Los Angeles County Flood Control District

DESIGN MANUAL

STRUCTURAL

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GENERAL CRITERIA AND
ALLOWABLE STRESSES

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

STRUCTURAL DESIGN CRITERIA

November, 1970

Section A

General Criteria and Allowable Stresses

A-1 Method of Design

The design of reinforced concrete members shall be made with reference to allowable working stresses, service loads, and the accepted straight-line theory of flexure. Designs made with reference to load factors and ultimate strengths are not acceptable unless prior District approval is obtained.

All members of frames or continuous construction shall be designed to resist at all sections the maximum effects of the prescribed loads. Loads shall be placed in the combination(s) that induce the maximum stresses at any section.

A-2 Allowable Stresses

A-2.1 Conduits and Hydraulic Structures

Allowable concrete and reinforcing steel unit stresses shall be as shown below.

Design criteria not specifically covered in this manual shall be as specified in the 1963 Edition of the "Building Code Requirements for Reinforced Concrete" (ACI 318-63) published by the American Concrete Institute.

Main stress - carrying bars shall comply with A.S.T.M. A-615, Grade 60. Longitudinal steel shall comply with either A.S.T.M. A-615, Grade 40 or A.S.T.M. A-615, Grade 60.

A-2 Allowable Stresses continued.
(A-2.1 Conduits and Hydraulic Structures)

The 28-day compressive strength of the concrete shall be assumed to be 4000 psi except for reinforced concrete pipe over 108 inches in diameter, cast-in-place pipe, and prestressed pipe.

See discussion herein for increases in allowable stresses for loadings of short duration.

Concrete	Maximum Stress	Any Strength Concrete	Stress for f'_c = 4000 psi
Flexure, f_c			
Extreme fiber in compression		$0.45\ f'_c$	1800 psi
Extreme fiber in tension, in plain concrete		$1.62\sqrt{f'_c}$	102
Extreme fiber in tension, reinforced concrete		None	
Shear, v			
Beams without web reinforcing		$1.1\sqrt{f'_c}$	70
Horizontal shear in shear keys		$.10\ f'_c$	400
Bond, u			
Top bars *	350 psi	$3.4\sqrt{f'_c}/D$	215/D
All others	500	$4.8\sqrt{f'_c}/D$	304/D
Bearing, f_c			
On full area			1000 psi
On 1/3 area or less			1500 psi

*Top bars are horizontal bars having more than 12 inches of concrete cast in the member below the bar.

A-2 Allowable Stresses continued.
(A-2.1 Conduits and Hydraulic Structures)

Reinforcing Steel	Unit Stresses
Tension	
Flexural members and web reinforcing	24,000 psi
Compression	
Combined flexure and axial stress Compression, flexural members	nfc n times the Compression in the surrounding concrete

For splices use 30 bar diameters minimum for stressed reinforcing steel carrying moment or direct stress, and 20 bar diameters for other reinforcing steel such as that carrying temperature and shrinkage stresses.

Shear stress shall be calculated in accordance with Section 1201 of ACI 318-63.

Anchorage requirements for reinforcing steel shall be as specified in Section 918 of ACI 318-63.

The minimum and maximum reinforcing bar size for cast-in-place conduits shall be No. 4 and No. 9, respectively. The clear distance between parallel bars shall not be less than the nominal bar diameter, 1-1/2 times the maximum size coarse aggregate, nor 1 inch. The principal reinforcement shall be centered not farther apart than 3 times the member thickness nor more than 18 inches. Where conduit is to be constructed on curves, special attention shall be given to steel details to insure that the spacing on the inside of curves is not less than the allowable.

A-2.2 Buildings

Allowable stresses for buildings shall be as specified in the current editions of the American Concrete Instutute's "Building Code Requirements for Reinforced Concrete" and the "Manual of Steel Construction" of the American Institute of Steel Construction.

A-2 Allowable Stresses continued.

A-2.3 Other Agencies

Where the structure is to be constructed in the right of way of other agencies, such as the Corps of Engineers, Railroad Companies, etc., the agency shall be consulted regarding their structural criteria. In general, all structures should be designed in accordance with District criteria, however, if these agencies have particular requirements, such as additional cover on steel, their criteria shall be followed.

Prior to submittal of the structural details for railroad crossings, the method of construction (i.e. jacking, open cut, etc.) shall be approved by the railroad. The District will arrange for conferences between the designing agency, the District and the railroad companies.

A-3 Loads

A-3.1 Conduits and Hydraulic Structures

A-3.1.1 Live Load

1. Structures should, in general, be designed to withstand loads imposed by one H20-S16-44 truck as defined by the American Association of State Highway Transportation Officials (A.A.S.H.T.O.). One truck per traffic lane should be assumed. Charts for the determination of these loads are included herein.

A-3.1.2 Earth Load

1. Vertical earth loads should be calculated in accordance with Marston's theory for loads on buried conduits. The project soil report shall be reviewed to determine the probable in place density of the backfill material. This shall be assumed to be 85 percent of the indicated maximum relative compaction; however, in no case shall the soil density be assumed to be less than 110 pounds per cubic foot.

2. Lateral soil pressures should be based on an equivalent fluid distribution. The equivalent fluid pressure shall be equal to one third the assumed soil density. This pressure shall be increased whenever it is indicated the soil may contain substantial amounts of water.

A-3 Loads continued.

A-3.2 Buildings

In general, buildings shall be designed for the loads specified in the applicable building code. For pump stations refer to loadings specified in the District's Pump Station Manual. Proposed loadings shall be approved by the District prior to start of structural design.

A-4 Economy of Design

Sufficient structural analysis shall be made to determine the economical section. This shall include investigation of various height to width ratios, maximum span, proportioning of members, steel layouts, etc. These are discussed in detail in the various sections herein.

SECTION B

COMPUTER DESIGN

Section B

Computer Design

B-1 General

The use of electronic computers for the production of structural data and details is acceptable and encouraged. Where applicable it is requested that District programs shall be used. Prior approval must be obtained if a program other than a District program is used.

Calculations for structures carrying railroad loads are subject to the approval of the railroad company involved. The acceptability of designs processed by a computer shall be checked with the company involved.

B-2 Programs Not Developed by the District

Programs developed by other agencies, engineering firms, or data processing companies may be acceptable provided the following procedure is complied with.

1. The District be consulted prior to the development or use of computer programs for structural design.

2. The program logic shall contain a routine that will result in the economical section.

3. A listing of the Source Program shall be submitted to the District for review.

4. The Program Input for each structure shall be printed by the computer and submitted to the District with the final drawings.

5. The Program Output for each structure shall be printed by the computer and submitted to the District with the final drawings.

6. The following is a list of the items that shall be submitted for a typical box conduit design. Similar items shall be sumitted for other type structures.

   Input or Calculated Values

   a. Box width and height

   b. Design cover

   c. Pressure head

B-2 Programs Not Developed by the District continued.

d. Live load, type and magnitude in psf (e.g. H20-S16-44, 245 psf)

e. Assumed thicknesses, if any.

Output Values

a. Required thicknesses

b. Area of steel required at critical sections

c. Perimeter of steel at critical sections.

d. Unit shear at critical sections.

e. Cutoff points and/or area of steel curves

f. Distribution steel.

g. Number of longitudinal bars.

h. Concrete and reinforcing steel quantities.

The District will review these programs and make an independent check of the output. However a detailed check to insure the accuracy of the statements and logic will not be made. It will be the responsibility of the designing agency to resolve any significant variance.

B-3 District Programs

The District has developed computer programs for the structural design and check of the following reinforced concrete structures. Preliminary write-ups for these programs can be found in pages S-107 to S-144.

1. Design of single barrel box conduits.

2. Check of single barrel box conduits.

B-3 District Programs continued.

3. Design of double barrel (symmetrical and unsymmetrical) box conduits.

4. Check of double barrel (symmetrical and unsymmetrical) box conduits.

5. Design of rectangular channels.

6. Design of concrete pipe.

Computer programs developed by the District are available for use by outside agencies and private engineers. The District will not process the data, however, listings of the program statements are available upon written request. The use of District programs will greatly facilitate processing of submitted plans by reducing our checking requirements and elimination of the corrections the submitting engineer is required to make.

Inquiries regarding structural computer programs should be directed to the Structural Section, Design Division.

Several local commercial data processing firms have indicated they will have District programs in their library.

B-4 Computer Checking

Structures will be checked through the use of computer programs where available. Using submitted details as input, these check programs will analyze the structure and print shear, bond and flexural stresses at several critical points within the structure. If this data indicates stresses are not within a reasonable tolerance of the specified allowables, the plans will be returned for redesign. To facilitate the preparation of the required input data and to expedite our check, structures shall be detailed in accordance with District nomenclature, and where applicable, District forms shall be utilized. Several District forms are shown on pages S 100 through S 102. These forms are available for use on District projects.

SECTION C

DRAWINGS AND CALCULATION SHEETS

Section C

Drawings and Calculation Sheets

C-1 General

1. The designer shall be held solely responsible for the correctness of all drawings and calculations submitted to the District. All work shall be independently checked by the designing agency.

2. All calculations shall be on 8-1/2" by 11" sheets, computer sheets or special tabulation forms, signed by the designer and checker. All calculations shall be original or legible copies of originals made by a permanent process.

3. In general, structures shall be detailed to not less than 3/8" = 1'-0" scale with sufficient details for construction purposes. Where standard forms, typical sections of box conduits, open channels, arch sections, etc., are used to reduce drafting requirements it is not required that these to be scale. Details shall be of sufficient scale to permit a one-half reduction without loss of clarity.

4. Where several conduits of the same type are to be used, it is requested the structural details be presented in tabular form. An example of the prefered form for box conduits and open channels is shown on pages S-100 to S-102 and the form for pipe conduits over 108 inches in diameter is discussed on page J-5.

5. The concrete and steel quantities for box, open channel, and arch sections shall be shown on the structural sheets. Quantities shall be per linear foot of conduit.

SECTION D

STANDARD DRAWINGS

Section D

Standard Drawings

D-1 General

The following criteria shall be the basis of selecting the type of standard structure to be utilized. Charts for this purpose are shown on pages S-103 to S-105.

D-2 Manholes

The following criteria shall be the basis of selecting the type of manhole to be utilized.

1. Manhole No. 1 (2-D 102)

   Main line = 33" inside diameter or less. (Exception - if the main line pipe downstream of the manhole is 36" to 42" inside diameter and the main line pipe upstream is 33" or less, use a Manhole No. 1.)

   The maximum size lateral that may be brought into a Manhole No. 1 is governed by the following:

   a. Refer to Standard Drawing No. 2-D 102 (PLAN). The distance from the outside of the lateral to the inside face of the end wall of the manhole, measured from the end of the lateral perpendicular to the end wall, shall be a minimum of 6".

   b. Refer to Standard Drawing No. 2-D 102 (SEC. A-A). The distance from the outside (top) of the lateral to the bottom of the 8" thick top of the manhole chamber, measured vertically from the end of the pipe, shall be a minimum of 6".

   If the size of the lateral, or the angle at which it is entering the manhole, is such that the above-specified minimum distances cannot be maintained, then one of the following alternate solutions must be used.

D-2 Manholes continued.

a. Provide a special structure.

b. Provide two standard structures, consisting of a Manhole No. 1 placed upstream or downstream from the applicable Junction Structure No. 2, or Transition Structure No. 3.

Manhole No. 2 or Manhole No. 4 is not applicable where the main line conduit is less than 36 inches in diameter.

2. Manhole No. 2 (2-D 184)

Main line = 36" inside diameter or larger. (See exception for Manhole No. 1.)

The outside diameter of the lateral must be less than or equal to 1/2 the inside diameter of the main line. If the upstream and downstream diameters of the manhole are not the same, the governing inside diameter of the main line shall be considered to be that where the extended center line of the lateral enters the manhole.

In no instance shall the inside diameter of the lateral to a Manhole No. 2 be greater than 30".

3. Manhole No. 4 (2-D 113)

A Manhole No. 4 is used when a Manhole No. 2 is inadequate. Main line = 36" inside diameter or larger

Lateral = 12" to 144" inside diameter; however, the inside diameter shall not exceed the inside diameter of the main line.

4. General Notes for Manholes

Laterals entering both sides of Manholes Nos. 1 and 2 are undesirable for safety reasons and should be avoided wherever possible. Laterals may enter both sides of a Manhole No. 4; however, the access shaft shall be located on the side of the manhole receiving the smaller lateral, and in addition, the length of the manhole must be such that the lateral opening will not interfere with access to the structure.

D-3 Junction Structures

The following criteria shall be the basis of selecting the type of junction structure to be utilized.

1. Junction Structure No. 4 (2-D 193)

   Use a Junction Structure No. 4 when the lateral, inleting into a pipe conduit, is less than or equal to 24" inside diameter. The outside diameter of the lateral must be less than or equal to 1/2 the inside diameter of the main line conduit. The prolongation of the axis of the lateral should intersect the axis of the main line conduit.

2. Junction Structure No. 2 (2-D 112)

   Use a Junction Structure No. 2 when the outside diameter of the lateral, inleting into a pipe conduit, is greater than 1/2 of the inside diameter of the main line, or when the inside diameter of the lateral is greater than 24". However, the inside diameter of the lateral must be less than or equal 3/4 of the inside diameter of the main line, and in addition, must be less than or equal to 39:.

   If the inside diameter of the lateral is greater than 3/4 of the inside diameter of the main line, or if the inside diameter of the lateral is greater than 39", it will be necessary to use a Transition No. 3 (2-D 188).

3. Junction Structure No. 3 (2-D 191)

   Use a Junction Structure No. 3 when the inside diameter of the lateral into box conduits is 30" or less for reinforced or non-reinforced concrete pipe, and 60 inches or less for corrugated metal pipe. Use of this standard for Case 1 and Case 2 is also limited to connections of laterals where the outside of the connector pipe is a minimum of 12" below the soffit and also a minimum of 12" above the invert of the main line; further, the angle of convergence shall be 45 degrees or greater.

D-3 Junction Structures continued.

4. Junction Structure No. 1 (2-D 189)

In general, Junction Structure No. 1 is used for connecting laterals to main line box conduits where the limitations listed hereinabove preclude the use of Junction Structure No. 3. If the inlet opening is of such size that the opening does not fall below the top slab haunch and 6" above the invert slab and/or angle A is less than 30 degrees the structural adequacy of the structure shall be investigated.

D-4 D-Load Tables

D-Load Tables for Design of Reinforced Concrete Pipe (2-D 213.1 to 2-D 213.27)

Standard Drawings Nos. 2-D 213.1 to 2-D 213.27, "D-Load Tables for Design of Reinforced Concrete Pipe", shall not be included in the list of project drawings. Refer to page I-8.

D-5 Design Pipe

Steel Areas for Reinforced Concrete Pipe (2-D 214.1 to .6)

Standard Drawings Nos. 2-D 214.1 to .6, "Steel Areas for Reinforced Concrete Pipe", shall be included in the list of project drawings when applicable. In addition the pipe must be detailed on the project drawings.

D-6 Subdrainage System (2-D 295.1, .2, and .3)

Standard Drawings Nos. 2-D 295.1 to .3, "Subdrainage Suystem for R. C. Rectangular Open Channel", shall be included in the list of project drawings when applicable.

See discussion in Section R (Floor Slab Drains), page R-2, for use of this standard.

D-7 Inlet No. 1 (2-D 265)

Standard Drawing No. 2-D 265, "Inlet No. 1", shall be included in the list of the project drawings when applicable.

An Inlet No. 1 should not be used in watercourses subject to debris flow; use an inlet structure incorporating a standard protection barrier (2-D 261) for this condition.

D-8 Subdrainage System (2-D 295.1, .2, and .3)

Standard Drawings Nos. 2-D 295.1 to .3, "Subdrainage System for R. C. Rectangular Open Channel", shall be included in the list of project drawings when applicable.

See discussion in Section R (Floor Slab Drains), page R-2, for use of this standard.

D-9 Inlet No. 1 (2-D 265)

Standard Drawing No. 2-D 265, "Inlet No. 1", shall be included in the list of the project drawings when applicable.

An Inlet No. 1 should not be used in watercourses subject to debris flow; use an inlet structure incorporating a standard protection barrier (2-D 261) for this condition.

SECTION E

DESIGN DATA

Section E

Design Data

E-1 General

The design data for all structures shall appear on the project drawings. This data shall include: Depth of earth cover, live load, if any, and allowable stresses. See discussion on pages J-5 and J-6 for additional data and notes required for reinforced concrete pipe over 108 inches in diameter.

SECTION F

STRUCTURAL NOTES

Section F

Structural Notes

F-1 General

The following notes, as applicable, shall appear on the project drawings in the form presented below together with such others as may be needed on a particular project.

F-2 General Notes

Design of the pipe shown hereon is based on the assumption the pipe will be installed in accordance with Case III bedding as shown on Standard Drawing No. 2-D 177 unless otherwise shown. "W" values shall be as specified on Standard Drawing No. 2-D 177 for Case III bedding, Notes 3(a), 3(b) and 3(c). If the "W" value at the top of the pipe is exceeded the bedding shall be modified and/or pipe of additional strength shall be provided. The proposed modification shall be approved by the District.

F-3 Structural Notes

General Notes (All Types of Structures)

1. Dimensions from face of concrete to steel are to center of bar unless otherwise shown.

2. Concrete dimensions shall be measured horizontally or vertically on the profile, and parallel to or at right angles (or radially) to centerline of conduit on the plan except as otherwise shown.

3. All bar bends and hooks shall conform to the 1971 American Concrete Instututes's "Building Code Requirements for Reinforced Concrete" Section 7.1.

4. Placing of reinforcement shall conform to the 1971 American Concrete Institute's "Building Code Requirements for Reinforced Concrete" Section 7.3.

5. Transverse construction joints shall not be placed within 30 inches of manhole or junction structure openings.

F-3 Structural Notes continued.

6. Transverse construction joints in walls and slabs shall be in the same plane. No staggering of joints will be permitted. Transverse construction joints shall be normal or radial to the centerline of construction.

7. The transverse reinforcing steel shall terminate 1-1/2 inches from the concrete surfaces unless otherwise shown on the structural details.

8. Exposed edges of concrete members shall be rounded or beveled.

9. No splices in transverse steel reinforcement will be permitted other than shown on the drawings without approval of the Engineer. No more than 2 splices will be permitted in any longitudinal bar between transverse joints. Splices shall be staggered.

10. Longitudinal steel shall be lapped 20 bar diameters at splices. Transverse steel shall be lapped 30 bar diameters at splices.

Additional Notes for Box Sections:

1. Longitudinal steel shall be continuous and extend through all construction joints.

2. Unless otherwise shown on the drawings, transverse joint keyways (in both slabs and walls), as detailed for longitudinal keyways at the base of the walls, shall be placed at the end of each pour, but the spacing thereof shall not exceed 50 feet or be less than 10 feet. Spacing may be decreased to avoid proximity to inlets. All construction joints in bottom slab, top slab, and side walls shall be in the same plane. No staggering of joints will be permitted.

3. Unless otherwise shown on the details, in curved sections transverse bars shall be placed radially. Straight transverse bars in top and bottom slabs shall be spaced as shown on the typical sections; spacing shall be at the centerline of construction for single-barrel boxes, and at the centerline of the barrel on the outside of the curve for multi-barrel boxes. Straight bars and L-bars in walls shall be spaced as shown on the typical sections, with the spacing measured between the vertical legs of bars.

   (Note: This note shall be modified as required to eliminate any reference to sections not on the project; i.e. delete all reference to multi-barrel box if there is none on the project.)

F-3 Structural Notes continued.

4. At the beginning and ending of all pours, a complete curtain of main reinforcement shall be placed three inches from the transverse construction joint.

5. The vertical wall steel in interior walls and in the interior face of the exterior walls may be spliced at the construction joint at the base of the wall. The splice shall be 20 bar diameters in length.

6. The design of box sections identified by a numerical value only is based on a width of trench equal to the outside width of the conduit plus 3 feet. When the cover is equal to 10 feet or less, the trench width is unrestricted. When the cover is greater than 10 feet and the trench width is greater than the outside width of the conduit plus 3 feet for a distance in excess of 10 feet, an alternate section shall be used as indicated below:

   A. When the depth of cover is less than 18 feet, sections with the suffix "B" shall be used.

   B. When the depth of cover is greater than 18 feet and:

      1. the trench width is less than the outside width of conduit plus 6 feet, sections with the suffix "A" shall be used.

      2. the trench width is greater than the outside width of conduit plus 6, sections with the suffix "B" shall be used.

Additional Notes for Open Channel Sections

1. Longitudinal steel shall terminate two inches from transverse construction joints.

2. Spacing of transverse joints shall not exceed 50 feet or be less than 10 feet, measured along the centerline of construction, except as otherwise shown on the plan and profile sheets. Spacing may be decreased to avoid proximity to inlets.

3. Transverse joints shall be placed at the junction of rectangular open channel sections with closed conduit sections. The joint shall not be keyed and shall have a 3/8" layer of expansion joint material in walls and invert.

4. All rectangular open channel walls shall be fenced in accordance with Standard Drawing 2-D 180.

5. In curved sections, the maximum spacing of bars shall not exceed that shown for the typical sections. Steel shall be placed radially from the maximum spacing.

6. At the beginning and ending of all pours, a complete curtain of main reinforcement shall be placed three inches from the transverse construction joints.

Additional Notes for Cast-in-Place Tunnel Sections

1. The concrete tunnel lining may be poured in the longest practical section which will permit each section or portion of section to be completed in one continuous operation. Transverse construction joints as detailed hereon shall be placed at the ends of each pour.

F-3 Structural Notes continued.

Where the length of pour exceeds fifty feet, a dummy groove ribbon or premolded contraction joint shall be placed at intervals not exceeding fifty feet. The required transverse joints shall be continuous and extend throughout the entire section and be in the same vertical plane; i.e. at all locations where a transverse joint is required in the invert slab, a transverse joint is required in the arch section and likewise a joint in the arch section will necessitate a joint in the invert slab.

2. Longitudinal steel shall be continuous and extend through all construction joints.

3. At the beginning and ending of all pours, a complete curtain of transverse reinforcement shall be placed three inches from the transverse construction joint.

4. In Curved sections transverse steel shall be placed radially. Straight transverse bars in the invert slab shall be spaced as shown on the typical sections; spacing shall be at the centerline of construction. Curved bars on the inside face at the crown shall be spaced as shown on the typical sections; spacing shall be at the centerline of construction. The maximum spacing of all other bars shall not exceed that shown for the typical sections.

5. In the event steel rib tunnel supports are used, the District reserves the right to eliminate extrados bars above the top of the footing as noted below.

Rib Spacing	Bars to be Eliminated
4'-0" and under	1 Bar per rib
Over 4'-0"	2 Bars per rib

Additional Notes for Box Sections to be Jacked in Place

1. The Contractor shall use jacking heads or load spreading beams of such design and size as to spread the jacking force uniformly over the entire invert section.

F-3 Structural Notes continued.

2. If the load spreading device or jacking head selected does not permit the required 20 bar diameter extension of the normal longitudinal steel, continuity may be maintained by doweling from the adjacent section.

3. The leading edge of the conduit shall be equipped with a jacking head securely anchored thereto. The length and details of the jacking head shall be subject to the approval of the Engineer.

4. The use of guide rails, slabs, cradles, etc, will be subject to written approval by the Engineer.

Additional Notes for Design Pipe

The following notes shall appear on the project drawings where applicable.

1. If the pipe design is based on Standard Drawings Nos. 2-D 214.1 to 2-D 214.6 and the steel area values are from the chart based on the ditch condition with trench width equal to the outside diameter of the pipe plus 24 inches, the following note shall appear on the project drawings:

   Design of the pipe shown hereon is based on Standard Drawings Nos. 2-D 214.1 to 2-D 214.6 (Case III bedding - ditch condition). "W" values shall be as specified on Standard Drawing No. 2-D 177 for Case III bedding, Notes 3(a) and 3(c). If the "W" value at the top of the pipe is exceeded, pipe shall be redesigned per Standard Drawings Nos. 2-D 214.1 to 2-D 214.6 (projection condition - unrestricted trench width), or as otherwise approved by the District.

2. If the pipe design is based on Standard Drawings Nos. 2-D 214.1 to 2-D 214.6 and the steel area values are from the chart based on unrestricted trench width, the following note shall appear on the project drawing.

F-3 Structural Notes continued.

Design of the pipe shown hereon is based on Standard Drawings Nos. 2-D 214.1 to 2-D 214.6 (projection condition - unrestricted trench width). "W" value at spring line of pipe shall be as specified on Standard Drawing No. 2-D 177 for Case III bedding, Note 3(a). "W" value at top of pipe may be any dimension.

3. If the pipe design is NOT based on Standard Drawings Nos. 2-D 214.1 to .6, an appropriate note stating the case of bedding, earth load condition, and limits of "W" values shall be noted on the project drawings.

Additional Notes for Cast-In-Place Pipe Construction

1. Junction Structures shown on the plans are for reinforced concrete pipe. The following substitutions shall be made for Junctions Structures for use with cast-in-place pipe:

   a. A Junction Structure No. 4 (2-D 193) shall be replaced with either a Junction Structure No. 2 (2-D 112) or a Transition Structure No. 3 (2-D 188).

   b. A Junction Structure No. 2 (2-D 112) shall be replaced with a Transition Structure No. 3 (2-D 188).

2. Standard Drawing No. 2-D 112, Junction Structure No. 2 when used with cast-in-place pipe shall be modified to include concrete backfill 1 foot over the cast-in-place pipe.

3. At the end of all pours and at the end of each working day, the contractor shall install #4 dowels 24" long, 12-inches into the last pour at 12-inch centers around circumference of cast-in-place pipe.

SECTION G

DESIGN OF

BOX CONDUITS

Section G

Design of Box Conduits

G-1 Economy of Design

1. Height to Width Ratio

Careful economic studies should be made to determine the greatest economy of the entire storm drain. As an aid to determine the most economical ratio of height to span, where it is possible to vary this ratio, a curve "Total Cost Comparison Curve for Rectangular R.C. Sections" is included (page S-21) showing relative costs for different ratios of height to span, assuming the unit costs shown and a common invert grade for all ratios. This curve is not directely applicable where the soffit grade is to be held. Where box and pipe alternates are specified, the height of the box should, if possible, equal the internal diameter of the pipe. It will be seen that this gives a relatively economical ratio of height to span.

2. Maximum Span

Where the clear span of box conduits exceeds 12'-0" a cost study should be initiated to determine the advisability of using additional cell(s) with shorter spans. As an aid to determine the maximum economical span, a curve showing span vs. cost is included (page S-22). As noted, this curve is based on the analysis of boxes of one height only. Therefore, careful judgment is required to determine if the curve is applicable.

G-1 Economy of Design continued.

3. Length of Reach

It is considered desirable for economy of concrete and steel to change concrete thickness and reinforcing for a particular cross section at about two-foot increments of cover where the depth of cover is varying gradually. The maximum variation in cover should not, in general, exceed 4 feet for a given section. Small changes in interior area should be avoided, but where necessary should be made by varying the height rather than the width of the box.

G-2 Method of Design

Box conduits shall be designed, in general, for the dead weight of the structure, and vertical and horizontal earth load together with the combination of vertical live load, horizontal live load, internal water pressure and uplift pressure wich give the greatest stresses in the various parts of the structure. Box conduits shall be checked for construction loads as discussed on page G-11. Drawings showing loading conditions to give maximum stresses in box conduits are included (pages S-17 to S-20). Design sections shall be shown on the drawings and shall be identified by numberical designations.

When the cover on a box conduit exceeds 10 feet the design shall include provisions for wide trenches resulting from construction operations. These sections shall be identified by the same numerical designations plus a letter suffix. (See page G-8).

Closed conduits shall be designed as rigid frames. Shear determination and Moment Distribution shall be based on center line spans. In analysis where the members are assumed to be of constant cross-section, the stiffness of the invert slab shall be calculated using the thickness at the center of the span. Design moment shall be that at the face of the support. Correction of moments from center line to face of support shall be based on the assumption that the variation in shear between the face of the support and the center line is linear. For design, the maximum shear shall be considered as that at the section a distance, d, (d = effective depth of the member, do not include depth of haunch) from the face of the support. Axial thrust shall be considered in the design of the walls but not in that of the top and bottom slabs. In determining the negative steel in the bottom slab, credit shall be taken for the additional 1-inch depth at the walls due to the invert drop. Where nominal haunches, 4 to 6 inches, are used in construction of the conduit, they shall be neglected in all phases of the design such as in calculating unit shear, bond, area of steel and stiffness of members. In large structures where structural considerations indicate substantial haunches are required, they may be considered in the design.

G-2 Method of Design continued.

Where box conduits are of relatively short length, such as are used for channel crossings, and the centerline of the roadway is not normal to the center line of the channel, a skew analysis is required. The angle of skew is defined as the angle between a line perpendicular to the roadway center line and a line parallel to the supporting walls. The modified skew angle is the angle of skew in a place tangent to the neutral surface at any section. In slab analysis the modified skew angle is equal to the skew angle. In vertical wall analysis the modified skew angle is equal to zero. The method of skew analysis shall be as presented in Paper 2474, ASCE Transactions, Vol. 116, 1951, titled "Practical Design of Solid Barrel Reinforced Concrete Skew Structures" by Bernard L. Weiner. Under this method the sample section for rigid frame analysis shall be taken perpendicular to the center line of the conduit. Basic moments, thrusts and shears are determined for this right angle section. Design moments, thrusts and shears are obtained by multiplying the basic moments, thrusts and shears by the square of the secant of the modified skew angle. In this method of design the steel is placed parallel to the center line of the roadway.

Edge beams shall be provided at the termination of all cast-in-place box conduits. Edge beams shall also be provided where traffic requirements are such that skewed construction joints will be required.

Moments induced in restrained structural members due to temperature variations or changes in moisture content of the concrete shall be considered. The temperature variation shall be assumed as a 30 degree F. rise and a 40 degree F. fall. When utilizing these forces, the basic allowable stresses are increased by one third.

Temperature variation is not considered to be a major factor in the design of conduits with a significant depth of earth cover or in culverts of short length where the top slab is exposed, such as at street crossings, and need not be considered.

Where a large portion of a structure is poured at one time shrinkage will be realized. Where the resultant stresses are high, consideration should be given to utilization of details that will prevent these stresses. For example, by leaving a small portion at the span center as a final pour, the effects of shrinkage are greatly reduced or practically eliminated.

G-2 Method of Design continued.

Where the structure is subject to unbalanced lateral loads a sidesway analysis is required. This is not intended to apply to the normal trench installation where unbalanced loads result from live load application.

G-3 Vertical Loads

G-3.1 Live Load

G-3.1.1 Highway Loading

Box conduits shall be designed for one H20-S16-44 truck per lane except where passing beneath railroad tracks.

1. For box conduits where the earth cover is 2'-11" or less, wheel loads shall be distributed on the top slab in accordance with A.A.S.H. T.O. 1.2.3. and impact shall be added in accordance with the provisions of A.A.S.H.T.O. 1.2.12(c). for culverts; i.e., 30 percent for 0' to 1'-0" cover, 20 percent for 1'-1" to 2'-0" cover, and 10 percent for 2'-1" to 2'-11" cover. One standard H20-S16-44 truck per lane shall be considered on the structure and placed so as to produce maximum positive and negative moments or shear. For spans 12 feet or less, a single wheel load centered on the span is considered sufficient.

2. Where the cover is over 2'-11" but not greater than 10', the wheel loads shall be distributed through the fill to the top slab in accordance with the following equations:

   Transverse (with reference to the truck) spread of wheel load = 1.2+1.6F

   Longitudinal (with reference to the truck) spread of wheel load = 1.5+1.5F

   where F = depth of fill over box in feet.

G-3 Vertical Loads
(G-3.1.1 Highway Loading)

The following tabulated pressures apply for covers of three feet and over:

TABLE OF VERTICAL LIVE LOADS

Cover "F" Feet	Wheel Load Kips	L.L. Pressure on Top Slab psf
3	16.0	489
4	16.0	314
5	16.0	234
6	16.0	182
7	16.0	145
8	16.0	119
9	16.0	199
10	16.0	84

These values include the effect of overlapping wheel loads.

Wheel loads shall be distributed to the bottom slab as follows for covers of 10 feet or less:

Transverse (with reference to the truck) spread of wheel load = 1.2+1.6F+H for traffic parallel to main reinforcing
= 1.2+1.6F for traffic perpendicular to main reinforcing

Longitudinal (with reference to the truck) spread of wheel load = 1.5+1.5F+H for traffic perpendicular to main reinforcing
= 1.5+5F for traffic parallel to main reinforcing

where F = depth of fill over box in feet and H = height of box from invert at base of wall to soffit.

The effect of overlapping wheel loads shall be taken into account.

G-3 Vertical Loads continued.
(G-3.1.1 Highway Loading)

Charts for H20 truck loads on invert slabs are included (pages S-3 to S-9). For covers from 0' to 2'-11", charts are included for the conditions of traffic parallel and perpendicular to the main reinforcing in the conduit. In general, the maximum value of the two conditions shall be used. However, where the length or location of the conduit is such that traffic flow is possible in one direction only, the applicable condition shall be used.

4. Where the cover exceeds 10 feet, the effect of truck loads on box conduits shall be assumed to be negligible.

G-3.1.2 Railroad Loading

Conduits passing under railroads shall be designed in accordance with the requirements of the particular railroad. In general, the minimum design loads are as follows:

Railroad	Cooper Loading
Atchison, Topeka and Santa Fe	E 80
Southern Pacific	E 72
Union Pacific	E 72

Cooper E 65 loading may be used under industrial spur and connecting tracks under jurisdiction of Union Pacific Railroad Company.

A set of curves is included showing railroad loads at various depths of fill for Cooper's loadings (pages S-10 to S-16).

G-3.2 Dead Load

G-3.2.1 Dead Weight of Structure

The unit weight of concrete shall be taken as 150 pcf.

G-3.2.2 Dead Weight of Overburden Soil

Earth loads shall be calculated using formulas derived by Marston for load on buried conduits. The design unit weight shall ordinarily be taken as 110 pcf. This is assumed to be the actual weight of compacted backfill. Where soil analysis and judgment indicates that the actual unit weight is significantly greater, the design unit weight shall be increased accordingly.

Conduits shall be designed for the appropriate loading condition shown below and shall be detailed on the drawings.

G-3 Vertical Loads continued.
(G-3.2.2 Dead Weight of Overburden Soil)

1. Trench or ditch condition (Refer to Wide Trench, page G-8)

$$W = C_d \cdot w \cdot B_d^2$$

2. Negative projection (Refer to Transition Depth, page G-9)

This is the condition where the conduit is installed in a relatively narrow trench of such depth that the top of the conduit is below the adjacent natural ground surface and then covered by an embankment which extends above this ground level.

$$W = C_n \cdot w \cdot B_d \cdot B'_d$$

3. Positive projection

This is the condition where the top of the conduit projects above the surface of the natural ground and then is covered with an embankment. This condition is also assumed for calculation of loads on those conduits which are installed in trenches wider than one and one-half to three times the overall width of the conduit.

$$W = C_c \cdot w \cdot B_c^2$$

4. Imperfect ditch condition

This is a method of construction in which the soil on both sides of the conduit for a distance not less than twice its width on each side, and a distance not less than the height of the conduit plus one foot above its top is thoroughly compacted. Then a ditch is dug in the compacted fill by removing the prism of material directly over the conduit. The ditch is refilled with very loose compressible material, after which the embankment is completed in a normal manner. The method is economically justified only in the case of relatively high fills. This method is generally not acceptable to the District and will only be approved in special situations. It is requested the District be consulted prior to beginning a detailed design using this method.

$$W = C_n \cdot w \cdot B_d^2$$

G-3 Vertical Loads continued.
(G-3.2.2 Dead Weight of Overburden Soil)

5. Wide Trenches

If a trench or subtrench is widened progressively, other conditions being unchanged, the fill loads does not continue to increase according to trench condition, $W = C_d.w.B_d^2$ but reaches the limiting value of $W = C_c.w.B_c^2$ as in the positive project condition. The trench width at which this limit is reached is known as the "Transition Width", and any increase in width beyond this does not increase the load on the conduit. When the trench width is known and is approximately equal to, or greater than, 1-1/2 times the outside width of conduit both the trench and positive projection conditions (r_{sd} = 1.0 p = 1.0) should be checked. If the load indicated by the trench formula exceeds that indicated by the projection formula, the design load shall be the latter.

When the trench width is unknown, as in most cases and the cover is greater than 10 feet additional structural sections shall be included on the drawings as outlined below:

A. Depth of fill is greater than 10 feet but less than 18 feet:

   1. Add a section for the transition width (positive projection, p = 1). Trench width is unrestricted. Section identification shall be the numeric designation for the trench condition plus the suffix "B".

B. Depth of fill is greater than 18 feet.

   1. Add a section for width of trench equal to the outside width of the conduit plus 6 feet. Section identification shall be the numeric designation for the trench condition plus the suffix "A".

   2. Add a section for the transition width. See A.1. above.

G-3 Vertical Loads continued.
(G-3.2.2 Dead Weight of Overburden Soil)

6. Transition Depth

In an embankment condition a positive projection installation is assumed if the natural ground surface is at or below the top of the conduit; a negative projection installation is assumed if the natural ground surface is above the top of the conduit. A load calculations for a given condition would indicate a very high differential if the assumed natural ground is varied from the top of conduit to a relatively small distance above. It is not felt this is realistic; therefore, the positive projection condition should be assumed for load calculations where the conduit is in an embankment and the natural ground surface is less than a depth equal to one-half the height of conduit above the top of the conduit.

Definitions

H = Height of fill measured from the top of conduit, in feet.

W = Load per foot of length of conduit, in pounds per foot.

Cd = Load coefficient for the trench condition, abstract number, based on ratio of H over Bd. See curve on page S-1.

Cn = Load coefficient for the negative projecting condition and imperfect trench, abstract number based on ratio of H over Bb. See curve on page S-2.

Cc = Load coefficient for positive projecting conditions, abstract number based on ratio of H over Bc. See curve on Page S-2.

w = The design unit weight of the fill material, in pounds per cubic foot.

Bc = Overall width of the conduit, in feet.

Bd = The width of the trench, measured at the top of the conduit, in feet. For box conduits use Bc + 36", except as indicated in B.2. under wide trenches.

B'd = Bd-0.67, for Bc = 33 inches or less

= Bd-1.00, for Bc greater than 33 inches

p = The positive projection ratio. In case of positive projecting conduits, the projection ratio is equal to the vertical distance between the top of the conduit and the natural ground surface adjacent thereto divided by the overall width of the conduit.

G-3 Vertical Loads continued.
(G-3.2.2 Dead Weight of Overburden Soil)

p' = Projection ratio for negative projection and imperfect ditch conditions. In the case of negative projecting conduits, it is the vertical distance between the top of the conduit and the natural ground surface adjacent thereto divided by the width of the trench. In the case of imperfect ditch conduits, it is the distance between the top of the conduit and the surface of the first stage compacted fill divided by the width of the trench.

rsd = The settlement ratio. For ordinary soil foundations use:

+0.7 for positive projecting conduits

-0.5 for negative projecting conduits and the imperfect ditch condition.

K = The ratio of active horizontal pressure at any point in the fill to the vertical pressure which causes the active horizontal pressure, abstract number.

u = The "Coefficient of Internal Friction", abstract number.

u' = The "Coefficient of Sliding Friction", abstract number.

Ku = 0.150 shall be used for ordinary conditions.

= 0.110 for saturated clay

= 0.130 for clay

= 0.150 for saturated top soil

= 0.165 for sand and gravel

= 0.193 for granular materials without cohesion

G-3.3 Other External Loads

Vertical loads due to existing or proposed structures, such as buildings, abutment, etc., shall be considered in the design of box conduits.

G-4 Horizontal Loads

G-4.1 Live Load

Horizontal loads due to highway and railroad loading shall be considered in the design of box conduits. Curves are included for lateral H20-S16-44 truck loads and railroad loads (pages S-3 and S-11 to S-13).

G-4 Horizontal Loads continued.

G-4.2 Dead Load

Box conduits shall be designed for active horizontal earth pressure based on the Rankine theory. The Rankine "K" shall ordinarily be taken as 1/3 This criteria shall be used except where a soils engineer, because of extreme conditions, recommends a different value. For extreme conditions lateral earth pressure may exceed 100 pcf equivalant fluid pressure. Special consideration shall be given where expansive soils are encountered. Where lateral loads may vary or are time dependent it may be necessary to use a composite section based on both maximum and minimum horizontal loads.

G-4.3 Other External Loads

Horizontal loads due to existing or proposed structures, such as buildings, abutments, etc., shall be considered in the design of box conduits.

G-5 Internal Water Pressure

Internal water pressure shall be calculated for the conduit flowing just full in combination with other loading conditions at standard allowable unit stresses. An additional structural analysis shall be made if the hydraulic gradient is substantially above the top of the conduit. The hydraulic gradient shall be assumed at the maximum elevation possible. This analysis shall be made using the following loads: pressure due to the hydraulic head from the soffit of the conduit to the hydraulic gradient, the internal water assuming the conduit flowing just full, the dead weight of the structure, and vertical and horizontal earth loadings. For this loading condition, the allowable stresses may be increased by one-third.

G-6 Construction Loads

Structures shall be checked for loads sustained during construction. Stresses for temporary construction loads should not exceed fs = 36,000 p.s.i. and fc = 2,700 p.s.i. In particular, the loads resulting from flooded backfill to the top of the conduit combined with the dead weight of the structure shall be considered.

G-7 Allowable Stresses

Allowable stresses shall be as listed in Section A, except as modified hereinabove for temporary loadings.

G-8 Thickness of Members

The minimun thickenss of vertical walls shall be eight inches where two curtains of steel are used and six inches where one curtain is used.

The minimum thickness of top slabs shall be six and one-half inches.

The thickness of the invert slab shall be measured at the center of the span. The minimum thickness shall be seven inches and shall be increased by an amount equal to the sum of the increases of the steel clearances indicated below for the top of the invert.

G-9 Steel Clearances

Steel clearances should be shown on the project drawings from the center of the bar to the face of the concrete. Said clearances shall not be less than the following distances:

Top slab and side walls, inside and outside - 2 inches

Bottom of invert slab - 2-1/2 inches

Top of invert slab - In accordance with the following table:

Velocity-fps.	Clearance-in.	Concrete Mix
< 5	3.0	560-C-4,000
5 to 20	3.0	610-B-4,000
20 to 40	3.5	680-B-5,000
> 40	Not allowed without prior District approval.	

Where concrete is subjected to the action of sea water or harmful ground water etc., all clearances shall be increased 1/2 inch. Where there is appreciable debris in the flow the clearance on the top invert steel shall be increased 1/2 inch for velocities greater than 5 fps.

That portion of the steel clearance greater than 3 inches in the invert shall be considered as sacrificial and shall not be used in the design of the steel in the opposite face. The concrete mix shown in the above table applies to the invert only and shall be shown on the plans. Debris in the flow may require a richer concrete mix. This will be determined by the Materials Section of the Contract Administration Division. Increased concrete strengths shall not be considered in the design of the section.

G-10 Steel Pattern

In general, transverse reinforcement for single barrel boxes should consist of straight bars in the inner faces of the top and bottom slab and side wall, L-bars running from the outer face of the top

G-10 Steel Pattern continued.

slab into the outer face of the side walls and resting on the bottom construction joint and lapping with L-bars continuing into the outer face of the bottom slab. Alternate top L-bars should be cut off if possible. An optional 20 bar diameter lap shall be indicated at the base of the wall for the vertical reinforcement in the interior walls of multiple boxes and in interior face of the exterior walls for all boxes. It is preferred that bars be spaced on a common spacing or a multiple thereof, but non-uniform spacing may be used if economy is thereby affected. In multi-barrel boxes, excessively long complexly bent bars should be avoided if possible.

G-11 Longitudinal Reinforcement

Longitudinal reinforcement shall consist of #4 bars at 18" centers in each reinforced face of slabs and wall except where the top slab is exposed or the conduit is limited to length and serving as a channel crossing. In this and other cases where appreciable temperature variations can be anticipated, the longitudinal reinforcement area in each exposed face shall be equal to 0.001 of the cross sectional concrete area but not less than #4 bars at 18" centers. Longitudinal steel shall be continuous through joints.

G-12 Distribution Steel

When the design cover is 2'-11" or less, distribution steel shall be placed in the top slab transverse to the main reinforcing. The amount of distribution steel per foot of slab width including normal longitudinal reinforcement shall be equal to the percentage of the transverse reinforcing steel required for positive moment in the top slab as given by the formula

$$\text{Percentage} = \frac{100}{\sqrt{S}}, \text{ Maximum } 50\%$$

where S equals the centerline span of the slab in feet.

G-13 Fillets and Invert Slope

Fillets shall be placed at the junction of vertical walls and top slab. These fillets may be either 4" x 4" or 6" x 6", at the Contractor's option. These are nominal fillets and shall be incorporated in all sections. Larger fillets may be used if structural requirements so dictate.

G-13 Fillets and Invert Slope continued.

There shall be a one-inch drop from the base of the vertical walls to the center of the invert for inside widths of 20 feet or less and a two-inch drop for widths greater than 20 feet, unless a low flow channel in the center of conduit is used. Low flow channels are limited to special conditions. Their use shall be approved by the District prior to the structural design of the box conduit.

G-14 Construction Joints

Construction joint details shall be shown on the project drawings.

Optional longitudinal construction joints at the top of the vertical exterior walls shall consist of a stepped key to take shear from exterior lateral loads and shall be two inches high and located in the center of the wall. Longitudinal construction joints at the bottom of the vertical exterior walls shall be formed with keys 1-inch deep and one-third of the wall thickness in width centered in the wall. The bottom wall joint shall be located 4 inches to 12 inches, at the Contractor's option, above the top of the invert slab (see construction joint details on page S-23). Longitudinal construction joints at the top and bottom of vertical interior walls of multi-compartment box conduits shall be roughened joints without keys; the top joint shall be optional. Where box structures are to be jacked, longitudinal joints shall be keyed to resist jacking forces (see details on page S-23).

Transverse construction joints shall be formed with keys one-inch deep and one-third the member thickness in width centered in the member. Transverse construction joints shall be spaced not more than 50 feet nor less than 10 feet and shall be in the same plane.

If the box conduit is subject to the action of sea water, the construction joints must be sealed with epoxy. Special longitudinal and transverse construction joint details will be required.

If the box conduit is designed to withstand pressure head, water stops shall be incorporated in the construction joints. Special longitudinal and transverse construction joint details will be required.

G-15 Design Tables and Charts for Single Barrel Reinforced Concrete Box Conduits

Standard Drawings Nos. 2-D 236.1 to .14, "Design Tables for Reinforced Concrete Box Conduits" (pages S-23 to S-36), may be used for design so long as the loading conditions shown correspond to those of the box to be designed. The standard is intended as an aid to the designer only; it should not be included in the list of Standard Drawings for a project. If concrete thicknesses are increased because of high velocity, sea water, etc., the lengths of the reinforcing bars, and concrete and steel quantities indicated in the tables must also be correspondingly increased.

A structural detail of the box conduit shall be shown on the project drawings. Where several box sections are to be used, a typical box section shall be detailed on the drawings, and the data for the box sections shown in tabular form. See pages S-100 to S-101 for example.

G-16 Windows

In multi-barrel boxes, windows should be placed in interior walls as required to equalize flows; however, the interval shall not exceed 500 feet. Standard Drawing No. 2-D 205 applies within the limits given on the standard. Designed windows should be 5-feet wide and as deep as possible.

G-17 Access Structures

The District reserves the right to require that access structures to permit the entrance of vehicles and/or equipment be provided where the conduit is equal to or greater than an 84-inch diameter pipe or box equivalent. The need for an access structure will be determined by the District when the preliminary plans for a project are submitted, and the designer will be required to make the necessary changes, if any, on the final plans.

Details of a typical access structure are available as an unnumbered design aid and will be forwarded upon request.

G-18 Box Conduits to be Jacked

G-18.1 General

In general, jacking of box conduits should not be specified where the cover is less than 6'-0". In addition the cover should also be at least 1/2 of the overall height or width, whichever is greater, when jacking under railroads.

Prior to specifying long reaches of boxes with substantial cross sectional area to be jacked under railroad tracks, the cost of trestle construction in comparison to jacking costs should be investigated. Trestles are designed and constructed by the railroad company. Therefore, the designer shall obtain the estimated construction cost from the railroad company concerned.

In many cases it is possible to close tracks for a short time or even a weekend. In this case the possibility of precasting the box conduit and sliding or lifting it into place shall be investigated. This procedure is considerably less expensive than jacking.

Where conduit is to be jacked under existing railroad tracks, the minimum jacking distance shall be fifteen feet on each side of the center line of the tracks measured normal to the tracks, with the exception of the Union Pacific tracks where the minimum distance shall be ten feet. At crossings where there is a possibility the conduit could be constructed in open cut, or where the cover is less than six feet in jacking situations, the designer shall contact the railroad to clarify the method of construction prior to submitting the preliminary plans to the District.

Where box conduit is to be jacked in place a reinforced concrete pipe alternate shall be specified where pipe of sufficient diameter is available. Large diameter pipe is usually more economical than box conduit in such installations due to the high cost of deadmen and sliding slab requirements for box conduit.

Provision shall be made for jacking excessively large double boxes as two single barrels side by side.

The entire reach of box conduit to be jacked must be constructed prior to the start of the jacking operation; therefore, a relatively long straight reach must be available for construction of the jacking pit.

G-18 Box conduits to be Jacked continued.

G-18.2 Reinforcement

The leading and trailing 5 feet of all box sections to be jacked shall have additional transverse and longitudinal reinforcement. The cross sectional area of longitudinal steel in each face of all members, except interior walls of multiple boxes, shall not be less than 0.002 times the gross concrete area for the leading and trailing five feet of the box conduit. This steel shall be tied. In addition, the cross sectional area of transverse steel in each face of the slabs and exterior walls of box conduits to be jacked shall not be less than 0.002 times the gross concrete area for the leading and trailing five feet.

G-18.3 Structural Notes

All drawings indicating box conduits to be jacked shall contain the following notes.

1. The Contractor shall use jacking heads or load spreading beams of such design and size as to spread the jacking force uniformly over the entire invert section.

2. If the load spreading device or jacking head selected does not permit the required 20 bar diameter extension of the normal longitudinal steel, continuity may be maintained by doweling from the adjacent section.

3. The leading edge of the conduit shall be equipped with a jacking head securely anchored thereto. The length and details of the jacking head shall be subject to the approval of the Engineer.

4. The use of guide rails, slabs, cradles, etc. will be subject to written approval by the Engineer.

G-19 Computer Programs

Refer to Section B.

As discussed in Section B, the District has developed a computer program for the design of reinforced concrete box conduits. This program is based on the criteria given in this section with the exception of the steel clearance on the top of the invert slab. This parameter must be overridden in the input until the program is rewritten. Refer to pages S-107 to S-117 for a write-up for this program.

G20 Structural Detailing

Refer to Section C.

Reinforced concrete box conduits be detailed in accordance with District practice; when numerous sections are required they should be tabled. Refer to page S-100 for an example of standard detail and form. Copies of this on District standard size drawing sheet are available for all District projects.

All drawings shall include all applicable notes listed in Section F.

SECTION H

DESIGN OF

TUNNEL SECTIONS

Section H

Design of Tunnel Sections

H-1 General

Two methods of construction shall be given consideration: One, placing of a precast pipe in tunnel; two, pouring of a cast-in-place section. Within the range where precast pipe of sufficient hydraulic capacity is available, the project drawings should indicate both alternates.

Prior to the design of cast-in-place sections a careful study should be made to determine the most economical size and shape. The study should include a survey to determine the shape and size of forms, shields, and excavating equipment available. For a given internal diameter it is not economical to vary the concrete thicknesses unless very long reaches are involved. Where loads vary significantly in relatively short tunnels the outside dimensions should be maintained and the area of reinforcing steel varied. The project drawings shall include at least two alternate cast-in-place sections: One of circular interior and exterior shape and one of horseshoe interior and exterior shape.

Vertical and lateral loads for tunnel design shall be established by a soil engineer or geologist. It is recommended these loads be submitted to the District for approval prior to start of the structural design. The material on earth loads given below is general and should be modified if it is not supported by data obtained in the project soil report.

H-2 Precast Pipe Alternate

1. Pipes 108 inches in diameter and under shall be designed in accordance with Section I, "Design of Reinforced Concrete Pipe 108-inch in Diameter and Under", except vertical earth loads shall be as specified hereinbelow for the cast-in-place tunnel section alternate.

   Load factor of 1.8 shall be used in determining D-loads.

2. Pipes over 108-inch in diameter shall be designed in accordance with Section J, "Design of Reinforced Concrete Pipe over 108-inch Diameter", except vertical earth loads shall be as specified hereinbelow for the cast-in-place tunnel section alternate.

H-3 Cast-in-Place Section Alternate

H-3.1 Method of Design

1. The design in general shall be based on the assumption that the system is semiflexible and that passive pressures develop as the system deflects. The passive pressures shall be assumed to be proportional to the horizontal deflection and shall be based on the modulus of subgrade reaction as determined by the soil engineer. The method of design may be any recognized published method either emperical or theoretical, such as that described in the publication "Determination of Lateral Soil Pressures and its Effect on Tunnel Systems" by M. A. Drucker or may be based on a series of spring supports with spring constants based on the modulus of subgrade reaction. In any case the decrease in vertical height shall not exceed one-half of one per cent of the design height.

   Where passive pressures cannot be adequately determined or relied upon or in other instances where the design engineer deems appropriate the design shall be based on the elastic theory and the method of analysis shall be that prescribed in "Analysis of Arches, Rigid Frames and Sewer Sections" publication ST-53 of Portland Cement Association; or the so-called "Method of Indeterminate Structures" as described in "American Sewerage Practice, Volume I" by Metcalf and Eddy. The design method selected should be discussed with the District before beginning the design.

2. Analysis for the following cases will be required.

   a. The dead weight of the structure, and the vertical and horizontal earth and live loads noted hereinbelow.

   b. The dead weight of the structure, the vertical and horizontal earth and live loads, and the internal water pressure assuming the conduit flowing just full.

   c. If the hydraulic gradient is substantially above the top of the conduit, an analysis shall be made using the following loads: Pressure due to the hydraulic head from the soffit of the conduit to the hydraulic gradient, the internal water pressure for the conduit flowing just full, the dead weight of the structure, and the vertical and horizontal earth loads. The hydraulic gradient shall be assumed at the maximum elevation possible. For this loading condition, the allowable stresses may be increased by one-third.

H-3 Cast-in-Place Section Alternate continued.
(H-3.2.2 Dead Load)

H-3.2 Vertical Loads

H-3.2.1 Live Load

As listed for box conduit design (pages G-4 to G-10).

H-3.2.2 Dead Load

1. Weight of Structure

The unit weight of concrete shall be taken as 150 pcf.

2. Earth Loads

The design unit weight of earth for cast-in-place sections for tunnel shall be equal to the weight of the material at the site as determined from soil investigation, but shall not be less than 110 pcf.

Estimates of earth loads in tunnels shall be based on a careful consideration of soil characteristics, location of water table, depth to tunnel and possible railroad or highway loads.

In general, a reduction in the vertical earth load on structures in tunnel is permitted if the height of the earth cover exceeds the value "C" in the formula:

$$C = 0.60\ (B+H_t) + 5'$$

Where

B = outside design width for cast-in-place structures, or out-to-out width of tunnel supports for precast pipe tunnels.

H_t = outside design height for cast-in-place structures, or outside height of tunnel supports for precast pipe tunnels.

However, reduced vertical earth load shall not be less than that calculated using the method described in "Earth Tunneling with Steel Supports" by R. V. Proctor and T. L. White, the Commercial Stamping and Shearing Co., Youngstown, Ohio, 1977; or "Theoretical Soil Mechanics" by Karl Terzaghi, John Wiley and Sons, Inc., New York, 1943.

In cases where the earth cover does not exceed the value "C", or where the soil is not considered homogeneous because of voids due to buildings or utilities, or where vibrations

H-3 Cast-in-Place Section Alternate continued.
(H-3.2.2 Dead Load)

due to live loads may result in loss of arching action, the vertical earth load shall be calculated by Marston's formulas, using a design unit weight of earth as discussed on page A-4.

H-3.2.3 Other External Loads

Vertical loads due to existing or proposed structures, such as buildings, abutments, etc., shall be considered in the design.

H-3.2.4 Internal Water Pressure

The conduit shall be assumed to be flowing full.

H-3.2.5 Reaction

When using the elastic theory design method, the upward pressure or reacting force on the invert slab shall be assumed to be uniformly distributed over the invert slab for sections of exterior arch shape, and over the bottom 120° of arc for sections of exterior circular shape.

H-3.3 Horizontal Loads

H-3.3.1 Live Load

As listed for box conduit design (page G-10).

H-3.3.2 Dead Load

The horizontal earth pressure in general may be assumed to be active lateral pressure based on the Rankine Theory. The Rankine "k" shall ordinarily be taken as 1/3. Special consideration shall be given where expansive soils are encountered and where there is a potential for ground water. Where lateral loads may vary or are time dependant, it may be necessary to use a composite section based on both the maximum and minimum values.

H-3.3.3 Other External Loads

Horizontal loads due to existing or proposed structures, such as buildings, abutments etc., shall be considered in the design.

H-3.3.4 Internal Water Pressure

The conduit shall be assumed to be flowing full.

H-3 Cast-in-Place Section Alternate continued.

H-3.4 Allowable Stresses and Steel Clearances

The same as stated for box conduit design (pages G-11 and G-12).

H-3.5 Steel Pattern

The required steel in the arch portion of the lining may be placed in two partial rings or a single elliptical ring. Consideration shall be given to placement problems; keeping in mind the restricted working area in tunnel construction. The use of lengthy, high weight bars should be avoided.

H-3.6 Longitudinal Reinforcement

Longitudinal reinforcement shall consist of #4 bars at 18-inch centers in each reinforced face of the arch and invert. The longitudinal bars shall be continuous through the transverse joints. A 10-inch lap is assumed sufficient for maintaining continuity.

H-3.7 Invert Slope

There shall be a one-inch drop from the base of the arch to the centerline of the invert slab in archs with horseshoe shaped interior.

H-3.8 Construction Joints

A keyed longitudinal construction joint shall be provided at the junction of the arch and invert slab. Joint details shall be similar to the joint at the base of wall for box conduits. The concrete tunnel lining may be poured in the longest practical section which will permit each section or portion of section to be completed in one continuous operation. Transverse construction joints similar to the joint at the base of wall for box conduits shall be placed at the ends of each pour. Where the length of pour exceeds fifty feet, a dummy grove ribbon or premolded contraction joint shall be placed at intervals not exceeding fifty feet. The required transverse joints shall be continuous and extend throughout the entire section and be in the same vertical plane; i.e., at all locations where a transverse joint is required in the invert slab, a transverse joint is required in the arch section and likewise a joint in the arch section will necessitate a joint in the invert slab; no partial joints will be permitted.

H-3 Cast-in-Place Section Alternate continued.

H-3.9 Member Thickness

The section thickness shall not be less than 6 inches where one curtain of steel is used or less than 8 inches where two curtains are used.

H-3.10 Deletion of Reinforcing Steel

In the event steel rib tunnel supports are used, it is desirable to eliminate certain extrados bars above the top of the footing as noted below.

Rib Spacing	Bars to be Eliminated
4'-0" and under	1 bar per rib
Over 4'-0"	2 bars per rib

The bars to be eliminated shall be designated on the typical section.

H-4 Alternate Sections

The project specifications shall provide for alternate sections. Where, for reasons of economy, the project contractor indicates he wants to construct a section other than shown on the contract plans, this will be approved provided: (1) The section is hydraulically equivalent, (2) The contractor submits structural calculations based on criteria established by the District, (3) The design is approved by the District.

H-5 Computer Programs

The District computer program for reinforced concrete arches referred to in previous editions of this manual is no longer valid and shall not be used. The use of the ICES STRUDL-II computer program developed by the Massachusetts Institute of Technology is acceptable.

H-6 Structural Detailing

Refer to Section C.

It is requested that wherever applicable reinforced concrete archs be detailed in accordance with District practice; when numerous sections are required they should be tabled.

Drawings shall include all applicable notes listed in Section F.

SECTION I

DESIGN OF

REINFORCED CONCRETE PIPE

108 INCHES IN DIAMETER AND UNDER

Section I

Design of Reinforced Concrete Pipe 108-inch in Diameter and Under

I-1 Method of Design

1. D - Load = $\frac{\text{(Total Vert. Load per Lin. Ft. of Pipe) (Safety Factor)}}{\text{(Internal Diameter)} \quad \text{(Load Factor)}}$

   Safety Factor = 1.25

   Load Factor depends upon bedding conditions and upon whether conduit is in trench or embankment. See discussion on pages I-6 and I-7.

2. D-loads shall be specified on project drawings as follows:

   (Values on Standard Drawings Nos. 2-D 213.1 to 2-D 213.27 have been rounded off to the values listed.)

   36-inch diameter and under - to next highest 250 of calculated value.

   39 to 60-inch diameter - to next highest 100 of calculated value.

   63 to 108-inch diameter - to next highest 50 of calculated value.

3. The minimum D-load specified shall be 800-D, except for:

   a. Pipe conduits in State Highways where the minimum value is 1000-D.

   b. Pipe conduits supporting railroad loads where the minimum value is 2000-D with the exception of the Atchison, Topeka and Santa Fe which requires 3000-D.

4. Maximum Values

   Where the calculated D-Load based on Case III Bedding exceeds the values tabulated below, the project drawing shall indicate D-Loads based on a higher degree of bedding.

I-1 Method of Design continued.

Maximum D-Loads

Pipe Diameter In Inches	D-Load
12	6000
15	5000
18	4750
21	4500
24	4250
27 - 30	4000
33 - 39	3750
42 - 48	3500
51 - 57	3250
60 - 63	3000
66 - 72	2750
75 - 78	2500
81 - 87	2250
90 - 108	2000

I-2 Minimum Cover

It is undesirable to install main line reinforced concrete pipe where the earth cover is less than one foot. If this is absolutely necessary, the project plans shall provide for concrete backfill per Standard Drawing No. 2-D 177. This applies to all pipe sizes. For small diameter pipe concrete encasement shall be used where indicated on Standard Drawing 2-D 213.1 to 5.

I-3 Vertical Loads

I-3.1 Live Load

I-3.1.1 Highway Loading

Pipe conduits shall be designed for one H20-S16-44 truck per lane except where passing beneath railroad tracks. The wheel loads shall be distributed through the fill to the top of the pipe as follows:

Transverse (with reference to truck) spread of wheels = 1.2 + 1.6F

Longitudinal (with reference to truck) spread of wheels = 1.5 + 1.5F

Where F = depth of fill over top of conduit in feet.

1. Truck loads on pipe conduits for covers of 10 feet and less are as follows:

TABLE OF VERTICAL LIVE LOADS

Cover "F"	Wheel Load	L.L. Pressure
Feet	Kips	PSF
1	20.8	2480 *
2	19.2	970 *
3	17.6	489
4	16.0	314
5	16.0	234
6	16.0	182
7	16.0	145
8	16.0	119
9	16.0	99
10	16.0	84

These values include the effect of overlapping wheel loads, and also the effect of impact: 30% for F=1', 20% for F=2', 10% for F=3'.

* Wheel loads do not overlap.

2. For covers exceeding 10 feet, the effect of truck loads shall be assumed to be negligible.

I-3 Vertical Loads continued.

I-3.1.2 Railroad Loading

Conduits passing under railroads shall be designed in accordance with the requirements of the particular railroad. In general, the minimum design loads are as follows:

Railroad	Cooper Loading
Atchison, Topeka and Santa Fe----------	E 80
Southern Pacific----------	E 72
Union Pacific----------	E 72

Cooper E 65 loading may be used for industrial spur and connecting tracks under the Jurisdiction of Union Pacific Railroad Company.

Values from the chart "Vertical Railroad Loads on Top Slab of Box Conduit" (page S-10) may be used in determining vertical railroad loads on pipe. (Refer to minimum D-Load values page I-1)

I-3.2 Earth Load

I-3.2.1 General

1. For covers of 10 feet or less, pipe shall be designed for the positive projection condition (assume projection ratio to be one).

2. For covers greater than 10 feet, pipe shall be designed for the applicable condition of trench, negative projection, or positive projection.

I-3.2.2 Open Cut Condition

As discussed for box conduit design (pages G-6 to G-10), except that the trench width (B_d) equals the outside diameter of the pipe plus 20 inches (in State Highways B_d equals the outside diameter plus 48 inches).

When pipe conduits are placed in State Highways and the cover is greater than 10 feet; it is requested that, in addition to the D-loads indicated on the project drawings for B_d equals to the O. D. of the pipe plus 48 inches, alternate D-loads for B_d equal to the O. D. of the pipe plus 20 inches be shown in tabular form, by station, on the drawings. The pipes affected shall be marked with an asterisk and reference made by note to the table of alternate D-loads. These D-loads may be used if the Contractor elects to backfill with concrete.

I-3 Vertical Loads continued.
(I-3.2.2 Open-Condition)

Where pipe is laid in heavy clay-type soils, higher unit soil weights and a smaller value of sliding friction greatly increases soil loads. Saturation from flooded backfill or ground water further increases loads. Therefore, the design unit soil weight shall be increased where soil analysis and judgment so indicate.

Where pipe is laid in expansive clay or where lateral surcharges are anticipated probable lateral pressures shall be analyzed. Where these loads are appreciable the special provisions of the project specifications shall specify that the pipe shall be reinforced with two equal circular cages or a single circular cage located in the center of the barrel. If the lateral pressure exceeds the vertical pressure the D-load calculation shall be based on the former and the circular cages as mentioned above shall be specified.

Pipe laid in sand having low cohesive values, particularly dune or beach sand, shall be designed for the positive projection condition.

I-3.2.3 Jacking Condition

The design unit weight of earth for jacked-in-place pipe 108 inches in diameter or under shall be 110 pcf, unless soil investigation at the site discloses material of a greater weight.

1. Where the depth of cover is 15 feet or less, it is considered that the prism of soil above the pipe may be caused to settle downward by traffic vibrations, climatic variations, etc., to such an extent that the load on the pipe will be essentially equal to that for the trench condition as discussed hereinabove under "Open Cut condition", except that the width factor, B_d, is assumed to be the outside diameter of the pipe.

2. Where the depth of cover exceeds 15 feet, the effect of the live load is negligible and the supporting effect of the cohesion of the overburden soil as well as the soil friction may be considered. For this condition the following modification to the formula for trench condition is used.

$$W = C_d . w . B_d^2 - 2C_d . B_d . c$$

I-3 Vertical Loads continued.
(I-3.2.2 Open Conditions)

where:

c = Cohesion of overburden soil

RECOMMENDED VALUES OF
COHESION (c) FOR VARIOUS SOILS

Material	Cohesion Lbs. per Sq. Ft.
Clay, very soft	40
Clay, medium	250
Clay, hard	1,000
Sand, loose dry	0
Sand, silty	100
Sand, dense	300
Top Soil, saturated	100

I-3.3 Other External Loads

Vertical loads due to existing or proposed structures, such as buildings, abutments, etc., shall be considered in the design.

I-4 Load Factor

I-4.1 Trench Condition and Negative Projection Condition

Use load factors corresponding to desired bedding condition per Standard Drawing 2-D 177 (page S-37). The ordinary condition is Case III bedding with consolidated fill to 90 percent relative compaction around the pipe: Load Factor = 1.8

I-4.2 Embankment or Positive Projection Condition

Load factors may be determined using either of the following:

1. Use load factors per Standard Drawing 2-D 177 (page S-37), as discussed hereinabove for trench and negative projection conditions.

I-4 Load Factor continued.
(I-4.2 Embankment or Positive Projection Condition)

2. Use Spangler's Formula: $L_f = \frac{1.431}{N-xq}$

Where:

L_f = Load Factor

N = .840, Case III bedding, uncompacted soil around pipe
= .707, Case III bedding, consolidated soil at 90 percent relative compaction around pipe
= .505, where concrete cradle is used

x = A factor which is a function of the area of the vertical projection of the pipe in which the active lateral pressure of the fill material acts.

Projection Ratio	Value of x
0	0
0.3	0.217
0.5	0.423
0.7	0.549
0.9	0.655
1.0	0.638

q = the ratio of the total lateral pressure to the total vertical load

$= \frac{pK}{C_c}\left[\left(\frac{H}{B_c}\right)+\left(\frac{p}{2}\right)\right]$

Where K = the ratio of active lateral pressure to vertical pressure in Rankine's Formula. May ordinarily be taken as 1/3.

p = the projection ratio

I-4.3 Jacking Condition

Assume Case III bedding with load factor = 1.8.

I-5 D-Load Tables for Design of Reinforced Concrete Pipe

Standard Drawings Nos. 2-D 213.1 to 2-D 213.27, "D-Load Tables for Design of Reinforced Concrete Pipe" (pages S-38 to S-64), may be used to determine D-Loads for pipes if the loading conditions shown correspond to those of the pipe to be designed. It should be noted that in State Highways: (1) The minimum D-load value is 1000; (2) as discussed on page I-4, the State has wider trench requirements.

As indicated on page A-4, in calculating D-loads the design unit soil weight shall ordinarily be taken as 110 pcf, except where soil analysis and judgment indicate earth loads should be increased. Therefore, D-loads should normally be taken from Standard Drawing No. 2-D 213.2. However, on all projects the soil report should be carefully analyzed and the applicable standard drawing used. Where unusual conditions exist that are not covered by the standard drawings, calculations must be submitted.

Pipe designs based on the maximum amount of earth fill plus live load are not always the critical loading condition; the minimum amount of fill plus live load may be the control. This occurs most frequently with catch basin connector pipes, especially connector pipe for catch basins in series.

I-6 Steel Clearances

Ordinarily, it is not necessary to call out steel clearances on D-load pipe. However, where velocities are between 20 fps and 30 fps, the concrete cover on the inside face of the pipe must be increased 1/2-inch. Where velocities are in excess of 30 fps, the cover on the inside face of the pipe must be increased 1 inch. Velocities in excess of 40 fps shall not be used without prior District approval. If the pipe carries debris or abrasive materials an additional 1/2-inch of concrete cover on the inside is required. If the pipe is subject to the action of sea water or harmful ground water, an additional 1/2-inch of cover on the inside or outside face is required. Pipes subject to harmful industrial wastes may require additional cover. These increases are accumulative. The amount of additional cover needed, and the locations of the pipes affected shall be noted in the special provisions section of the detailed specifications.

I-7 Pipe to be Jacked

Refer to Section G, Paragraph G-18, Box Conduits to be Jacked.

The minimum length of jacking pit is one pipe length plus 10 feet.

I-7 Pipe to be Jacked continued.

The design of pipe to be jacked shall be based on superimposed loads and not upon loads which may be placed upon the pipe as a result of jacking operations. Any increase in pipe strength required in order to withstand jacking loads shall be the responsibility of the Contractor.

In general, the jacking of pipe conduits should not be specified where the cover is less than 6'-0", or under railroads where the cover is less than the greater of 6' or 1/2 the outside diameter of the conduit.

I-8 Rubber Gasket Joint Pipe

Rubber gasket joint pipe should be used when:

1. The pipe conduit is under substantial pressure head. Amount of head is a function of depth of cover, type of backfill, etc.

2. Pipe conduits, which outlet to pump stations, are placed in sandy soil and there is a possibility of sand infiltrating into the pipe through the joints.

3. There is a possibility of the pipe conduit deflecting due to settlement, as in the case of a future freeway fill being placed over the pipe, and installations with varying cover or varying subgrade conditions. An elastomeric sealant may also be considered in this case.

It is requested that the District be consulted prior to the start of detailed design if the hydraulic grade line is 10 feet or more above the soffit or finish grade.

Where rubber gasket joint bell and spigot pipe is specified the pipe shall be reinforced per Standard Drawing No. 2-D 395.

Where pressure pipe is specified the plan shall include, where applicable, a detail for a pressure joint where pipe is joined to cast-in-place structures such as manhole bases, transition structures, etc.

I-9 Pressure Test

A pressure test is required when the pipe conduit is under a substantial head. It is requested that the District be consulted when the pressure is greater than 1.5 times the depth of cover.

I-10 General Notes

The following note shall appear on all project drawings where concrete pipe is specified:

> Design of the pipe shown hereon is based on the assumption the pipe will be installed in accordance with Case III bedding as shown on Standard Drawing No. 2-D 177 unless otherwise shown. "W" values shall be as specified on Standard Drawing No. 2-D 177 for Case III bedding, Notes 3(a), 3(b) and 3(c). If the "W" value at the top of the pipe is exceeded the bedding shall be modified and/or pipe of additional strength shall be provided. The proposed modification shall be approved by the District.

SECTION J

DESIGN OF

REINFORCED CONCRETE PIPE

OVER 108 INCHES IN DIAMETER

Section J

Design of Reinforced Concrete Pipe Over 108-Inch in Diameter

J-1 Method of Design

1. Analysis for the following cases will be required:

   a. The dead weight of the structure, and the vertical and horizontal earth and live loads noted hereinbelow.

   b. The dead weight of the structure, the vertical and horizontal earth and live loads, and the internal water pressure assuming the conduit flowing just full.

   c. If the hydraulic gradient is substantially above the top of conduit, an analysis shall be made using the following loads: Pressure due to the hydraulic head from the soffit of the conduit to the hydraulic gradient, the internal water pressure for the conduit flowing just full, the dead weight of the structure, and the vertical and horizontal earth loads. The hydraulic gradient shall be assumed at the maximum elevation possible. For this loading condition, the allowable stresses may be increased by one-third.

2. Determination of Moments and Thrusts

   Use coefficients (page S-71) calculated from information presented in Engineering News-Record, page 768, November 10, 1921.

3. Conditions of Support

   For Case III bedding, load factor = 1.8, use vertical loads uniform over top 180°, and bottom 90°.

   For concrete bedding, the bottom support shall be equal to the degree of pipe encased but nor more than 120°.

J-2 Minimum Cover

It is undesirable to install main line reinforced concrete pipe where the earth cover is less than one foot. If this is absolutely necessary, the project plans shall provide for concrete backfill per Standard Drawing No. 2-D 177.

J-3 Vertical Loads

J-3.1 Live Load

As specified for "Design of Reinforced Concrete Pipe 108-Inches in Diameter and Under" (page I-3).

J-3.2 Dead Load

J-3.2.1 Earth Load

As specified for "Design of Reinforced Concrete Pipe 108 Inches in Diameter and Under" (page I-4), except the trench width (B_d) equals the outside diameter of the pipe plus 24 inches (48 inches for pipe in State Highways).

J-3.2.2 Weight of Pipe

The unit weight of concrete shall be taken as 150 pcf.

J-3.3 Weight of Contained Water

The effect of the horizontal component of internal water pressure has been taken into account in the coefficients listed on page S-71 for loading due to water.

J-3.4 Other External Loads

Vertical loads due to existing or proposed structures, such as buildings, abutments, etc., shall be considered in the design.

J-3.5 Pressure Head

Pressure due to hydraulic head, if any, shall be considered.

J-4 Horizontal Loads

J-4.1 Trench Condition

Neglect horizontal external loads.

J-4.2 Embankment or Projection Condition

J-4.2.1 Earth Load

For horizontal earth load, use equivalent fluid pressure of 37 psf.

J-4.2.2 Live Load

Neglect horizontal live loads.

J-4.2.3 Other External Loads

Horizontal loads due to existing or proposed structures, such as buildings, abutments, etc., shall be considered in the design.

J-5 Allowable Stresses

Allowable stresses shall be as listed in Section A.

The 28-day compressive strength of the concrete shall be assumed to be 4500 psi. A one-third increase in allowable stresses shall be used for the analysis including pressure head.

J-6 Thickness of Wall

Thicknesses shall be as shown on Standard Drawings Nos. 2-D 214.1 to 2-D 214.6 (pages S-65 to S-70). Where greater thicknesses are required for extreme loads, pipe manufacturers shall be contacted regarding ability to manufacture non-standard thicknesses.

J-7 Steel Clearances

The minimum concrete cover between reinforcement surface and pipe surface for transverse steel shall be 1-1/4 inches. Assume 1-1/2 inches to center of bar when calculating effective depth. Where velocities are between 20 and 30 fps the concrete cover on the inside face of the pipe shall be increased 1/2 inch. Where velocities exceed 30 fps, the clearance on the inside face shall be increased 1 inch. Velocities in excess of 40 fps shall not be used without prior District approval. An additional 1/2 inch clearance shall

J-7 Steel Clearances continued.

be provided on the inside and/or outside where conduit is subject to the action of sea water or harmful ground water. Pipes subject to harmful industrial waste may require added cover. If the pipe carries debris or abrasive material an additional 1/2 inch of concrete cover on the inside is required. The additional cover where required is accumulative. In this case, the wall thicknesses shown on Standard Drawings No. 2-D 214.1 to 2-D 214.6 shall be maintained and the steel areas shown on this drawing modified. Structural calculations are required.

J-8 Steel Pattern

Three alternate methods of reinforcement shall be designed: (1) An inner circular cage plus an outer circular cage, (2) on inner circular cage plus an elliptical cage and (3) a single elliptical cage. Since approximately 3 square inches of steel per foot is the maximum amount that can be placed in one face, the elliptical cage alternates can sometimes be omitted.

J-9 Pipe to be Jacked

As discussed for "Design of Reinforced Concrete Pipe 108 Inches in Diameter and Under" (page I-5). Where pipe greater than 108 inches in diameter is to be jacked, two circular cages of steel are required, therefore other alternates should not be specified.

J-10 Rubber Gasket Joint Pipe

As discussed for "Design of Reinforced Concrete Pipe 108 Inch in Diameter and Under" (page I-9).

J-11 Design Tables for Reinforced Concrete Pipe

Standard Drawings Nos. 2-D 214.1 to .6 "Steel Areas for Reinforced Concrete Pipe" (pages S-65 to S-70), may be used for design so long as the loading conditions, the wall thickness and the steel clearances correspond to those of the pipe to be designed. It should be noted that in State Highways Standard Drawings No.s 2-D 214.1 to 2-D 214.6 do not apply because of the State's wider trench requirements (see page I-4).

J-11 Design Tables for Reinforced Concrete Pipe continued.

These tables shall be included in the list of standard drawings for a project when applicable. In addition, typical pipe details shall be shown on the project drawings, and data for the applicable pipe sections tabulated.

Standard Drawings Nos. 2-D 214.1 to .6 show the steel areas required per foot for circular and elliptical alternates.

J-12 Required Data and Notes

The following data and notes are required on the project drawings.

1. Tabular Form

Typical Tabulation Form

Pipe Dia. Ins.	T Ins.	Design Cover Ft.	Reinf. Steel (Sq. Ins. Per Lin. Ft. of Pipe)					
			Alternate No. 1		Alternate No. 2			Alternate No. 3
			Cage A	Cage B	Min. Cage C	Min. Cage D	Min. Cages C+D	Cage E
120	11	8	0.73	1.09	0.73	0.36	1.09	1.09

(Note: For this example, values of reinforcing steel were taken from Standard Drawing 2-D 214.2)

The steel area required in Cage E (elliptical cage only) is equal to the value specified for the minimum value of Cage C plus Cage D.

2. Typical pipe sections for circular and elliptical reinforcement cage alternates are shown on Standard Drawings Nos. 2-D 214.1 to 2-D 214.6.

J-12 Required Data and Notes continued.

3. Notes

In order to insure a proper design in the event field conditions vary from those assumed at the design stage, it is required that the following notes appear on the project drawings where applicable.

a. If the pipe design is based on Standard Drawings Nos. 2-D 214.1 to 2-D 214.6 and the steel area values are from the chart based on the ditch condition with trench width equal to the outside diameter of the pipe plus 24 inches, the following note shall appear on the project drawings:

> Design of the pipe shown hereon is based on Standard Drawings Nos. 2-D 214.1 to 2-D 214.6 (Case III bedding - ditch condition). "W" values shall be as specified on Standard Drawing No. 2-D 177 for Case III bedding, Notes 3(a) and 3(c). If the "W" value at the top of the pipe is exceeded, the pipe shall be redesigned per Standard Drawings Nos. 2-D 214.1 to 2-D 214.6 (projection condition - unrestricted trench width), or as otherwise approved by the District.

b. If the pipe design is based on Standard Drawings Nos. 2-D 214.1 to 2-D 214.6 and the steel area values are from the chart based on unrestricted trench width, the following note shall appear on the project drawing.

> Design of the pipe shown hereon is based on Standard Drawings Nos. 2-D 214.1 to 2-D 214.6 projection condition - unrestricted trench width). "W" values at the spring line of the pipe shall be as specified on Standard Drawing No. 2-D 177 for Case III bedding , Note 3 (a). "W" values at the top of the pipe may be any dimension.

c. If the pipe design is NOT based on Standard Drawings Nos. 2-D 214.1 to .6, an appropriate note stating the case of bedding, earth load condition and limits of "W" values shall be put on the project drawings.

4. Design Data

As discussed in Section E.

J-13 Computer Programs

Refer to Section B.

As discussed in Section B, , the District has developed a computer program for the design of reinforced concrete pipe. This program is based on the criteria given in this section. Refer to pages S-137 to S-144 for a write-up for this program.

J-14 Structural Detailing

Refer to Section C.

Reinforced concrete pipe shall be detailed in accordance with District practice; when numerous sections are required they should be tabled.

SECTION K

DESIGN OF

PRESTRESSED CONCRETE PIPE

Section K

Design of Prestressed Concrete Pipe

K-1 General

Prestressed concrete pipe shall consist of (1) a concrete core with tongue and groove joint, (2) one or more layers of prestressing wire wrapped circumferentially at a predetermined stress on the outside surface of the concrete core and (3) a dense cement mortar coating over the prestressed core and wire.

Prior to the inclusion of prestressed concrete pipe on any project, approval shall be obtained from the District. Due to limited availability and questionable economics, each project will be considered individually. In general, this product should be considered for only diameters above 108 inches.

K-2 Method of Design

1. Design procedure should be based on a working stress analysis.

2. Analysis for the following cases will be required:

   a. The dead weight of the structure, and the vertical and horizontal earth and live loads noted hereinbelow.

   b. The dead weight of the structure, the vertical and horizontal earth and live loads, and the internal water pressure assuming the conduit flowing just full.

   c. If the hydraulic gradient is substantially above the top of conduit, an analysis shall be made using the following loads: Pressure due to the hydraulic head from the soffit of the conduit to the hydraulic gradient, the internal water pressure for the conduit flowing just full, the dead weight of the structure, and the vertical and horizontal earth loads. The hydraulic gradient shall be assumed at the maximum elevation possible. For this loading condition, the allowable stresses may be increased by one-third.

K-2 Method of Design continued.

3. Determination of Moments

Use coefficients (page S-71) calculated from information presented in Engineering News-Record, Page 768, November 10, 1921.

4. Conditions of Support

For Case III bedding, load factor = 1.8, use vertical loads uniform over top 180°, and bottom 90°.

For concrete bedding, the bottom support shall be equal to the degree of pipe encased, but not more than 120°.

K-3 Vertical Loads

K-3.1 Live Load

As specified for "Design of Reinforced Concrete Pipe 108-inches in Diameter and Under" (page I-3).

K-3.2 Dead Load

K-3.2.1 Earth Load

As specified for "Design of Reinforced Concrete Pipe 108-inches in Diameter and Under" (page I-4), except the trench width (B_d) equals the outside diameter of the pipe plus 24 inches (48 inches for pipe in State Highways).

K-3.2.2 Weight of Pipe

The unit weight of concrete shall be taken as 150 pcf.

K-3.2.3 Weight of Contained Water

The effect of the horizontal component of internal water pressure has been taken into account in the coefficients listed on page S-71 for loading due to water.

K-3 Vertical Loads continued.

K-3.3 Other External Loads

Vertical loads due to existing or proposed structures, such as buildings, abutments, etc., shall be considered in the design.

K-3.4 Pressure Head

Pressure due to hydraulic head, if any, shall be considered.

K-4 Horizontal Loads

K-4.1 Trench Condition

Neglect horizontal external loads.

K-4.2 Embankment or Projection Condition

K-4.2.1 Earth Load

For horizontal earth load, use equivalent fluid pressure of 37 psf.

K-4.2.2 Live Load

Neglect horizontal live loads.

K-4.2.3 Other External Loads

Horizontal loads due to existing or proposed structures, such as buildings, abutments, etc., shall be considered in the design.

K-5 Allowable Stresses and Losses

K-5.1

The design concrete compressive strength shall not exceed 7,000 psi.

K-5 Allowable Stresses and Losses continued.

K-5.2

The compressive strength of the concrete at the time of prestressing shall not be less than 3,000 psi nor less than 2 times the initial compression induced in the core by prestressing.

K-5.3

Concrete compressive stress under design loads shall not exceed 40 per cent of the specified ultimate compressive concrete strength.

K-5.4

Concrete tensile stresses under design loads shall not exceed 7.5 times the square root of the specified ultimate compressive concrete strength.

K-5.5

Wrapping stress shall not exceed 75 per cent of the minimum ultimate strength of the prestressing wire.

K-5.6

Prestress losses shall be based on the following values.

1. Wire relaxation loss 0.05
2. Wire embedment loss 0.05
3. Creek factor 2.00

K-6 Physical Properties

1. Section properties of pipe shall be based on the assumption that the mortar coating is not effective in tension.
2. The minimum cover provided by the concrete coating shall be 3/4 inch over the prestressing wire or 1 inch over the core, which ever is greater.
3. Minimum core thickness shall be 4 inches.
4. A thickness of concrete equal to the amount that would be added to the steel clearance on pipe over 108 inches (Section J-7) due to velocity and debris shall be consdered sacrificial and shall not be considered in the design.

SECTION L

DESIGN OF

ASBESTOS CEMENT PIPE

Section L

Design of Asbestos Cement Pipe

L-1 General

Asbestos cement pipe, subject to the following limitations, shall be specified as an alternate to non-reinforced and reinforced concrete pipe. The criteria for determining the use and strength requirements of asbestos cement pipe shall be as follows:

L-2 Criteria for Use

1. Asbestos cement pipe may be used for main line and lateral construction provided that:

   a. The pipe diameter is 42 inches or less.

   b. The velocity does not exceed 5 feet per second under abrasive conditions. Abrasive conditions are considered to exist where the tributary drainage areas include undeveloped land that may contribute significant amounts of erosive materials to the drain, such as slate, hard shales and granitic materials, large cobbles and boulders, etc.

   c. The velocity does not exceed 20 feet per second.

2. Asbestos cement pipe may be used for catch basin connector pipe 42 inches or less in diameter except where significant amounts of erosive materials may enter the catch basins during storms.

L-3 Structural Criteria

1. Asbestos cement pipe shall be accepted on a D-load basis. The D-load shall be calculated in accordance with the D-load criteria for reinforced concrete pipe except that the factor of safety shall be 1.9. This will give D-loads 1.5 times those calculated for reinforced concrete pipe. Where the main line and lateral velocity is between 10 and 20 feet per second, the D-load requirement for main line and lateral pipe shall be increased to account for a potential loss in barrel thickness of 1/2 inch.

L-3 Structural Criteria continued.

2. In reaches where the velocity is less than 10 feet per second, the required D-load shall be 1.5 times that required for reinforced concrete pipe.

3. In reaches where the velocity is between 10 and 20 feet per second, the D-load requirement for main line and lateral pipe shall be increased to account for a potential loss in barrel thickness of 1/2 inch. That is, the pipe test load shall be sufficiently high to insure that the pipe will carry the required test load after a 1/2 inch reduction in wall thickness. The D-loads for this condition are shown on Standard Drawing 2-D 431 (page S-106). The D-loads indicated in the left hand column are the required values for reinforced concrete pipe the other values are the theoretical values the pipe must sustain if it is to sustain the required D-load subsequent to a 1/2 inch reduction in wall thickness. The District will determine the values to be specified after it is determined what wall thickness are to be furnished.

L-4 Required Data and Notes

Refer to Paragraph B-5.5 of the Hydraulic Design Manual.

SECTION M

DESIGN OF

CAST-IN-PLACE PIPE

Section M

Design of Cast-in-Place Pipe

M-1 General

Cast-in-place non-reinforced concrete pipe may be used as an alternate under certain conditions subject to District approval. In all cases where a cast-in-place pipe is specified a reinforced concrete pipe alternate is required.

M-2 Criteria for Use

1. Cast-in-place pipe may be constructed only in ground capable of standing unsupported from the bottom of the trench to the top of the pipe without sloughing. The ground shall not contain trash, debris, or bituminous materials.

   If cast-in-place pipe is to be constructed in fill that extends below the top of the pipe, the fill shall be placed to a minimum relative compaction of 90 per cent. In addition the pipe shall be designed based on soil parameters determined by the soils engineer. After the fill has been placed, and before the pipe is constructed, the fill shall be tested. If the minimum soil parameters assumed for design are not met, the reinforced concrete pipe alternate shall be used.

   Cast-in-place pipe shall not be constructed in fills that extend below the pipe for a distance of more than twice the outside pipe diameter.

