ALIGNMENT	ALN
38	COORD/POA	CPA
39	COORD/OFFSET	COF
40	OFFSET/ALIGN	OFA
41	STATION/FROM/COORD	SFC
42	SIMPLE/SPIRAL	S/S
43	SPIRAL/LENGTH	S/L
44	SPIRAL/OFFSET	S/O
45	COORD/POSP	COP
46	LINE/SPIRAL	L/S
47	COMPOUND/SPIRAL	C/S
48	SPIRAL/SPIRAL	SS
49	CURVE/SPIRAL	CS
50	FIT/ALIGNMENT	FA

51	AREA	AR
52	AREA/AZIMUTHS	ARA
53	AREA/BEARINGS	ARB
54	AREA/STORI	AST
55	MULTIPLY/AREA	MUA
56	TOTAL/AREA	TOA
57	LOTS/COMP	LOT
58	DIVIDE/AREA	DA
59	ADJUST/DEFLECTION/LS	ADS
60	ADJUST/AZIMUTH/LS	AAS
61	ADJUST/BEARING/LS	ABS
62	VERTICAL/START	VS
63	VERTICAL/END	VE
64	EVEN/STATIONS	ES
65	OFFSET/ELEV	OL
66	CURVE/DRAIN	CD
67	SLOPE/LENGTH	SL
68	SCALE	SCL
69	PLOT	PLT
70	PLOT LINES	PLL
71	PLOT/CURVE	PLC
72	PLOT/ALIGNMENT	PLA
73	PLOT/POINTS	PLP
74	PLOT/DASHL	FDL
75	SCALE	SCL
76	PLOT/SPIRAL	PLS
77	PLOT/DESCRIPTION	PTD
78	PLOT/SYMBOL	PTS
79	STOP/PLOT	STP
80	OPEN/FILE	OPF
81	CLOSE FILE	CLF
82	READ/FILE	REF
83	WRITE/FILE	WRF
84	RT/TRI/PT	RTP

ATE
MED
8