11. Loading Analysis of Existing Pipelines.

a. General.

1) The intent of the following guidelines is to establish criteria and procedures to evaluate the impact of changing the grade or loading conditions over the existing water and sewer pipelines. Use these guidelines in conjunction with Part Three, Section 12 (Related Design and Analysis).

2) Submit the documentation along with your analysis to support the parameters and assumptions used such as, as-built plans, Specifications, special provisions to the Specifications, Standard Details, ASTM standards, evidence of existing and proposed soil cover, test pit data, etc.

3) During the analysis of the existing pipeline, request the WSSC research the break/leak history of the existing pipeline. Compare the cost of replacing the existing pipeline within the impact area verses repair/restoration after the impact of changing the grade or loading conditions.

b. Abbreviations.

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
ASA	American Standards Association
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
SAMM	Spangle and Marston Method
USAS	USA Standards

c. Ductile Iron Pipe (DIP) Water Pipelines.

1) DIP is considered a flexible pipe, therefore, the method of thickness design is based on flexible pipe principles. The required thickness of DIP is determined by considering internal pressure and trench load separately, both of which are applicable to water mains. Evaluate the proposed change in loading conditions or soil cover by calculating the required pipe thickness class using ANSI A21.50/AWWA C150. Compare the required thickness for the proposed conditions, with the actual pipe class provided.

2) In order to evaluate existing DIP for a change in loading conditions, the following information is needed to calculate the required pipe thickness class using ANSI A21.50/AWWA C150:

a) Pipe soil cover. Determine pipe soil cover from the proposed design and the existing pipe invert from the as-built plans. If there is evidence that the pipe may be at an elevation significantly different than that shown on the as-builts or if the proposed depth of cover is within one (1) foot of the maximum or minimum allowable, then perform test pit(s) to determine the actual elevation of the pipe.

b) Pipe working and surge pressures, see Part One, Section 5 (Total Internal and Transient Pressures).

c) Standard pipe laying condition. Determine the standard pipe laying condition according to ANSI A21.50/AWWA C150 under which the original pipe was installed. Information on bedding and backfill for the pipe may be found in the Specifications and Standard Details in effect at the time of the pipe installation to determine the laying condition used. If the actual laying condition for the pipe in question cannot be determined by researching the contract documents, then for analysis assume Type 1, flat bottom trench with loose backfill.

d) Class of pipe. Type and class of DIP is typically indicated on the drawings. If the pipe class is not indicated on the as-built drawings, it may be found by researching the available contract documents and correspondence contained on microfilm or original construction files, which are available through the WSSC. If the actual class cannot be determined from the available contract documents, assume the weakest class for analysis.

d. Cast Iron Pipe (CIP) Water Pipelines.

1) CIP is considered a rigid pipe. The required thickness of cast iron pipe is determined by considering internal pressure and trench load in combination, both of which apply to water mains. Improvements in manufacturing techniques and the development of higher strengths of iron have resulted in having two types of CIP with different iron strengths, which include pit cast and centrifugally cast pipe in the WSSC system. The method of evaluating the required thickness class of both types and iron strengths is the same using ASA/USAS A21.1, (AWWA H1).

2) CIP analysis considerations. Some of the existing CIP water mains in the WSSC system may be older than 75 years. When evaluating existing CIP for additional loading, consider the age and probable condition of the pipe. It is preferable that additional loading be avoided on old existing CIP because the condition of the pipe is usually not known. The WSSC has repair history records of the pipes in the system which has had leaks or breaks. This information should be used to determine the serviceability of the existing pipe. Prior to changing the loading conditions over old CIP, make a judgment and recommendation to WSSC as to the serviceability and apparent condition of the pipe.

3) To evaluate existing CIP for a change in soil cover or loading conditions according to ASA/USAS A21.1 (AWWA H1), the following information is needed:

a) Soil pipe cover. Determine pipe soil cover from the proposed design and the existing pipe invert from the as-built plans. If there is evidence that the pipe may be at an elevation significantly different than that shown on the as-builts or if the proposed depth of cover is within one (1) foot of the maximum or minimum allowable, then perform test pit(s) to determine the actual elevation of the pipe.

b) Working and surge pressures, see Part One, Section 5 (Total Internal and Transient Pressures).

c) Standard pipe laying condition. Determine the standard pipe laying condition according to ASA/USAS A 21.1, also called "Field Condition" in the 1939 and 1957 version of A21.1. The majority of cast iron pipes in the WSSC system were laid using a Type "A" condition, which is a flat bottom trench with untamped backfill. If it can be conclusively determined that other than a Type "A" condition was used, from either researching the contract documents and applicable Standard Details and Specifications, or test pit (i.e. presence and extent of granular bedding), then use the actual laying condition in the analysis.

d) Type of pipe and thickness class. The following guidelines are for information only and intended to aid in determining the class/type of pipe used. However, they are general guidelines only and the necessary research is to be performed to determine the actual type/class of existing pipe.