2. Cast-in-place concrete pipe will not be permitted in ground which is saturated or which contains water in such quantities as to be harmful to the concrete unless provisions are made to dewater the trench so that flowing or standing water is eliminated. An acceptable method, although not guaranteed to produce the required result, would be the placement of a six-inch layer of rock at pipe subgrade.

3. The minimum cover over the pipe shall be the greater of two feet or 1/2 the inside diameter.

4. The maximum interanal hydrostatic head shall be the lesser of 2 feet or 2 feet below finished grade.

M-3 Method of Design

In general cast-in-place pipe installed in either a negative projection or trench condition with a modulus of subgrades of at least 165 pci will be accepted with the Industry standard wall thickness.

In positive projection installations, when the modulus of subgrade reaction is less than 165 pci or when unusual load conditions may exist the pipe shall be designed.

The design shall be based on the assumption that there is soil-structure interaction. Passive pressure is assumed to be generated as the system deflects. The magnitude of the passive pressure shall be no greater than the product of the deflection and modulus of subgrade reaction. The modulus of subgrade reaction shall be determined by the soils engineer and shall be assumed to act on the lower 210 degree of the pipe.

M-4 Vertical Loads

M-4.1 Live Loads

Live loads shall be the same as for reinforced concrete pipe. Refer to subsection I-3.1. (Page I-3)

M-4.2 Dead Loads

Earth loads shall be calculated in accordance with Marston's theory for earth loads on conduits. Bd shall equal Bc. Refer to subsection G-3.2.2. (Page G-6)

M-5 Horizontal Loads

In general horizontal load shall be neglected. If the horizontal load, because of expansive soil or large surcharges, is anticipated to approach or exceed the vertical load, the pipe shall be designed both with and without the horizontal loads.

M-6 Internal Loads

The pipe shall be designed both full of water and ampty. Internal pressure shall be included where appropriate.

M-7 Concrete Stress

M-7.1 Ultimate Stress

The minimum ultimate compressive strength of the concrete (f'c) at 28 days shall be 4000 pounds per square inch or the minimum flexural tensile strength (fr, modulus of rupture) shall be 600 pounds per square inch. (Generally $9.5\sqrt{f'c}$)

M-7.2 Allowable Stress

A. The allowable compressive strength, fc shall be 0.45 f'c or 1800 psi for 4000 pound concrete.

B. The allowable tensile strength ft shall be 0.53 fr or 320 pounds per square inch for 4000 pound concrete.

M-8 Wall Thickness

The minimum wall thickness shall be the Industry Standard thickness as listed below:

Pipe Size Inches	Wall Thickness Inches	Pipe Size Inches	Wall Thickness Inches
24	3	72	7
36	3 1/2	84	8
48	5	96	9
60	6	108	10

The following conditions and restrictions shall apply to the use and design of cast-in-place pipe:

1. No abrasive materials in the flow.

Velocity Foot Per Second	Additional Wall Thickness Inches	Concrete Strength Pounds Per Square Inch
10	0	Standard
10 to 20	1/2	5000
20	Cast-in-place pipe shall not be used	

2. Abrasive materials in the flow.

Velocity Foot Per Second	Additional Wall Thickness Inches	Concrete Strength Pounds Per Square Inch
5	1/2	5000
5 to 10	1	5000
10 to 15	1 1/2	5000
15 to 20	2	5000
20	Cast-in-place pipe shall not be used	

The above listed thicknesses are in addition to the standard or design thickness and shall apply to the lower 120° of the conduit and shall be considered sacrificial and shall not be included in a structural analysis.

M-9 Standard Strutures

Standard structures shall be shown on the plans as though reinforced concrete pipe were to be installed. "Additional Notes for Cast-In-Place Pipe Construction" modifying certain structures as shown on page F-7 shall be included on the plans.

SECTION N

DESIGN OF

CORRUGATED METAL PIPE

Section N

Design of Corrugated Metal Pipe

N-1 General

Installation of corrugated metal pipe is recommended in locations where rigid pipe is difficult or unduly expensive to install because of grade, foundation, condition, remotness of site or where the drain is of a temporary nature. District approval shall be obtained prior to use.

N-2 Method of Design

1. The design of corrugated metal pipe shall be based on the ring compression method, soil-structure interaction theory or the deflection-limit theory. If the latter is used, the deflection shall be limited to five per cent of the internal pipe diameter.

2. Seam strengths, physical properties, etc., shall be as specified by a recognized manufacturer such as Armco, United States Steel or Kaiser Steel.

N-3 Vertical Loads

Vertical loads shall be as specified for "Design of Reinforced Concrete Pipe 108 Inches in Diameter and Under" (page I-3).

N-4 Structures and Fittings

In general, manufacturers standard fittings shall be used. The District shall be consulted with respect to the type of access structures to be used.

SECTION O

DESIGN OF
RECTANGULAR OPEN CHANNELS

Section O

Design of Rectangular Open Channels

O-1 Economy of Design

Consideration shall be given in each individual project to the conditions of soil, ground water level, slope of adjacent ground surface and live loading, existing or proposed. For ordinary conditions the rigid frame "U" Channel shall be used. For extreme conditions a cost study should be made to determine the relative merits of the "U" Channel as compared to the "L" Channel. The "L" Channel consists of retaining walls with a nominal thickness central invert connecting slab.

In general the wall height shall be varied in two-foot increments.

O-2 Method of Design

1. Two analyses shall be made of each section, empty and flowing full.
2. "U" Channels shall be designed as rigid frames.
3. "L" Channels shall be designed as cantilever retaining walls with a nominal non-structural connecting floater slab.

O-3 Horizontal Loads

O-3.1 Channel Empty

O-3.1.1

Channel walls 13 feet or less in height shall be designed for an equivalent fluid pressure (E.F.P.) of 62.5 psf applied on the earth face of the wall, except when the earth load due to the sloping surcharge exceeds this, or where the wall is adjacent to or within a street or highway easement. For the latter condition see criteria hereinbelow.

(Note: Where sloping surcharge exists, it may be advisable to increase the width of berm to prevent excessive earth loads.)

0-3 Horizontal Loads continued.

0-3.1.2

For wall heights greater than 13 feet, a careful study should be made of soil types, excavation and backfill conditions, ground water levels, sub-drainage systems, topography and other pertinent factors to determine the design loading. Walls over 13 feet in height adjacent to access roads, public streets or probable future streets shall ordinarily be designed for a loading of 37 psf E.F.P. combined with the lateral loads produced by one H20-S16-44 truck with wheels 2 feet from the wall (measured from centerline of wheel to outer edge of wall).

Curves showing moments and shears for 62.5 psf E.F.P., and for lateral H15 and H20 truck loads on open rectangular channel walls are included (pages S-76 to S-78).

0-3.2 Channel Full

Channel walls regardless of height shall be designed for 40 psf equivalent fluid pressure applied on the water side to top of wall. This assumes active resistance from the soil outside the walls, or allows an increase in stresses for short time loading should active pressure not exist. Moment and shear curves for 40 psf E.F.P. are included (pages S-76 to S-78).

0-3.3 Stability and Sliding

Rigid frame "U" sections with differential lateral loadings shall be checked for stability, soil reaction and sliding. "L" walls shall be checked for stability, soil reaction and sliding. The center invert slab shall also be checked for buckling forces transmitted by adjoining retaining walls. The thrust delivered to central invert slab shall be the total horizontal force minus the product of the effective vertical force and the coefficient of sliding friction. The factor of safety against sliding shall be 1.5.

0-4 Vertical Loads

0-4.1 Soil Pressure

Soil pressures on "U" channels shall be computed considering the invert slab as a slab on an elastic foundation (see "Beams on Elastic Foundations" by M. Hetenyi, University of Michigan Press, Ann Arbor, Michigan, 1946). Curves showing moments and soil pressure in "U" channels are included (pages S-84 to S-99). When the width of channel is less than the minimum values shown on the curves, uniform soil pressure shall be assumed.

0-4 Vertical Loads continued.

0-4.2 Uplift Pressure

See discussion of methods of design for ground water forces under Section Q. Where invert slabs are designed for uplift forces required to float the structure, allowable stresses may be increased to fs = 32,000 psi and fc = 2,400 psi.

0-4.3 Flotation Forces

The structure shall be designed to resist flotation forces. The factor of safety against flotation shall be 1.5.

0-5 Allowable Stresses

Allowable stresses shall be as listed in Section A except for increases noted hereinabove for the uplift analysis.

0-6 Thicknesses of Members

Side walls shall have a minimum thickness of 8 inches. The earth face of walls shall be battered from the required thickness at the base to the minimum thickness at the top.

0-6 Thicknesses of Members continued.

Floor slabs of "U" Channels shall generally have a minimum thickness of 9 inches. Floor slabs of "L" retaining walls shall have a minimum thickness of 9 inches. Thickness of floor slabs shall be measured at the wall.

For all channels there shall be a minimum projection of the floor slab beyond the walls (i.e. a heel) of 6", but not less than the distance required for adequate anchorage of the reinforcement.

Central invert connecting slabs of "L" Channels shall generally be not less than 8 inches thick.

0-7 Steel Clearances

As specified for box conduit design (page G-12).

0-8 Steel Pattern

1. Earth face wall steel shall be "L" Bars bent into the bottom face of invert slab.
2. Channel face wall steel shall be "L" Bars bent into the bottom face of heel.
3. Channel face invert slab steel shall be bent to conform to the slope of the floor slab.
4. "U" Bars shall not be used.
5. Unduly long bars shall be avoided.

0-9 Longitudinal Reinforcement

1. Longitudinal steel shall be #4 bars at 18-inch centers in each face of walls and slabs.
2. Longitudinal steel shall not be continuous through the joints.

O-10 Transverse Slope Floor Slab

On the channel face side, there shall be a one inch drop from the wall to the center of the floor slab for inside channel widths of 20 feet or less and a two inch drop for widths greater than 20 feet, unless a low flow channel is used.

The earth face of floor slabs shall be battered from the required thickness at the inside face of the wall to the required thickness at the center of the floor slab, unless a low flow channel is used.

O-11 Construction Joints

Construction joint details shall be shown on the project drawings.

O-11.1 Transverse Construction Joints

Spacing of transverse construction joints shall not exceed 50 feet or be less than 10 feet, unless otherwise shown on the project drawings. Transverse joints in walls and slabs shall be in the same plane. Steel should not be continuous through the joints.

1. Vertical Wall Joints

   Paint with a tack coat of asphalt paint.

2. Transverse Floor Joints

   Separate slabs with 3/8-inch premold asphalt filler.

O-11.2 Longitudinal Construction Joints

1. Longitudinal Floor Joints

   Paint with tack coat of asphalt paint. Dowel central invert connecting slabs to wall bases with #4 at 12" by 4'-0" dowels.

2. Longitudinal Wall Joints

   Shall be the same as the construction joints at the base of exterior walls of box conduits.

If the channel is subject to the action of sea water, the longitudinal construction joints must be sealed with epoxy, elastameric sealants or water stops. Special longitudinal construction joints details will be required. The District will furnish details of typical joints for use on District projects.

O-12 Berms

Normal channel design should provide for a roadway berm sloping toward the channel walls on a grade of two percent on each side of the channel. Cut slopes from the natural ground to the back or outside edge of the berm may vary from 1:1 to 1-1/2:1 depending upon the soil characteristics.

In some instances, conditions may be such that a roadway berm can be placed only on one side of the channel and in other cases, it may be necessary to eliminate it entirely. For channels in cut the minimum berm shall be two feet measured from the outside edge of the wall.

O-13 Subdrainage

See discussion under Section Q.

O-14 Computer Program

Refer to Section B.

As discussed in Section B, the District has developed a computer program for the design of reinforced concrete open rectangular channel. This program is based on the criteria given in this section except for top steel cover in the invert. This must be adjusted by hand until the program is rewritten. Refer to pages S-118 to S-126 for a write-up for this program.

O-15 Structural Detailing

Refer to Section C.

Reinforced concrete open rectangular channel sections shall be detailed in accordance with District practice; when numerous sections are required they should be tabled. Refer to pages S-102 for an example of standard detail and form. Copies of standard size District drawing sheet are available for use on District projects.

Drawing shall include the applicable notes listed in Section F.

SECTION P

DESIGN OF

OPEN TRAPEZOIDAL CHANNELS

Section P

Design of Open Trapezoidal Channels

P-1 General

The use of trapozoidal channels and design criteria shall be discussed with the District before detailed designs are started. Since trapezoidal channels are inherently weak against uplift pressures, careful investigation of ground water conditions and the need for subdrains should be made. See Sections Q and R for further discussion of subdrainage systems and types of subdrains.

SECTION Q

SUBDRAINAGE SYSTEMS

Section Q

Subdrainage Systems

Q-1 General

Subdrainage is an important feature in the design of reinforced concrete rectangular sections and lined trapezoidal channels. Effective subdrainage increases the bearing capacities of subgrades, decreases lateral and upward external pressures, and thus allows the use of lighter and more economic structures.

The nature and extent of the subdrainage system is dependent upon the type of channel structure and upon judgment and experience as to how much water will have to be outletted in order to relieve unbearable hydrostatic pressures. If ground water levels are above proposed invert grades, it will usually be desirable to provide for more extensive subdrainage than would be necessary in the case of "perched water" or local infiltrations of surface water.

A thorough investigation shall be made to establish the maximum level of ground water that can be expected. In addition to the information contained in the project soil report, ground water records are available at the District and at the office of the State Department of Water Resources.

Generally, each project will require the exercise of specific judgment and experience as to subdrainage requirements. It is requested that the District be consulted before detailed design is begun. Prints detailing the various types of subdrainage systems are available from the District upon request.

Q-2 Rigid Frame "U" Sections

"U" Sections are designed and constructed to act as rigid frames.

Any such section, not provided with subdrainage, should at least have adequate weight and strength to withstand hydrostatic forces consistent with the assumed maximum level of external ground water. For this case, the structure should be designed for the full flotation force. Often times, sufficient weight can be obtained by an extension

Q-2 Rigid Frame "U" Sections continued.

of the wall heels. This is probably the safest method which can be used. In case it proves to be uneconomical, then it may be used in combination with subdrains. With a subdrainage system, uplift pressures may be reduced to the extent considered as warranted by the type and expected effectiveness of the subdrainage system. The assumed ground water level shall not be lower than two feet above the bottom of the floor slab for channels without subdrainage, or at the top of the outlets for channels with a subdrainage system.

Where a subdrain is required the minimum system shall consist of a perforated 6 inch minimum diameter pipe line on each wall heel laid in drainage material. Where justified by conditions of high ground water or poor drainage, blankets of sand and gravel may be used for base slab subgrade. The use of weepholes is not favored.

Q-3 "L" Wall Sections

For special conditions, open channel sections consisting of two "L" shaped cantilever retaining walls with a central concrete invert slab may be used. The invert slab has little weight and must be well protected from uplift pressures. Generally, "Heel Drains" and Floor Slab Drains", outletted at intervals into the channel, are used when uplift conditions are not severe. Sometimes the heel and floor slab drains are interconnected, and sometimes sand and gravel blankets may be desirable, depending upon the severity of the uplift conditions. Vertical cutoff walls shall be spaced along the channel reach to localize damage to the invert slab.

For "Low-Flow Channels", reference is made to Section R (page R-1).

Q-4 Box Conduits

In general, where ground water is encountered, no subdrainage system is required; however, the effect of external pressure on the conduit shall be investigated. In cases where ground water is excessively high or where foundation conditions are unstable, it may be desirable to drain the ground water into the conduit or otherwise provide for relief.

Q-5 Open Trapezoidal Sections

The invert slab and bank linings of trapezoidal sections are incapable of resisting much hydrostatic head. Consequently, the subdrainage system must be so chosen to assure that the upward pressure will be less than the weight of lining.

For permanent structures, longitudinal heel drains, longitudinal and transverse floor slab drains should be so placed, and possibly interconnected so as to reduce the hydrostatic heads to bearable limits. The use of filter blankets, or sand and gravel blankets is a desirable method of equalizing pressure and usually results in minimizing the number of pipe drains required and results in a safer structure.

Q-6 Ground Water Quantities

Design flow rates shall be determined from information in the soil report and shall be based on the soil permeability and the observed and historic ground water levels.

SECTION R

TYPE OF SUBDRAINS

Section R

Types of Subdrains

R-1 Low Flow Channels

Low flow channels are usually small rigid frame "U" sections constructed in the invert subgrade at the centerline of the channel. They concentrate low flows, promote adequate velocities for the movement of sand and provide a very effective means of outletting drainage waters collected by the subdrainage system. They are also of aid during construction. Low flow channels are used when ground water conditions are severe.

R-2 Heel Drains

Heel drains are longitudinal perforated pipe lines, laid in gravel or in mixtures of sand and gravel, on the wall heels of rectangular sections, or near the outer ends of the invert base in the case of trapezoidal sections. The drains should be at the lowest level consistent with outletting requirements, since their purpose is to protect invert slabs and other linings not designed to resist much uplift. The six-inch minimum diameter subdrain pipe shall be either bell and spigot concrete, bell and spigot vitrified clay or asbestos pipe at the contractor's option.

Generally, the drains are discharged by spigot ells directly into the channel through flap-gated outlets at specified intervals. In other cases, the flow in the heel drain may be diverted into lateral drains in the invert subgrade, so as to outlet into a low flow channel or a longitudinal invert drain. The heel drains should be continuous except that a gap of about three feet should be provided, unless otherwise directed, at about 200-foot intervals.

Material around heel drains shall in general be D1 drain material and shall be enclosed in a filter fabric appropriately sized to prevent movement of the fines.

All drain pipes are laid with the bell ends upstream. The bell at the upstream end of each drainage unit should be entirely closed by a mortared-in precast concrete cap.

R-3 Floor Slab Drains

Floor slab drains are longitudinal pipe, lateral pipe, or combination of the two laid in gravel filled trenches or pervious blankets in the channel floor subgrade. Details of floor slab drains are shown on Standard Drawings Nos. 295.1 to .3. Where these details are applicable they may be included with the project drawings provided the case to be used is specified on the project drawings.

R-4 Sand and Gravel Blankets

Sand and gravel blankets should be used for either rectangular or trapezoidal sections, where subsoil testing indicates that the excavated subgrades will be wet and soft, or that subdrainage requirements will be extensive for a considerable period of time. These blankets, where deemed necessary because of particle size shall be placed on appropriately designed filter fabric. In addition to "drying up" the subgrade and improving its bearing capacity, the blanket is considered effective in filtering out the colloids and transferring subgrade flows to the main collector system.

The blanket material, when used as backfill for a rectangular section, or as subgrade for a bank lining, should not be extended to ground surface. It is preferable that the upper two or three feet of soil be less pervious in order to minimize the infiltration of surface water.

The blanket material in general shall be D1 drain material and should be subjected to moderate rolling.

R-5 Filter Blankets

Filter blankets, such as used by the District for East Compton Creek and by the U.S.C.E. for various projects, consists of a layer of sand overlaid by a layer of gravel. Theoretically, they afford optimum subdrainage. However, they are difficult to place and are subject to infiltrations of colloids from beneath, and of mortar from above during the pouring of concrete. Ordinarily, sand and gravel blankets and filter fabric should be provided in lieu of filter blankets.

SECTION S

DESIGN CHARTS AND DRAWINGS

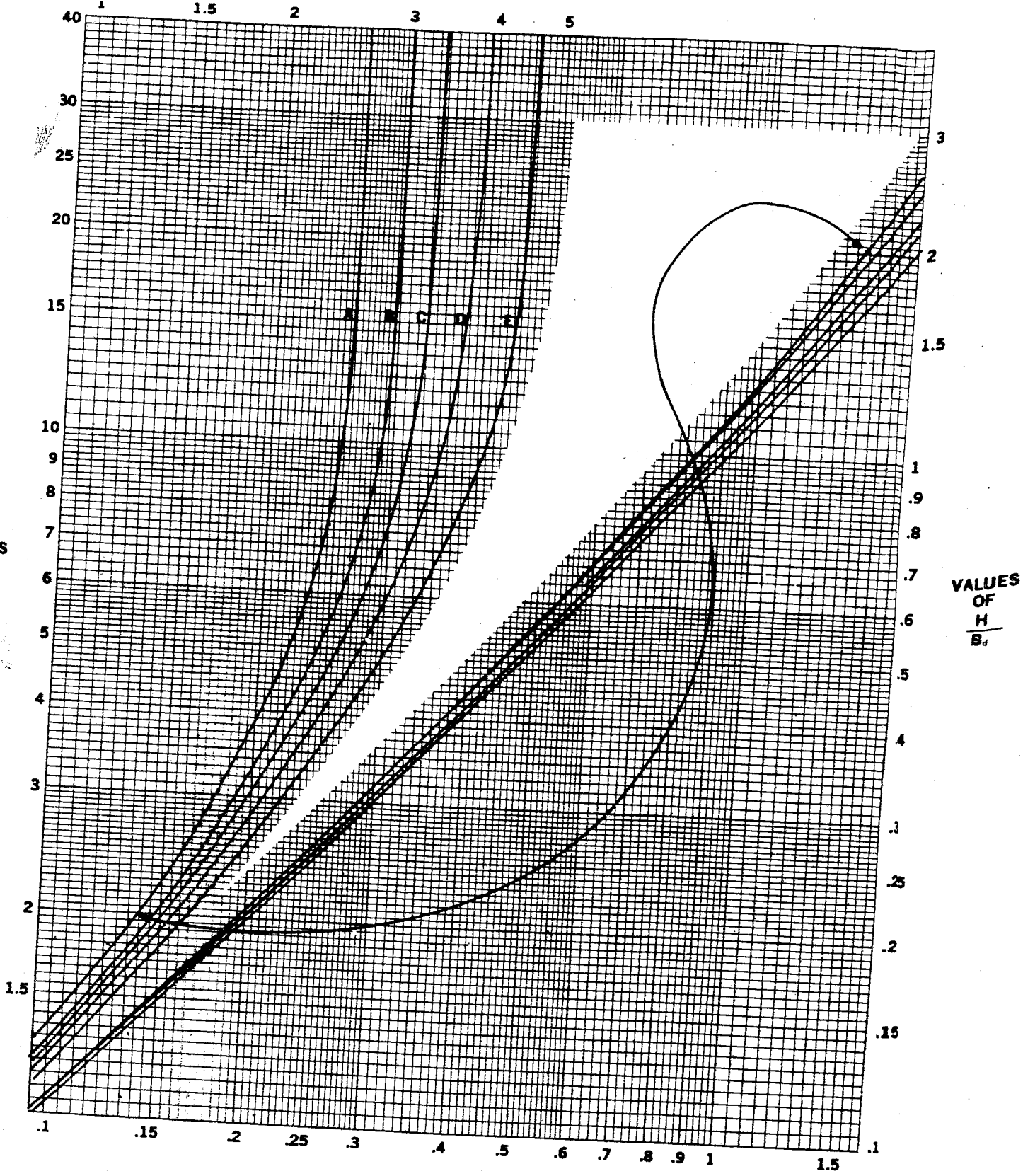


FIGURE 3

COMPUTATION DIAGRAM FOR EARTH LOADS ON TRENCH CONDUITS
(CONDUITS BURIED IN TRENCHES)

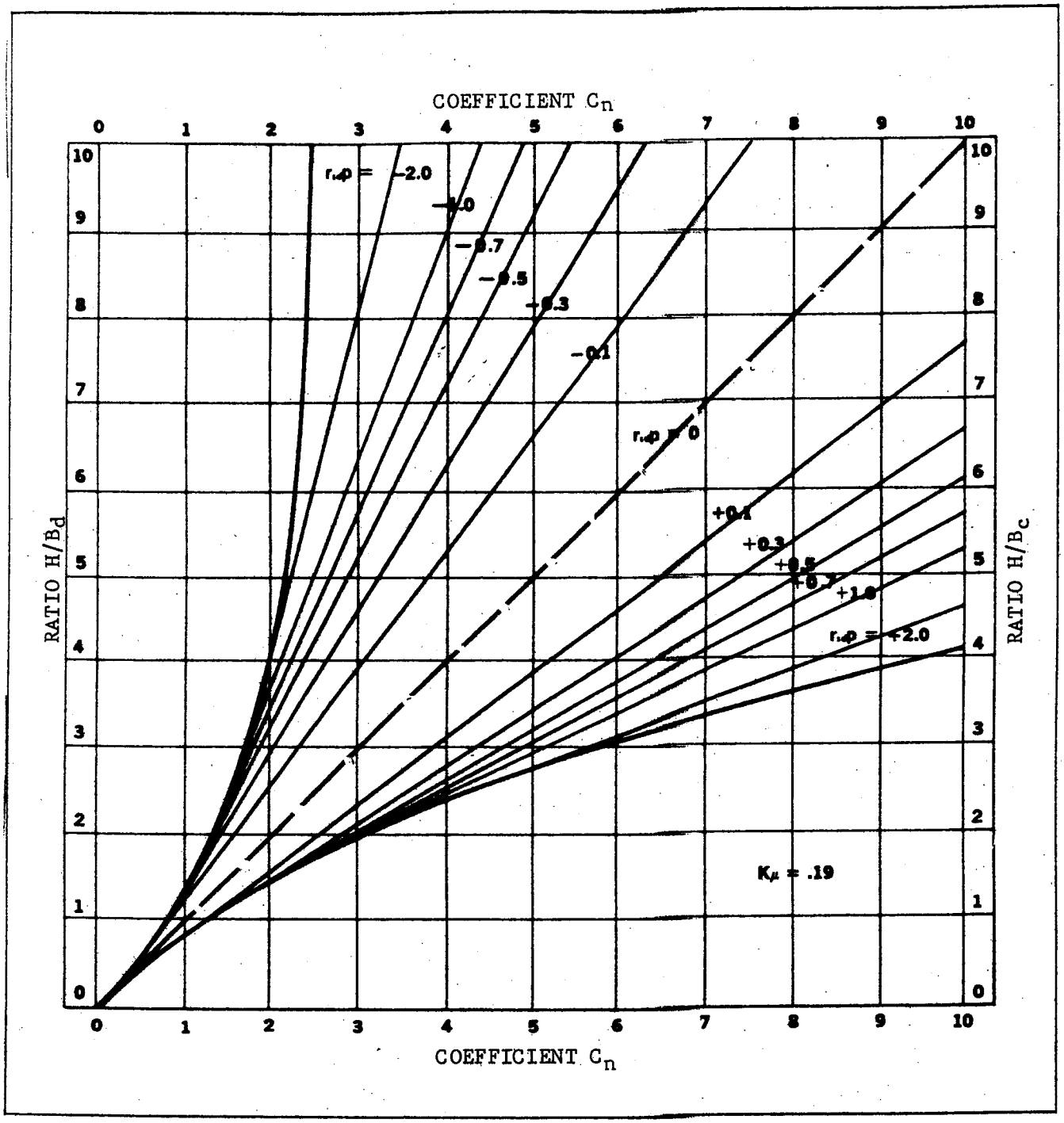


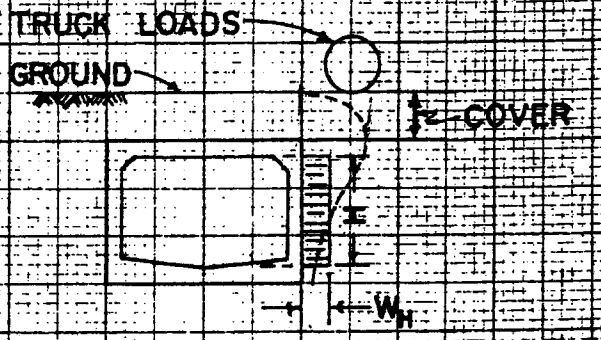
FIGURE 5. COMPUTATION DIAGRAM FOR PROJECTING CONDUITS

AVERAGE SIDE H-20 TRUCK LOADS ON BOX CONDUITS

IMPACT COEFFICIENTS:

0' TO 1' COVER	30 %
1'-1" TO 2' COVER	20 %
2'-1" TO 2'-11" COVER	10 %
3' COVER AND OVER	0 %

} INCLUDED IN CURVES



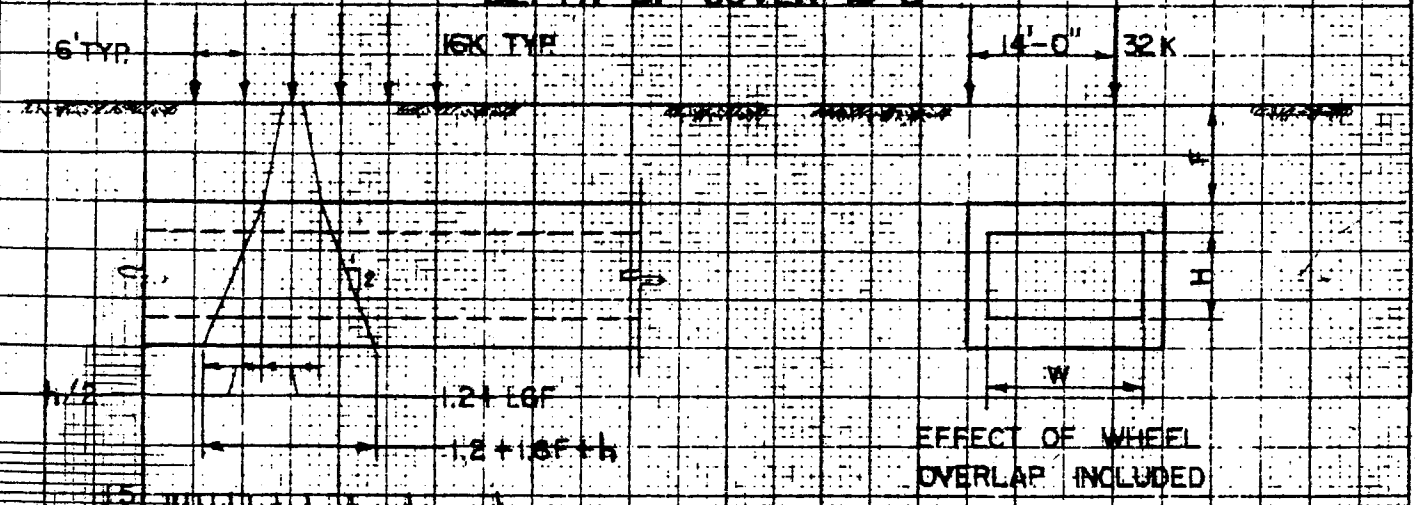
INFORMATION BASED ON L.A.C.F.C.D. CURVE FOR SIDE TRUCK LOADS.

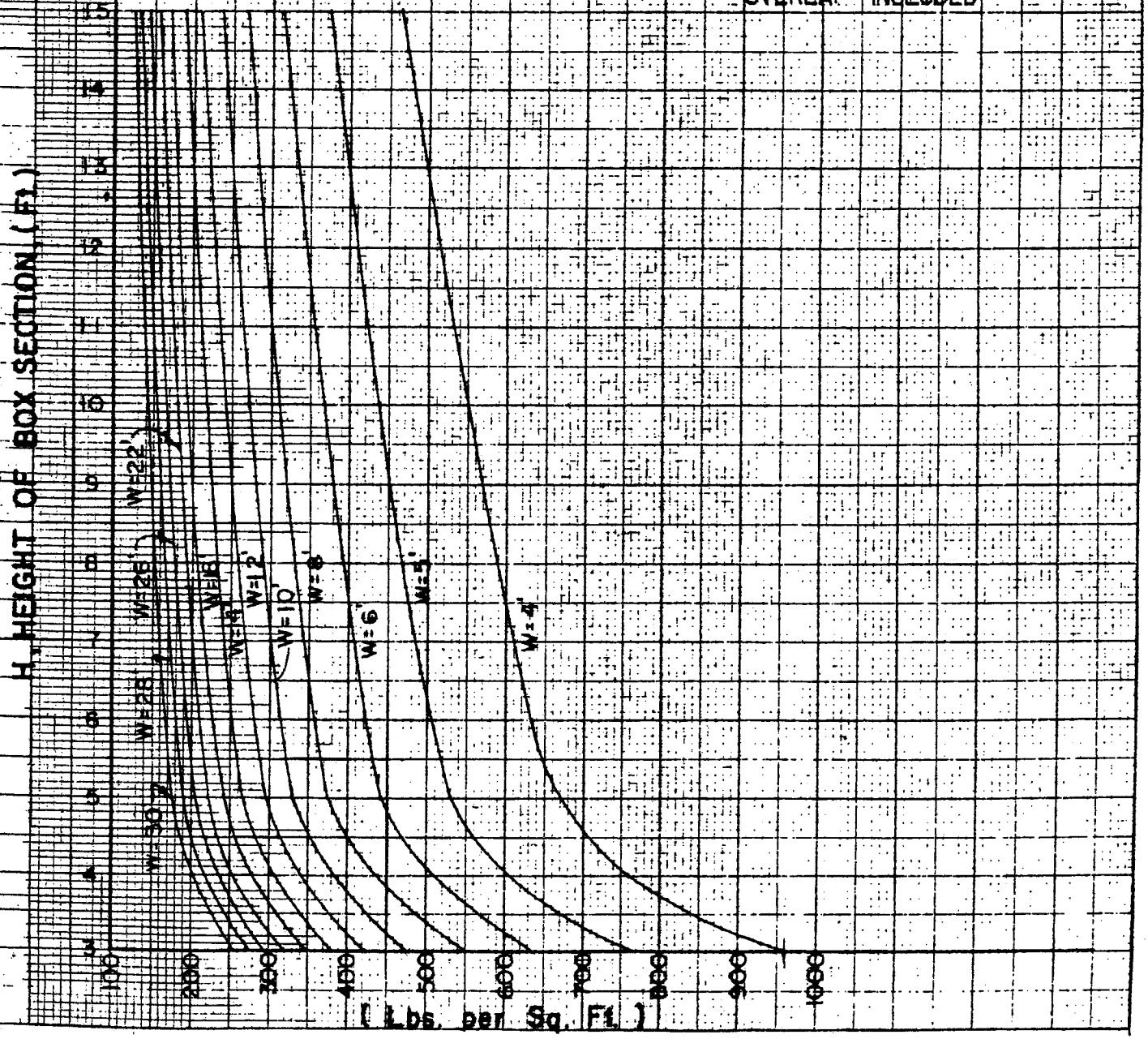
H-20 TRUCK LOADS ON INVERT SLABS OF BOX CONDUITS

IN POUNDS PER SQUARE FOOT

MAIN REINFORCEMENT IS PARALLEL TO TRAFFIC

DEPTH OF COVER IS C'



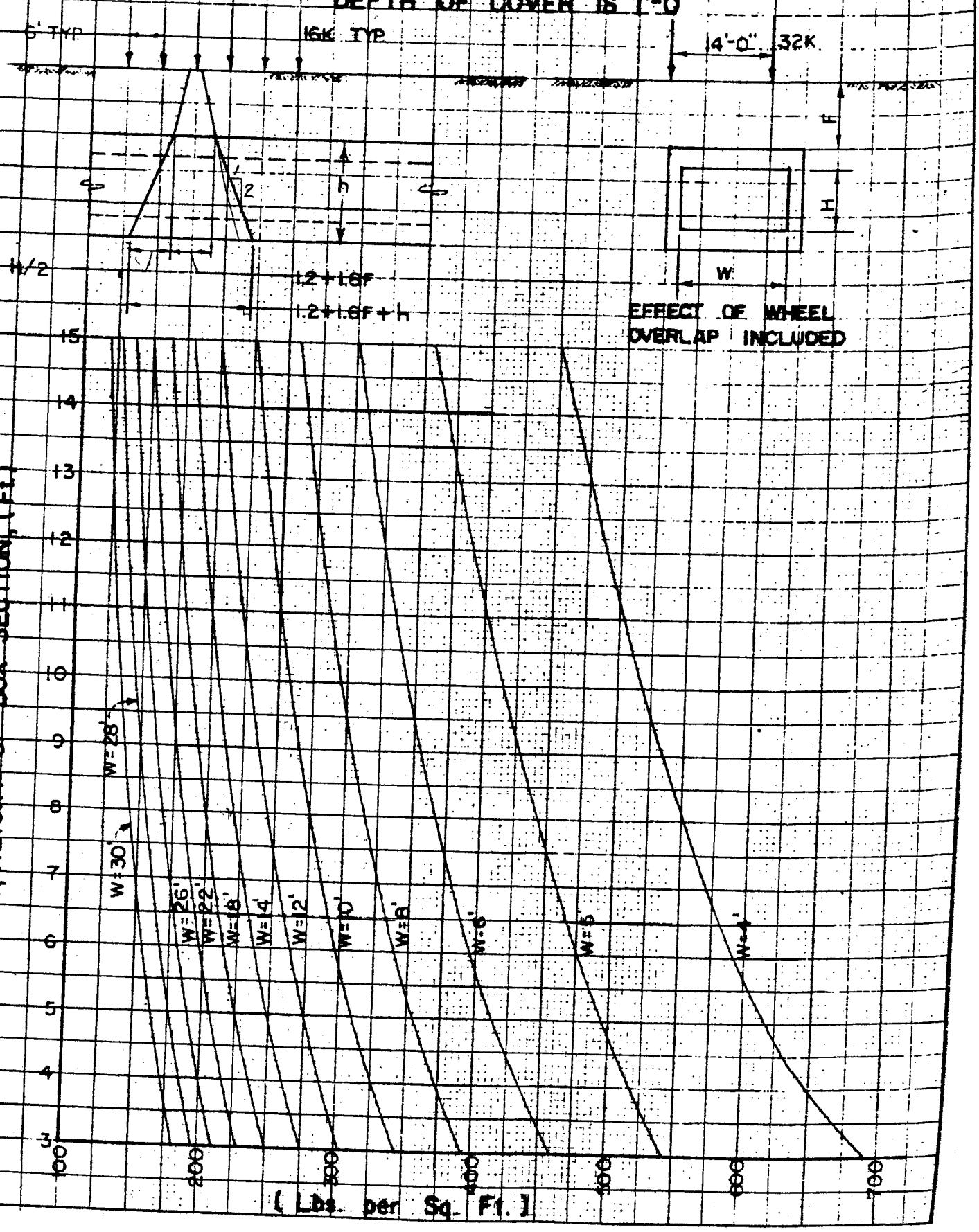


H-20 TRUCK LOADS ON INVERT SLABS OF BOX CONDUITS

IN POUNDS PER SQUARE FOOT

MAIN REINFORCEMENT IS PARALLEL TO TRAFFIC

DEPTH OF COVER IS 1'-0"

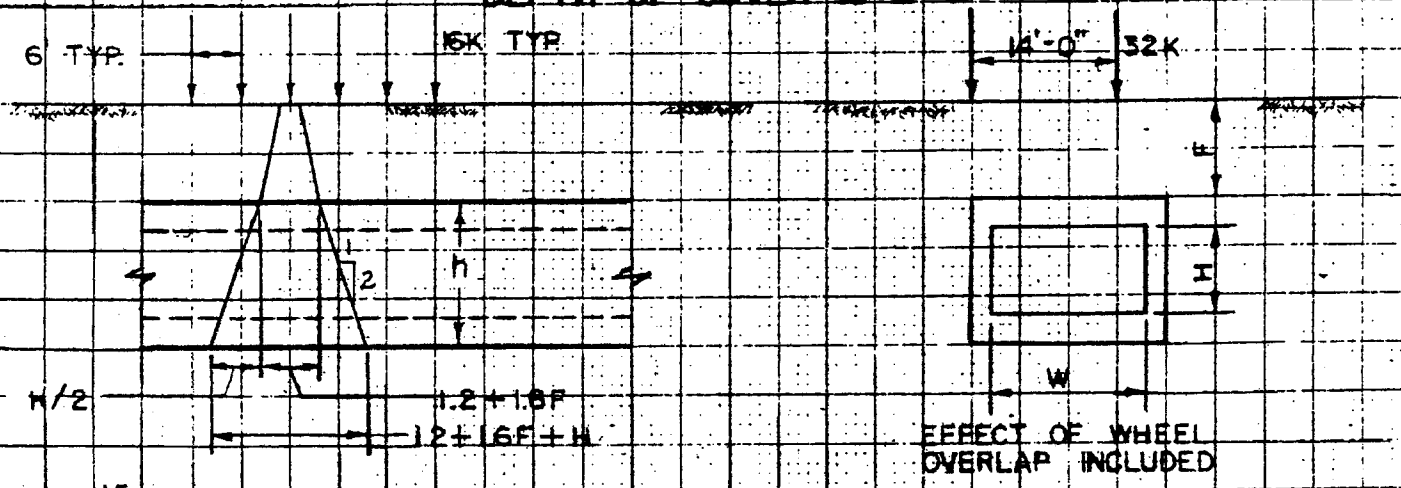


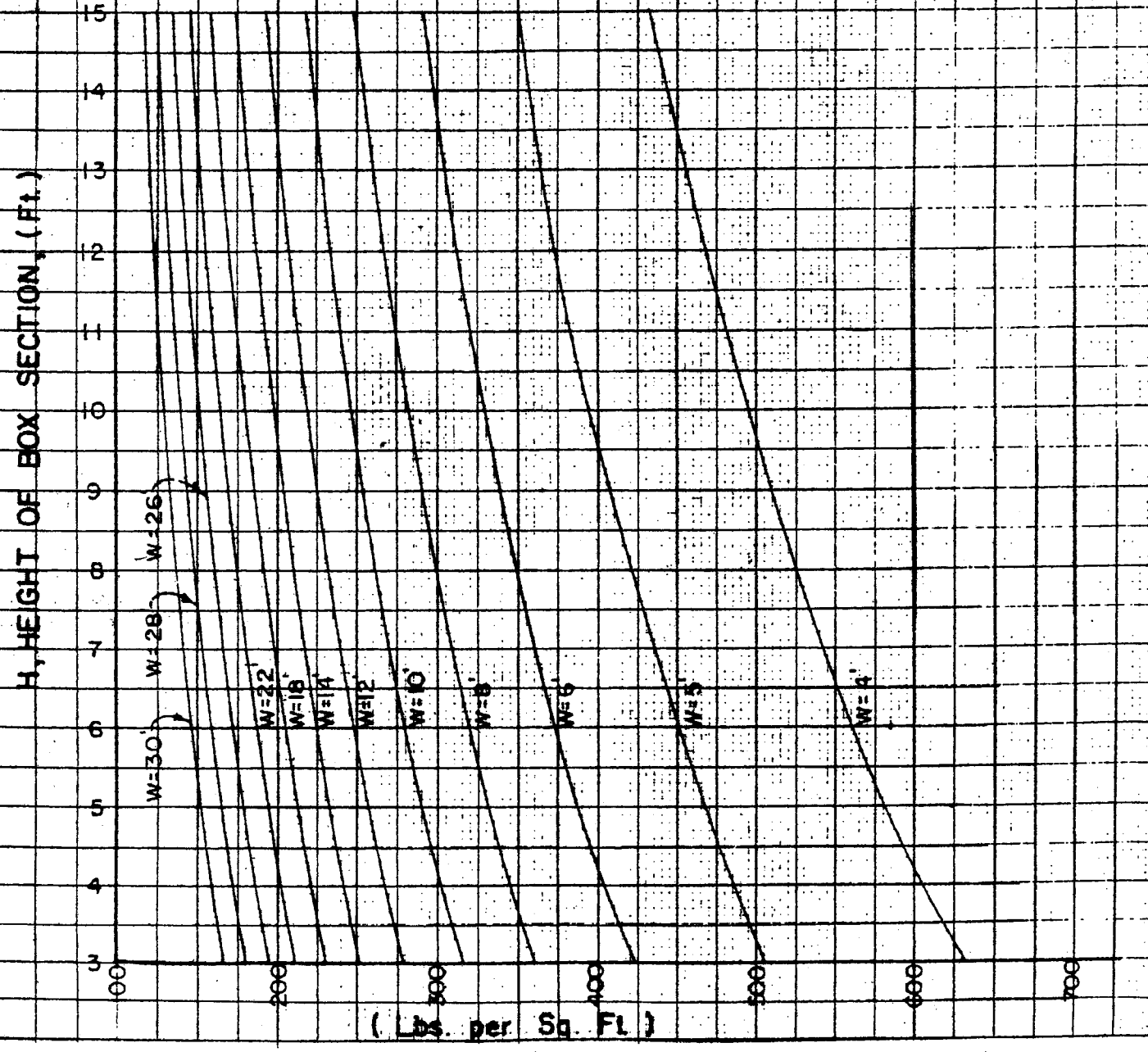
H-20 TRUCK LOADS ON INVERT SLABS OF BOX CONDUITS

IN POUNDS PER SQUARE FOOT

MAIN REINFORCEMENT IS PARALLEL TO TRAFFIC

DEPTH OF COVER IS 2'-0"



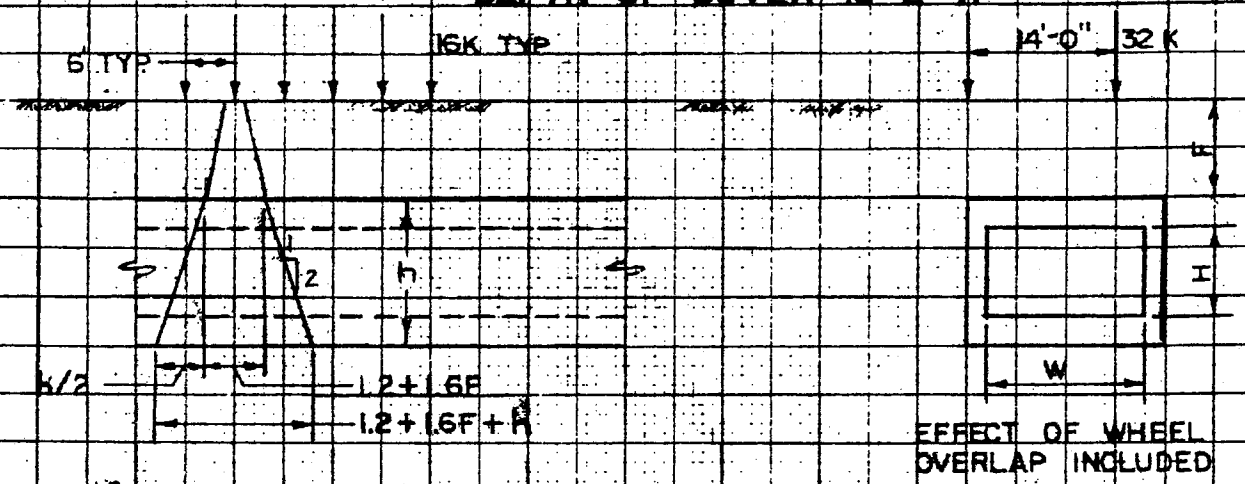


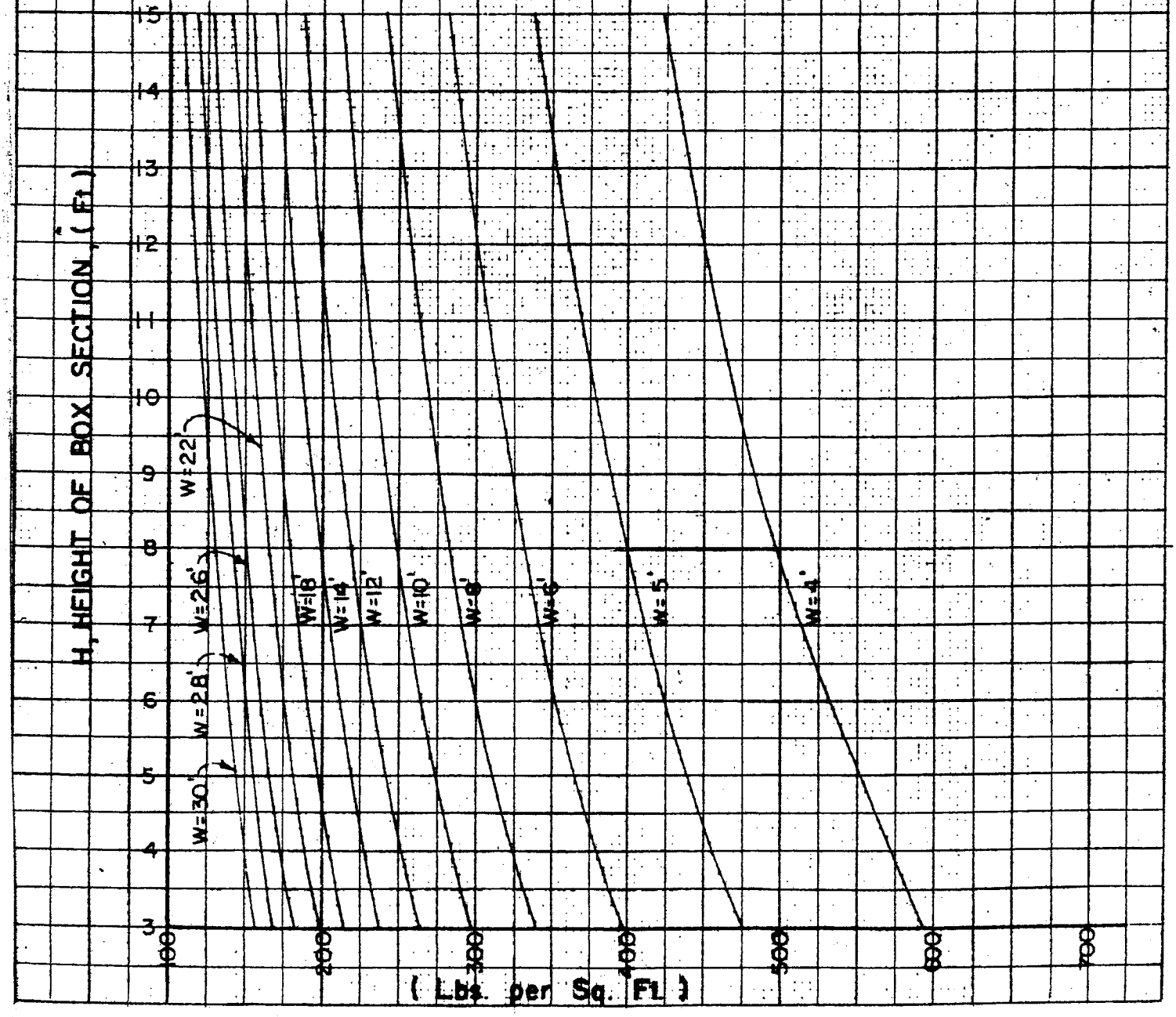
H-20 TRUCK LOADS ON INVERT SLABS OF BOX CONDUITS

IN POUNDS PER SQUARE FOOT

MAIN REINFORCEMENT IS PARALLEL TO TRAFFIC

DEPTH OF COVER IS 2'-11"



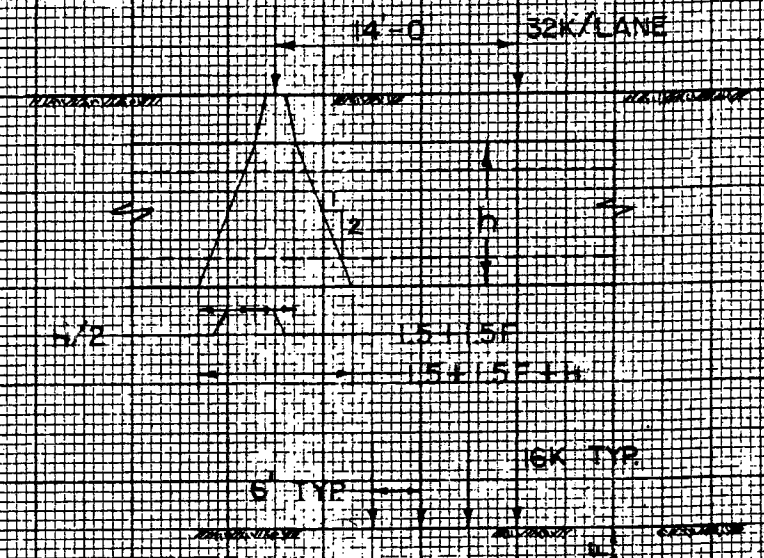


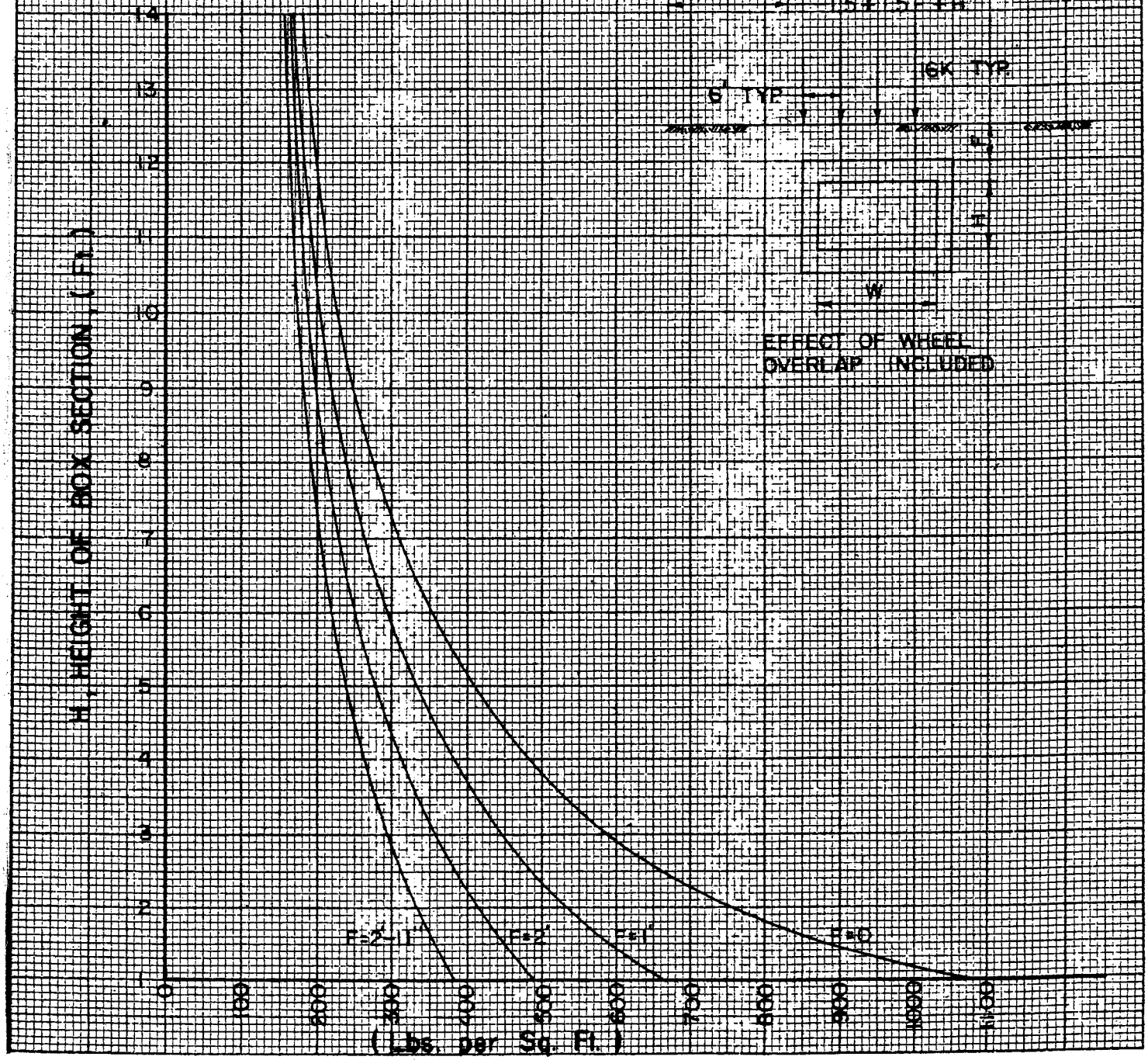
H-20 TRUCK LOADS ON INVERT SLABS OF BOX CONDUITS

IN POUNDS PER SQUARE FOOT

MAIN REINFORCEMENT IS PERPENDICULAR TO TRAFFIC

DEPTH OF COVER IS 0' TO 2'-11"



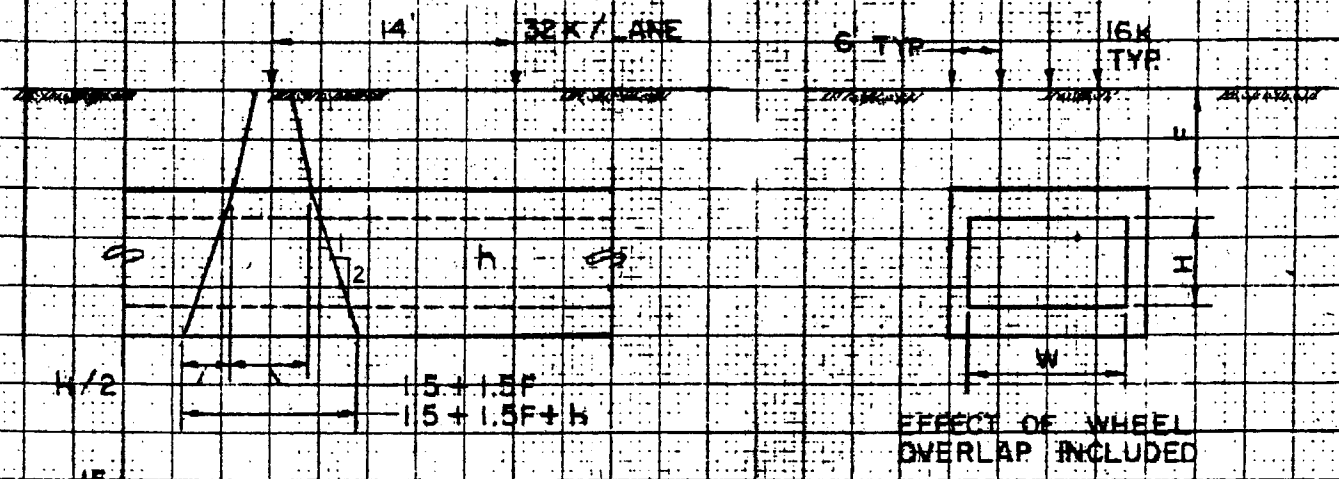


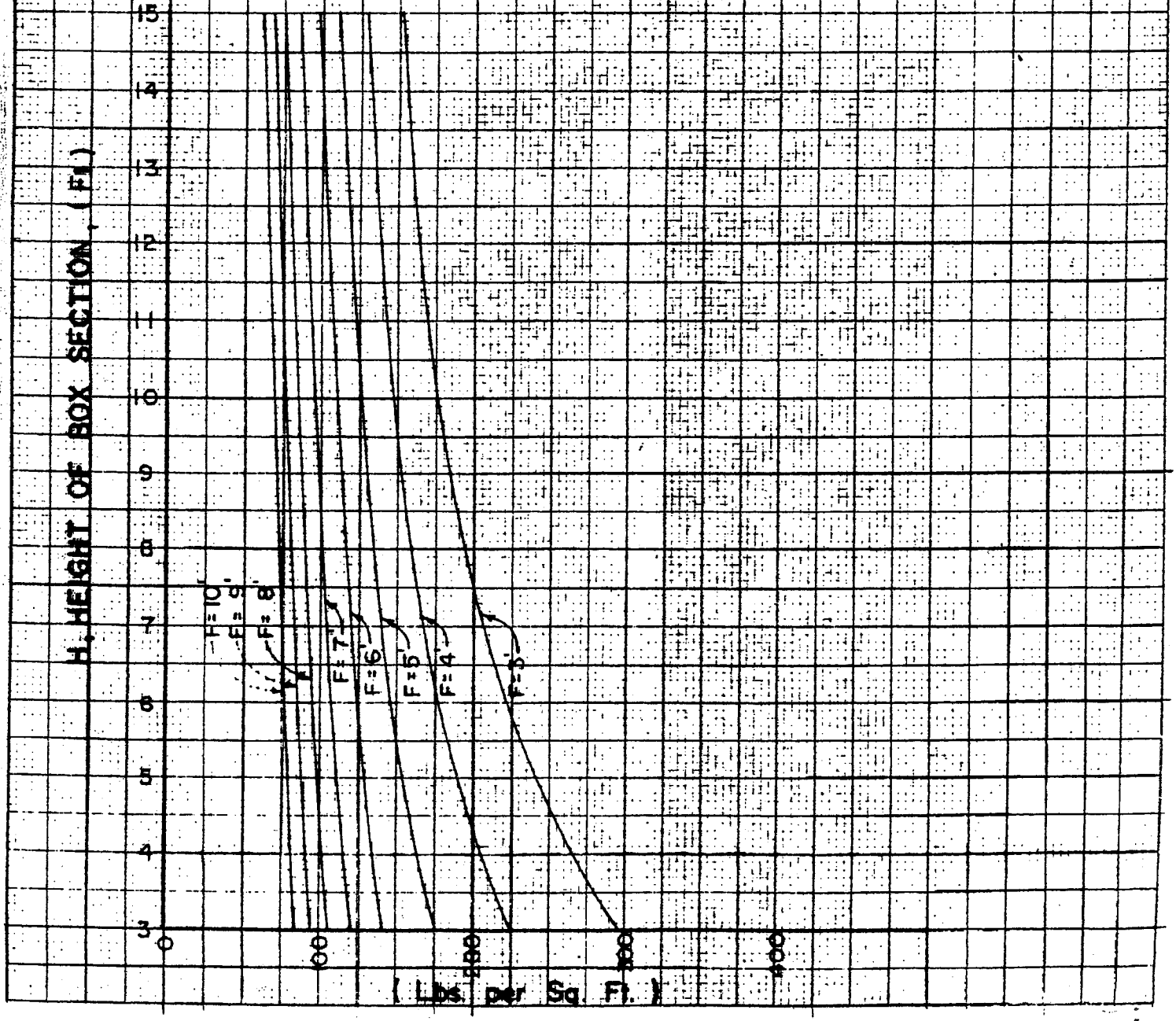
H-20 TRUCK LOADS ON INVERT SLABS OF BOX CONDUITS

IN POUNDS PER SQUARE FOOT

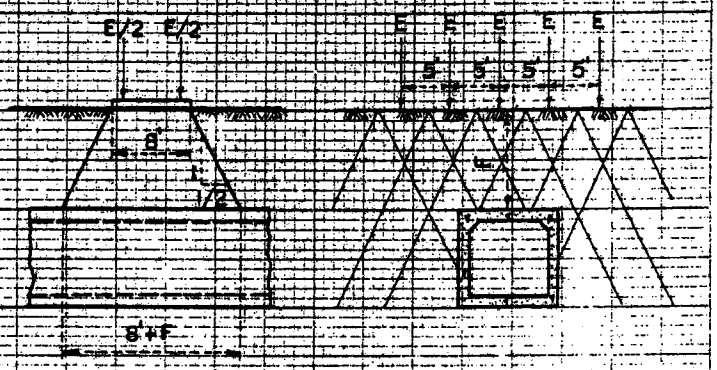
MAIN REINFORCEMENT IS PERPENDICULAR AND/OR PARALLEL TO TRAFFIC

DEPTH OF COVER IS 3' TO 10'





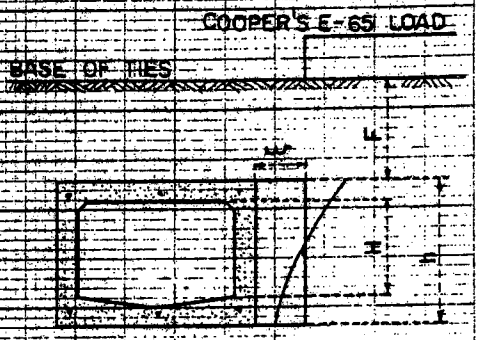
VERTICAL RAILROAD LIVE LOADS ON TOP SLABS OF BOX CONDUITS IN POUNDS PER SQUARE FOOT
COOPER'S E-65, E-72, AND E-80 RAILROAD LOADS



DATA:
SINGLE TRACK
IMPACT = L.L. / (D.L. + L.L.)
D.L. NOT INCLUDED

THE FOLLOWING ASSUMPTIONS WERE MADE:
RAILS, BALLAST, TIES, ETC. = 115 #/□'
TOP SLAB = 150 #/□'
EARTH = 120 #/C.F. * COVER IN FT.

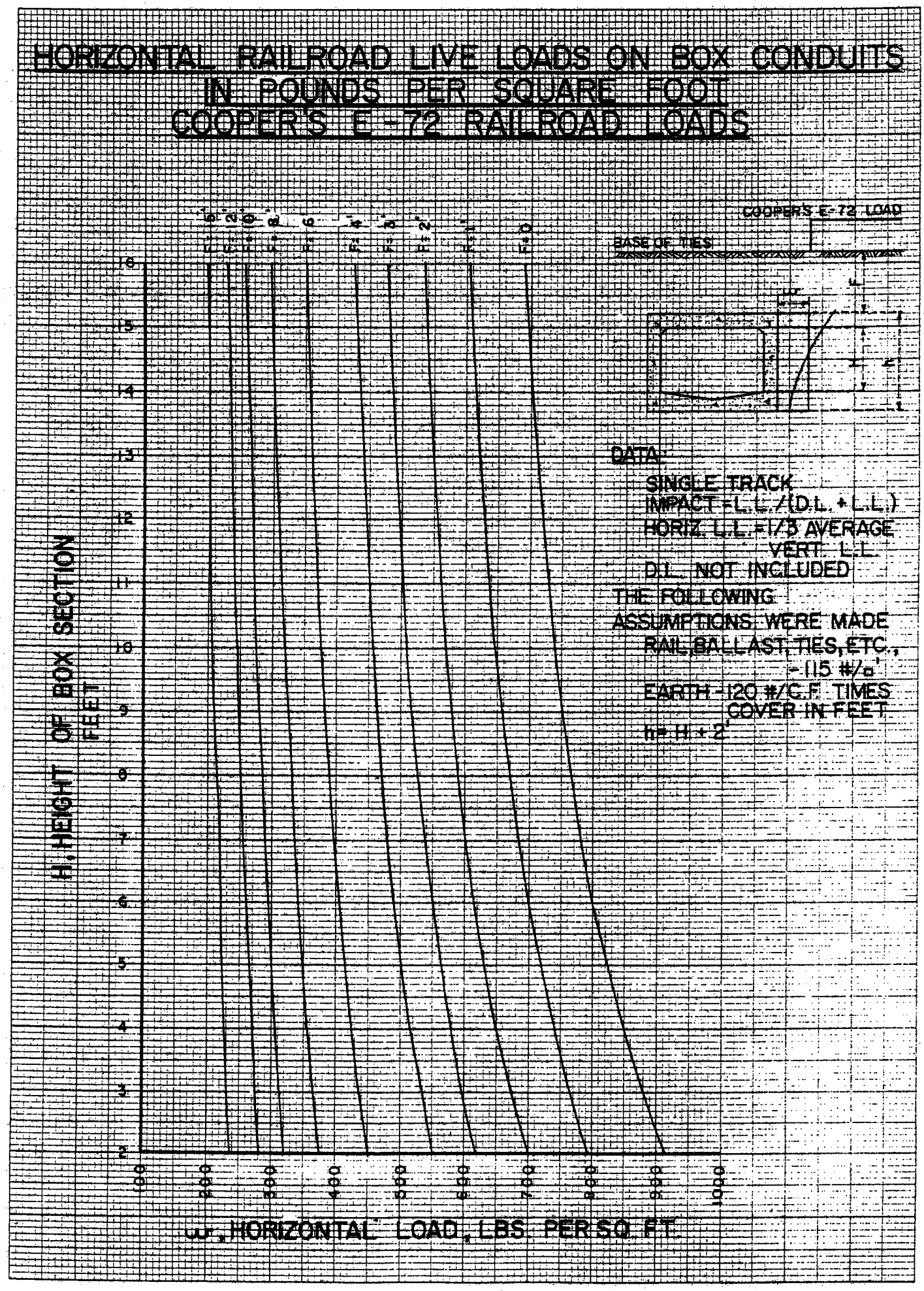
HORIZONTAL RAILROAD LIVE LOADS ON BOX CONDUITS IN POUNDS PER SQUARE FOOT COOPER'S E-65 RAILROAD LOADS



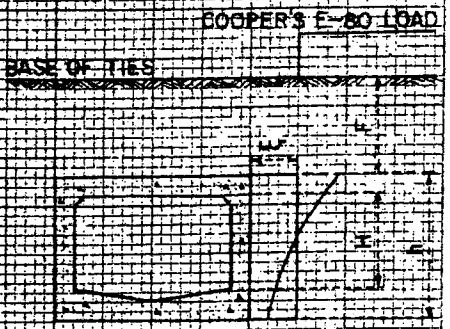
DATA:

SINGLE TRACK
IMPACT = L.L./(D.L. + L.L.)
HORIZ. L.L. = 1/3 AVERAGE VERT. L.L.
D.L. NOT INCLUDED
THE FOLLOWING ASSUMPTIONS WERE MADE:
RAIL, BALLAST, TIES, ETC., = 115 #/□'
EARTH = 120 #/C.F. TIMES COVER IN FEET
h = H + 2'

HORIZONTAL RAILROAD LIVE LOADS ON BOX CONDUITS IN POUNDS PER SQUARE FOOT COOPER'S E-72 RAILROAD LOADS



HORIZONTAL RAILROAD LIVE LOADS ON BOX CONDUITS
IN POUNDS PER SQUARE FOOT
COOPER'S E-80 RAILROAD LOADS



DATA

SINGLE TRACK

IMPACT = L.L./(D.L. + L.L.)

HORIZ. L.L. = 1/3 AVERAGE VERT. L.L.

D.L. NOT INCLUDED

THE FOLLOWING ASSUMPTIONS WERE MADE

RAIL, BALLAST, TIES, ETC. = 115 #/ft²

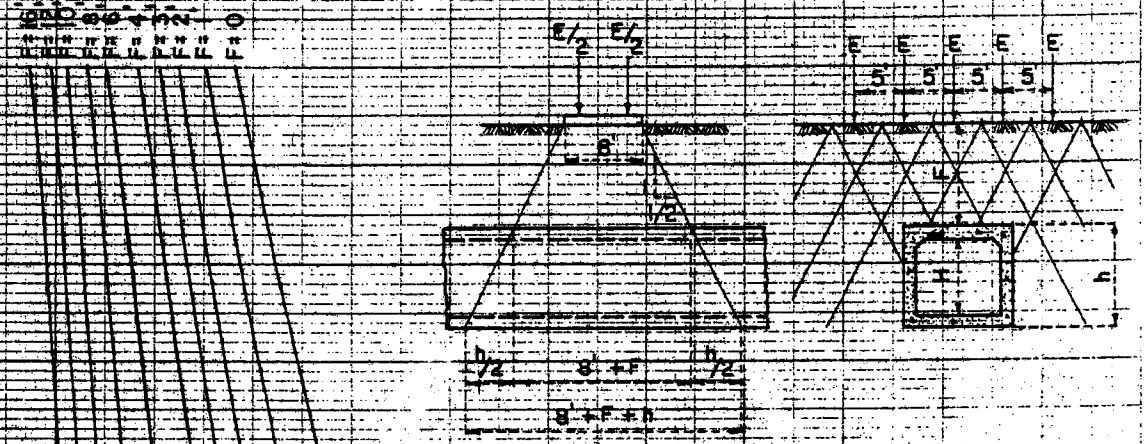
EARTH = 120 #/C.F. TIMES COVER IN FEET

h = H + 2'

H, HEIGHT OF BOX SECTION IN FEET

w, HORIZONTAL LOAD, LBS. PER SQ. FT.

VERTICAL RAILROAD LIVE LOADS ON BOTTOM SLABS OF BOX CONDUITS IN POUNDS PER SQUARE FOOT
COOPER'S E-65 RAILROAD LOADS



DATA:

SINGLE TRACK
IMPACT = L.L. / (D.L. + L.L.)
D.L. NOT INCLUDED

THE FOLLOWING ASSUMPTIONS WERE MADE:

RAILS, BALLAST, TIES, ETC., -115 #/□'
TOP SLAB - 150 #/□'
EARTH - 120 #/C.F. x COVER IN FT.
SIDE WALLS - 175 #/□'
h = H + 2'

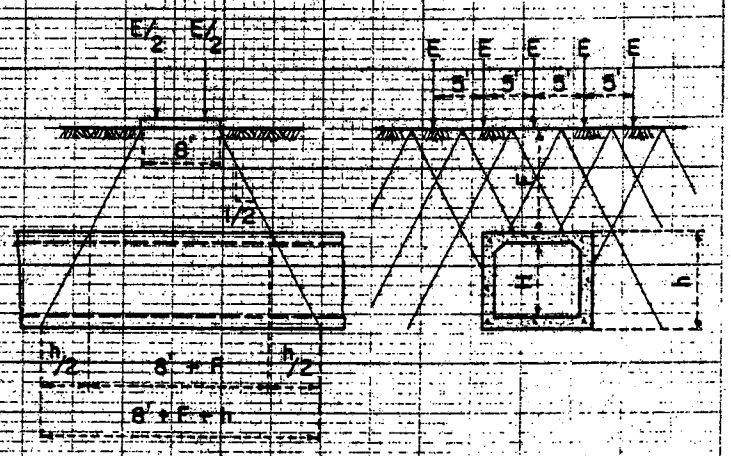
H, HEIGHT OF BOX SECTION FEET

16 15 14 13 12 11 10 9 8 7 6 5 4 3 2

200 400 600 800 1000 2000 4000 6000 8000 10000

w, VERTICAL LOAD, LBS. PER SQ. FT.

VERTICAL RAILROAD LIVE LOADS ON BOTTOM SLABS OF BOX CONDUITS IN POUNDS PER SQUARE FOOT
COOPER'S E-72 RAILROAD LOADS



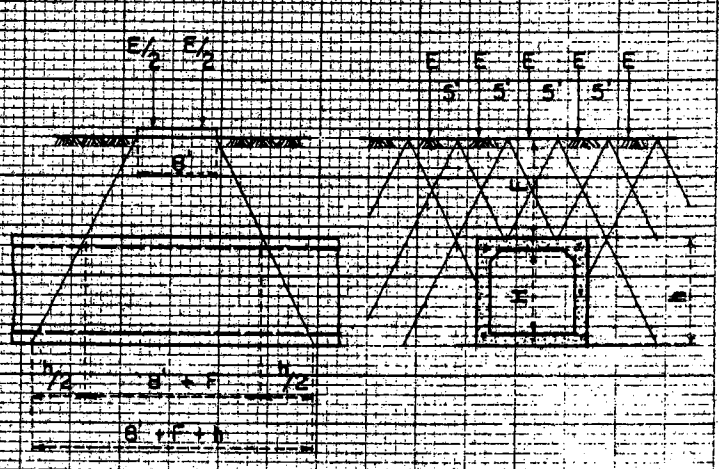
DATA:
SINGLE TRACK
IMPACT = L.L. / (D.L. + L.L.)
D.L. NOT INCLUDED

THE FOLLOWING ASSUMPTIONS WERE MADE:
RAILS, BALLAST, TIES, ETC., - 115 #/□'
TOP SLAB - 150 #/□'
EARTH - 120 #/C.F. x COVER IN FT.
SIDE WALLS - 175 #/□'
h = H + 2'

H, HEIGHT OF BOX SECTION IN FEET

wf, VERTICAL LOAD, LBS. PER SQ. FT.

VERTICAL RAILROAD LIVE LOADS ON BOTTOM SLABS OF BOX CONDUITS IN POUNDS PER SQUARE FOOT
COOPER'S E-80 RAILROAD LOADS



DATA:

SINGLE TRACK
IMPACT = I.L./(D.L. + L.L.)
D.L. NOT INCLUDED

THE FOLLOWING ASSUMPTIONS WERE MADE:

RAILS, BALLAST, TIES, ETC. - 115 #/□'
TOP SLAB - 150 #/□'
EARTH - 120 #/C.F. x COVER IN FT.
SIDE WALLS - 175 #/□'
h = H + 2'

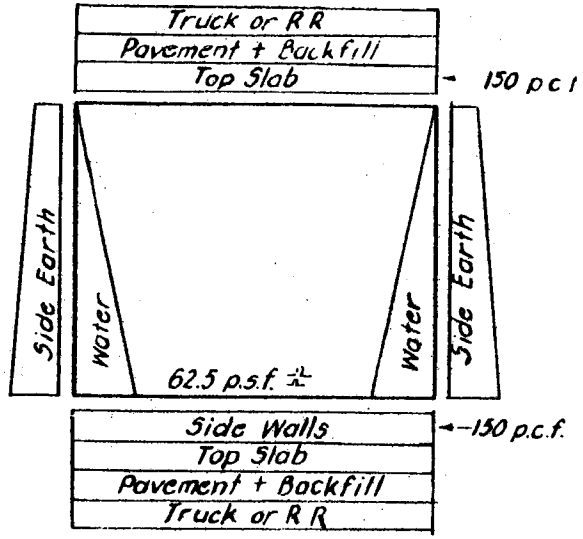
H, HEIGHT OF BOX SECTION FEET

6 5 4 3 2

400 600 800 1000 1200 1400 1600 1800 2000 2200 2400

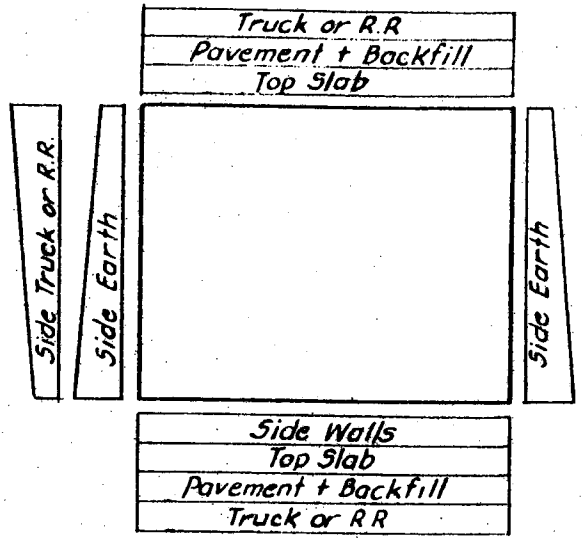
w, VERTICAL LOAD, LBS. PER SQ. FT.

40 1323



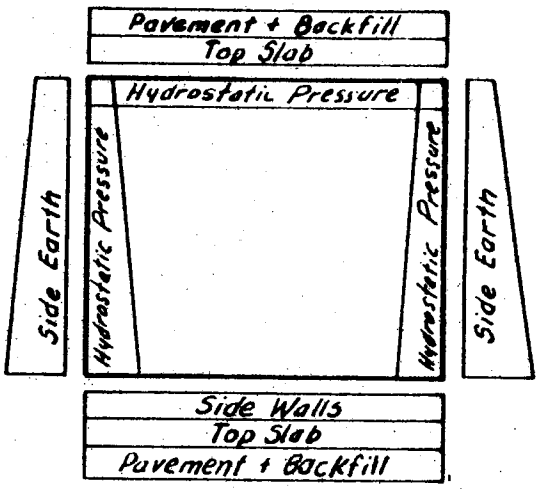
CASE I

MAX. (+) MOMENT, TOP AND BOTTOM SLABS
MAX. (−) MOMENT, SIDE WALLS



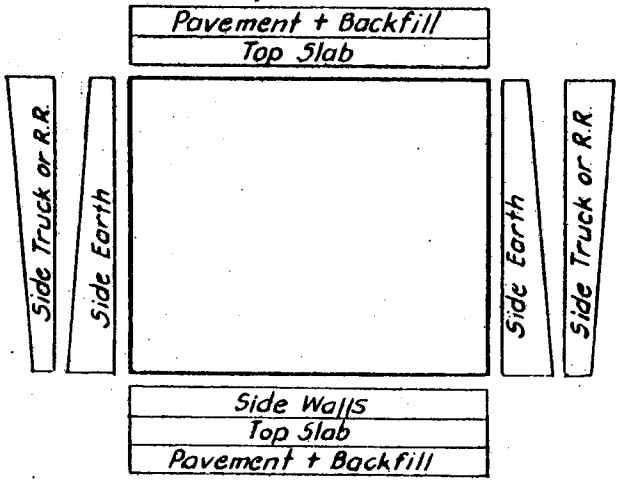
CASE II

MAX. (−) MOMENT CORNERS
MAX. SHEARS



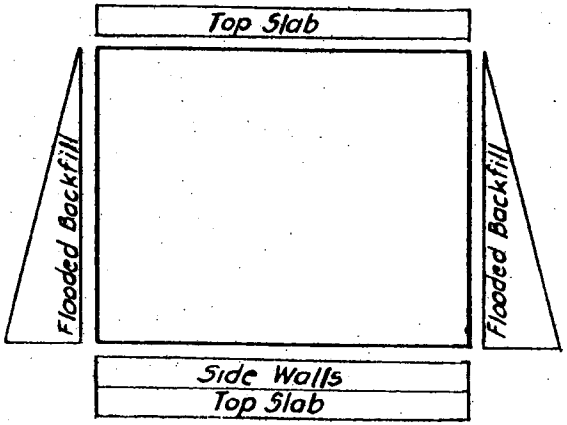
CASE IV

MAX. (−) MOMENT TOP SLAB AND SIDE WALLS WITH HYDROSTATIC HEAD



CASE III

MAX. (+) MOMENT, SIDE WALLS



CASE V

MAX. (+) MOMENT, SIDE WALLS

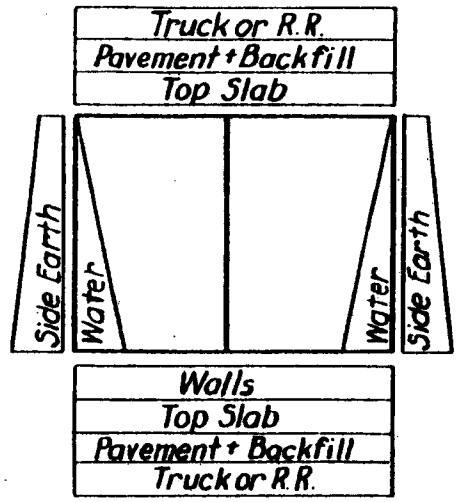
Flooded Backfill
At 80 p.s.f.
$f_c = 2{,}700$ p.s.i
$f_s = 36{,}000$ p.s.i

Special Conditions - All boxes
1. 0'-2' Cover, treat as bridge.
2. Box under hydrostatic head.

Note
(+) Indicates tension on inside of box.
(−) Indicates tension on outside of box.

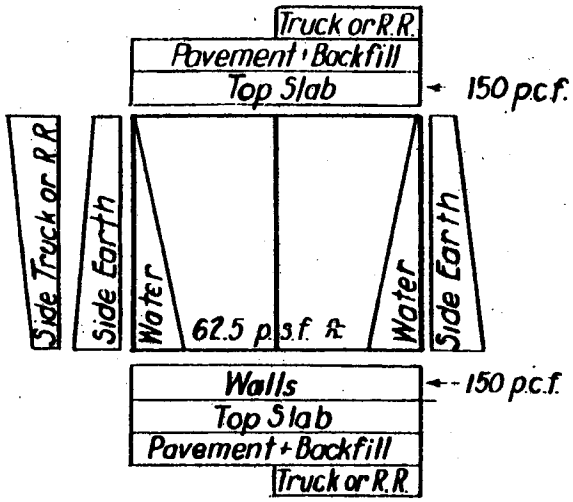
STANDARD LOADING CONDITIONS FOR DESIGN OF SINGLE BARREL BOX CONDUIT

L.A. COUNTY FLOOD CONTROL DISTRICT



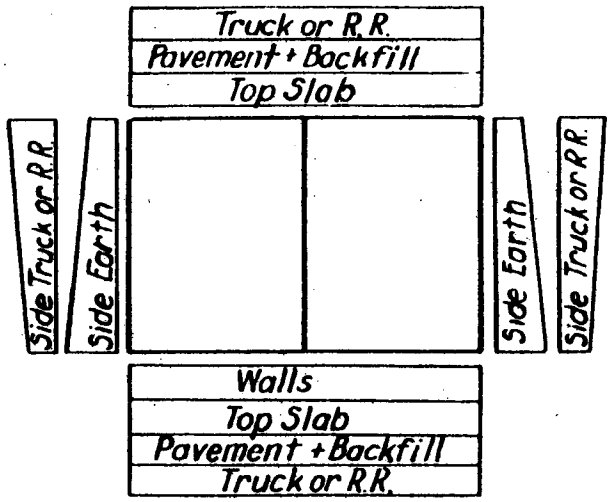
CASE I

MAX.(-) MOMENT, TOP AND BOTTOM SLABS AT CENTER WALLS.



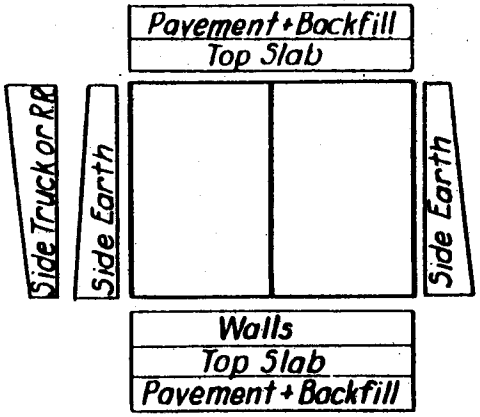
CASE II

MAX.(+) MOMENT, TOP AND BOTTOM SLABS.
MAX.(-) MOMENT, SIDE WALLS.



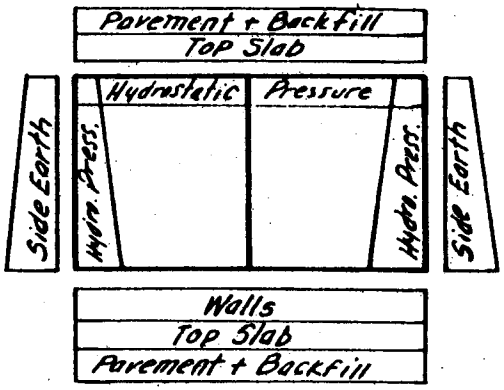
CASE III

MAX.(-) MOMENT, CORNERS
MAX. SHEARS



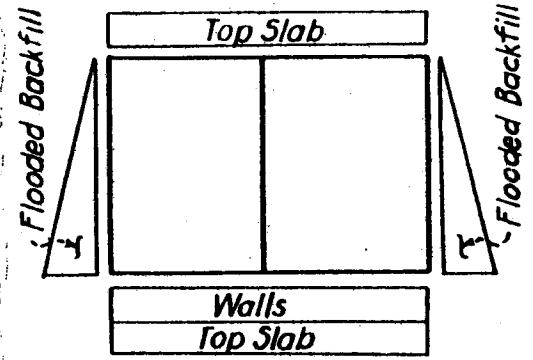
CASE IV

MAX (+) MOMENT, SIDE WALLS



CASE V

MAX. (-) MOMENT TOP SLAB AND SIDE WALLS. MAX. TENSION CENTER WALL, WHEN HYDRO. HEAD EXISTS.



CASE IV

MAX. (+) MOMENT SIDE WALLS
FLOODED BACKFILL
AT 80 P.S.F.
f_c = 2700 p.s.i. ; f_s = 36,000 p.s.i.

Special Conditions - All boxes

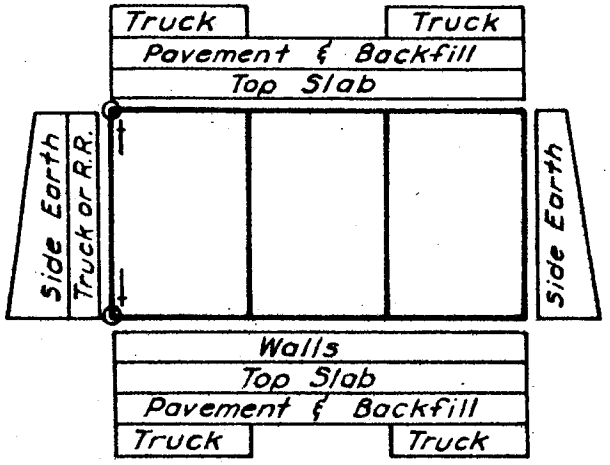
1. 0'-2' Cover treat as bridge.
2. Box under hydrostatic head

Note

(+) Indicates tension on inside of box.
(-) Indicates tension on outside of box.

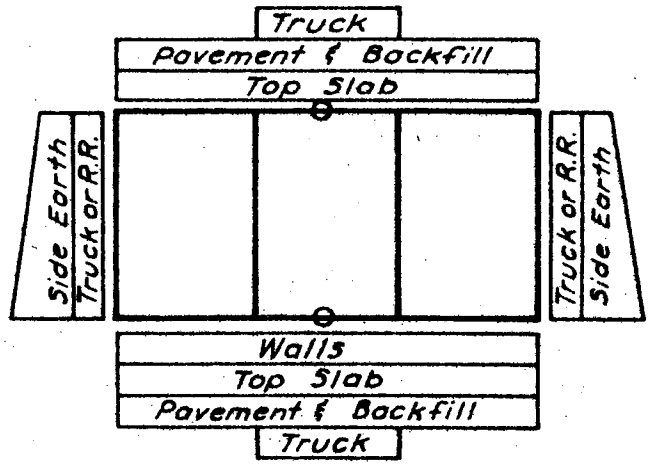
STANDARD LOADING CONDITIONS FOR DESIGN OF DOUBLE BARREL BOX CONDUIT

L.A. COUNTY FLOOD CONTROL DISTRICT



Case I

Max. (-) Moment, Corners
Max. Shear, Corners



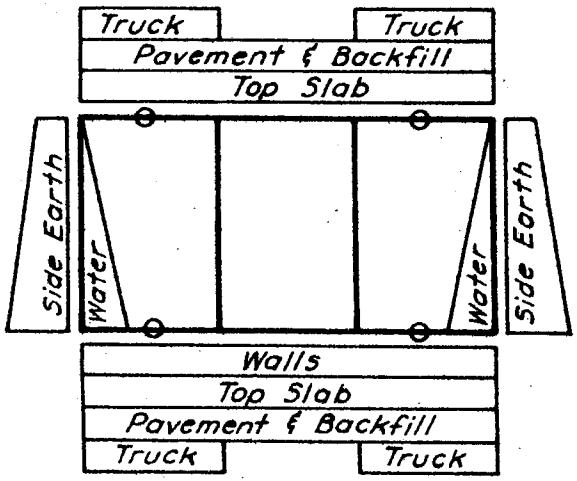
Case II

Max. (+) Moment Center
Barrel Top and Bottom Slabs

NOTES:

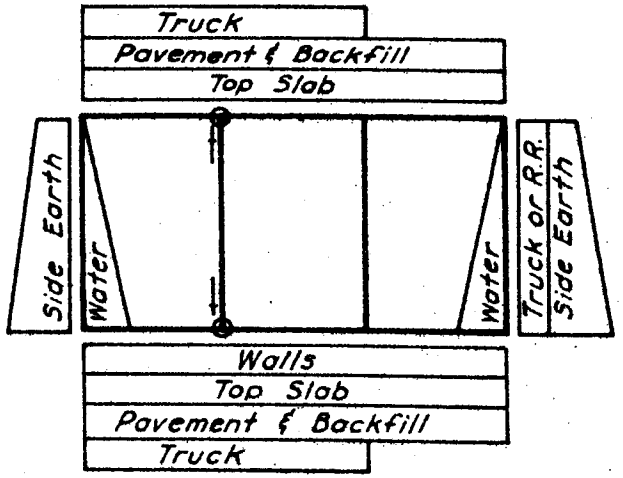
1. O Point of critical moment
   † Point of critical shear

2. (+) Indicates tension on inside of box.
   (-) Indicates tension on outside of box.



Case III

Max. (+) Moment Outside
Barrels Top and Bottom Slabs



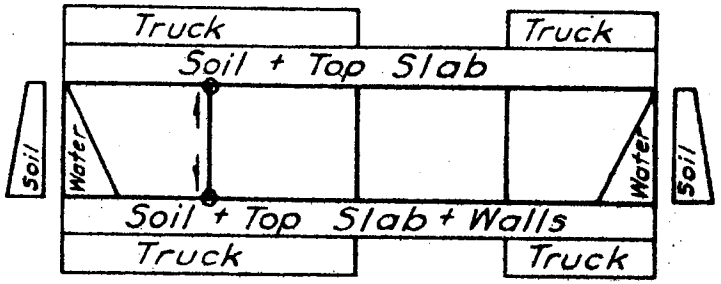
Case IV

Max.(-) Moment at Centerwall
Max. Shear at Centerwall

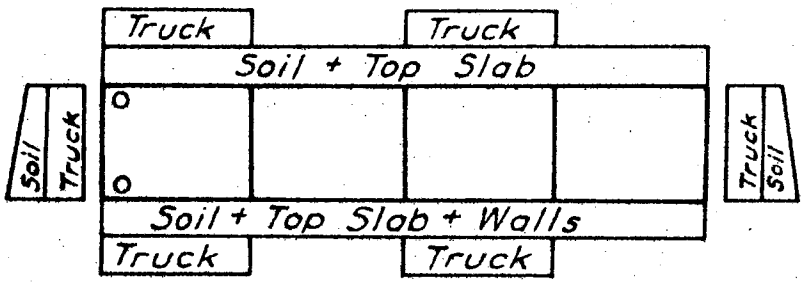
STANDARD LOADING CONDITIONS FOR DESIGN OF TRIPLE BARREL BOX CONDUIT

L. A. COUNTY FLOOD CONTROL DISTRICT

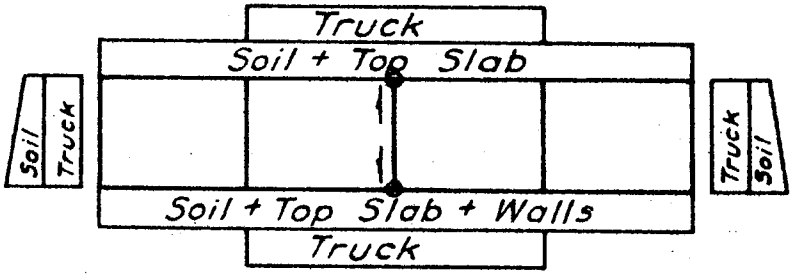
S-19



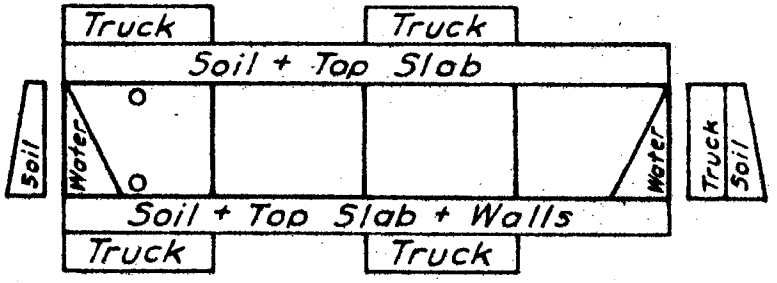
CASE 1



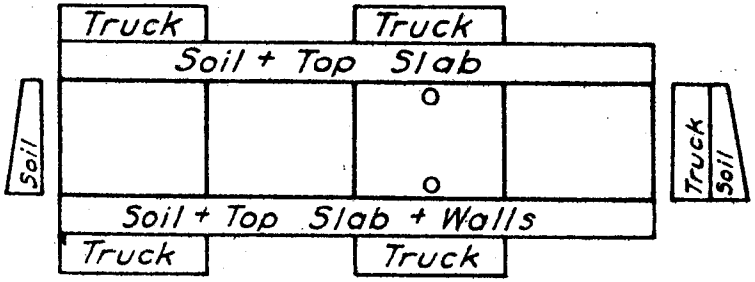
CASE 2



CASE 3



CASE 4



CASE 5

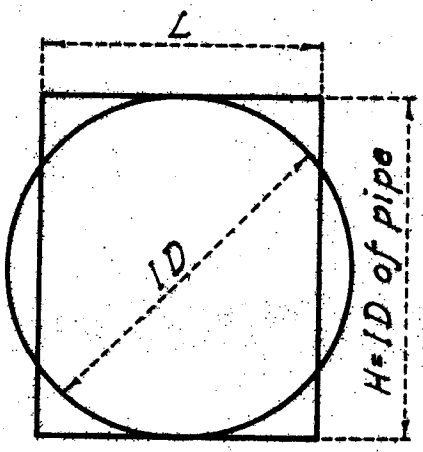
Note:
o Point of critical moment
| Point of critical shear

STANDARD LOADING CONDITIONS FOR DESIGN OF FOUR BARREL BOX CONDUIT

L. A. CO. FLOOD CONTROL DIST.

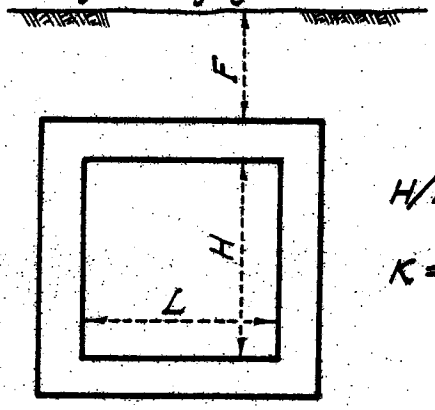
S-20

TOTAL COST COMPARISON CURVE FOR RECTANGULAR RC SECTIONS



$\frac{\pi D^2}{4} = H \times L$

$\frac{H}{L} = 1.28$



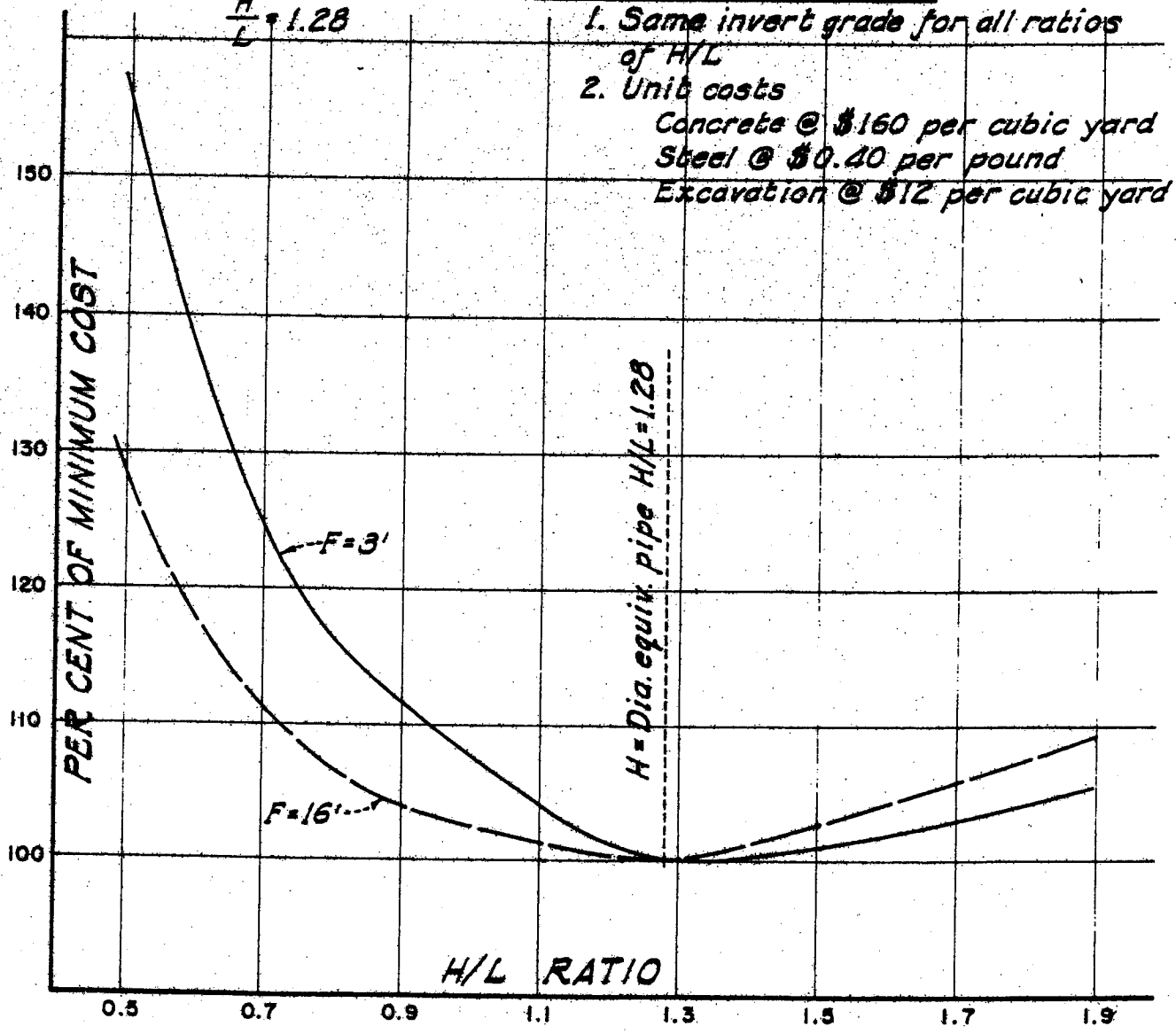
SECTION

H/L Varies

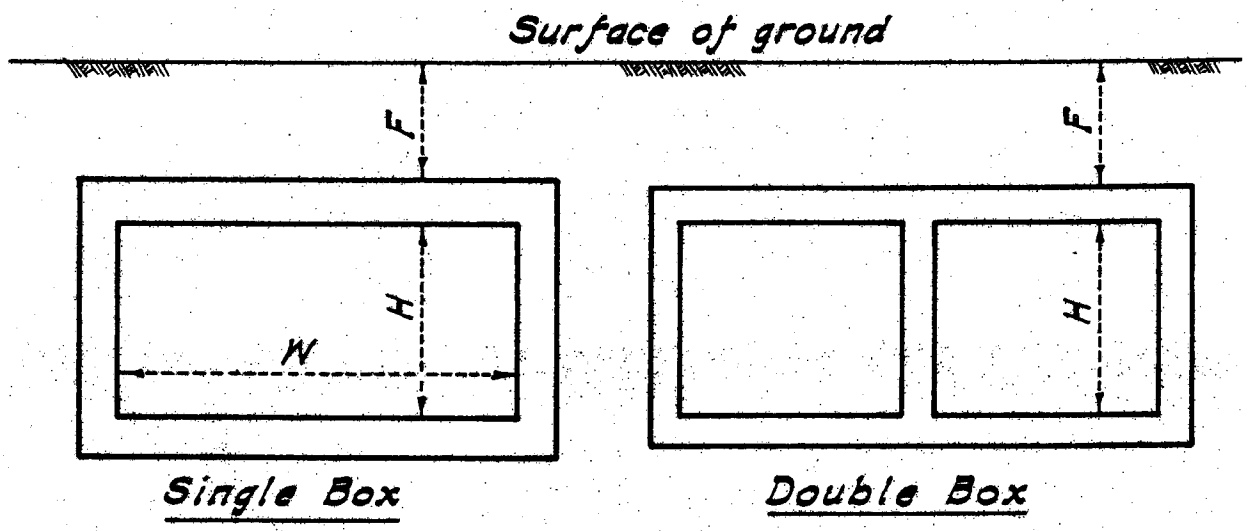
$K = ACR^{1/2}$ = Constant

BASIS OF CALCULATIONS

1. Same invert grade for all ratios of H/L
2. Unit costs
   - Concrete @ $160 per cubic yard
   - Steel @ $0.40 per pound
   - Excavation @ $12 per cubic yard

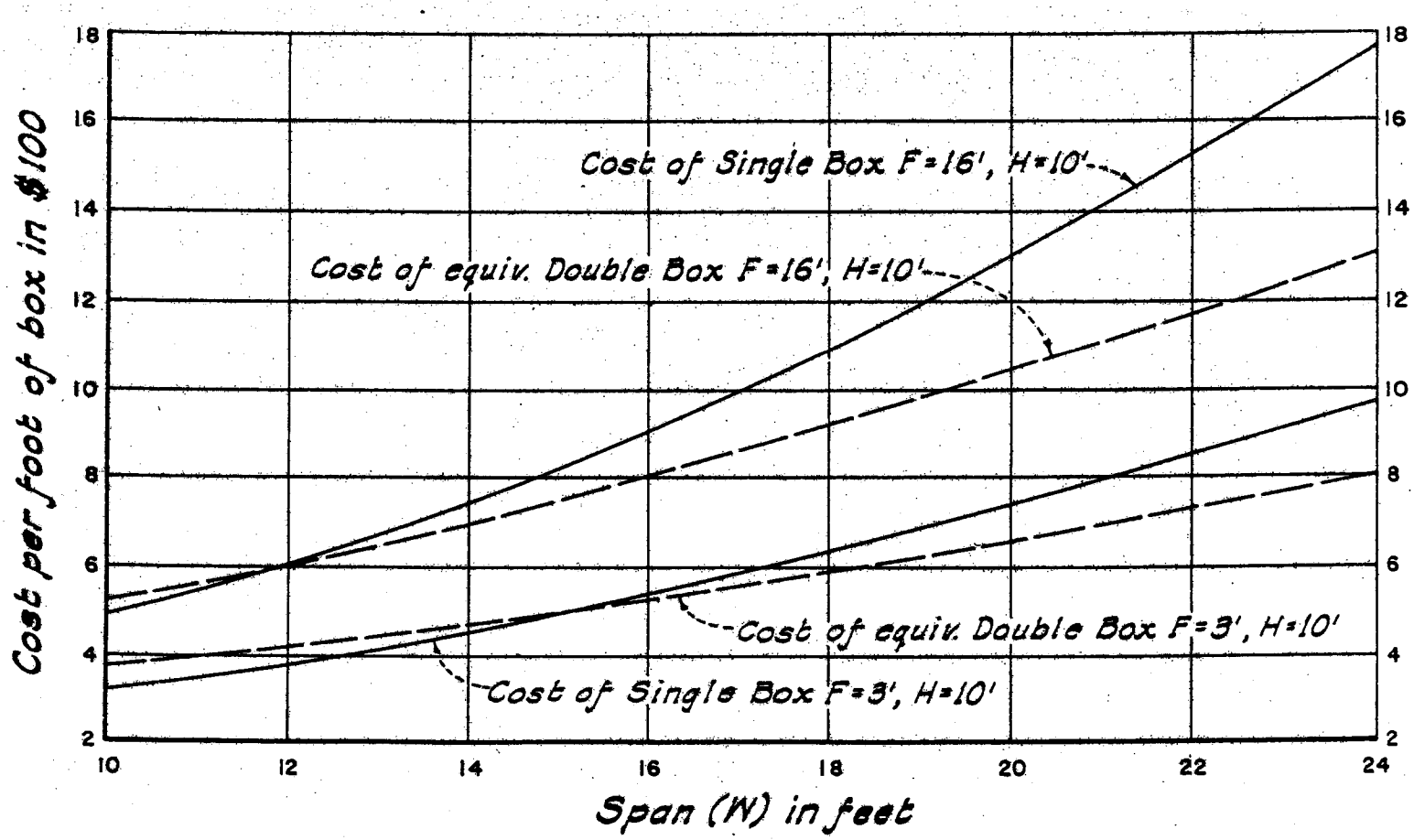


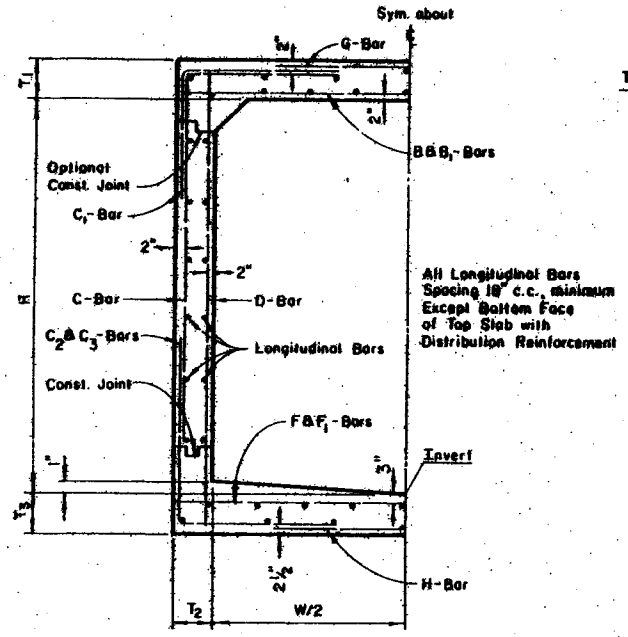
COST COMPARISON BETWEEN SINGLE AND DOUBLE BOXES



BASIS OF CALCULATION

Concrete unit cost @ $160 per cu. yd.
Steel @ $0.40 per pound
Excavation @ $12 per cu. yd.
——— Single Box
– – – Double Box (with equivalent hydraulic capacity)





TYPICAL R.C. BOX SECTION

DESIGN DATA

LIVE LOAD:

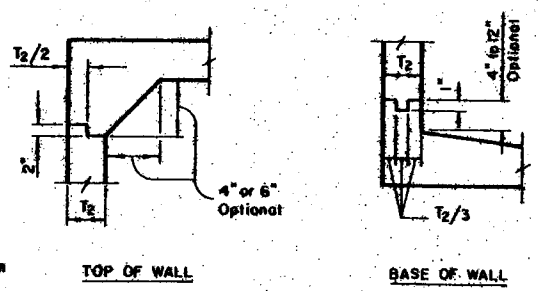
H20-S16-44 unless otherwise noted

DEAD LOAD:

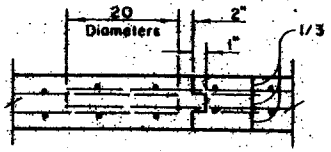
Earth load per Marston's formula: w=110 p.c.f.
Ku=Ku'=0.150
Bd = Outside width of box plus 3 feet
Side earth 37 p.s.f. per foot of depth
External water pressure: 62.4 p.s.f. per foot of depth
Weight of concrete: 150 p.c.f.

ALLOWABLE STRESSES:

f'_c = 4000 p.s.i. at 28 days
f_c = 1800 p.s.i.
f_s = 24,000 p.s.i.
n = 8
shear and bond stresses per A.C.I. 318-63

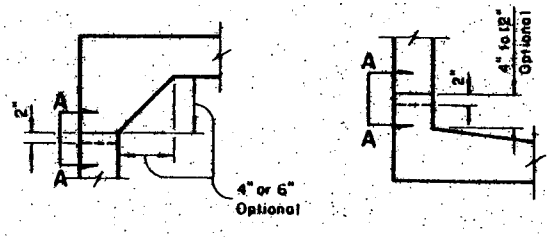


TOP OF WALL BASE OF WALL

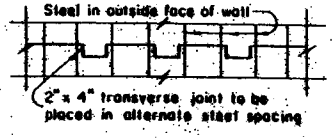


TRANSVERSE JOINT

CONSTRUCTION JOINT DETAILS



TOP OF WALL BASE OF WALL



SECTION A-A

CONSTRUCTION JOINT DETAILS FOR BOXES JACKED IN PLACE

DESIGN NOTES

1. THE FOLLOWING NOTES APPLY TO STANDARD DRAWINGS 2-D 236.1 TO 2-D 236.14. REFER TO L.A.C.F.C.D. STRUCTURAL DESIGN MANUAL FOR ADDITIONAL NOTES.
2. DIMENSIONS FROM FACE OF CONCRETE TO STEEL ARE TO CENTER OF BAR AND SHALL BE TWO INCHES UNLESS OTHERWISE SHOWN.
3. CONCRETE DIMENSIONS SHALL BE MEASURED HORIZONTALLY OR VERTICALLY ON THE PROFILE, AND PARALLEL TO OR AT RIGHT ANGLES (OR RADIALLY) TO CENTER LINE OF CONDUIT ON THE PLAN EXCEPT AS OTHERWISE SHOWN.
4. NO SPLICES IN TRANSVERSE STEEL REINFORCEMENT WILL BE PERMITTED OTHER THAN SHOWN ON THE DRAWING WITHOUT APPROVAL OF THE ENGINEER.
5. THE TRANSVERSE REINFORCING STEEL SHALL TERMINATE ONE AND ONE-HALF INCHES FROM THE CONCRETE SURFACES UNLESS OTHERWISE SHOWN ON THE STRUCTURAL DETAILS.
6. D-BARS MAY BE SPLICED 20 DIAMETERS AT THE LOWER CONSTRUCTION JOINT.
7. IN ALL SECTIONS LAP C AND C_2 BARS. THE VERTICAL LENGTH OF THE C AND C_2 BARS HAS BEEN CALCULATED FOR A FOUR-INCH STARTER WALL. IF THE HEIGHT OF THE STARTER WALL IS VARIED, THE VERTICAL LENGTH OF THE C AND C_2 BARS SHALL BE VARIED CORRESPONDINGLY SO AS TO MAINTAIN A 30 DIAMETER LAP BETWEEN THE TWO BARS. THE LAPS SHALL BE BASED ON THE SMALLER BAR. THIS ALSO APPLIES TO C_1 AND C_2 BARS IF VERTICAL LENGTH OF C_1 = C. THE C_1 BAR SHALL LAP 30 DIAMETERS WITH THE C_3 BAR.
8. ALL LONGITUDINAL BARS SHALL BE NO. 4 BARS. SPACING SHALL BE 18 INCHES UNLESS OTHERWISE SHOWN. BARS IN TOP AND BOTTOM SLABS SHALL BE SPACED SYMMETRICALLY ABOUT THE CENTER LINE. BARS IN WALLS SHALL BE SPACED SYMMETRICALLY ABOUT MID-HEIGHT OF THE WALLS.
9. CONCRETE QUANTITIES ARE BASED ON A SIX-BY-SIX INCH FILLET AND THE STEEL QUANTITIES DO NOT INCLUDE ANY OPTIONAL SPLICE.
10. INVERT THICKNESS IS CALCULATED FOR BAR COVERS SHOWN. IT MUST BE INCREASED FOR HIGH VELOCITIES, SALT WATER, INDUSTRIAL WASTES, ABRASIVE BED LOAD, OR HARMFUL GROUNDWATER (USUALLY ONE-HALF INCH FOR EACH CONDITION).

DESIGN TABLE FOR STANDARD R.C. BOX CONDUIT

BOX SIZE: W = 5'-10", H = 7'-0" DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 84"

		DEPTH OF COVER IN FEET																			
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS, t_1		6.50	6.75	6.75	8.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.75	7.25	7.50	7.75	8.00	8.25	8.50	8.75	9.00
SIDE WALL THICKNESS, t_2		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
BOTTOM SLAB THICKNESS, t_3		7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.25	7.50	7.50	7.75	8.25	8.50	8.75	9.25	9.50	9.75	10.00	10.25
		TRANSVERSE REINFORCEMENT																			
B BARS	BAR NO. & SPACING	5@18"	7@10"	6@15"	4@17"	4@13"	5@19"	4@11"	6@20"	6@16"	6@15"	6@16"	6@15"	7@18"	6@14"	7@17"	8@20"	7@16"	8@19"	8@18"	8@18"
	LENGTH, h	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"
B_1 BARS	BAR NO. & SPACING	8@18"		6@15"	5@17"	4@13"	5@19"	4@11"	5@20"	4@16"	4@15"	4@16"	4@15"	4@18"	4@14"	4@17"	4@20"	4@16"	4@19"	4@18"	4@18"
	LENGTH, h	6'-11"		6'-11"	5'-4.5"	4'-9"	4'-8.5"	4'-7.5"	4'-4"	3'-11"	3'-11"	3'-11.5"	3'-11.5"	3'-9.0"	4'-1.5"	3'-11.5"	3'-7.5"	4'-1"	3'-9"	3'-8.5"	3'-10.5"
C BARS	BAR NO. & SPACING	4@14"	4@14"	4@14"	4@10"	4@10"	4@9"	4@14"	4@14"	4@14"	4@13"	4@14"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"
	VERT. LENGTH, v	6'-11.5"	7'-0"	7'-0"	6'-11.5"	6'-11.5"	6'-11.5"	6'-11.5"	6'-11.5"	6'-11.5"	6'-11.5"	6'-11.5"	7'-0"	7'-0.5"	7'-0.5"	7'-1"	7'-1"	7'-1.5"	7'-1.5"	7'-2"	7'-2"
C_1 BARS	BAR NO. & SPACING	4@14	4@14	4@14"				4@14"	4@14"	4@14"	4@13"	4@14"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	1'-4.5"	1'-4"	1'-4"				1'-2"	1'-2.5"	1'-2.5"	1'-3"	1'-3"	1'-3"	1'-3.5"	1'-3.5"	1'-3.5"	1'-4"	1'-4"	1'-4.5"	1'-4.5"	1'-4.5"
	VERT. LENGTH, v	2'-8"	2'-4"	2'-1"				1'-0"	1'-1.5"	1'-3"	1'-3"	1'-3"	1'-3"	1'-5"	1'-5"	1'-5.5"	1'-6"	1'-6.5"	1'-6.5"	1'-5.5"	1'-5.5"
C_2 BARS	BAR NO. & SPACING	4@14"	5@14"	5@14"	4@10"	5@10"	4@9"	4@14"	4@14"	4@14"	4@13"	4@14"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	2'-10.5"	2'-10.5"	2'-10.5"	2'-10.5"	2'-10.5"	2'-10.5"	2'-10.5"	2'-10.5"	2'-10.5"	3'-1.5"	3'-1.5"	3'-3"	3'-2.0"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"
	VERT. LENGTH, v	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0.5"	2'-0.5"	2'-0.5"	2'-1"	2'-1.5"	2'-1.5"	2'-2"	2'-2.5"	2'-2.5"	2'-3"	2'-3"	2'-3.5"
C_3 BARS	BAR NO. & SPACING							4@14"	4@14"	4@14"	4@13"	4@14"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h							1'-2"	1'-2.5"	1'-3"	1'-2.5"	1'-3"	1'-3"	1'-3.5"	1'-3.5"	1'-3.5"	1'-4"	1'-4.0"	1'-4.0"	1'-4.5"	1'-4.5"
	VERT. LENGTH, v							2'-0"	2'-0"	2'-0.5"	2'-0.5"	2'-0.5"	2'-1"	2'-1.5"	2'-1.5"	2'-2"	2'-2.5"	2'-2.5"	2'-3"	2'-3"	2'-3.5"
D BARS	BAR NO. & SPACING	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"
	LENGTH, y	7'-10.5"	7'-10.5"	7'-10.5"	7'-10.5"	7'-10.5"	7'-10.5"	7'-10.5"	7'-10.5"	7'-10.5"	7'-11"	7'-11"	7'-11.5"	8'-0.5"	8'-1"	8'-1.5"	8'-2"	8'-2.5"	8'-3.5"	8'-3.5"	8'-4"
F BARS	BAR NO. & SPACING	5@20"	5@18"	5@20"	5@16"	5@18"	6@20"	6@16"	7@20"	7@17"	7@17"	7@17"	8@20"	8@20"	8@19"	7@15"	8@18"	8@18"	7@14"	8@17"	9@20"
	LENGTH, h	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"	6'-11"
F_1 BARS	BAR NO. & SPACING	4@20"	4@18"	5@20"	4@16"	5@18"	5@20"	4@16"	5@20"	4@17"	4@17"	4@17"	4@20"	4@20"	4@19"	4@15"	4@18"	4@18"	4@14"	4@17"	4@20"
	LENGTH, h	5'-1.5"	5'-0.5"	5'-4.5"	4'-9.0"	5'-2"	4'-8.5"	4'-4"	4'-3.5"	4'-0"	4'-2"	4'-1.5"	3'-9.5"	4'-1.0"	4'-0"	4'-4.5"	4'-2"	4'-4"	4'-6.5"	4'-5"	4'-1.5"
G BARS	BAR NO. & SPACING	4@14"	4@14"	4@14"	4@10"	4@10"	4@9"	4@14"	4@14"	4@14"	4@13"	4@14"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	LENGTH, h	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"
H BARS	BAR NO. & SPACING													4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	LENGTH, h													2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"	2'-11"
		LONGITUDINAL REINFORCEMENT																			
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	15	15	15	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	NUMBER IN BOTTOM SLAB	12	12	12	12	12	12	12	12	12	14	14	14	12	12	12	12	12	12	12	12
	NUMBER IN WALLS	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
	TOTAL NUMBER	43	43	43	40	40	40	40	40	40	42	42	42	40	40	40	40	40	40	40	40
CONCRETE: CU. YDS. PER LIN. FT.		0.66	0.67	0.67	0.66	0.66	0.66	0.66	0.66	0.67	0.67	0.67	0.68	0.71	0.72	0.73	0.75	0.76	0.77	0.78	0.79
STEEL: LBS. PER LIN. FT.		82.7	85.9	85.9	74.9	80.0	79.9	77.0	78.9	80.7	85.1	82.5	86.1	85.8	86.6	87.6	89.1	89.4	90.6	91.8	92.6

HYDRAULIC PROPERTIES (BOX)

n = .013

Area = 40.3 sq. ft.

$K = \frac{Q}{S^{\frac{1}{2}}} = \frac{1.486}{n} AR^{\frac{2}{3}} = 6,357$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

BOX SIZE: W = 6'-1" , H = 7'-3" DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 87"

		DEPTH OF COVER IN FEET																			
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS, t_1		6.50	6.75	6.75	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	7.00	7.25	7.75	8.00	8.25	8.50	8.75	9.00	9.25
SIDE WALL THICKNESS, t_2		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
BOTTOM SLAB THICKNESS, t_3		7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.50	7.75	7.75	8.00	8.50	8.75	9.00	9.50	9.75	10.00	10.25	10.50
TRANSVERSE REINFORCEMENT																					
B BARS	BAR NO. & SPACING	6@14"	4@19"	9@16"	5@20"	5@19"	5@18"	6@20"	6@16"	6@15"	7@18"	6@15"	7@18"	7@17"	7@17"	8@20"	8@19"	8@19"	8@18"	8@18"	8@17"
	LENGTH, h	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"
B_1 BARS	BAR NO. & SPACING	6@14"	9@19"		5@20"	5@19"	5@18"	5@20"	4@16"	4@15"	4@18"	4@15"	4@18"	4@17"	4@17"	4@20"	4@19"	4@19"	4@18"	4@18"	4@17"
	LENGTH, h	7'-2"	7'-2"		4'-11"	4'-11"	4'-10.5"	4'-5.5"	4'-0.5"	4'-0.5"	3'-10"	4'-0.5"	3'-10.5"	3'-10.0"	4'-1"	3'-10"	3'-9"	4'-0"	3'-10.5"	4'-1"	3'-11.5"
C BARS	BAR NO. & SPACING	4@14"	4@14"	4@14"	4@9"	4@14"	4@14"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"
	VERT. LENGTH, v	7'-2.5"	7'-3"	7'-3"	7'-2.5"	7'-2.5"	7'-2.5"	7'-2.5"	7'-2.5"	7'-2.5"	7'-3"	7'-2.5"	7'-3"	7'-3.5"	7'-4"	7'-4"	7'-4.5"	7'-4.5"	7'-5"	7'-5"	7'-5.5"
C_1 BARS	BAR NO. & SPACING	4@14"	4@14"	4@14"		4@14"	4@14"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	1'-5"	1'-4.5"	1'-4.5"		1'-2"	1'-2.5"	1'-2.5"	1'-3"	1'-3"	1'-3.5"	1'-3"	1'-3.5"	1'-3.5"	1'-4"	1'-4.5"	1'-4.5"	1'-4.5"	1'-5"	1'-5"	1'-5"
	VERT. LENGTH, v	3'-3.5"	2'-10"	2'-6"		0'-11"	1'-1"	1'-2.5"	1'-3.5"	1'-3.5"	1'-4.5"	1'-3.5"	1'-4.0"	1'-4.5"	1'-6"	1'-6.5"	1'-7"	1'-6"	1'-6"	1'-6.5"	1'-6.5"
C_2 BARS	BAR NO. & SPACING	5@14"	5@14"	5@14"	4@9"	5@14"	4@14"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-2.5"	3'-4.5"	3'-5"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"
	VERT. LENGTH, v	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0.5"	2'-1"	2'-1"	2'-1"	2'-1.5"	2'-2"	2'-2"	2'-2.5"	2'-3"	2'-3"	2'-3.5"	2'-3.5"
C_3 BARS	BAR NO. & SPACING						4@14"	4@14"	5@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h						1'-2.5"	1'-3"	1'-3.5"	1'-3"	1'-3.5"	1'-3.5"	1'-3.5"	1'-3.5"	1'-4"	1'-4.5"	1'-4.5"	1'-4.5"	1'-5"	1'-5"	1'-5.5"
	VERT. LENGTH, v						2'-0"	2'-0"	1'-4"	2'-0.5"	2'-1"	2'-1"	2'-1"	2'-1.5"	1'-6"	1'-6"	1'-6.5"	1'-6.5"	2'-3"	1'-7.5"	1'-7.5"
D BARS	BAR NO. & SPACING	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"
	LENGTH, v	8'-1.5"	8'-1.5"	8'-1.5"	8'-1.5"	8'-1.5"	8'-1.5"	8'-1.5"	8'-1.5"	8'-2"	8'-2.5"	8'-2.5"	8'-3"	8'-4"	8'-4.5"	8'-5"	8'-5.5"	8'-6.5"	8'-7"	8'-7.5"	8'-8"
F BARS	BAR NO. & SPACING	4@15"	5@17"	4@12"	5@18"	6@20"	6@16"	5@11"	7@19"	8@13"	7@16"	8@20"	6@12"	7@15"	7@15"	8@18"	7@14"	8@17"	9@20"	8@16"	8@16"
	LENGTH, h	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"	7'-2"
F_1 BARS	BAR NO. & SPACING	4@15"	4@17"	4@12"	5@18"	5@20"	4@16"	4@11"	5@19"	4@13"	4@16"	4@20"	4@12"	4@15"	4@15"	4@18"	4@14"	4@17"	4@20"	4@16"	4@16"
	LENGTH, h	5'-9"	5'-2"	5'-6.5"	5'-4"	4'-10.5"	4'-5"	4'-7"	4'-5.5"	4'-5.5"	4'-4"	4'-0"	4'-6"	4'-5"	4'-6.5"	4'-4.5"	4'-7.5"	4'-5"	4'-1.5"	4'-3.5"	4'-7.5"
G BARS	BAR NO. & SPACING	4@14"	4@14"	4@14"	4@9"	4@14"	4@14"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	LENGTH, h	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"
H BARS	BAR NO. & SPACING												4@13"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	LENGTH, h												3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"	3'-0.5"
LONGITUDINAL REINFORCEMENT																					
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	15	15	15	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	NUMBER IN BOTTOM SLAB	14	14	14	14	14	14	14	14	14	14	14	12	12	12	12	12	12	12	12	12
	NUMBER IN WALLS	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	TOTAL NUMBER	49	49	49	46	46	46	46	46	46	46	46	44	44	44	44	44	44	44	44	44
CONCRETE: CU. YDS. PER LIN. FT.		0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.70	0.71	0.70	0.72	0.74	0.75	0.77	0.78	0.79	0.81	0.82	0.83
STEEL: LBS. PER LIN. FT.		93.4	93.5	93.7	84.4	80.4	82.3	84.6	87.2	89.8	91.4	90.6	92.5	93.7	91.4	92.9	94.3	94.8	97.1	97.0	98.0

HYDRAULIC PROPERTIES (BOX)

n = .013

Area = 43.58 sq. ft.

$K = Q/S^{\frac{1}{2}} = \frac{1.486}{n} AR^{\frac{2}{3}} = 7,040$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

BOX SIZE: W = 6'-4", H = 7'-6" DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 90"

		DEPTH OF COVER IN FEET																			
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS, t_1		6.75	6.75	6.75	6.50	6.50	6.50	6.50	6.50	6.50	7.00	6.75	7.25	7.50	7.75	8.25	8.50	8.75	9.00	9.25	9.75
SIDE WALL THICKNESS, t_2		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
BOTTOM SLAB THICKNESS, t_3		7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.25	7.50	8.00	8.00	8.25	8.75	9.00	9.25	9.75	10.00	10.25	10.50	10.75
		TRANSVERSE REINFORCEMENT																			
B BARS	BAR NO. & SPACING	4@18"	5@20"	6@14"	4@12"	4@11"	6@20"	6@19"	6@15"	6@14"	7@17"	6@14"	7@17"	6@13"	7@16"	8@19"	7@15"	8@18"	8@17"	8@17"	9@20"
	LENGTH, h	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"
B_1 BARS	BAR NO. & SPACING	9@18"	9@20"	6@14"	4@12"	4@11"	5@20"	5@19"	4@15"	4@14"	4@17"	4@14"	4@17"	4@13"	4@16"	4@19"	4@15"	4@18"	4@17"	4@17"	4@20"
	LENGTH, h	7'-5"	7'-5"	7'-5"	5'-1"	4'-11.5"	4'-7"	4'-7.5"	4'-2"	4'-1.5"	3'-11.5"	4'-2"	4'-0"	4'-4"	4'-2.5"	3'-11.5"	4'-4"	4'-1"	4'-0"	4'-2.5"	3'-11.5"
C BARS	BAR NO. & SPACING	4@14"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"	4@13"	4@14"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"
	VERT. LENGTH, v	7'-6"	7'-6"	7'-6"	7'-5.5"	7'-5.5"	7'-5.5"	7'-5.5"	7'-5.5"	7'-5.5"	7'-6"	7'-6"	7'-6.5"	7'-6.5"	7'-7"	7'-7.5"	7'-7.5"	7'-8"	7'-8"	7'-8.5"	7'-9"
C_1 BARS	BAR NO. & SPACING	4@14"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"	4@13"	5@14"	5@14"	5@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	1'-6"	1'-5"	1'-4.5"	1'-2.5"	1'-3"	1'-3"	1'-3.5"	1'-3.5"	1'-4.5"	1'-4.5"	1'-4"	1'-4"	1'-4"	1'-4"	1'-4.5"	1'-5"	1'-5.5"	1'-5.5"	1'-5.5"	1'-6"
	VERT. LENGTH, v	3'-11.5"	2'-10"	2'-4"	1'-0.5"	1'-1.5"	1'-3"	1'-4.5"	1'-4.5"	1'-6.5"	1'-8.5"	1'-6"	1'-8.5"	1'-5.5"	1'-6"	1'-8.5"	1'-6.5"	1'-7"	1'-7"	1'-7"	1'-7.5"
C_2 BARS	BAR NO. & SPACING	5@14"	5@13"	5@13"	5@14"	4@14"	4@14"	4@14"	4@13"	4@14"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	3'-2.5"	3'-2.5"	3'-2"	3'-2.5"	3'-2.5"	3'-2.5"	3'-2.5"	3'-3"	3'-6"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"	3'-3.5"
	VERT. LENGTH, v	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0.5"	2'-0.5"	2'-1"	2'-1"	2'-1.5"	2'-2"	2'-2"	2'-2.5"	2'-3"	2'-3"	2'-3.5"	2'-3.5"	2'-4"
C_3 BARS	BAR NO. & SPACING					4@14"	4@14"	5@14"	5@13"	5@14"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h					1'-3"	1'-3.5"	1'-4"	1'-3.5"	1'-4"	1'-4.5"	1'-4.5"	1'-4"	1'-4.5"	1'-4.5"	1'-4.5"	1'-5"	1'-5.5"	1'-5.5"	1'-6"	1'-6"
	VERT. LENGTH, v					2'-0"	2'-0"	1'-5"	1'-4.5"	1'-5.5"	1'-6"	1'-5.5"	2'-1.5"	2'-2"	2'-2"	2'-2.5"	2'-3"	1'-7.5"	1'-8"	1'-8.5"	1'-8.5"
D BARS	BAR NO. & SPACING	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"
	LENGTH, v	8'-4.5"	8'-4.5"	8'-5"	8'-4.5"	8'-4.5"	8'-4.5"	8'-4.5"	8'-5"	8'-5"	8'-6"	8'-6.5"	8'-6.5"	8'-7"	8'-8"	8'-8.5"	8'-9"	8'-10"	8'-10"	8'-11"	8'-11.5"
F BARS	BAR NO. & SPACING	5@16"	5@16"	4@11"	5@17"	6@19"	6@15"	7@19"	6@13"	6@12"	7@15"	8@19"	7@15"	8@18"	7@14"	8@17"	9@20"	7@13"	9@19"	9@19"	8@15
	LENGTH, h	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"	7'-5"
F_1 BARS	BAR NO. & SPACING	4@18"	4@16"	4@11"	5@17"	5@19"	4@15"	5@19"	4@13"	4@12"	4@15	4@19"	4@15"	4@18"	4@14"	4@17"	4@20"	4@13"	4@19"	4@19"	4@15"
	LENGTH, h	5'-5"	5'-3"	5'-7"	5'-6"	5'-0.5"	4'-6.5"	4'-6.5"	4'-7"	4'-6"	4'-5"	4'-6.5"	4'-6.5"	4'-4.5"	4'-8"	4'-5.5"	4'-2.5"	4'-10"	4'-3.5"	4'-6"	4'-8"
G BARS	BAR NO. & SPACING	4@14"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"	4@13"	4@14"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"
	LENGTH, h	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"
H BARS	BAR NO. & SPACING										4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"
	LENGTH, h										3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"	3'-2"
		LONGITUDINAL REINFORCEMENT																			
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	NUMBER IN BOTTOM SLAB	14	14	14	14	14	14	14	14	14	12	12	12	12	12	12	12	12	12	12	12
	NUMBER IN WALLS	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	TOTAL NUMBER	50	50	50	46	46	46	46	46	46	44	44	44	44	44	44	44	44	44	44	44
CONCRETE: CU. YDS. PER LIN. FT.		0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.72	0.74	0.74	0.76	0.77	0.79	0.80	0.82	0.83	0.84	0.86	0.87
STEEL: LBS. PER LIN. FT.		98.1	99.4	99.1	81.9	84.0	85.7	88.7	90.6	94.8	94.5	93.5	95.6	96.8	98.0	99.4	100.5	98.6	100.3	100.7	102.2

HYDRAULIC PROPERTIES (BOX)

n = .013

Area = 47.0 sq. ft.

$K = Q/S^{\frac{1}{2}} = \frac{1.486}{n} AR^{\frac{2}{3}} = 7,780$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

BOX SIZE: W = 6'-5", H = 7'-9" — DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 93"

		DEPTH OF COVER IN FEET																			
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS,	t_1	6.75	6.75	6.75	6.50	6.50	6.50	6.50	6.50	6.75	7.00	6.75	7.25	7.75	8.00	8.25	8.50	8.75	9.25	9.50	9.75
SIDE WALL THICKNESS,	t_2	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
BOTTOM SLAB THICKNESS,	t_3	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.25	7.75	8.00	8.00	8.50	8.75	9.00	9.50	9.75	10.25	10.25	10.50	11.00
		TRANSVERSE REINFORCEMENT																			
B BARS	BAR NO. & SPACING	7@9"	4@18"	5@17"	5@18"	4@11"	4@10"	6@18"	5@11"	6@14"	7@17"	6@14"	7@17"	6@13"	8@12"	7@15"	8@18"	7@14"	8@17"	8@12"	9@20"
	LENGTH, h	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"
B_1 BARS	BAR NO. & SPACING		9@18"	8@17"	5@18"	4@11"	4@10"	5@18"	4@11"	4@14"	4@17"	4@14"	4@17"	4@13"	4@12"	4@15"	4@18"	4@14"	4@17"	4@12"	4@20"
	LENGTH, h		7'-6.5"	7'-6.5"	5'-1"	5'-1"	5'-0"	4'-7"	4'-5"	4'-3"	4'-1"	4'-3"	4'-1.5"	4'-3.5"	4'-5"	4'-3.5"	3'-11.5"	4'-3.5"	4'-1.5"	4'-4"	4'-0.5"
C BARS	BAR NO. & SPACING	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"
	VERT. LENGTH, v	7'-9"	7'-9"	7'-9"	7'-8.5"	7'-8.5"	7'-8.5"	7'-8.5"	7'-8.5"	7'-9"	7'-9"	7'-9"	7'-9.5"	7'-10"	7'-10"	7'-10.5"	7'-10.5"	7'-11"	7'-11.5"	7'-11.5"	8'-0"
C_1 BARS	BAR NO. & SPACING	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@13"	5@14"	5@14"	5@14"	5@14"	5@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	1'-6"	1'-5.5"	1'-5"	1'-3"	1'-3"	1'-3.5"	1'-3.5"	1'-4.5"	1'-4.5"	1'-4.5"	1'-4.5"	1'-4.5"	1'-4.5"	1'-4.5"	1'-4.5"	1'-5"	1'-5"	1'-5"	1'-6"	1'-6"	1'-6.5"
	VERT. LENGTH, v	3'-7"	3'-10.5"	2'-5"	1'-1.5"	1'-2.5"	1'-4"	1'-3.5"	1'-6"	1'-7"	1'-7"	1'-6.5"	1'-7"	1'-6"	1'-6.5"	1'-6.5"	1'-7"	1'-7"	1'-8"	1'-8"	1'-8"	1'-8"
C_2 BARS	BAR NO. & SPACING	4@13"	5@13"	5@13"	4@14"	4@14"	4@14"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-8"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"	3'-4"
	VERT. LENGTH, v	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0.5"	2'-1"	2'-1"	2'-1"	2'-1.5"	2'-2"	2'-2"	2'-2.5"	2'-3"	2'-3.5"	2'-3.5"	2'-3.5"	2'-4"
C_3 BARS	BAR NO. & SPACING	4@13"			4@14"	4@14"	4@14"	4@13"	5@14"	5@14"	5@14"	5@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	1'-0.5"			1'-3"	1'-3.5"	1'-4"	1'-4"	1'-4"	1'-4.5"	1'-4.5"	1'-4.5"	1'-5"	1'-4.5"	1'-5"	1'-5"	1'-5"	1'-5"	1'-6"	1'-6"	1'-6.5"
	VERT. LENGTH, v	2'-0"			2'-0"	2'-0"	1'-4"	1'-4.5"	1'-6.5"	1'-6.5"	1'-6.5"	1'-6"	1'-6.5"	1'-6"	1'-6.5"	1'-6"	1'-6.5"	1'-7"	1'-7.5"	1'-8.5"	1'-9"	1'-9.5"
D BARS	BAR NO. & SPACING	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"
	LENGTH, v	8'-7.5"	8'-7.5"	8'-8"	8'-7.5"	8'-7.5"	8'-7.5"	8'-7.5"	8'-8"	8'-8.5"	8'-9"	8'-9"	8'-9.5"	8'-10.5"	8'-11"	8'-11.5"	9'-0.5"	9'-1"	9'-1.5"	9'-2"	9'-2.5"
F BARS	BAR NO. & SPACING	5@17"	5@19"	4@11"	6@20"	6@18"	5@16"	6@13"	7@16"	8@19"	7@15"	7@15"	8@18"	8@19"	7@14"	9@20"	9@20"	8@16"	9@19"	8@15"	8@15"
	LENGTH, h	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"	7'-6.5"
F_1 BARS	BAR NO. & SPACING	4@17"	5@19"	4@11"	5@20"	5@18"	4@11"	4@13"	4@16"	4@19"	4@15"	4@15"	4@18"	5@19"	4@14"	4@20"	4@20"	4@16"	4@19"	4@15"	4@15"
	LENGTH, h	5'-4.5"	5'-10"	5'-8.5"	5'-1.5"	5'-0"	4'-10"	4'-8.5"	4'-4.5"	4'-2"	4'-6.5"	4'-5.5"	4'-3"	4'-8.5"	4'-9"	4'-1.5"	4'-4"	4'-7.5"	4'-5"	4'-7"	4'-9.5"
G BARS	BAR NO. & SPACING	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"
	LENGTH, h	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"
H BARS	BAR NO. & SPACING									4@14"	4@14"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"
	LENGTH, h									3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"	3'-3"
		LONGITUDINAL REINFORCEMENT																			
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	16	16	16	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	NUMBER IN BOTTOM SLAB	14	14	14	14	14	14	14	14	12	12	12	12	12	12	12	12	12	12	12	12
	NUMBER IN WALLS	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	TOTAL NUMBER	50	50	50	46	46	46	46	46	44	44	44	44	44	44	44	44	44	44	44	44
CONCRETE: CU. YDS. PER LIN. FT.		0.73	0.73	0.73	0.72	0.72	0.72	0.72	0.73	0.75	0.76	0.75	0.78	0.80	0.81	0.83	0.84	0.86	0.87	0.88	0.90
STEEL: LBS. PER LIN. FT.		101.8	101.6	101.0	84.2	85.8	87.1	91.0	95.0	96.5	97.5	96.7	96.4	97.6	99.0	100.6	101.4	102.5	101.7	102.5	103.5

HYDRAULIC PROPERTIES (BOX)

n = .013

Area = 49.41 sq. ft.

$K = Q/S^{\frac{1}{2}} = \frac{1.486}{n} AR^{\frac{2}{3}} = 8{,}300$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

BOX SIZE: W = 6'-9", H = 8'-0" DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 96"

		DEPTH OF COVER IN FEET																			
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS, t_1		6.75	6.75	6.75	6.50	6.50	6.50	6.50	6.50	7.00	7.25	7.25	7.50	8.00	8.25	8.50	8.75	9.25	9.50	9.75	10.00
SIDE WALL THICKNESS, t_2		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
BOTTOM SLAB THICKNESS, t_3		7.00	7.00	7.00	7.00	7.00	7.00	7.25	7.50	8.00	8.25	8.25	8.75	9.00	9.50	9.75	10.25	10.50	10.75	11.00	11.25
		TRANSVERSE REINFORCEMENT																			
B BARS	BAR NO. & SPACING	5 @ 13"	6 @ 15"	6 @ 13"	6 @ 20"	4 @ 10"	6 @ 18"	5 @ 11"	7 @ 19"	6 @ 13"	7 @ 17"	6 @ 13"	7 @ 17"	6 @ 12"	8 @ 20"	8 @ 19"	7 @ 14"	9 @ 20"	8 @ 16"	9 @ 19"	9 @ 20"
	LENGTH, h	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"
B_1 BARS	BAR NO. & SPACING	7 @ 13"	7 @ 15"	6 @ 13"	5 @ 20"	4 @ 10"	5 @ 18"	4 @ 11"	5 @ 19"	4 @ 13"	5 @ 17"	4 @ 13"	5 @ 17"	4 @ 12"	4 @ 20"	5 @ 19"	4 @ 14"	4 @ 20"	4 @ 16"	4 @ 19"	5 @ 20"
	LENGTH, h	7'-10"	7'-10"	7'-10"	4'-10"	5'-3"	4'-10"	4'-7.5"	4'-5"	4'-5"	4'-5.5"	4'-5.5"	4'-6"	4'-7"	4'-7"	4'-7"	4'-7"	5'-11.5"	4'-3.5"	4'-1"	4'-2.5"
C BARS	BAR NO. & SPACING	4 @ 12"	4 @ 12"	4 @ 12"	4 @ 14"	4 @ 14"	4 @ 13"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 13"	4 @ 13"	4 @ 13"	4 @ 13"	4 @ 13"
	HORIZ. LENGTH, h	3'-5"	3'-5"	3'-6"	3'-8"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"
	VERT. LENGTH, v	8'-0"	8'-0"	8'-0"	7'-11.5"	7'-11.5"	7'-11.5"	7'-11.5"	7'-11.5"	8'-0"	8'-0.5"	8'-0.5"	8'-0.5"	8'-1"	8'-1.5"	8'-1.5"	8'-2"	8'-2.5"	8'-2.5"	8'-3"	8'-3"
C_1 BARS	BAR NO. & SPACING	4 @ 12"	4 @ 12"	4 @ 12"	4 @ 14"	4 @ 14"	4 @ 13"	5 @ 14"	5 @ 14"	5 @ 14"	5 @ 14"	5 @ 14"	5 @ 14"	5 @ 14"	5 @ 14"	5 @ 14"	4 @ 13"	4 @ 13"	4 @ 13"	4 @ 13"	4 @ 13"
	HORIZ. LENGTH, h	1'-6.5"	1'-6"	1'-5"	1'-4"	1'-4.5"	1'-4.5"	1'-5"	1'-5.5"	1'-5"	1'-5"	1'-5"	1'-5"	1'-5.5"	1'-5.5"	1'-6"	1'-6.5"	1'-6"	1'-6"	1'-6.5"	1'-6.5"
	VERT. LENGTH, y	3'-8.5"	3'-2"	2'-5.5"	1'-4.5"	1'-9.5"	1'-5"	1'-7.5"	1'-9"	1'-8.5"	1'-8.5"	1'-8"	1'-8"	1'-8"	1'-8.5"	1'-8.5"	1'-8"	1'-8.5"	1'-8.5"	1'-8.5"	1'-8.5"
C_2 BARS	BAR NO. & SPACING	4 @ 12"	4 @ 12"	5 @ 12"	4 @ 14"	4 @ 14"	4 @ 13"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 13"	4 @ 13"	4 @ 13"	4 @ 13"	4 @ 13"
	HORIZ. LENGTH, h	3'-7"	3'-7"	3'-6.5"	3'-7"	3'-7"	3'-7"	3'-7"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"	3'-5"
	VERT. LENGTH, v	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0"	2'-0.5"	2'-0.5"	2'-1"	2'-1.5"	2'-1.5"	2'-2"	2'-2"	2'-2.5"	2'-3"	2'-3.5"	2'-3.5"	2'-4"	2'-4"	2'-4.5"
C_3 BARS	BAR NO. & SPACING	4 @ 12"	4 @ 12"		4 @ 14"	4 @ 14"	5 @ 13"	5 @ 14"	5 @ 14"	5 @ 14"	5 @ 14"	5 @ 14"	5 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 13"	4 @ 13"	4 @ 13"	4 @ 13"	4 @ 13"
	HORIZ. LENGTH, h	1'-1"	1'-1.5"		1'-4"	1'-4.5"	1'-4.5"	1'-5.5"	1'-5"	1'-5.5"	1'-5.5"	1'-5.5"	1'-5.5"	1'-6"	1'-6"	1'-6.5"	1'-6"	1'-6"	1'-6.5"	1'-6.5"	1'-7"
	VERT. LENGTH, v	2'-0"	2'-0"		2'-0"	1'-5"	1'-5.5"	1'-9"	1'-8"	1'-8"	1'-7.5"	1'-7.5"	1'-7.5"	1'-8"	1'-8.5"	1'-8.5"	1'-8"	1'-8.5"	1'-9"	1'-9"	1'-9.5"
D BARS	BAR NO. & SPACING	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"	4 @ 18"
	LENGTH, v	8'-10.5"	8'-10.5"	8'-11"	8'-10.5"	8'-10.5"	8'-10.5"	8'-10.5"	8'-11"	9'-0"	9'-0.5"	9'-0.5"	9'-1"	9'-2"	9'-2.5"	9'-3.5"	9'-4"	9'-4.5"	9'-5"	9'-6"	9'-6.5"
F BARS	BAR NO. & SPACING	5 @ 20"	4 @ 11"	5 @ 16"	5 @ 15"	6 @ 17"	7 @ 19"	6 @ 12"	7 @ 15"	8 @ 19"	7 @ 14"	8 @ 19"	8 @ 17"	9 @ 20"	7 @ 13"	9 @ 19"	9 @ 20"	9 @ 20"	9 @ 18"	8 @ 14"	8 @ 14"
	LENGTH, h	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"	7'-10"
F_1 BARS	BAR NO. & SPACING	5 @ 20"	4 @ 11"	5 @ 16"	5 @ 15"	5 @ 17"	5 @ 19"	4 @ 12"	4 @ 15"	5 @ 19"	4 @ 14"	5 @ 19"	4 @ 17"	4 @ 20"	4 @ 13"	4 @ 19"	5 @ 20"	5 @ 20"	4 @ 16"	4 @ 14"	4 @ 14"
	LENGTH, h	6'-1.5"	5'-11"	5'-10.5"	5'-8.5"	5'-3"	4'-10.5"	4'-8"	4'-6.5"	4'-8"	4'-8.5"	4'-9"	4'-6"	4'-3"	4'-11"	4'-4.5"	4'-11.5"	5'-1"	4'-8"	4'-9"	4'-11"
G BARS	BAR NO. & SPACING	4 @ 12"	4 @ 12"	4 @ 12"	4 @ 14"	4 @ 14"	4 @ 13"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 13"	4 @ 13"	4 @ 13"	4 @ 13"	4 @ 13"
	LENGTH, h	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"
H BARS	BAR NO. & SPACING								4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 14"	4 @ 13"	4 @ 13"	4 @ 13"	4 @ 13"	4 @ 13"
	LENGTH, h								3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"	3'-4.5"
		LONGITUDINAL REINFORCEMENT																			
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	18	18	17	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	NUMBER IN BOTTOM SLAB	14	14	14	14	14	14	14	13	13	13	13	13	13	13	13	13	13	13	13	13
	NUMBER IN WALLS	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	TOTAL NUMBER	52	52	51	47	47	47	47	46	46	46	46	46	46	46	46	46	46	46	46	46
CONCRETE: CU. YDS. PER LIN. FT.		0.76	0.76	0.76	0.75	0.75	0.75	0.76	0.76	0.79	0.80	0.80	0.81	0.84	0.86	0.87	0.89	0.91	0.92	0.93	0.94
STEEL: LBS. PER LIN. FT.		109.7	110.1	108.6	88.9	89.6	95.5	98.8	101.1	102.9	104.0	102.9	104.6	103.8	104.9	106.6	107.5	108.9	110.2	111.8	112.4

HYDRAULIC PROPERTIES (BOX)

n= .013

Area = 53.5 sq. ft.

$K = \frac{Q}{S^{\frac{1}{2}}} = \frac{1.486}{n} AR^{\frac{2}{3}} = 9,256$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

BOX SIZE: W = 7'-1" , H = 8'-6" DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 102"

		DEPTH OF COVER IN FEET																			
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS, t_1		7.00	7.00	7.00	6.50	6.50	6.50	6.50	6.75	7.25	7.50	7.50	7.75	8.00	8.50	8.75	9.25	9.50	9.75	10.25	10.50
SIDE WALL THICKNESS, t_2		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
BOTTOM SLAB THICKNESS, t_3		7.00	7.00	7.00	7.00	7.00	7.25	7.50	7.75	8.25	8.50	8.50	9.00	9.25	9.75	10.25	10.50	11.00	11.00	11.50	11.75
		TRANSVERSE REINFORCEMENT																			
B BARS	BAR NO. & SPACING	6@12"	6@12"	5@15"	5@15"	6@15"	5@11"	5@10"	7@17"	7@17"	7@15"	7@17"	6@12"	6@11"	7@14"	8@18"	7@13"	8@19"	9@20"	8@15"	9@18"
	LENGTH, h	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"
B_1 BARS	BAR NO. & SPACING	6@12"	6@12"	8@19"	5@15"	4@15"	4@11"	4@10"	5@17"	5@17"	4@15"	5@17"	4@12"	4@11"	4@14"	5@18"	4@13"	4@19"	5@20"	4@15"	4@18"
	LENGTH, h	8'-2"	8'-2"	8'-2"	5'-5.5"	4'-6.5"	4'-10.5"	4'-9"	4'-6"	4'-8.5"	4'-5.5"	4'-8.5"	4'-9"	4'-8"	4'-7.5"	4'-9"	4'-8.5"	4'-1.5"	4'-8.5"	4'-7.5"	4'-5.5"
C BARS	BAR NO. & SPACING	4@11"	4@11"	4@10"	4@13"	4@14"	4@14"	4@14"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"
	VERT. LENGTH, v	8'-6"	8'-6"	8'-6"	8'-5.5"	8'-5.5"	8'-5.5"	8'-5.5"	8'-6"	8'-6.5"	8'-6.5"	8'-6.5"	8'-7"	8'-7"	8'-7.5"	8'-8"	8'-8.5"	8'-8.5"	8'-9"	8'-9.5"	8'-9.5"
C_1 BARS	BAR NO. & SPACING	4@11"	4@11"	4@10"	4@13"	5@14"	5@14"	5@14"	5@13"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"
	HORIZ. LENGTH, h	1'-7"	1'-6.5"	1'-5.5"	1'-5"	1'-5.5"	1'-6"	1'-6.5"	1'-6"	1'-6"	1'-6"	1'-6"	1'-6"	1'-6"	1'-6.5"	1'-6.5"	1'-7"	1'-7.5"	1'-7.5"	1'-8"	1'-8"
	VERT. LENGTH, v	3'-9.5"	3'-2"	2'-1"	1'-5.5"	1'-8"	1'-9"	1'-11"	1'-9"	1'-11"	1'-9.5"	1'-9.5"	1'-9.5"	1'-9.5"	1'-10"	1'-10"	1'-10"	1'-10"	1'-10"	1'-10.5"	1'-10.5"
C_2 BARS	BAR NO. & SPACING	4@11"	4@11"	4@10"	4@13"	4@14"	4@14"	4@14"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"
	VERT. LENGTH, v	2'-0"	2'-0"	2'-0	2'-0"	2'-0"	2'-0.5"	2'-0.5"	2'-1"	2'-1.5"	2'-1.5"	2'-1.5"	2'-2"	2'-2.5"	2'-3"	2'-3.5"	2'-3.5"	2'-4"	2'-4"	2'-4.5"	2'-5"
C_3 BARS	BAR NO. & SPACING	4@11"	4@11"	4@10"	4@13"	5@14"	5@14"	5@14"	5@13"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	1'-2"	1'-2.5"	1'-2.5"	1'-5"	1'-6"	1'-6.5"	1'-6"	1'-5.5"	1'-6.5"	1'-6.5"	1'-6.5"	1'-7"	1'-7"	1'-7.5"	1'-7.5"	1'-7.5"	1'-8"	1'-8"	1'-8.5"	1'-9"
	VERT. LENGTH, v	2'-0"	2'-0"	2'-0"	1'-4.5"	1'-8.5"	1'-2"	1'-11"	1'-8.5"	1'-9.5"	1'-9"	1'-9"	1'-9"	1'-9"	1'-9.5"	1'-10"	1'-10.5"	1'-11"	1'-11"	1'-9"	1'-9"
D BARS	BAR NO. & SPACING	4@16"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"
	LENGTH, v	9'-4.5"	9'-4.5"	9'-4.5"	9'-4.5"	9'-4.5"	9'-4.5"	9'-5"	9'-5.5"	9'-6.5"	9'-7"	9'-7"	9'-8"	9'-8.5"	9'-9"	9'-10"	9'-10.5"	9'-11.5"	10'-0"	10'-0.5"	10'-1"
F BARS	BAR NO. & SPACING	4@12"	6@20"	6@18"	5@11"	6@13"	6@12"	8@19"	8@19"	8@18"	7@13"	8@18"	7@13"	9@19"	9@20"	8@15"	9@19"	9@19"	8@14"	9@16"	9@16"
	LENGTH, h	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"	8'-2"
F_1 BARS	BAR NO. & SPACING	4@12"	5@20"	5@18"	4@11"	4@13"	4@12"	5@19"	5@19"	5@18"	4@13"	5@18"	4@13"	4@19"	5@20"	4@15"	5@19"	5@19"	4@14"	4@16"	4@16"
	LENGTH, h	6'-4.5"	5'-9"	5'-7.5"	5'-3.5"	4'-10"	4'-10.5"	4'-8"	4'-10.5"	4'-11"	4'-10"	5'-0"	5'-0"	4'-5.5"	5'-0.5"	5'-0"	5'-2"	5'-3.5"	5'-1"	4'-6"	4'-8"
G BARS	BAR NO. & SPACING	4@11"	4@11"	4@10"	4@13"	4@14"	4@14"	4@14"	4@13	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	LENGTH, h	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"
H BARS	BAR NO. & SPACING	4@11"	4@11"	4@10"	4@13"	4@14"	4@14"	4@14"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	LENGTH, h	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"	3'-6.5"
		LONGITUDINAL REINFORCEMENT																			
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	19	19	19	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	NUMBER IN BOTTOM SLAB	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	NUMBER IN WALLS	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	TOTAL NUMBER	52	52	52	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
CONCRETE: CU. YDS. PER LIN. FT.		0.80	0.80	0.80	0.79	0.79	0.80	0.80	0.82	0.84	0.86	0.86	0.87	0.89	0.91	0.93	0.95	0.97	0.98	1.00	1.02
STEEL: LBS. PER LIN. FT.		121.33	120.7	123.9	96.3	100.8	103.4	106.2	109.6	108.5	109.3	108.4	109.2	111.6	112.5	111.9	113.3	114.5	115.7	117.5	118.2

HYDRAULIC PROPERTIES (BOX)

n = .013

Area =

$K = Q/S^{\frac{1}{2}} = \frac{1.486}{n} AR^{\frac{2}{3}} = 10,685$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

BOX SIZE: W = 7'-6", H = 9'-0" DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 108"

		DEPTH OF COVER IN FEET																			
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS, t_1		7.00	7.00	7.00	6.50	6.50	6.50	6.75	7.00	7.50	8.00	7.75	8.25	8.50	8.75	9.25	9.50	10.00	10.25	10.75	11.00
SIDE WALL THICKNESS, t_2		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.25
BOTTOM SLAB THICKNESS, t_3		7.00	7.00	7.00	7.00	7.25	7.50	7.75	8.00	8.50	8.75	9.00	9.25	9.75	10.25	10.50	11.00	11.50	11.75	12.00	12.25
		TRANSVERSE REINFORCEMENT																			
B BARS	BAR NO. & SPACING	5@14"	5@14"	5@14"	5@11"	7@19"	7@18"	7@17"	8@20"	6@11"	8@19"	6@11"	8@19	8@18"	7@13"	9@19"	9@20"	9@18"	9@19"	8@14"	8@14"
	LENGTH, h	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7.5"
B_1 BARS	BAR NO. & SPACING	8@14"	8@14"	8@14"	4@11"	5@19"	5@18"	5@17"	5@20"	4@11"	5@19"	4@11"	5@19"	5@18"	4@13"	4@19"	5@20"	4@18"	5@19"	4@14"	4@14"
	LENGTH, h	8'-7"	8'-7"	8'-7"	5'-1"	4'-10"	4'-10"	4'-10"	4'-7.5"	4'-9.5"	4'-10.5"	4'-9"	4'-10.5"	4'-11"	4'-10.5"	4'-4"	4'-11"	4'-5.5"	5'-0.5"	4'-10"	5'-0.5"
C BARS	BAR NO. & SPACING	4@10"	4@10"	4@9"	4@14"	4@14"	4@13"	4@12"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7.5"
	VERT. LENGTH, v	9'-0"	9'-0"	9'-0"	8'-11.5"	8'-11.5"	8'-11.5"	9'-0"	9'-0"	9'-0.5"	9'-1"	9'-1"	9'-1.5"	9'-1.5"	9'-2"	9'-2.5"	9'-2.5"	9'-3"	9'-3.5"	9'-4"	9'-4"
C_1 BARS	BAR NO. & SPACING	4@10"	4@10"	4@9"	5@14"	5@14"	5@13"	5@12"	5@13"	5@13"	5@13"	5@13"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"
	HORIZ. LENGTH, h	1'-8"	1'-7.5"	1'-6.5"	1'-6.5"	1'-7"	1'-7"	1'-7"	1'-7"	1'-6.5"	1'-6.5"	1'-6.5"	1'-7"	1'-7.5"	1'-7.5"	1'-8"	1'-8"	1'-8.5"	1'-9"	1'-9"	1'-9.5"
	VERT. LENGTH, v	3'-11.5"	3'-3.5"	2'-0"	2'-2"	2'-3"	2'-0.5"	1'-10.5"	2'-0"	1'-11"	1'-10.5"	1'-10"	1'-11"	1'-11.5"	1'-11.5"	1'-11.5"	1'-11.5"	2'-0"	2'-0"	2'-0"	2'-0.5"
C_2 BARS	BAR NO. & SPACING	4@10"	4@10"	4@9"	4@14"	4@14"	5@13"	4@12"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-10.5"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7"	3'-7.5"
	VERT. LENGTH, v	2'-0"	2'-0"	2'-0"	2'-0"	2'-0.5"	2'-0.5"	2'-1"	2'-1"	2'-1.5"	2'-2"	2'-2"	2'-2.5"	2'-3"	2'-3.5"	2'-3.5"	2'-4"	2'-4.5"	2'-5"	2'-5"	2'-5.5"
C_3 BARS	BAR NO. & SPACING	4@10"	4@10"	4@9"	5@14"	5@14"	5@13"	5@12"	5@13"	5@13"	5@13"	5@13"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"	5@14"
	HORIZ. LENGTH, h	1'-3"	1'-3.5"	1'-3.5"	1'-7.5"	1'-7.5"	1'-5"	1'-6.5"	1'-7"	1'-7"	1'-7.5"	1'-7.5"	1'-8"	1'-8.5"	1'-8.5"	1'-9"	1'-9"	1'-9.5"	1'-9.5"	1'-10"	1'-10.5"
	VERT. LENGTH, v	2'-0"	2'-0"	2'-0"	2'-1.5"	2'-6.5"	1'-3.5"	1'-9.5"	1'-10.5"	1'-10"	1'-10"	1'-10"	1'-10.5"	1'-10.5"	1'-11"	1'-10"	1'-10.5"	1'-10"	1'-10"	1'-10.5"	1'-11"
D BARS	BAR NO. & SPACING	4@14"	4@15"	4@15"	4@15"	4@15"	4@15"	4@16"	4@16"	4@16"	4@17"	4@17"	4@17"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"	4@18"
	LENGTH, v	9'-10.5"	9'-10.5"	9'-10.5"	9'-10.5"	9'-10.5"	9'-10.5"	9'-11.5"	10'-0"	10'-1"	10'-2"	10'-1.5"	10'-2.5"	10'-3"	10'-4"	10'-5"	10'-5.5"	10'-6"	10'-7"	10'-7.5"	10'-8.5"
F BARS	BAR NO. & SPACING	4@11"	5@15"	7@20"	6@15"	8@20"	8@18"	8@18"	7@13"	9@20"	9@20"	9@20"	7@12"	9@19"	8@14"	8@14"	9@18"	9@16"	9@16"	8@13"	9@15"
	LENGTH, h	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7"	8'-7.5"
F_1 BARS	BAR NO. & SPACING	4@11"	5@15"	5@20"	5@15"	5@20"	5@18"	5@18"	4@13"	5@20"	5@20"	5@20"	4@12"	5@19"	4@14"	4@14"	5@18"	4@16"	4@16"	4@13"	4@15"
	LENGTH, h	6'-7.5"	6'-5.5"	5'-6"	5'-8"	4'-11"	4'-10"	5'-0.5"	5'-0"	4'-11"	5'-1"	5'-0.5"	5'-2.5"	5'-2.5"	5'-0"	5'-2.5"	5'-5.5"	4'-9.5"	4'-11.5"	5'-5.5"	4'-10.5"
G BARS	BAR NO. & SPACING	4@10"	4@10"	4@9"	4@14"	4@14"	4@13"	4@12"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	LENGTH, h	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"
H BARS	BAR NO. & SPACING	4@10"	4@10"	4@9"	4@14"	4@14"	5@13"	4@12"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@14	4@14"	4@14"	4@14"	4@14"	4@14"
	LENGTH, h	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"	3'-9"
		LONGITUDINAL REINFORCEMENT																			
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	20	20	20	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
	NUMBER IN BOTTOM SLAB	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
	NUMBER IN WALLS	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
	TOTAL NUMBER	58	58	58	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
CONCRETE: CU. YDS. PER LIN. FT.		0.85	0.85	0.85	0.83	0.84	0.85	0.86	0.87	0.90	0.92	0.92	0.94	0.96	0.98	1.00	1.02	1.05	1.07	1.09	1.12
STEEL: LBS. PER LIN. FT.		137.7	137.4	141.7	112.1	115.6	123.8	122.8	121.2	123.3	123.0	122.8	121.0	122.4	124.0	125.2	126.3	128.4	129.0	130.4	132.1

HYDRAULIC PROPERTIES (BOX)

n = .013

Area = 59.7 sq. ft.

$K = \frac{Q\sqrt{I}}{S} = \frac{1.486}{n} AR^{\frac{2}{3}} = 12,452$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

BOX SIZE: W = 8.00 , H = 9.50 DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 114" RCP

		DEPTH OF COVER IN FEET																			
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS, t_1		7.50	7.50	7.50	6.50	6.50	6.75	7.00	7.50	7.75	8.25	8.00	8.50	8.75	9.25	9.75	10.00	10.50	10.75	11.26	11.50
SIDE WALL THICKNESS, t_2		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.25	8.50	8.75
BOTTOM SLAB THICKNESS, t_3		7.00	7.00	7.25	7.50	7.50	7.75	8.00	8.50	8.75	9.25	9.25	9.75	10.25	10.75	11.00	11.50	11.75	12.50	12.50	13.00
TRANSVERSE REINFORCEMENT																					
B BARS	BAR NO. & SPACING	5@14"	5@14"	9@14"	6@15"	7@17"	7@16"	6@11"	8@18"	8@18"	8@10"	8@16"	6@10"	9@20"	7@12"	9@19"	8@14"	9@18"	9@16"	9@16"	8@13"
	LENGTH, h	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1.5"	9'-2"	9'-2"
B_1 BARS	BAR NO. & SPACING	8@14"	8@14"	4@14"	5@15"	5@17"	5@16"	4@11"	5@18"	5@18"	4@10"	5@16"	4@10"	5@20"	4@12"	5@19"	4@14"	5@18"	4@16"	4@16"	4@13"
	LENGTH, h	9'-1"	9'-1"	2'-3.5"	5'-5.5"	5'-0"	5'-0.5"	4'-11.5"	4'-10.5"	5'-1"	5'-3"	5'-0.5"	5'-3"	4'-11.5"	5'-2"	5'-2.5"	4'-11"	5'-4"	4'-7"	4'-10.5"	5'-3.5"
C BARS	BAR NO. & SPACING	5@14"	5@14"	4@11"	4@13"	4@12"	4@11"	4@12"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@13"
	HORIZ. LENGTH, h	4'-0"	4'-0"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-9"	3'-9"
	VERT. LENGTH, v	9'-6.5"	9'-6.5"	9'-6.5"	9'-5.5"	9'-5.5"	9'-6"	9'-6"	9'-6.5"	9'-7"	9'-7.5"	9'-7"	9'-7.5"	9'-8"	9'-8.5"	9'-9"	9'-9"	9'-9.5"	9'-10"	9'-10.5"	9'-10.5"
C_1 BARS	BAR NO. & SPACING	4@14"	4@14"	4@11"	5@13"	5@12"	5@11"	5@12"	6@14"	6@14"	5@13"	5@13"	5@13"	5@13"	5@13"	5@13"	5@13"	5@13"	6@14"	6@14"	5@13"
	HORIZ. LENGTH, h	1'-6.5"	1'-6"	1'-8"	1'-8"	1'-8"	1'-8"	1'-8"	1'-8.5"	1'-8"	1'-7.5"	1'-7.5"	1'-8"	1'-8"	1'-8.5"	1'-9"	1'-9"	1'-10"	1'-10"	1'-10.5"	1'-10.5"
	VERT. LENGTH, v	1'-11"	1'-11.5"	3'-9.5"	2'-9.5"	2'-4"	2'-1.5"	2'-2.5"	2'-5.5"	2'-4.5"	2'-1"	2'-0"	2'-0"	2'-0.5"	2'-0.5"	2'-1"	2'-1"	2'-1.5"	2'-2"	2'-1.5"	2'-1.5"
C_2 BARS	BAR NO. & SPACING	4@14"	4@14"	4@11"	4@13"	4@12"	4@11"	4@12"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@13"
	HORIZ. LENGTH, h	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-8.5"	3'-9"	3'-9"	3'-9"
	VERT. LENGTH, v	2'-0"	2'-0"	2'-0.5"	2'-0.5"	2'-0.5"	2'-1"	2'-1"	2'-1.5"	2'-2"	2'-2.5"	2'-2.5"	2'-3"	2'-3.5"	2'-4"	2'-4"	2'-4.5"	2'-5"	2'-5.5"	2'-5.5"	2'-6"
C_3 BARS	BAR NO. & SPACING	4@14"	5@14"	4@11"	5@13"	5@12"	5@11"	5@12"	6@14"	6@14"	5@13"	5@13"	5@13"	5@13"	5@13"	5@13"	5@13"	5@13"	5@14"	5@14"	5@13"	5@13"
	HORIZ. LENGTH, h	1'-9.5"	1'-9"	1'-7.5"	1'-8"	1'-8"	1'-7.5"	1'-8"	1'-8.5"	1'-9"	1'-9"	1'-9"	1'-9"	1'-9"	1'-9.5"	1'-10"	1'-10"	1'-10"	1'-11"	1'-11.5"	1'-11.5"	2'-0"
	VERT. LENGTH, v	2'-0"	2'-0"	1'-4.5"	1'-10.5"	1'-11"	1'-11"	2'-1"	2'-4.5"	2'-2"	1'-11.5"	1'-11.5"	1'-11.5"	1'-11"	1'-11"	1'-11"	1'-11"	2'-0"	2'-0"	2'-0"	2'-0"
D BARS	BAR NO. & SPACING	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@15"	4@15"	4@15"	4@15"	4@16"	4@16"	4@16"	4@17"	4@17"	4@18"	4@18"
	LENGTH, v	10'-5.5"	10'-5.5"	10'-5.5"	10'-5"	10'-5"	10'-5"	10'-6"	10'-7"	10'-7.5"	10'-8.5"	10'-8.5"	10'-9.5"	10'-10"	10'-11"	11'-0"	11'-0.5"	11'-1"	11'-2.5"	11'-3"	11'-3.5"
F BARS	BAR NO. & SPACING	4@10"	6@20"	6@18"	6@14"	6@11"	8@17"	9@20"	8@16"	8@14"	9@18"	8@14"	9@18"	9@16"	9@16"	8@13"	7@10"	9@15"	9@15"	8@12"	9@14"
	LENGTH, h	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1"	9'-1.5"	9'-2"	9'-2"
F_1 BARS	BAR NO. & SPACING	4@10"	6@20"	6@18"	5@14"	4@11"	5@17"	5@20"	5@16"	4@14"	5@18"	4@14"	5@18"	4@16"	4@16"	4@13"	4@10"	4@15"	4@15"	4@12"	4@14"
	LENGTH, h	6'-10"	6'-8.5"	6'-8"	6'-1.5"	5'-5.5"	5'-3"	5'-1.5"	5'-5.5"	4'-11"	5'-3.5"	5'-0.5"	5'-8.5"	4'-10"	5'-1"	5'-6.5"	5'-9"	5'-3"	5'-4"	5'-8.5"	5'-2"
G BARS	BAR NO. & SPACING	5@14"	5@14"	4@11"	4@13"	4@12"	4@11"	4@12"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@13"	4@13"
	LENGTH, h	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"
H BARS	BAR NO. & SPACING	4@14"	4@14"	4@11"	4@13"	4@12"	4@11"	4@12"	4@14"	4@14"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@13"	4@14"	4@13"	4@13"
	LENGTH, h	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"
LONGITUDINAL REINFORCEMENT																					
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	20	20	20	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	15
	NUMBER IN BOTTOM SLAB	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	15
	NUMBER IN WALLS	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
	TOTAL NUMBER	58	58	58	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
CONCRETE: CU. YDS. PER LIN. FT.		0.91	0.91	0.92	0.89	0.89	0.91	0.92	0.95	0.97	0.99	0.99	1.02	1.04	1.07	1.09	1.11	1.13	1.18	1.21	1.23
STEEL: LBS. PER LIN. FT.		138.2	142.0	140.7	123.8	129.5	136.4	134.3	136.3	137.0	133.7	132.1	133.8	136.3	136.5	137.7	139.9	140.8	143.9	144.4	146.3

HYDRAULIC PROPERTIES (BOX)

n = .013

Area = 75.4 sq. ft.

$K = Q/S^{\frac{1}{2}} = \frac{1.486}{n} AR^{\frac{2}{3}} = 14{,}598$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

BOX SIZE: W = 8'-5" , H = 10'-0" DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 120"

		DEPTH OF COVER IN FEET																			
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS,	t_1	7.75	7.75	7.75	6.75	6.75	7.00	7.25	7.75	8.25	8.50	8.50	9.00	9.00	9.75	10.00	10.50	11.00	11.25	11.75	12.00
SIDE WALL THICKNESS,	t_2	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.25	8.50	8.50	8.75	9.00
BOTTOM SLAB THICKNESS,	t_3	7.00	7.25	7.50	7.75	8.50	8.00	8.25	8.75	9.25	9.50	9.75	10.00	10.50	11.00	11.50	12.00	12.25	12.75	13.00	13.50
		TRANSVERSE REINFORCEMENT																			
B BARS	BAR NO. & SPACING	6@13"	9@13"	9@14"	7@19"	7@16"	7@15"	7@13"	6@10"	9@20"	7@12"	8@17"	7@12"	6@16"	8@15"	7@11"	9@16"	8@13"	7@10"	9@15"	9@15"
	LENGTH, h	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-7"	9'-7.5"	9'-8"
B_1 BARS	BAR NO. & SPACING	7@13"	4@13"	4@14"	6@19"	5@16"	5@15"	4@13"	4@10"	5@20"	4@12"	5@17"	4@12"	5@16"	5@15"	4@11"	4@16"	4@13"	4@10"	4@15"	4@15"
	LENGTH, h	9'-6.5"	2'-0.5"	2'-8"	5'-10"	5'-3.5"	5'-3.5"	4'-11"	5'-4.5"	5'-1"	5'-3"	5'-4.5"	5'-3"	5'-7"	5'-8.5"	5'-6"	4'-9.5"	5'-4"	5'-7"	5'-0"	5'-2.5"
C BARS	BAR NO. & SPACING	5@14"	5@14"	4@10"	4@12"	4@11"	4@11"	4@13"	4@13"	4@14"	4@14"	4@14"	4@12"	4@14"	4@12"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	4'-1.5"	4'-1.5"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10.5"	3'-10.5"	3'-11"
	VERT. LENGTH, v	10'-1"	10'-1"	10'-1"	10'-0"	10'-0"	10'-0"	10'-0.5"	10'-1"	10'-1.5"	10'-1.5"	10'-1.5"	10'-2"	10'-2.5"	10'-3"	10'-3"	10'-3.5"	10'-4"	10'-4.5"	10'-5"	10'-5"
C_1 BARS	BAR NO. & SPACING	4@14"	4@14"	4@10"	5@12"	5@11"	5@11"	6@13"	6@13"	6@14"	6@14"	6@14"	5@12"	6@14"	5@12"	6@14"	6@14"	6@14"	6@14"	6@14"	6@14"
	HORIZ. LENGTH, h	1'-8"	1'-7"	1'-8.5"	1'-8.5"	1'-8.5"	1'-9"	1'-9.5"	1'-9"	1'-9"	1'-9"	1'-9"	1'-8.5"	1'-10"	1'-9.5"	1'-10.5"	1'-11"	1'-11.5"	2'-0"	2'-0.5"	2'-1"
	VERT. LENGTH, v	2'-0.5"	2'-1"	3'-1.5"	2'-9"	2'-3.5"	2'-5.5"	2'-8.5"	2'-5.5"	2'-6.5"	2'-6.5"	2'-8"	2'-1"	2'-5.5"	2'-1.5"	2'-6"	2'-5"	2'-3.5"	2'-3.5"	2'-4"	2'-4"
C_2 BARS	BAR NO. & SPACING	4@14"	4@14"	4@10"	4@12"	4@11"	4@11"	4@13"	4@13"	4@14"	4@14"	4@14"	4@12"	4@14"	4@12"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	HORIZ. LENGTH, h	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10"	3'-10.5"	3'-10.5"	3'-10.5"	3'-11"
	VERT. LENGTH, v	2'-0"	2'-0.5"	2'-0.5"	2'-1"	2'-1"	2'-1"	2'-1.5"	2'-2"	2'-2.5"	2'-2.5"	2'-3"	2'-3"	2'-3.5"	2'-4"	2'-4.5"	2'-5"	2'-5.5"	2'-6"	2'-6"	2'-6.5"
C_3 BARS	BAR NO. & SPACING	5@14"	5@14"	4@10"	5@12	5@11"	5@11"	6@13"	6@13"	6@14"	6@14"	6@14"	5@12"	6@14"	5@12"	6@14"	6@14"	6@14"	6@14"	6@14"	5@14"
	HORIZ. LENGTH, h	2'-0.5"	1'-10.5"	1'-7.5"	1'-9"	1'-8.5"	1'-9"	1'-10"	1'-9.5"	1'-10.5"	1'-10.5"	1'-10.5"	1'-10"	1'-11"	1'-10.5"	2'-0"	2'-0.5"	2'-1"	2'-1"	2'-1.5"	2'-2"
	VERT. LENGTH, v	2'-0"	2'-0.5"	1'-4.5"	1'-10.5"	1'-10.5"	2'-2"	2'-7"	2'-4"	2'-4.5"	2'-1.5"	2'-2.5"	2'-0"	2'-1"	2'-0"	2'-1"	2'-1"	2'-2"	2'-2"	2'-2"	2'-2.5"
D BARS	BAR NO. & SPACING	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@12"	4@12"	4@12"	4@13"	4@13"	4@13"	4@13"	4@14"	4@14"	4@14"	4@15"	4@15"	4@16"	4@16"
	LENGTH, v	10'-11.5"	10'-11.5"	11'-0.5"	10'-11.5"	10'-11.5"	10'-11.5"	11'-0.5"	11'-1.5"	11'-2.5"	11'-3"	11'-3"	11'-4"	11'-5"	11'-5.5"	11'-6.5"	11'-7.5"	11'-8"	11'-9"	11'-10"	11'-10.5"
F BARS	BAR NO. & SPACING	5@12"	7@19"	6@17"	6@13"	6@10"	8@16"	8@14"	8@15"	9@16"	8@13"	9@16"	9@17"	7@10"	9@15"	9@16"	8@12"	9@14"	9@14"	8@11"	8@11"
	LENGTH, h	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-6.5"	9'-7"	9'-7.5"	9'-7.5"	9'-8"
F_1 BARS	BAR NO. & SPACING	4@12"	8@19"	6@17"	5@13"	4@10"	5@16"	4@14"	5@15"	4@16"	4@13"	4@16"	5@17"	4@10"	4@15"	5@16"	4@12"	4@14"	4@14"	4@11"	4@11"
	LENGTH, h	6'-6"	6'-0"	7'-0.5"	6'-5.5"	5'-8"	5'-6"	5'-0"	5'-8.5"	4'-10.5"	5'-4.5"	5'-0"	5'-8.5"	5'-9"	5'-3"	5'-11.5"	5'-9.5"	5'-4"	5'-6.5"	5'-8"	5'-10.5"
G BARS	BAR NO. & SPACING	5@14"	5@14"	4@10"	4@12"	4@11"	4@11"	4@13"	4@13"	4@14"	4@14"	4@14"	4@12"	4@14"	4@12"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	LENGTH, h	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"
H BARS	BAR NO. & SPACING	4@14"	4@14"	4@10"	4@12"	4@11"	4@11"	4@13"	4@13"	4@14"	4@14"	4@14"	4@12"	4@14"	4@12"	4@14"	4@14"	4@14"	4@14"	4@14"	4@14"
	LENGTH, h	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"	4'-3"
		LONGITUDINAL REINFORCEMENT																			
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	22	22	22	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
	NUMBER IN BOTTOM SLAB	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
	NUMBER IN WALLS	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
	TOTAL NUMBER	61	61	61	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	4
CONCRETE: CU. YDS. PER LIN. FT.		0.96	0.96	0.98	0.95	0.96	0.97	0.99	1.01	1.04	1.06	1.07	1.09	1.12	1.14	1.18	1.21	1.25	1.28	1.32	1.36
STEEL: LBS. PER LIN. FT.		151.7	154.6	154.2	137.9	144.5	148.5	150.4	150.1	149.5	148.5	147.5	148.1	150.6	151.4	152.8	155.1	156.1	157.7	159.3	156.8

HYDRAULIC PROPERTIES (BOX)

n = .013

Area = 83.6 sq. ft.

$K = Q/S^{\frac{1}{2}} = \frac{1.486}{n} AR^{\frac{2}{3}} = 16{,}726$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

BOX SIZE: W = 8'-10", H = 10'-6" DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 126"

		DEPTH OF COVER IN FEET																			
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS, t_1		7.75	7.75	8.00	6.75	6.75	7.25	7.50	8.00	8.50	9.00	8.75	9.25	9.75	10.00	10.50	11.00	11.25	11.75	12.25	12.75
SIDE WALL THICKNESS, t_2		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.25	8.50	8.75	9.00	9.00	9.25
BOTTOM SLAB THICKNESS, t_3		7.25	7.50	7.75	8.00	8.25	8.50	8.50	9.00	9.50	10.00	10.00	10.50	11.00	11.50	12.00	12.50	12.75	13.25	13.75	14.00
		TRANSVERSE REINFORCEMENT																			
B BARS	BAR NO. & SPACING	9 #12"	9 #14"	9 #14"	7 #15"	7 #13"	6 #10"	7 #12"	8 #16"	8 #9"	8 #15"	8 #16"	8 #14"	8 #15"	8 #13"	9 #17"	7 #10"	9 #15"	8 #12"	9 #15"	9 #15"
	LENGTH, h	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11.5"	10'-00"	10'-0.5"	10'-1"	10'-1"	10'-1.5"
B_1 BARS	BAR NO. & SPACING		4 #14"	4 #14"	5 #15"	4 #13"	4 #10"	4 #12"	5 #16"	4 #9"	5 #15"	5 #16"	4 #14"	5 #15"	4 #13"	5 #17"	4 #10"	4 #15"	4 #12"	5 #15"	5 #15"
	LENGTH, h		2'-11"	3'-0.5"	5'-5"	4'-11.5"	5'-5.5"	5'-1"	5'-5.5"	5'-8"	5'-7.5"	5'-7"	5'-1.5"	5'-9.5"	5'-2"	5'-8"	5'-9"	5'-2"	5'-6"	5'-8"	5'-10.5"
C BARS	BAR NO. & SPACING	4 #9"	4 #9"	4 #10"	4 #10"	4 #10"	4 #12"	4 #12"	4 #13"	4 #13"	4 #13"	4 #13"	4 #14"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"
	HORIZ. LENGTH, h	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11.5"	3'-11.5"	4'-0"	4'-0"	4'-0"	4'-0.5"
	VERT. LENGTH, v	10'-7"	10'-7"	10'-7"	10'-6"	10'-6"	10'-6.5"	10'-6.5"	10'-7"	10'-7.5"	10'-8"	10'-8"	10'-8.5"	10'-9"	10'-9"	10'-9.5"	10'-10"	10'-10.5"	10'-11"	10'-11.5"	11'-0"
C_1 BARS	BAR NO. & SPACING	4 #9"	4 #9"	4 #10"	5 #10"	5 #10"	6 #12"	6 #12"	8 #13"	6 #13"	6 #13"	6 #13"	6 #14"	6 #13"	6 #13"	6 #13"	6 #13"	6 #13"	6 #13"	6 #13"	6 #13"
	HORIZ. LENGTH, h	1'-9"	1'-8.5"	1'-9.5"	1'-9.5"	1'-9.5"	1'-10.5"	1'-10"	1'-10"	1'-10"	1'-10"	1'-10"	1'-10.5"	1'-10.5"	1'-11"	1'-11.5"	2'-0"	2'-0.5"	2'-1"	2'-1.5"	2'-2"
	VERT. LENGTH, v	2'-0"	2'-2"	3'-6"	2'-8.5"	2'-6.5"	2'-11.5"	2'-8"	2'-8"	2'-7"	2'-7"	2'-6.5"	2'-8.5"	2'-6.5"	2'-7"	2'-7"	2'-6"	2'-4.5"	2'-5"	2'-5"	2'-5.5"
C_2 BARS	BAR NO. & SPACING	4 #9"	4 #9"	4 #10"	4 #10"	4 #10"	5 #12"	4 #12"	4 #13"	4 #13"	4 #13"	4 #13"	4 #14"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"
	HORIZ. LENGTH, h	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11"	3'-11.5"	3'-11.5"	4'-0"	4'-0"	4'-0"	4'-0.5"
	VERT. LENGTH, v	2'-0.5"	2'-0.5"	2'-1"	2'-1"	2'-1.5"	2'-1"	2'-1.5"	2'-2"	2'-2.5"	2'-3"	2'-3"	2'-3.5"	2'-4"	2'-4.5"	2'-5"	2'-5.5"	2'-6"	2'-6.5"	2'-7"	2'-7"
C_3 BARS	BAR NO. & SPACING	4 #9"	4 #9"	4 #10"	4 #10"	4 #10"	5 #12"	6 #12"	6 #13"	6 #13"	6 #13"	6 #13"	6 #14"	6 #13"	6 #13"	6 #13"	6 #13"	6 #13"	6 #13"	5 #13"	5 #13"
	HORIZ. LENGTH, h	1'-8.5"	1'-7.5"	1'-9"	1'-9"	1'-9.5"	1'-7.5"	1'-11"	1'-11"	1'-11.5"	1'-11.5"	2'-0"	2'-0.5"	2'-0.5"	2'-1"	2'-1"	2'-1.5"	2'-2"	2'-2.5"	2'-3"	2'-3.5"
	VERT. LENGTH, v	2'-0.5"	2'-0.5"	1'-7"	1'-9"	1'-10"	1'-9"	2'-5"	2'-6"	2'-4"	2'-2"	2'-2"	2'-2.5"	2'-2"	2'-2	2'-2"	2'-2.5"	2'-3"	2'-3.5"	2'-3.5"	2'-3.5"
D BARS	BAR NO. & SPACING	4 #10"	4 #10"	4 #10"	4 # 9"	4 #10"	4 #10"	4 #10"	4 #10"	4 #11"	4 #11"	4 #11"	4 #11"	4 #12"	4 #12"	4 #12"	4 #13"	4 #13"	4 #14"	4 #14"	4 #15"
	LENGTH, v	11'-6"	11'-6"	11'-6.5"	11'-5.5"	11'-6"	11'-6.5"	11'-7"	11'-8"	11'-9"	11'-10"	11'-9.5"	11'-10.0	11'-11.5"	12'-0.5"	12'-1.5"	12'-2.5"	12'-3"	12'-4"	12'-5"	12'-5.5"
F BARS	BAR NO. & SPACING	7 #20"	5 #10"	6 #16"	6 #12"	8 #18"	9 #20"	9 #16"	9 #17"	7 #10"	9 #16"	7 #10"	9 #16"	9 #15"	9 #14"	9 #14"	9 #15"	8 #11"	8 #11"	9 #13"	9 #13"
	LENGTH, h	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11"	9'-11.5"	10'-0"	10'-0.5"	10'-1"	10'-1"	10'-1.5"
F_1 BARS	BAR NO. & SPACING	5 #20"	4 #10"	6 #16"	5 #12"	6 #18"	6 #20"	4 #16"	5 #17"	4 #10"	5 #16"	4 #10"	5 #16"	5 #15"	4 #14"	4 #14"	5 #15"	4 #11"	4 #11"	4 #13"	4 #13"
	LENGTH, h	6'-4"	6'-9"	7'-4.5"	6'-9.5"	6'-4"	6'-0.5"	4'-10.5"	5'-9"	5'-10"	5'-10.5"	5'-11.5"	6'-0"	5'-9.5"	5'-4.5"	5'-7"	6'-4"	6'-0"	6'-2.5"	5'-9"	5'-11.5"
G BARS	BAR NO. & SPACING	4 #9"	4 #9"	4 #10"	4 #10"	4 #10"	4 #12"	4 #12"	4 #13"	4 #13"	4 #13"	4 #13"	4 #14"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"
	LENGTH, h	4'-4.5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"
H BARS	BAR NO. & SPACING	4 #9"	4 #9"	4 #10"	4 #10"	4 #10"	5 #12"	4 #12"	4 #13"	4 #13"	4 #13"	4 #13"	4 #14"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"	4 #13"
	LENGTH, h	4'-4.5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"	4'-5"
		LONGITUDINAL REINFORCEMENT																			
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	23	23	23	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
	NUMBER IN BOTTOM SLAB	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
	NUMBER IN WALLS	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
	TOTAL NUMBER	67	67	67	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
CONCRETE: CU. YDS. PER LIN. FT.		1.01	1.02	1.04	1.00	1.01	1.04	1.04	1.07	1.11	1.14	1.13	1.16	1.19	1.22	1.27	1.32	1.35	1.40	1.44	1.48
STEEL: LBS. PER LIN. FT.		170.3	169.0	166.8	159.8	160.6	167.8	169.6	166.2	165.9	167.6	165.2	164.4	168.7	170.9	171.9	172.4	174.8	175.2	174.4	174.5

HYDRAULIC PROPERTIES (BOX)

n = .013

Area = 92.1 sq ft.

$K = Q/S^{\frac{1}{2}} = \frac{1.486}{n} AR^{\frac{2}{3}} = 19026$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

BOX SIZE: W = 9'-2", H = 11'-0" DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 132"

		DEPTH OF COVER IN FEET																		
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS, t_1		8.00	8.00	8.00	7.00	7.50	7.50	7.75	8.25	8.75	9.25	9.00	9.50	10.00	10.25	10.75	11.25	11.75	12.25	12.50	13.00
SIDE WALL THICKNESS, t_2		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.25	8.50	8.75	9.00	9.25	9.25	9.50
BOTTOM SLAB THICKNESS, t_3		7.50	7.75	8.50	8.25	8.50	8.75	9.00	9.25	9.75	10.25	10.25	10.75	11.25	11.75	12.50	13.00	13.25	13.75	14.00	14.50
		TRANSVERSE REINFORCEMENT																			
B BARS	BAR NO. & SPACING	9@13"	8@11"	9@13"	8@19"	8@19"	7@16"	6@9"	8@15"	8@15"	9@16"	8@15"	9@19"	8@13"	7@10"	7@10"	9@16"	9@15"	9@15"	9@14"	8@11"
	LENGTH, h	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-4.0"	10'-4.5"	10'-5.0"	10'-5.5"	10'-6.0"	10'-6.0"
B_1 BARS	BAR NO. & SPACING	4@13"	4@11"	4@13"	6@19"	6@19"	4@12"	4@9"	5@15"	5@15"	4@16"	5@15"	6@19"	4@15"	4@10"	4@10"	5@16"	5@15"	5@15"	4@14"	4@11"
	LENGTH, h	2'-6.5"	3'-2.5"	2'-11.5"	5'-9"	5'-11.5"	5'-4"	5'-7.5"	5'-7.0"	5'-10"	4'-11"	5'-8.5"	6'-0"	5'-4.5"	5'-8.5"	5'-11"	5'-11"	5'-8"	5'-11"	5'-6.0"	5'-8.5"
C BARS	BAR NO. & SPACING	4@9"	4@9"	5@13"	4@10"	4@11"	4@12"	4@12"	4@12"	4@12"	4@11"	4@11"	4@13"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"
	HORIZ. LENGTH, h	4'-0"	4'-0"	4'-4"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0.5"	4'-0.5"	4'-1.0"	4'-1.0"	4'-1.5"	4'-1.5"	4'-1.5"
	VERT. LENGTH, v	11'-1.0"	11'-1.0"	11'-1.0"	11'-0"	11'-0.5"	11'-0.5"	11'-1.0"	11'-1.5"	11'-2.0"	11'-2.5"	11'-2.0"	11'-2.5"	11'-3.0"	11'-3.5"	11'-4.0"	11'-4.5"	11'-5.0"	11'-5.5"	11'-5.5"	11'-6.0"
C_1 BARS	BAR NO. & SPACING	4@9"	4@9"	5@13"	5@10"	5@11"	6@12"	6@12"	6@12"	6@12"	5@11"	6@13"	6@12"	6@12"	6@12"	6@12"	6@12"	6@12"	6@12"	6@12"	6@12"
	HORIZ. LENGTH, h	1'-10.0"	1'-9.5"	1'-10"	1'-10.5"	1'-10.5"	1'-11"	1'-11.0"	1'-10.5"	1'-10.5"	1'-10.5"	1'-11.0"	1'-11.0"	1'-11.5"	1'-11.5"	2'-0.5"	2'-1.0"	2'-1.5"	2'-2.0"	2'-2.5"	2'-3.0"
	VERT. LENGTH, v	2'-1.0"	2'-2"	2'-10"	3'-0"	2'-8.0"	3'-1"	2'-10.0"	2'-7.5"	2'-7"	2'-5.0"	2'-9.0"	2'-7.0"	2'-7.0"	2'-7.5"	2'-7.0"	2'-6.0"	2'-6.0"	2'-6.0"	2'-6.0"	2'-6.5"
C_2 BARS	BAR NO. & SPACING	4@9"	4@9"	4@13"	4@10"	4@11"	5@12"	4@12"	4@12"	4@12"	4@11"	4@13"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"
	HORIZ. LENGTH, h	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-4"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0"	4'-0.5"	4'-0.5"	4'-1.0"	4'-1.0"	4'-1.5"	4'-1.5"	4'-1.5"
	VERT. LENGTH, v	2'-0.5"	2'-1"	2'-1.5"	2'-1.5"	2'-1.5"	2'-2"	2'-2.0"	2'-2.5"	2'-3.0"	2'-3.5"	2'-3.5"	2'-4.0"	2'-4.5"	2'-5.0"	2'-5.5"	2'-6.0"	2'-6.5"	2'-7.0"	2'-7.0"	2'-7.5"
C_3 BARS	BAR NO. & SPACING	4@9"	4@9"	5@13"	4@10"	5@11"	5@12"	6@12"	6@12"	6@12"	5@11"	6@13"	6@12"	6@12"	6@12"	6@12"	6@12"	6@12"	6@12"	5@12"	5@12"
	HORIZ. LENGTH, h	1'-10"	1'-9"	2'-4"	1'-11.0"	1'-11.5"	1'-8.5"	2'-0.5"	2'-0"	2'-0.5"	2'-0"	2'-2.5"	2'-1.0"	2'-1.5"	2'-1.5"	2'-2.5"	2'-3.0"	2'-3.0"	2'-4.0"	2'-4.0"	2'-4.5"
	VERT. LENGTH, v	2'-0.5"	2'-1"	2'-6.5"	1'-10.5"	2'-1.0"	1'-10.5"	2'-6.5"	2'-4.5"	2'-2.5"	2'-2"	2'-3.0"	2'-2.5"	2'-2.5"	2'-2.5"	2'-3.5"	2'-3.5"	2'-4.0"	2'-4.5"	2'-4.5"	2'-5.0"
D BARS	BAR NO. & SPACING	4@8"	4@8"	4@9"	4@8"	4@9"	4@9"	4@8"	4@9"	4@9"	4@10"	4@10"	4@10"	4@10"	4@11"	4@11"	4@12"	4@12"	4@13"	4@13"	4@13"
	LENGTH, v	12'-0.5"	12'-0.5"	12'-1"	12'-0"	12'-1.0"	12'-1"	12'-1.5"	12'-2.5"	12'-3.5"	12'-4.5"	12'-4"	12'-5.5"	12'-6.5"	12'-7.0"	12'-8.0"	12'-9.0"	12'-10.0"	12'-11.0"	12'-11.5"	13'-0.5"
F BARS	BAR NO. & SPACING	7@19"	6@14"	7@16"	6@11"	7@13"	8@13"	7@10"	9@16"	9@15"	9@15"	9@15"	9@15"	9@15"	7@9"	8@11"	8@11"	9@13"	8@10"	8@10"	8@10"
	LENGTH, h	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-3.5"	10'-4.0"	10'-4.5"	10'-5.0"	10'-5.5"	10'-6.0"	10'-6.0"
F_1 BARS	BAR NO. & SPACING	5@19"	5@14"	5@16"	5@11"	5@13"	4@13"	4@10"	5@16"	5@15"	5@18"	5@15"	5@15"	5@15"	4@9"	4@11"	4@11"	4@13"	4@10"	4@10"	4@10"
	LENGTH, h	6'-7.5"	7'-2"	6'-10.5"	6'-11.5"	6'-6.5"	5'-5.5"	5'-10"	5'-10.5"	5'-9"	5'-11"	5'-10"	6'-1.0"	6'-3.0"	6'-4.5"	6'-1.5"	6'-4.0"	5'-11.0"	5'-10.5"	5'-0.5"	6'-3.0"
G BARS	BAR NO. & SPACING	4@9"	4@9"	5@13"	4@10"	4@11"	4@12"	4@12"	4@12"	4@12"	4@11"	4@13"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"
	LENGTH, h	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"
H BARS	BAR NO. & SPACING	4@9"	4@9"	4@13"	4@10"	4@11"	4@12"	4@12"	4@12"	4@12"	4@11"	4@13"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"	4@12"
	LENGTH, h	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"	4'-7.5"
		LONGITUDINAL REINFORCEMENT																			
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	25	24	24	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
	NUMBER IN BOTTOM SLAB	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
	NUMBER IN WALLS	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
	TOTAL NUMBER	69	68	68	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
CONCRETE: CU. YDS. PER LIN. FT.		1.07	1.08	1.10	1.06	1.09	1.09	1.11	1.13	1.17	1.20	1.19	1.22	1.26	1.30	1.36	1.41	1.46	1.51	1.53	1.58
STEEL: LBS. PER LIN. FT.		179.6	181.0	184.3	170.8	167.1	176.6	179.5	180.1	181.9	178.1	176.4	181.5	183.0	183.9	185.6	185.6	189.3	191.1	187.6	189.8

HYDRAULIC PROPERTIES (BOX)

n = .013

Area = 100.3 sq.ft.

$K = Q/S^{\frac{1}{2}} = \frac{1.486}{n} AR^{\frac{2}{3}} = 21,303$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

BOX SIZE: W = 9'-7", H = 11'-6" DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 138"

		DEPTH OF COVER IN FEET																			
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS, t_1		8.25	8.25	8.25	7.25	7.75	7.50	8.00	8.50	9.00	9.50	9.25	9.75	10.50	10.75	11.25	11.75	12.25	12.75	13.00	13.50
SIDE WALL THICKNESS, t_2		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.25	8.25	8.50	8.75	9.00	9.25	9.50	9.75	10.00
BOTTOM SLAB THICKNESS, t_3		7.75	8.00	8.25	8.50	8.75	9.00	9.25	9.50	10.00	10.50	10.50	11.25	11.75	12.25	13.00	13.50	14.00	14.25	14.75	15.25
		TRANSVERSE REINFORCEMENT																			
B BARS	BAR NO. & SPACING	8 @ 11"	8 @ 11"	8 @ 11"	8 @ 18"	8 @ 18"	6 @ 9"	9 @ 19"	9 @ 17"	8 @ 14"	7 @ 10"	8 @ 13"	8 @ 14"	7 @ 10"	9 @ 16"	9 @ 15"	9 @ 15"	9 @ 15"	8 @ 11"	8 @ 11"	9 @ 15"
	LENGTH, h	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8.5"	10'-9"	10'-9.5"	10'-10"	10'-10.5"	10'-11"	10'-11.5"	10'-11.5"
B_1 BARS	BAR NO. & SPACING	4 @ 11"	4 @ 11"	4 @ 11"	6 @ 18"	6 @ 18"	4 @ 9"	6 @ 19"	5 @ 17"	5 @ 14"	4 @ 10"	4 @ 13"	5 @ 14"	4 @ 10"	5 @ 16"	5 @ 15"	5 @ 15"	5 @ 15"	4 @ 11"	4 @ 11"	4 @ 13"
	LENGTH, h	3'-5"	3'-7.5"	3'-9"	6'-0.5"	6'-3"	5'-10.5"	5'-10.5"	5'-6.5"	6'-0"	5'-10.5"	5'-4.5"	6'-2"	6'-0.5"	6'-0.5"	5'-9.5"	6'-0.5"	6'-3"	5'-11"	6'-1.5"	5'-8.5"
C BARS	BAR NO. & SPACING	4 @ 9"	4 @ 9"	4 @ 9"	4 @ 10"	4 @ 10"	4 @ 11"	4 @ 11"	4 @ 10"	4 @ 12"	4 @ 10"	4 @ 12"	4 @ 10"	4 @ 10"	4 @ 11"	4 @ 11"	4 @ 11"	4 @ 10"	4 @ 10"	4 @ 12"	4 @ 12"
	HORIZ. LENGTH, h	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-2"	4'-2"	4'-2.5"	4'-2.5"	4'-3"	4'-3"	4'-3.5"
	VERT. LENGTH, v	11'-7.5"	11'-7.5"	11'-7.5"	11'-6.5"	11'-7"	11'-6.5"	11'-7"	11'-7.5"	11'-8"	11'-8.5"	11'-8.5"	11'-9"	11'-9.5"	11'-10"	11'-10.5"	11'-11"	11'-11.5"	12'-0"	12'-0"	12'-0.5"
C_1 BARS	BAR NO. & SPACING	4 @ 9"	4 @ 9"	4 @ 9"	5 @ 10"	5 @ 10"	6 @ 11"	6 @ 11"	5 @ 10"	6 @ 12"	5 @ 10"	6 @ 12"	5 @ 10"	5 @ 10"	6 @ 11"	6 @ 11"	6 @ 11"	5 @ 10"	5 @ 10"	6 @ 12"	6 @ 12"
	HORIZ. LENGTH, h	1'-11.5"	1'-10.5"	1'-10.5"	1'-11.5"	1'-11"	2'-0"	1'-11.5"	1'-11"	1'-11.5"	1'-11"	1'-11.5"	1'-11"	2'-0"	2'-1"	2'-1.5"	2'-2"	2'-2"	2'-2.5"	2'-4"	2'-4.5"
	VERT. LENGTH, v	2'-1.5"	2'-3"	2'-5"	3'-4"	2'-4"	3'-1"	2'-9.5"	2'-5.5"	2'-9.5"	2'-5.5"	2'-9.5"	2'-5"	2'-4.5"	2'-8"	2'-7.5"	2'-6.5"	2'-6.5"	2'-6.5"	2'-8"	2'-8.5"
C_2 BARS	BAR NO. & SPACING	4@9"	4@9"	4@9"	4@10"	4@10"	4@11"	4@11"	4@10"	4@12"	4@10"	4@12"	4@10"	4@10"	4@11"	4@11"	4@11"	4@10"	4@10"	4@12"	4@12"
	HORIZ. LENGTH, h	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-1.5"	4'-2"	4'-2"	4'-2.5"	4'-2.5"	4'-3"	4'-3"	4'-3.5"
	VERT. LENGTH, v	2'-1"	2'-1"	2'-1.5"	2'-1.5"	2'-2"	2'-2"	2'-2.5"	2'-2.5"	2'-3"	2'-3.5"	2'-3.5"	2'-4.5"	2'-5"	2'-5.5"	2'-6"	2'-6.5"	2'-7"	2'-7.5"	2'-8"	2'-8.5"
C_3 BARS	BAR NO. & SPACING	4 @ 9"	4 @ 9"	4 @ 9"	5 @ 10"	5 @ 10"	5 @ 11"	6 @ 11"	5 @ 10"	6 @ 12"	5 @ 10"	6 @ 12"	5 @ 10"	5 @ 10"	6 @ 11"	6 @ 11"	5 @ 11"	5 @ 10"	5 @ 10"	6 @ 12"	6 @ 12"
	HORIZ. LENGTH, h	2'-0"	1'-11"	1'-11.5"	2'-1"	2'-0.5"	2'-4"	2'-3"	2'-0.5"	2'-5.5"	2'-1"	2'-5"	2'-1.5"	2'-1.5"	2'-3"	2'-3.5"	2'-4"	2'-3.5"	2'-4"	2'-6"	2'-6.5"
	VERT. LENGTH, v	2'-1"	1'-6.5"	1'-8.5"	1'-11.5"	2'-1"	2'-2.5"	2'-3.5"	2'-2"	2'-3.5"	2'-2"	2'-3.5"	2'-2.5"	2'-3"	2'-4"	2'-4.5"	2'-4.5"	2'-4.5"	2'-5"	2'-6.5"	2'-7"
D BARS	BAR NO. & SPACING	5 @ 12"	5 @ 12"	4 @ 8"	5 @ 12"	4 @ 8"	4 @ 8"	4 @ 8"	4 @ 8"	4 @ 8"	4 @ 9"	4 @ 8"	4 @ 9"	4 @ 9"	4 @ 10"	4 @ 10"	4 @ 11"	4 @ 11"	4 @ 11"	4 @ 12"	4 @ 12"
	LENGTH, v	12'-7"	12'-7"	12'-7.5"	12'-7"	12'-7.5"	12'-7.5"	12'-8.5"	12'-9"	12'-10"	12'-11"	12'-11"	13'-0"	13'-1"	13'-2"	13'-3"	13'-4"	13'-5"	13'-6"	13'-7"	13'-7.5"
F BARS	BAR NO. & SPACING	5 @ 10"	7 @ 16"	5 @ 10"	7 @ 13"	7 @ 12"	9 @ 18"	8 @ 13"	9 @ 15"	7 @ 9"	8 @ 11"	7 @ 9"	8 @ 11"	9 @ 14"	9 @ 14"	8 @ 10"	8 @ 10"	8 @ 10"	8 @ 10"	9 @ 12"	9 @ 12"
	LENGTH, h	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8"	10'-8.5"	10'-9"	10'-9.5"	10'-10"	10'-10.5"	10'-11"	10'-11.5"	10'-11.5"
F_1 BARS	BAR NO. & SPACING	4 @ 10"	5 @ 16"	5 @ 10"	5 @ 13"	5 @ 12"	6 @ 18"	5 @ 13"	5 @ 15"	4 @ 9"	4 @ 11"	4 @ 9"	4 @ 11"	5 @ 14"	5 @ 14"	4 @ 10"	4 @ 10"	4 @ 10"	4 @ 10"	4 @ 12"	4 @ 12"
	LENGTH, h	7'-5.5"	6'-10.5"	8'-1"	6'-10.5"	6'-9"	6'-7"	6'-4.5"	6'-1"	6'-3.5"	6'-1"	6'-4.5"	6'-2.5"	6'-5"	6'-7"	5'-10.5"	6'-1"	6'-3"	6'-7.5"	6'-3"	6'-6"
G BARS	BAR NO. & SPACING	4 @ 9"	4 @ 9"	4 @ 9"	4 @ 10"	4 @ 10"	4 @ 11"	4 @ 11"	4 @ 10"	4 @ 12"	4 @ 10"	4 @ 12"	4 @ 10"	4 @ 10"	4 @ 11"	4 @ 11"	4 @ 11"	4 @ 10"	4 @ 10"	4 @ 12"	4 @ 12"
	LENGTH, h	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"
H BARS	BAR NO. & SPACING	4 @ 9"	4 @ 9"	4 @ 9"	4 @ 10"	4 @ 10"	5 @ 11"	4 @ 11"	4 @ 10"	4 @ 12"	4 @ 10"	4 @ 12"	4 @ 10"	4 @ 10"	4 @ 11"	4 @ 11"	4 @ 10"	4 @ 10"	4 @ 10"	4 @ 12"	4 @ 12"
	LENGTH, h	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"	4'-9.5"
		LONGITUDINAL REINFORCEMENT																			
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	25	25	25	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
	NUMBER IN BOTTOM SLAB	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
	NUMBER IN WALLS	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
	TOTAL NUMBER	70	70	70	62	62	64	62	62	62	62	62	62	62	62	62	62	62	62	62	62
CONCRETE: CU. YDS. PER LIN. FT.		1.13	1.14	1.15	1.12	1.15	1.15	1.17	1.20	1.23	1.27	1.26	1.32	1.36	1.41	1.47	1.53	1.58	1.63	1.68	1.73
STEEL: LBS. PER LIN. FT.		187.8	189.4	190.9	185.3	184.4	189.7	197.0	194.7	196.0	195.5	196.0	195.2	198.0	201.5	206.5	201.0	203.1	205.6	204.3	206.8

HYDRAULIC PROPERTIES (BOX)

n = .013

Area = 109.5 sq ft.

$K = Q/S^{\frac{1}{2}} = \frac{1.486}{n} AR^{\frac{2}{3}} = 23,954$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

BOX SIZE: W = 10'-0", H = 12'-0" DIAMETER OF HYDRAULICALLY EQUIVALENT PIPE = 144"

		DEPTH OF COVER IN FEET																			
		1	2	2'-11"	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TOP SLAB THICKNESS,	t_1	8.50	8.50	8.50	7.50	7.50	7.75	8.25	8.75	9.25	9.75	9.50	10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.50	14.00
SIDE WALL THICKNESS,	t_2	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.25	8.25	8.50	8.75	8.75	9.00	9.25	9.50	9.75	10.00	10.25
BOTTOM SLAB THICKNESS,	t_3	8.00	8.25	8.50	9.00	9.25	9.25	9.50	10.00	10.50	11.00	11.00	11.50	12.25	12.75	13.50	13.50	14.50	14.75	1525	15.50
		TRANSVERSE REINFORCEMENT																			
B BARS	BAR NO. & SPACING	9 @14"	9 @14"	9 @14"	6@9"	7 @ 12"	9@17"	7@10"	7@10"	8@13"	9 @15"	7@10"	9@16"	8@13"	9@15"	9 @15"	8 @11"	9 @14"	9 @13"	8 @10"	8 @10"
	LENGTH, h	11'-1"	11'-1"	11'-1"	11'-1"	11'-1"	11'-1"	11'-1"	11'-1"	11'-1"	11'-1.5"	11'-1.5"	11'-2"	11'-2.5"	11'-2.5"	11'-3"	11'-3.5"	11'-4"	11'-4.5"	11'-5"	11'-5.5"
B_1 BARS	BAR NO. & SPACING	5@14"	5@14"	5@14"	4 9"	5@12"	5@17"	4@10"	4@10"	5@13"	5@15"	4@10"	5@16"	5@13"	5@15"	5@15"	4@11"	5@14"	4@13"	4@10"	4@10"
	LENGTH, h	3'-10"	4'-0.5"	4'-2.5"	6'-1"	6'-1.5"	5'-6"	5'-9.5"	5'-11.5"	6'-2"	5'-9"	6'-0.5"	6'-1.5"	6'-6.5"	6'-1"	6'-5"	6'-0"	6'-4"	5'-11"	5'-10.5"	6'-1.5"
C BARS	BAR NO. & SPACING	4@9"	4@9"	4@9"	5@14"	4@9"	4@9"	4@9"	4@11"	4@11"	4@9"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"
	HORIZ. LENGTH, h	4'-2.5"	4'-2.5"	4'-2.5"	4'-6"	4'-2.5"	4'-2.5"	4'-2.5"	4'-2.5"	4'-2.5"	4'-3"	4'-3"	4'-3"	4'-3.5"	4'-3.5"	4'-3.5"	4'-4"	4'-4"	4'-4.5"	4'-4.5"	4'-5"
	VERT. LENGTH, v	12'-1.5"	12'-1.5"	12'-1.5"	12'-0.5"	12'-0.5"	12'-1"	12'-1.5"	12'-2"	12'-2.5"	12'-3"	12'-2.5"	12'-3.5"	12'-4"	12'-4.5"	12'-5"	12'-5.5"	12'-6"	12'-6.5"	12'-6.5"	12'-7"
C_1 BARS	BAR NO. & SPACING	4@9"	4@9"	4@9"	6@14"	5@9"	5@9"	5@9"	6@11"	6@11"	5@9"	6@11"	6@11"	6@11"	6@11"	6@11"	6@11"	6@11"	6@11"	6@11"	6@11"
	HORIZ. LENGTH, h	2'-1"	1'-11.5"	2'-0"	1'-11.5"	2'-0"	2'-0"	2'-0"	2'-0.5"	2'-0.5"	1'-11.5"	2'-0.5"	2'-1.5"	2'-2"	2'-2.5"	2'-3"	2'-3.5"	2'-4"	2'-5"	2'-5"	2'-6"
	VERT. LENGTH, v	2'-2.5"	2'-11"	2'-9.5"	2'-10.5"	2'-11"	2'-7"	2'-6.5"	2'-10"	2'-10"	2'-5.5"	2'-10"	2'-10.5"	2'-10"	2'-9.5"	2'-10.5"	2'-10"	2'-9"	2'-9"	2'-9.5"	2'-9.5"
C_2 BARS	BAR NO. & SPACING	4@9"	4@9"	4@9"	5@14"	4@9"	4@9"	4@9"	4@11"	4@11"	4@9"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"
	HORIZ. LENGTH, h	4'-2.5"	4'-2.5"	4'-2.5"	4'-6"	4'-2.5"	4'-2.5"	4'-2.5"	4'-2.5"	4'-2.5"	4'-3"	4'-3"	4'-3"	4'-3.5"	4'-3.5"	4'-3.5"	4'-4"	4'-4"	4'-4.5"	4'-4.5"	4'-5"
	VERT. LENGTH, v	2'-1"	2'-1.5"	2'-1.5"	2'-6"	2'-2.5"	2'-2.5"	2'-2.5"	2'-3"	2'-3.5"	2'-4"	2'-4"	2'-4.5"	2'-5.5"	2'-6"	2'-6.5"	2'-7"	2'-7.5"	2'-8"	2'-8.5"	2'-9"
C_3 BARS	BAR NO. & SPACING	4@9"	4@9"	4@9"	5@14"	5@9"	5@9"	5@9"	6@11"	6@11"	5@9"	6@11"	6@11"	6@11"	6@11"	6@11"	6@11"	6@11"	6@11"	6@11"	6@11"
	HORIZ. LENGTH, h	2'-2.5"	2'-1.5"	2'-1.5"	2'-1.5"	2'-1.5"	2'-1.5"	2'-1.5"	2'-8.5"	2'-8"	2'-2"	2'-8"	2'-5.5"	2'-4.5"	2'-5"	2'-5.5"	2'-6"	2'-6.5"	2'-6.5"	2'-7.5"	2'-7.5"
	VERT. LENGTH, v	2'-1"	1'-8.5"	1'-10"	2'-1"	2'-0.5"	2'-1"	2'-3.5"	2'-4"	2'-4"	2'-3"	2'-4.5"	2'-5"	2'-5.5"	2'-5.5"	2'-6"	2'-6.5	2'-6.5"	2'-7.5"	2'-7.5"	2'-8"
D BARS	BAR NO. & SPACING	5@10"	5@11"	5@11"	5@10"	5@11"	5@11"	5@11"	5@11"	5@12"	4@8"	4@8"	4@8"	4@8"	4@8"	4@9"	4@9"	4@10"	4@10"	4@10"	4@11"	4@11"
	LENGTH, v	13'-1.5"	13'-1.5"	13'-2"	13'-1.5"	13'-1.5"	13'-2"	13'-2"	13'-3.5"	13'-4.5"	13'-6"	13'-5.5"	13'-7"	13'-8"	13'-9"	13'-10"	13'-11"	14'-0"	14'-1"	14'-2"	14'-3"
F BARS	BAR NO. & SPACING	6@12"	7@20"	7@14"	7@12"	6@8"	9@17"	9@14"	9@14"	9@14"	8@10"	9@14"	8@11"	8@10"	8@10"	8 @10"	8 @10"	9@12"	9@12"	9@12"	8@9"
	LENGTH, h	11'-1"	11'-1"	11'-1"	11'-1"	11'-1"	11'-1"	11'-1"	11'-1"	11'-1"	11'-1.5"	11'-1.5"	11'-2"	11'-2.5"	11'-2.5"	11'-3"	11'-3.5"	11'-4"	11'-4.5"	11'-5"	11'-5.5"
F_1 BARS	BAR NO. & SPACING	4@12"	7@20"	5@14"	5@12"	4@8"	6@17"	5@14"	5@14"	5@14"	4@10"	5@14"	5@11"	4@10"	4@10"	4@10"	4@10"	4@12"	5@12"	5@12"	4@9"
	LENGTH, h	7'-1"	8'-5.5"	7'-3"	7'-1.5"	6'-11.5"	6'-10.5"	6'-1.5"	6'-3.5"	6'-6.5"	5'-10.5"	6'-7.5"	6'-9"	6'-2"	6'-4.5"	6'-8"	6'-10.5"	6'-5.5"	6'-9.5"	7'-0.5"	6'-8"
G BARS	BAR NO. & SPACING	4@9"	4@9"	4@9"	5@14"	4@9"	4@9"	4@9"	4@11"	4@11"	4@9"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"
	LENGTH, h	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"
H BARS	BAR NO. & SPACING	4 @ 9"	4 @ 9"	4 @ 9"	5@14"	4@9"	4@9"	4@9"	4@11"	4@11"	4@9"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"	4@11"
	LENGTH, h	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"
		LONGITUDINAL REINFORCEMENT																			
NO. 4 LONG. BARS	NUMBER IN TOP SLAB	26	26	26	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
	NUMBER IN BOTTOM SLAB	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
	NUMBER IN WALLS	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
	TOTAL NUMBER	75	75	75	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66
CONCRETE: CU. YDS. PER LIN. FT.		1.19	1.20	1.21	1.19	1.20	1.21	1.24	1.27	1.31	1.36	1.36	1.42	1.49	1.52	1.59	1.64	1.70	1.75	1.80	1.86
STEEL: LBS. PER LIN. FT.		204.2	204.3	206.5	205.6	209.3	211.9	217.7	217.1	216.2	220.5	214.3	217.5	219.3	218.4	220.3	220.1	222.7	225.9	228.0	229.9

HYDRAULIC PROPERTIES (BOX)

n = .013

Area = 119.4 sq. ft.

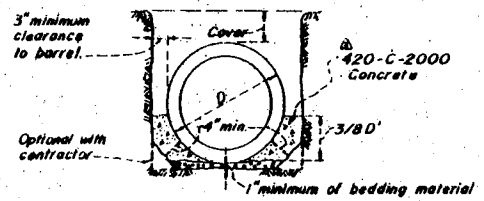
$K = Q/S^{\frac{1}{2}} = \frac{1.486}{n} AR^{\frac{2}{3}} = 26,849$

DESIGN TABLE

FOR STANDARD

R.C. BOX CONDUIT

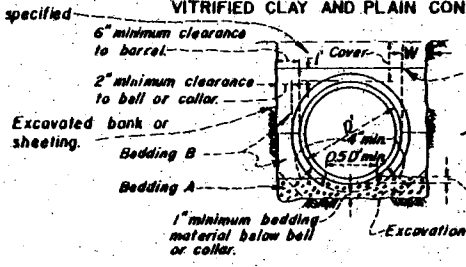
CASE I



1. CASE I BEDDING (Load Factor 2.1)

shall be used where specified on plans or where required as an alternative to Case II or Case III Bedding as provided herein. Case IV Bedding shall be used instead of Case I against sheeting or unstable trench sides if so required by the Engineer.

CASE II
VITRIFIED CLAY AND PLAIN CONCRETE PIPE



○ Top of Bedding B unless otherwise noted in the Specifications.

Screed Bedding A to fit curvature and grade of pipe. Type of screed and the method of use to be approved by the Engineer.

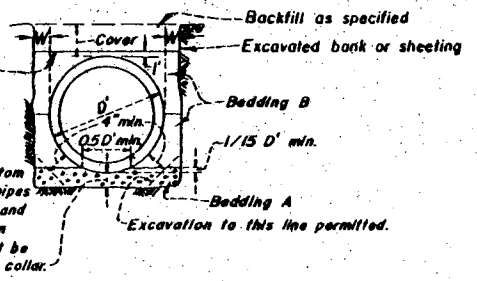
2. CASE II BEDDING & BACKFILL AROUND PIPE (Load Factor 1.8)

● (a) "W" at springing line shall not be less than 6" for any depth of trench. This dimension may include the thickness of any sheeting.

(b) Where cover is 8' or less, "W" measured at top of pipe may be any dimension greater than 6".

(c) Where cover is greater than 8', "W" measured at top of pipe shall not be greater than 8" unless the contractor at his own expense provides Case I bedding or stronger pipe. The stated 8" includes the thickness of any sheeting.

CASE III
REINFORCED CONCRETE PIPE



Bedding material below bottom of pipe shall be 1/12 D' for pipes 39" and larger in diameter, and 4" for pipes less than 39" in diameter. In no case shall it be less than 1" below any bell or collar.

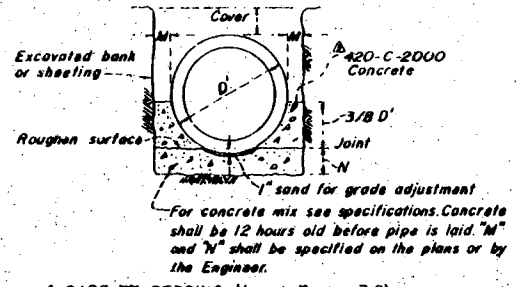
3. CASE III BEDDING & BACKFILL AROUND PIPE (Load Factor 1.8)

● (a) "W" at springing line shall not be less than the following: 6" for pipe 60" or less in diameter, 10" for pipe 63" to 108" inclusive in diameter, and 12" for pipe larger than 108" in diameter. These dimensions may include the thickness of any sheeting.

*(b) Where cover is 10' or less, "W" measured at the top of the pipe may be any dimension greater than the above specified minimum, unless otherwise specified on the project drawing.

*(c) Where cover is greater than 10' "W" measured at the top of the pipe shall not be greater than 10" for pipe 108" in diameter or less, or 12" for pipe over 108" in diameter unless the contractor at his own expense provides Case I bedding or stronger pipe. These dimensions include the thickness of any sheeting.

CASE IV

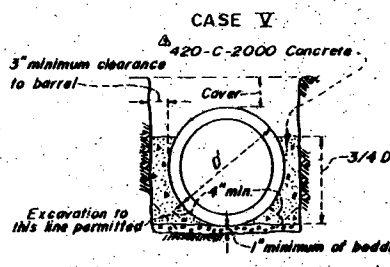


For concrete mix see specifications. Concrete shall be 12 hours old before pipe is laid. "N" and "W" shall be specified on the plans or by the Engineer.

4. CASE IV BEDDING (Load Factor 3.0)

Where required by the Engineer as an alternative to Case I or Case V to meet conditions arising during construction.

CASE V



5. CASE V BEDDING (Load Factor 2.7)

shall be used where specified on the plans. Case IV Bedding shall be used instead of Case V against sheeting or unstable trench walls if so required by the Engineer.

3-Edge Bearing Test Load Factor 1.0

GENERAL NOTES

1. Use Case III for R.C.P. and A.C.P., Case II for vitrified clay and plain concrete pipe unless otherwise specified or shown on the project drawings.

△2. Bedding A shall be composed of sand, 3/4-inch or 1/2-inch crushed rock, No. 3 or No. 4 concrete aggregate or gravel, or other granular material as specified, unless otherwise approved by the Engineer. Any of the materials listed with a gradation no coarser than that of No. 3 concrete aggregate shall be used for pipe 27 inches in diameter and larger, and materials with a gradation no coarser than that of 1/2-inch crushed rock shall be used for pipe smaller than 27 inches in diameter.

Bedding B shall be composed of sand or other granular material as specified, unless otherwise approved by the Engineer, and shall be completed prior to placing balance of backfill.

3. Concrete backfill, where called for on Std. Dwg. 2-D213 or where specified on the project drawings, shall be △420-C-2000 concrete poured wall to wall of trench from top of Bedding A to a minimum depth of 4" over top of pipe. △Concrete backfill shall be used for R.C.P. and A.C.P. as required on Std. Dwg. No. 2-D213.

GENERAL NOTES (CONT'D)

○ 4. Bedding B shall contain no rocks larger than 4-inch in greatest dimension

○ 5. Where rocks are included in the bedding, "nesting" thereof will not be permitted.

SUPERSEDES 2-D148

REFERENCES	REVISIONS			LOS ANGELES COUNTY FLOOD CONTROL DISTRICT
2-D213	MARK	DATE	DESCRIPTION	PIPE BEDDING IN TRENCHES
		6-54	Revised	
	*	12-54	REVISED	
	△	5-55	Revised Note	
	●	10-59	Revised Notes	
	○	3-61	Revised ¶ 4 & 5 Notes	
	△	7-65	Revised Notes 1 & 3	
	△	10-68	Revised 96" to 108"	
	△	4-72	Rev. Conc. designation	
	△	4-76	Revised note 4	

SUBMITTED [signature] RECOMMENDED BY [signature] APPROVED BY [signature] Chief Engineer

DATE JUNE, 54 NO. 2-D177 SHEET 1 OF 1

DESIGN DATA

$$D\text{-LOAD} = \frac{(\text{DEAD + LIVE LOADS ON TOP OF PIPE})(\text{SAFETY FACTOR})}{(\text{LOAD FACTOR})(\text{INSIDE DIAMETER})}$$

SAFETY FACTOR = 1.25
LOAD FACTOR (SEE APPLICABLE DRAWING)
LIVE LOAD (SEE APPLICABLE DRAWING)
EARTH LOAD PER MARSTON'S FORMULA
D-LOAD WILL PRODUCE A 0.01 INCH CRACK UNDER THE THREE EDGE BEARING METHOD
DESIGN DENSITY = (0.90)(MAX. DRY DENSITY)(100 + OPTIMUM MOISTURE)

INDEX TO STANDARD DRAWING 2-D213.1 to .27

SHEET NO.	DESIGN DENSITY (p.c.f.)	LIVE LOAD	DESCRIPTION
1			Index, General Notes, and Design Data
2	110	I H20-S16 Truck	Earth Cover 1-10 feet, Projection Condition with Unrestricted Trench Width and Earth Cover 11-25 feet, Trench Condition with Trench Width equal to Outside Diameter plus 20 inches, Load Factor 1.8
3	120		
4	130		
5	140		
6	110 and 120	I H20-S16 Truck	Earth Cover 11-25 feet, Trench Condition with trench width equal to Outside Diameter plus 20 inches, Load Factor 2.1
7	130 and 140		
8	110 and 120	I H20-S16 Truck	Earth Cover 11-25 feet, Projection Condition with unrestricted trench width. Load Factor Variable (See Note 7)
9	130 and 140		
10	110 and 120	I H20-S16 Truck STATE HIGHWAY	Earth Cover 11-25 feet, Trench Condition with trench width equal to Outside Diameter plus 48 inches, Load Factor 1.8
11	130 and 140		
12	110	RAILROAD COOPER'S E 75	Earth Cover from bottom of ties 4-25 feet, Jacked R.C.P. with trench width equal to Outside Diameter. Load Factor 1.8
13	120		
14	130		
15	140		
16	110	RAILROAD COOPER'S E 72	
17	120		
18	130		
19	140		
20	110	RAILROAD COOPER'S E 75	Earth Cover from bottom of ties 2-25 feet, Trench Condition with trench width equal to Outside Diameter plus 20 inches. Load Factor 1.8
21	120		
22	130		
23	140		
24	110	RAILROAD COOPER'S E 72	
25	120		
26	130		
27	140		

GENERAL NOTES

1. CONCRETE BACKFILL – Use as indicated on applicable sheet and on all pipe with less than 1 foot of cover. Refer to Standard Drawing 2-D177.
2. CROSS-HATCHED AREA – Check with pipe plant for availability of required D-LOAD or use bedding with a higher load factor.
3. STATE HIGHWAY REQUIREMENTS
   a. Minimum D-LOAD = 1000 D△
   b. Classification
      Class I = 800 D Class IV 2000 D
      Class II = 1000 D Class V 3000 D
      Class III = 1350 D
   c. For earth covers greater than 10 feet provide two alternate D-LOADS. Trench Condition with trench width equal to O.D. + 20" and O.D. + 48".
4. RAILROAD REQUIREMENTS
   a. Minimum D-LOADS and Cooper's Loading

A.T. & S.F. R.R.	3000 D	E80△
S.P. R.R.	2000 D	E72
U.P. R.R.	2000 D	E75

   b. Minimum earth cover for Jacked R.C.P. equals 6 feet.
5. For truck loading with earth covers of 10 feet or less, pipe shall be designed for positive projection condition.
6. For covers greater than 10 feet, pipe shall be designed for the applicable condition.
7. Load factor, for positive projection with earth covers greater than 10 feet, was computed using Spangler's Formula: N = 0.707, p = 1.

DRAWN BY	REVISIONS		
G.D.M.	MARK	DATE	DESCRIPTION
CHECKED BY V.C.M.	△	12-82	Changed D-Load & E.
DESIGNED BY F.W.R.			
SUBMITTED BY C.W.H.			

SUPERSEDES DRAWING OF THE SAME NUMBER DATED 12/54

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: Deputies — ASSISTANT CHIEF DEPUTY ENGINEER
APPROVAL RECOMMENDED BY: C. Magnuson — ASSISTANT CHIEF DEPUTY ENGINEER
APPROVED BY: A. E. Remington — CHIEF ENGINEER — 12/22/70

SCALE	DATE	DWG. NO. 2-D213.1
NONE	DEC. '70	SHEET 1 OF 27

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D 177

CASE III BEDDING DESIGN DENSITY = 110 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																											PIPE SIZE
	1	1.25	1.5	1.75	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2000	2000	1500	1500	1500	1250	1250	1250	1500	1750	2000	2250	2500	1750	2000	2000	2000	2250	2250	2250	2250	2250	2250	2250	2250	2500	2500	2500	12
15	CONCRETE		CONCRETE			1000				1500	1750	2000	2250		1750	1750		2000	2000	2000	2000					2250	2250	2250	15
18	BACKFILL		BACKFILL		1250		1000		1250				2000	1500			1750	1750				2000	2000						18
21		1500										1750			1500				1750	1750				2000	2000	2000			21
24	1500			1500				1000			1500					1500					1750						2000		24
27		2000	1750							1250							1500					1750						2000	27
30													1750	1250				1500											30
33		1750	1500									1500											1750						33
36				1250					1000					1250															36
39	1600	1500	1400	1300	1100					1100	1300		1600	1200	1300	1300	1400		1500	1600	1700	1700	1800	1800	1900	1900	1900		39
42	1500	1400	1300	1200								1400									1600				1800				42
45	1400	1300	1200	1100	1000						1200				1200								1700						45
48	1300												1500					1400											48
51		1200	1100	1000								1300		1100															51
54	1200	1100								1000																			54
57			1000																										57
60				900	900	800	800	800	900		1100		1400				1300			1500									60
63				950	850				850			1250			1150	1250			1450			1650		1750		1850		1950	63
66		1150	1050							950																			66
69	1250											1200	1350																69
72	1300	1200	1100								1050										1550								72
75	1350			1000										1050				1350											75
78		1250											1300			1200													78
81	1400											1150																2000	81
84			1150						800	900																	1950		84
87	1450	1300									1000																		87
90													1250																90
93			1200	1050	900																					1900			93
96	1500	1350										1100																	96
102	1550																												102
108		1400											1200		1100										1850				108

Projection Condition
Unrestricted Trench Width

Trench Condition
Trench Width = O.D. + 20 inches

DATA:

Load factor = 1.8

Live load - 1 H 20 S 16 truck.

NOTE:

See General Notes on Sheet 1.

SUPERSEDES DRAWING OF THE SAME NUMBER DATED 12/54

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: [signature] DIVISION ENGINEER (DESIGN)

APPROVAL RECOMMENDED BY: [signature] ASST. CHIEF DEPUTY ENGINEER

APPROVED BY: [signature] 12/30/70 CHIEF ENGINEER

SCALE	DATE	DWG. NO.
NONE	DEC. '70	2-D213.2

SHEET 2 OF 27

DRAWN BY	REVISIONS		
S.Y.H.	MARK	DATE	DESCRIPTION
CHECKED BY			
V.C.M.			
DESIGNED BY			
G.S.			
SUBMITTED BY			
C.W.H.			

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D 177

CASE III BEDDING DESIGN DENSITY = 120 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																												PIPE SIZE
	1	1.25	1.5	1.75	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2000	2000	1500	1500	1500	1250	1250	1500	1750	1750	2000	2250	2500	2000	2000	2250	2250	2250	2500	2500	2500	2500	2500	2750	2750	2750	2750	2750	12
15	CONCRETE					1000		1250	1500					1750		2000	2000	2000	2250	2250	2250	2250		2500	2500	2500	2500	2500	15
18	BACKFILL										1750	2000	2250		1750	1750			2000	2000			2250	2250	2250				18
21		1500	CONCRETE		1250		1000		1250	1500				1500			1750				2000					2250	2250	2250	21
24	1500												2000		1500			1750				2000	2000						24
27	BACKFILL			1500				1000				1750							1750										27
30											1500					1500								2000					30
33		1750	1500							1250										1750					2000				33
36																													36
39	1600	1500	1400	1300	1100				1100	1200	1400	1600	1800	1300	1400		1500	1600	1700	1700	1800	1900	1900			2100	2100	2200	39
42	1500	1400	1300	1200								1500	1700			1400						1800						2100	42
45	1400	1300							1000		1300																		45
48			1200	1100	1000										1300				1600					1900					48
51	1300	1200	1100	1000						1100			1600	1200												2000			51
54	1200											1400																	54
57		1100	1000															1500										2200	57
60					900	800	800	900			1200										1700								60
63			1050	950	850			850	950	1050		1350	1500			1350	1450			1650			1850		1950			2150	63
66	1250	1150						800	900						1250											2050			66
69											1150	1300																	69
72	1300	1200	1100	1000						1000			1450	1150			1400		1550										72
75	1350				900																								75
78		1250																											78
81	1400		1150								1100	1250	1400																81
84		1300																							2000				84
87	1450			1050					850							1300													87
90			1200																							2050	2100	2150	90
93	1500	1250								950		1200	1350																93
96			1300	1150																									96
102	1550	1400	1200	1000							1050																	2200	102
108			1250	1050									1300		1200			1450											108

Projection Condition
Unrestricted Trench Width

Trench Condition
Trench Width = O.D. + 20 inches

DATA:

Load factor = 1.8

Live load - 1 H 20 S 16 truck.

NOTE:

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
S.Y.H.	MARK	DATE	DESCRIPTION
CHECKED BY			
Y.C.			
DESIGNED BY			
J.C.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: DIVISION ENGINEER

APPROVAL RECOMMENDED BY: ASST. CHIEF DEPUTY ENGINEER

APPROVED BY: A. G. Barrington 12/22/70 CHIEF ENGINEER

SCALE	DATE	DWG. NO.
NONE	DEC. '70	2-D213 3
		SHEET 3 OF 27

S-140

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D 177

CASE III BEDDING DESIGN DENSITY = 130 pcf

PIPE SIZE	DEPTH OF COVER IN FEET																											PIPE SIZE
	1	1.25	1.5	1.75	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2000	CONC.		1500		1250	1250	1500	1750	2000	2250	2500	2750	2250	2250	2250	2500	2500	2500	2750	2750	2750	2750	2750	3000	3000	3000	3000	12
15	BACK-	CONCRETE		BACKFILL						1750	2000	2250	2500	2000	2000		2250	2250	2250	2500	2500	2500	2500	2500	2750	2750	2750	2750	15
18	FILL					1000		1250	1500					1750		2000	2000			2250	2250				2500	2500	2500	2500	18
21			1750	1500	1250							2000	2250		1750			2000	2000			2250	2250						21
24	1500						1000			1500	1750					1750				2000				2250					24
27									1250					1500			1750								2250				27
30																					2000					2250			30
33												1750	2000		1500			1750											33
36		1750	1500					1000			1500											2000					2250		36
39	1600	1500	1400	1300	1200				1100	1300		1700	1900	1400		1600	1700	1700	1800	1900			2100	2100	2200	2300	2300		39
42	1500	1400	1300	1200	1100												1600				1900								42
45	1400										1400	1600	1800																45
48		1300	1200	1100	1000					1200						1500				1900			2000						48
51	1300													1300	1400														51
54	1200	1200	1100	1000								1500	1700																54
57									1000		1300								1700										57
60					900	800	800	900																					60
63										1150		1450	1650			1450	1550	1650			1850	1950		2050	2150		2250		63
66	1250							850		1100	1250		1600		1350														66
69	1300											1900						1600											69
72									950				1550	1250															72
75	1350																												75
78											1200	1350								1750								2350	78
81	1400	1250								1050			1500															2350	81
84																	1500												84
87	1450	1300	1150	1000																		1900							87
90								800	900															2050	2150	2200	2300		90
93	1500	1350	1200	1050							1150	1300	1450																93
96																1400													96
102	1550									1000												1950		2100					102
108												1250	1400													2250			108

Projection Condition
Unrestricted Trench Width

Trench Condition
Trench Width = O. D. + 20 inches

DATA:

Load factor = 1.8
Live load - 1 H20 - S16 truck.

NOTE:

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
J.C.D.	MARK	DATE	DESCRIPTION
CHECKED BY			
G.S.			
DESIGNED BY			
J.J.S.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: H. Milne, DIVISION ENGINEER (acting)
APPROVED BY: C. Figueroa, ASST. CHIEF DEPUTY ENGINEER
APPROVED BY: A. E. Bruington, CHIEF ENGINEER, 12/22/70

SCALE	DATE	DWG. NO.
NONE	DEC. '70	2-D213.4

SHEET 4 OF 27

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D 177

CASE III BEDDING DESIGN DENSITY = 140 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																									PIPE SIZE
	1	1.25	1.5	1.75	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2000	CONC.	1500	1500	1500	1250	1500	1750	1750	2250	2500	2750	3000	2250	2500	2500	2500	2750	2750	2750	3000	3000	3000	3000	3000	3250	3250	3250	12
15	BKFILL	1800					1250	1500		2000	2250	2500	2750	2000	2250	2250	2250	2500	2500	2500	2750	2750	2750	2750	2750	3000	3000	3000	15
18		CONCRETE		BACKFILL						1750	2000	2250	2500		2000			2250			2500	2500	2500			2750	2750	2750	18
21						1000			1500					1750		2000	2000		2250	2250				2500	2500				21
24	1500		2000	1750	1250			1250							1750						2250					2500			24
27							1000				1750	2000	2250					3000				2250					2500		27
30		2000	1750	1500						1500						1750			2000				2250					2500	30
33																													33
36		1750	1500						1250					1500						2000									36
39	1700	1600		1400	1200			1100	1200	1400	1600	1800	2000		1600	1700	1800	1900			2100	2200	2200	2300	2300	2400			39
42	1600	1500	1400	1300				1000											1900								2400		42
45	1500	1400	1300	1200	1100					1300	1500	1700						1800				2100							45
48	1400	1300	1200	1100	1000								1900				1700												48
51	1300								1100					1400	1500	1600													51
54	1200	1200	1100									1600									2000								54
57				1000							1400		1800																57
60					900	800	900			1200																			60
63		1150					850	950	1050		1350	1550	1750				1650	1750	1850	1950			2150	2200		2350			63
66	1250	1200						900								1550				1900									66
69	1300						800					1500	1700	1350	1450												2450		69
72										1150												2050							72
75	1350	1250	1150	1050		750			1000		1300		1650																75
78	1400	1300										1450							1800				2250						78
81																									2200	2350	2450	2500	81
84	1450	1350	1200										1600																84
87										1100	1250															2400			87
90	1500							850				1400										2050	2150	2250					90
93		1400	1250	1100	950													1700										2500	93
96									950				1550																96
102	1550															1500	1600												102
108	1600	1450	1300	1150			750			1050	1200	1350	1500	1300	1400														108

Projection Condition
Unrestricted Trench Width

Trench Condition
Trench Width = O.D. + 20 inches

DATA:

Load factor = 1.8

Live load - 1 H20 - S16 truck

NOTE:

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
S.Y.H.	MARK	DATE	DESCRIPTION
CHECKED BY			
J.J.S.			
DESIGNED BY			
G.S.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: W. Mulhe
DIVISION ENGINEER (HYDRAULIC)

APPROVED BY: C. Magnuson
ASST. CHIEF DEPUTY ENGINEER

APPROVED BY: A. E. Bennett 12/22/70
CHIEF ENGINEER

SCALE	DATE	DWG. NO. 2-D213.5
NONE	DEC. '70	SHEET 5 OF 27

5142

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D 177

CASE I BEDDING

PIPE SIZE	DEPTH OF COVER IN FEET																														PIPE SIZE
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	1500	1750	1750	1750	1750	2000	2000	2000	2000	2000	2000	2000	2250	2250	2250	1750	1750	2000	2000	2000	2000	2000	2250	2250	2250	2250	2250	2250	2250	2500	12
15		1500	1500			1750	1750	1750	1750				2000	2000	2000	1500	1750	1750	1750	1750			2000	2000	2000	2000				2250	15
18	1250			1500	1500					1750	1750	1750					1500	1500			1750	1750					2000	2000	2000	2000	18
21		1250				1500	1500						1750	1750					1500				1750	1750							21
24			1250					1500							1750	1250				1500					1750						24
27									1500								1250				1500					1750					27
30				1250						1500																	1750				30
33																						1500						1750			33
36					1250													1250													36
39	1000	1100	1200	1200	1300	1300	1400	1400			1600	1600	1600	1700	1700	1100	1200	1300	1300	1400	1400		1600	1600	1600	1700	1700	1800	1800	1900	39
42			1100								1500							1200					1500							1800	42
45																															45
48					1200																										48
51							1300		1400								1100			1300											51
54		1000																													54
57																														1900	57
60																						1400									60
63	950		1050	1150		1250		1350		1450		1550		1650		1000		1150	1250		1350			1550		1650		1750		1850	63
66																															66
69				1100															1200				1450								69
72																															72
75	900																														75
78																															78
81																	1050														81
84					1150																										84
87																															87
90																				1250											90
93																															93
96		950																													96
102																															102
108																														1900	108

Trench Condition - Design Density = 110 P.C.F.
Trench Width = O.D. + 20"

Trench Condition — Design Density = 120 P.C.F.
Trench Width = O.D. + 20"

DATA:

Load factor = 2.1

Live load — 1 H20 - S16 truck.

NOTE:

See General Notes on Sheet 1.

DRAWN BY	REVISIONS		
G.D.M.	MARK	DATE	DESCRIPTION
CHECKED BY			
Y.C.			
DESIGNED BY			
F.C.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: D. J. Mulvihill, DIVISION ENGINEER (DESIGN)

APPROVAL RECOMMENDED BY: C. Magnuson, ASST. CHIEF DEPUTY ENGINEER

APPROVED BY: A. E. Bumpus, CHIEF ENGINEER — 12/22/70

SCALE	DATE	DWG. NO.	SHEET
NONE	DEC. '70	2-D213.6	6 OF 27

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D 177

CASE I BEDDING

PIPE SIZE	DEPTH OF COVER IN FEET																											PIPE SIZE
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	1750	2000	2000	2000	2250	2250	2250	2250	2250	2500	2500	2500	2500	2500	2500	2000	2000	2250	2250	2250	2500	2500	2500	2500	2500	2750	2750	2750	2750	2750	12
15		1750	1750		2000	2000	2000			2250	2250	2250	2250	2250		1750		2000	2000	2000	2250	2250	2250	2250		2500	2500	2500	2500	2500	15
18	1500			1750	1750			2000	2000	2000					2250		1750	1750			2000	2000			2250	2250	2250				18
21		1500	1500			1750	1750				2000	2000				1500			1750	1750			2000	2000	2000			2250	2250	2250	21
24				1500				1750	1750				2000	2000			1500				1750	1750									24
27																															27
30	1250				1500					1750					2000			1500				1750			2000	2000					30
33																															33
36																															36
39	1200	1300	1400	1400		1600	1600	1700	1700	1900	1800	1900	1900			1300	1400		1500	1600	1700	1700	1800	1900	1900			2100	2100	2200	39
42			1300															1400						1800						2100	42
45						1500																									45
48								1600									1300				1600					1900						48
51		1200														1200												2000			51
54					1400																										54
57	1100									1700										1500										2200	57
60																							1700								60
63			1250	1350		1450	1550		1650			1850		1950				1350	1450			1650			1850		1950			2150	63
66											1750						1250											2050			66
69																															69
72		1150		1300												1150			1400		1550									72
75											1800																				75
78							1500																								78
81																															81
84																											2000				84
87	1050																	1300													87
90																												2050	2100	2150	90
93																															93
96			1200																												96
102					1350										2050															2200	102
108																	1200			1450											108

Trench Condition - Soil Weight = 130 P.C.F.
Trench Width = O.D. + 20"

Trench Condition - Soil Weight = 140 P.C.F.
Trench Width = O.D. + 20"

DATA:

Load factor = 2.1
Live load - 1 H20 - S16 truck

NOTE:

See General Notes on Sheet 1.

DRAWN BY	REVISIONS		
J.C.D.	MARK	DATE	DESCRIPTION
CHECKED BY G.S.			
DESIGNED BY J.J.S.			
CHECKED BY C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: Division Engineer - Design

APPROVAL RECOMMENDED BY: Asst. Chief Deputy Engineer

APPROVED BY: A. E. Bumpus, Jr. 12/28/70
Chief Engineer

SCALE	DATE	DWG. NO.
NONE	DEC. '70	2-D213.7

SHEET 7 OF 27

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D 177

CASE III BEDDING

PIPE SIZE	DEPTH OF COVER IN FEET																												PIPE SIZE
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2000	2250	2500	2750	3000	3500	4000	4750	5500	6500	7750	9250				2250	2500	2750	3000	3500	4000	4500	5250	6000	7250	8500	10000	10000	10000	10000	12
15		2000	2250			3000	3250	3500	4000	4500	5000	5750	6750	7750	9000		2250		2500		3250	3500	4000	4500	5000	5500	6500	7250	8500	9750	15
18				2250	2500			3000	3250	3750	4000	4500	5000	5500	6250		2000			2750			3250	3750	4000	4500	5000	5500	6000	6750	18
21		1750							3000	3250	3500	3750	4000	4500	5000								3000		3500	3750	4250	4500	5000	5500	21
24											3250	3500	3750	4000	4250									3250			3750	4000	4250	4750	24
27				2000		2250			2750				3500	3750	4000		1750		2250				2750						4000	4250	27
30								2500			3000				3750	1500		2000			2500						3500	3750		4000	30
33	1500												3250	3500										3000							33
36																										3250				3750	36
39	1300	1400	1600	1700	1900	2000	2200	2300		2600	2700	2900	3000	3200	3300	1400	1600	1700	1900	2100	2200	2400	2500	2700	2900	3000	3200	3400	3500	3700	39
42					1800		2100		2400					3100			1500		1800	2000		2300			2800		3100	3300		3600	42
45	1200		1500		1900		2200			2500		2800			3200	1300		1600			2100		2400	2600		2900		3200	3400		45
48		1300		1600					2300		2600		2900							1900		2200			2700		3000			3500	48
51					1700		2000			2400		2700		3000			1400		1700		2000			2500		2800			3300		51
54	1100		1400			1800		2100				2800			3100	1200		1500		1800			2300		2600			3100		3400	54
57		1200		1500	1600		1900		2200	2300	2500	2600		2900								2100		2400			2900		3200		57
60			1300			1700		2000				2700			3000		1300		1600		1900		2200			2700		3000	3200	3500	60
63		1150		1400	1550		1850	1950	2100	2250	2400	2550		2800	2950			1450		1750		2050		2350	2500	2650	2800	2950	3100		63
66			1250			1650	1800			2200	2350	2500	2650	2800	2900		1250	1400	1550	1700	1850	2000	2150	2300	2450	2600	2750	2950		3250	66
69				1350	1500		1750	1900	2050		2300	2450	2600	2750	2900				1500	1650	1800	1950	2100	2250	2400			2900	3050	3200	69
72						1600			2000	2150			2550		2850	1100		1350								2550	2700	2850	3000	3150	72
75	1050				1450		1700	1850		2100	2250	2400	2550	2700	2800					1600	1750	1900	2050	2200	2350	2500	2650	2800	2950		75
78			1200	1300		1550		1800	1950			2350	2500	2650					1450											3100	78
81					1400		1650			2050	2200	2350	2500	2600	2750					1550	1700	1850	2000	2150	2300	2450	2600	2750	2900	3050	81
84						1500			1900		2150	2300	2450		2700				1400				1950	2100	2250	2400	2550	2700	2850	3000	84
87				1250				1750		2000		2300	2400	2550				1300			1650	1800									87
90					1350		1600		1850		2100	2250			2650					1500			1900	2050	2200	2350	2500	2650	2800	2950	90
93				1200		1450		1700		1950	2100		2350	2500							1600	1750									93
96							1550		1800		2050	2200		2450	2600									2000	2150	2300	2450	2600	2750	2900	96
102				1150			1500	1650	1750	1900	2050	2150	2300	2400	2550						1550	1700	1850	1950	2100	2250	2400	2550	2700	2850	102
108		1100						1600		1850	2000	2100	2250	2350	2500		1200			1450		1650	1800		2050	2200	2300	2500	2650	2800	108

Projection Condition - Design Density = 110 p.c.f.
Unrestricted Trench Width

Projection Condition - Design Density = 120 p.c.f.
Unrestricted Trench Width

DATA:

Load factor = Variable
Live Load - 1H 20-S16 truck.

NOTE:

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
S.Y.H.	MARK	DATE	DESCRIPTION
CHECKED BY J.C.			
DESIGNED BY Y.C.			
SUBMITTED BY C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY _____ DIVISION ENGINEER (DESIGN)

APPROVAL RECOMMENDED BY _____ ASST. CHIEF DEPUTY ENGINEER

APPROVED BY A. E. Bruington 12/23/70 CHIEF ENGINEER

SCALE	DATE	DWG. NO.
NONE	DEC. '70	2-D213.8

SHEET 8 OF 27

S-45

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D 177

CASE III BEDDING

PIPE SIZE	DEPTH OF COVER IN FEET																															PIPE SIZE
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2250	2500	3000	3250	3750	4250	5000	5750	6750	7750						2500	2750	3250	3500	4000	4500	5250	6250	7250	8500						12
15			2500	2750	3250	3500	3750	4250	4750	5500	6000	7000	8000	9250		2250	2500	2750	3000	3500	3750	4250	4500	5250	6250	7250	8500	10,000	10,000			15
18	2000	2250			3000	3000	3500	3750	4000	4500	4750	5750	6000	6500	7500					3000	3500	3750	4000	4250	4750	5000	5750	6750	7250	8000			18
21			2250	2500	2750		3250	3500	3750	4000	4250	4500	5000	5500	6000	2000	2250	2500	2750		3250	3500	3750	4000	4250	4500	5000	5750	6250	6500			21
24		2000				2750	3000	3250	3500	3750	4000	4250	4500	4750	5000					2750				3750	4000	4250	4500	5000	5250	5500			24
27	1750				2500			3000	3250	3500	3750	4000	4250	4500	4750				2250	2500	2750						4500	4750	5000				27
30				2250						3500	3750	4000	4250	4500																		30
33			2000			2500	2750			3250			4000	4250		1750	2000				2750	3000	3250	3500	3750	4000	4250						33
36		1750							3000				3750							2500												36
39	1500	1700	1900	2100	2200	2400	2600	2800		3100	3300	3500	3700	3900	4000	1700	1900	2100	2300	2400					3250	3500	3750	4000	4250	4500	4500		39
42			1800	2000				2700	2900			3400	3600	3800		1600	1800	2000	2200		2600	2800	3000	3200		3400	3600	3800	4000	4250	4400		42
45		1600				2300	2500			3000	3200			3700	3900																		45
48	1400			1900	2100			2600	2800			3300	3500																				48
51			1700			2200	2400			2900	3100	3300	3500	3600	3800	1500	1700	1900	2100	2300	2500	2700	2900	3100	3200	3400				4200		51
54		1500			2000			2500	2700			3200	3400													3400	3600	3800	4000			54
57	1300			1800			2300			2800	3000			3500	3700				1800		2200	2400	2600							4100		57
60			1600			2100			2600			3200	3300			1400	1600		2000					2700	2900		3700	3900				60
63		1400	1550	1750	1900	2050	2250	2400	2550	2750	2900	3100	3250	3450	3600		1550	1700	1900	2050	2250	2450		2800	3000		3350	3550	3750	3900		63
66				1700	1850		2200	2350		2700	2850	3050	3200	3400	3550		1500																66
69			1500			2000	2150		2500			3000	3150	3350	3500				1850				2400	2600	2750	2950	3100		3500	3700			69
72				1650	1800			2300		2650	2800	2950		3300	3450					2000	2200					2900	3100		3450	3650	3850		72
75			1450			1950	2100	2250	2450	2600	2750		3150	3250					1650														75
78				1600	1750	1900	2050		2400	2550		2900	3050		3400	1350				1900													78
81								2200	2350		2700	2850	3000	3200	3350				1550														81
84		1350		1550	1700	1850	2000	2150		2500	2650			3150	3300																		84
87	1250								2300	2450		2800	2950	3100						1700	1850	2050											87
90				1500	1650	1800	1950	2100			2600	2750	2900		3250																		90
93									2250	2400	2550			3050	3200																		93
96					1600	1750	1900	2050	2200			2700	2850	3000																				96
102			1400					2000	2200	2350	2500	2650	2800	2950	3100																		102
108						1700	1850		2150	2300	2450	2600	2750	2900	3050	1300	1400																108

Projection Condition - Design Density = 130 p.c.f.
Unrestricted Trench Width

Projection Condition - Design Density = 140 p.c.f.
Unrestricted Trench Width

DATA:

Load factor = Variable
Live Load - 1H 20 - S16 truck

NOTE:

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
H. C. M.	MARK	DATE	DESCRIPTION
CHECKED BY			
G.S.			
DESIGNED BY			
J.J.S.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: D. Smith, DIVISION ENGINEER (DESIGN)
APPROVAL RECOMMENDED BY: C. Magnuson, ASST. CHIEF DEPUTY ENGINEER
APPROVED BY: A. E. Bumpton, CHIEF ENGINEER, 12/22/70

SCALE	DATE	DWG. NO. 2-D213.9
NONE	DEC '70	SHEET 9 OF 27

STATE HIGHWAY
REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D 177
CASE III BEDDING

PIPE SIZE	DEPTH OF COVER IN FEET																													PIPE SIZE
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	3750	4000	4000	4250	4500	4750	4750	5000	5250	5250	5500	5500	5750	5750	6000	4000	4250	4500	4750	5000	5000	5250	5500	5750	5750	6000	6000	6250	6500	6500	12
15	3250	3250	3500	3750	4000	4000	4250	4250	4500	4500	4750	4750	5000	5000	5250	3500	3750	3750	4000	4250	4500	4500	4750	5000	5000	5250	6250	6250	6500	6750	15
18	2750	3000	3250	3250	3500	3500	3750	4000	4000	4250	4250	4250	4500	4500	4750	3000	3250	3500	3500	3750	4000	4000	4250	4250	4500	4500	4750	4750	6000	6000	18
21	2500	2750	2750	3000	3250	3250	3500	3500	3750	3750	4000	4000	4000	4250	4250	2750	3000	3000	3250	3500	3500	3750	3750	4000	4000	4250	4250	4500	4500	4750	21
24	2250	2500		2750	3000	3000	3250	3250	3500	3500	3750	3750	3750	4000	4000	2500	2750		3000	3250	3250	3500	3500	3750	3750	4000	4000	4250	4250	4250	24
27		2250	2500		2750		3000	3000	3250	3250	3500	3500	3500	3750	3750		2500	2750	2750	3000		3250		3500	3500	3750	3750	4000	4000	4000	27
30	2000		2250	2500	2500	2750	2750		3000		3250	3250		3500	3500	2250		2500		2750	3000	3000	3250	3250			3500				30
33						2500		2750		3000			3250				2250		2500		2750		3000		3250		3500	3500	3750	3750	33
36		2000		2250					2750		3000	3000		3250	3250	2000		2250		2500		2750		3000						3750	36
39	1800	1900	2000	2100	2300	2400	2500	2600	2700	2800	2900	2900	3000	3100	3200	1900	2100	2200	2300		2500		2750		3000		3250		3500		39
42	1700				2200	2300	2400	2500	2600	2700	2800		2900	3000	3100		2000	2100		2400	2500	2600	2700	2800	2900	3000	3100	3200	3300	3400	3500	42
45		1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800			3000	1800			2200	2300	2400						3000	3100	3200	3300	45
48	1600											2700	2800	2900			1900	2000				2500	2600	2700	2800	2900				3200	48
51		1700	1800	1900	2000	2100	2200	2300	2400	2500	2600			2800	2900	1700			2100	2200	2300	2400	2500	2600	2700	2800	2900	3000	3100		51
54												2600	2700				1800	1900												3100	54
57	1500	1600							2300	2400	2500				2800				2000	2100	2200					2700	2800	2900	3000		57
60			1700	1800	1900	2000	2100	2200					2600	2700		1600						2300	2400	2500	2600					3000	60
63	1450	1550					2050	2150	2250	2350	2450	2500		2650	2750		1700	1850	1950	2050	2150	2250	2350	2450	2550	2650	2750	2800	2900		63
66			1650	1750	1850	1950				2300	2400		2550		2700			1800	1900	2000					2500	2600	2700	2800	2850	2850	66
69	1400						2000	2100	2200		2350	2450		2600		1550												2650	2750			69
72		1500	1600	1700	1800	1900				2250			2500		2650		1650									2100	2200	2300	2400			72
75								2050	2150		2300	2400		2550		1500		1750	1850	1950					2350	2450	2550		2800	2900	75
78	1350	1450	1550	1650	1750	1850	1950			2200			2450		2600		1600				2050	2150	2250				2550	2650	2700		78
81									2100		2250	2350		2500		1450		1700	1800								2400	2500	2750	2850	81
84							1900	2000					2400		2550		1550			1900	2000	2100	2200	2300	2400	2500	2600		2850			84
87					1700	1800				2150				2550													2450	2550		2900	87
90	1300	1400	1500	1600					2050		2200	2300	2500		2600			1650	1750					2250	2350				2700		90
93								1950						2450						1850	1950	2050	2150	2250	2350			2600			93
96							1850						2350		2500	1400											2400	2500		2750	96
102			1450	1550	1650	1750			2000	2100		2250		2400			1500								2300				2650		102
108	1250	1350						1900			2250					1350		1600	1700	1800	1900	2000	2100	2250						2600	2700	108

Trench Condition – Design Density = 110 p.c.f.
Trench Width = O.D. + 48"

Trench Condition – Design Density = 120 p.c.f.
Trench Width = O.D. + 48"

DATA: Load factor = 1.8
Live load – 1 H20-S16 truck

NOTE:
For General Notes see Sheet 1

DRAWN BY	REVISIONS		
JCH	MARK	DATE	DESCRIPTION
CHECKED BY			
FWR			
DESIGNED BY			
GS			
SUBMITTED BY			
GWH			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: H. Symons, DIVISION ENGINEER, LOW FLOW
APPROVAL RECOMMENDED BY: C. Magnuson, ASST. CHIEF DEPUTY ENGINEER
APPROVED BY: A. E. Bunyston, CHIEF ENGINEER 12/22/70

SCALE	DATE	DWG. NO. 2-D213.10
NONE	DEC. '70	SHEET 10 OF 27

STATE HIGHWAY

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D 177

CASE III BEDDING

PIPE SIZE	DEPTH OF COVER IN FEET																															PIPE SIZE
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	4250	4500	4750	5000	5250	5500	5750	6000	6000	6250	6500	6500	6750	7000	7000	4750	5000	5250	5500	5750	6000	6250	6500	6500	6750	7000	7000	7250	7500	7500	12
15	3750	4000	4250	4250	4500	4750	5000	5000	5250	5500	5500	5750	5750	6000	6000	4000	4250	4500	4750	5000	5000	5250	5500	5750	5750	6000	6250	6250	6500	6500	15
18	3250	3500	3750	4000	4000	4250	4500	4500	4750	4750	5000	5000	5250	5250	5500	3500	3750	4000	4250	4250	4500	4750	5000	5000	5250	5250	5500	5750	5750	6000	18
21	3000	3250	3250	3500	3750	3750	4000	4250	4250	4500	4500	4750	4750	5000	5000	3250	3500	3500	3750	4000	4250	4250	4500	4750	4750	5000	5000	5250	5250	5500	21
24	2750	3000	3000	3250	3500	3500	3750	4000	4000	4250	4250	4500	4500	4500	4750	3000	3250	3250	3500	3750	3750	4000	4250	4250	4500	4500	4750	4750	5000	5000	24
27	2500	2750		3000	3250		3500	3750	3750	4000	4000	4250	4250	4250	4500	2750	3000		3250	3500		3750	4000	4000	4250	4250	4500	4500	4750	4750	27
30		2500	2750		3000	3250	3250	3500	3500	3750	3750	4000	4000		4250	2750	2750	3000		3250	3500	3500	3750	3750	4000	4000	4250	4250	4500	4500	30
33	2250			2750		3000		3250	3500	3500		3750	4000	4000	4000	2500		2750	3000		3250		3500		3750	4000	4000			4250		33
36			2500		2750		3000		3250		3500		3750	3750			2500															36
39	2100	2200	2400	2500	2700	2800	2900	3000	3200	3300	3400	3500	3600	3700	3800	2300	2400	2600	2700	2900	3000	3100	3300	3400	3500	3600	3700	3800	3900	4000	39
42	2000		2300		2600	2700	2800	2900	3100	3200	3300	3400	3500	3600	3700	2200	2300	2600	2800	2900	3000	3200	3300	3400	3500	3600	3700	3800	3900		42
45		2100	2300	2400	2500	2600			3000	3100	3200	3300	3400	3500	3600	2100			2400		2700	2800			3100	3200	3300	3400	3500			45
48	1900		2200	2300			2700	2800	2900	3000	3100	3200	3300	3400	3500		2200			2500	2600		2900	3000	3100				3600	3700	3800	48
51		2000			2400	2500	2600						3300	3400	3400	2000		2300				2700	2800			3200	3300	3400	3500	3600	3700	51
54	1800		2100	2200				2700	2800	2900	3000	3100	3200	3300			2100		2400	2500			2900	3000	3100	3200	3300			3600		54
57		1900			2300	2400	2500								3300	1900		2200			2600	2700						3400	3500			57
60			2000					2600	2700	2800	2900	3000	3100	3200			2000		2300	2400			2800	2900	3000	3100					3500	60
63	1700	1850		2100	2200	2350	2450	2550	2650	2750	2850	2950	3050	3150	3250	1850		2150	2250		2500	2650	2750	2850	2950		3200	3300	3400			63
66		1800	1950	2050		2300	2400	2500			2850	2950	3000	3100	3200	1800	1950	2100		2350		2600	2700	2850	2950	3050	3150	3250	3350	3450	66
69	1650		1900		2150	2250			2600	2700	2800	2900		3150				2050	2200	2300	2450	2550		2800	2900	3000	3100	3200				69
72				2000			2350	2450	2550	2650	2750	2850	2950	3050			1900		2150		2400		2650	2750	2850				3300	3400		72
75		1750			2100	2200			2550	2650	2750			3000	3100	1750		2000		2250		2500	2600	2750		2950	3050	3150	3250	3350		75
78	1600		1850	1950			2300	2400	2500	2600	2700	2800	2900				1850		2100		2350			2700	2800							78
81		1700			2050		2300	2400	2500						3050	1700					2350	2450				2900	3000	3100	3200	3300		81
84			1800			2150	2250	2350				2750	2850	2950				1950		2200			2550	2650	2750							84
87	1550			1900					2450	2550	2650						1800		2050		2300	2400				2850	2950	3050	3150	3250		87
90		1650			2000	2150	2250							2900	3000	1650		1900	2050	2150			2500									90
93						2100	2200	2300			2600	2700	2800						2250					2600	2700	2800				3200		93
96			1750						2400	2500							1750		2000			2350					2900	3000	3100			96
102	1500	1600		1850	1950	2050							2750	2850	2950	1600		1850		2100			2450	2550	2650							102
108			1700				2150	2250	2350	2450	2550	2650					1700		1950		2200	2300				2750	2850	2950	3050	3150		108

Trench Condition - Design Density = 130 p.c.f.
Trench Width = O.D. + 48"

Trench Condition - Design Density = 140 p.c.f.
Trench Width = O.D. + 48"

DATA:

Load factor = 1.8

Live load - H20-S16 truck

NOTES:

For general notes see sheet 1.

DRAWN BY	REVISIONS		
J.C.D.	MARK	DATE	DESCRIPTION
CHECKED BY			
Y.L.C. & F.R.			
DESIGNED BY			
J.C.C.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: DIVISION ENGINEER (DESIGN)

APPROVAL RECOMMENDED BY: ASST. CHIEF/DEPUTY ENGINEER

APPROVED BY: CHIEF ENGINEER — 12/22/70

SCALE	DATE	DWG. NO. 2-D213.11
NONE	DEC. '70	SHEET 11 OF 27

S 148

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE DESIGN DENSITY = 110 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																					PIPE SIZE
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2250	2000	2000	1750	1750	1750	1500	1500	1500	1500	1500	1500	1500	1500	1250	1250	1250	1250	1250	1250	1250	1250	12
15						1500									1500	1500							15
18	2000		1750														1500	1500					18
21																			1500	1500	1500	1500	21
24		1750																					24
27																							27
30																							30
33																							33
36																							36
39	1800	1700	1700	1600	1500											1600	1600	1600	1600	1600	1600	1800	39
42			1600										1600	1600	1600								42
45												1600									1700	1700	45
48											1600								1700	1700			48
51																	1700	1700					51
54										1600						1700						1800	54
57															1700						1800		57
60									1600					1700					1800	1800			60
63	1750	1650		1550					1550	1550				1650	1650			1750	1750	1750			63
66													1650		1700					1800		1850	66
69																	1750		1800		1850		69
72																1750		1800					72
75												1650		1700						1850		1900	75
78	1700							1550		1600							1800		1850		1900		78
81															1750								81
84													1700					1850		1900		1950	84
87																1800					1950		87
90											1650								1900				90
93														1750			1850			1950		2000	93
96																							96
102									1600			1700			1800			1900	1950		2000	2050	102
108																1850				2000			108

JACKED RCP TRENCH WIDTH = O.D.

DATA:

Load factor = 1.8

Live load – Railroad Coopers E 75

NOTE :

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
J.C.D	MARK	DATE	DESCRIPTION
CHECKED BY J.C.C.			
DESIGNED BY A.Y.L.			
SUBMITTED BY C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED: Division Engineer (acting)

APPROVAL RECOMMENDED BY: Asst. Chief Deputy Engineer

APPROVED BY: Chief Engineer 12/22/70

SCALE	DATE	DWG. NO.
NONE	DEC. '70	2-D213.12
		SHEET 12 OF 27

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE DESIGN DENSITY = 120 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																						PIPE SIZE
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2250	2000	2000	2000	1750	1750	1750	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1250	1250	1250	1250	1250	12
15				1750			1500											1500	1500	1500			15
18	2000																				1500	1500	18
21			1750																				21
24																							24
27																							27
30		1750											1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	30
33									1750	1750	1750	1750											33
36								1750															36
39	1800	1800	1700	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1700	1700	1700	1700	1700	1700	39
42														1700	1700	1700							42
45													1700							1800	1800	1800	45
48		1700										1700						1800	1800				48
51											1700						1800						51
54																1800					1900	1900	54
57															1800					1900			57
60										1700				1800					1900				60
63	1750		1650			1550	1550			1650	1650			1750	1750			1850	1850			1950	63
66													1750		1800		1850		1900		1950		66
69											1700							1900		1950		2000	69
72														1800		1850					2000		72
75									1650			1750					1900		1950				75
78															1850			2000		2000		2050	78
81																1900					2050		81
84										1700			1800						2000			2100	84
87							1600							1850			1950			2050			87
90																				2050	2100	2100	90
93											1750								2050			2150	93
96																1950							96
102						1600						1800					2000			2100	2150		102
108		1650						1650					1850					2050	2100			2200	108

JACKED R.C.P. TRENCH WIDTH = O.D.

DATA:

Load factor = 1.8

Live load - Railroad Coopers E75

NOTE:

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
J.C.D.	MARK	DATE	DESCRIPTION
CHECKED BY G.S.			
DESIGNED BY F.R.			
SUBMITTED BY C.H.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: DIVISION ENGINEER (MAINT.)

APPROVAL RECOMMENDED BY: ASS'T CHIEF DEPUTY ENGINEER

APPROVED BY: CHIEF ENGINEER 12/22/70

SCALE	DATE	DWG. NO.
NONE	DEC '70	2-D213.13
		SHEET 13 OF 27

S-50

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE DESIGN DENSITY = 130 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																						PIPE SIZE
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2250	2250	2000	2000	1750	1750	1750	1750	1500	1500	1500	1500	1500	1500	1500	1500	1800	1500	1500	1500	1500	1250	12
15		2000		1750																		1500	15
18	2000								1750														18
21										1750	1750												21
24			1750									1750	1750	1750	1750	1750	1750						24
27																		1750	1750	1750	1750	1750	27
30																							30
33																							33
36																							36
39	1900	1800	1700	1700	1700	1600	1600	1600	1600	1700	1700	1700	1700	1700	1700	1700	1800	1800	1800	1800	1800	1800	39
42									1700						1800	1800							42
45														1800						1900	1900	1900	45
48								1700					1800					1900	1900				48
51	1800											1800					1900					2000	51
54																1900				2000	2000		54
57											1800				1900				2000				57
60														1900				2000				2100	60
63		1750		1650	1650		1650	1650			1750			1850	1850		1950	1950			2050	2050	63
66										1750			1850		1900			2000		2050		2100	66
69						1650										1950			2050		2100		69
72											1800			1900			2000			2100		2150	72
75															1950			2050			2150		75
78								1700				1850				2000			2100			2200	78
81		1700											1900				2050			2150			81
84																		2100			2200		84
87									1750					1950					2150			2250	87
90															2000	2050	2050	2100	2150	2200	2200	2250	90
93										1800							2000				2250		93
96	1750										1850							2150				2300	96
102												1900	1950						2200	2250	2300		102
108														2000	2050	2100	2150					2350	108

JACKED RCP TRENCH WIDTH = OD

DATA:

Load factor = 1.8

Live load = Railroad Coopers E75

NOTE:

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
J.C.D.	MARK	DATE	DESCRIPTION
CHECKED BY			
J.C.			
DESIGNED BY			
J.C.C.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: D. Mulvihill, DIVISION ENGINEER (HYDRAULIC)

APPROVED RECOMMENDED BY: C. Magnuson, ASST CHIEF DEPUTY ENGINEER

APPROVED BY: A. E. Remington, CHIEF ENGINEER, 12/21/70

SCALE	DATE	DWG. NO.
NONE	DEC '70	2-D213.14

SHEET 14 OF 27

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RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE DESIGN DENSITY = 140 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																						PIPE SIZE
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2250	2250	2000	2000	1750	1750	1750	1750	1750	1750	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	12
15		2000									1750												15
18												1750	1750	1750									18
21	2000			1750											1750	1750	1750	1750	1750	1750			21
24																					1750	1750	24
27																							27
30																							30
33																							33
36			1750														2000	2000	2000	2000	2000	2000	36
39	1900	1800	1800	1700	1700	1700	1700	1700	1700	1700	1800	1800	1800	1800	1800	1800	1800	1900	1900	1900	1900	1900	39
42										1800						1900	1900						42
45														1900	1900					2000	2000	2000	45
48									1800				1900					2000	2000				48
51																	2000				2100	2100	51
54												1900				2000				2100			54
57															2000				2100				57
60											1900			2000				2100			2200	2200	60
63	1850		1750					1750	1750		1850	1850		1950			2050	2050		2150	2150		63
66		1750										1900				2050		2100	2150		2200		66
69									1800				1950				2100			2200		2250	69
72	1800									1850				2000				2150			2250		72
75															2050	2100			2200			2300	75
78											1900	1950					2150				2300		78
81													2000					2200			2300	2350	81
84														2050	2100					2300			84
87																2150	2200				2350	2400	87
90														2050	2100	2150	2200	2250	2300				90
93			1700																	2350	2400		93
96							1750															2450	96
102								1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	2300	2350	2400			102
108																					2450	2500	108

JACKED R.C.P. TRENCH WIDTH = O.D.

DATA:

Load factor = 1.8

Live load – Railroad Coopers E75

NOTE:

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
J.C.D.	MARK	DATE	DESCRIPTION
CHECKED BY			
V.C.M.			
DESIGNED BY			
G.S.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: DE Mulhe — DIVISION ENGINEER (HIGHWAYS)

APPROVAL RECOMMENDED BY: C Tragniaa — ASST. CHIEF DEPUTY ENGINEER

APPROVED BY: AC Bumiller 12/22/70 — CHIEF ENGINEER

SCALE	DATE	DWG. NO. 2-D213.15
NONE	DEC '70	SHEET 15 OF 27

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE DESIGN DENSITY = 110 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																						PIPE SIZE
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2250	2000	2000	1750	1750	1500	1500	1500	1500	1500	1500	1500	1500	1250	1250	1250	1250	1250	1250	1250	1250	1250	12
15	2000		1750											1500									15
18															1500	1500	1500						18
21		1750			1500													1500	1500	1500	1500		21
24																						1500	24
27																							27
30																							30
33	1750																						33
36																							36
39	1800	1700	1600	1600														1600	1600	1600	1600	1600	39
42															1600	1600	1600						42
45	1700													1600									45
48				1500									1600							1700	1700	1700	48
51												1600						1700	1700				51
54		1600									1600						1700						54
57																1700						1800	57
60															1700					1800	1800		60
63			1550			1450	1450			1550	1550				1650	1650			1750	1750	1750		63
66														1650		1700		1750			1800		66
69																				1800		1850	69
72	1650												1650		1700		1750		1800		1850		72
75											1600												75
78									1550							1750		1800		1850		1900	78
81														1700					1850		1900		81
84							1500					1650					1800					1950	84
87															1750					1900			87
90						1500												1850			1950		90
93										1600			1700			1800			1900				93
96																						2000	96
102														1750			1850			1950	2000		102
108																		1900				2050	108

JACKED R.C.P. TRENCH WIDTH = O.D.

DATA:

Load factor = 1.8

Live load = Railroad Coopers E72

NOTE:

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
G.D.M.	MARK	DATE	DESCRIPTION
CHECKED BY			
V.C.M.			
DESIGNED BY			
F.R.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: DIVISION ENGINEER (DESIGN)

APPROVAL RECOMMENDED BY: ASST. CHIEF DEPUTY ENGINEER

APPROVED BY: CHIEF ENGINEER 12/22/70

SCALE	DATE	DWG. NO.
NONE	DEC. '70	2-D213.16

SHEET 16 OF 27

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE DESIGN DENSITY = 120 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																					PIPE SIZE
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2250	2000	2000	1750	1750	1750	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1250	1250	1250	1250	1250	1250	12
15	2000		1750			1500											1500	1500					15
18																			1500	1500	1500	1500	18
21																							21
24		1750																					24
27																							27
30																							30
33													1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	33
36											1750	1750											36
39	1800	1700	1700	1600	1600					1600	1600	1600	1600	1600	1600	1600	1600	1600	1700	1700	1700	1700	39
42			1600						1600							1700	1700	1700					42
45														1700	1700							1800	45
48								1600					1700						1800	1800	1800		48
51																		1800					51
54												1700					1800					1900	54
57	1700															1800					1900		57
60						1600	1600				1700				1800				1900	1900			60
63		1650		1550	1550	1550	1550	1550			1650	1650			1750				1850	1850			63
66												1700		1750				1850		1900		1950	66
69															1800		1850		1900		1950		69
72										1650			1750					1900		1950		2000	72
75																1850					2000		75
78											1700			1800			1900		1950			2050	78
81								1600												2000			81
84															1850			1950			2050		84
87												1750				1900			2000			2100	87
90													1800				1950			2050	2050	2100	90
93									1650												2100		93
96														1850				2000				2150	96
102										1700					1900								102
108																1950	2000				2150	2200	108

JACKED RCP TRENCH WIDTH = O.D

DATA:

Load factor = 1.8

Live load = Railroad Coopers E72

NOTE:

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
JCD	MARK	DATE	DESCRIPTION
CHECKED BY			
JJS			
DESIGNED BY			
F.R.			
SUBMITTED BY			
CWH			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: Division Engineer (Design)

APPROVAL RECOMMENDED BY: Asst. Chief Deputy Engineer

APPROVED BY: A. E. Pennington, Chief Engineer, 12/22/70

SCALE	DATE	DWG. NO.
NONE	DEC '70	2-D213.17

SHEET 17 OF 27

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RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE DESIGN DENSITY = 130 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																						PIPE SIZE
	4'	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2250	2000	2000	1750	1750	1750	1750	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1250	1250	1250	12
15	2000						1500													1500	1500	1500	15
18			1750																				18
21																							21
24							1750	1750	1750	1750													24
27		1750									1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	27
30																							30
33																							33
36																							36
39	1800	1800	1700	1700	1600	1600	1600	1600	1600	1600	1700	1700	1700	1700	1700	1700	1700	1700	1800	1800	1800	1800	39
42		1700														1800	1800	1800					42
45										1700					1800						1900	1900	45
48				1600										1800					1900	1900			48
51									1700				1800					1900					51
54																	1900				2000	2000	54
57												1800				1900				2000			57
60															1900				2000				60
63	1750		1650					1650	1650		1750	1750			1850			1950	1950			2050	63
66														1850			1950		2000		2050		66
69												1800			1900			2000		2050		2100	69
72									1700				1850			1950			2050		2100		72
75																	2000			2100		2150	75
78										1750				1900				2050			2150		78
81															1950				2100			2200	81
84		1650									1800					2000				2150			84
87												1850					2050				2200		87
90	1700												1900				2050	2100	2150	2150	2200	2250	90
93														1950						2200			93
96							1650								2000	2050					2250		96
102																	2100	2150	2200			2300	102
108								1700												2250	2300	2350	108

JACKED R.C.P. TRENCH WIDTH = O.D.

DATA:

Load factor = 1.8

Live load – Railroad Coopers E72

NOTE:

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
J.C.D.	MARK	DATE	DESCRIPTION
CHECKED BY J.C.C.			
DESIGNED BY Y.S.			
SUBMITTED BY C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: DIVISION ENGINEER

APPROVAL RECOMMENDED BY: ASST. CHIEF DEPUTY ENGINEER

APPROVED BY: CHIEF ENGINEER 12/22/70

SCALE	DATE	DWG. NO. 2-0213.18
NONE	DEC '70	SHEET 18 OF 27

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE DESIGN DENSITY = 140 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																						PIPE SIZE
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2250	2000	2000	2000	1750	1750	1750	1750	1750	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	12
15				1750						1750													15
18	2000										1750	1750											18
21													1750	1750	1750	1750	1750	1750					21
24			1750																1750	1750	1750	1750	24
27																							27
30																							30
33																							33
36		1750																	2000	2000	2000	2000	36
39	1900	1800	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1800	1800	1800	1800	1800	1800	1900	1900	1900	1900	39
42	1800											1800					1900	1900					42
45											1800				1900	1900					2000	2000	45
48										1800				1900					2000	2000			48
51													1900				2000	2000				2100	51
54																2000				2100	2100		54
57									1800			1900							2100				57
60															2000			2100				2150	60
63		1750		1650	1650	1650	1650		1750			1850			1950						2150		63
66		1700									1850			1950			2050			2150		2200	66
69	1750														2000	2050			2150		2200		69
72							1700					1900	1950				2100			2200		2300	72
75														2000				2150			2250		75
78								1750							2050				2200	2250			78
81									1800							2100	2150				2300	2300	81
84										1850								2200	2250			2350	84
87											1900	1950	2000							2300			87
90														2050	2100	2100	2150	2200	2250		2350	2400	90
93																2150	2200	2250					93
96																			2300	2350	2400		96
102						1700							2000									2450	102
108													2050	2100	2150	2200	2250	2300	2350	2400	2450	2500	108

JACKED R.C.P. TRENCH WIDTH = O.D.

DATA:

Load factor = 1.8

Live load – Railroad Coopers E72

NOTE:

For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
JCH	MARK	DATE	DESCRIPTION
CHECKED BY			
CYL			
DESIGNED BY			
GS			
SUBMITTED BY			
CWH			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: DIVISION ENGINEER (Design)

APPROVAL RECOMMENDED BY: ASS'T CHIEF/DEPUTY ENGINEER

APPROVED BY: CHIEF ENGINEER 12/24/70

SCALE	DATE	DWG. NO. 2-D213.19
NONE	DEC '70	SHEET 19 OF 27

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D177

CASE III BEDDING DESIGN DENSITY = 110 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																							PIPE SIZE
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	12
15		2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500		2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	15
18	2500			2250	2250	2250	2250	2250	2250	2250				2500	2500	2500	2500	2500	2500						18
21		2250	2250								2250	2250	2250							2500	2500	2500	2500	2500	21
24							2000	2000						2250	2250										24
27	2250				2000	2000			2000	2000						2250	2250								27
30				2000							2000							2250							30
33			2000									2000							2250						33
36													2000							2250					36
39	2200	2000		1900	1900	1900	1900	1800	1900	1900	1900			2100	2100	2100	2200	2200	2200	2300	2300	2300	2400	2400	39
42	2100					1800	1800		1800					2000									2300		42
45			1900		1800							1900					2100			2200					45
48										1800															48
51															2000										51
54				1800																					54
57													1900					2100							57
60		1900				1700	1700				1800														60
63	2050		1850		1750	1700			1750	1750		1850		1950		2050	2050		2150		2250	2250		2350	63
66	2000			1750					1700																66
69			1800													2000									69
72					1700										1950										72
75														1900											75
78													1850												78
81							1650	1650				1800										2300	2300	2250	81
84		1850									1750														84
87						1850				1700															87
90									1650								2050	2100	2150	2200	2250				90
93	1950			1700																			2350		93
96																									96
102			1750																					2400	102
108					1650																				108

TRENCH CONDITION – TRENCH WIDTH = O.D. + 20 INCHES

DATA:

Load factor = 1.8

Live load – Railroad Coopers E-75

NOTES:

1. For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
G.D.M.	MARK	DATE	DESCRIPTION
CHECKED BY			
G.S.			
DESIGNED BY			
J.J.S.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: Division Engineer (Design)

APPROVED BY: A. E. Bumgardner, Chief Engineer, 12/1/70

SCALE	DATE	DWG. NO. 2-0213.20
NONE	DEC. '70	SHEET 20 OF 27

S-57

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D177

CASE III BEDDING DESIGN DENSITY = 120 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																								PIPE SIZE
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	3000	2750	2750	2750	2750	2750	2750	2750	2750	2750	3000	3000	3000	3000	3000	3000	3250	3250	3250	3250	3250	3250	3250	3250	12
15	2750		2500	2500	2500	2500	2500	2500	2500		2750	2750	2750	2750	2750	2750	3000	3000	3000	3000	3000	3000	3000	3000	15
18	2500	2500								2500	2500	2500	2500				2750	2750	2750	2750	2750	2750			18
21			2250	2250	2250	2250	2250	2250	2250	2250				2500	2500	2500							2750	2750	21
24		2250									2250						2500	2500							24
27												2250	2250						2500	2500					27
30	2250				2000	2000	2000	2000						2250							2500				30
33				2000					2000						2250							2500			33
36			2000							2000						2250							2500		36
39	2200	2100			1900	1900	1900				2100	2100	2100	2200	2200	2300	2300	2400	2400	2400				2600	39
42					1900				1900		2000							2300						2500	42
45	2100	2000		1900												2200					2400				45
48										1900		2000		2100											48
51			1900																						51
54						1800	1800	1800											2300						54
57					1800																				57
60															2100		2200								60
63	2050	1950		1850					1800	1850	1900	1950	2000	2050		2150		2250		2350		2450			63
66			1850	1800																					66
69						1750	1750																		69
72		1900						1750																2550	72
75	2000				1750																			2850	75
78																									78
81									1750										2300	2350	2400	2450	2800		81
84										1800	1850														84
87			1800									1900													87
90				1750									1950	2050	2100	2100	2200	2250							90
93																									93
96						1700	1700							2000											96
102								1700																	102
108		1850			1700										2050										108

TRENCH CONDITION – TRENCH WIDTH = O.D. + 20 INCHES

DATA:

Load factor = 1.8

Live load – Railroad Coopers E-75

NOTES:

1. For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
GDM	MARK	DATE	DESCRIPTION
CHECKED BY			
YLC			
DESIGNED BY			
JCC			
SUBMITTED BY			
CWH			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: E. Grube, DIVISION ENGINEER (HYDRAULIC)

APPROVAL RECOMMENDED BY: C. Tragresser, ASST. CHIEF DEPUTY ENGINEER

APPROVED BY: A. E. Plumley, CHIEF ENGINEER 12/22/71

SCALE	DATE	DWG. NO. 2-D213.21
NONE	DEC. '70	SHEET 21 OF 27

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D177

CASE III BEDDING DESIGN DENSITY = 130 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																									PIPE SIZE
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25		
12	3000	3000	2750	2750	2750	3000	3000	3000	3000	3000	3000	3000	3250	3250	3250	3250	3250	3250	3500	3500	3500	3500	3500	3500		12
15	2750	2750				2750	2750	2750	2750	2750	2750	2750	3000	3000	3000	3000	3000	3000	3250	3250	3250	3250	3250	3250		15
18	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500			2750	2750	2750				3000	3000	3000	3000	3000	3000		18
21											2500	2500				2750	2750	2750	2750							21
24			2250	2250	2250	2250	2250	2250	2250				2500	2500						2750	2750					24
27		2250								2250					2500							2750	2750			27
30	2250										2250					2500	2500							2750		30
33												2250														33
36					2000	2000	2000											2500								36
39	2200	2100	2100	2000				2000	2100	2100	2200	2200	2300	2300	2400	2400			2500	2600	2600	2700	2700	2700		39
42			2000						2000		2100						2400									42
45						1900							2200		2300							2600				45
48										2000																48
51	2100	2000			1900		1900	1900				2100								2500						51
54				1900										2200		2300		2400								54
57																										57
60									1900																	60
63	2050		1900		1850	1850	1850			1950	2000		2150		2250		2350		2450		2550		2650		63
66		1950		1850				1850				2050														66
69													2100													69
72														2150												72
75						1800			1850												2500	2800	2650	2700		75
78					1800		1800								2200											78
81			1850							1900						2300	2350	2400	2450	2500						81
84	2000							1800																		84
87		1900		1800							1950					2250										87
90												2050	2100	2100	2200	2250										90
93												2000												2750		93
96																							2700			96
102																										102
108						1750							2050									2650				108

TRENCH CONDITION — TRENCH WIDTH = O.D. + 20 INCHES

DATA:

Load factor = 1.8

Live load Railroad Coopers E-75

NOTES:

1. For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
G.D.M.	MARK	DATE	DESCRIPTION
CHECKED BY			
G.S.			
DESIGNED BY			
J.J.S.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: DIVISION ENGINEER (OPERATIONS)

APPROVAL RECOMMENDED BY: ASS'T CHIEF/DEPUTY ENGINEER

APPROVED BY: A. E. Bennington 12/24/70 CHIEF ENGINEER

SCALE	DATE	DWG. NO.
NONE	DEC. '70	2-D213.22

SHEET 22 OF 27

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D177

CASE III BEDDING DESIGN DENSITY = 140 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																								PIPE SIZE
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	3000	3000	3000	3000	3000	3000	3000	3000	3000	3250	3250	3250	3250	3500	3500	3500	3500	3500	3500	3500	3750	3750	3750	3750	12
15	2750	2750	2750	2750	2750	2750	2750	2750	2750	3000	3000	3000	3000	3250	3250	3250	3250	3250	3250	3250	3500	3500	3500	3500	15
18		2500	2500	2500	2500	2500	2500			2750	2750	2750		3000	3000	3000	3000	3000			3250	3250	3250	3250	18
21	2500							2500	2500	2500			2750	2750					3000	3000	3000				21
24											2500				2750	2750						3000	3000	3000	24
27		2250	2250	2250	2250	2250	2250	2250				2500					2750	2750							27
30									2250				2500						2750						30
33	2250									2250				2500						2750					33
36															2500										36
39	2200	2200	2100	2100	2100	2100	2100	2100	2000	2200	2300	2300	2400			2600	2600	2700	2700	2700	2800	2800	2900	2900	39
42		2100							2100					2400		2500		2600							42
45				2000	2000	2000	2000				2200														45
48			2000										2300										2800		48
51								2000		2100					2400										51
54	2100											2200					2500								54
57									2000										2600		2700				57
60		2000												2300											60
63			1950	1950	1900	1900	1950	1950		2050	2150		2250			2450		2550		2650		2750		2850	63
66				1900											2350								2800	2850	66
69	2050						1900					2150											2800	2900	69
72									1950							2400									72
75			1900					1900										2550	2600	2650	2700	2800			75
78		1950								2000			2200												78
81					1850	1850								2300	2350	2400	2500								81
84																	2450								84
87				1850							2050														87
90							1850				2050	2150	2200	2250											90
93																					2750				93
96																									96
102	2000								1900		2050	2100													102
108			1850					1850																	108

TRENCH CONDITION – TRENCH WIDTH = O.D.+ 20 INCHES

DATA:

Load factor = 1.8

Live load – Railroad Coopers E-75

NOTES:

1. For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
G.D.M.	MARK	DATE	DESCRIPTION
CHECKED BY			
J.C.C.			
DESIGNED BY			
Y.L.C.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: DIVISION ENGINEER (DESIGN)

APPROVAL RECOMMENDED BY: ASST. CHIEF DEPUTY ENGINEER

APPROVED BY: CHIEF ENGINEER 12/22/70

SCALE	DATE	DWG. NO. 2-D213.23
NONE	DEC. '70	SHEET 23 OF 27

S-60

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D177

CASE III BEDDING DESIGN DENSITY = 110 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																								PIPE SIZE
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2750	2750	2750	2500	2500	2500	2500	2500	2500	2750	2750	2750	2750	2750	2750	3000	3000	3000	3000	3000	3000	3000	3000	3000	12
15	2500	2500	2500							2500	2500	2500	2500	2500		2750	2750	2750	2750	2750	2750	2750	2750	2750	15
18			2250	2250	2250	2250	2250	2250	2250	2250	2250				2500	2500	2500	2500	2500	2500					18
21		2250										2250	2250	2250							2500	2500	2500	2500	21
24	2250				2000	2000	2000	2000	2000						2250	2250									24
27			2000	2000						2000							2250	2250							27
30											2000	2000							2250						30
33		2000																		2250					33
36													2000								2250				36
39	2100		1900	1900	1800	1800	1800	1800	1800	1900	1900			2000	2100	2100	2200	2200	2200	2300	2300	2300	2300	2400	39
42				1800								1900					2100			2200					42
45	2000	1900								1800					2000										45
48													1900					2100							48
51			1800				1700	1700																	51
54						1700					1800										2200				54
57					1700				1700							2000									57
60																									60
63	1950	1850		1750						1750		1850		1900	1950		2050		2150			2250		2350	63
66			1750				1650	1650				1800	1850												66
69				1700		1650					1750									2150					69
72										1700															72
75					1650				1650																75
78	1900	1800																							78
81																							2300	2350	81
84																									84
87																									87
90							1600										2050	2100	2150	2150	2200	2250			90
93			1700	1650				1600																	93
96						1600																			96
102																				2200					102
108										1650	1700	1750	1800	1850	1900						2250				108

TRENCH CONDITION – TRENCH WIDTH = O.D. + 20 INCHES

DATA:

Load factor = 1.8

Live load – Railroad Coopers E-72

NOTES:

1. For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
J.C.D.	MARK	DATE	DESCRIPTION
CHECKED BY J.J.S.			
DESIGNED BY Y.S.			
SUBMITTED BY C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY H. Milne
DIVISION ENGINEER (DESIGN)

APPROVAL RECOMMENDED BY C. Magnuson
ASST. CHIEF DEPUTY ENGINEER

APPROVED BY A. E. Bumpton 12/22/70
CHIEF ENGINEER

SCALE	DATE	DWG. NO. 2-D213.24
NONE	DEC. '70	SHEET 24 OF 27

S-69

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D177

CASE III BEDDING DESIGN DENSITY = 120 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																								PIPE SIZE
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	3000	3000	3000	3000	3000	3000	3250	3250	3250	3250	3250	3250	3250	12
15	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500		2750	2750	2750	2750	2750	2750	3000	3000	3000	3000	3000	3000	3000	15
18				2250	2250	2250	2250	2250			2500	2500	2500	2500				2750	2750	2750	2750	2750	2750		18
21		2250	2250						2250	2250					2500	2500	2500							2750	21
24	2250										2250	2250						2500	2500						24
27					2000	2000	2000						2250							2500	2500				27
30				2000				2000	2000					2250	2250							2500			30
33			2000							2000													2500		33
36		2000														2250									36
39	2100			1900	1900	1900	1900	1900	1900		2000	2100	2100	2200	2200	2300	2300	2300	2400	2400	2400			2500	39
42			1900											2100		2200									42
45										1900		2000							2300						45
48					1800	1800	1800	1800																	48
51	2000																2200								51
54		1900		1800					1800		1900		2000		2100							2400			54
57																									57
60																									60
63			1800		1750	1750	1750	1750		1850		1950		2050		2150		2250		2350			2450		63
66	1950			1750																					66
69		1850							1750	1800															69
72											1850	1900													72
75						1700	1700						1950	2000											75
78					1700										2050							2450			78
81								1700								2100			2300	2350	2400	2450	2450	2500	81
84																	2150						2500		84
87			1750																					2550	87
90															2050	2100	2150	2250							90
93	1900			1700														2300							93
96		1800																							96
102									1700	1750															102
108						1650	1650				1800														108

TRENCH CONDITION — TRENCH WIDTH = O.D. + 20 INCHES

DATA:

Load factor = 1.8

Live load – Railroad Coopers E-72

NOTES:

1. For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
G.D.M.	MARK	DATE	DESCRIPTION
CHECKED BY			
J.S.S.			
DESIGNED BY			
F.R.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: DIVISION ENGINEER (HIGHWAYS)

APPROVAL RECOMMENDED BY: ASST CHIEF DEPUTY ENGINEER

APPROVED BY: A. E. Bruington 12/24/70 CHIEF ENGINEER

SCALE	DATE	DWG. NO. 2-D213.25
NONE	DEC. '70	SHEET 25 OF 27

S-62

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D177

CASE III BEDDING DESIGN DENSITY = 130 p.c.f.

PIPE SIZE	DEPTH OF COVER IN FEET																								PIPE SIZE
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	2750	2750	2750	2750	2750	2750	2750	3000	3000	3000	3000	3000	3250	3250	3250	3250	3250	3250	3250	3500	3500	3500	3500	3500	12
15		2500	2500	2500	2500	2500	2500	2750	2750	2750	2750	2750	3000	3000	3000	3000	3000	3000	3000	3250	3250	3250	3250	3250	15
18	2500							2500	2500	2500			2750	2750	2750	2750				3000	3000	3000	3000	3000	18
21			2250	2250	2250	2250	2250	2250			2500	2500	2500				2750	2750	2750						21
24		2250							2250					2500	2500					2750	2750	2750			24
27	2250									2250	2250					2500							2750	2750	27
30												2250					2500								30
33				2000	2000	2000	2000											2500							33
36			2000					2000					2250						2500						36
39	2100	2100							2000	2100	2100	2200	2200	2300	2300	2400	2400			2600	2600	2600	2700	2700	39
42		2000		1900	1900	1900																			42
45				1900			1900			2000										2500					45
48			1900					1900				2100		2200		2300		2400							48
51									1900																51
54																									54
57	2000										2000														57
60		1900											2100												60
63			1850	1850	1800	1800	1850	1850		1950		2050		2150	2250		2350		2450		2550		2650		63
66				1800			1800		1850						2200										66
69										1900						2250									69
72								1800			1950						2300								72
75	1950																			2550	2600	2650	2700	2750	75
78			1800									2000													78
81		1850			1750	1750											2300	2350	2400	2500					81
84													2050												84
87							1750		1800																87
90				1750									2050	2150	2200	2250									90
93														2100											93
96										1850															96
102								1750																	102
108	1900										1900													2750	108

TRENCH CONDITION – TRENCH WIDTH = O.D. + 20 INCHES

DATA:

Load factor = 1.8

Live load – Railroad Coopers E-72

NOTES:

1. For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
JCH	MARK	DATE	DESCRIPTION
CHECKED BY			
AYC			
DESIGNED BY			
JCC			
SUBMITTED BY			
CWH			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY: DIVISION ENGINEER (HEADS)

APPROVAL RECOMMENDED BY: ASST. CHIEF/DEPUTY ENGINEER

APPROVED BY: CHIEF ENGINEER — 12/22/70

SCALE	DATE	DWG. NO.
NONE	DEC. '70	2-D21326
		SHEET 26 OF 27

S-193

RAILROAD

REQUIRED "D" LOAD FOR REINFORCED CONCRETE PIPE LAID PER STD. DWG. 2-D177

CASE III BEDDING DESIGN DENSITY = 140 P.C.F.

PIPE SIZE	DEPTH OF COVER IN FEET																							PIPE SIZE
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
12	3000	2750	2750	3000	3000	3000	3000	3000	3000	3250	3250	3250	3250	3250	3500	3500	3500	3500	3500	3500	3500	3750	3750	3750	12
15	2750			2750	2750	2750	2750	2750	2750	2750	3000	3000	3000	3000	3250	3250	3250	3250	3250	3250	3250	3500	3500	3500	15
18	2500	2500	2500	2500	2500	2500	2500	2500			2750	2750			3000	3000	3000	3000				3250	3250	3250	18
21									2500	2500			2750	2750	2750				3000	3000	3000	3000			21
24		2250	2250	2250	2250	2250	2250				2500	2500				2750	2750						3000	3000	24
27	2250							2250	2250				2500					2750							27
30										2250				2500					2750						30
33															2500					2750					33
36											2250										2750				36
39	2200	2100	2100	2000	2000	2000	2100	2100	2100	2200	2300	2300	2400	2400		2500	2600	2600	2700	2700	2800	2800	2900	2900	39
42	2100		2000				2000				2200		2300										2800		42
45		2000						2000		2100					2400										45
48																	2500		2600		2700				48
51									2000			2200													51
54				1900	1900	1900								2300											54
57			1900				1900				2100														57
60																2400									60
63	2000	1950						1950	1950	2050		2150	2250		2350			2550		2650		2750		2850	63
66				1850	1850	1850		1900		2000			2200				2450						2800	2850	66
69																									69
72		1900					1850							2250											72
75			1850								2050							2500	2600	2650	2700	2750			75
78																									78
81									1900						2250	2400	2450	2500						2900	81
84	1950				1800			1850				2100			2300										84
87				1800		1800																	2850		87
90										1950	2050	2100	2200	2250											90
93																									93
96													2150												96
102		1850	1800				1800															2800			102
108											2000														108

TRENCH CONDITION – TRENCH WIDTH = O.D. + 20 INCHES

DATA:

Load factor = 1.8

Live load – Railroad Coopers E-72

NOTES:

1. For General Notes see Sheet 1.

DRAWN BY	REVISIONS		
JCH	MARK	DATE	DESCRIPTION
CHECKED BY JJS			
DESIGNED BY FR			
SUBMITTED BY CWH			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR
DESIGN OF REINFORCED
CONCRETE PIPE

RECOMMENDED BY _____ DIVISION ENGINEER (DESIGN)

APPROVAL RECOMMENDED BY _____ ASST. CHIEF DEPUTY ENGINEER

APPROVED BY A. C. Bruington 12/22/70 CHIEF ENGINEER

SCALE	DATE	DWG. NO. 2-D213.27
NONE	DEC. '70	SHEET 27 OF 27

S-64

CASE III PER STANDARD DRAWING 2-DI77-PROJECTION CONDITION-UNRESTRICTED TRENCH WIDTH

WALL THICKNESS = 10-1/2 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	0.99	0.65	0.54	0.53	0.55	0.59	0.63	0.69	0.74	0.80	0.83	0.90	0.97	1.05	1.12	1.20	1.27	1.35	1.43	1.51
B	1.46	0.97	0.81	0.80	0.84	0.89	0.95	1.03	1.11	1.20	1.24	1.34	1.44	1.55	1.65	1.76	1.87	1.99	2.10	2.22
C	0.99	0.65	0.54	0.53	0.55	0.59	0.63	0.69	0.74	0.80	0.83	0.90	0.97	1.05	1.12	1.20	1.27	1.35	1.43	1.51
D	0.48	0.32	0.27	0.27	0.28	0.30	0.32	0.34	0.37	0.39	0.41	0.44	0.47	0.50	0.53	0.57	0.77	1.14	1.61	2.23
C+D	1.46	0.97	0.81	0.80	0.84	0.89	0.95	1.03	1.11	1.20	1.24	1.34	1.44	1.55	1.65	1.76	2.04	2.49		
0.8D	0.38	0.26	0.22	0.22	0.22	0.24	0.26	0.27	0.30	0.31	0.33	0.35	0.38	0.40	0.42	0.46	0.62	0.92	1.29	1.78

WALL THICKNESS = 10-1/2 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	0.99	0.65	0.54	0.53	0.55	0.59	0.63	0.69	0.74	0.80	0.83	0.90	0.97	1.05	1.12	1.20	1.27	1.35	1.43	1.51
B	1.55	1.03	0.86	0.85	0.89	0.94	1.01	1.09	1.18	1.27	1.31	1.42	1.53	1.64	1.76	1.87	1.99	2.11	2.23	2.35
C	0.99	0.65	0.54	0.53	0.55	0.59	0.63	0.69	0.74	0.80	0.83	0.90	0.97	1.05	1.12	1.20	1.27	1.35	1.43	1.51
D	0.51	0.34	0.29	0.29	0.30	0.32	0.34	0.36	0.39	0.42	0.43	0.47	0.50	0.54	0.68	1.06	1.54	2.19		
C+D	1.55	1.03	0.86	0.85	0.89	0.94	1.01	1.09	1.18	1.27	1.31	1.42	1.53	1.64	1.87	2.32	2.89			
0.8D	0.41	0.27	0.23	0.23	0.24	0.26	0.27	0.29	0.31	0.34	0.34	0.38	0.40	0.43	0.54	0.85	1.23	1.75		

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	0.86	0.56	0.47	0.47	0.48	0.51	0.55	0.59	0.64	0.69	0.72	0.78	0.84	0.90	0.96	1.03	1.09	1.16	1.22	1.29
B	1.32	0.87	0.73	0.73	0.75	0.80	0.85	0.92	0.99	1.07	1.11	1.19	1.28	1.38	1.47	1.57	1.66	1.76	1.86	1.96
C	0.86	0.56	0.47	0.47	0.48	0.51	0.55	0.59	0.64	0.69	0.72	0.78	0.84	0.90	0.96	1.03	1.09	1.16	1.22	1.29
D	0.46	0.31	0.26	0.26	0.27	0.28	0.30	0.32	0.35	0.37	0.39	0.42	0.45	0.48	0.51	0.54	0.57	0.61	0.64	0.67
C+D	1.32	0.87	0.73	0.73	0.75	0.80	0.85	0.92	0.99	1.07	1.11	1.19	1.28	1.38	1.47	1.57	1.66	1.76	1.86	1.96
0.8D	0.37	0.25	0.21	0.21	0.22	0.22	0.24	0.26	0.28	0.30	0.31	0.34	0.36	0.38	0.41	0.43	0.46	0.49	0.51	0.54

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	0.86	0.56	0.47	0.47	0.48	0.51	0.55	0.59	0.64	0.69	0.72	0.78	0.84	0.90	0.96	1.03	1.09	1.16	1.22	1.29
B	1.39	0.92	0.77	0.76	0.79	0.84	0.90	0.97	1.04	1.12	1.16	1.26	1.35	1.45	1.55	1.65	1.75	1.85	1.96	2.07
C	0.86	0.56	0.47	0.47	0.48	0.51	0.55	0.59	0.64	0.69	0.72	0.78	0.84	0.90	0.96	1.03	1.09	1.16	1.22	1.29
D	0.49	0.33	0.28	0.28	0.29	0.30	0.32	0.34	0.37	0.40	0.41	0.44	0.47	0.51	0.54	0.57	0.61	0.64	0.68	0.86
C+D	1.39	0.92	0.77	0.76	0.79	0.84	0.90	0.97	1.04	1.12	1.16	1.26	1.35	1.45	1.55	1.65	1.75	1.85	1.96	2.21
0.8D	0.39	0.26	0.22	0.22	0.23	0.24	0.26	0.27	0.30	0.32	0.33	0.35	0.38	0.41	0.43	0.46	0.49	0.51	0.54	0.69

CASE III PER STANDARD DRAWING 2-DI77-DITCH CONDITION-TRENCH WIDTH = O.D. + 24 INCHES

WALL THICKNESS = 10-1/2 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.74	0.78	0.82	0.86	0.90	0.93	0.97	1.01	1.04	1.08
B	1.10	1.16	1.22	1.27	1.33	1.38	1.44	1.49	1.54	1.59
C	0.74	0.78	0.82	0.86	0.90	0.93	0.97	1.01	1.04	1.08
D	0.36	0.38	0.40	0.42	0.43	0.45	0.47	0.48	0.50	0.51
C+D	1.10	1.16	1.22	1.27	1.33	1.38	1.44	1.49	1.54	1.59
0.8D	0.29	0.30	0.32	0.34	0.34	0.36	0.38	0.38	0.40	0.41

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.64	0.67	0.71	0.74	0.77	0.81	0.84	0.87	0.90	0.93
B	0.98	1.04	1.09	1.14	1.19	1.24	1.28	1.33	1.38	1.42
C	0.64	0.67	0.71	0.74	0.77	0.81	0.84	0.87	0.90	0.93
D	0.35	0.36	0.38	0.40	0.42	0.43	0.45	0.46	0.48	0.49
C+D	0.98	1.04	1.09	1.14	1.19	1.24	1.28	1.33	1.38	1.42
0.8D	0.28	0.29	0.30	0.32	0.34	0.34	0.36	0.37	0.38	0.39

WALL THICKNESS = 10-1/2 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.74	0.78	0.82	0.86	0.90	0.93	0.97	1.01	1.04	1.08
B	1.17	1.23	1.29	1.35	1.41	1.47	1.52	1.58	1.63	1.69
C	0.74	0.78	0.82	0.86	0.90	0.93	0.97	1.01	1.04	1.08
D	0.39	0.41	0.43	0.45	0.46	0.48	0.50	0.52	0.53	0.55
C+D	1.17	1.23	1.29	1.35	1.41	1.47	1.52	1.58	1.63	1.69
0.8D	0.31	0.33	0.34	0.36	0.37	0.38	0.40	0.42	0.42	0.44

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

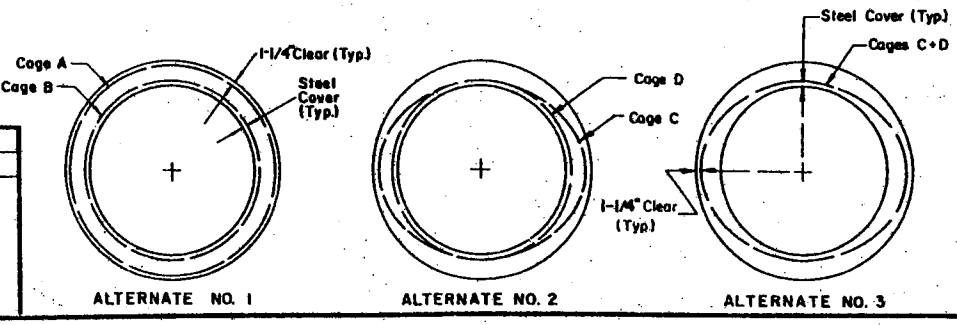
CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.64	0.67	0.71	0.74	0.77	0.81	0.84	0.87	0.90	0.93
B	1.04	1.09	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.49
C	0.64	0.67	0.71	0.74	0.77	0.81	0.84	0.87	0.90	0.93
D	0.37	0.39	0.40	0.42	0.44	0.46	0.47	0.49	0.51	0.52
C+D	1.04	1.09	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.49
0.8D	0.30	0.31	0.32	0.34	0.35	0.37	0.38	0.39	0.41	0.42

NOTES:

1. THE VALUES SHOWN APPLY ONLY FOR THE BEDDING AND LOADING CONDITIONS NOTED.
2. FOR COVERS OF 10FT. OR LESS, PIPE SHALL BE DESIGNED FOR THE PROJECTION CONDITION WITH UNRESTRICTED TRENCH WIDTH.
3. FOR COVERS OVER 10FT., PIPE SHALL BE DESIGNED FOR APPLICABLE CONDITION. FOR DITCH CONDITION USE O.D. + 24 IN.

DESIGN DATA:

EARTH LOAD PER MARSTON'S FORMULAS:
W = 110 p.c.f. (CORRESPONDING TO AN ACTUAL EARTH WEIGHT)
K = K' = .150
LIVE LOAD = 1-H20-S16 TRUCK
LOADS UNIFORM OVER 180° TOP AND 90° BOTTOM.
NO LATERAL LOADS
f'_c = 4500 p.s.i. fs = 24,000 p.s.i.
fc = 2025 p.s.i. n = 8



DRAWN BY	REVISIONS		
J.C.H.	MARK	DATE	DESCRIPTION
CHECKED BY			
R.J.S.			
DESIGNED BY			
V.C.M.			
SUBMITTED BY			
C.W.H.			

SUPERSEDES DWG. NO. 2-D214.1-4 DATED JAN. '55

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

STEEL AREAS FOR
114-INCH REINFORCED
CONCRETE PIPE

RECOMMENDED BY: DIVISION ENGINEER (DESIGN)
APPROVAL RECOMMENDED BY: ASST. CHIEF DEPUTY ENGINEER
APPROVED BY: CHIEF ENGINEER 1/5/70

SCALE	DATE	DWG. NO.
NONE	1-1-71	2-D214.1

SHEET 1 OF 6

S-165

CASE III PER STANDARD DRAWING 2-D177 - PROJECTION CONDITION - UNRESTRICTED TRENCH WIDTH

WALL THICKNESS = 11 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.06	0.69	0.57	0.57	0.59	0.63	0.67	0.73	0.78	0.85	0.88	0.95	1.02	1.10	1.17	1.25	1.33	1.41	1.49	1.58
B	1.57	1.04	0.86	0.86	0.89	0.94	1.01	1.09	1.17	1.26	1.31	1.41	1.52	1.62	1.73	1.85	1.96	2.08	2.20	2.32
C	1.06	0.69	0.57	0.57	0.59	0.63	0.67	0.73	0.78	0.85	0.88	0.95	1.02	1.10	1.17	1.25	1.33	1.41	1.49	1.58
D	0.51	0.34	0.29	0.29	0.30	0.32	0.34	0.36	0.39	0.41	0.43	0.46	0.49	0.53	0.56	0.59	0.75	1.11	1.58	2.18
C+D	1.57	1.04	0.86	0.86	0.89	0.94	1.01	1.09	1.17	1.26	1.31	1.41	1.52	1.62	1.73	1.85	2.08	2.53		
0.8D	0.41	0.28	0.24	0.24	0.24	0.26	0.28	0.29	0.32	0.33	0.35	0.37	0.40	0.43	0.45	0.48	0.60	0.89	1.27	1.75

WALL THICKNESS = 11 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.06	0.69	0.57	0.57	0.59	0.63	0.67	0.73	0.78	0.85	0.88	0.95	1.02	1.10	1.17	1.25	1.33	1.41	1.49	1.58
B	1.66	1.09	0.91	0.91	0.94	1.00	1.07	1.15	1.24	1.33	1.38	1.49	1.60	1.72	1.83	1.95	2.07	2.20	2.32	2.45
C	1.06	0.69	0.57	0.57	0.59	0.63	0.67	0.73	0.78	0.85	0.88	0.95	1.02	1.10	1.17	1.25	1.33	1.41	1.49	1.58
D	0.54	0.37	0.31	0.31	0.32	0.34	0.36	0.38	0.41	0.44	0.46	0.49	0.52	0.56	0.64	1.00	1.47	2.08	2.89	
C+D	1.66	1.09	0.91	0.91	0.94	1.00	1.07	1.15	1.24	1.33	1.38	1.49	1.60	1.72	1.88	2.32	2.87			
0.8D	0.44	0.30	0.25	0.25	0.26	0.28	0.29	0.31	0.33	0.36	0.37	0.40	0.42	0.45	0.52	0.80	1.18	1.67	2.32	

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	0.97	0.63	0.52	0.52	0.54	0.57	0.62	0.66	0.71	0.77	0.80	0.86	0.93	1.00	1.06	1.13	1.21	1.28	1.35	1.43
B	1.47	0.97	0.81	0.80	0.83	0.88	0.94	1.01	1.09	1.17	1.21	1.31	1.41	1.50	1.61	1.71	1.81	1.92	2.03	2.14
C	0.97	0.63	0.52	0.52	0.54	0.57	0.62	0.66	0.71	0.77	0.80	0.86	0.93	1.00	1.06	1.13	1.21	1.28	1.35	1.43
D	0.50	0.33	0.28	0.28	0.29	0.31	0.33	0.35	0.37	0.40	0.41	0.45	0.48	0.51	0.54	0.57	0.61	0.64	0.68	0.79
C+D	1.47	0.97	0.81	0.80	0.83	0.88	0.94	1.01	1.09	1.17	1.21	1.31	1.41	1.50	1.61	1.71	1.81	1.92	2.03	2.21
0.8D	0.40	0.27	0.23	0.23	0.24	0.25	0.27	0.28	0.30	0.32	0.33	0.36	0.39	0.41	0.44	0.46	0.49	0.52	0.55	0.64

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	0.97	0.63	0.52	0.52	0.54	0.57	0.62	0.66	0.71	0.77	0.80	0.86	0.93	1.00	1.06	1.13	1.21	1.28	1.35	1.43
B	1.54	1.02	0.85	0.85	0.88	0.93	0.99	1.06	1.15	1.23	1.28	1.38	1.48	1.58	1.69	1.80	1.91	2.02	2.13	2.25
C	0.97	0.63	0.52	0.52	0.54	0.57	0.62	0.66	0.71	0.77	0.80	0.86	0.93	1.00	1.06	1.13	1.21	1.28	1.35	1.43
D	0.53	0.35	0.30	0.30	0.31	0.33	0.35	0.37	0.40	0.43	0.44	0.47	0.51	0.54	0.57	0.61	0.65	0.68	1.03	1.45
C+D	1.54	1.02	0.85	0.85	0.88	0.93	0.99	1.06	1.15	1.23	1.28	1.38	1.48	1.58	1.69	1.80	1.91	2.02	2.45	2.94
0.8D	0.43	0.28	0.24	0.24	0.25	0.27	0.28	0.30	0.32	0.35	0.36	0.38	0.41	0.44	0.46	0.49	0.52	0.55	0.83	1.16

CASE III PER STANDARD DRAWING 2-D177 - DITCH CONDITION - TRENCH WIDTH = O.D. + 24 INCHES

WALL THICKNESS = 11 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.78	0.83	0.87	0.91	0.95	0.99	1.03	1.07	1.10	1.14
B	1.17	1.23	1.29	1.35	1.41	1.47	1.52	1.58	1.63	1.69
C	0.78	0.83	0.87	0.91	0.95	0.99	1.03	1.07	1.10	1.14
D	0.38	0.40	0.42	0.44	0.46	0.48	0.49	0.51	0.53	0.54
C+D	1.17	1.23	1.29	1.35	1.41	1.47	1.52	1.58	1.63	1.69
0.8D	0.31	0.32	0.34	0.36	0.37	0.39	0.40	0.41	0.43	0.44

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.71	0.75	0.79	0.83	0.86	0.90	0.94	0.97	1.00	1.04
B	1.09	1.14	1.20	1.26	1.31	1.36	1.42	1.47	1.52	1.57
C	0.71	0.75	0.79	0.83	0.86	0.90	0.94	0.97	1.00	1.04
D	0.37	0.39	0.41	0.43	0.45	0.46	0.48	0.50	0.51	0.53
C+D	1.09	1.14	1.20	1.26	1.31	1.36	1.42	1.47	1.52	1.57
0.8D	0.30	0.32	0.33	0.35	0.36	0.37	0.39	0.40	0.41	0.43

WALL THICKNESS = 11 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.78	0.83	0.87	0.91	0.95	0.99	1.03	1.07	1.10	1.14
B	1.23	1.30	1.36	1.43	1.49	1.55	1.61	1.67	1.73	1.78
C	0.78	0.83	0.87	0.91	0.95	0.99	1.03	1.07	1.10	1.14
D	0.41	0.43	0.45	0.47	0.49	0.51	0.53	0.55	0.56	0.58
C+D	1.23	1.30	1.36	1.43	1.49	1.55	1.61	1.67	1.73	1.78
0.8D	0.33	0.35	0.36	0.38	0.40	0.41	0.43	0.44	0.45	0.47

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.71	0.75	0.79	0.83	0.86	0.90	0.94	0.97	1.00	1.04
B	1.14	1.20	1.26	1.32	1.38	1.43	1.49	1.54	1.60	1.65
C	0.71	0.75	0.79	0.83	0.86	0.90	0.94	0.97	1.00	1.04
D	0.40	0.42	0.44	0.45	0.47	0.49	0.51	0.53	0.54	0.56
C+D	1.14	1.20	1.26	1.32	1.38	1.43	1.49	1.54	1.60	1.65
0.8D	0.32	0.34	0.36	0.36	0.38	0.40	0.41	0.43	0.44	0.45

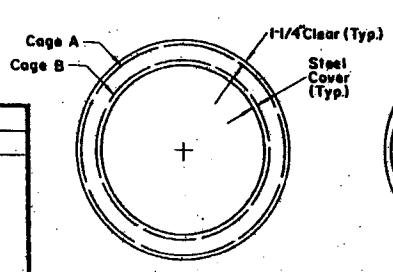
NOTES:

1. THE VALUES SHOWN APPLY ONLY FOR THE BEDDING AND LOADING CONDITIONS NOTED.
2. FOR COVERS OF 10FT. OR LESS, PIPE SHALL BE DESIGNED FOR THE PROJECTION CONDITION WITH UNRESTRICTED TRENCH WIDTH.
3. FOR COVERS OVER 10FT., PIPE SHALL BE DESIGNED FOR APPLICABLE CONDITION. FOR DITCH CONDITION USE O.D. + 24 IN.

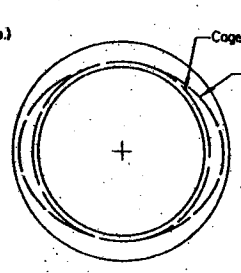
DESIGN DATA:

EARTH LOAD PER MARSTON'S FORMULAS:
W = 110 p.c.f. (CORRESPONDING TO AN ACTUAL EARTH WEIGHT)
K = K' = .150
LIVE LOAD = 1-H20-S16 TRUCK
LOADS UNIFORM OVER 180° TOP AND 90° BOTTOM.
NO LATERAL LOADS
f'_c = 4500 p.s.i. f_s = 24,000 p.s.i.
f_c = 2025 p.s.i. n = 8

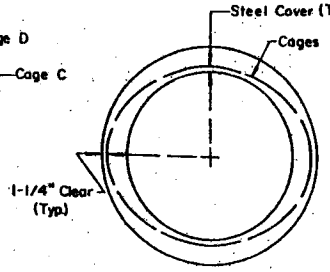
SUPERSEDES DWG. NO. 2-D214.1-.4 DATED JAN. '55



ALTERNATE NO. 1



ALTERNATE NO. 2



ALTERNATE NO. 3

DRAWN BY	REVISIONS		
J.C.H.	MARK	DATE	DESCRIPTION
CHECKED BY			
R.J.S.			
DESIGNED BY			
V.C.M.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

STEEL AREAS FOR 120-INCH REINFORCED CONCRETE PIPE

RECOMMENDED BY: DIVISION ENGINEER (DESIGN)
APPROVAL RECOMMENDED BY: ASST. CHIEF DEPUTY ENGINEER
APPROVED BY: CHIEF ENGINEER — 1/5/70

SCALE	DATE	DWG. NO.
NONE	1-1-71	2-D214.2

SHEET 2 OF 6

S-66

CASE III PER STANDARD DRAWING 2-D177-PROJECTION CONDITION-UNRESTRICTED TRENCH WIDTH

WALL THICKNESS = 11 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.19	0.77	0.64	0.63	0.66	0.70	0.73	0.80	0.87	0.94	0.97	1.05	1.13	1.21	1.29	1.38	1.47	1.55	1.64	1.73
B	1.75	1.14	0.95	0.93	0.98	1.04	1.11	1.19	1.28	1.38	1.43	1.54	1.65	1.77	1.89	2.01	2.13	2.26	2.39	2.52
C	1.19	0.77	0.64	0.63	0.66	0.70	0.75	0.80	0.87	0.94	0.97	1.05	1.13	1.21	1.29	1.38	1.47	1.55	1.64	1.73
D	0.56	0.37	0.31	0.31	0.32	0.34	0.36	0.39	0.41	0.44	0.46	0.49	0.52	0.56	0.59	0.86	1.29	1.84	2.56	
C+D	1.75	1.14	0.95	0.95	0.98	1.04	1.11	1.19	1.28	1.38	1.43	1.54	1.65	1.77	1.89	2.24	2.75			
O.D	0.44	0.30	0.25	0.25	0.26	0.27	0.29	0.31	0.33	0.35	0.37	0.39	0.42	0.45	0.48	0.69	1.03	1.47	2.05	

WALL THICKNESS = 11 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.19	0.77	0.64	0.63	0.66	0.70	0.75	0.80	0.87	0.94	0.97	1.05	1.13	1.21	1.29	1.38	1.47	1.55	1.64	1.73
B	1.85	1.21	1.01	1.00	1.04	1.10	1.17	1.26	1.36	1.46	1.51	1.63	1.75	1.87	2.00	2.13	2.26	2.39	2.52	2.66
C	1.19	0.77	0.64	0.63	0.66	0.70	0.75	0.80	0.87	0.94	0.97	1.05	1.13	1.21	1.29	1.38	1.47	1.55	1.64	1.73
D	0.65	0.40	0.34	0.33	0.34	0.36	0.39	0.41	0.44	0.47	0.49	0.52	0.56	0.72	1.13	1.67	2.39			
C+D	1.91	1.21	1.01	1.00	1.04	1.10	1.17	1.26	1.36	1.46	1.51	1.63	1.75	2.00	2.49					
O.D	0.52	0.32	0.27	0.27	0.27	0.29	0.31	0.33	0.35	0.36	0.39	0.42	0.45	0.58	0.91	1.34	1.91			

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.09	0.71	0.58	0.58	0.60	0.64	0.68	0.73	0.79	0.85	0.88	0.95	1.02	1.10	1.17	1.25	1.33	1.41	1.49	1.57
B	1.63	1.07	0.89	0.89	0.92	0.97	1.03	1.11	1.19	1.28	1.32	1.43	1.53	1.64	1.75	1.86	1.97	2.09	2.21	2.32
C	1.09	0.71	0.58	0.58	0.60	0.64	0.68	0.73	0.79	0.85	0.88	0.95	1.02	1.10	1.17	1.25	1.33	1.41	1.49	1.57
D	0.54	0.36	0.31	0.30	0.31	0.33	0.35	0.37	0.40	0.43	0.44	0.47	0.51	0.54	0.58	0.61	0.65	0.68	0.94	1.33
C+D	1.63	1.07	0.89	0.89	0.92	0.97	1.03	1.11	1.19	1.28	1.32	1.43	1.53	1.64	1.75	1.86	1.97	2.09	2.43	2.90
O.D	0.43	0.29	0.25	0.24	0.25	0.27	0.28	0.30	0.32	0.35	0.35	0.38	0.41	0.43	0.47	0.49	0.52	0.55	0.75	1.07

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.09	0.71	0.58	0.58	0.60	0.64	0.68	0.73	0.79	0.85	0.88	0.95	1.02	1.10	1.17	1.25	1.33	1.41	1.49	1.57
B	1.71	1.12	0.94	0.93	0.96	1.02	1.09	1.17	1.25	1.35	1.39	1.50	1.61	1.72	1.84	1.96	2.07	2.20	2.32	2.44
C	1.09	0.71	0.58	0.58	0.60	0.64	0.68	0.73	0.79	0.85	0.88	0.95	1.02	1.10	1.17	1.25	1.33	1.41	1.49	1.57
D	0.57	0.38	0.32	0.32	0.33	0.35	0.37	0.40	0.42	0.45	0.47	0.50	0.54	0.57	0.61	0.65	0.82	1.21	1.69	2.32
C+D	1.71	1.12	0.94	0.93	0.96	1.02	1.09	1.17	1.25	1.35	1.39	1.50	1.61	1.72	1.84	1.96	2.21	2.68		
O.D	0.46	0.31	0.26	0.26	0.27	0.28	0.30	0.32	0.34	0.36	0.38	0.40	0.43	0.46	0.49	0.52	0.66	0.97	1.35	1.86

CASE III PER STANDARD DRAWING 2-D177-DITCH CONDITION-TRENCH WIDTH = O.D. + 24 INCHES

WALL THICKNESS = INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.87	0.92	0.96	1.01	1.06	1.10	1.14	1.19	1.23	1.27
B	1.28	1.35	1.42	1.48	1.55	1.61	1.67	1.73	1.79	1.85
C	0.87	0.92	0.96	1.01	1.06	1.10	1.14	1.19	1.23	1.27
D	0.41	0.43	0.45	0.47	0.49	0.51	0.53	0.55	0.57	0.58
C+D	1.28	1.35	1.42	1.48	1.55	1.61	1.67	1.73	1.79	1.85
O.D	0.33	0.35	0.36	0.38	0.39	0.41	0.43	0.44	0.46	0.47

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.79	0.84	0.89	0.92	0.96	1.00	1.04	1.08	1.12	1.15
B	1.19	1.26	1.32	1.38	1.44	1.50	1.55	1.61	1.67	1.72
C	0.79	0.84	0.89	0.92	0.96	1.00	1.04	1.08	1.12	1.15
D	0.40	0.42	0.44	0.46	0.48	0.50	0.51	0.53	0.55	0.57
C+D	1.19	1.28	1.32	1.38	1.44	1.50	1.55	1.61	1.67	1.72
O.D	0.32	0.34	0.35	0.37	0.39	0.40	0.41	0.43	0.44	0.46

WALL THICKNESS = INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.87	0.92	0.96	1.01	1.06	1.10	1.14	1.19	1.23	1.27
B	1.36	1.43	1.50	1.57	1.64	1.70	1.77	1.83	1.90	1.96
C	0.87	0.92	0.96	1.01	1.06	1.10	1.14	1.19	1.23	1.27
D	0.44	0.46	0.48	0.51	0.53	0.55	0.57	0.58	0.79	0.99
C+D	1.36	1.43	1.50	1.57	1.64	1.70	1.77	1.83	2.09	2.32
O.D	0.35	0.37	0.39	0.41	0.43	0.44	0.46	0.47	0.63	0.79

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

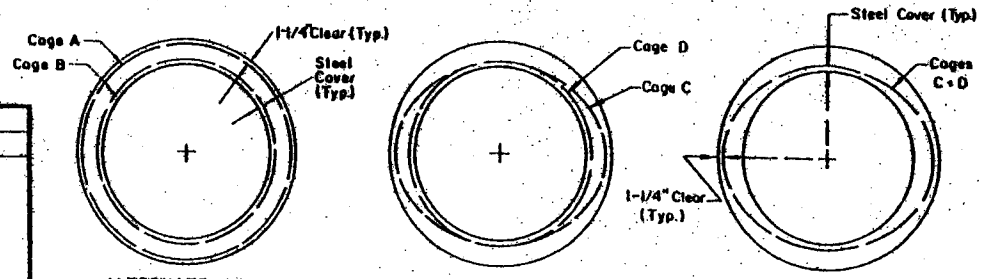
CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.79	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12	1.15
B	1.26	1.32	1.39	1.45	1.51	1.57	1.63	1.69	1.75	1.81
C	0.79	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12	1.15
D	0.42	0.45	0.47	0.49	0.51	0.53	0.55	0.56	0.58	0.60
C+D	1.26	1.32	1.39	1.45	1.51	1.57	1.63	1.68	1.75	1.81
O.D	0.34	0.36	0.38	0.39	0.41	0.43	0.44	0.45	0.47	0.48

NOTES:

1. THE VALUES SHOWN APPLY ONLY FOR THE BEDDING AND LOADING CONDITIONS NOTED.
2. FOR COVERS OF 10 FT. OR LESS, PIPE SHALL BE DESIGNED FOR THE PROJECTION CONDITION WITH UNRESTRICTED TRENCH WIDTH.
3. FOR COVERS OVER 10 FT., PIPE SHALL BE DESIGNED FOR APPLICABLE CONDITION. FOR DITCH CONDITION USE O.D. + 24 IN.

DESIGN DATA:

EARTH LOAD PER MARSTON'S FORMULAS:
W = 110 p.c.f. (CORRESPONDING TO AN ACTUAL EARTH WEIGHT)
K = K' = .150
LIVE LOAD = 1-H20-S16 TRUCK
LOADS UNIFORM OVER 180° TOP AND 90° BOTTOM.
NO LATERAL LOADS
f'_c = 4500 p.s.i. f_s = 24,000 p.s.i.
f_c = 2025 p.s.i. n = 8



ALTERNATE NO. 1 ALTERNATE NO. 2 ALTERNATE NO. 3

SUPERSEDES DWG. NO. 2-D214.1-.4 DATED JAN. '55

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

STEEL AREAS FOR
126- INCH REINFORCED
CONCRETE PIPE

RECOMMENDED BY: Division Engineer
APPROVAL RECOMMENDED BY: Asst. Chief County Engineer
APPROVED BY: A. E. Bumgardner 12/70, CHIEF ENGINEER

SCALE	DATE	DWG. NO. 2-0214.3
NONE	1-1-71	SHEET 3 OF 6

DRAWN BY	REVISIONS		
J.C.H.	MARK	DATE	DESCRIPTION
CHECKED BY			
R.J.S.			
DESIGNED BY			
V.C.M.			
SUBMITTED BY			
C.W.H.			

S-67

CASE III PER STANDARD DRAWING 2-D177 - PROJECTION CONDITION - UNRESTRICTED TRENCH WIDTH

WALL THICKNESS = 11.5 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER 0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.27	0.82	0.66	0.67	0.70	0.74	0.79	0.85	0.91	0.98	1.02	1.10	1.18	1.26	1.35	1.44	1.53	1.62	1.71	1.80
B	1.86	1.21	1.01	1.00	1.04	1.10	1.11	1.25	1.35	1.45	1.59	1.61	1.73	1.85	1.97	2.10	2.22	2.35	2.48	2.62
C	1.27	0.82	0.66	0.67	0.70	0.74	0.79	0.85	0.91	0.98	1.02	1.10	1.18	1.26	1.35	1.44	1.53	1.62	1.71	1.80
D	0.59	0.39	0.33	0.33	0.34	0.36	0.38	0.41	0.43	0.46	0.48	0.51	0.55	0.58	0.62	0.65	0.69	0.73	0.77	0.81
C+D	1.86	1.21	1.01	1.00	1.04	1.10	1.17	1.25	1.35	1.45	1.60	1.61	1.73	1.85	1.97	2.27	2.78			
OBD	0.41	0.31	0.27	0.27	0.27	0.29	0.31	0.33	0.35	0.37	0.39	0.41	0.44	0.47	0.50	0.67	1.00	1.42	1.90	2.71

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER 0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.22	0.79	0.65	0.64	0.67	0.71	0.75	0.81	0.87	0.94	0.97	1.05	1.13	1.21	1.29	1.37	1.45	1.54	1.63	1.72
B	1.79	1.17	0.98	0.97	1.01	1.06	1.13	1.21	1.30	1.40	1.44	1.56	1.67	1.78	1.90	2.02	2.14	2.26	2.39	2.52
C	1.22	0.79	0.65	0.64	0.67	0.71	0.75	0.81	0.87	0.94	0.97	1.05	1.13	1.21	1.29	1.37	1.45	1.54	1.63	1.72
D	0.50	0.36	0.33	0.33	0.34	0.35	0.38	0.40	0.43	0.46	0.47	0.50	0.54	0.57	0.61	0.65	0.69	1.09	1.54	2.12
C+D	1.79	1.17	0.98	0.97	1.01	1.06	1.13	1.21	1.30	1.40	1.44	1.53	1.67	1.78	1.90	2.02	2.14	2.63		
OBD	0.47	0.31	0.27	0.27	0.27	0.28	0.30	0.32	0.35	0.37	0.39	0.40	0.43	0.46	0.49	0.52	0.55	0.87	1.23	1.70

WALL THICKNESS = 11.5 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER 0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.27	0.82	0.68	0.67	0.70	0.74	0.79	0.85	0.91	0.98	1.02	1.10	1.18	1.26	1.35	1.44	1.53	1.62	1.71	1.80
B	1.95	1.28	1.06	1.06	1.10	1.16	1.23	1.32	1.42	1.53	1.58	1.70	1.82	1.95	2.09	2.21	2.34	2.48	2.62	2.76
C	1.27	0.82	0.68	0.67	0.70	0.74	0.79	0.85	0.91	0.98	1.02	1.10	1.18	1.26	1.35	1.44	1.53	1.62	1.71	1.80
D	0.70	0.42	0.35	0.35	0.36	0.38	0.41	0.43	0.46	0.49	0.51	0.53	0.58	0.62	1.07	1.58	2.26			
C+D	2.04	1.28	1.06	1.06	1.10	1.16	1.23	1.32	1.42	1.53	1.50	1.70	1.82	1.95	2.48					
OBD	0.50	0.34	0.28	0.28	0.29	0.31	0.33	0.35	0.37	0.39	0.41	0.44	0.47	0.50	0.86	1.26	1.81	2.54		

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER 0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.22	0.79	0.65	0.64	0.67	0.71	0.75	0.81	0.87	0.94	0.97	1.05	1.13	1.21	1.29	1.37	1.45	1.54	1.63	1.72
B	1.89	1.24	1.03	1.02	1.06	1.12	1.19	1.27	1.37	1.47	1.52	1.63	1.75	1.87	2.00	2.12	2.25	2.38	2.51	2.65
C	1.22	0.79	0.65	0.64	0.67	0.71	0.75	0.81	0.87	0.94	0.97	1.05	1.13	1.21	1.29	1.37	1.45	1.54	1.63	1.72
D	0.61	0.41	0.35	0.35	0.36	0.38	0.40	0.42	0.45	0.48	0.50	0.54	0.57	0.61	0.65	0.93	1.37	1.93	2.67	
C+D	1.99	1.24	1.03	1.02	1.06	1.12	1.19	1.27	1.37	1.47	1.52	1.63	1.75	1.87	2.00	2.36	2.89			
OBD	0.49	0.33	0.28	0.28	0.29	0.31	0.33	0.34	0.36	0.39	0.41	0.43	0.46	0.49	0.52	0.75	1.10	1.55	2.14	2.92

CASE III PER STANDARD DRAWING 2-D177 - DITCH CONDITION - TRENCH WIDTH = O.D. + 24 INCHES

WALL THICKNESS = 11.5 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER 11	12	13	14	15	16	17	18	19	20
A	0.92	0.97	1.02	1.06	1.11	1.16	1.20	1.25	1.29	1.34
B	1.35	1.42	1.49	1.56	1.63	1.70	1.76	1.83	1.89	1.96
C	0.92	0.97	1.02	1.06	1.11	1.16	1.20	1.25	1.29	1.34
D	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.61
C+D	1.36	1.42	1.49	1.56	1.63	1.70	1.76	1.83	1.89	1.95
OBD	0.35	0.37	0.39	0.40	0.42	0.43	0.45	0.47	0.48	0.49

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER 11	12	13	14	15	16	17	18	19	20
A	0.88	0.92	0.97	1.02	1.06	1.11	1.15	1.19	1.23	1.27
B	1.31	1.38	1.44	1.51	1.57	1.64	1.70	1.76	1.82	1.88
C	0.88	0.92	0.97	1.02	1.06	1.11	1.15	1.19	1.23	1.27
D	0.43	0.45	0.47	0.49	0.51	0.53	0.55	0.57	0.59	0.60
C+D	1.31	1.38	1.44	1.51	1.57	1.64	1.70	1.76	1.82	1.88
OBD	0.35	0.36	0.38	0.39	0.41	0.43	0.44	0.46	0.47	0.48

WALL THICKNESS = 11.5 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER 11	12	13	14	15	16	17	18	19	20
A	0.92	0.97	1.02	1.06	1.11	1.16	1.20	1.25	1.29	1.34
B	1.43	1.50	1.58	1.65	1.72	1.79	1.86	1.93	1.99	2.06
C	0.92	0.97	1.02	1.06	1.11	1.16	1.20	1.25	1.29	1.34
D	0.46	0.49	0.51	0.53	0.55	0.57	0.59	0.61	0.79	0.98
C+D	1.43	1.50	1.58	1.65	1.72	1.79	1.86	1.93	2.15	2.39
OBD	0.37	0.39	0.41	0.43	0.44	0.46	0.47	0.49	0.63	0.79

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER 11	12	13	14	15	16	17	18	19	20
A	0.88	0.92	0.97	1.02	1.06	1.11	1.15	1.19	1.23	1.27
B	1.37	1.45	1.52	1.59	1.66	1.72	1.79	1.85	1.91	1.98
C	0.88	0.92	0.97	1.02	1.06	1.11	1.15	1.19	1.23	1.27
D	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64
C+D	1.37	1.45	1.52	1.59	1.66	1.72	1.79	1.85	1.91	1.98
OBD	0.37	0.39	0.40	0.42	0.43	0.45	0.47	0.48	0.50	0.51

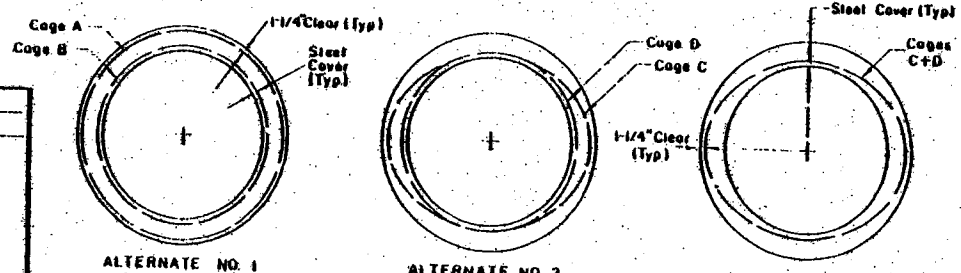
NOTES:

1. THE VALUES SHOWN APPLY ONLY FOR THE BEDDING AND LOADING CONDITIONS NOTED.
2. FOR COVERS OF 10 FT. OR LESS, PIPE SHALL BE DESIGNED FOR THE PROJECTION CONDITION WITH UNRESTRICTED TRENCH WIDTH.
3. FOR COVERS OVER 10 FT., PIPE SHALL BE DESIGNED FOR APPLICABLE CONDITION. FOR DITCH CONDITION USE O.D. + 24 IN.

DESIGN DATA:

EARTH LOAD PER MARSTON'S FORMULAS:
W = 110 p.c.f. (CORRESPONDING TO AN ACTUAL EARTH WEIGHT)
K = K' = .150
LIVE LOAD = 1-H20-S16 TRUCK
LOADS UNIFORM OVER 180° TOP AND 90° BOTTOM.
NO LATERAL LOADS
f'_c = 4500 p.s.i. f_s = 24,000 p.s.i.
f_c = 2025 p.s.i. n = 8

SUPERSEDES DWG. NO. 2-D214.1-4 DATED JAN. '55



ALTERNATE NO. 1 — ALTERNATE NO. 2 — ALTERNATE NO. 3

DRAWN BY	REVISIONS		
GDM	MARK	DATE	DESCRIPTION
CHECKED BY			
SM			
DESIGNED BY			
VCM			
SUBMITTED BY			
CWH			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

STEEL AREAS FOR 132-INCH REINFORCED CONCRETE PIPE

RECOMMENDED BY: Division Engineer (Design)
APPROVAL RECOMMENDED BY: Asst. Chief Deputy Engineer
APPROVED BY: A. E. Bruington, Chief Engineer

SCALE	DATE	DWG. NO. 2-D214.4
NONE	1-1-71	SHEET 4 OF 6

S-88

CASE III PER STANDARD DRAWING 2-D177 - PROJECTION CONDITION - UNRESTRICTED TRENCH WIDTH

WALL THICKNESS = 11-1/2 INCHES
STEEL COVER = 1'-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.41	0.91	0.75	0.74	0.77	0.81	0.87	0.93	1.00	1.08	1.11	1.20	1.29	1.38	1.47	1.57	1.67	1.76	1.86	1.97
B	2.04	1.33	1.11	1.10	1.14	1.20	1.28	1.37	1.47	1.57	1.62	1.75	1.87	2.00	2.13	2.27	2.40	2.54	2.68	2.82
C	1.41	0.91	0.75	0.74	0.77	0.81	0.87	0.93	1.00	1.08	1.11	1.20	1.29	1.38	1.47	1.57	1.67	1.76	1.86	1.97
D	0.63	0.42	0.36	0.36	0.37	0.39	0.41	0.43	0.46	0.50	0.51	0.55	0.58	0.62	0.92	1.38	1.99	2.80		
C+D	2.04	1.33	1.11	1.10	1.14	1.20	1.28	1.37	1.47	1.57	1.62	1.75	1.87	2.00	2.39	2.95				
OBD	0.51	0.34	0.29	0.29	0.30	0.31	0.33	0.35	0.37	0.40	0.41	0.44	0.47	0.50	0.74	1.11	1.59	2.24		

WALL THICKNESS = 11-1/2 INCHES
STEEL COVER = 1'-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.41	0.91	0.75	0.74	0.77	0.81	0.87	0.93	1.00	1.08	1.11	1.20	1.29	1.38	1.47	1.57	1.67	1.76	1.86	1.97
B	2.15	1.40	1.17	1.16	1.20	1.26	1.35	1.44	1.58	1.66	1.71	1.84	1.97	2.11	2.25	2.39	2.53	2.68	2.83	2.98
C	1.41	0.91	0.75	0.74	0.77	0.81	0.87	0.93	1.00	1.08	1.11	1.20	1.29	1.38	1.47	1.57	1.67	1.76	1.86	1.97
D	1.31	0.45	0.38	0.38	0.39	0.41	0.43	0.46	0.49	0.53	0.54	0.58	0.72	1.15	1.72	2.49				
C+D	2.79	1.40	1.17	1.16	1.20	1.26	1.35	1.44	1.55	1.66	1.71	1.84	2.08	2.60						
OBD	1.05	0.36	0.31	0.31	0.31	0.33	0.35	0.37	0.39	0.43	0.43	0.47	0.58	0.92	1.38	1.99	2.83			

WALL THICKNESS = 12 INCHES
STEEL COVER = 1'-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.35	0.87	0.72	0.71	0.74	0.78	0.83	0.89	0.96	1.03	1.06	1.15	1.23	1.32	1.41	1.50	1.59	1.68	1.78	1.87
B	1.97	1.29	1.07	1.06	1.10	1.16	1.23	1.32	1.42	1.52	1.57	1.68	1.80	1.93	2.05	2.18	2.31	2.44	2.58	2.72
C	1.35	0.87	0.72	0.71	0.74	0.78	0.83	0.89	0.96	1.03	1.06	1.15	1.23	1.32	1.41	1.50	1.59	1.68	1.78	1.87
D	0.62	0.42	0.35	0.35	0.36	0.38	0.40	0.43	0.46	0.48	0.50	0.54	0.57	0.61	0.65	0.81	1.22	1.74	2.42	
C+D	1.97	1.29	1.07	1.06	1.10	1.16	1.23	1.32	1.42	1.52	1.57	1.68	1.80	1.93	2.05	2.31	2.81			
OBD	0.50	0.34	0.28	0.28	0.29	0.31	0.32	0.35	0.37	0.39	0.40	0.43	0.46	0.49	0.58	0.65	0.98	1.39	1.94	

WALL THICKNESS = 12 INCHES
STEEL COVER = 1'-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.35	0.87	0.72	0.71	0.74	0.78	0.83	0.89	0.96	1.03	1.06	1.15	1.23	1.32	1.41	1.50	1.59	1.68	1.78	1.87
B	2.07	1.35	1.13	1.12	1.16	1.22	1.30	1.39	1.49	1.60	1.65	1.77	1.90	2.03	2.16	2.29	2.43	2.57	2.71	2.86
C	1.35	0.87	0.72	0.71	0.74	0.78	0.83	0.89	0.96	1.03	1.06	1.15	1.23	1.32	1.41	1.50	1.59	1.68	1.78	1.87
D	0.76	0.44	0.37	0.37	0.38	0.40	0.43	0.45	0.48	0.52	0.53	0.57	0.61	0.69	1.02	1.51	2.16	3.00		
C+D	2.18	1.36	1.13	1.12	1.16	1.22	1.30	1.39	1.49	1.60	1.65	1.77	1.90	2.03	2.49					
OBD	0.61	0.35	0.30	0.30	0.30	0.32	0.35	0.36	0.39	0.42	0.43	0.46	0.49	0.52	0.82	1.21	1.73	2.40		

CASE III PER STANDARD DRAWING 2-D177 - DITCH CONDITION - TRENCH WIDTH = O.D. + 24 INCHES

WALL THICKNESS = 11-1/2 INCHES
STEEL COVER = 1'-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	1.01	1.06	1.12	1.17	1.22	1.28	1.33	1.37	1.42	1.47
B	1.48	1.55	1.63	1.71	1.78	1.85	1.92	1.99	2.06	2.13
C	1.01	1.06	1.12	1.17	1.22	1.28	1.33	1.37	1.42	1.47
D	0.47	0.49	0.51	0.53	0.56	0.58	0.60	0.62	0.64	0.90
C+D	1.48	1.55	1.63	1.71	1.78	1.85	1.92	1.99	2.06	2.37
OBD	0.38	0.39	0.41	0.43	0.44	0.47	0.48	0.50	0.51	0.72

WALL THICKNESS = 12 INCHES
STEEL COVER = 1'-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.97	1.02	1.07	1.12	1.17	1.22	1.27	1.31	1.36	1.40
B	1.43	1.50	1.57	1.65	1.72	1.79	1.85	1.92	1.98	2.05
C	0.97	1.02	1.07	1.12	1.17	1.22	1.27	1.31	1.36	1.40
D	0.46	0.48	0.50	0.53	0.55	0.57	0.59	0.61	0.63	0.65
C+D	1.43	1.50	1.57	1.65	1.72	1.79	1.85	1.92	1.98	2.05
OBD	0.37	0.38	0.40	0.42	0.44	0.46	0.47	0.49	0.51	0.52

WALL THICKNESS = 11-1/2 INCHES
STEEL COVER = 1'-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	1.01	1.06	1.12	1.17	1.22	1.28	1.33	1.37	1.42	1.47
B	1.56	1.64	1.72	1.80	1.88	1.95	2.03	2.10	2.17	2.24
C	1.01	1.06	1.12	1.17	1.22	1.28	1.33	1.37	1.42	1.47
D	0.50	0.52	0.54	0.57	0.59	0.61	0.87	1.11	1.38	1.69
C+D	1.66	1.64	1.72	1.80	1.88	1.95	2.26	2.56	2.88	
OBD	0.40	0.42	0.43	0.46	0.47	0.49	0.70	0.89	1.11	1.35

WALL THICKNESS = 12 INCHES
STEEL COVER = 1'-3/4 INCHES CLEAR

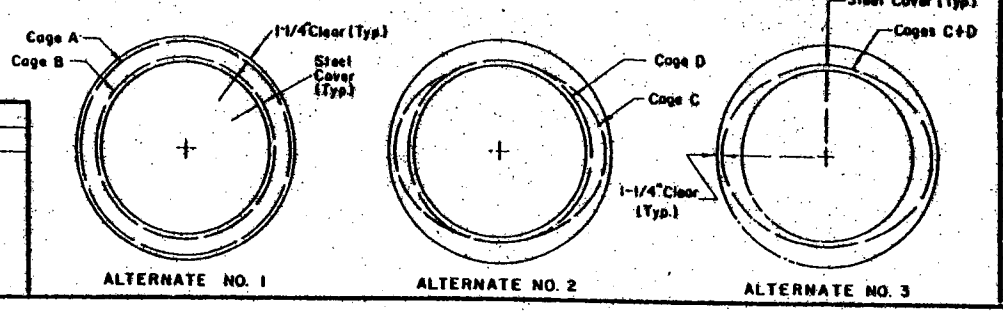
CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	0.97	1.02	1.07	1.12	1.17	1.22	1.27	1.31	1.36	1.40
B	1.50	1.58	1.65	1.73	1.80	1.88	1.95	2.02	2.09	2.15
C	0.97	1.02	1.07	1.12	1.17	1.22	1.27	1.31	1.36	1.40
D	0.49	0.51	0.53	0.56	0.58	0.60	0.62	0.64	0.80	1.00
C+D	1.50	1.58	1.65	1.73	1.80	1.88	1.95	2.02	2.22	2.47
OBD	0.39	0.41	0.43	0.45	0.47	0.48	0.50	0.51	0.64	0.80

NOTES:

1. THE VALUES SHOWN APPLY ONLY FOR THE BEDDING AND LOADING CONDITIONS NOTED.
2. FOR COVERS OF 10FT. OR LESS, PIPE SHALL BE DESIGNED FOR THE PROJECTION CONDITION WITH UNRESTRICTED TRENCH WIDTH.
3. FOR COVERS OVER 10FT., PIPE SHALL BE DESIGNED FOR APPLICABLE CONDITION. FOR DITCH CONDITION USE O.D. + 24 IN.

DESIGN DATA:

EARTH LOAD PER MARSTON'S FORMULAS:
W = 110 p.c.f. (CORRESPONDING TO AN ACTUAL EARTH WEIGHT)
K = K' = .150
LIVE LOAD = 1-H20-S16 TRUCK
LOADS UNIFORM OVER 180° TOP AND 90° BOTTOM.
NO LATERAL LOADS
f'_c = 4500 p.s.i. f_s = 24,000 p.s.i.
f_c = 2025 p.s.i. n = 8



DRAWN BY	REVISIONS		
G.D.M.	MARK	DATE	DESCRIPTION
CHECKED BY			
S.M.			
DESIGNED BY			
V.C.M.			
SUBMITTED BY			
C.W.H.			

SUPERSEDES DWG NO. 2-D214.1-4 DATED JAN '55

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

STEEL AREAS FOR
138 - INCH REINFORCED
CONCRETE PIPE

RECOMMENDED BY: D. J. Mitchell, DIVISION ENGINEER, HYDRAULIC
APPROVAL RECOMMENDED BY: E. Tregunna, ASST. CHIEF DEPUTY ENGINEER
APPROVED BY: A. E. Bourgeois, CHIEF ENGINEER, 1/5/70

SCALE	DATE	DWG. NO. 2-D214.5
NONE	1-1-71	SHEET 5 OF 6

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CASE III PER STANDARD DRAWING 2-D177 - PROJECTION CONDITION - UNRESTRICTED TRENCH WIDTH

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.49	0.96	0.79	0.78	0.81	0.85	0.91	0.98	1.05	1.13	1.16	1.25	1.34	1.44	1.53	1.63	1.73	1.83	1.93	2.03
B	2.16	1.40	1.17	1.16	1.20	1.26	1.34	1.43	1.53	1.64	1.70	1.82	1.95	2.08	2.22	2.35	2.49	2.63	2.78	2.92
C	1.49	0.96	0.79	0.78	0.81	0.85	0.91	0.98	1.05	1.13	1.16	1.25	1.34	1.44	1.53	1.63	1.73	1.83	1.93	2.03
D	0.67	0.45	0.36	0.36	0.39	0.41	0.43	0.46	0.49	0.52	0.53	0.57	0.61	0.64	0.68	1.33	1.92	2.69		
C+D	2.16	1.40	1.17	1.16	1.20	1.26	1.34	1.43	1.53	1.64	1.70	1.82	1.95	2.08	2.42	2.98				
OBD	0.54	0.36	0.30	0.30	0.31	0.33	0.34	0.37	0.39	0.42	0.42	0.46	0.49	0.51	0.70	1.06	1.53	2.15		

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

CAGE	DEPTH OF COVER																			
	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1.49	0.96	0.79	0.78	0.81	0.85	0.91	0.98	1.05	1.13	1.16	1.25	1.34	1.44	1.53	1.63	1.73	1.83	1.93	2.03
B	2.27	1.48	1.23	1.22	1.26	1.33	1.41	1.51	1.61	1.73	1.78	1.92	2.05	2.19	2.33	2.47	2.62	2.77	2.92	
C	1.49	0.96	0.79	0.78	0.81	0.85	0.91	0.98	1.05	1.13	1.16	1.25	1.34	1.44	1.53	1.63	1.73	1.83	1.93	2.03
D	1.38	0.48	0.40	0.40	0.41	0.43	0.46	0.49	0.52	0.55	0.56	0.60	0.64	1.09	1.63	2.35				
C+D	2.94	1.48	1.23	1.22	1.26	1.33	1.41	1.51	1.61	1.73	1.78	1.92	2.05	2.59						
OBD	1.10	0.38	0.32	0.32	0.33	0.34	0.37	0.38	0.42	0.44	0.45	0.48	0.51	0.87	1.30	1.88				

CASE III PER STANDARD DRAWING 2-D177 - DITCH CONDITION - TRENCH WIDTH = O.D. + 24 INCHES

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-1/4 INCHES CLEAR

CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	1.08	1.12	1.17	1.23	1.28	1.34	1.39	1.44	1.49	1.54
B	1.55	1.63	1.71	1.79	1.87	1.94	2.01	2.08	2.16	2.23
C	1.08	1.12	1.17	1.23	1.28	1.34	1.39	1.44	1.49	1.54
D	0.49	0.51	0.54	0.56	0.59	0.60	0.63	0.65	0.67	0.92
C+D	1.55	1.63	1.71	1.79	1.87	1.94	2.01	2.08	2.16	2.46
OBD	0.39	0.41	0.43	0.45	0.46	0.48	0.50	0.52	0.54	0.74

WALL THICKNESS = 12 INCHES
STEEL COVER = 1-3/4 INCHES CLEAR

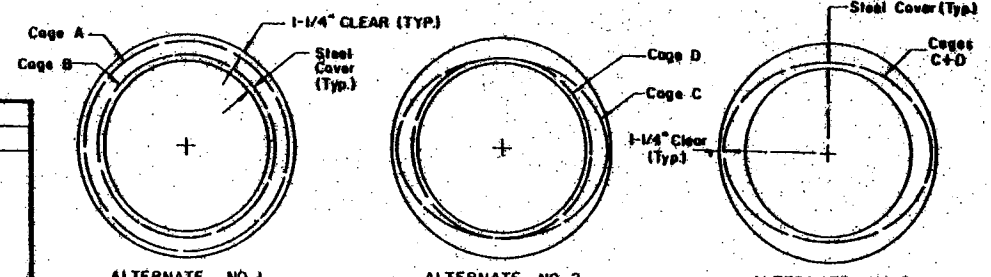
CAGE	DEPTH OF COVER									
	11	12	13	14	15	16	17	18	19	20
A	1.06	1.12	1.17	1.23	1.28	1.34	1.39	1.44	1.49	1.54
B	1.63	1.72	1.80	1.88	1.96	2.04	2.12	2.19	2.27	2.34
C	1.06	1.12	1.07	1.23	1.28	1.34	1.39	1.44	1.49	1.54
D	0.52	0.54	0.57	0.59	0.62	0.64	0.86	1.10	1.37	1.68
C+D	1.63	1.72	1.80	1.88	1.96	2.04	2.32	2.61	2.93	
OBD	0.42	0.43	0.46	0.47	0.50	0.51	0.69	0.88	1.10	1.34

NOTES:

1. THE VALUES SHOWN APPLY ONLY FOR THE BEDDING AND LOADING CONDITIONS NOTED.
2. FOR COVERS OF 10FT. OR LESS, PIPE SHALL BE DESIGNED FOR THE PROJECTION CONDITION WITH UNRESTRICTED TRENCH WIDTH.
3. FOR COVER OVER 10FT., PIPE SHALL BE DESIGNED FOR APPLICABLE CONDITION. FOR DITCH CONDITION USE O.D. + 24 IN.

DESIGN DATA:

EARTH LOAD PER MARSTON'S FORMULAS:
W = 110 p.c.f. (CORRESPONDING TO AN ACTUAL EARTH WEIGHT)
K = K' = .150
LIVE LOAD = 1-H20-S16 TRUCK
LOADS UNIFORM OVER 180° TOP AND 90° BOTTOM.
NO LATERAL LOADS
f'_c = 4500 p.s.i. f_s = 24,000 p.s.i.
f_c = 2025 p.s.i. n = 8



DRAWN BY	REVISIONS		
J.C.M.	MARK	DATE	DESCRIPTION
CHECKED BY			
S.M.			
DESIGNED BY			
V.C.M.			
SUBMITTED BY			
C.W.H.			

SUPERSEDES DWG. NO. 2-D214.1-4 DATED JAN. '55

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

STEEL AREAS FOR
144-INCH REINFORCED
CONCRETE PIPE

RECOMMENDED BY: H. J. Milne, Division Engineer, Design
APPROVAL RECOMMENDED BY: C. Chapman, Asst. Chief Deputy Engineer
APPROVED BY: A. E. Bumpton, Chief Engineer, 11/5/70

SCALE	DATE	DWG. NO.
NONE	1-1-71	2-D214.6

SHEET 6 OF 6

S-70

MOMENT, THRUST, AND SHEAR COEFFICIENTS FOR ELASTIC RINGS
TYPICAL PIPE LOADINGS

SED -53

REFERENCE : ENGINEERING NEWS RECORD, VOLUME 87 - 1921; PAGE 768

SIGN CONVENTION
+M = TENSION ON INSIDE FACE
+N = COMPRESSION
+V = SHEAR POSITIVE FOR LEFT SIDE

MOMENT COEFFICIENT = WR
THRUST COEFFICIENT = W
SHEAR COEFFICIENT = W
W = TOTAL LOAD IN EACH CASE
R = MEAN RADIUS OF RING

UNIFORM LOAD ON 180° TOP

	Concentrated Support at Bottom			θ = 60°			θ = 90°			θ = 120°			θ = 180°		
	M	N	V	M	N	V	M	N	V	M	N	V	M	N	V
TOP	+.1495	-.0530	0	+.1435	-.0400	0	+.1368	-.0268	0	+.1304	-.0132	0	+.1250	0	0
SIDE	-.1535	+.5000	+.0530	-.1465	+.5000	+.0400	-.1401	+.5000	+.0268	-.1327	+.5000	+.0132	-.1250	+.5000	0
BOTTOM	+.2935	+.0530	±.5000	+.1685	+.0400	0	+.1572	+.0268	0	+.1376	+.0132	0	+.1250	0	0

UNIFORM LOAD ON 90° TOP

	Concentrated Support at Bottom			θ = 60°			θ = 90°			θ = 120°			θ = 180°		
	M	N	V	M	N	V	M	N	V	M	N	V	M	N	V
TOP	+.1817	-.0262	0	+.1757	-.0132	0	+.1690	0	0	+.1627	+.0136	0	+.1572	+.0269	0
SIDE	-.1683	+.5000	+.0262	-.1613	+.5000	+.0132	-.1549	+.5000	0	-.1475	+.5000	-.0136	-.1398	+.5000	-.0269
BOTTOM	+.3055	+.0262	±.5000	+.2005	+.0132	0	+.1690	0	0	+.1496	-.0136	0	+.1370	-.0269	0

LOADING DUE TO WEIGHT OF RING

	Concentrated Support at Bottom			θ = 60°			θ = 90°			θ = 120°			θ = 180°		
	M	N	V	M	N	V	M	N	V	M	N	V	M	N	V
TOP	+.0796	-.0796	0	+.0736	-.0666	0	+.0669	-.0534	0	+.0606	-.0389	0	+.0551	-.0266	0
SIDE	-.0909	+.2500	+.0796	-.0839	+.2500	+.0667	-.0775	+.2500	+.0536	-.0701	+.2500	+.0399	-.0624	+.2500	-.0267
BOTTOM	+.2389	+.0796	±.5000	+.1339	+.0666	0	+.1025	+.0534	0	+.0829	+.0389	0	+.0704	+.0266	0

LOADING DUE TO WATER; PIPE FULL, ZERO PRESSURE HEAD ON SOFFIT

	Concentrated Support at Bottom			θ = 60°			θ = 90°			θ = 120°			θ = 180°		
	M	N	V	M	N	V	M	N	V	M	N	V	M	N	V
TOP	+.0796	-.2389	0	+.0736	-.2257	0	+.0669	-.2124	0	+.0606	-.1991	0	+.0551	-.1859	0
SIDE	-.0909	-.0680	+.0797	-.0838	-.0680	+.0667	-.0775	-.0680	+.0532	-.0701	-.0680	+.0399	-.0624	-.0680	+.0267
BOTTOM	+.2389	-.3981	±.5000	+.1337	-.4109	0	+.1025	-.4243	0	+.0829	-.4379	0	+.0704	-.4511	0

	M	N	V
TOP	-.1250	+.5000	0
SIDE	+.1250	0	0
BOTTOM	-.1250	+.5000	0

UNIFORM LOAD ON SIDES

TRIANGULAR LOAD ON SIDES

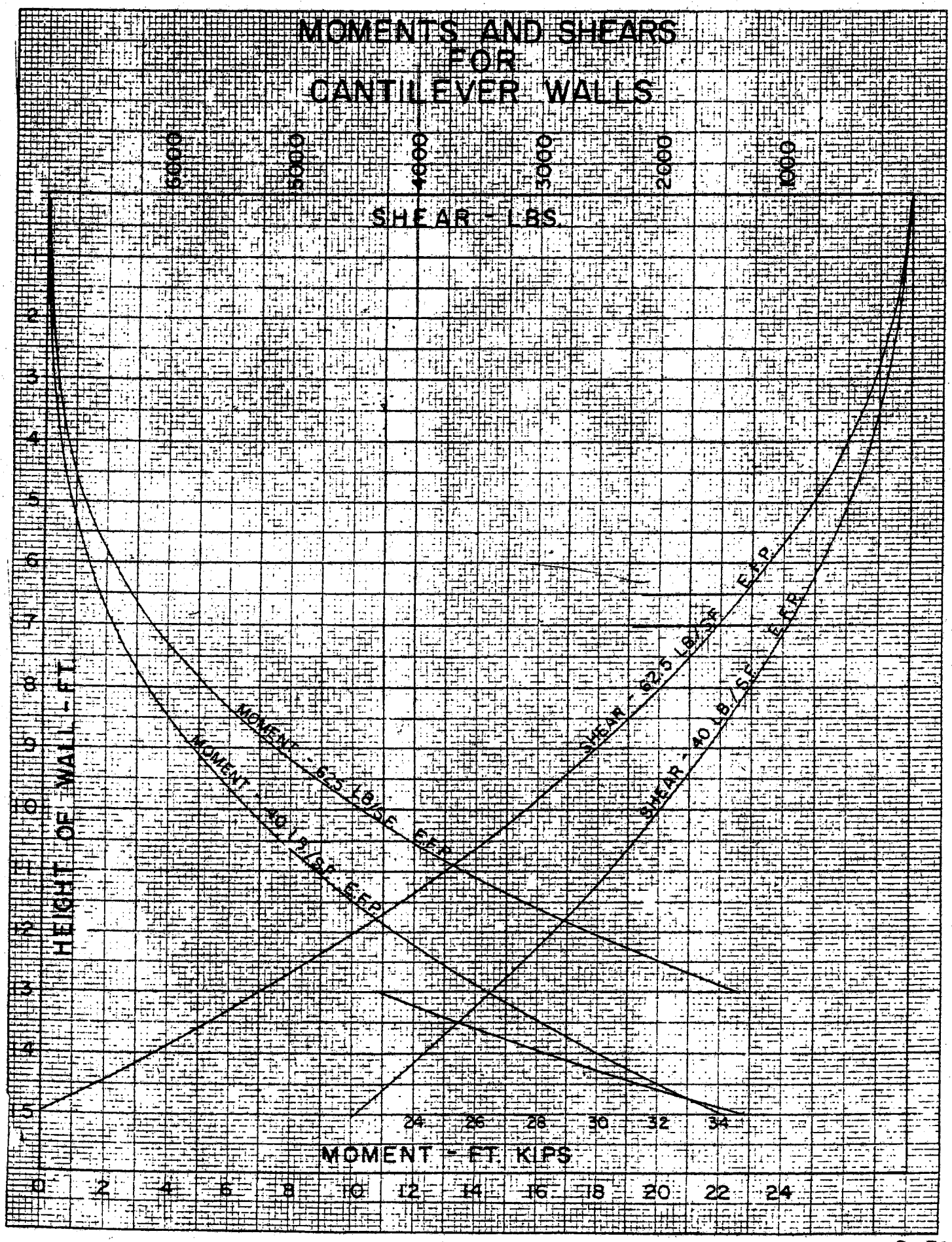
	M	N	V
TOP	-.1042	+.3125	0
SIDE	+.1250	0	-.0625
BOTTOM	-.1458	+.6875	0

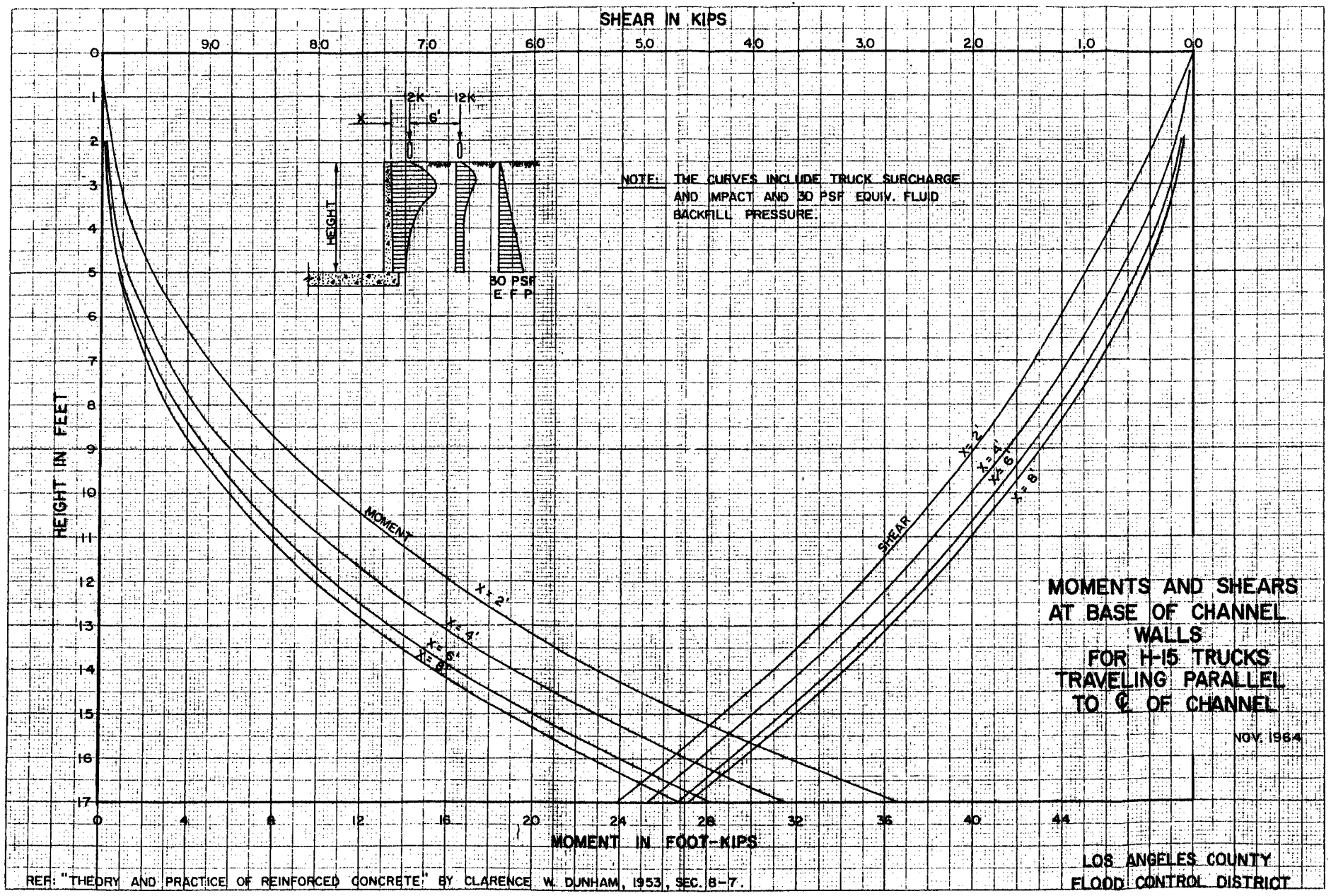
RESERVED

RESERVED

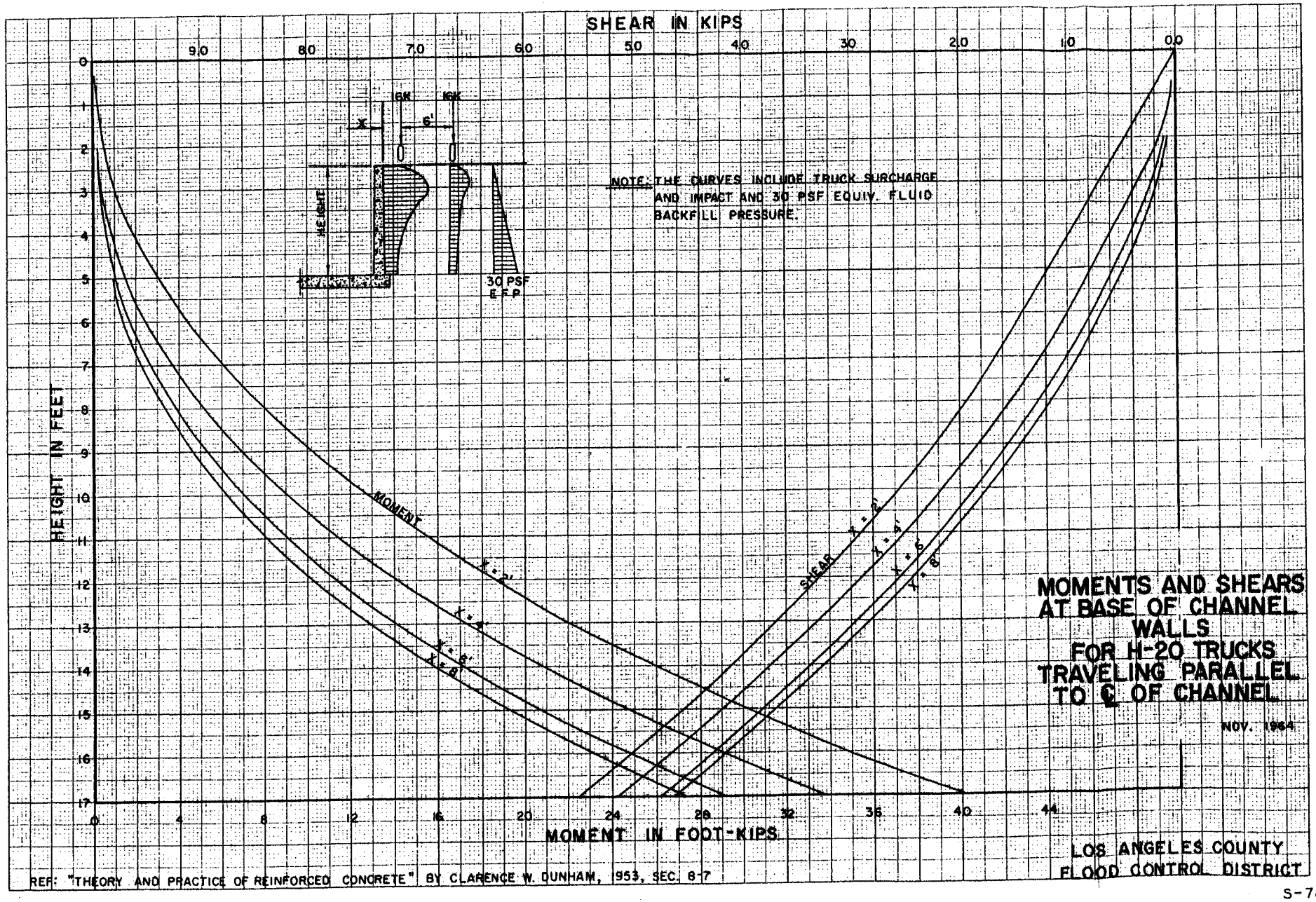
RESERVED

RESERVED


MOMENTS AND SHEARS
FOR
CANTILEVER WALLS
SHEAR - LBS.
6000
5000
4000
3000
2000
1000
HEIGHT OF WALL - FT.
MOMENT - 62.5 LB/CF E.F.P.
MOMENT - 40 LB/CF E.F.P.
SHEAR - 62.5 LB/CF E.F.P.
SHEAR - 40 LB/CF E.F.P.
MOMENT - FT. KIPS
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34

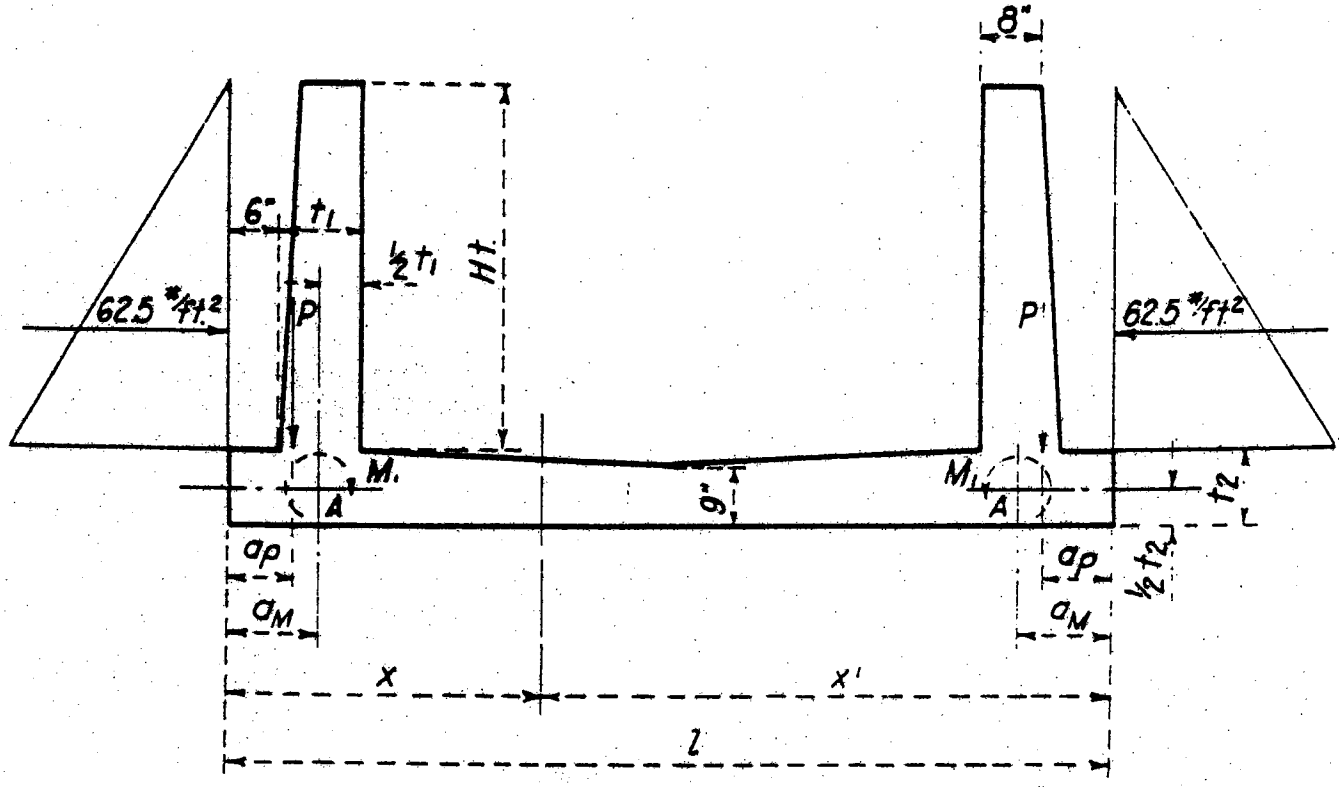


REF: "THEORY AND PRACTICE OF REINFORCED CONCRETE" BY CLARENCE W. DUNHAM, 1953, SEC. 8-7.



REF: "THEORY AND PRACTICE OF REINFORCED CONCRETE" BY CLARENCE W. DUNHAM, 1953, SEC. 8-7

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS



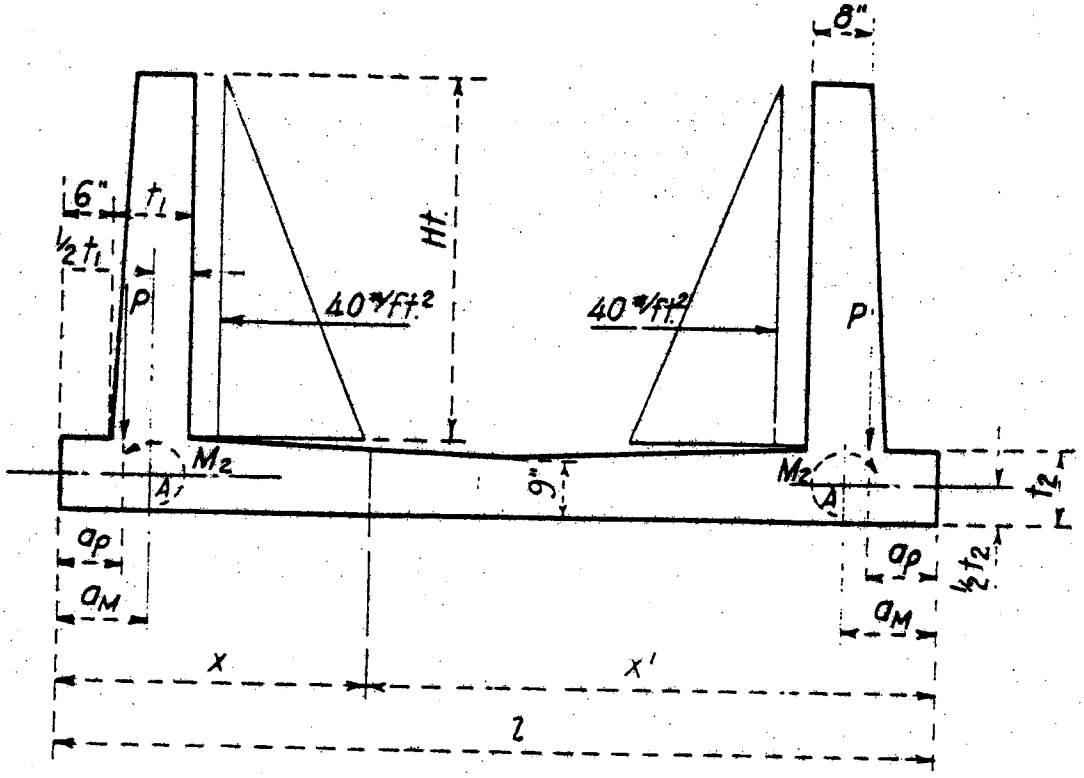
CASE I

Channel Empty

P = Resultant load due to weight of wall and earth load (110 lbs./ft.³) on heel.

M_1 = Moment at "A" due to external horizontal forces acting on wall.

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS



CASE II

Channel Full

P = Resultant load due to weight of wall and earth load (110 #/ft.³) on heel.

M_2 = Moment at "A" due to equivalent differential hydrostatic pressure.

FINITE BEAM EQUATIONS
EQUATIONS FOR MOMENTS

Moment for Case I, $M_I = M_P + M_{M_1}$
Moment for Case II, $M_2 = M_P + M_{M_2}$

$$M_P = \frac{(P_o)_P}{4\lambda}(C_\lambda x + C_\lambda x') + \frac{(M_o)_P}{2}(D_\lambda x + D_\lambda x') + \frac{P}{4\lambda}[C_\lambda(x-a_P) + C_\lambda(x'-a_P)]$$

(2) $$M_{M_1} = \frac{(P_o)_{M_1}}{4\lambda}(C_\lambda x + C_\lambda x') + \frac{(M_o)_{M_1}}{2}(D_\lambda x + D_\lambda x') \mp \frac{M_1}{2}[D_\lambda(x-a_M) + D_\lambda(x'-a_M)]$$

(2) $$M_{M_2} \frac{(P_o)_{M_2}}{4\lambda}(C_\lambda x + C_\lambda x') + \frac{(M_o)_{M_2}}{2}(D_\lambda x + D_\lambda x') \pm \frac{M_2}{2}[D_\lambda(x-a_M) + D_\lambda(x'-a_M)]$$

Upper signs for $0 < x < a_M$

EQUATIONS FOR SOIL PRESSURES

Soil Pressure for Case I, $p_I = p_P + p_{M_1} + p_S$
Soil Pressure for Case II, $p_{II} = p_P + p_{M_2} + p_S + p_W$

p_S = pressure due to weight of slab
p_W = pressure due to weight of water

<u>for $0 \le x \le a$</u>

$$p_P = \frac{(P_o)_P\lambda}{2}(A_\lambda x + A_\lambda x') + (M_o)_P\lambda^2(B_\lambda x + B_\lambda x') + \frac{P\lambda}{2}[A_\lambda(a_P - x) + A_\lambda(x'-a_P)]$$

$$p_{M_1} = \frac{(P_o)_{M_1}\lambda}{2}(A_\lambda x + A_\lambda x') + (M_o)_{M_1}\lambda^2(B_\lambda x + B_\lambda x') - M_1\lambda^2[B_\lambda(a_M - x) - B_\lambda(x'-a_M)]$$

$$p_{M_2} = \frac{(P_o)_{M_2}\lambda}{2}(A_\lambda x + A_\lambda x') + (M_o)_{M_2}\lambda^2(B_\lambda x + B_\lambda x') + M_2\lambda^2[B_\lambda(a_M - x) - B_\lambda(x'-a_M)]$$

<u>for $a \le x \le (l-a)$</u>

$$p_P = \frac{(P_o)_P\lambda}{2}(A_\lambda x + A_\lambda x') + (M_o)_P\lambda^2(B_\lambda x + B_\lambda x') + \frac{P\lambda}{2}[A_\lambda(x-a_P) + A_\lambda(x'-a_P)]$$

$$p_{M_1} = \frac{(P_o)_{M_1}\lambda}{2}(A_\lambda x + A_\lambda x') + (M_o)_{M_1}\lambda^2(B_\lambda x + B_\lambda x') + M_1\lambda^2[B_\lambda(x-a_M) + B_\lambda(x'-a_M)]$$

$$p_{M_2} = \frac{(P_o)_{M_2}\lambda}{2}(A_\lambda x + A_\lambda x') + (M_o)_{M_2}\lambda^2(B_\lambda x + B_\lambda x') - M_2\lambda^2[B_\lambda(x-a_M) + B_\lambda(x'-a_M)]$$

<u>Note:</u> Curves shown as solid lines on accompanying sheets have been calculated using Finite Beam Equations.

(2) Revised 6/14/65

where:

$$P_o = 4E_1 [Q_A (1 + D_{\lambda l}) + \lambda M_A (1 - A_{\lambda l})]$$

$$M_o = -\frac{2E_1}{\lambda} [Q_A (1 + C_{\lambda l}) + 2\lambda M_A (1 - D_{\lambda l})]$$

and:

$$E_1 = \frac{1}{2} \frac{e^{\lambda l}}{\sinh \lambda l + \sin \lambda l}$$

for P $\begin{cases} Q_A = \frac{P}{2} [D_{\lambda a_P} + D_\lambda (l - a_P)] \\ M_A = \frac{P}{4\lambda} [C_{\lambda a_P} + C_\lambda (l - a_P)] \end{cases}$

for M_1 $\begin{cases} Q_A = -\frac{M_1 \lambda}{2} [A_{\lambda a_M} - A_\lambda (l - a_M)] \\ M_A = -\frac{M_1}{2} [D_{\lambda a_M} - D_\lambda (l - a_M)] \end{cases}$

for M_2 $\begin{cases} Q_A = \frac{M_2 \lambda}{2} [A_{\lambda a_M} - A_\lambda (l - a_M)] \\ M_A = \frac{M_2}{2} [D_{\lambda a_M} - D_\lambda (l - a_M)] \end{cases}$

"Characteristic," λ

$$\lambda = \sqrt[4]{\frac{k}{4EI}}$$

Where:

λ = characteristic of system, L^{-1}.
$k = bk_o$, F/L^2.
b = width of beam, usually taken as unity, L.
k_o = modulus of the foundation F/L^3, use 165 #/in³.
E = modulus of elasticity of beam, F/L^2.
I = moment of inertia of beam, L^4.

Functions, A, B, C & D.

$A_{\lambda u} = e^{-\lambda u} (\cos \lambda u + \sin \lambda u)$
$B_{\lambda u} = e^{-\lambda u} \sin \lambda u$
$C_{\lambda u} = e^{-\lambda u} (\cos \lambda u - \sin \lambda u)$
$D_{\lambda u} = e^{-\lambda u} \cos \lambda u$

References:

"Beams on Elastic Foundations" by M. Hetenyi.
Equations derived by T.J. Koyamatsu.

SEMI-INFINITE BEAM EQUATIONS

EQUATIONS FOR MOMENTS

$$M_P = \frac{P}{4\lambda}\left[\alpha C_{\lambda x} - 2\beta D_{\lambda x} + C_{\lambda(x-a_P)}\right]$$

△2 $$M_{M_1} = -\frac{M_1}{2}\left[\mathit{\Omega} C_{\lambda x} - \delta D_{\lambda x} \pm D_{\lambda(x-a_M)}\right]$$ Upper sign when $x<a_M$

△2 $$M_{M_2} = \frac{M_2}{2}\left[\mathit{\Omega} C_{\lambda x} - \delta D_{\lambda x} \pm D_{\lambda(x-a_M)}\right]$$ Upper sign when $x<a_M$

EQUATIONS FOR SOIL PRESSURES

for $0 \leq x \leq a$

$$p_P = \frac{P\lambda}{2}\left[\alpha A_{\lambda x} - 2\beta B_{\lambda x} + A_{\lambda(a_P - x)}\right]$$

$$p_{M_1} = M_1\lambda^2\left[-\mathit{\Omega} A_{\lambda x} + \delta B_{\lambda x} - B_{\lambda(a_M - x)}\right]$$

$$p_{M_2} = M_2\lambda^2\left[\mathit{\Omega} A_{\lambda x} - \delta B_{\lambda x} + B_{\lambda(a_M - x)}\right]$$

for $a \leq x \leq (\ell - a)$

△2 $$p_P = \frac{P\lambda}{2}\left[\alpha A_{\lambda x} - 2\beta B_{\lambda x} + A_{\lambda(x-a_P)}\right]$$

$$p_{M_1} = M_1\lambda^2\left[-\mathit{\Omega} A_{\lambda x} + \delta B_{\lambda x} + B_{\lambda(x-a_M)}\right]$$

△2 $$p_{M_2} = M_2\lambda^2\left[\mathit{\Omega} A_{\lambda x} - \delta B_{\lambda x} - B_{\lambda(x-a_M)}\right]$$

Where:

$$\beta = C_{\lambda a_P} + D_{\lambda a_P}$$
$$\alpha = C_{\lambda a_P} + 2D_{\lambda a_P}$$
$$\mathit{\Omega} = D_{\lambda a_M} + A_{\lambda a_M}$$
$$\delta = A_{\lambda a_M} + 2D_{\lambda a_M}$$

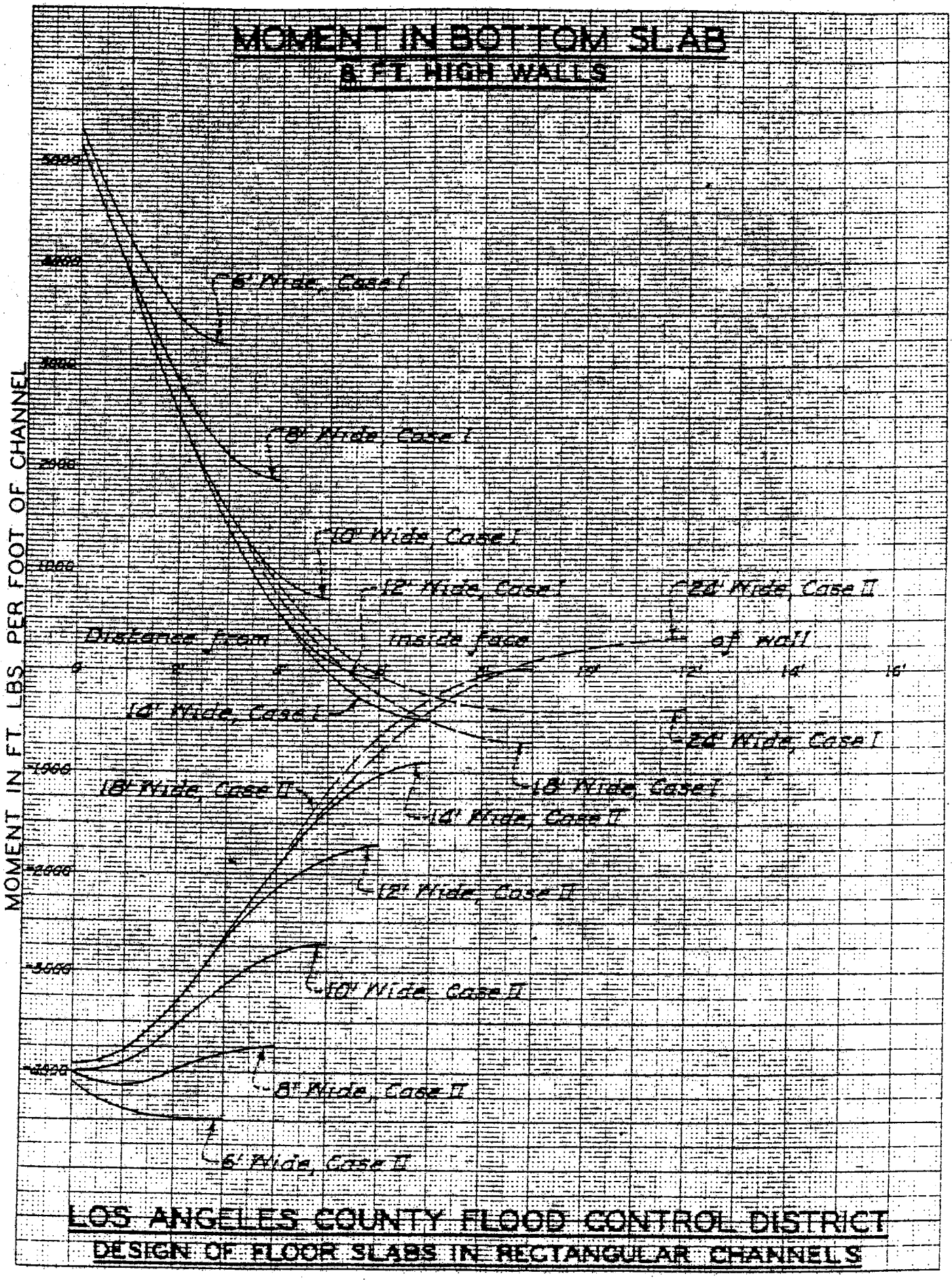
References:

"Beams on Elastic Foundations" by M. Hetenyi.
Equations derived by B. Glidden.

△2 Revised 6/14/65

Note. Curves shown as dashed lines on the accompanying sheets have been calculated using the Semi-Infinite Beam Equations.

MOMENT IN BOTTOM SLAB
8 FT. HIGH WALLS

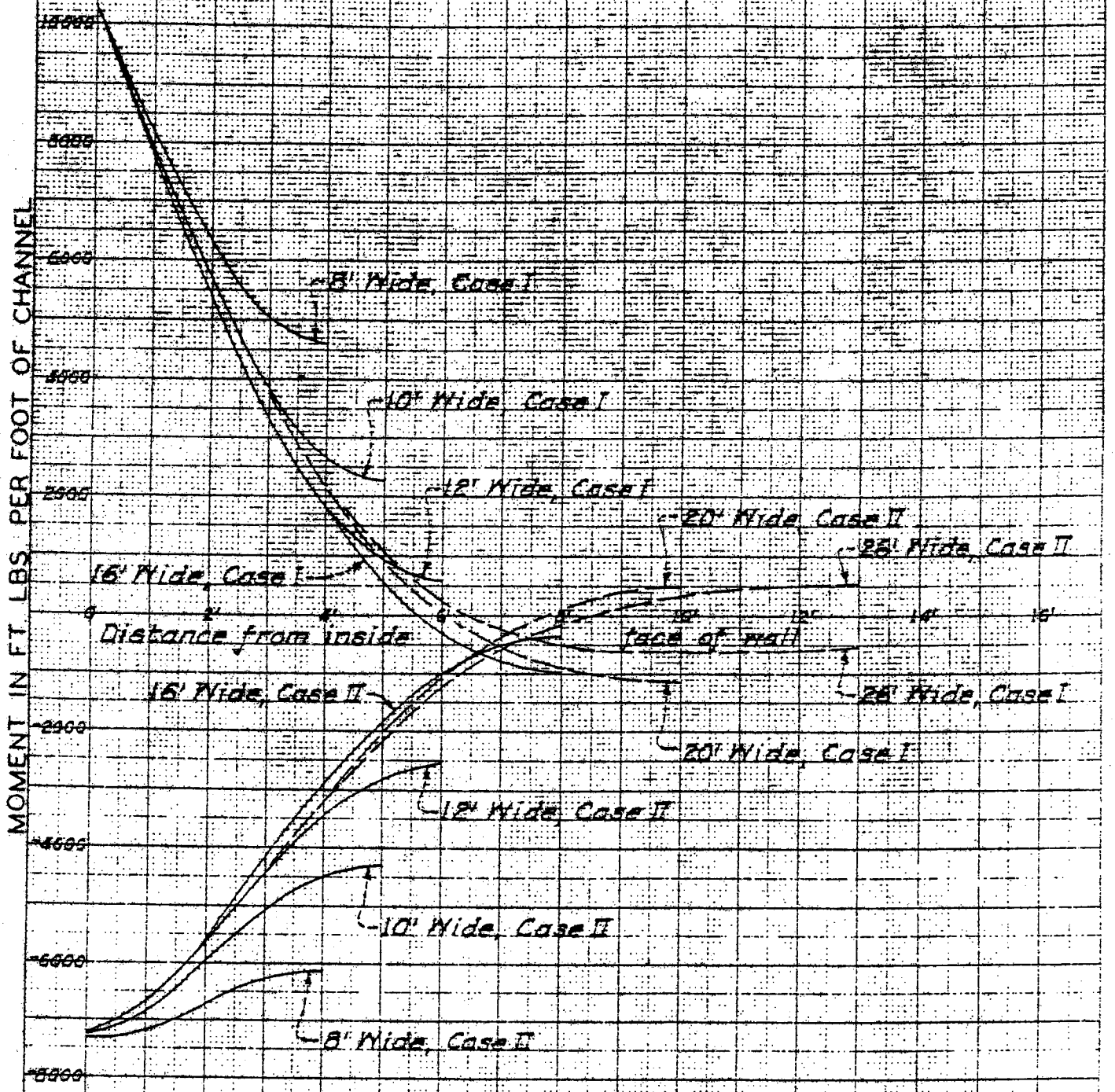


LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB

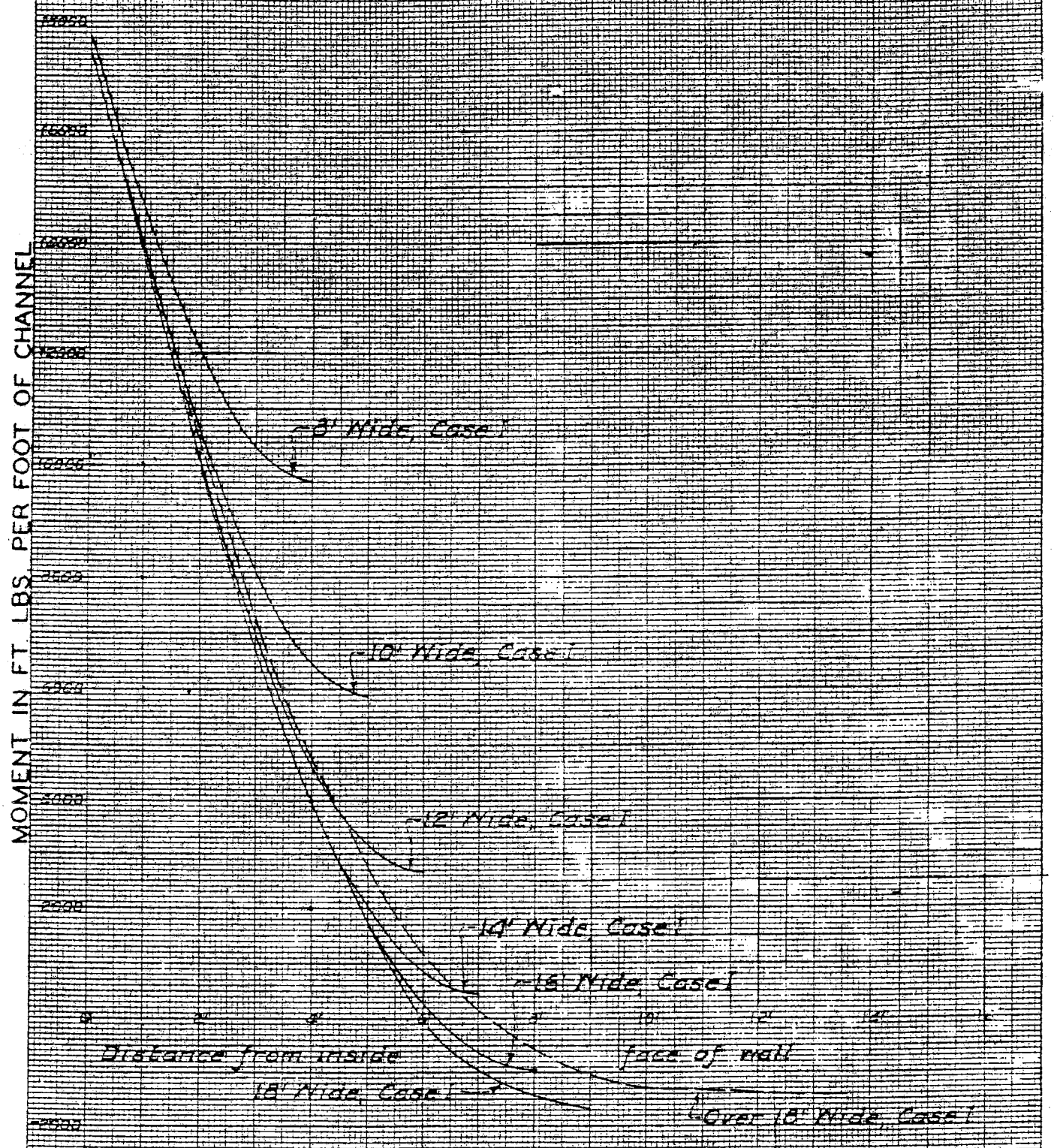
18 FT. HIGH WALLS



LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB
12 FT. HIGH WALLS

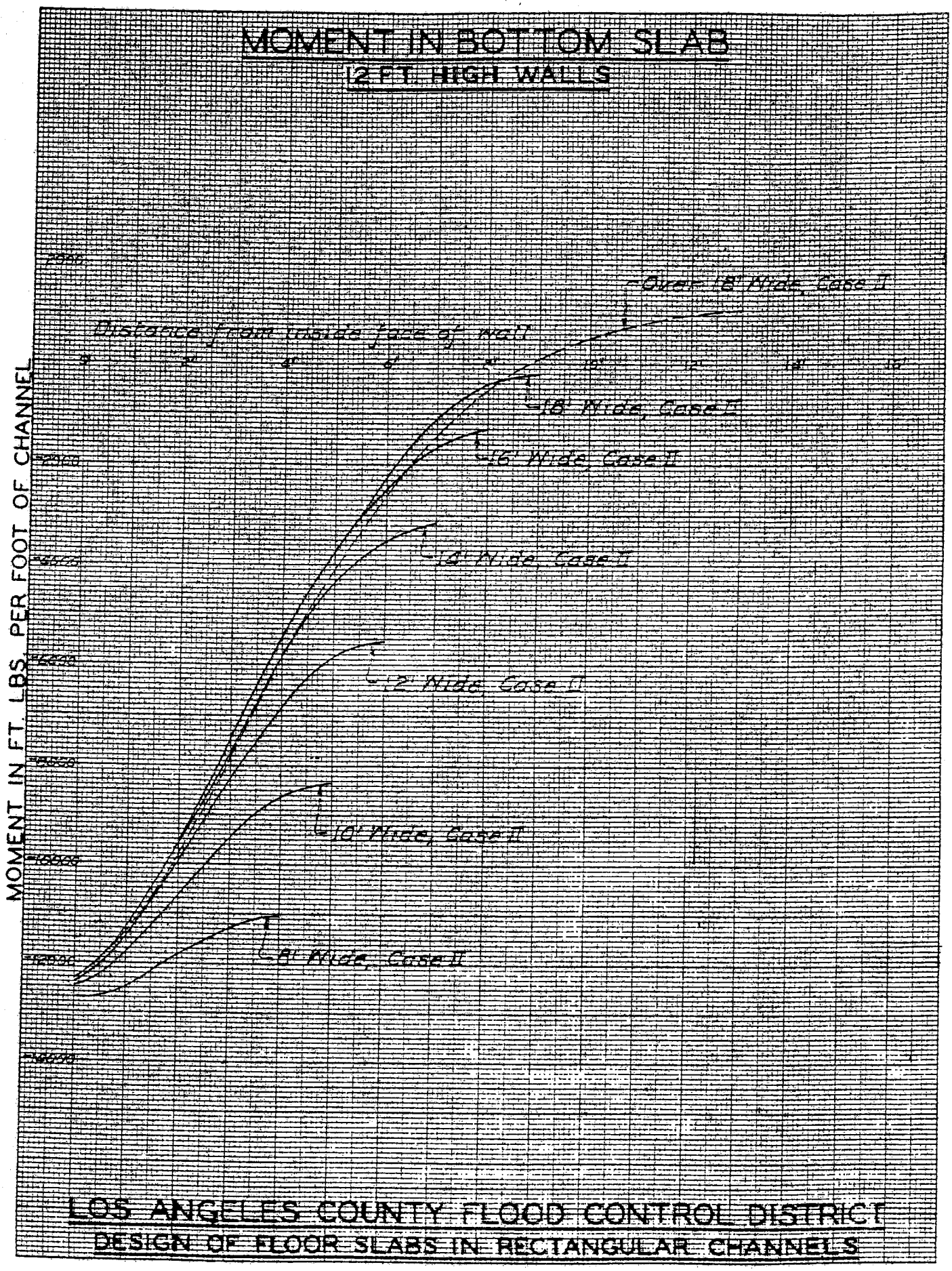


LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB

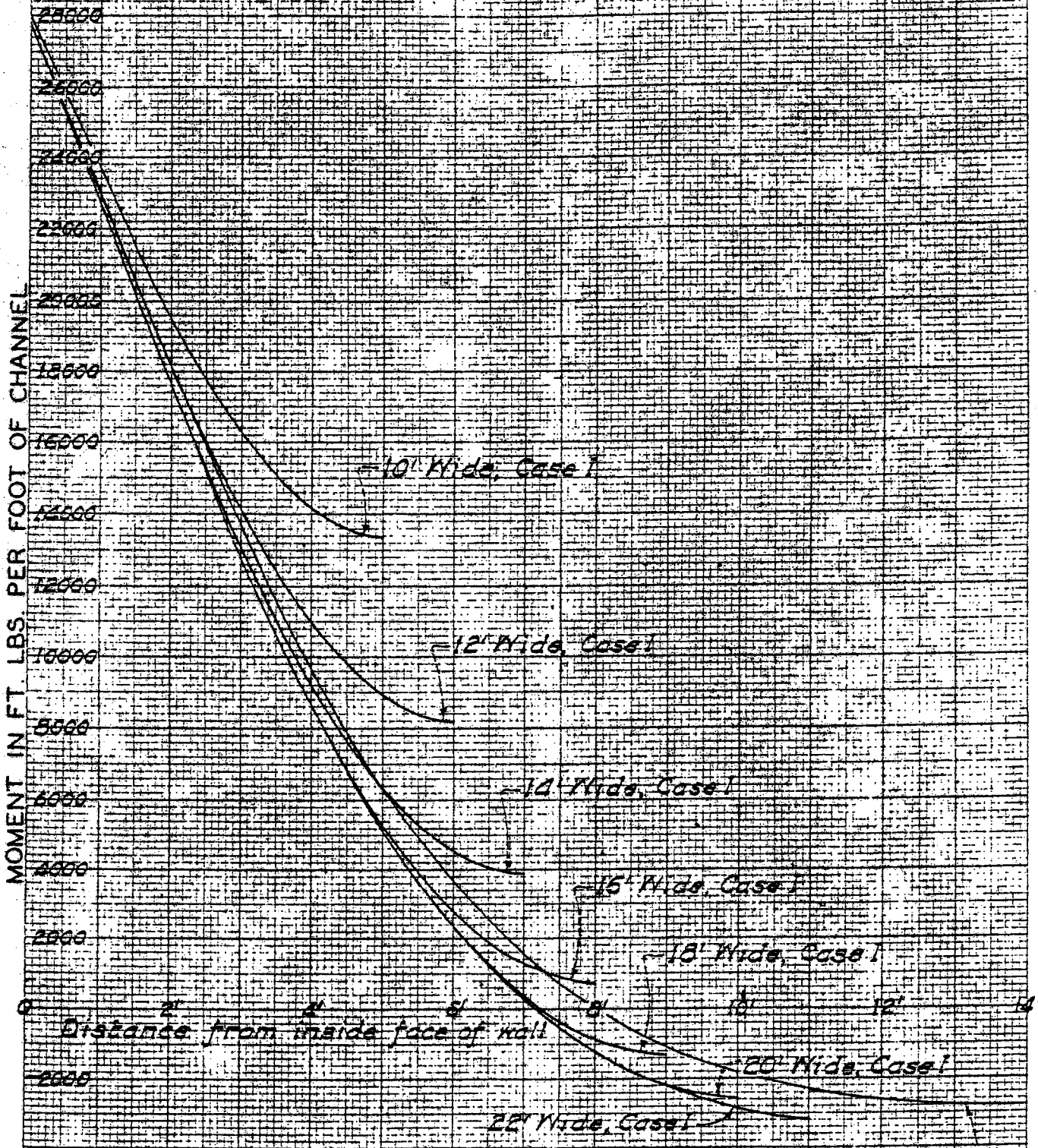
2 FT. HIGH WALLS



LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

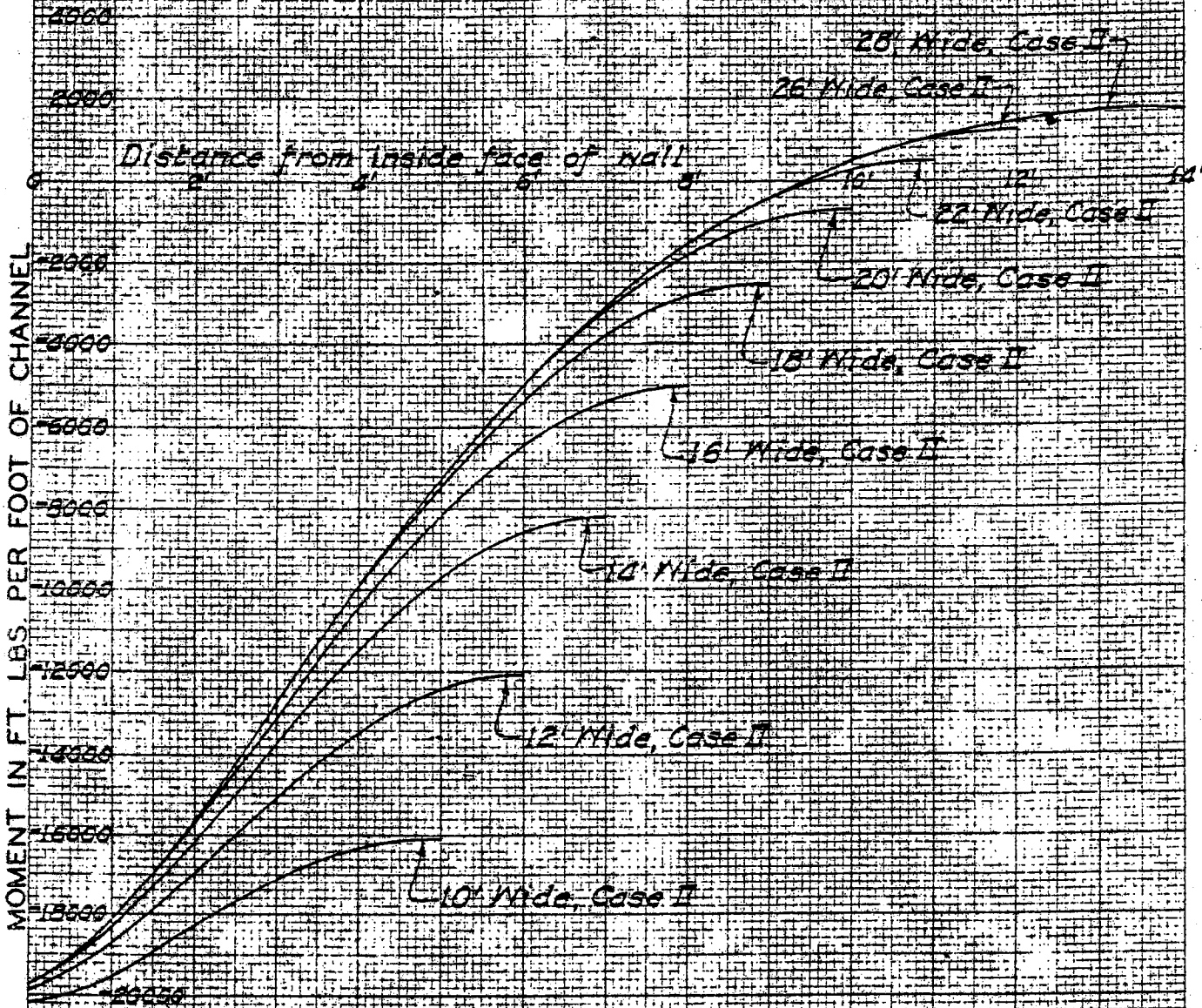
MOMENT IN BOTTOM SLAB
14 FT. HIGH WALLS



LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB
14 FT. HIGH WALLS

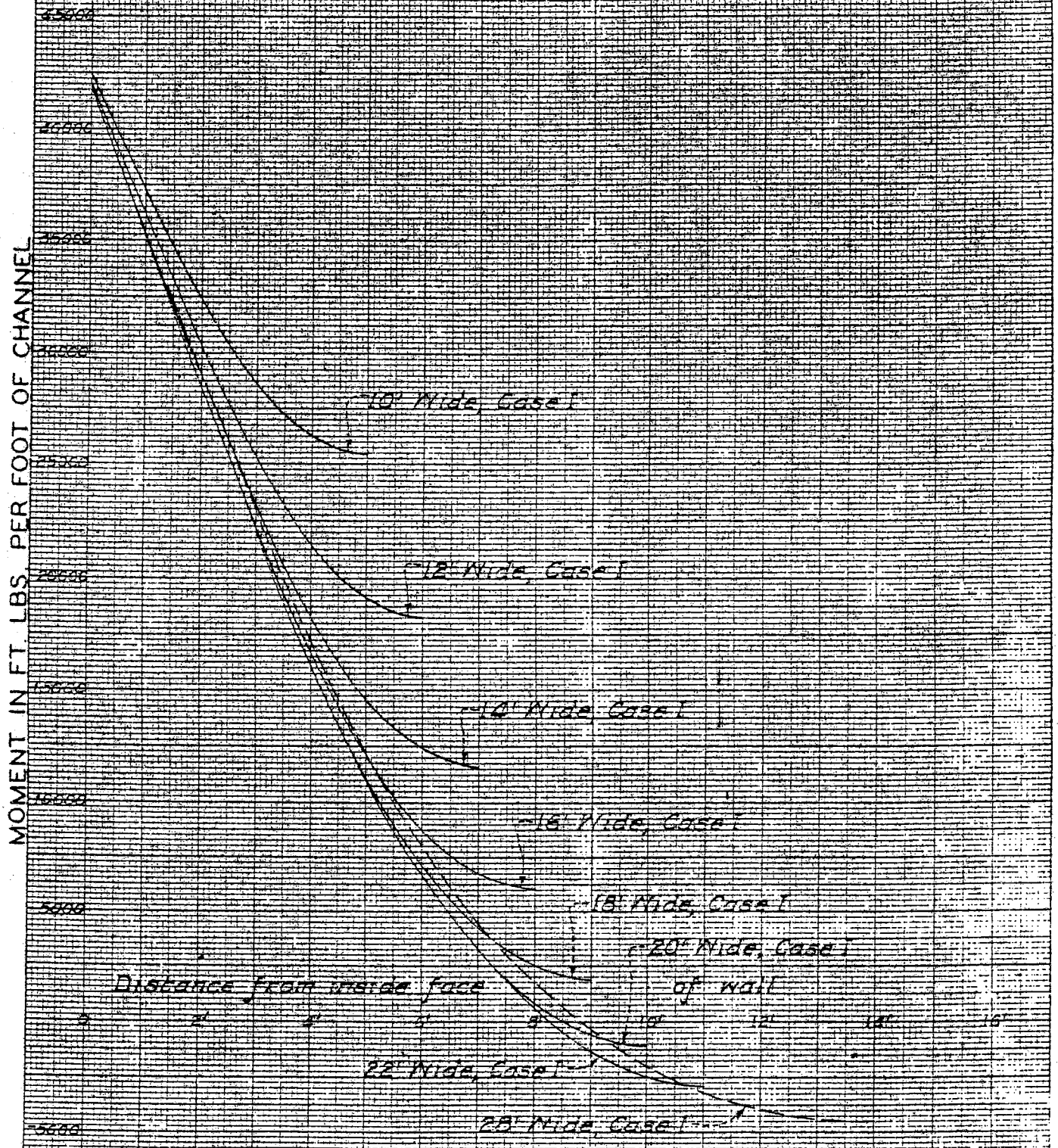


LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB

16 FT. HIGH WALLS

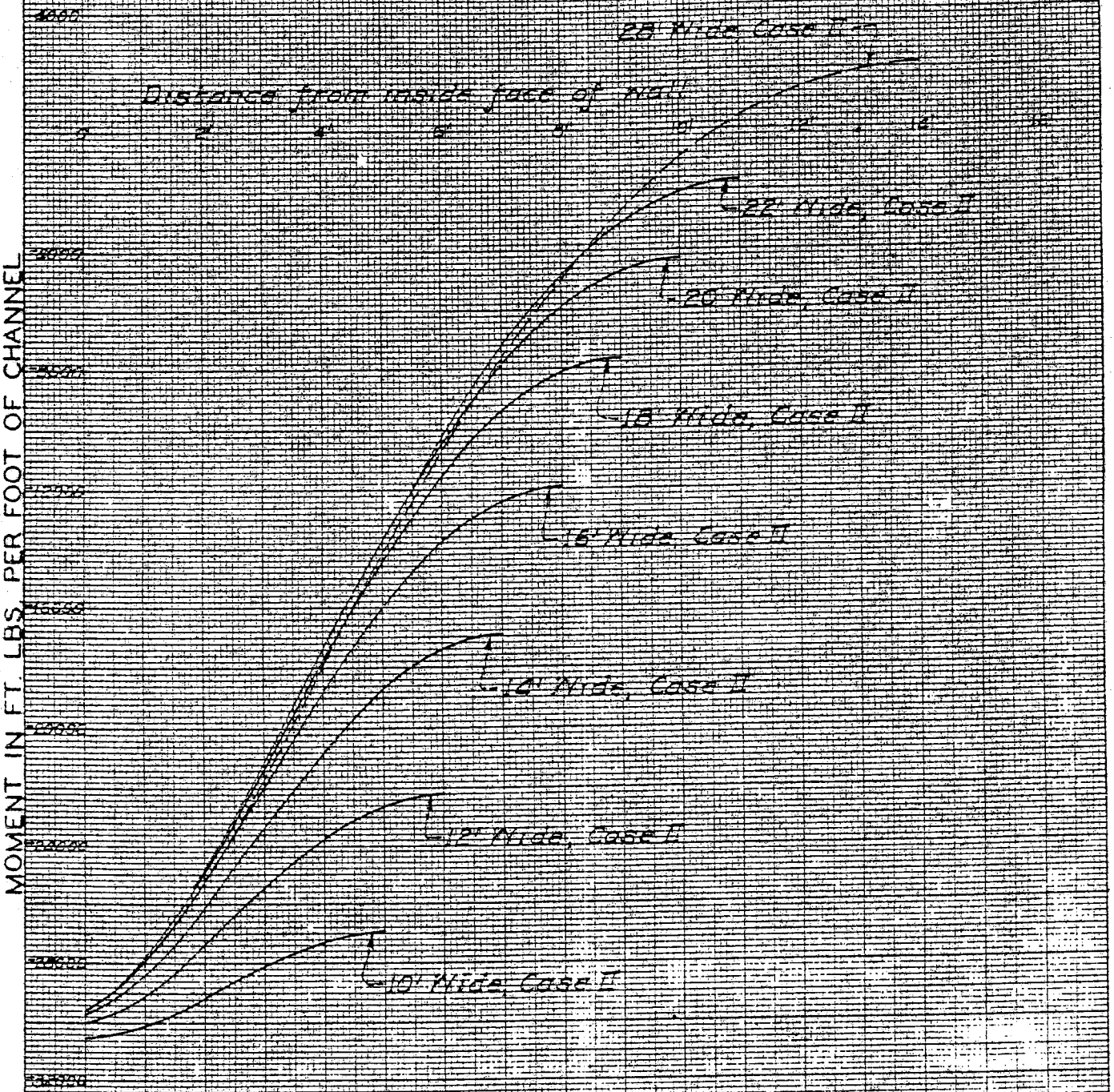


LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB

16 FT. HIGH WALLS



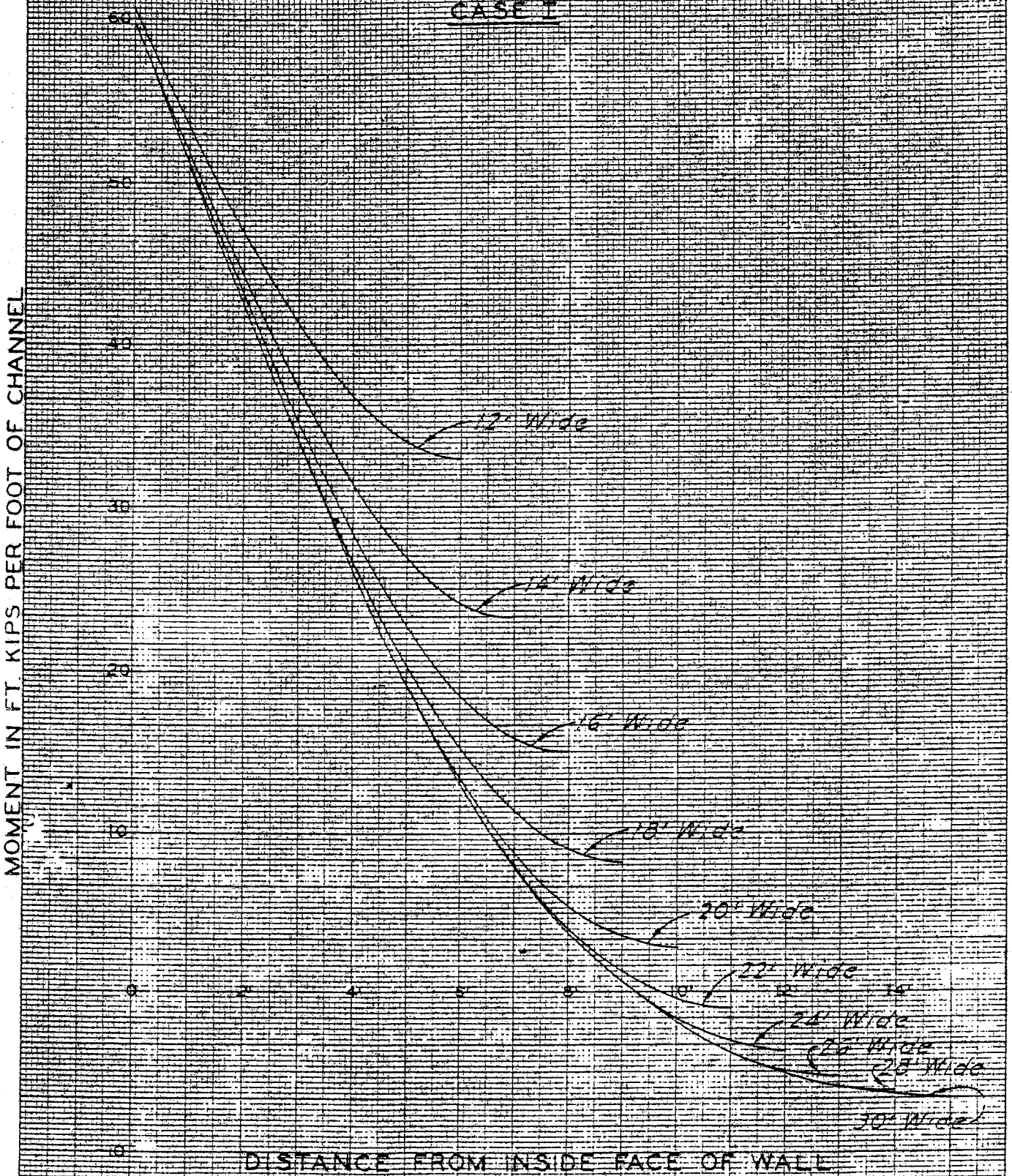
LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB

8 FT. HIGH WALLS

CASE I



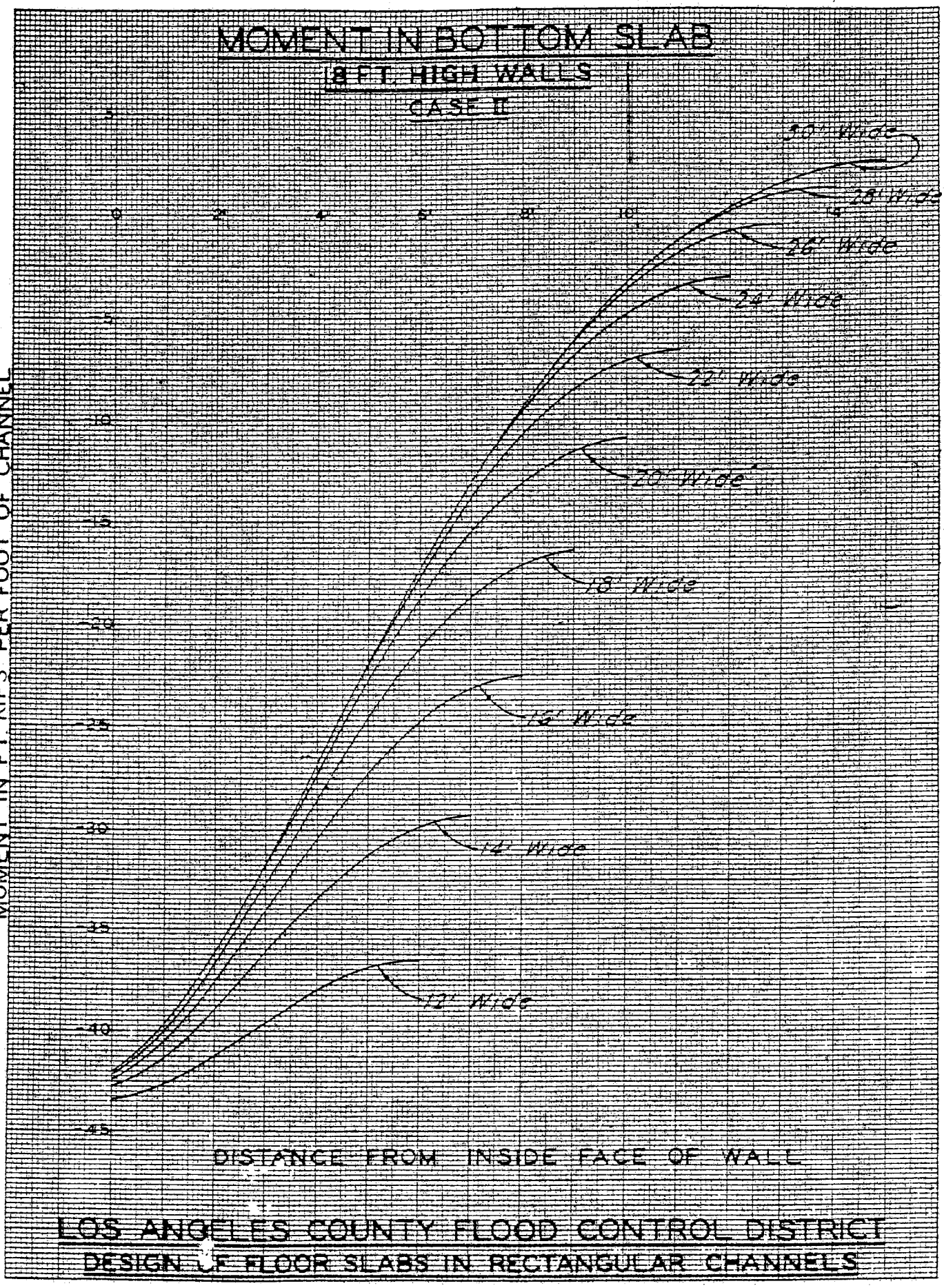
LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB

18 FT. HIGH WALLS

CASE II



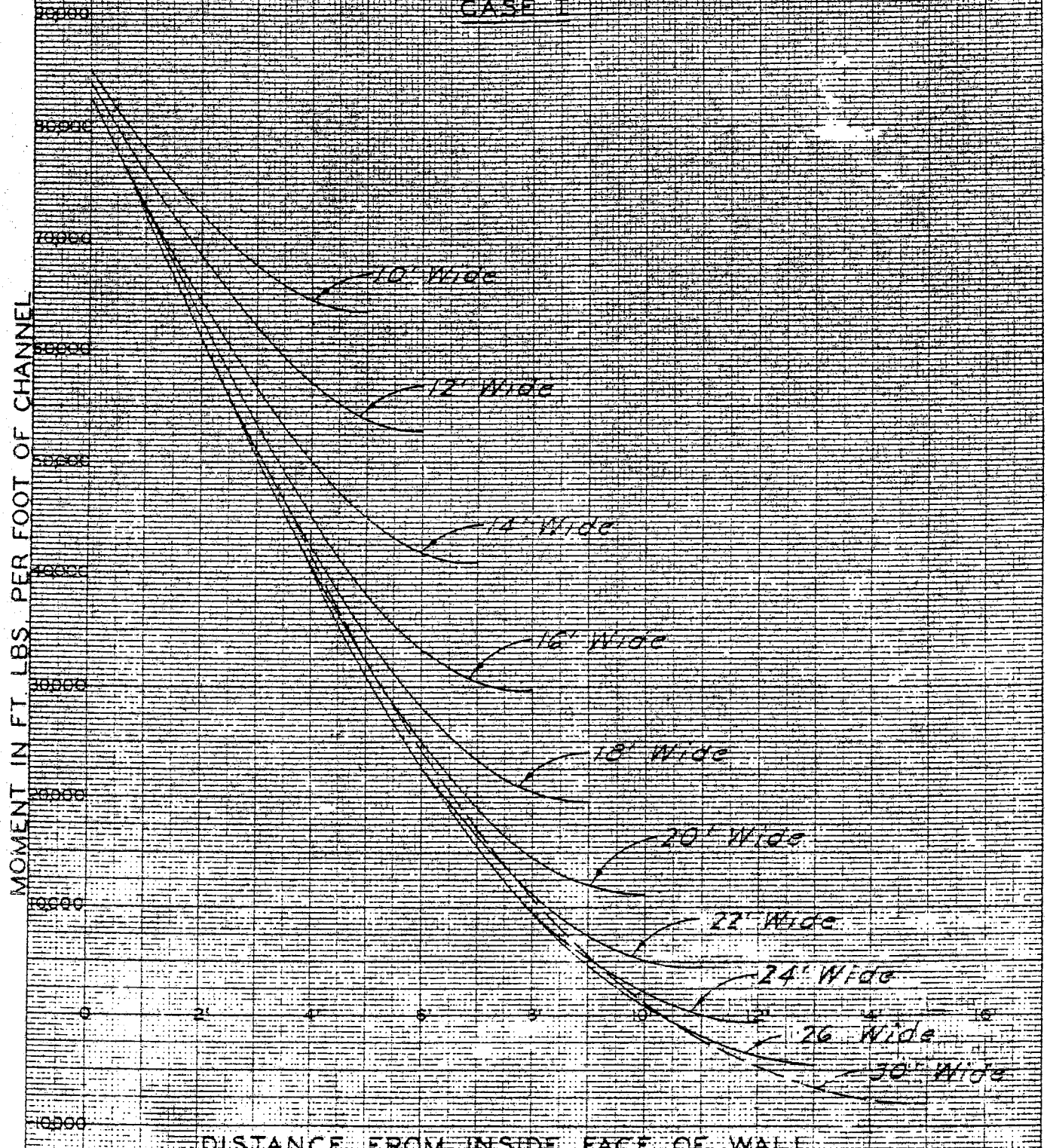
LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB

20FT. HIGH WALLS

CASE I



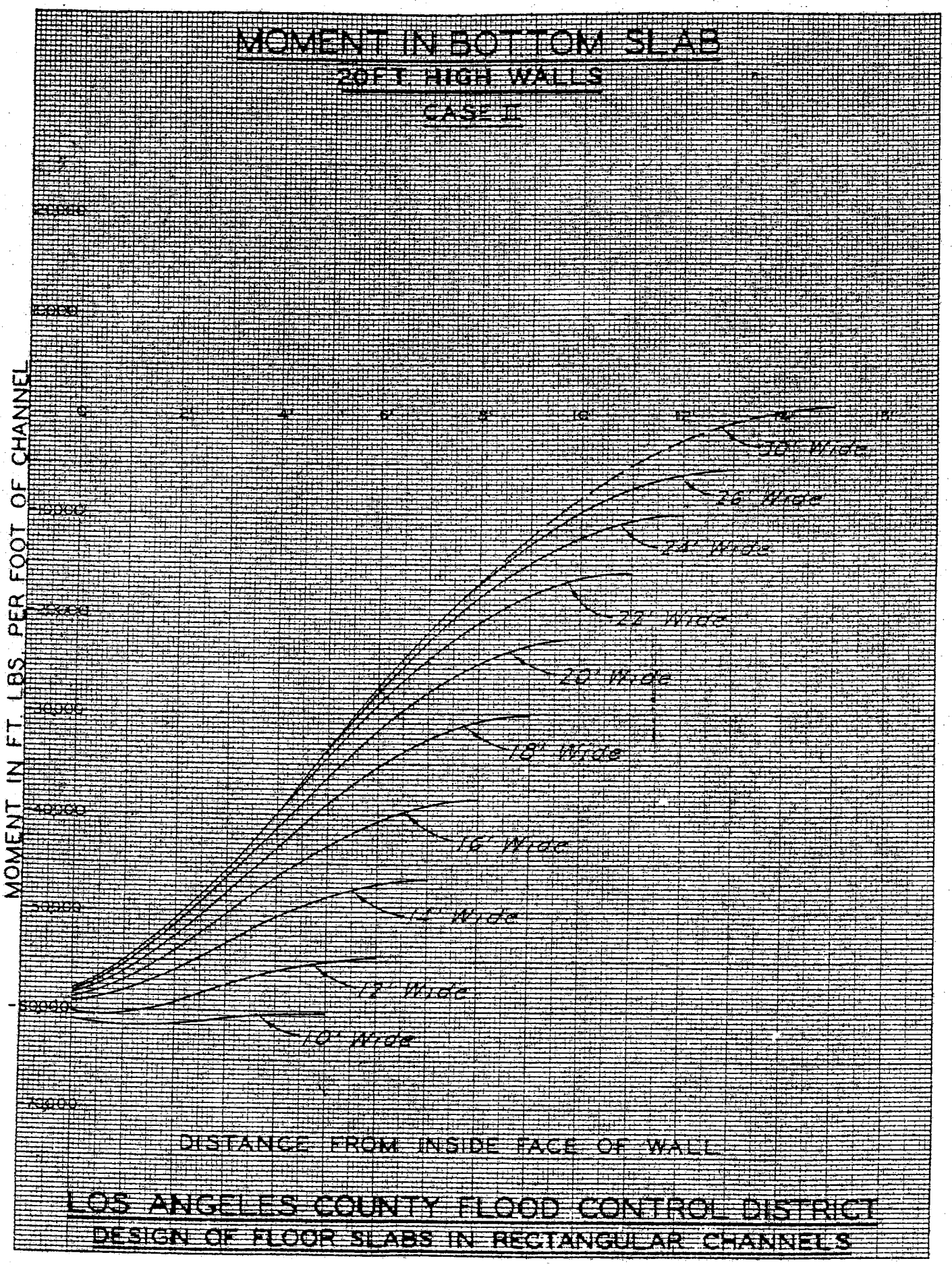
LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB

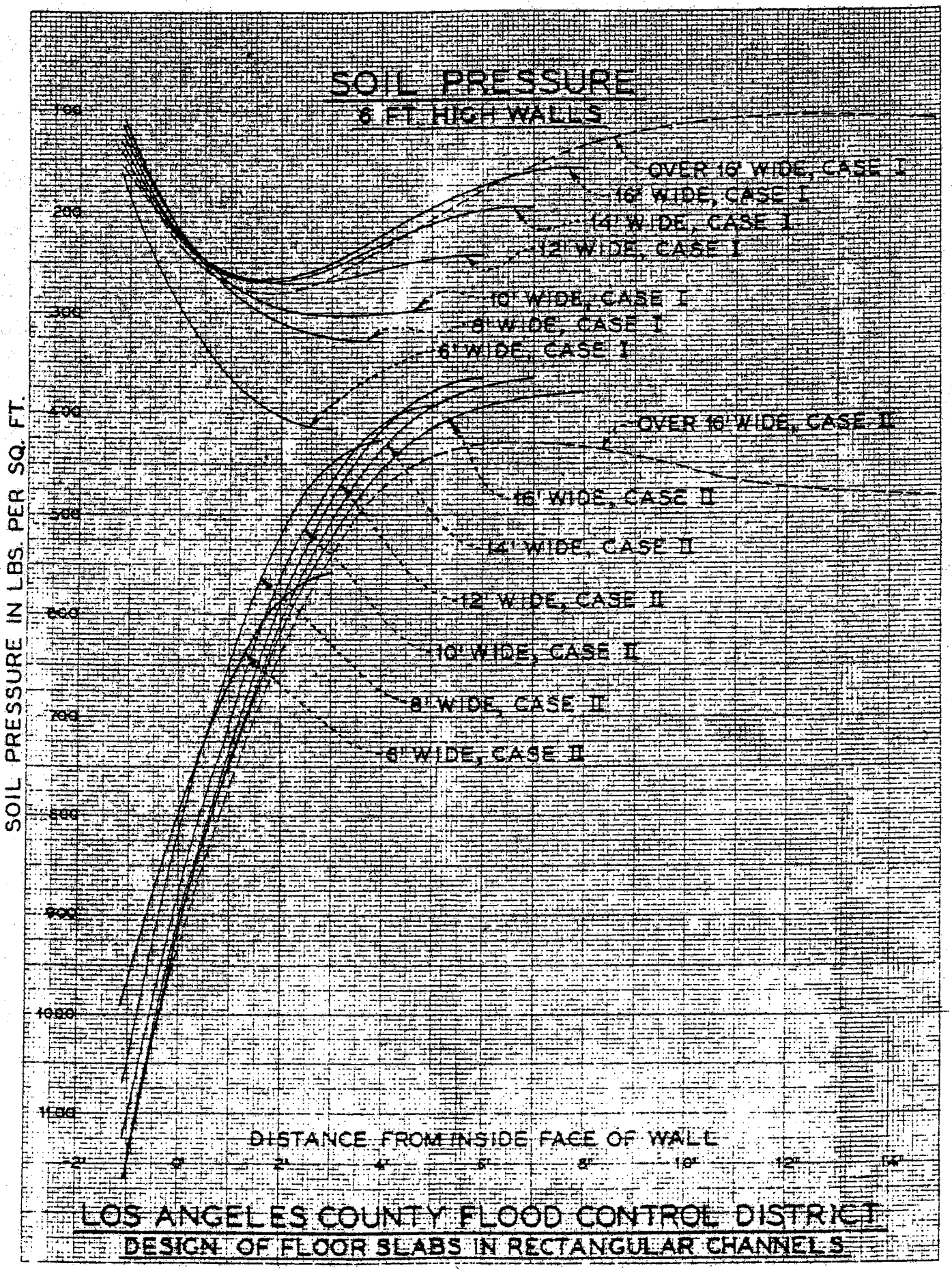
20 FT. HIGH WALLS

CASE II



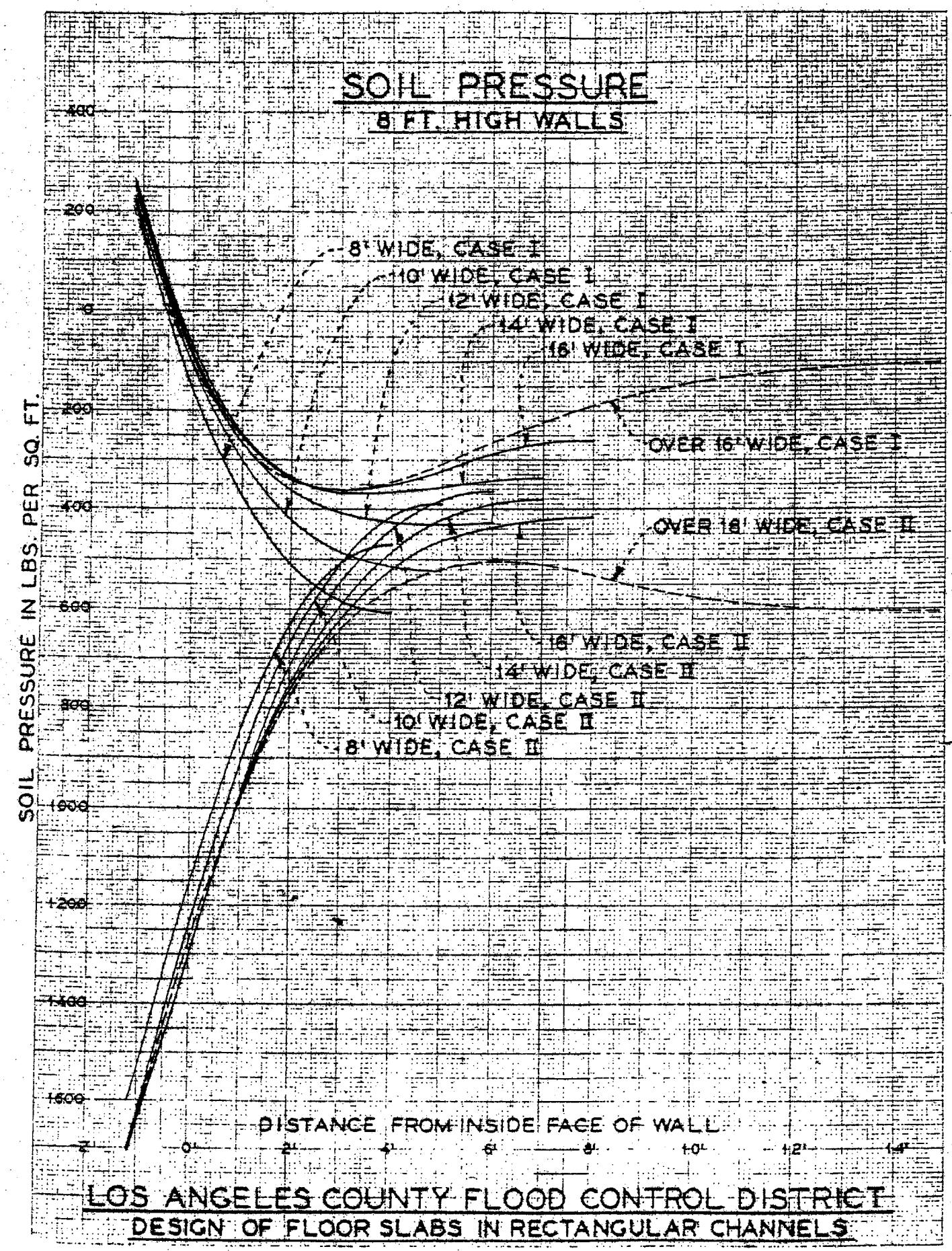
LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS



LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

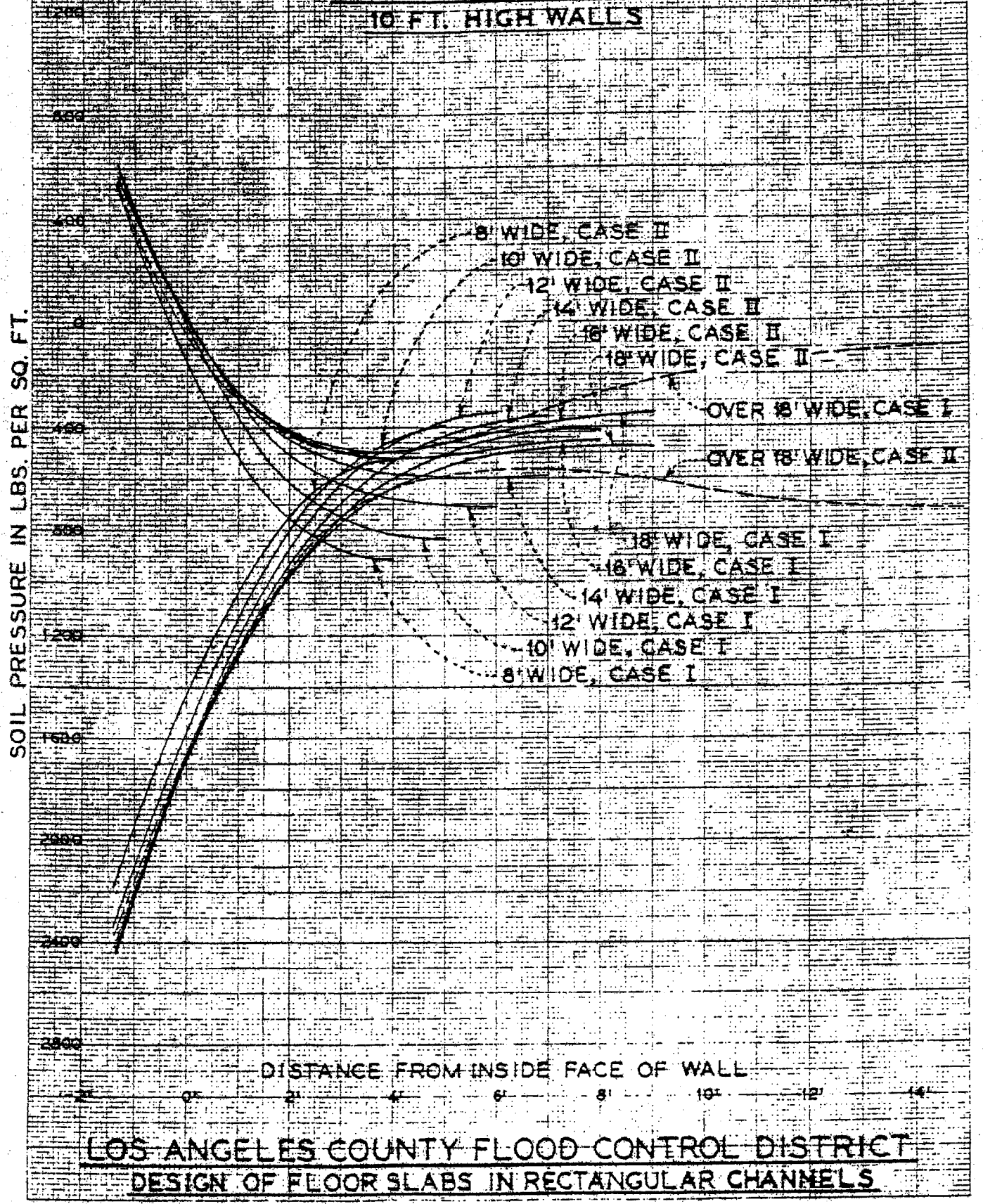


LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

SOIL PRESSURE

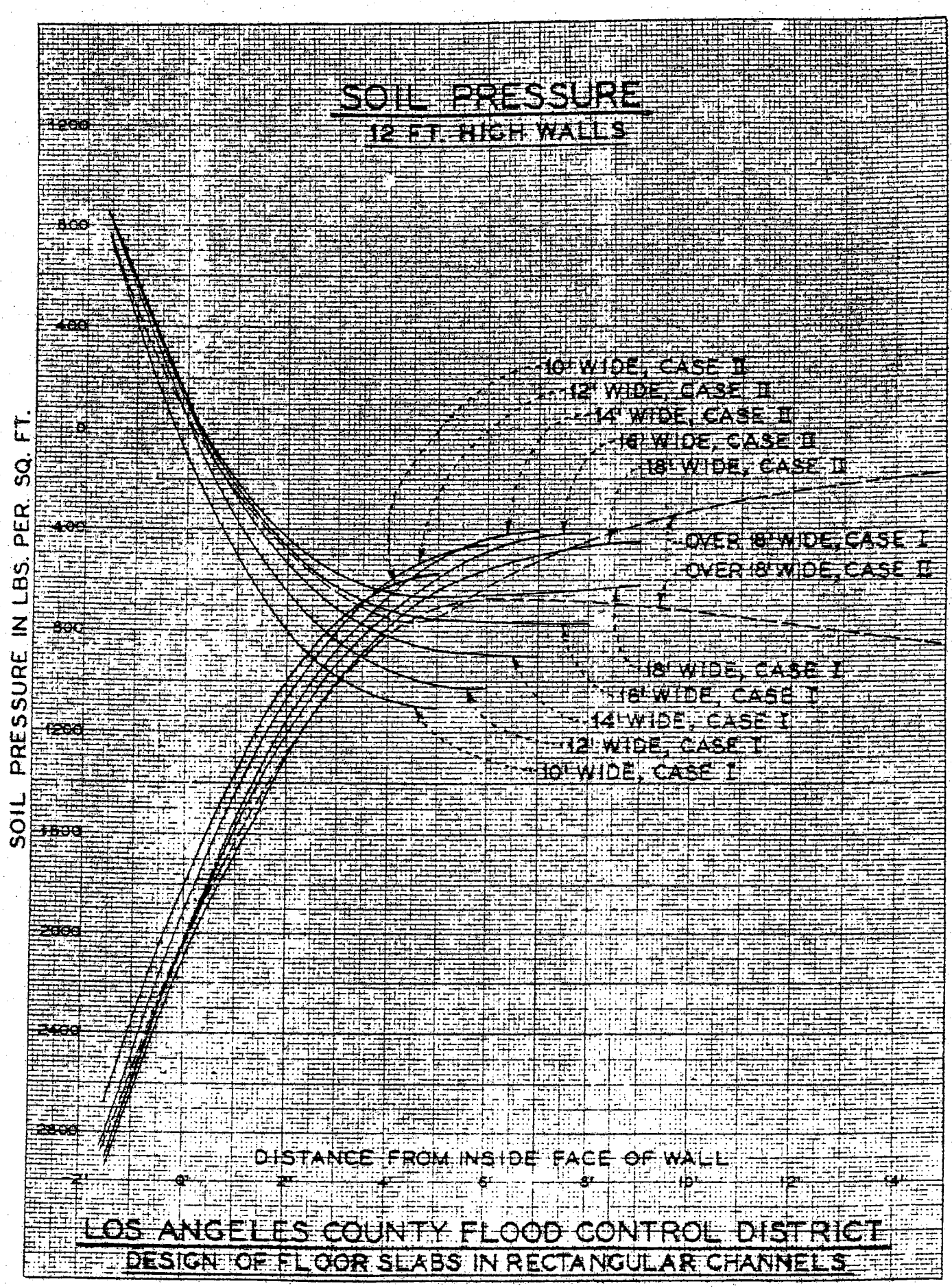
16 FT. HIGH WALLS



LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

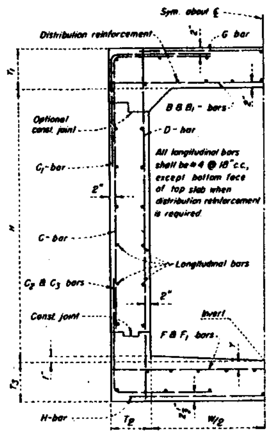
DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

SOIL PRESSURE
12 FT. HIGH WALLS

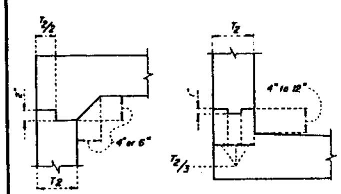


LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS



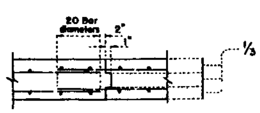
TYPICAL R C BOX SECTION
NOT TO SCALE



TOP OF WALL

BASE OF WALL

LONGITUDINAL JOINT



TRANSVERSE JOINT

CONSTRUCTION JOINT DETAILS
NOT TO SCALE

STRUCTURAL NOTES

1. DIMENSIONS FROM FACE OF CONCRETE TO STEEL ARE TO CENTER OF BAR, UNLESS OTHERWISE SHOWN.
2. CONCRETE DIMENSIONS SHALL BE MEASURED HORIZONTALLY OR VERTICALLY ON THE PROFILE, AND PARALLEL TO OR AT RIGHT ANGLES (OR RADIALLY) TO CENTERLINE OF CONDUIT ON THE PLAN EXCEPT AS OTHERWISE SHOWN.
3. ALL BAR BENDS AND HOOKS SHALL CONFORM TO THE AMERICAN CONCRETE INSTITUTE'S "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE", 1971 EDITION, SECTION 7.1.
4. PLACING OF REINFORCEMENT SHALL CONFORM TO THE AMERICAN CONCRETE INSTITUTE'S "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE", 1971 EDITION, SECTION 7.5.
5. TRANSVERSE CONSTRUCTION JOINTS SHALL NOT BE PLACED WITHIN 30 INCHES OF MANHOLE OR JUNCTION STRUCTURE OPENINGS.
6. TRANSVERSE CONSTRUCTION JOINTS IN WALLS AND SLABS SHALL BE IN THE SAME PLANE. NO STAGGERING OF JOINTS WILL BE PERMITTED. TRANSVERSE CONSTRUCTION JOINTS SHALL BE NORMAL OR RADIAL TO THE CENTERLINE OF CONSTRUCTION.
7. THE TRANSVERSE REINFORCING STEEL SHALL TERMINATE ONE AND ONE-HALF INCHES FROM THE CONCRETE SURFACES UNLESS OTHERWISE SHOWN ON THE STRUCTURAL DETAILS.
8. EXPOSED EDGES OF CONCRETE MEMBERS SHALL BE ROUNDED OR BEVELED.
9. NO SPLICES IN TRANSVERSE STEEL REINFORCEMENT WILL BE PERMITTED OTHER THAN SHOWN ON THE DRAWING WITHOUT APPROVAL OF THE ENGINEER. NO MORE THAN TWO SPLICES WILL BE PERMITTED IN ANY LONGITUDINAL BAR BETWEEN TRANSVERSE JOINTS. SPLICES SHALL BE STAGGERED.
10. LONGITUDINAL STEEL SHALL BE LAPPED 20 BAR DIAMETERS AT SPLICES. TRANSVERSE STEEL SHALL BE LAPPED 3[illegible] BAR DIAMETERS AT SPLICES.
11. LONGITUDINAL STEEL SHALL BE CONTINUOUS AND EXTEND THROUGH ALL CONSTRUCTION [illegible].
12. UNLESS OTHERWISE SHOWN ON THE DRAWINGS, TRANSVERSE CONSTRUCTION JOINTS (IN SLABS AND WALLS), SHALL BE PLACED AT THE END OF EACH POUR, AND THE SPACING THEREOF SHALL NOT EXCEED 50 FEET OR BE LESS THAN 10 FEET.
13. UNLESS OTHERWISE SHOWN ON THE DETAILS, IN CURVED SECTIONS TRANSVERSE BARS SHALL BE PLACED RADIALLY. THE SPACING OF STRAIGHT TRANSVERSE BARS IN TOP AND BOTTOM SLABS SHALL BE MEASURED AT THE CENTERLINE OF CONSTRUCTION. THE SPACING OF STRAIGHT BARS AND L-BARS IN WALLS SHALL BE MEASURED BETWEEN THE VERTICAL LEGS OF BARS.
14. AT THE BEGINNING AND ENDING OF ALL POURS, A CURTAIN OF REINFORCEMENT COMPOSED OF B, C, C2, D, F, G, AND H BARS SHALL BE PLACED THREE INCHES FROM THE TRANSVERSE CONSTRUCTION JOINT.
15. D-BARS MAY BE SPLICED 20 BAR DIAMETERS AT THE LOWER LONGITUDINAL CONSTRUCTION JOINT, AT CONTRACTOR'S OPTION.
16. IN ALL SECTIONS LAP C AND C2 BARS. THE VERTICAL LENGTH OF C AND C2 HAS BEEN CALCULATED FOR A FOUR INCH STARTER WALL. IF THE HEIGHT OF THE STARTER WALL IS VARIED, THE VERTICAL LENGTH OF THE C AND C2 BARS SHALL BE VARIED CORRESPONDINGLY SO AS TO MAINTAIN A 30 DIAMETER LAP BETWEEN THE TWO BARS. THE LAPS SHALL BE BASED ON THE SMALLER BAR.
17. CONCRETE QUANTITIES ARE BASED ON A SIX-BY-SIX INCH FILLET AND THE STEEL QUANTITIES DO NOT INCLUDE ANY OPTIONAL SPLICES.
18. IF WALL THICKNESS IS SIX INCHES, PLACE REINFORCEMENT AT THE CENTERLINE OF THE WALL.
19. THE DESIGN OF BOX SECTIONS IDENTIFIED BY A NUMERICAL VALUE ONLY IS BASED ON A WIDTH OF TRENCH EQUAL TO THE OUTSIDE WIDTH OF THE CONDUIT PLUS 3 FEET. WHEN THE COVER IS EQUAL TO 10 FEET OR LESS THE TRENCH WIDTH IS UNRESTRICTED. WHEN THE COVER IS GREATER THAN 10 FEET AND THE TRENCH WIDTH IS GREATER THAN THE OUTSIDE WIDTH OF THE CONDUIT PLUS 3 FEET FOR A DISTANCE IN EXCESS OF 10 FEET AN ALTERNATE SECTION SHALL BE USED AS INDICATED BELOW:
   A. WHEN THE DEPTH OF COVER IS LESS THAN 10 FEET, SECTIONS WITH THE SUFFIX "B" SHALL BE USED.
   B. WHEN THE DEPTH COVER IS GREATER THAN 10 FEET AND:
      1. THE TRENCH WIDTH IS LESS THAN THE OUTSIDE WIDTH OF THE CONDUIT PLUS 6 FEET, SECTIONS WITH SUFFIX "A" SHALL BE USED.
      2. THE TRENCH WIDTH IS GREATER THAN THE OUTSIDE WIDTH OF CONDUIT PLUS 6 FEET, SECTIONS WITH THE SUFFIX "B" SHALL BE USED.

BOX SECTION											
Design Cover											
Width	W										
Height	H										
Top Slab Thickness	T_1										
Side Wall Thickness	T_2										
Bottom Slab Thickness	T_3										
Concrete Cover (Chan.)	Y										
B	Bar No. & Spacing										
Bars	Length										
B_1	Bar No. & Spacing										
Bars	Length										
C	Bar No. & Spacing										
	Hor. Length										
Bars	Vert. Length										
C_1	Bar No. & Spacing										
Bars	Hor. Length										
	Vert. Length										
C_2	Bar No. & Spacing										
	Hor. Length										
Bars	Vert. Length										
C_3	Bar No. & Spacing										
	Hor. Length										
Bars	Vert. Length										
D	Bar No. & Spacing										
Bars	Length										
F	Bar No. & Spacing										
Bars	Length										
F_1	Bar No. & Spacing										
Bars	Length										
G	Bar No. & Spacing										
Bars	Length										
H	Bar No. & Spacing										
Bars	Length										
NUMBER OF LONGITUDINAL REINFORCEMENT #4 BARS											
Top Slab (Includes distribution reinforcement)											
Bottom Slab											
Side Walls											
TOTAL											
QUANTITIES											
Concrete Cu. Yds./Lin. Ft.											
Steel Lbs./Lin. Ft.											

STRUCTURAL DESIGN CRITERIA
L.A.C.F.C.D. STRUCTURAL DESIGN MANUAL
DATED APRIL 1962

LIVE LOAD
H20-S16-44 unless otherwise noted

DEAD LOAD
Earth load per Marston's formula: w = p c f
Ku = Ku' = 0.150
Bd = Outside width of box plus 3 feet
Side earth p s f per foot of depth
Internal water pressure: 62.4 p s f per foot of depth
Weight of concrete: 150 p c f

ALLOWABLE STRESSES
f'_c = 4000 p s i at 28 days
f_c = 1800 p s i
f_s = 24,000 p s i
n = 8
Shear and bond stresses per A.C.I. 318-63

R C BOX LOCATION SCHEDULE					
Box Sect.	Station		Box Sect.	Station	
	From	To		From	To

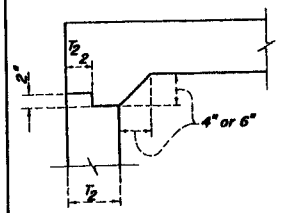
REVISIONS		
NO.	DATE	DESCRIPTION

DESIGNED BY
CHECKED BY
DRAWN BY
PROJECT ENGINEER

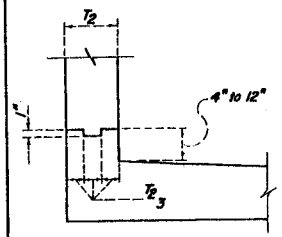
LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

SINGLE R C BOX
STRUCTURAL SCHEDULE, NOTES AND DETAILS

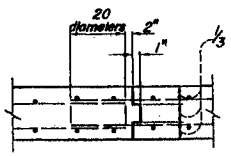
RECOMMENDED BY
DIVISION ENGINEER
DATE
SCALE
NO.
SHEET OF



TOP OF WALL



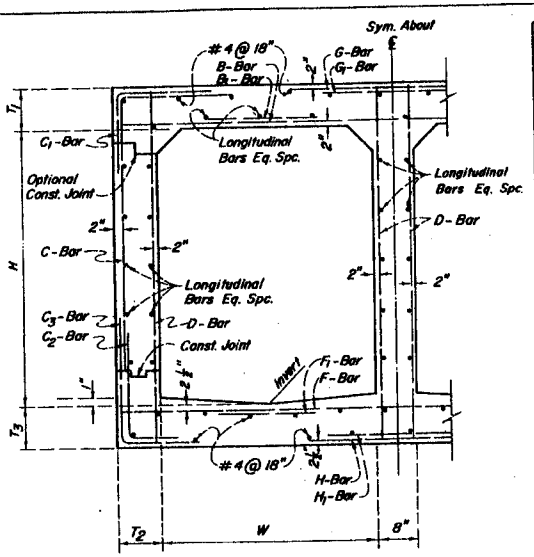
BASE OF WALL



TRANSVERSE JOINT

CONSTRUCTION JOINT DETAILS

NOT TO SCALE



TYPICAL R. C. BOX SECTION

NOT TO SCALE

DESIGN DATA

LIVE LOAD

H20-S16-44 unless otherwise noted

DEAD LOAD

Earth load per Marston's formula: w = 110 p.c.f.
Ku = Ku' = 0.150
Bd = Outside width of box plus 3 feet
Side earth 37 p.s.f. per foot of depth
Internal water pressure: 62.4 p.s.f. per foot of depth
Weight of concrete: 150 p.c.f.

ALLOWABLE STRESSES

f'_c = 4000 p.s.i. at 28 days
f_c = 1800 p.s.i.
f_s = 24000
n = 8
shear and bond stresses per A.C.I. 318-63

BOX SECTION NO.											
Design Cover											
Width	W										
Height	H										
Live Load											
Top Slab Thickness	T_1										
Side Wall Thickness	T_2										
Bottom Slab Thickness	T_3										
B Bars	Bar No. & Spacing										
	Length										
B_1 Bars	Bar No. & Spacing										
	Length										
C Bars	Bar No. & Spacing										
	Horiz. Length										
	Vert. Length										
C_1 Bars	Bar No. & Spacing										
	Horiz. Length										
	Vert. Length										
C_2 Bars	Bar No. & Spacing										
	Horiz. Length										
	Vert. Length										
C_3 Bars	Bar No. & Spacing										
	Horiz. Length										
	Vert. Length										
D Bars	Bar No. & Spacing										
	Length										
F Bars	Bar No. & Spacing										
	Length										
F_1 Bars	Bar No. & Spacing										
	Length										
G Bars	Bar No. & Spacing										
	Length										
G_1 Bars	Bar No. & Spacing										
	Length										
H Bars	Bar No. & Spacing										
	Length										
H_1 Bars	Bar No. & Spacing										
	Length										
NUMBER LONGITUDINAL REINFORCEMENT #4 BARS											
Top Slab (Includes Distrib.)											
Ext. Walls											
Int. Walls											
Inv. Slab											
TOTAL											
QUANTITIES											
Concrete Cu. Yds./Lin. Ft.											
Steel Lbs./Lin. Ft.											

STRUCTURAL NOTES

GENERAL

1. DIMENSIONS FROM FACE OF CONCRETE TO STEEL ARE TO CENTER OF BAR AND SHALL BE TWO INCHES UNLESS OTHERWISE SHOWN.
2. CONCRETE DIMENSIONS SHALL BE MEASURED HORIZONTALLY OR VERTICALLY ON THE PROFILE, AND PARALLEL TO OR AT RIGHT ANGLES (OR RADIALLY) TO CENTERLINE OF CONDUIT ON THE PLAN EXCEPT AS OTHERWISE SHOWN.
3. ALL BAR BENDS AND HOOKS SHALL CONFORM TO THE AMERICAN CONCRETE INSTITUTE'S "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE" SECTION 891.
4. PLACING OF REINFORCEMENT SHALL CONFORM TO THE AMERICAN CONCRETE INSTITUTE'S "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE" SECTION 805.
5. TRANSVERSE CONSTRUCTION JOINTS SHALL NOT BE PLACED WITHIN 30 INCHES OF MANHOLE OR JUNCTION STRUCTURE OPENINGS.
6. TRANSVERSE CONSTRUCTION JOINTS IN WALLS AND SLABS SHALL BE IN THE SAME PLANE. NO STAGGERING OF JOINTS WILL BE PERMITTED. TRANSVERSE CONSTRUCTION JOINTS SHALL BE NORMAL OR RADIAL TO THE CENTERLINE OF CONSTRUCTION.
7. THE TRANSVERSE REINFORCING STEEL SHALL TERMINATE ONE AND ONE-HALF INCHES FROM THE CONCRETE SURFACES UNLESS OTHERWISE SHOWN ON THE STRUCTURAL DETAILS.
8. EXPOSED EDGES OF CONCRETE MEMBERS SHALL BE ROUNDED OR BEVELED.
9. NO SPLICES IN TRANSVERSE STEEL REINFORCEMENT WILL BE PERMITTED OTHER THAN SHOWN ON THE DRAWING WITHOUT APPROVAL OF THE ENGINEER. NO MORE THAN TWO SPLICES WILL BE PERMITTED IN ANY LONGITUDINAL BAR BETWEEN TRANSVERSE JOINTS. SPLICES SHALL BE STAGGERED.
10. LONGITUDINAL STEEL SHALL BE LAPPED 20 BAR DIAMETERS AT SPLICES. TRANSVERSE STEEL SHALL BE LAPPED 30 BAR DIAMETERS AT SPLICES.

ADDITIONAL NOTES FOR BOX SECTIONS

1. LONGITUDINAL STEEL SHALL BE CONTINUOUS AND EXTEND THROUGH ALL CONSTRUCTION JOINTS.
2. UNLESS OTHERWISE SHOWN ON THE DRAWINGS, TRANSVERSE JOINT KEYWAYS (IN BOTH SLABS AND WALLS), AS DETAILED FOR LONGITUDINAL KEYWAYS AT THE BASE OF THE WALLS, SHALL BE PLACED AT THE END OF EACH POUR, BUT THE SPACING THEREOF SHALL NOT EXCEED 50 FEET OR BE LESS THAN 10 FEET. ALL CONSTRUCTION JOINTS IN BOTTOM SLAB, TOP SLAB, AND SIDE WALLS SHALL BE IN THE SAME PLANE. NO STAGGERING OF JOINTS WILL BE PERMITTED.
3. UNLESS OTHERWISE SHOWN ON THE DETAILS, IN CURVED SECTIONS TRANSVERSE BARS SHALL BE PLACED RADIALLY. STRAIGHT TRANSVERSE BARS IN TOP AND BOTTOM SLABS SHALL BE SPACED AS SHOWN ON THE TYPICAL SECTIONS. SPACING SHALL BE AT THE CENTERLINE OF CONSTRUCTION FOR SINGLE-BARREL BOXES. STRAIGHT BARS AND L-BARS IN WALLS SHALL BE SPACED AS SHOWN ON THE TYPICAL SECTIONS, WITH THE SPACING MEASURED BETWEEN THE VERTICAL LEGS OF BARS
4. AT THE BEGINNING AND ENDING OF ALL POURS, A CURTAIN OF REINFORCEMENT COMPOSED OF B, C, C_2, D, AND F, G, AND H BARS SHALL BE PLACED THREE INCHES FROM THE TRANSVERSE CONSTRUCTION JOINT.
5. THE VERTICAL WALL STEEL IN INTERIOR WALLS AND IN THE INTERIOR FACE OF EXTERIOR WALLS MAY BE SPLICED AT THE CONSTRUCTION JOINT AT THE BASE OF THE WALL. THE SPLICE SHALL BE 20 BAR DIAMETERS IN LENGTH.
6. IN ALL SECTIONS LAP C AND C_2 BARS. THE VERTICAL LENGTH OF C AND C_2 BARS HAS BEEN CALCULATED FOR A FOUR-INCH STARTER WALL. IF THE HEIGHT OF THE STARTER WALL IS VARIED, THE VERTICAL LENGTH OF THE C AND C_2 BARS SHALL BE VARIED CORRESPONDINGLY SO AS TO MAINTAIN A 30 DIAMETER LAP BETWEEN THE TWO BARS. THE LAPS SHALL BE BASED ON THE SMALLER BAR.
7. CONCRETE QUANTITIES ARE BASED ON A SIX-BY-SIX-INCH FILLET AND THE STEEL QUANTITIES DO NOT INCLUDE ANY OPTIONAL SPLICES.
8. IF WALL THICKNESS IS SIX INCHES, PLACE REINFORCEMENT AT THE CENTERLINE OF THE WALL.

R. C. BOX LOCATION SCHEDULE

Box Sect.	Station From	Station To	Box Sect.	Station From	Station To

REVISIONS			
M. E. D.	MARK	DATE	DESCRIPTION
V. C. M.			
F. W. R.			
C. W. N.			

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DOUBLE R. C. BOX SCHEDULE & DETAILS

SCALE: NONE | DATE | DWG. NO. S-101

S-101

REINFORCED CONCRETE RECTANGULAR CHANNEL

SECTION	STATION LIMITS FROM	TO	SIZE W	H	THICKNESS (INCHES) T_1	T_2	T_3	QUANTITIES CONCRETE CU. YDS./ LIN. FT.	STEEL LBS./ LIN. FT.	B_1 BAR NO. & SPACING	B_1 VERT. LENGTH	B_1 HORIZ. LENGTH	B_2 BAR NO. & SPACING	B_2 VERT. LENGTH	B_2 HORIZ. LENGTH	B_3 BAR NO. & SPACING	B_3 VERT. LENGTH	B_3 HORIZ. LENGTH	B_4 BAR NO. & SPACING	B_4 VERT. LENGTH	B_4 HORIZ. LENGTH	B_5 BAR NO. & SPACING	B_5 VERT. LENGTH	B_5 HORIZ. LENGTH	B_6 BAR NO. & SPACING	B_6 VERT. LENGTH	B_6 HORIZ. LENGTH	B_7 BAR NO. & SPACING	B_7 HORIZ. LENGTH	B_8 BAR NO. & SPACING	B_8 HORIZ. LENGTH	B_9 BAR NO. & SPACING	B_9 HORIZ. LENGTH	LONGITUDINAL BARS TOTAL	WALLS	SLAB

GENERAL STRUCTURAL NOTES

1. DIMENSIONS FROM FACE OF CONCRETE TO STEEL ARE TO CENTER OF BAR AND SHALL BE TWO INCHES UNLESS OTHERWISE SHOWN.
2. CONCRETE DIMENSIONS SHALL BE MEASURED HORIZONTALLY OR VERTICALLY ON THE PROFILE, AND PARALLEL TO OR AT RIGHT ANGLES (OR RADIALLY) TO CENTERLINE OF CONDUIT ON THE PLAN EXCEPT AS OTHERWISE SHOWN.
3. ALL BAR BENDS AND HOOKS SHALL CONFORM TO THE AMERICAN CONCRETE INSTITUTE'S "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE" SECTION 801.
4. PLACING OF REINFORCEMENT SHALL CONFORM TO THE AMERICAN CONCRETE INSTITUTE'S "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE" SECTION 803.
5. TRANSVERSE CONSTRUCTION JOINTS SHALL NOT BE PLACED WITHIN 30 INCHES OF MANHOLE OR JUNCTION STRUCTURE OPENINGS.
6. TRANSVERSE CONSTRUCTION JOINTS IN WALLS AND SLABS SHALL BE IN THE SAME PLANE. NO STAGGERING OF JOINTS WILL BE PERMITTED. TRANSVERSE CONSTRUCTION JOINTS SHALL BE NORMAL OR RADIAL TO THE CENTERLINE OF CONSTRUCTION.
7. THE TRANSVERSE REINFORCING STEEL SHALL TERMINATE ONE AND ONE-HALF INCHES FROM THE CONCRETE SURFACES UNLESS OTHERWISE SHOWN ON THE STRUCTURAL DETAILS.
8. EXPOSED EDGES OF CONCRETE MEMBERS SHALL BE ROUNDED OR BEVELED.
9. NO SPLICES IN TRANSVERSE STEEL REINFORCEMENT WILL BE PERMITTED OTHER THAN SHOWN ON THE DRAWING WITHOUT APPROVAL OF THE ENGINEER. NO MORE THAN TWO SPLICES WILL BE PERMITTED IN ANY LONGITUDINAL BAR BETWEEN TRANSVERSE JOINTS. SPLICES SHALL BE STAGGERED.
10. LONGITUDINAL STEEL SHALL BE LAPPED 70 BAR DIAMETERS AT SPLICES. TRANSVERSE STEEL SHALL BE LAPPED 30 BAR DIAMETERS AT SPLICES.

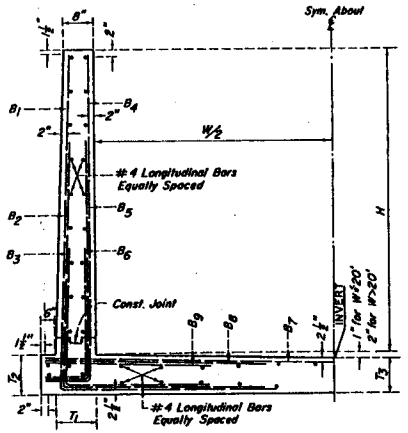
OPEN CHANNEL STRUCTURAL NOTES

1. LONGITUDINAL STEEL SHALL TERMINATE TWO INCHES FROM TRANSVERSE CONSTRUCTION JOINTS.
2. TRANSVERSE JOINTS SHALL BE SPACED NOT TO EXCEED 30 FEET NOR BE LESS THAN 10 FEET, MEASURED ALONG THE CENTERLINE OF CONSTRUCTION, EXCEPT AS OTHERWISE SHOWN ON THE DRAWINGS.
3. TRANSVERSE JOINTS SHALL BE PLACED AT THE JUNCTION OF RECTANGULAR OPEN CHANNEL SECTIONS WITH CLOSED CONDUIT SECTIONS.
4. ALL RECTANGULAR OPEN CHANNEL WALLS SHALL BE FENCED IN ACCORDANCE WITH STANDARD DRAWING I-5018, EXCEPT AS OTHERWISE SHOWN ON THE DRAWINGS.
5. UNLESS OTHERWISE SHOWN ON THE DRAWINGS, IN CURVED SECTIONS THE MAXIMUM SPACING OF BARS SHALL NOT EXCEED THAT SHOWN ON THE TYPICAL SECTIONS. STEEL SHALL BE PLACED RADIALLY FROM THE MAXIMUM SPACING.
6. AT THE BEGINNING AND ENDING OF ALL POURS, A COMPLETE CURTAIN OF REINFORCEMENT COMPOSED OF B_1, $\frac{1}{2}$, AND B_7 BARS SHALL BE PLACED THREE INCHES FROM THE TRANSVERSE CONSTRUCTION JOINT.

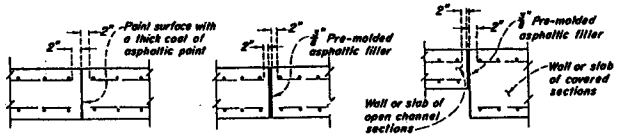
RECTANGULAR CHANNEL DESIGN DATA

Loads
- External 62.5 p.s.f. E.F.P.
- Internal 40.0 p.s.f. E.F.P.

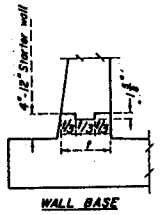
$f_c' = 4000$ p.s.i.
$f_c = 1800$ p.s.i.
$f_s = 24000$ p.s.i.
$n = 8$



TYPICAL CHANNEL SECTION
NOT TO SCALE



TRANSVERSE CONSTRUCTION JOINT DETAILS
NOT TO SCALE



LONGITUDINAL CONSTRUCTION JOINT OPEN CHANNEL
NOT TO SCALE

REVISIONS			
	MARK	DATE	DESCRIPTION
M.E.D.			
V.C.M.			
F.W.H.			
C.W.H.			

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

R.C. RECTANGULAR CHANNEL SCHEDULE AND DETAILS

SCALE	DATE	DWG. NO.
NONE		SHEET OF

S-102

SIDE INLET CONNECTIONS

STRUC.	M.L.	LATERAL	STD. DWG.
J.S. No. 4	Pipe	I.D. of lat. ≤ 24", A ≥ 45° O.D. of lat. ≤ ½ I.D. of M.L.	2-D193
J.S. No. 2	Pipe	O.D. of lat. ≥ ½ I.D. of M.L. or I.D. of lat. ≥ 24" I.D. of lat. ≤ ¾ I.D. of M.L., & ≤ 39" No more than 1 opening per pipe length (8'). Check if A < 45° & B > 24" for horiz. clearance Use T.S. No. 3 if vertical angle ≥ 45° Req'd. - A, B, C, D (El. R & S, See Std. Dwg.)	2-D112
T.S. No. 3	Pipe	I.D. of lat. ≥ ¾ I.D. of M.L. or ≥ 39" Req'd. - A, B, C, D_1, D_2 (El. R & S, See Std Dwg.) I.D. of lat. ≤ I.D. of M.L.	2-D188
J.S. No 3	Box	I.D. of lat. ≤ 30" for C.P. & R.C.P., 60" for C.M.P. Provide 12" below soffit and 13" above invert of M.L., A ≥ 45°	2-D191
J.S. No. 1	Box	I.D. of lat. = 12" - 144" If inlet does not permit 7" above invert & 6" below soffit, or A < 30°; investigate. Req'd. - A, B, C (El. R & S, See Std. Dwg.)	2-D189

STANDARD MANHOLES

M.H.	MAINLINE	**LATERAL	STD. DWG.
1	Pipe (33" or less). Also use if upstream ≤ 33" & down ≥ 36" (Cannot exceed 42" because width of M.H. = 3'-6").	Provide 6" below soffit of M.H. Box. See table below.	2-D102
2	Pipe (36"* or greater) see exception for M.H. No. 1	O.D. of lat. ≤ ½ I.D of M.L. Also 30" or less	2-D184
3	Box or Arch		2-D104
4	Pipe (36" * or greater)	12"-144" lat. I.D. of lat. ≤ I.D of M.L. Check horiz. clearance Req'd. - A, B, C, D_1, D_2, El. R & S.	2-D113

*Do not use M.H. No's 2 or 4 for pipe less than 36" diameter. If pipe is smaller, make D_1 = 36" and pour wall around pipe (other possibility is to increase L & H of M.H. #1).

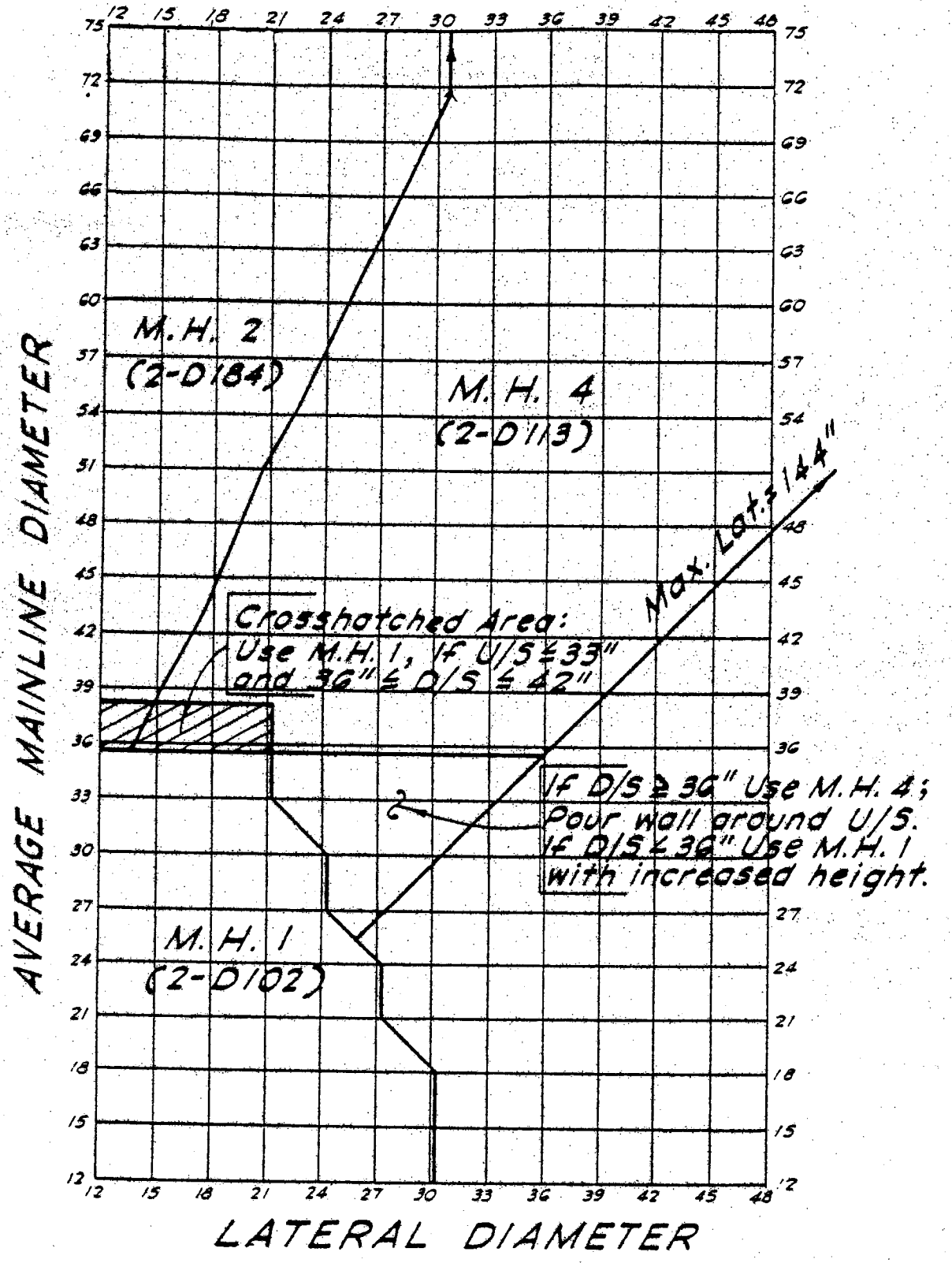
**Inlets shall be located to avoid interference with steps.

C.B.	STD. "V"
1	3'-6"
2	4'-0"
3	4'-0"
4	3'-6"
5	3'-0"
5A	3'-0"
6	4'-6"
7	3'-6"
8A	5'-0"
8B	5'-0"

T.S.	STRUCTURE
1	Pipe or Arch to Box or Arch
2	Box to Box
3	Pipe to Pipe with Inlet
4	Single Box to Double Box
5	Double Box to Double Box
6	Double Box to Triple Box
7	Triple Box to triple Box

M.H. No. 1	
M.L.	MAX. LAT.
15	30
18	30
21	27
24	27
27	24
30	24
33	21

PIPE MANHOLES

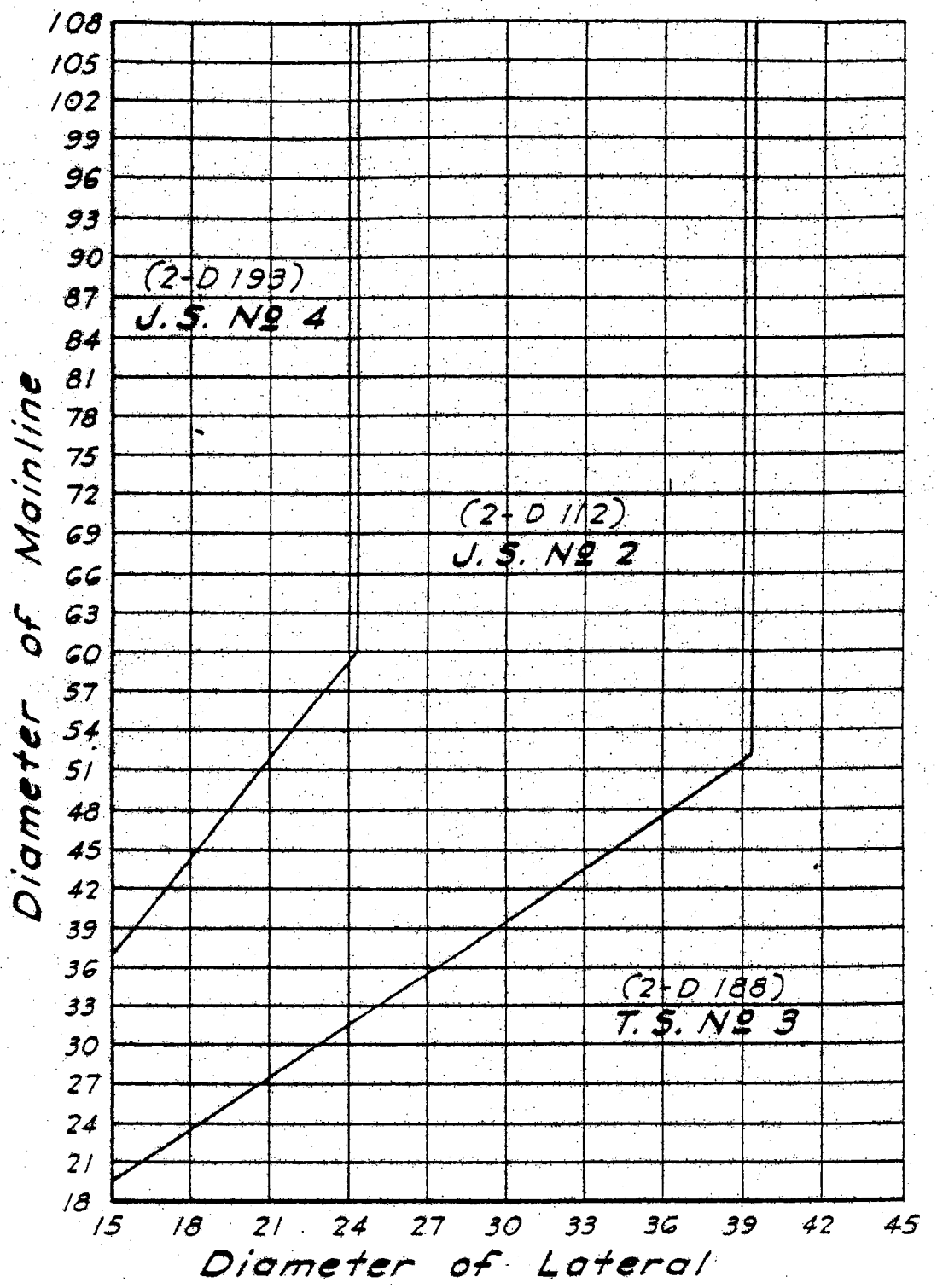


Notes:
1. Length of Standard M.H. shall be increased if:
   a. Lateral openings interfere with M.H. steps.
   b. Hor. angle of divergence or convergence exceeds 5°-45°.
2. M.H. 2 & 4 line based on std. wall thickness.
3. Lateral inlets may enter both sides of M.H. structure.

Los Angeles County Flood Control District

S-104

PIPE TO PIPE JUNCTIONS



Does not apply for: (a) 18" Non-R.C.P. lateral
(b) thickwall R.C.P. lateral

ASBESTOS CEMENT PIPE D-LOADS

R.C. PIPE D-LOAD	A.C. PIPE WALL THICKNESS	A.C. PIPE INSIDE DIAMETER (INCHES)									
		15	18	21	24	27	30	33	36	39	42
800	1.00 inches	5350	5250	5200	5150	5100	5100	5050	5050	5050	5050
	1.25	3700	3650	3600	3600	3550	3550	3550	3500	3500	3500
	1.50	3000	2950	2950	2900	2900	2900	2850	2850	2850	2850
	1.75	2650	2600	2550	2550	2550	2500	2500	2500	2500	2500
	2.00	2400	2350	2350	2300	2300	2300	2300	2250	2250	2250
	2.25	2250	2200	2150	2150	2150	2150	2100	2100	2100	2100
1000	1.00	6550	6550	6500	6450	6400	6350	6350	6300	6300	6250
	1.25	4650	4550	4500	4500	4450	4400	4400	4400	4400	4350
	1.50	3750	3700	3650	3650	3600	3600	3600	3550	3550	3550
	1.75	3200	3250	3200	3150	3150	3150	3100	3100	3100	3100
	2.00	3000	2950	2900	2900	2850	2850	2850	2800	2800	2800
	2.25	2750	2750	2700	2700	2650	2650	2650	2650	2600	2600
1200	1.00	8000	7850	7750	7700	7650	7600	7600	7550	7550	7500
	1.25	5550	5450	5400	5350	5350	5300	5300	5250	5250	5250
	1.50	4500	4450	4400	4350	4300	4300	4300	4250	4250	4250
	1.75	3950	3850	3850	3800	3750	3750	3750	3700	3700	3700
	2.00	3350	3500	3450	3450	3400	3400	3400	3400	3350	3350
	2.25	3300	3250	3250	3200	3200	3150	3150	3150	3150	3150
1400	1.00	9300	9150	9050	9000	8900	8900	8900	8850	8800	8750
	1.25	6450	6350	6300	6250	6200	6150	6150	6150	6100	6100
	1.50	5250	5150	5100	5050	5050	5000	5000	4950	4950	4950
	1.75	4550	4500	4450	4400	4400	4350	4350	4350	4300	4300
	2.00	4150	4100	4050	4000	4000	3950	3950	3950	3900	3900
	2.25	3850	3800	3750	3750	3700	3700	3650	3650	3650	3650
1600	1.00	10600	10450	10350	10250	10200	10150	10100	10050	10000	10000
	1.25	7400	7350	7300	7150	7100	7050	7000	7000	6950	6950
	1.50	6000	5900	5850	5800	5750	5700	5700	5650	5650	5650
	1.75	5200	5150	5100	5050	5000	5000	4950	4950	4950	4900
	2.00	4750	4650	4600	4600	4550	4500	4500	4500	4500	4450
	2.25	4400	4350	4300	4250	4250	4200	4200	4200	4150	4150
1800	1.00	11950	11750	11650	11550	11450	11400	11350	11300	11250	11250
	1.25	8300	8250	8100	8000	7950	7900	7900	7850	7850	7800
	1.50	6750	6650	6550	6500	6450	6450	6400	6350	6350	6350
	1.75	5850	5800	5700	5650	5650	5600	5600	5550	5550	5550
	2.00	5300	5250	5200	5150	5100	5100	5050	5050	5050	5000
	2.25	4950	4900	4800	4800	4750	4750	4700	4700	4700	4650

R.C. PIPE D-LOAD	A.C. PIPE WALL THICKNESS	A.C. PIPE INSIDE DIAMETER (INCHES)									
		15	18	21	24	27	30	33	36	39	42
2000	1.00 inches	13250	13050	12900	12800	12700	12650	12600	12550	12500	12500
	1.25	9200	9100	9050	8980	8850	8800	8750	8750	8700	8700
	1.50	7450	7350	7300	7200	7150	7100	7100	7100	7050	7050
	1.75	6300	6400	6350	6300	6250	6200	6200	6200	6150	6150
	2.00	5900	5800	5750	5700	5650	5650	5600	5600	5600	5550
	2.25	5500	5400	5350	5300	5300	5250	5250	5250	5200	5200
2200	1.00	14600	14350	14250	14100	14000	13900	13850	13800	13750	13750
	1.25	10150	10000	9850	9800	9730	9650	9650	9600	9580	9550
	1.50	8200	8100	8000	7950	7900	7850	7800	7800	7750	7750
	1.75	7150	7050	6950	6900	6850	6850	6800	6800	6750	6750
	2.00	6500	6400	6350	6300	6250	6200	6200	6150	6150	6100
	2.25	6050	5950	5900	5850	5800	5750	5750	5750	5700	5700
2400	1.00	15900	15650	15500	15350	15250	15200	15100	15050	15000	14950
	1.25	11050	10900	10750	10650	10600	10550	10500	10450	10450	10400
	1.50	8950	8800	8700	8650	8600	8550	8500	8500	8450	8450
	1.75	7800	7700	7600	7550	7500	7450	7400	7400	7350	7350
	2.00	7100	6950	6900	6850	6800	6750	6750	6700	6700	6650
	2.25	6600	6500	6400	6350	6300	6300	6250	6250	6200	6200
2600	1.00	17200	17000	16750	16650	16500	16450	16350	16300	16250	16200
	1.25	11950	11800	11650	11550	11500	11400	11350	11350	11300	11250
	1.50	9700	9550	9450	9350	9300	9250	9200	9200	9150	9150
	1.75	8450	8300	8250	8150	8100	8050	8050	8000	8000	7950
	2.00	7650	7550	7450	7400	7350	7300	7300	7250	7250	7200
	2.25	7150	7000	6950	6900	6850	6800	6800	6750	6750	6700
2800	1.00	18550	18250	18050	17900	17800	17700	17600	17550	17500	17450
	1.25	12900	12700	12550	12450	12350	12300	12250	12200	12150	12150
	1.50	10450	10300	10150	10100	10000	9950	9950	9900	9850	9850
	1.75	9100	8950	8850	8800	8750	8700	8650	8650	8600	8550
	2.00	8250	8150	8050	7950	7900	7900	7850	7800	7800	7800
	2.25	7650	7550	7500	7400	7350	7350	7300	7250	7250	7250
3000	1.00	19850	19550	19350	19200	19050	18950	18850	18800	18750	18700
	1.25	13800	13600	13450	13350	13250	13150	13100	13050	13050	13000
	1.50	11200	11000	10900	10800	10750	10700	10650	10600	10550	10550
	1.75	9750	9600	9500	9400	9350	9300	9250	9250	9200	9200
	2.00	8850	8700	8600	8550	8500	8450	8400	8400	8350	8350
	2.25	8200	8100	8000	7950	7900	7850	7800	7800	7750	7750

NOTES:

1. D-loads listed are for Asbestos Cement Pipe where the velocity exceeds 10 feet per second.
2. D-loads for Asbestos Cement Pipe, where the velocity is 10 feet per second or less, shall be 1.5 times the D-load for comparable Reinforced Concrete Pipe. Refer to District Standard Drawing 2-D213.1.

DRAWN BY	REVISIONS		
G.D.M.	MARK	DATE	DESCRIPTION
CHECKED BY			
V.C.M.			
DESIGNED BY			
R.J.S.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR DESIGN OF ASBESTOS CEMENT PIPE

RECOMMENDED BY: C. Magnuson, DIVISION ENGINEER - DESIGN
APPROVAL RECOMMENDED BY: W. Van U. Rasmussen, ASST. CHIEF DEPUTY ENGINEER
APPROVED BY: Walter J. Wood, CHIEF ENGINEER

SCALE	DATE	DWG. NO.
NONE	10-15-69	2-D431

SHEET 1 OF 1

S-106

Structural Design of
Reinforced Concrete Box Conduits

Computer Program No. 0501

Purpose:

The prupose of Program No. 0501 is to furnish structural details for the construction of reinforced concrete box conduits and/or check structural calculations for these structures.

Scope:

The program is limited at the present time to single and double barrel boxes. The double barrel box may be either symmetrical or unsymmetrical.

The design phase of this program produces complete structural details including final member thicknesses, steel layout, and concrete and steel quantities.

The checking phase of this program calculates stresses at preset sections. The input data for this phase is previously calculated structural details.

The working stress design method is used.

The District's design criteria is set internally. This criteria is as set forth in the District Structural Design Manual. Provisions has been made to override the allowable stress criteria and load specification.

Live load may be zero, truck load or railroad load.

Installation condition may be trench, negative projection, or positive projection. Vertical earth loads are calculated in accordance with Marston's equations.

Procedure:

The program is basically a six part program: (1) Single barrel box, design (2) Single barrel box, check, (3) Symmetrical double box design, (4) Symmetrical double barrel box, check, (5) Unsymmetrical double barrel box, design, (6) Unsymmetrical double box, check. There are numerous routines, such as establishment of criteria, load calculations, moment distribution, etc., that are common to several or all of the above parts.

The program logic is based on the method of analysis set forth in detail in the District's Structural Design Manual. The following is a brief outline of the program procedure, with comments on significant items.

A. Establishment of Stress Criteria

1. District criteria is set
2. Optional criteria is checked and modifications indicated are set.

B. Calculation of Loads

1. Earth loads are checked in accordance with Marston's equation.
   a. Trench condition - Check made for wide trench
   b. Negative projection
   c. Positive projection

2. Live Loads

   a. Zero

   b. Truck (variable axle load)

   c. Railroad (variable axle load)

C. Loading Cases

1. Vertical and lateral earth, dead, internal water, and live loads are combined to give maximum stresses at critical sections. These are fixed combinations and cannot be modified by user.

2. The various cases are incremented.

3. Eleven locations along each member are analyzed. The loading case used at any point is that case that results in the maximum stress at that point.

D. Thicknesses Are Initialized

Initial thickness for each member is set. The values are based on empirical formula.

E. Fixed End Moments Are Set For The Loading Case Incremented

Fixed end moments are based on center line spans.

F. Moments Are Distributed

A four cycle Hardy Cross distribution is utilized.

G. Moments, Shears, And Thrusts Are Accumulated

Maximum values are retained. Design moment is at face of support.

H. Thicknesses Are Finalized

1. Thicknesses are calculated for each member. Thickness are based on shear and flexure requirements. The flexure check assumed balanced design and working stress theory.
2. Calculated thicknesses are checked against previous set values. If differential is not within set tolerance, steps B through H are rerun.

I. Design Variables Are Calculated

Moment, shear, thrust, area of steel requirements, etc., are calculated at eleven points in each member.

J. Steel Layout Is Developed

1. Numerous steel patterns are checked
   a. Minimum steel is No. 4 bars at 18 inch centers.
   b. Minimum bar size is No. 4, maximum size No. 9.
   c. Minimum bar spacing is 4 inches, maximum spacing 18 inches.
2. Longitudinal steel is set based on No. 4 bars.

K. Concrete And Steel Quantities Are Calculated

L. Output Is Printed

1. Title card
2. Design criteria
3. Concrete Thickness
4. Steel layout
5. Quantities

Input Data:

The basic input data consists of the following:

Code numbers to indicate type of structure, design or check, criteria, type of live load, installation condition.

Depth to finish grade

Axle load

Pressure head

Box dimensions

If optional criteria or the check phase is to be used, additional input is required.

Output Data:

For the design phase the output consists of the following:

Title card

Design criteria

Concrete thicknesses

Steel layout

Quantities

For the check phase, the output consists of resulting shear, bond and flexure stresses at preset critical sections.

Design Criteria:

The basic criteria is set forth internally. This consists of the following:

PARAMETER	DISTRICT CRITERIA	ALTERNATE CRITERIA
Ultimate Concrete Stress	4000 p.s.i.	3000 p.s.i.
Allowable Concrete Snress	1800 p.s.i.	1000 p.s.i.

Yield Point Steel Stress	60000 p.s.i.	40,000 p.s.i.
Allowable Steel Stress	24000 p.s.i.	20,000 p.s.i.
Modular Ratio	8	10
Allowable Bond	ACI 318-63	300 p.s.i.
Allowable Unit Shear	ACI 318-63	90 p.s.i. face of support
Steel Cover (To Center Line of Bar)		
Pos. Steel Top Slab	2.0 in.	2.0 in.
Neg. Steel Top Slab	2.0 in.	2.0 in.
Pos. Steel Invert Slab	2.5 in. *	2.5 in. *
Neg. Steel Invert Slab	2.5 in.	2.5 in.
Pos. Steel Wall	2.0 in..	2.0 in.
Neg. Steel Wall	2.0 in.	2.0 in.

* Current criteria is 3.0 inches. Output must corrected manually until program is mcdified.

References

1. District Structural Design Manual
2. District Manual for Structural Computer Programs

OPTIONAL DESIGN CRITERIA

The use of the design criteria listed above is optional. Any or all may be used or over-riden. For details see input instructions.

R.C. BOX DESIGN INPUT INSTRUCTIONS

To use the design criteria (District or Alternate) with values noted above, only two cards are required.

Card No. 1 Tile Card - Starting from card column 5 the spaces may be used in any desired manner to state the title of the job.

Card No. 2 Data Card -

Card column 4; DC = Design Criteria
- Alternate District Criteria DC = 1
- District Criteria DC = 2
- Optional Alternate Critaria DC = 3
- Optional District Criteria DC = 4

Card column 5; NB = Number of Barrels
- Single Box NB = 1
- Double Box NB = 2
- Triple Box NB = 3
- Quadruple Box NB = 4

Card column 6; IC = Installation Condition
- Trench Condition IC = 1
- Positive Projection Condition IC = 2
- Negative Projection Condition IC = 3

Card column 7; LL = Type of Live Load
- No Live Load LL = 1
- Truck Live Load LL = 2 When depth of cover greater than 10', program sets Live Load = 0.
- Railroad Live Load = 3

Card column 8-13
Distance from top of box to Finish Grade (Feet). For double box with unequal heights, code the depth to finish grade of the taller barrel.

Card column 14-19
Distance from top of box to Natural Grade (Feet). For trench conditon Distance to Finish Grade = Distance to Natural Grade. For double box with unequal heights, code the depth to natural grade of the taller barrel.

Card column 20-23
Axle Loads (KIPS)
For Example: H20-S16 Axle Load = 32
E-72 Axle Load = 72

Card columns 30-41
Left Barrel = Left Barrel Dimensions (Feet)

Card columns 42-53
Right Barrel = Right Barrel Dimensions (Feet)

Code right barrel dimensions only when it is an unsymmertrical double box. Barrel with the greater width must be left barre.

"v" Denotes the location of the decimal point. It is located on the line between columns and can be overridden by placing a decimal point where required; however, the added decimal will occupy a column space.

To use optional design criteria, two more data cards are required. (Cards with card code 016. See optional design criteria input form.) The program will override the corresponding stored criteria when new criteria is entered in data columns. Card columns of criteria that are not to be changed are to be left blank.

Error Messages

Error messages produced by this program are of the following form:

TITLE CARD (76 characters) ERROR NO. E

where TITLE CARD is the information from the first input card (012 card) and E equals the condition code assigned to the error.

Permissable values of E are 1 - 4 as defined below:

Error No. 1
Title Card Errors:
1. Card columns 1-3 do not contain 012.
2. Card column 4 does not contain either blank, 0, or 1.

Error No. 2
Design Data Card Errors:
1. Card columns 1-3 do not contain 013.
2. Design criteria indicator (card column 4) is not 1-4.
3. Numbert of barrels (card column 5) is not 1 or 2.
4. Installation condition indicator (card dolumn 6) is not 1-3.
5. Live load indicator (card column 7) is not 1-3.
6. Distance to finish grade (card columns 8-13) is negative.
7. Axle load (card columns 20-23) is negative.
8. Pressure head (card columns 24-29) is negative.
9. Interior dimensions (card columns 30-53) are either negative or greater than 50.

Error No. 3
Check Thickness Data Card Errors:
1. Card columns 1-3 do not contain 014.
Check Bar Data Card Errors:
1. Card columns 1-3 do not contain 015.
2. Bar subscript (card columns 5-6, 27-28, or 49-50) is negative or greater than 27.

Error No. 4
Design Criteria Card Errors:
1. Card columns 1-3 do not contain 016.

Error No. 5
Premature End of File on Card Reader:
1. Design data card missing.
2. Check specified (in cc4 on title card) and thickness and/or bar cards missing or incomplete.
3. Alternate design criteris specified (3 or 4 in cc4 on design data card) and design criteria cards missing or incomplete.
4. The last bar data card did not have 9 in cc4.

Output descriptions

Refer to sample output and standard schematic of box design. At the bottom of output sheet under Input Data and Design Criteria, reading from left to right and top to bottom the values are:

1. Depth to finish grade
2. Depth to natural grade
3. Axle load
4. Hydrostatic pressure head
5. Interior width of box
6. Interior heighth of box
7. Minimum top slab thickness
8. Minimum invert slab thickness
9. Minimum wall thickness
10. Positive steel cover - top slab
11. Positive steel cover - invert slab
12. Positive steel cover - wall

13. Negative steel cover - top slab
14. Negative steel cover - invert slab
15. Negative steel cover - wall
16. Trench clearance
17. Positive projection settlement ratio
18. Negative projection settlement ratio
19. Soil friction coefficient
20. Compressive concrete stress at 28 days f'c
21. Allowable concrete stress fc
22. Yield point steel stress fy
23. Allowable steel stress fs
24. Modular ratio
25. Allowable bond stress
26. Allowable shear stress
27. Soil density
28. Allowable bond stress top bar
29. Lateral soil equivalent fluid pressure

Warning Messages

Warning messages are produced by the steel design subroutines. These messages are produced when the maximum size and minimum spacing for a given bar cannot satisfy the steel area or perimiter requirements.

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

STRUCTURAL DESIGN OF REINFORCED CONCRETE BOX
INPUT FORM
PROGRAM NO. FO501P

Job No. _____
Data entered by _____
checked by _____
Sheet ___ of _____
Date ___ Div. ___ Sec. ___
Ext. No. _____

TITLE

SAMPLE PROBLEM FOR DESIGN MANUAL

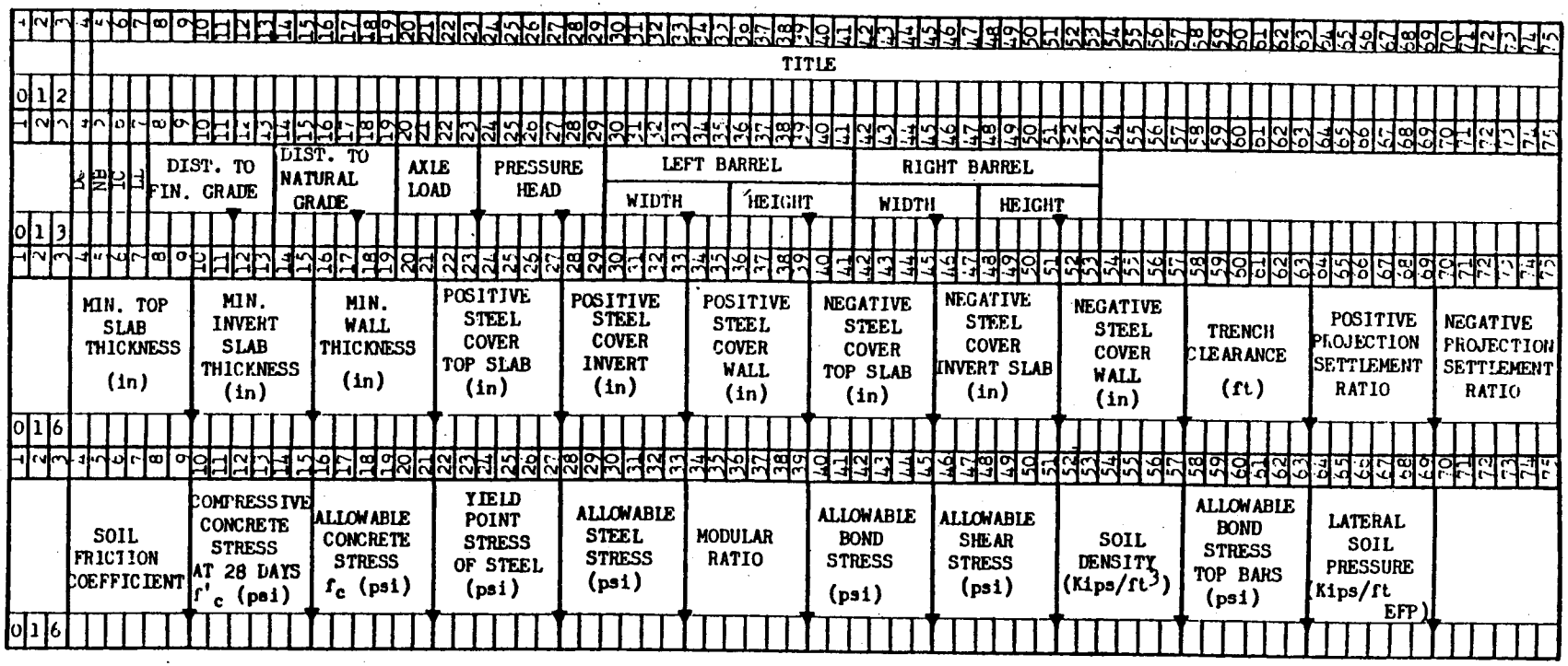
	DC	NB	TC	LL	DIST. TO FINISH GRADE	DIST. TO NATURAL GRADE	AXLE LOAD	PRESSURE HEAD	LEFT BARREL WIDTH	LEFT BARREL HEIGHT	RIGHT BARREL WIDTH	RIGHT BARREL HEIGHT
013	2	1	1	2	0	0	32		10	12		

NOTES: 1. Refer to Program Abstract prior to completing cards.
2. All four cards are required for one R. C. box section.
3. Leave card column 4 of title card blank.

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

STRUCTURAL DESIGN OF REINFORCED CONCRETE BOX
INPUT FORM - OPTIONAL DESIGN CRITERIA
PROGRAM NO. FO501P

Job No. _____
Data entered by _____
checked by _____
Sheet ___ of _____
Date ___ Div. ___ Sec. ___
Ext. No. _____

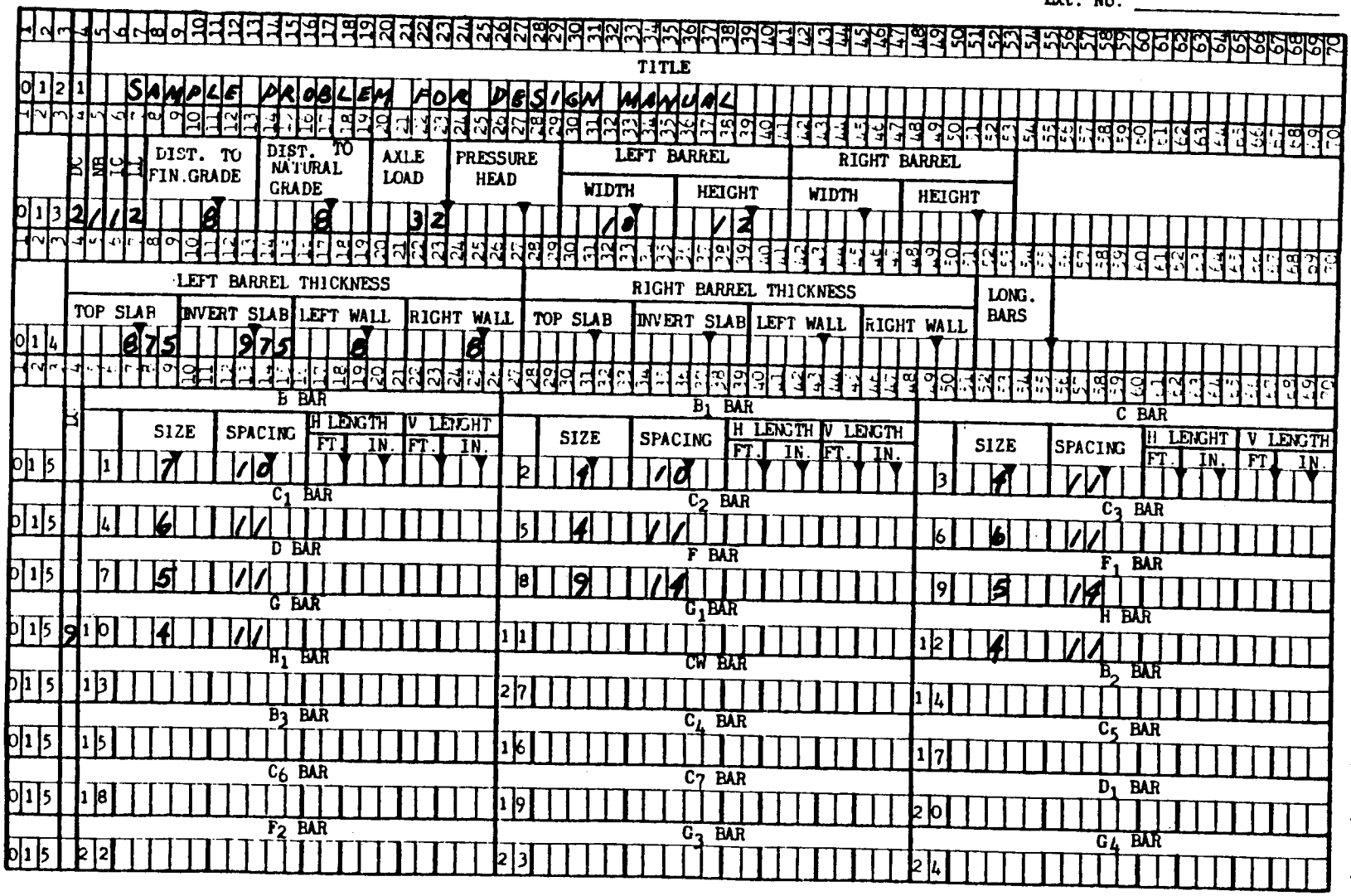


NOTES: 1. Refer to Program Abstract prior to completing cards.
2. All four cards are required for one R. C. box section.
3. Leave card column 4 of title card blank.

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

STRUCTURAL CHECK OF REINFORCED CONCRETE BOX
INPUT FORM
PROGRAM NO. FO501P

Job No. _____
Data entered by _____
checked by _____
Sheet ____ of _____
Date ____ Div. ____ Sec. _____
Ext. No. _____



Struct. Han.

SAMPLE PROBLEM
DESIGN OUTPUT

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN DIVISION
DESIGN OF SINGLE BARREL REINFORCED CONCRETE BOX
BARREL # 1

SAMPLE PROBLEM FOR DESIGN MANUAL

10.00 WIDE BY 12.00 HIGH
TYPE INSTALLATION TRENCH
PROJECTION RATIO 0.0
LIVE LOAD TRUCK
TOTAL DESIGN VERTICAL LOAD TOP 13.23 KIPS INVERT 14.50 KIPS
PRESSURE HEAD 0.0 FT
DESIGN STRESSES FC = 1800. PSI FS = 24000. PSI

DESIGN COVER 8.0 FT
SOIL DENSITY .110 KCF
AXLE LOAD 32.0 KIPS

THICKNESSES (IN) TOP 8.75 INV(C.L.) 9.75 LW 8.00 RW 8.00

STEEL LAYOUT

BAR DESIGNATION	BAR SIZE	BAR SPACING (IN)	HORIZONTAL LENGTH (FT)(IN)	VERTICAL LENGTH (FT)(IN)
B	7.	10.0	11. 1.0	0. 0.0
B1	4.	10.0	5. 11.5	0. 0.0
C	4.	11.0	4. 2.5	12. 2.0
C1	6.	11.0	2. 0.5	2. 10.0
C2	4.	11.0	4. 2.5	2. 3.0
C3	6.	11.0	2. 8.5	2. 5.0
D	5.	11.0	0. 0.0	13. 3.5
F	9.	14.0	11. 1.0	0. 0.0
F1	5.	14.0	6. 2.5	0. 0.0
G	4.	11.0	5. 0.0	0. 0.0
H	4.	11.0	5. 0.0	0. 0.0

LONGITUDINAL BARS 66. NO. 4 BARS
IN TOP SLAB 17. IN INVERT SLAB 17. IN WALLS 32.

QUANTITIES
CONCRETE 1.26 CU. YDS./FT. REINFORCING STEEL 217.2 LBS./FT.

INPUT DATA & DESIGN CRITERIA:

8.00000	8.00000	32.00000	0.0	10.00000
12.00000	6.50000	7.00000	8.00000	2.00000
2.50000	2.00000	2.00000	2.50000	2.00000
3.00000	0.70000	-0.50000	0.15000	4000.00000
1800.00000	60000.00000	24000.00000	8.00000	500.00000
70.00000	0.11000	350.00000	0.03700	

SAMPLE PROBLEM
CHECK OUTPUT

SAMPLE PROBLEM FOR DESIGN MANUAL

CASE NUMBER 1

	RESULTANT STRESSES (P.S.I.)			
	CONCRETE	RE-STEEL	UNIT SHEAR	BOND
TOP SLAB				
CORNER	680.	12196.	68.0	235.0
MIDSPAN	1594.	23635.		
WALL				
TOP	775.	12959.	17.9	61.5
CENTERLINE	0.	0.		
BOTTOM	622.	10400.	11.8	38.4
INVERT SLAB				
CORNER	463.	8662.	68.8	238.9
MIDSPAN	1642.	23176.		

NOTE:

SIMILAR SHEET IS PRODUCED FOR EACH LOADING CASE.

Structural Design of Open Rectangular Reinforced Concrete Channel

Computer Program No. 0502

Purpose:

The purpose of Program No.F0502 is to furnish complete structural details for the construction of symmetrical rectangular reinforced concrete channels. Quantities are also furnished.

Scope:

The calculations and structural details furnished are for a "U" channel. The walls are designed as cantilever members, the slab is designed as a series of beams on an elastic foundation. Thicknesses of members are calculated, steel patterns developed, and concrete and reinforcing steel quantities calculated.

The District's design criteria is set internally. Provision will be made in the future to override any or all of this criteria by means of additional input. There is no schedule set at this time to add this provision and this discussion is limited to set criteria.

Procedure:

The program is basically divided into three parts: (1) Calculation of design variables for walls, (2) Calculation of design variables for the slab, (3) Development of the steel layout and calculation of quantities.

Two loading cases are analyzed: (1) channel empty, (2) channel flowing full. For the case with the channel empty, a triangular load based on an equivalent fluid pressure of 62.6 p.s.f. is imposed. For the case with the channel flowing full, the design is based on a net triangular outward load of 40.0 p.s.f. equivalent fluid pressure.

The slab is designed as a beam on an elastic foundation subjected to concentrated loads and applied moments. Equations used for soil pressure distribution and moment determination are based on the theory presented by M. Hetenyi. The equations (given in attachments) are for a beam of uniform moment of inertia and finite length. The moment of inertia used in these equations is based on the slab thickness at the inside face of the wall. In actuality, the thicknesses at the wall and center line are computed to provide balanced design, except where minimums control, and the slab varies uniformly between these points. The slab thickness at the face of the wall is initialized at a value equal to the thickness of the base of the wall plus one-half inch, an iterative routine is introduced to develop final thicknesses.

Design variables at the ends and tenth points of the walls and ends and twentieth points of the slabs are calculated and stored. These values will be printed only if the number 2 appears in the first card column of the first data card.

Three steel patterns are developed. One for the earth faces of the wall and slab, one for the channel face of the wall, and one for the channel

face of the slab. For each pattern, 250 layouts representing various combinations of bars sizes and spacing are developed. Each layout is basically a three-bar layout. Utilizing various parameters such as minimum bar size, maximum bar size, minimum and maximum bar spacing, and least weight the optimum pattern is selected and listed in the output.

The number of longitudinal bars are calculated and listed in the output. The number of longitudinal bars is based on an 18-inch spacing in each reinforced face. Where transverse reinforcing steel terminates in the earth face of the invert slab, longitudinal bars are not placed beyond the end of this steel.

Concrete and reinforcing steel quantities are calculated and listed in the output.

Input Data:

If the design is to be based on the criteria listed below, only two cards are required.

Card No. 1 Title Card - Card Column No. 4 - 1 if design variables are not to be printed, 2 if they are to be printed.

Starting from card Column No. 5, the spaces may be used in any desired manner to write down the title of the project, name of the engineer, etc.

Card No. 2 Data Card - Card Column No. 4 through 10 - Channel width in feet.
Card Column No. 18 through 17 - Channel height in feet. Height is measured at inside face of wall.

Refer to attachment for sample input sheet.

Design Criteria:

The basic District criteria is set forth internally. This consists of the following:

Description	Value
Allowable Concrete Stresses	1800 p.s.i.
Allowable Steel Stress	24000 p.s.i.
Modular Ratio	8
Uniform Inward Load	0
Triangular Inward Load	62.5 p.s.f. Equiv. Fluid Pressure
Triangular Outward Load	40.0 p.s.f. Equiv. Fluid Pressure
Steel Cover to Center Line of Bar	
Wall, Inside	2.0 Ins.
Wall, Outside	2.0 Ins.
Slab, Inside	2.5 Ins*
Slab, Outside	2.5 Ins
Foundation Modulus	165.0 p.s.f.

Output Description

The output lists the following data:

1. Design variables (optional).
2. Title Card.

* Current criteria is 3.0 inches. Output must be adjusted by hand until program is modified.

Struct. Man.

3. Member thicknesses
4. Size spacing, vertical length, and horizontal length of transverse steel.
5. Number of longitudinal bars in walls, slab, and section.
6. Concrete and steel quantities.
7. Principal design criteria.

Refer to attachment for sample output sheet.

Detailed Computer Procedure:

The program consists of three basic parts: (1) MAIN, Design of Walls, (2) PART 2, Design of Slab, (3) PART 3, Steel layout and quantities. The following is a summary of the steps followed in the program.

MAIN

1. Read basic input
2. Calculate wall thickness
3. Increment loading cases
4. Calculate design variables for wall
5. Print design variables for wall (if requested)
6. Call for PART 2, slab design
7. Call for PART 3, steel layout and quantities
8. Print output

PART 2

1. Calculate loads and moments on slab
2. Increment loading cases

3. Calculate slab thicknesses
4. Calculate design variables for slab
5. Print design variables for wall (if requested)

PART 3

1. Increment cases for steel patterns
   - 1 - Earth face, wall
   - 2 - Earth face, slab
   - 3 - Channel face, wall
   - 4 - Channel face, slab
2. Set constants for each case
3. Increment steel spacing
4. Increment Bar No. 1
5. Increment Bar No. 2
6. Calculate Bar No. 3
7. Calculate cutoff points
8. Calculate lengths
9. Calculate weight of pattern
10. Check for optimum pattern
11. Calculate longitudinal bars
12. Calculate quantities

Sample Problem:

The design of a 11'-0" high by 18'-0" wide channel is shown in the attachments.

The input data for this section is shown in the attachment. This is on two cards; a title card and a card indicating the width and height of the section. The output data is shown in the attachment.

Future Modifications

The program will be modified at a later date to provide an optimization routine and provision for alternate design criteria.

The concrete thicknesses and steel areas provided are based on a balanced design at the critical section except where minimum values control. An optimization routine to arrive at the economical section will be added at a later date.

The basic District criteria is set forth internally in the program. At a later date, provision will be made to override any or all of criteria with criteria of the engineer's choice.

The program was intially written as a three phase program for processing on a relatively low capacity computer. It was later expediently converted to a single program for use on an IBM 360 Model 50. This has resulted in a rather unsophisticated program. It is anticipated the program will be refined at a later date.

References

1. District Structural Design Manual
2. "Beams on Elastic Foundations" by M. Hetenyi
3. District Manual for Structural Computer Programs.

OPEN RECTANGULAR CHANNEL INPUT SHEET

COMPUTER PROGRAM NO. F0502

Project No.____________________
Division____________________
Data entered by____________________
Checked by____________________
Date____________________
Ext. No.____________________
Prog. No. ☐ 0502A ☐ 0502P ☐ 0502B

CARD NO. 1

TITLE CARD

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
0	5	7	1																																								

CARD NO. 2

WIDTH										HEIGHT						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
0	5	8					.							.		

CARD NO. 1

TITLE CARD

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
0	5	7	1																																								

CARD NO. 2

WIDTH										HEIGHT						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
0	5	8					.							.		

CARD NO. 1

TITLE CARD

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
0	5	7	1																																								

CARD NO. 2

WIDTH										HEIGHT						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
0	5	8					.							.		

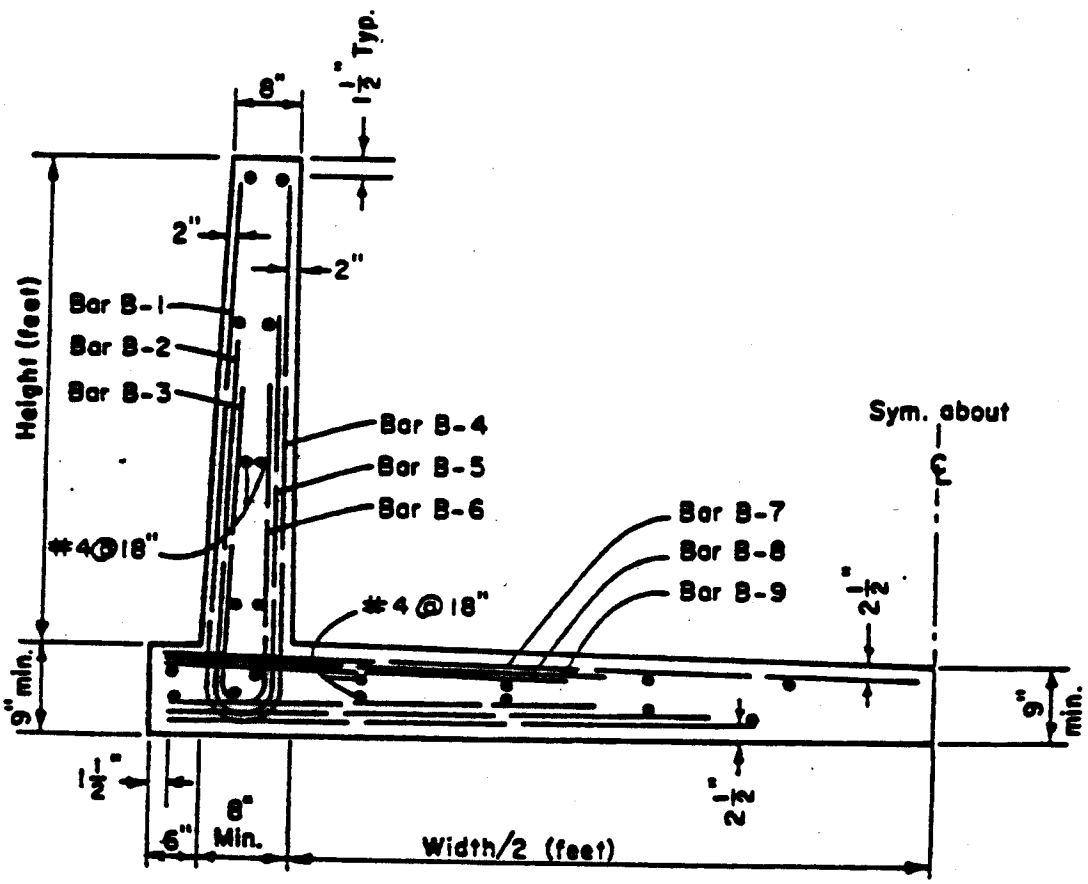
CARD NO. 1

TITLE CARD

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
0	5	7	1																																								

CARD NO. 2

WIDTH										HEIGHT						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
0	5	8					.							.		



TYPICAL SECTION

DESIGN DATA

STRESSES:

$f_c' = 4000$ p.s.i.

$f_c = 1800$ p.s.i.

$n = 8$

$f_s = 24000$ p.s.i.

LATERAL LOADS:

Inward - 62.5 #/□' E.F.P. (Case I)

Outward - 40.0 #/□' E. F. P. (Case II)

NOTES

1. If Bars B-1, B-2 and B-3 are required for full width, a 30 diameter lap is provided.
2. Program Numbers
   - 0502 A District Projects
   - 0502 P 1964 Bond Issue

SAMPLE PROBLEM
DESIGN OUTPUT

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

*** DESIGN DIVISION ***

18.00 WIDE BY 11.00 HIGH RECTANGULAR R.C. CHANNEL

SAMPLE PROBLEM

THICKNESSES

TOP OF WALL	8.00 INS.
BASE OF WALL	9.00 INS.
SLAB AT CENTER LINE	9.00 INS.
SLAB AT FACE OF WALL	9.25 INS.

*** STEEL LAYOUT ***

BAR DESIGNATION	BAR SIZE	BAR SPACING INS.	HORIZONTAL LENGTH FT.	HORIZONTAL LENGTH INS.	VERTICAL LENGTH FT.	VERTICAL LENGTH INS.
B-1	4	10.00	6.	6.75	11.	5.25
B-2	5	10.00	5.	3.50	5.	8.50
B-3	6	10.00	3.	7.25	3.	5.50
B-4	4	16.00	0.	11.50	11.	5.25
B-5	5	16.00	0.	11.50	5.	8.75
B-6	6	16.00	0.	11.50	3.	5.75
B-7	4	9.00	20.	3.00		
B-8	4	9.00	6.	1.75		
B-9	4	9.00	4.	2.75		

61 NO. 4 LONGITUDINAL BARS
29 IN SLAB 32 IN WALLS

QUANTITIES
R. CONCRETE 1.15 CU. YDS./FT.
RE-STEEL 192.1 LBS./FT.

DESIGN CRITERIA
FC = 1800. P.S.I.
FS = 24000. P.S.I.
N = 8.
LATERAL LOAD
OUTWARD (NET) = 40.0 P.S.F. E.F.PR.
INWARD (TRI.) = 62.5 P.S.F. E.F.PR.
(UN.) = 0.0 P.S.F.
STEEL COVER (INS. TO CENTER LINE OF BAR)
WALL INSIDE = 2.00 WALL OUTSIDE = 2.00
SLAB TOP FACE = 2.50 SLAB LOWER FACE = 2.50

Structural Design of Reinforced Concrete Pipe

Computer Program No. 0505

Purpose:

The purpose of Program No. 0505 is to furnish steel areas to be used in the construction of large diameter reinforced concrete pipe.

Scope:

The program was primarily intended to develop data for the preparation of design charts; however, it is applicable to single designs.

The diameter of the pipe is an input value and is not limited.

Earth loads are calculated in accordance with Marston's Theory. Installation condition may be trench, negative projection or positive projection. Projection condition loads are limited to values based on a settlement ratio of +0.7, vertical load angle to 180 degrees, and support angle to 90 degrees. (These limitations will be removed at a later date.)

Live load may be zero, truck, or railroad.

Allowable stresses are variable.

The design is based on the working stress theory.

Procedure:

A. General:

The basic procedure is that set forth in the District Structural Design Manual.

B. Method of Design:

Moments and thrusts are determined by use of the Engineering News Record furmulae.

The section is assumed to be subjected to combined axial thrust and bending. Design is based on the elastic theory using working stress theory.

Compression steel calculations use an effective modular ratio of 2n to transform the compression reinforcement. Compression steel is not considered unless it is required to maintain the concrete stress within the allowable.

C. Pipe Diameter:

Program will design pipe of all diameters. The pipe diameter is the input variable "IID".

D. Range of Covers:

Depth of cover can be any value. The number of designs obtained is dependent on the input values of "XF1", "XF2" and "XFX". The output will include designs for all depths from the input value of "XF1" to "XF2" in the increment indicated by "XFX. For a single design, "XF1" and "XF2" should tbe the depth desired and "XFX" set equal to zero.

E. Loading Conditions:

One loading condition is analyzed per run. The weight of the conduit, a vertical load angle of 180 degrees, and a support angle of 90 degrees are written into the program. All other loads are controlled by the input values.

F. Earth Load:

Earth loads are computed in accordance with Marston's Theory. The load is calculated for the trench condition, negative projection, or positive projection condition as indicated by the input value of "IIN". The soil density used is as indicated by the input value of "ISD". The trench width used is as indicated by the input value of "IW". Lateral load used is earth only. The value used is dependent on the input value of "XLAT".

G. Live Load·

Live load used is as indicated by the input value of "ILL". Any truck weight up to and including 29 tons may be used. Any railroad axle load from 31 to 99 kips may be used. Live load is neglected if "ILL" is set equal to 30. Truck live load distrubution is per the District's Structural Design Manual. The railroad loading is based on the following assumptions: (1) Axle load equal to the input value for "ILL"; (2) Longitudinal distribution equal to 5 feet, transverse distrubution euqal to 8 feet plus the depth of fill; (3) Impact equal to 40 percent for fills 1.69 feet or less in depth; this is reduced 5 percent for each additional foot of cover. The program utilizes a single track.

The values for live load are directly proportional to the input value of "ILL". Therefore, as an example, if the design live load due to an H-20 truck is 500 pounds per square foot and it is desirable to add 700 pounds per square foot to the design live load, set the input value of "ILL" at 28 (i.e., 20 x 700/500).

H. Internal Water and Pressure Head:

The conduit is analyzed empty, flowing full or under pressure. If the input variable "XIW" is 0, internal water is not considered. If "XIW" is set equal to 1, the conduit is assumed flowing full. For pressure flow, set "XIW" to equal to 1 and "XPH" equal to the pressure head, measured from the soffit of the pipe in feet.

I. Loading Angles:

Vertical loads are assumed to be acting on the upper 180 degrees and supported on the lower 90 degrees. These values are set in Part A of the program. A change in this criteria can be accomplished by modifying the statements defining the variables "ST", "XT", "SM", and "XM". These appear in Part A. If this change is made, it will also be necessary to change Format Statement No. 7 in Part B if the revised criteria is to be listed correctly.

Design Criteria:

The design procedure and criteria is that set forth in the District Structural Design Manual. However, in order to maintain a degree of flexibility, certain criteria is an input requirement. Refer to the input form in the attachments.

The concrete stress, reinforcing steel stress and modular ratio used are equal to the input values of "XCONC", "XSTL", and "XN", respectively. There is no limitation for these variables. In the elliptical alternates, the steel stress "XSTL" is reduced, where required, to limit the concrete stress to "XCONC".

Input Data:

A typical input form is attached. This form defines the input variables and shows the required format for the data.

Output:

A typical output sheet is attached. The following items are given:

Pipe diameter

Pipe wall thickness

Depth of fill

Required steel areas

Design criteria

Steel areas for three alternates are always given in the output. In the case of pipe under extremely heavy load, the steel area may be greater than can be placed. It is left to the designer's judgment to ignore these designs. In general, it is felt 3.00 square inches is the practical limit for the area that can be attained in a cage.

Sample Problem:

It is required to design a 132-inch reinforced concrete pipe with a wall thickness of 11.5 inches for covers of 2, 8, and 14 feet. The pipe is to be installed in a trench equal in width to the outside pipe diameter plus 20 inches, backfilled with soil with a density of 110 p.c.f. and subjected to loads imposed by an A.A.S.H.O. H-20 truck. A design is obtained for a double circular cage alternate, a circular cage and elliptical cage alternate, a single elliptical cage alternate. The required input data for the solution of this problem and the output are attached..

Future Modifications:

The program will be extended at a future date to remove the restrictions on projection ratio and loading angles.

References:

1. District Structural Design Manual
2. District Manual for Structural Computer Programs

DESIGN OF REINFORCED CONCRETE PIPE

BOND ISSUE

COMPUTER PROGRAM 0505

PROJECT: SAMPLE PROBLEM DATA ENTERED BY: R.J. SMITH
CHECKED BY: V. MARTINEZ DIVISION: DESIGN DATE: DEC. 1, 1970

DEFINITIONS: OF INPUT VALUES

CARD NO. 1

SYMBOL	NAME
IID	INSIDE DIAMETER (INCHES)
XT	THICKNESS (INCHES)
XFI	MINIMUM FILL (FEET)
XFZ	MAXIMUM FILL (FEET)
XFX	FILL INCREMENT (FEET)
XCONC	CONCRETE STRESS (P.S.I.)
XSTL	STEEL STRESS (P.S.I.)
XN	MODULAR RATIO
XLAT	LATERAL LOAD (P.S.F.)
XPH	PRESSURE HEAD (FEET)
XIW	INTERNAL WATER 0-NONE 1-FULL

CARD NO. 2

SYMBOL	NAME
ISD	SOIL DENSITY (P.C.F.)
IW	TRENCH CLEARANCE (INCHES - TOTAL)
PRA	PROJECTION RATIO
SRA	SETTLEMENT RATIO
IIN	TYPE INSTALLATION 1. TRENCH 2. POS. PROJ. 3. NEG. PROJ.
ILL	LIVE LOAD 30 ZERO 20 H-20, ETC. 65 E-65, ETC.
XCOV	STEEL COVER (TO ℄ BAR)

CARD NO. 1

IID	XT	XFI	XFZ	XFX	XCONC	XSTL	XN	XLAT	XIW	XPH
132	11.5	2.	14.	6.	2025.	24000.	8.	.0	1.	.0

CARD NO. 2

ISD	IW	PRA	SRA	IIN	ILL	XCOV
110	24	.	.	1	20	1.5

DESIGN OF REINFORCED CONCRETE PIPE

PIPE DIAMETER INS.	WALL THICKNESS INS.	DEPTH OF FILL FT.	STEEL REQUIREMENTS IN SQ. INS./LIN. FT.				
			DOUBLE CIRCULAR		CIR. AND ELLIPTICAL		ELL. ONLY
			INN. CIR.	OUT. CIR.	CIR.	ELL.	ELL.
132	11.50	2.0	1.21	0.82	0.39	0.82	1.21
132	11.50	8.0	1.18	0.80	0.38	0.80	1.18
132	11.50	14.0	1.52	1.04	0.48	1.04	1.52

DESIGN CRITERIA

ALLOWABLE STRESSES
CONCRETE 2025. PSI.
RE-STEEL 24000. PSI.

MODULAR RATIO 8.

EARTH LOAD
LATERAL 0.0 PSF. E.F.P.
VERTICAL (MARSTONS)
SOIL DENSITY 110 PCF.
TRENCH
0. DIA. + 24 INS.

CONDUIT FULL PRESSURE HEAD = 0.0 FT.

ANGLE OF LOADING
TOP 180 DEG.
BOTTOM 90 DEG.

COVER ON STEEL 1.50 INS.

LIVE LOAD
A.A.S.H.O. H- 20

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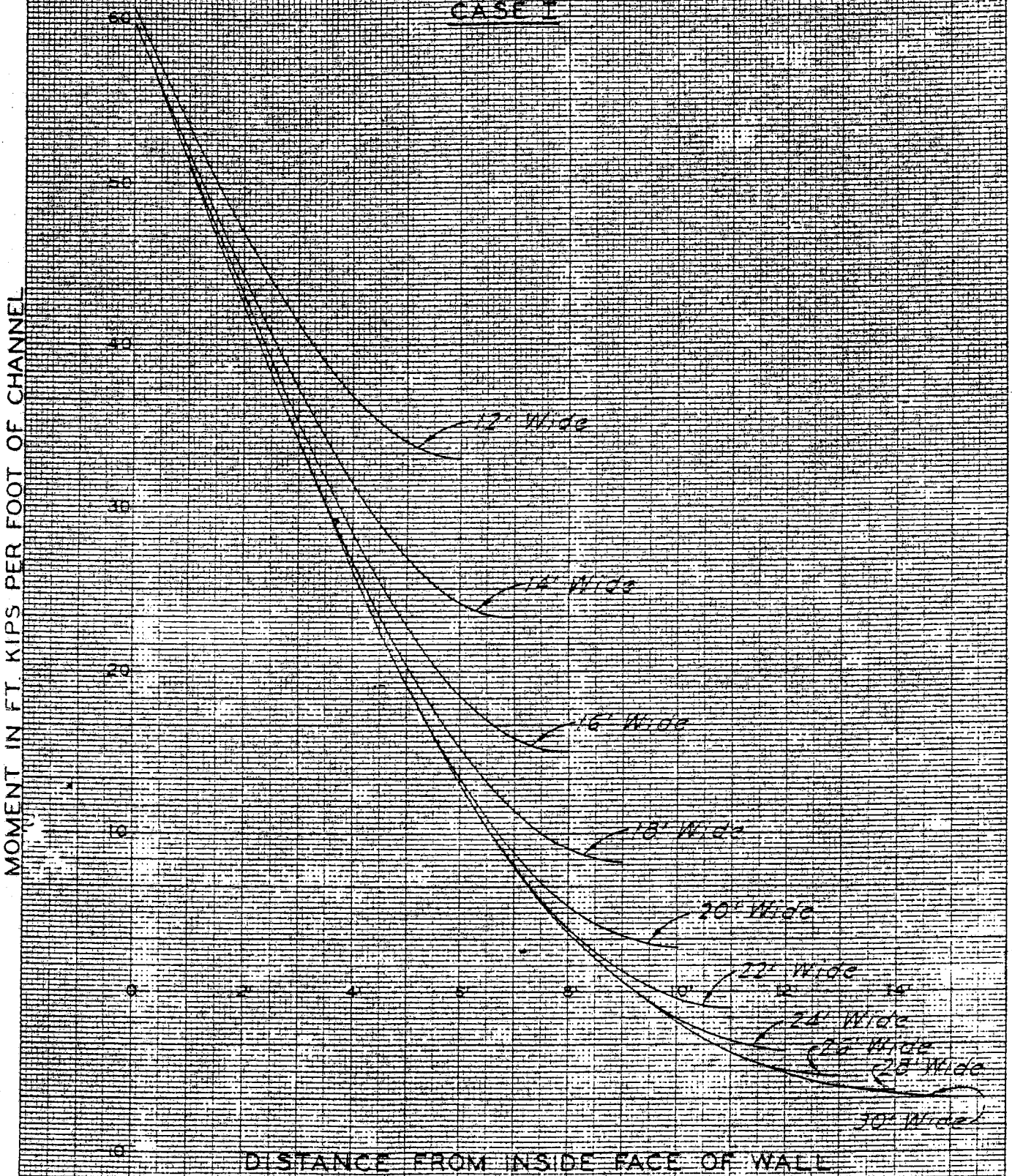
W

MOMENT IN BOTTOM SLAB

8 FT. HIGH WALLS

CASE I



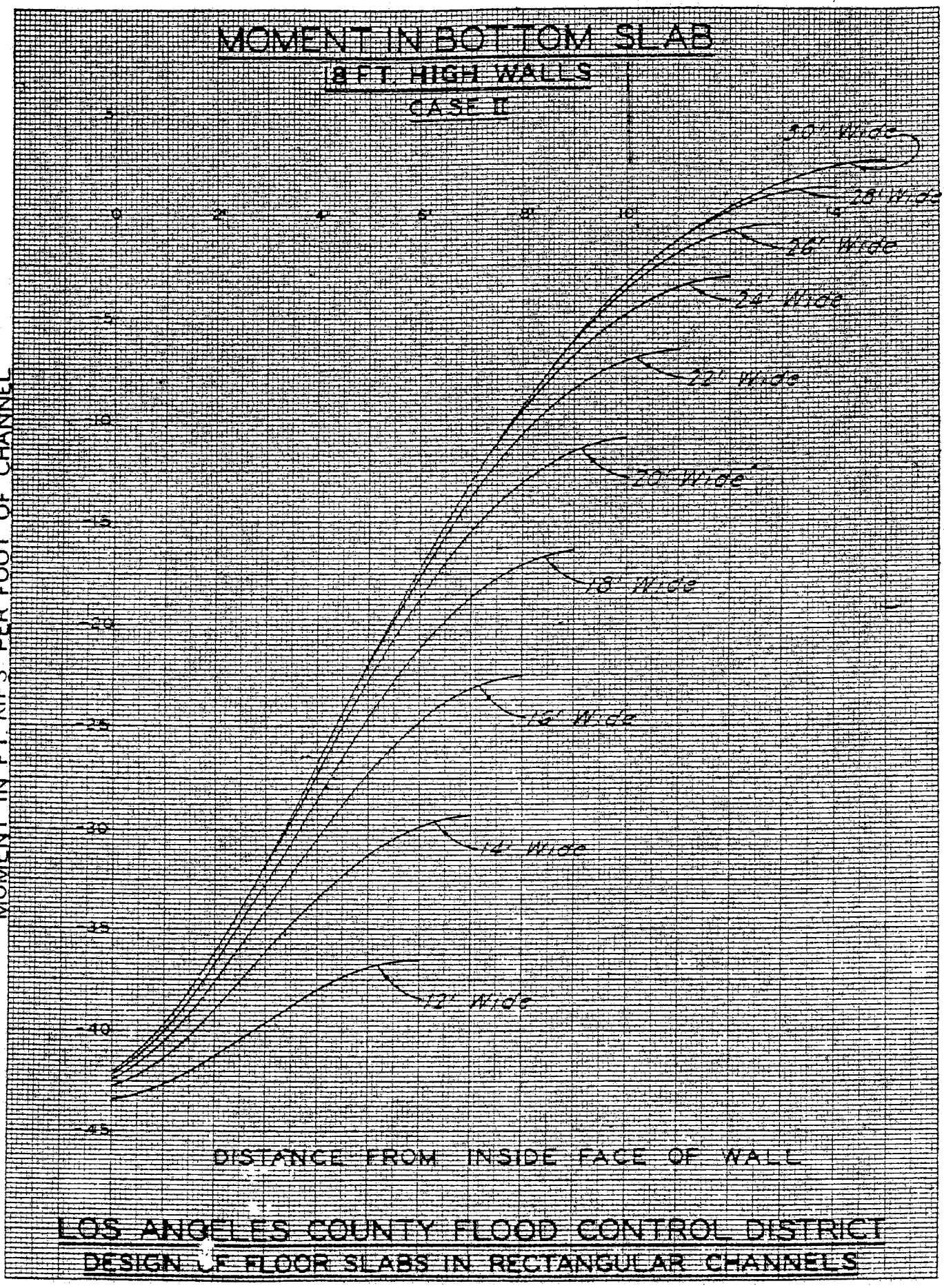
LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB

18 FT. HIGH WALLS

CASE II



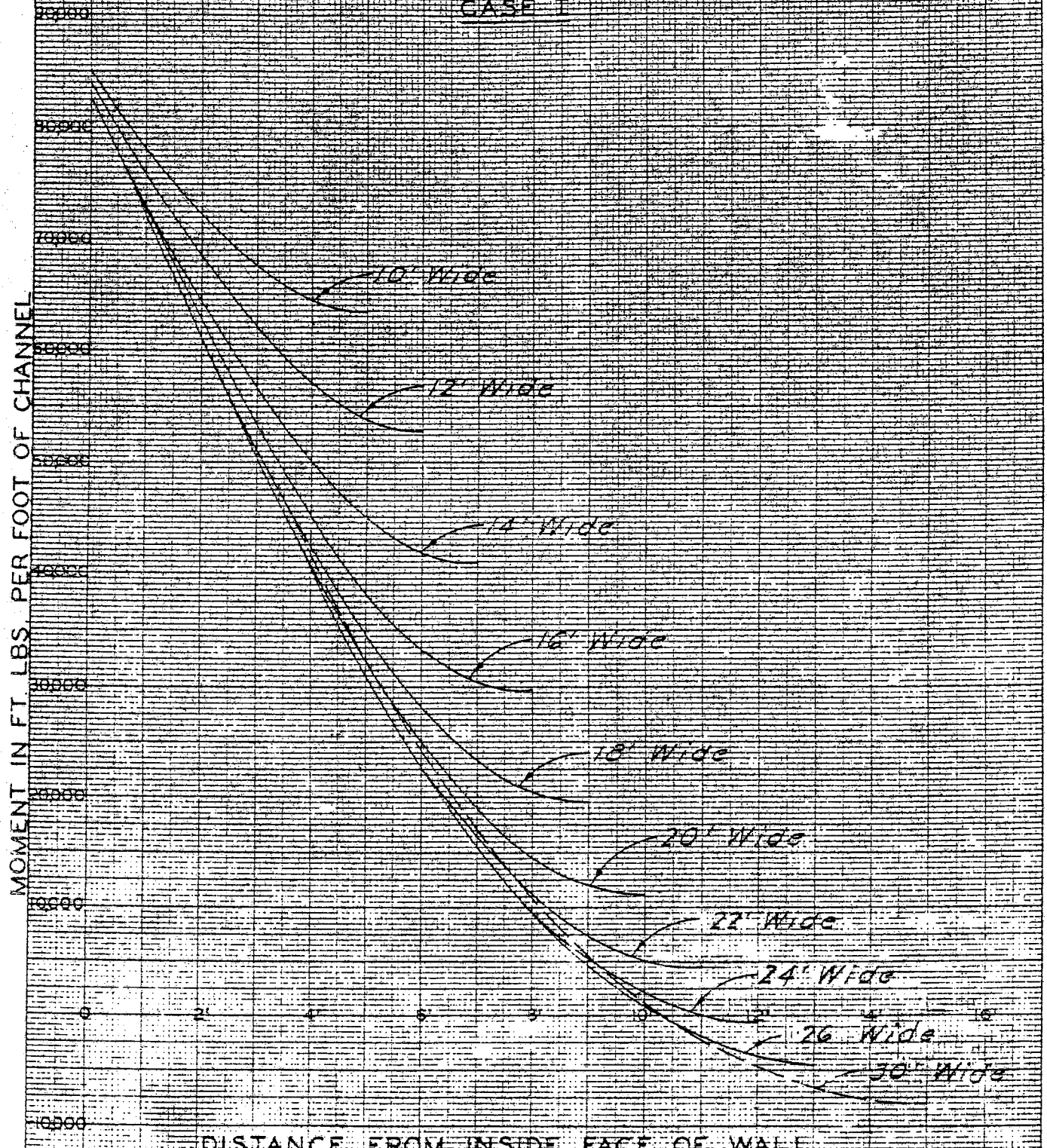
LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB

20FT. HIGH WALLS

CASE I



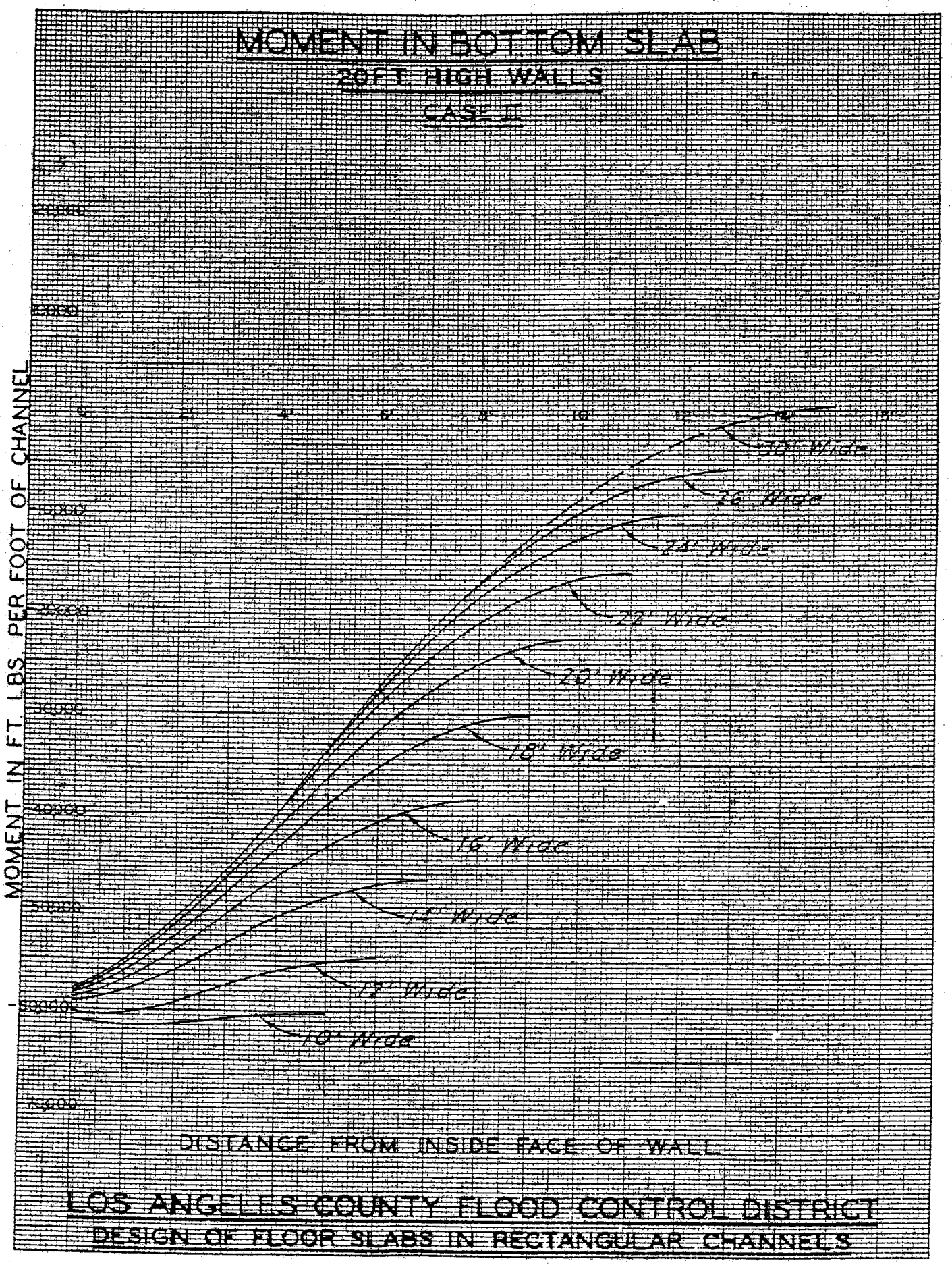
LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

MOMENT IN BOTTOM SLAB

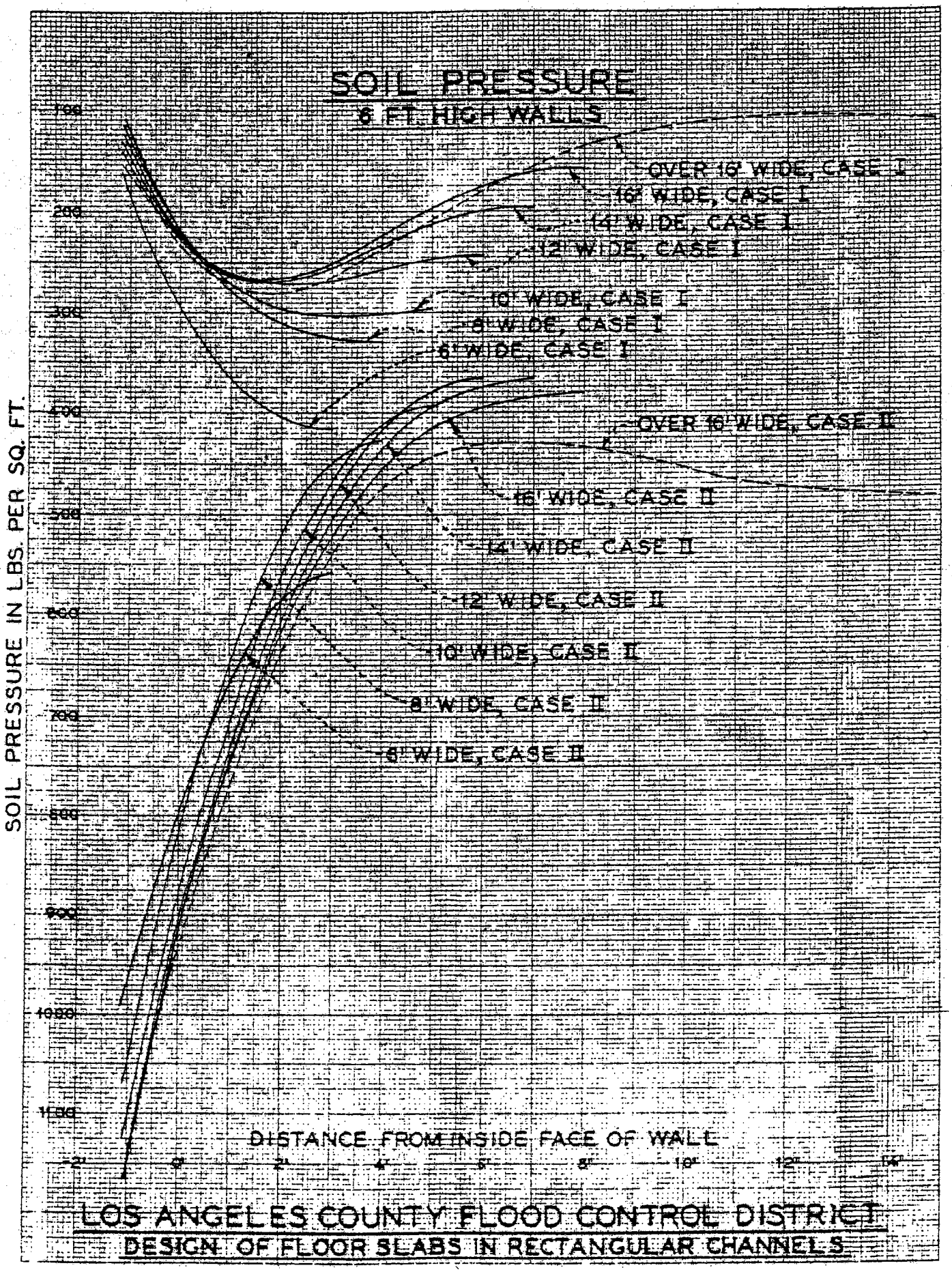
20 FT. HIGH WALLS

CASE II



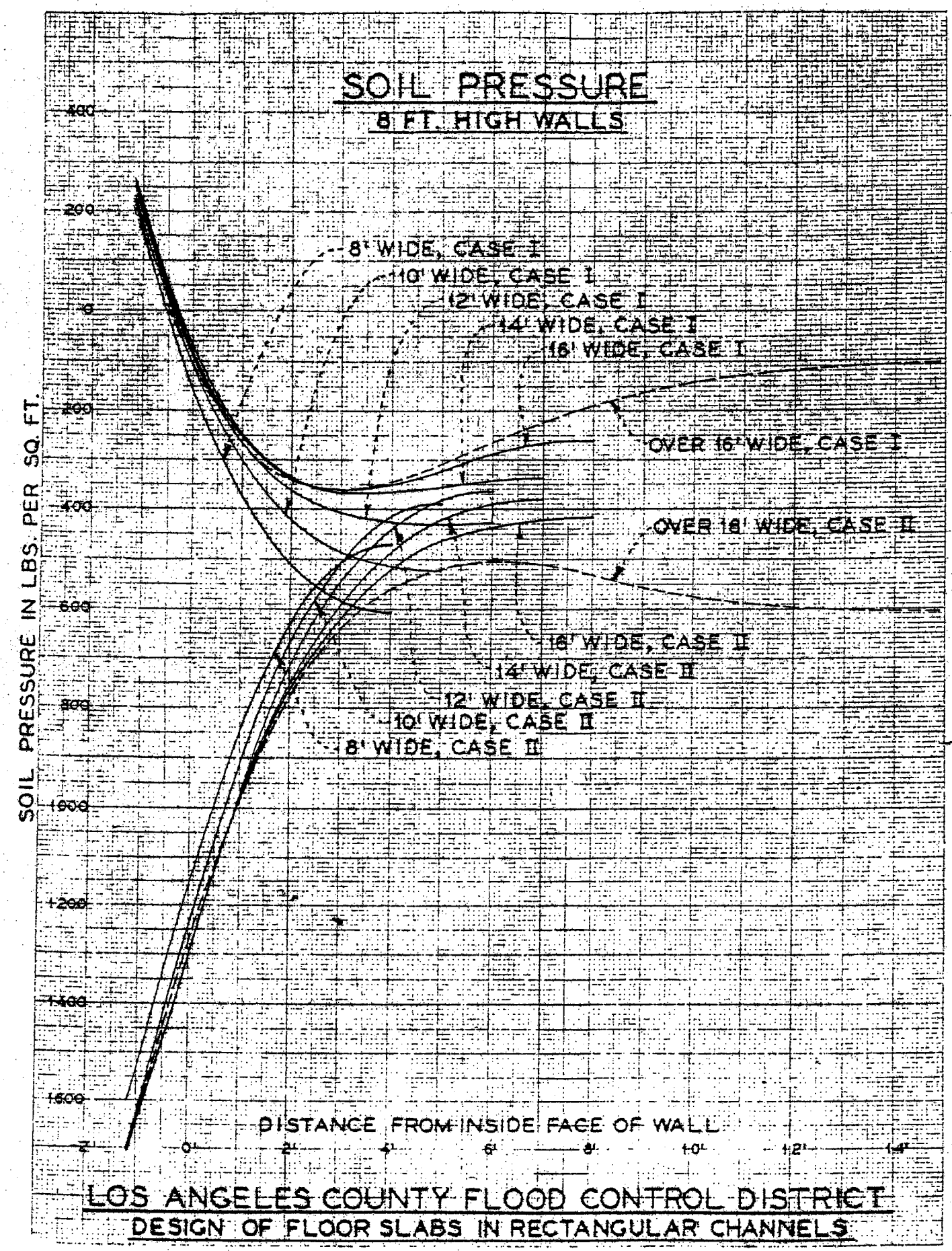
LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS



LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

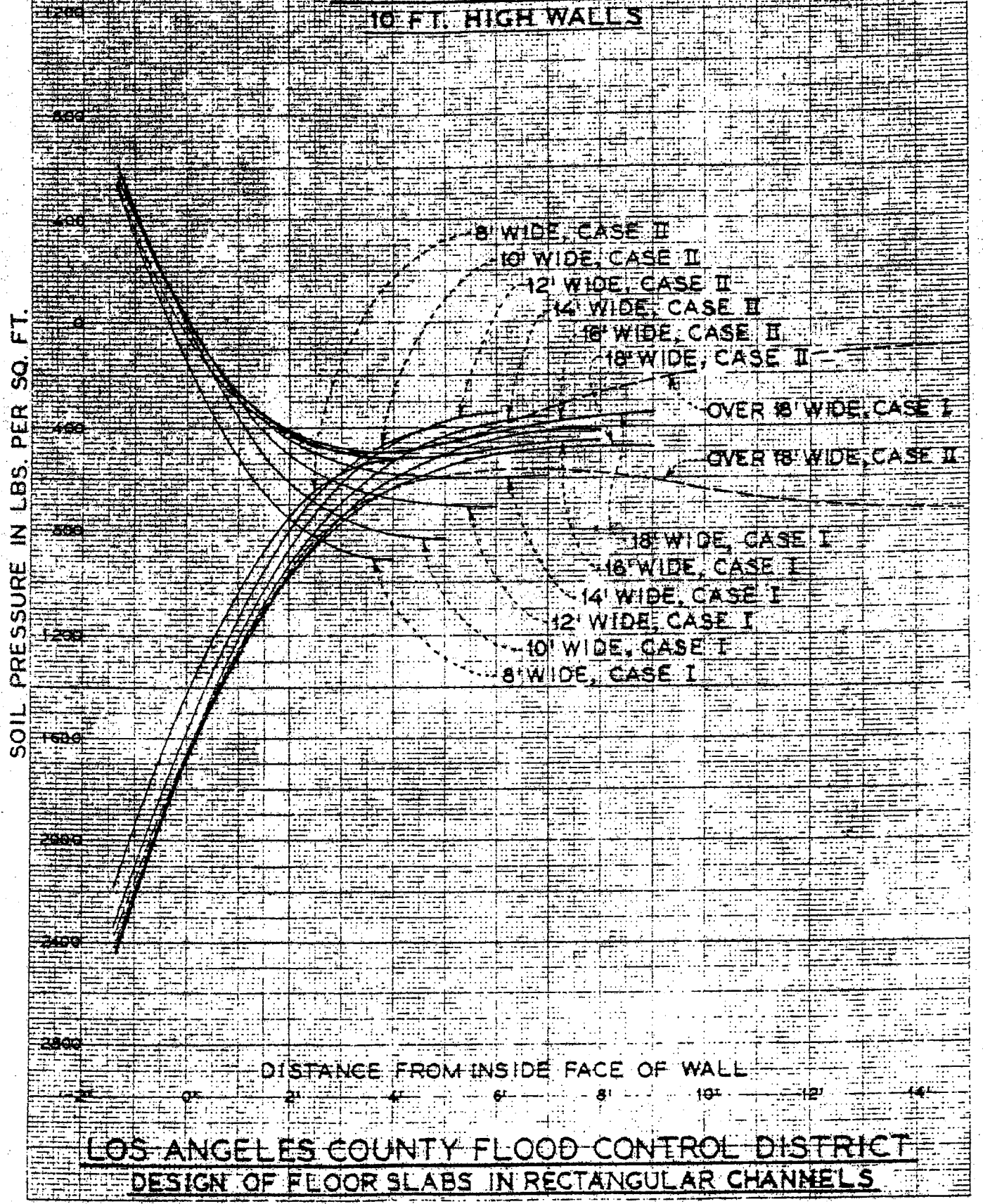


LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

SOIL PRESSURE

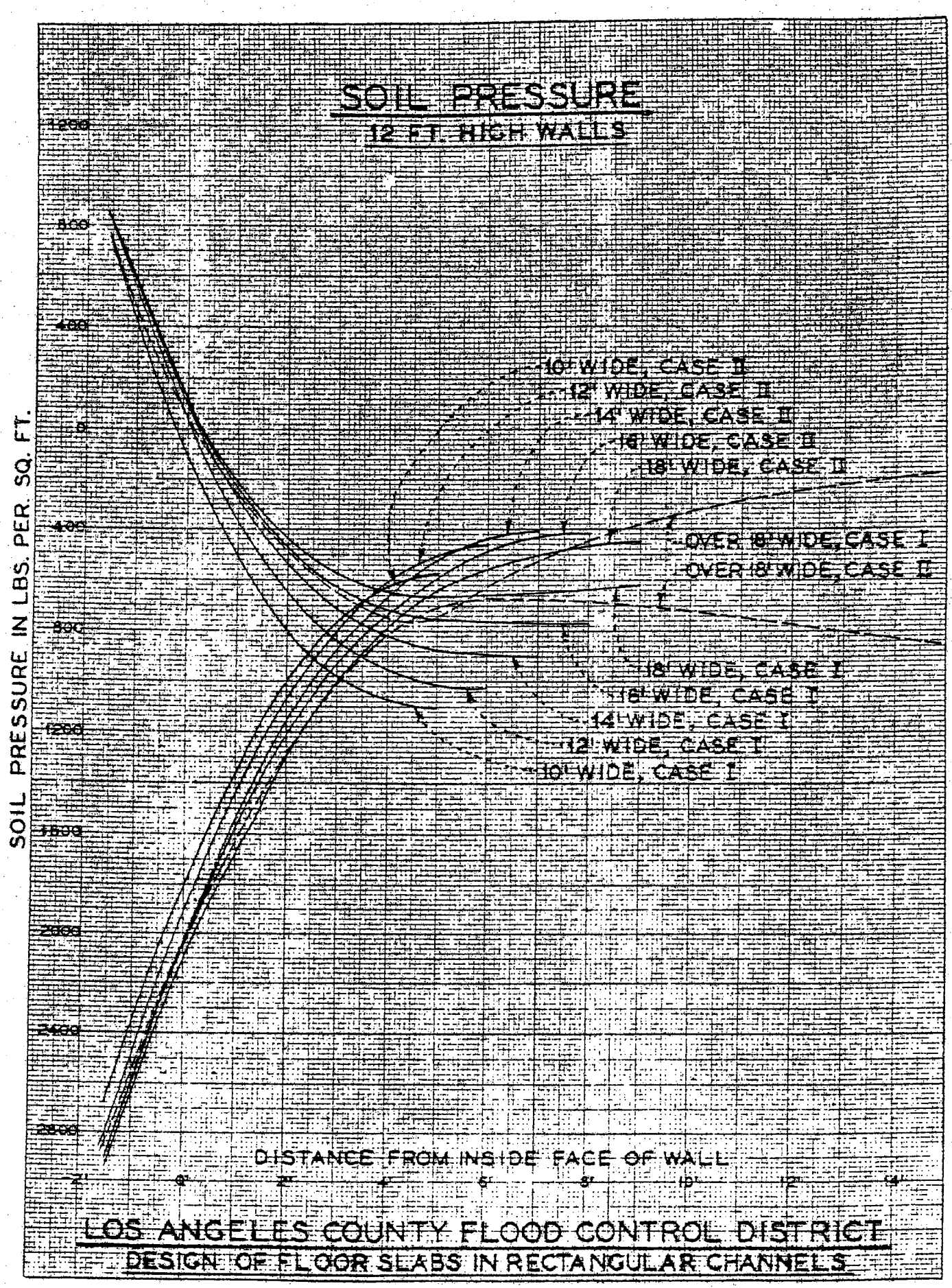
16 FT. HIGH WALLS



LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

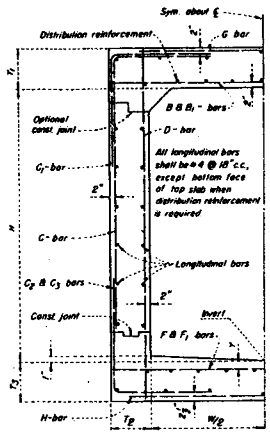
DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS

SOIL PRESSURE
12 FT. HIGH WALLS

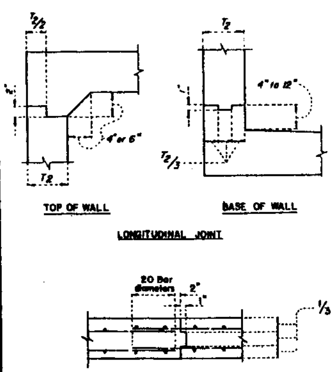


LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN OF FLOOR SLABS IN RECTANGULAR CHANNELS



TYPICAL R C BOX SECTION
NOT TO SCALE



CONSTRUCTION JOINT DETAILS
NOT TO SCALE

STRUCTURAL NOTES

1. DIMENSIONS FROM FACE OF CONCRETE TO STEEL ARE TO CENTER OF BAR, UNLESS OTHERWISE SHOWN.
2. CONCRETE DIMENSIONS SHALL BE MEASURED HORIZONTALLY OR VERTICALLY ON THE PROFILE, AND PARALLEL TO OR AT RIGHT ANGLES (OR RADIALLY) TO CENTERLINE OF CONDUIT ON THE PLAN EXCEPT AS OTHERWISE SHOWN.
3. ALL BAR BENDS AND HOOKS SHALL CONFORM TO THE AMERICAN CONCRETE INSTITUTE'S "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE", 1971 EDITION, SECTION 7.1.
4. PLACING OF REINFORCEMENT SHALL CONFORM TO THE AMERICAN CONCRETE INSTITUTE'S "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE", 1971 EDITION, SECTION 7.5.
5. TRANSVERSE CONSTRUCTION JOINTS SHALL NOT BE PLACED WITHIN 30 INCHES OF MANHOLE OR JUNCTION STRUCTURE OPENINGS.
6. TRANSVERSE CONSTRUCTION JOINTS IN WALLS AND SLABS SHALL BE IN THE SAME PLANE. NO STAGGERING OF JOINTS WILL BE PERMITTED. TRANSVERSE CONSTRUCTION JOINTS SHALL BE NORMAL OR RADIAL TO THE CENTERLINE OF CONSTRUCTION.
7. THE TRANSVERSE REINFORCING STEEL SHALL TERMINATE ONE AND ONE-HALF INCHES FROM THE CONCRETE SURFACES UNLESS OTHERWISE SHOWN ON THE STRUCTURAL DETAILS.
8. EXPOSED EDGES OF CONCRETE MEMBERS SHALL BE ROUNDED OR BEVELED.
9. NO SPLICES IN TRANSVERSE STEEL REINFORCEMENT WILL BE PERMITTED OTHER THAN SHOWN ON THE DRAWING WITHOUT APPROVAL OF THE ENGINEER. NO MORE THAN TWO SPLICES WILL BE PERMITTED IN ANY LONGITUDINAL BAR BETWEEN TRANSVERSE JOINTS. SPLICES SHALL BE STAGGERED.
10. LONGITUDINAL STEEL SHALL BE LAPPED 20 BAR DIAMETERS AT SPLICES. TRANSVERSE STEEL [illegible] LAPPED 3[illegible] BAR DIAMETERS AT SPLICES.
11. LONGITUDINAL STEEL SHALL BE CONTINUOUS AND EXTEND THROUGH ALL CONSTRUCTION [illegible].
12. UNLESS OTHERWISE SHOWN ON THE DRAWINGS, TRANSVERSE CONSTRUCTION JOINTS (IN SLABS AND WALLS), SHALL BE PLACED AT THE END OF EACH POUR, BUT THE SPACING THEREOF SHALL NOT EXCEED 50 FEET OR BE LESS THAN 10 FEET.
13. UNLESS OTHERWISE SHOWN ON THE DETAILS, IN CURVED SECTIONS TRANSVERSE BARS SHALL BE PLACED RADIALLY. THE SPACING OF STRAIGHT TRANSVERSE BARS IN TOP AND BOTTOM SLABS SHALL BE MEASURED AT THE CENTERLINE OF CONSTRUCTION. THE SPACING OF STRAIGHT BARS AND L-BARS IN WALLS SHALL BE MEASURED BETWEEN THE VERTICAL LEGS OF BARS.
14. AT THE BEGINNING AND ENDING OF ALL POURS, A CURTAIN OF REINFORCEMENT COMPOSED OF B, C, C2, D, F, G, AND H BARS SHALL BE PLACED THREE INCHES FROM THE TRANSVERSE CONSTRUCTION JOINT.
15. D-BARS MAY BE SPLICED 20 BAR DIAMETERS AT THE LOWER LONGITUDINAL CONSTRUCTION JOINT, AT CONTRACTOR'S OPTION.
16. IN ALL SECTIONS LAP C AND C2 BARS. THE VERTICAL LENGTH OF C AND C2 HAS BEEN CALCULATED FOR A FOUR INCH STARTER WALL. IF THE HEIGHT OF THE STARTER WALL IS VARIED, THE VERTICAL LENGTH OF THE C AND C2 BARS SHALL BE VARIED CORRESPONDINGLY SO AS TO MAINTAIN A 30 DIAMETER LAP BETWEEN THE TWO BARS. THE LAPS SHALL BE BASED ON THE SMALLER BAR.
17. CONCRETE QUANTITIES ARE BASED ON A SIX-BY-SIX INCH FILLET AND THE STEEL QUANTITIES DO NOT INCLUDE ANY OPTIONAL SPLICES.
18. IF WALL THICKNESS IS SIX INCHES, PLACE REINFORCEMENT AT THE CENTERLINE OF THE WALL.
19. THE DESIGN OF BOX SECTIONS IDENTIFIED BY A NUMERICAL VALUE ONLY IS BASED ON A WIDTH OF TRENCH EQUAL TO THE OUTSIDE WIDTH OF THE CONDUIT PLUS 3 FEET. WHEN THE COVER IS EQUAL TO 10 FEET OR LESS THE TRENCH WIDTH IS UNRESTRICTED. WHEN THE COVER IS GREATER THAN 10 FEET AND THE TRENCH WIDTH IS GREATER THAN THE OUTSIDE WIDTH OF THE CONDUIT PLUS 3 FEET FOR A DISTANCE IN EXCESS OF 10 FEET AN ALTERNATE SECTION SHALL BE USED AS INDICATED BELOW:
   A. WHEN THE DEPTH OF COVER IS LESS THAN 10 FEET, SECTIONS WITH THE SUFFIX "B" SHALL BE USED.
   B. WHEN THE DEPTH COVER IS GREATER THAN 10 FEET AND:
      1. THE TRENCH WIDTH IS LESS THAN THE OUTSIDE WIDTH OF THE CONDUIT PLUS 6 FEET, SECTIONS WITH SUFFIX "A" SHALL BE USED.
      2. THE TRENCH WIDTH IS GREATER THAN THE OUTSIDE WIDTH OF CONDUIT PLUS 6 FEET, SECTIONS WITH THE SUFFIX "B" SHALL BE USED.

BOX SECTION											
Design Cover											
Width	W										
Height	H										
Top Slab Thickness	T_1										
Side Wall Thickness	T_2										
Bottom Slab Thickness	T_3										
Concrete Cover (d"min.)	Y										
B	Bar No. & Spacing										
Bars	Length										
B_1	Bar No. & Spacing										
Bars	Length										
C	Bar No. & Spacing										
Bars	Hor. Length										
	Vert. Length										
C_1	Bar No. & Spacing										
Bars	Hor. Length										
	Vert. Length										
C_2	Bar No. & Spacing										
Bars	Hor. Length										
	Vert. Length										
C_3	Bar No. & Spacing										
Bars	Hor. Length										
	Vert. Length										
D	Bar No. & Spacing										
Bars	Length										
F	Bar No. & Spacing										
Bars	Length										
F_1	Bar No. & Spacing										
Bars	Length										
G	Bar No. & Spacing										
Bars	Length										
H	Bar No. & Spacing										
Bars	Length										
NUMBER OF LONGITUDINAL REINFORCEMENT #4 BARS											
Top Slab (include distribution reinforcement)											
Bottom Slab											
Side Walls											
TOTAL											
QUANTITIES											
Concrete Cu.Yds./Lin. Ft.											
Steel Lbs./Lin. Ft.											

STRUCTURAL DESIGN CRITERIA
L.A.C.F.C.D. STRUCTURAL DESIGN MANUAL
DATED APRIL 19__

LIVE LOAD
H20-S16-44 unless otherwise noted

DEAD LOAD
Earth load per Marston's formula: w = p c f
Ku = Ku' = 0.150
Bd = Outside width of box plus 3 feet
Side earth p s f per foot of depth
Internal water pressure: 62.4 p s f per foot of depth
Weight of concrete: 150 p c f

ALLOWABLE STRESSES
f'_c = 4000 p s i at 28 days
f_c = 1800 p s i
f_s = 24,000 p s i
n = 8
Shear and bond stresses per A.C.I. 318-63

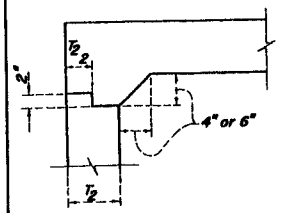
R C BOX LOCATION SCHEDULE					
Box Sect.	Station From	Station To	Box Sect.	Station From	Station To

REVISIONS

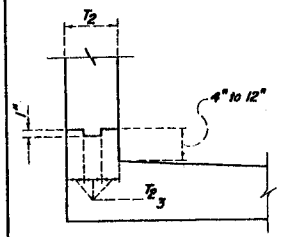
LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

SINGLE R C BOX
STRUCTURAL SCHEDULE, NOTES AND DETAILS

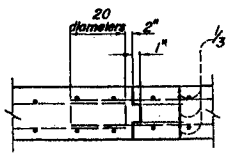
DATE | SCALE
NO.
SHEET | OF



TOP OF WALL



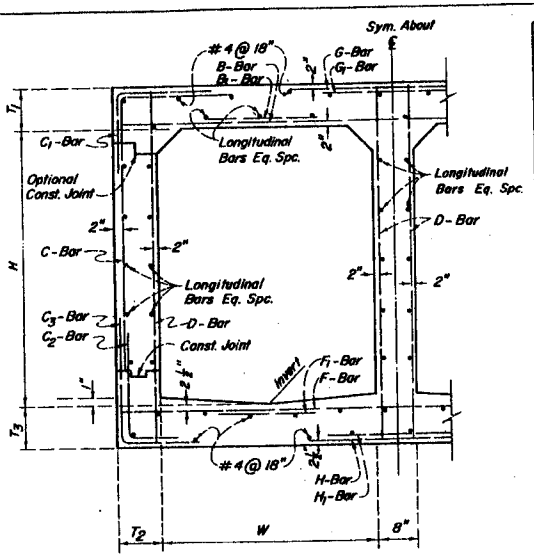
BASE OF WALL



TRANSVERSE JOINT

CONSTRUCTION JOINT DETAILS

NOT TO SCALE



TYPICAL R. C. BOX SECTION

NOT TO SCALE

DESIGN DATA

LIVE LOAD

H20-S16-44 unless otherwise noted

DEAD LOAD

Earth load per Marston's formula: w = 110 p.c.f.
Ku = Ku' = 0.150
Bd = Outside width of box plus 3 feet
Side earth 37 p.s.f. per foot of depth
Internal water pressure: 62.4 p.s.f. per foot of depth
Weight of concrete: 150 p.c.f.

ALLOWABLE STRESSES

f'_c = 4000 p.s.i. at 28 days
f_c = 1800 p.s.i.
f_s = 24000
n = 8
shear and bond stresses per A.C.I. 318-63

BOX SECTION NO.											
Design Cover											
Width	W										
Height	H										
Live Load											
Top Slab Thickness	T_1										
Side Wall Thickness	T_2										
Bottom Slab Thickness	T_3										
B Bars	Bar No. & Spacing										
	Length										
B_1 Bars	Bar No. & Spacing										
	Length										
C Bars	Bar No. & Spacing										
	Horiz. Length										
	Vert. Length										
C_1 Bars	Bar No. & Spacing										
	Horiz. Length										
	Vert. Length										
C_2 Bars	Bar No. & Spacing										
	Horiz. Length										
	Vert. Length										
C_3 Bars	Bar No. & Spacing										
	Horiz. Length										
	Vert. Length										
D Bars	Bar No. & Spacing										
	Length										
F Bars	Bar No. & Spacing										
	Length										
F_1 Bars	Bar No. & Spacing										
	Length										
G Bars	Bar No. & Spacing										
	Length										
G_1 Bars	Bar No. & Spacing										
	Length										
H Bars	Bar No. & Spacing										
	Length										
H_1 Bars	Bar No. & Spacing										
	Length										
NUMBER LONGITUDINAL REINFORCEMENT #4 BARS											
Top Slab (Includes Distrib.)											
Ext. Walls											
Int. Walls											
Inv. Slab											
TOTAL											
QUANTITIES											
Concrete Cu. Yds./Lin. Ft.											
Steel Lbs./Lin. Ft.											

STRUCTURAL NOTES

GENERAL

1. DIMENSIONS FROM FACE OF CONCRETE TO STEEL ARE TO CENTER OF BAR AND SHALL BE TWO INCHES UNLESS OTHERWISE SHOWN.
2. CONCRETE DIMENSIONS SHALL BE MEASURED HORIZONTALLY OR VERTICALLY ON THE PROFILE, AND PARALLEL TO OR AT RIGHT ANGLES (OR RADIALLY) TO CENTERLINE OF CONDUIT ON THE PLAN EXCEPT AS OTHERWISE SHOWN.
3. ALL BAR BENDS AND HOOKS SHALL CONFORM TO THE AMERICAN CONCRETE INSTITUTE'S "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE" SECTION 891.
4. PLACING OF REINFORCEMENT SHALL CONFORM TO THE AMERICAN CONCRETE INSTITUTE'S "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE" SECTION 805.
5. TRANSVERSE CONSTRUCTION JOINTS SHALL NOT BE PLACED WITHIN 30 INCHES OF MANHOLE OR JUNCTION STRUCTURE OPENINGS.
6. TRANSVERSE CONSTRUCTION JOINTS IN WALLS AND SLABS SHALL BE IN THE SAME PLANE. NO STAGGERING OF JOINTS WILL BE PERMITTED. TRANSVERSE CONSTRUCTION JOINTS SHALL BE NORMAL OR RADIAL TO THE CENTERLINE OF CONSTRUCTION.
7. THE TRANSVERSE REINFORCING STEEL SHALL TERMINATE ONE AND ONE-HALF INCHES FROM THE CONCRETE SURFACES UNLESS OTHERWISE SHOWN ON THE STRUCTURAL DETAILS.
8. EXPOSED EDGES OF CONCRETE MEMBERS SHALL BE ROUNDED OR BEVELED.
9. NO SPLICES IN TRANSVERSE STEEL REINFORCEMENT WILL BE PERMITTED OTHER THAN SHOWN ON THE DRAWING WITHOUT APPROVAL OF THE ENGINEER. NO MORE THAN TWO SPLICES WILL BE PERMITTED IN ANY LONGITUDINAL BAR BETWEEN TRANSVERSE JOINTS. SPLICES SHALL BE STAGGERED.
10. LONGITUDINAL STEEL SHALL BE LAPPED 20 BAR DIAMETERS AT SPLICES. TRANSVERSE STEEL SHALL BE LAPPED 30 BAR DIAMETERS AT SPLICES.

ADDITIONAL NOTES FOR BOX SECTIONS

1. LONGITUDINAL STEEL SHALL BE CONTINUOUS AND EXTEND THROUGH ALL CONSTRUCTION JOINTS.
2. UNLESS OTHERWISE SHOWN ON THE DRAWINGS, TRANSVERSE JOINT KEYWAYS (IN BOTH SLABS AND WALLS), AS DETAILED FOR LONGITUDINAL KEYWAYS AT THE BASE OF THE WALLS, SHALL BE PLACED AT THE END OF EACH POUR, BUT THE SPACING THEREOF SHALL NOT EXCEED 50 FEET OR BE LESS THAN 10 FEET. ALL CONSTRUCTION JOINTS IN BOTTOM SLAB, TOP SLAB, AND SIDE WALLS SHALL BE IN THE SAME PLANE. NO STAGGERING OF JOINTS WILL BE PERMITTED.
3. UNLESS OTHERWISE SHOWN ON THE DETAILS, IN CURVED SECTIONS TRANSVERSE BARS SHALL BE PLACED RADIALLY. STRAIGHT TRANSVERSE BARS IN TOP AND BOTTOM SLABS SHALL BE SPACED AS SHOWN ON THE TYPICAL SECTIONS. SPACING SHALL BE AT THE CENTERLINE OF CONSTRUCTION FOR SINGLE-BARREL BOXES. STRAIGHT BARS AND L-BARS IN WALLS SHALL BE SPACED AS SHOWN ON THE TYPICAL SECTIONS, WITH THE SPACING MEASURED BETWEEN THE VERTICAL LEGS OF BARS
4. AT THE BEGINNING AND ENDING OF ALL POURS, A CURTAIN OF REINFORCEMENT COMPOSED OF B, C, C_2, D, AND F, G, AND H BARS SHALL BE PLACED THREE INCHES FROM THE TRANSVERSE CONSTRUCTION JOINT.
5. THE VERTICAL WALL STEEL IN INTERIOR WALLS AND IN THE INTERIOR FACE OF EXTERIOR WALLS MAY BE SPLICED AT THE CONSTRUCTION JOINT AT THE BASE OF THE WALL. THE SPLICE SHALL BE 20 BAR DIAMETERS IN LENGTH.
6. IN ALL SECTIONS LAP C AND C_2 BARS. THE VERTICAL LENGTH OF C AND C_2 BARS HAS BEEN CALCULATED FOR A FOUR-INCH STARTER WALL. IF THE HEIGHT OF THE STARTER WALL IS VARIED, THE VERTICAL LENGTH OF THE C AND C_2 BARS SHALL BE VARIED CORRESPONDINGLY SO AS TO MAINTAIN A 30 DIAMETER LAP BETWEEN THE TWO BARS. THE LAPS SHALL BE BASED ON THE SMALLER BAR.
7. CONCRETE QUANTITIES ARE BASED ON A SIX-BY-SIX-INCH FILLET AND THE STEEL QUANTITIES DO NOT INCLUDE ANY OPTIONAL SPLICES.
8. IF WALL THICKNESS IS SIX INCHES, PLACE REINFORCEMENT AT THE CENTERLINE OF THE WALL.

R. C. BOX LOCATION SCHEDULE

Box Sect.	Station From	Station To	Box Sect.	Station From	Station To

REVISIONS			
M. E. D.	MARK	DATE	DESCRIPTION
V. C. M.			
F. W. R.			
C. W. N.			

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DOUBLE R. C. BOX SCHEDULE & DETAILS

SCALE: NONE | DATE | DWG. NO. S-101

S-101

REINFORCED CONCRETE RECTANGULAR CHANNEL

SECTION	STATION LIMITS FROM	TO	SIZE W	H	THICKNESS (INCHES) T_1	T_2	T_3	QUANTITIES CONCRETE CU. YDS./ LIN. FT.	STEEL LBS./ LIN. FT.	B_1 BAR NO. & SPACING	B_1 VERT. LENGTH	B_1 HORIZ. LENGTH	B_2 BAR NO. & SPACING	B_2 VERT. LENGTH	B_2 HORIZ. LENGTH	B_3 BAR NO. & SPACING	B_3 VERT. LENGTH	B_3 HORIZ. LENGTH	B_4 BAR NO. & SPACING	B_4 VERT. LENGTH	B_4 HORIZ. LENGTH	B_5 BAR NO. & SPACING	B_5 VERT. LENGTH	B_5 HORIZ. LENGTH	B_6 BAR NO. & SPACING	B_6 VERT. LENGTH	B_6 HORIZ. LENGTH	B_7 BAR NO. & SPACING	B_7 HORIZ. LENGTH	B_8 BAR NO. & SPACING	B_8 HORIZ. LENGTH	B_9 BAR NO. & SPACING	B_9 HORIZ. LENGTH	LONGITUDINAL BARS TOTAL	WALLS	SLAB

GENERAL STRUCTURAL NOTES

1. DIMENSIONS FROM FACE OF CONCRETE TO STEEL ARE TO CENTER OF BAR AND SHALL BE TWO INCHES UNLESS OTHERWISE SHOWN.
2. CONCRETE DIMENSIONS SHALL BE MEASURED HORIZONTALLY OR VERTICALLY ON THE PROFILE, AND PARALLEL TO OR AT RIGHT ANGLES (OR RADIALLY) TO CENTERLINE OF CONDUIT ON THE PLAN EXCEPT AS OTHERWISE SHOWN.
3. ALL BAR BENDS AND HOOKS SHALL CONFORM TO THE AMERICAN CONCRETE INSTITUTE'S "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE" SECTION 801.
4. PLACING OF REINFORCEMENT SHALL CONFORM TO THE AMERICAN CONCRETE INSTITUTE'S "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE" SECTION 803.
5. TRANSVERSE CONSTRUCTION JOINTS SHALL NOT BE PLACED WITHIN 30 INCHES OF MANHOLE OR JUNCTION STRUCTURE OPENINGS.
6. TRANSVERSE CONSTRUCTION JOINTS IN WALLS AND SLABS SHALL BE IN THE SAME PLANE. NO STAGGERING OF JOINTS WILL BE PERMITTED. TRANSVERSE CONSTRUCTION JOINTS SHALL BE NORMAL OR RADIAL TO THE CENTERLINE OF CONSTRUCTION.
7. THE TRANSVERSE REINFORCING STEEL SHALL TERMINATE ONE AND ONE-HALF INCHES FROM THE CONCRETE SURFACES UNLESS OTHERWISE SHOWN ON THE STRUCTURAL DETAILS.
8. EXPOSED EDGES OF CONCRETE MEMBERS SHALL BE ROUNDED OR BEVELED.
9. NO SPLICES IN TRANSVERSE STEEL REINFORCEMENT WILL BE PERMITTED OTHER THAN SHOWN ON THE DRAWING WITHOUT APPROVAL OF THE ENGINEER. NO MORE THAN TWO SPLICES WILL BE PERMITTED IN ANY LONGITUDINAL BAR BETWEEN TRANSVERSE JOINTS. SPLICES SHALL BE STAGGERED.
10. LONGITUDINAL STEEL SHALL BE LAPPED 70 BAR DIAMETERS AT SPLICES. TRANSVERSE STEEL SHALL BE LAPPED 30 BAR DIAMETERS AT SPLICES.

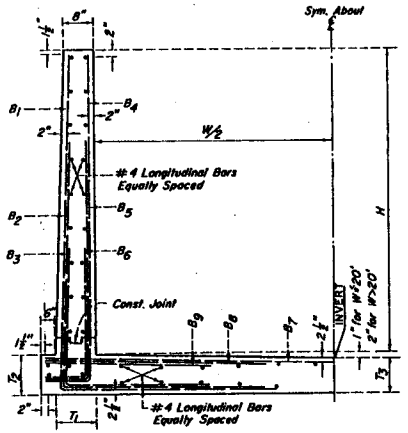
OPEN CHANNEL STRUCTURAL NOTES

1. LONGITUDINAL STEEL SHALL TERMINATE TWO INCHES FROM TRANSVERSE CONSTRUCTION JOINTS.
2. TRANSVERSE JOINTS SHALL BE SPACED NOT TO EXCEED 30 FEET NOR BE LESS THAN 10 FEET, MEASURED ALONG THE CENTERLINE OF CONSTRUCTION, EXCEPT AS OTHERWISE SHOWN ON THE DRAWINGS.
3. TRANSVERSE JOINTS SHALL BE PLACED AT THE JUNCTION OF RECTANGULAR OPEN CHANNEL SECTIONS WITH CLOSED CONDUIT SECTIONS.
4. ALL RECTANGULAR OPEN CHANNEL WALLS SHALL BE FENCED IN ACCORDANCE WITH STANDARD DRAWING I-5018, EXCEPT AS OTHERWISE SHOWN ON THE DRAWINGS.
5. UNLESS OTHERWISE SHOWN ON THE DRAWINGS, IN CURVED SECTIONS THE MAXIMUM SPACING OF BARS SHALL NOT EXCEED THAT SHOWN ON THE TYPICAL SECTIONS. STEEL SHALL BE PLACED RADIALLY FROM THE MAXIMUM SPACING.
6. AT THE BEGINNING AND ENDING OF ALL POURS, A COMPLETE CURTAIN OF REINFORCEMENT COMPOSED OF B_1, $\frac{1}{2}$, AND B_7 BARS SHALL BE PLACED THREE INCHES FROM THE TRANSVERSE CONSTRUCTION JOINT.

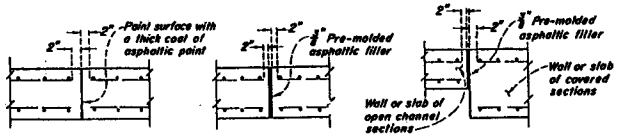
RECTANGULAR CHANNEL DESIGN DATA

Loads
- External 62.5 p.s.f. E.F.P.
- Internal 40.0 p.s.f. E.F.P.

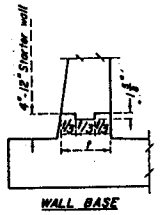
$f_c' = 4000$ p.s.i.
$f_c = 1800$ p.s.i.
$f_s = 24000$ p.s.i.
$n = 8$



TYPICAL CHANNEL SECTION
NOT TO SCALE



TRANSVERSE CONSTRUCTION JOINT DETAILS
NOT TO SCALE



LONGITUDINAL CONSTRUCTION JOINT OPEN CHANNEL
NOT TO SCALE

REVISIONS			
	MARK	DATE	DESCRIPTION
M.E.D.			
V.C.M.			
F.W.H.			
C.W.H.			

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

R.C. RECTANGULAR CHANNEL SCHEDULE AND DETAILS

SCALE	DATE	DWG. NO.
NONE		SHEET OF

S-102

SIDE INLET CONNECTIONS

STRUC.	M.L.	LATERAL	STD. DWG.
J.S. No. 4	Pipe	I.D. of lat. ≤ 24", A ≥ 45° O.D. of lat. ≤ ½ I.D. of M.L.	2-D193
J.S. No. 2	Pipe	O.D. of lat. ≥ ½ I.D. of M.L. or I.D. of lat. ≥ 24" I.D. of lat. ≤ ¾ I.D. of M.L., & ≤ 39" No more than 1 opening per pipe length (8'). Check if A < 45° & B > 24" for horiz. clearance Use T.S. No. 3 if vertical angle ≥ 45° Req'd. - A, B, C, D (El. R & S, See Std. Dwg.)	2-D112
T.S. No. 3	Pipe	I.D. of lat. ≥ ¾ I.D. of M.L. or ≥ 39" Req'd. - A, B, C, D_1, D_2 (El. R & S, See Std Dwg.) I.D. of lat. ≤ I.D. of M.L.	2-D188
J.S. No 3	Box	I.D. of lat. ≤ 30" for C.P. & R.C.P., 60" for C.M.P. Provide 12" below soffit and 13" above invert of M.L., A ≥ 45°	2-D191
J.S. No. 1	Box	I.D. of lat. = 12" - 144" If inlet does not permit 7" above invert & 6" below soffit, or A < 30°; investigate. Req'd. - A, B, C (El. R & S, See Std. Dwg.)	2-D189

STANDARD MANHOLES

M.H.	MAINLINE	**LATERAL	STD. DWG.
1	Pipe (33" or less). Also use if upstream ≤ 33" & down ≥ 36" (Cannot exceed 42" because width of M.H. = 3'-6").	Provide 6" below soffit of M.H. Box. See table below.	2-D102
2	Pipe (36"* or greater) see exception for M.H. No. 1	O.D. of lat. ≤ ½ I.D of M.L. Also 30" or less	2-D184
3	Box or Arch		2-D104
4	Pipe (36" * or greater)	12"-144" lat. I.D. of lat. ≤ I.D of M.L. Check horiz. clearance Req'd. - A, B, C, D_1, D_2, El. R & S.	2-D113

*Do not use M.H. No's 2 or 4 for pipe less than 36" diameter. If pipe is smaller, make D_1 = 36" and pour wall around pipe (other possibility is to increase L & H of M.H. #1).

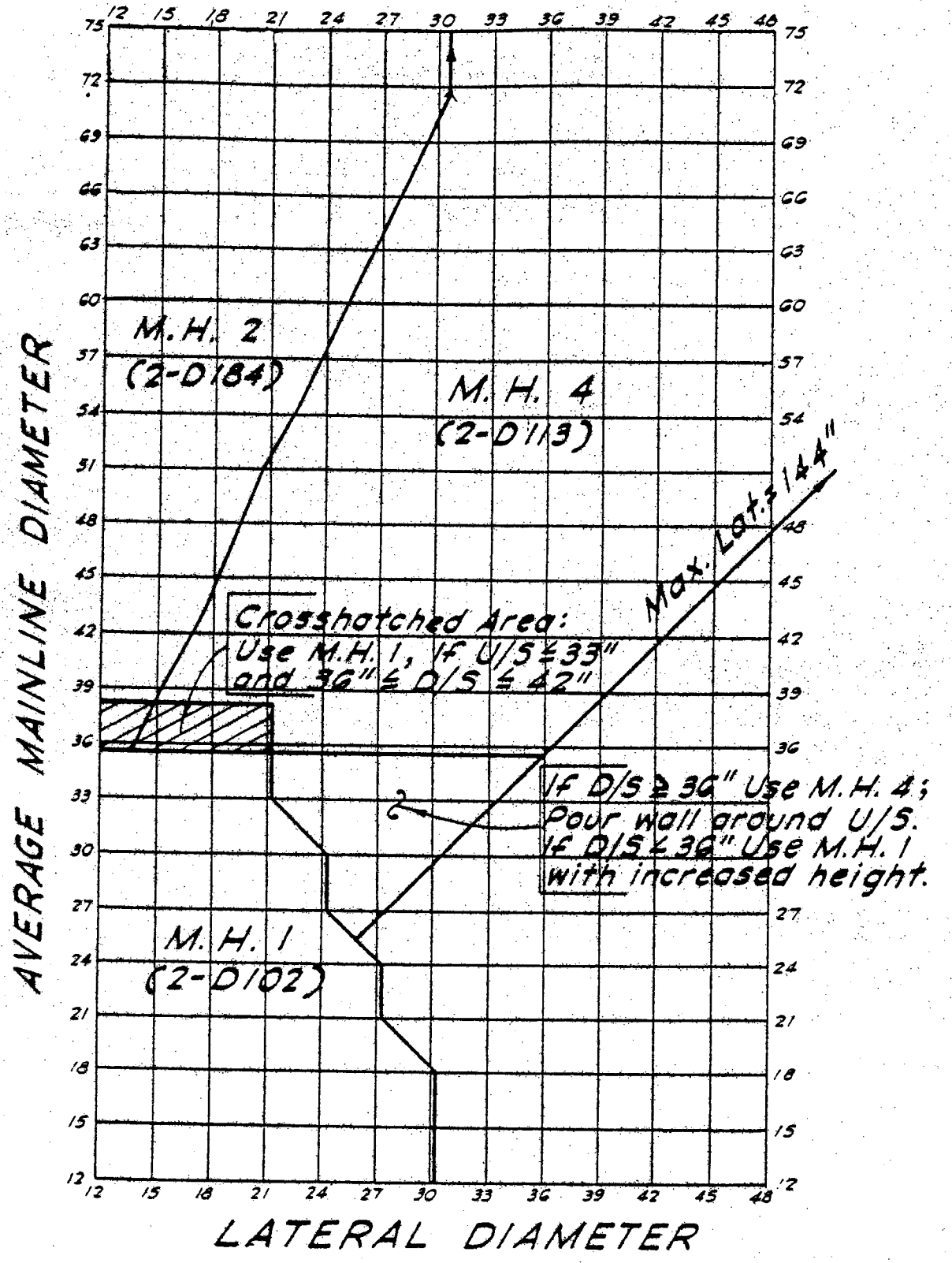
**Inlets shall be located to avoid interference with steps.

C.B.	STD. "V"
1	3'-6"
2	4'-0"
3	4'-0"
4	3'-6"
5	3'-0"
5A	3'-0"
6	4'-6"
7	3'-6"
8A	5'-0"
8B	5'-0"

T.S.	STRUCTURE
1	Pipe or Arch to Box or Arch
2	Box to Box
3	Pipe to Pipe with Inlet
4	Single Box to Double Box
5	Double Box to Double Box
6	Double Box to Triple Box
7	Triple Box to triple Box

M.H. No. 1	
M.L.	MAX. LAT.
15	30
18	30
21	27
24	27
27	24
30	24
33	21

PIPE MANHOLES

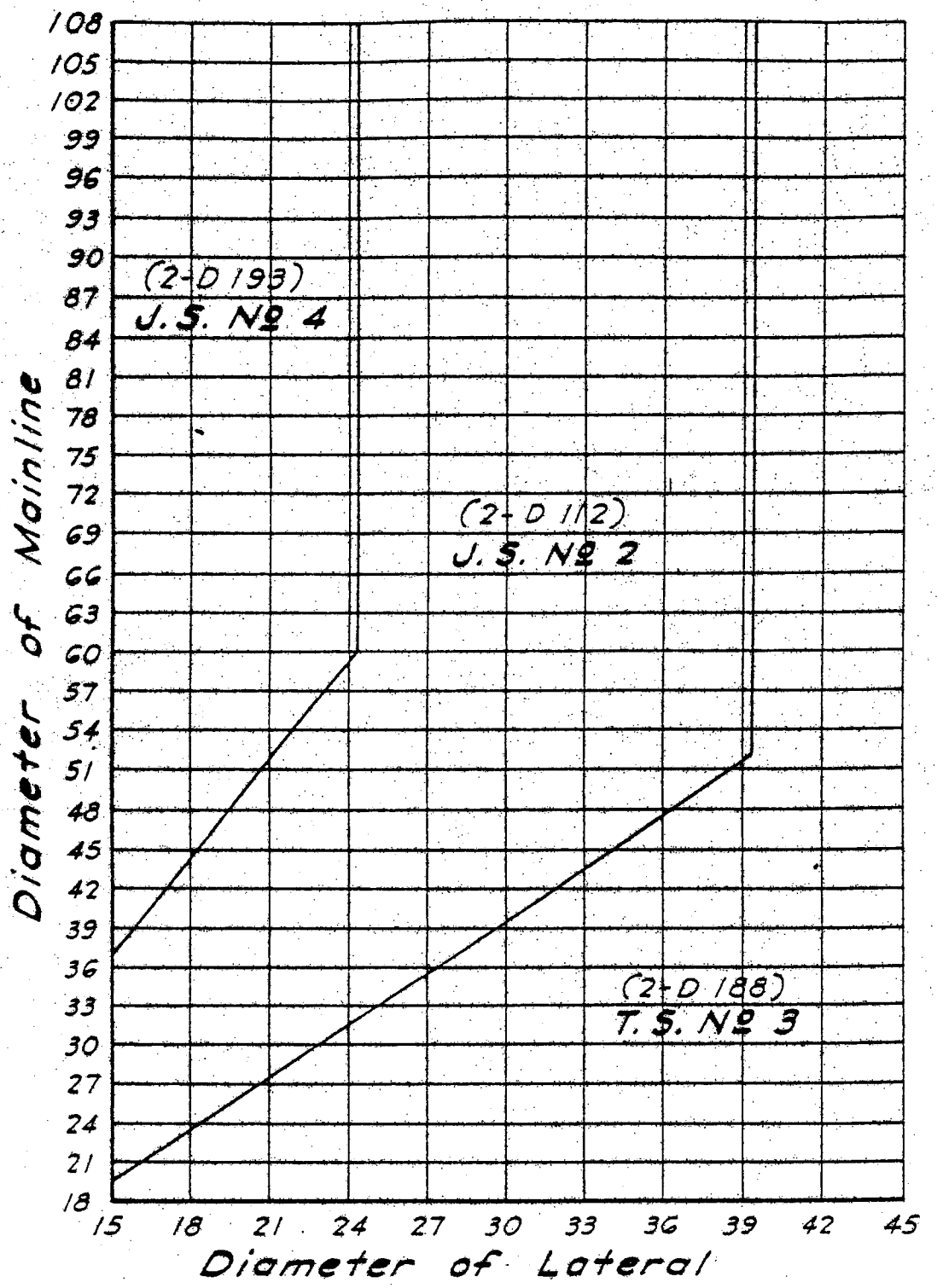


Notes:
1. Length of Standard M.H. shall be increased if:
   a. Lateral openings interfere with M.H. steps.
   b. Hor. angle of divergence or convergence exceeds 5°-45°.
2. M.H. 2 & 4 line based on std. wall thickness.
3. Lateral inlets may enter both sides of M.H. structure.

Los Angeles County Flood Control District

S-104

PIPE TO PIPE JUNCTIONS



Does not apply for: (a) 18" Non-R.C.P. lateral
(b) thickwall R.C.P. lateral

ASBESTOS CEMENT PIPE D-LOADS

R.C. PIPE D-LOAD	A.C. PIPE WALL THICKNESS	A.C. PIPE INSIDE DIAMETER (INCHES)									
		15	18	21	24	27	30	33	36	39	42
800	1.00 inches	5350	5250	5200	5150	5100	5100	5050	5050	5050	5050
	1.25	3700	3650	3600	3600	3550	3550	3550	3500	3500	3500
	1.50	3000	2950	2950	2900	2900	2900	2850	2850	2850	2850
	1.75	2650	2600	2550	2550	2550	2500	2500	2500	2500	2500
	2.00	2400	2350	2350	2300	2300	2300	2300	2250	2250	2250
	2.25	2250	2200	2150	2150	2150	2150	2100	2100	2100	2100
1000	1.00	6550	6550	6500	6450	6400	6350	6350	6300	6300	6250
	1.25	4650	4550	4500	4500	4450	4400	4400	4400	4400	4350
	1.50	3750	3700	3650	3650	3600	3600	3600	3550	3550	3550
	1.75	3200	3250	3200	3150	3150	3150	3100	3100	3100	3100
	2.00	3000	2950	2900	2900	2850	2850	2850	2800	2800	2800
	2.25	2750	2750	2700	2700	2650	2650	2650	2650	2600	2600
1200	1.00	8000	7850	7750	7700	7650	7600	7600	7550	7550	7500
	1.25	5550	5450	5400	5350	5350	5300	5300	5250	5250	5250
	1.50	4500	4450	4400	4350	4300	4300	4300	4250	4250	4250
	1.75	3950	3850	3850	3800	3750	3750	3750	3700	3700	3700
	2.00	3350	3500	3450	3450	3400	3400	3400	3400	3350	3350
	2.25	3300	3250	3250	3200	3200	3150	3150	3150	3150	3150
1400	1.00	9300	9150	9050	9000	8900	8900	8900	8850	8800	8750
	1.25	6450	6350	6300	6250	6200	6150	6150	6150	6100	6100
	1.50	5250	5150	5100	5050	5050	5000	5000	4950	4950	4950
	1.75	4550	4500	4450	4400	4400	4350	4350	4350	4300	4300
	2.00	4150	4100	4050	4000	4000	3950	3950	3950	3900	3900
	2.25	3850	3800	3750	3750	3700	3700	3650	3650	3650	3650
1600	1.00	10600	10450	10350	10250	10200	10150	10100	10050	10000	10000
	1.25	7400	7350	7300	7150	7100	7050	7000	7000	6950	6950
	1.50	6000	5900	5850	5800	5750	5700	5700	5650	5650	5650
	1.75	5200	5150	5100	5050	5000	5000	4950	4950	4950	4900
	2.00	4750	4650	4600	4600	4550	4500	4500	4500	4500	4450
	2.25	4400	4350	4300	4250	4250	4200	4200	4200	4150	4150
1800	1.00	11950	11750	11650	11550	11450	11400	11350	11300	11250	11250
	1.25	8300	8250	8100	8000	7950	7900	7900	7850	7850	7800
	1.50	6750	6650	6550	6500	6450	6450	6400	6350	6350	6350
	1.75	5850	5800	5700	5650	5650	5600	5600	5550	5550	5550
	2.00	5300	5250	5200	5150	5100	5100	5050	5050	5050	5000
	2.25	4950	4900	4800	4800	4750	4750	4700	4700	4700	4650

R.C. PIPE D-LOAD	A.C. PIPE WALL THICKNESS	A.C. PIPE INSIDE DIAMETER (INCHES)									
		15	18	21	24	27	30	33	36	39	42
2000	1.00 inches	13250	13050	12900	12800	12700	12650	12600	12550	12500	12500
	1.25	9200	9100	9050	8980	8850	8800	8750	8750	8700	8700
	1.50	7450	7350	7300	7200	7150	7100	7100	7100	7050	7050
	1.75	6300	6400	6350	6300	6250	6200	6200	6200	6150	6150
	2.00	5900	5800	5750	5700	5650	5650	5600	5600	5600	5550
	2.25	5500	5400	5350	5300	5300	5250	5250	5250	5200	5200
2200	1.00	14600	14350	14250	14100	14000	13900	13850	13800	13750	13750
	1.25	10150	10000	9850	9800	9730	9650	9650	9600	9580	9550
	1.50	8200	8100	8000	7950	7900	7850	7800	7800	7750	7750
	1.75	7150	7050	6950	6900	6850	6850	6800	6800	6750	6750
	2.00	6500	6400	6350	6300	6250	6200	6200	6150	6150	6100
	2.25	6050	5950	5900	5850	5800	5750	5750	5750	5700	5700
2400	1.00	15900	15650	15500	15350	15250	15200	15100	15050	15000	14950
	1.25	11050	10900	10750	10650	10600	10550	10500	10450	10450	10400
	1.50	8950	8800	8700	8650	8600	8550	8500	8500	8450	8450
	1.75	7800	7700	7600	7550	7500	7450	7400	7400	7350	7350
	2.00	7100	6950	6900	6850	6800	6750	6750	6700	6700	6650
	2.25	6600	6500	6400	6350	6300	6300	6250	6250	6200	6200
2600	1.00	17200	17000	16750	16650	16500	16450	16350	16300	16250	16200
	1.25	11950	11800	11650	11550	11500	11400	11350	11350	11300	11250
	1.50	9700	9550	9450	9350	9300	9250	9200	9200	9150	9150
	1.75	8450	8300	8250	8150	8100	8050	8050	8000	8000	7950
	2.00	7650	7550	7450	7400	7350	7300	7300	7250	7250	7200
	2.25	7150	7000	6950	6900	6850	6800	6800	6750	6750	6700
2800	1.00	18550	18250	18050	17900	17800	17700	17600	17550	17500	17450
	1.25	12900	12700	12550	12450	12350	12300	12250	12200	12150	12150
	1.50	10450	10300	10150	10100	10000	9950	9950	9900	9850	9850
	1.75	9100	8950	8850	8800	8750	8700	8650	8650	8600	8550
	2.00	8250	8150	8050	7950	7900	7900	7850	7800	7800	7800
	2.25	7650	7550	7500	7400	7350	7350	7300	7250	7250	7250
3000	1.00	19850	19550	19350	19200	19050	18950	18850	18800	18750	18700
	1.25	13800	13600	13450	13350	13250	13150	13100	13050	13050	13000
	1.50	11200	11000	10900	10800	10750	10700	10650	10600	10550	10550
	1.75	9750	9600	9500	9400	9350	9300	9250	9250	9200	9200
	2.00	8850	8700	8600	8550	8500	8450	8400	8400	8350	8350
	2.25	8200	8100	8000	7950	7900	7850	7800	7800	7750	7750

NOTES:

1. D-loads listed are for Asbestos Cement Pipe where the velocity exceeds 10 feet per second.
2. D-loads for Asbestos Cement Pipe, where the velocity is 10 feet per second or less, shall be 1.5 times the D-load for comparable Reinforced Concrete Pipe. Refer to District Standard Drawing 2-D213.1.

DRAWN BY	REVISIONS		
G.D.M.	MARK	DATE	DESCRIPTION
CHECKED BY			
V.C.M.			
DESIGNED BY			
R.J.S.			
SUBMITTED BY			
C.W.H.			

LOS ANGELES COUNTY
FLOOD CONTROL DISTRICT

"D" LOAD TABLE FOR DESIGN OF ASBESTOS CEMENT PIPE

RECOMMENDED BY: C. Magnuson, DIVISION ENGINEER - DESIGN
APPROVAL RECOMMENDED BY: W. Van U. Rasmussen, ASST. CHIEF DEPUTY ENGINEER
APPROVED BY: Walter J. Wood, CHIEF ENGINEER

SCALE	DATE	DWG. NO.
NONE	10-15-69	2-D431

SHEET 1 OF 1

S-106

Structural Design of
Reinforced Concrete Box Conduits

Computer Program No. 0501

Purpose:

The prupose of Program No. 0501 is to furnish structural details for the construction of reinforced concrete box conduits and/or check structural calculations for these structures.

Scope:

The program is limited at the present time to single and double barrel boxes. The double barrel box may be either symmetrical or unsymmetrical.

The design phase of this program produces complete structural details including final member thicknesses, steel layout, and concrete and steel quantities.

The checking phase of this program calculates stresses at preset sections. The input data for this phase is previously calculated structural details.

The working stress design method is used.

The District's design criteria is set internally. This criteria is as set forth in the District Structural Design Manual. Provisions has been made to override the allowable stress criteria and load specification.

Live load may be zero, truck load or railroad load.

2. Live Loads

   a. Zero

   b. Truck (variable axle load)

   c. Railroad (variable axle load)

C. Loading Cases

1. Vertical and lateral earth, dead, internal water, and live loads are combined to give maximum stresses at critical sections. These are fixed combinations and cannot be modified by user.

2. The various cases are incremented.

3. Eleven locations along each member are analyzed. The loading case used at any point is that case that results in the maximum stress at that point.

D. Thicknesses Are Initialized

Initial thickness for each member is set. The values are based on empirical formula.

E. Fixed End Moments Are Set For The Loading Case Incremented

Fixed end moments are based on center line spans.

F. Moments Are Distributed

A four cycle Hardy Cross distribution is utilized.

G. Moments, Shears, And Thrusts Are Accumulated

Maximum values are retained. Design moment is at face of support.

Input Data:

The basic input data consists of the following:

Code numbers to indicate type of structure, design or check, criteria, type of live load, installation condition.

Depth to finish grade

Axle load

Pressure head

Box dimensions

If optional criteria or the check phase is to be used, additional input is required.

Output Data:

For the design phase the output consists of the following:

Title card

Design criteria

Concrete thicknesses

Steel layout

Quantities

For the check phase, the output consists of resulting shear, bond and flexure stresses at preset critical sections.

Design Criteria:

The basic criteria is set forth internally. This consists of the following:

PARAMETER	DISTRICT CRITERIA	ALTERNATE CRITERIA
Ultimate Concrete Stress	4000 p.s.i.	3000 p.s.i.
Allowable Concrete Snress	1800 p.s.i.	1000 p.s.i.

R.C. BOX DESIGN INPUT INSTRUCTIONS

To use the design criteria (District or Alternate) with values noted above, only two cards are required.

Card No. 1 Tile Card - Starting from card column 5 the spaces may be used in any desired manner to state the title of the job.

Card No. 2 Data Card -

Card column 4; DC = Design Criteria
- Alternate District Criteria DC = 1
- District Criteria DC = 2
- Optional Alternate Critaria DC = 3
- Optional District Criteria DC = 4

Card column 5; NB = Number of Barrels
- Single Box NB = 1
- Double Box NB = 2
- Triple Box NB = 3
- Quadruple Box NB = 4

Card column 6; IC = Installation Condition
- Trench Condition IC = 1
- Positive Projection Condition IC = 2
- Negative Projection Condition IC = 3

Card column 7; LL = Type of Live Load
- No Live Load LL = 1
- Truck Live Load LL = 2 When depth of cover greater than 10', program sets Live Load = 0.
- Railroad Live Load = 3

Card column 8-13
Distance from top of box to Finish Grade (Feet). For double box with unequal heights, code the depth to finish grade of the taller barrel.

Card column 14-19
Distance from top of box to Natural Grade (Feet). For trench conditon Distance to Finish Grade = Distance to Natural Grade. For double box with unequal heights, code the depth to natural grade of the taller barrel.

Card column 20-23
Axle Loads (KIPS)
For Example: H20-S16 Axle Load = 32
E-72 Axle Load = 72

Error No. 3
Check Thickness Data Card Errors:
1. Card columns 1-3 do not contain 014.
Check Bar Data Card Errors:
1. Card columns 1-3 do not contain 015.
2. Bar subscript (card columns 5-6, 27-28, or 49-50) is negative or greater than 27.

Error No. 4
Design Criteria Card Errors:
1. Card columns 1-3 do not contain 016.

Error No. 5
Premature End of File on Card Reader:
1. Design data card missing.
2. Check specified (in cc4 on title card) and thickness and/or bar cards missing or incomplete.
3. Alternate design criteris specified (3 or 4 in cc4 on design data card) and design criteria cards missing or incomplete.
4. The last bar data card did not have 9 in cc4.

Output descriptions

Refer to sample output and standard schematic of box design. At the bottom of output sheet under Input Data and Design Criteria, reading from left to right and top to bottom the values are:

1. Depth to finish grade
2. Depth to natural grade
3. Axle load
4. Hydrostatic pressure head
5. Interior width of box
6. Interior heighth of box
7. Minimum top slab thickness
8. Minimum invert slab thickness
9. Minimum wall thickness
10. Positive steel cover - top slab
11. Positive steel cover - invert slab
12. Positive steel cover - wall

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

STRUCTURAL DESIGN OF REINFORCED CONCRETE BOX
INPUT FORM
PROGRAM NO. FO501P

Job No. _____
Data entered by _____
checked by _____
Sheet ___ of _____
Date ___ Div. ___ Sec. ___
Ext. No. _____

TITLE

SAMPLE PROBLEM FOR DESIGN MANUAL

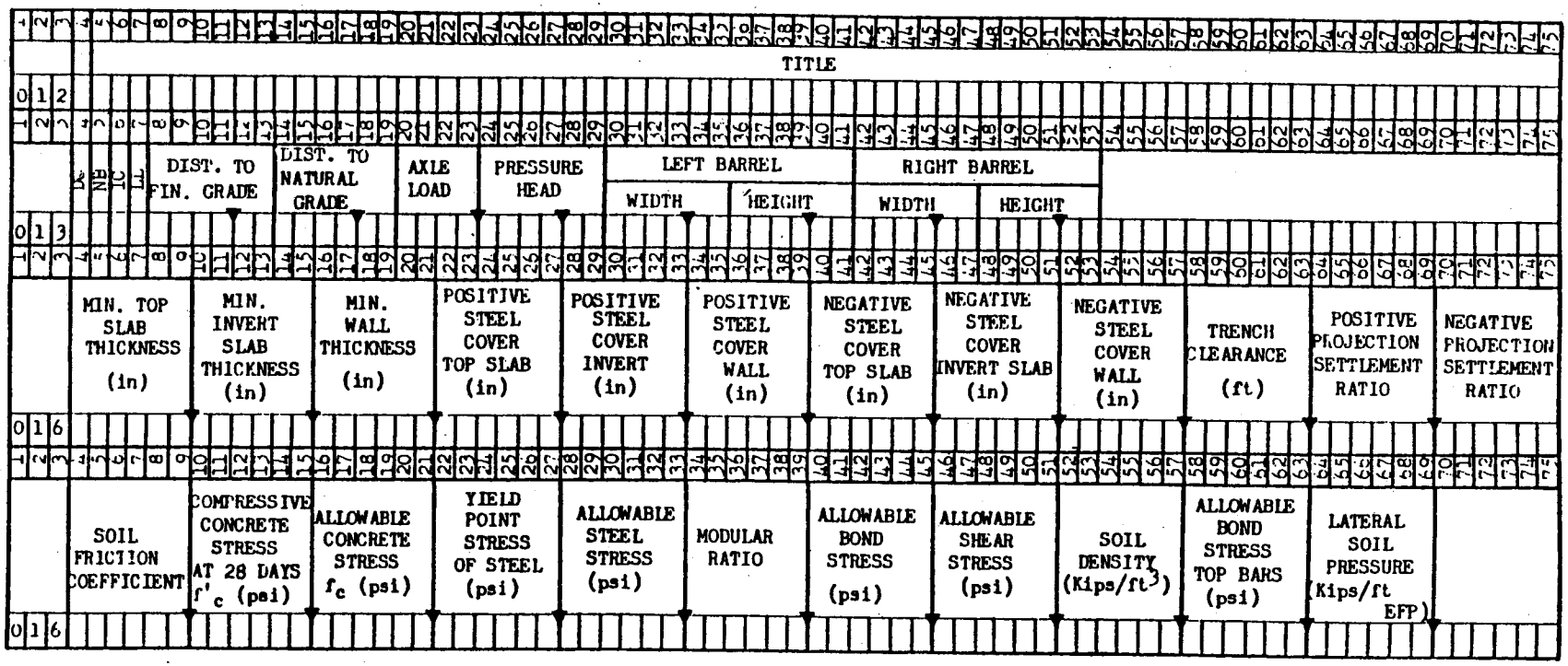
	DC	NB	TC	LL	DIST. TO FINISH GRADE	DIST. TO NATURAL GRADE	AXLE LOAD	PRESSURE HEAD	LEFT BARREL WIDTH	LEFT BARREL HEIGHT	RIGHT BARREL WIDTH	RIGHT BARREL HEIGHT
013	2	1	1	2	0	0	32		10	12		

NOTES: 1. Refer to Program Abstract prior to completing cards.
2. All four cards are required for one R. C. box section.
3. Leave card column 4 of title card blank.

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

STRUCTURAL DESIGN OF REINFORCED CONCRETE BOX
INPUT FORM - OPTIONAL DESIGN CRITERIA
PROGRAM NO. FO501P

Job No. _____
Data entered by _____
checked by _____
Sheet ___ of _____
Date ___ Div. ___ Sec. ___
Ext. No. _____



NOTES: 1. Refer to Program Abstract prior to completing cards.
2. All four cards are required for one R. C. box section.
3. Leave card column 4 of title card blank.

SAMPLE PROBLEM
DESIGN OUTPUT

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

DESIGN DIVISION
DESIGN OF SINGLE BARREL REINFORCED CONCRETE BOX
BARREL # 1

SAMPLE PROBLEM FOR DESIGN MANUAL

10.00 WIDE BY 12.00 HIGH
TYPE INSTALLATION TRENCH
PROJECTION RATIO 0.0
LIVE LOAD TRUCK
TOTAL DESIGN VERTICAL LOAD TOP 13.23 KIPS INVERT 14.50 KIPS
PRESSURE HEAD 0.0 FT
DESIGN STRESSES FC = 1800. PSI FS = 24000. PSI

DESIGN COVER 8.0 FT
SOIL DENSITY .110 KCF
AXLE LOAD 32.0 KIPS

THICKNESSES (IN) TOP 8.75 INV(C.L.) 9.75 LW 8.00 RW 8.00

STEEL LAYOUT

BAR DESIGNATION	BAR SIZE	BAR SPACING (IN)	HORIZONTAL LENGTH (FT)(IN)	VERTICAL LENGTH (FT)(IN)
B	7.	10.0	11. 1.0	0. 0.0
B1	4.	10.0	5. 11.5	0. 0.0
C	4.	11.0	4. 2.5	12. 2.0
C1	6.	11.0	2. 0.5	2. 10.0
C2	4.	11.0	4. 2.5	2. 3.0
C3	6.	11.0	2. 8.5	2. 5.0
D	5.	11.0	0. 0.0	13. 3.5
F	9.	14.0	11. 1.0	0. 0.0
F1	5.	14.0	6. 2.5	0. 0.0
G	4.	11.0	5. 0.0	0. 0.0
H	4.	11.0	5. 0.0	0. 0.0

LONGITUDINAL BARS 66. NO. 4 BARS
IN TOP SLAB 17. IN INVERT SLAB 17. IN WALLS 32.

QUANTITIES
CONCRETE 1.26 CU. YDS./FT. REINFORCING STEEL 217.2 LBS./FT.

INPUT DATA & DESIGN CRITERIA:

8.00000	8.00000	32.00000	0.0	10.00000
12.00000	6.50000	7.00000	8.00000	2.00000
2.50000	2.00000	2.00000	2.50000	2.00000
3.00000	0.70000	-0.50000	0.15000	4000.00000
1800.00000	60000.00000	24000.00000	8.00000	500.00000
70.00000	0.11000	350.00000	0.03700	

SAMPLE PROBLEM
CHECK OUTPUT

SAMPLE PROBLEM FOR DESIGN MANUAL

CASE NUMBER 1

	RESULTANT STRESSES (P.S.I.)			
	CONCRETE	RE-STEEL	UNIT SHEAR	BOND
TOP SLAB				
CORNER	680.	12196.	68.0	235.0
MIDSPAN	1594.	23635.		
WALL				
TOP	775.	12959.	17.9	61.5
CENTERLINE	0.	0.		
BOTTOM	622.	10400.	11.8	38.4
INVERT SLAB				
CORNER	463.	8662.	68.8	238.9
MIDSPAN	1642.	23176.		

NOTE:

SIMILAR SHEET IS PRODUCED FOR EACH LOADING CASE.