(1) Improvements in manufacturing and cast iron strengths resulted in having two types of CIP with differing iron strengths in WSSC system. The two types are pit cast, used primarily prior to 1954 and centrifugally cast used after 1954. For contracts newer than 1968, the class of pipe is typically noted on the as-built plans. For contracts between 1954 and 1968, typically centrifugally cast, class 150 CIP was used according to the 1954 Specifications, unless indicated otherwise on the plans or in the specifications. For contracts prior to 1954, the class of pipe typically is not included on the as-builts and specifications may not be available.

(2) In general, if the pipe class is not indicated on the as-built drawings, it may be found by researching the available contract documents and correspondence contained on microfilm or original construction files, which are available through the WSSC. If the type of pipe class cannot be conclusively determined through researching the contract documents, then for analysis use the weakest class/type of pipe available during the time period when the pipe was manufactured.

e) Earth and live loads.

(1) Compute the earth load using the Marston method of design for determining loads on rigid conduits, see ANSI A21.1 -1972 or the Concrete Pipe Handbook (1988) for the design method. In addition, the "SAMM" computer program (September 1990), distributed by American Concrete Pipe Association, can also be used for this purpose. In cases where a proposed surcharge fill is being added over an existing pipe which was originally installed under a ditch (trench) condition, the negative projection embankment condition shall be considered to evaluate the earth load on the rigid pipe due to the proposed fill. Determine the earth load using the following parameters:

(a) Unit weight of soil (γ).
Assume γ = 120 lb/ft^3, unless actual soil samples are taken to prove otherwise

(b) Trench width at top of pipe.

[1] For pipes smaller than 16-inch in diameter, use 30-inch or the trench width found in the applicable Standard Detail or Specification, whichever is greater.

[2] For 14-inch diameter pipe, use the trench width for a 15-inch pipe indicated in the applicable Standard Detail. If evidence of a wider trench width exists, then use the actual condition.

[3] For pipes 16-inch and larger in diameter, earth loads shall be calculated assuming original installation was in a transition width trench.

(c) Assume soil type as ordinary clay, unless actual soil samples are taken to prove otherwise.

(2) Evaluate truck and superimposed live loads on rigid pipe, using the method presented in the Concrete Pipe Design Manual, 1992 and/or the Concrete Pipe Handbook, 1988 both by the American Concrete Pipe Association which is based on Holl's integration of Boussineq's equations. In addition, the "SAMM" computer program (September 1990), distributed by American Concrete Pipe Association, can also be used for this purpose. The maximum highway wheel load used for analysis is the maximum of those specified by AASHTO in "Standard Specification for Highway Bridges" for H20 and HS20 plus impact for a single dual wheel, two (2) passing HS20 trucks and alternate loads in the passing mode. When the

depth, of cover over the pipe exceeds nine (9) feet, the live load can be neglected.

e. Prestressed Concrete Cylinder Pipe (PCCP) Water Pipelines.

1) Prestressed Concrete Cylinder Pipe (PCCP) is a rigid concrete pipe reinforced with high tension prestressing wire. The design of the pipe is site specific, i.e., the pipe is custom designed for the specific site conditions where it will be used. Therefore, the pipe specifications and pipe classes for each contract are typically unique and only apply to that contract.

The supporting strength of PCCP, like that of cast iron pipe, is determined by considering simultaneous combined loading of internal pressure and external load. The operating point (working pressure vs. earth load) of the pipe must fall within the bounds of the parabolic design curve for the pipe. The transient point (working pressure plus surge pressure vs. earth load plus live load) must fall within the bounds of a separate transient curve or first-crack curve.

2) Analysis. To determine the adequacy of PCCP under various loading conditions, first plot the design curve using information from the PCCP manufacturer's specification. The general design procedure is presented in Appendix A of AWWA C301, which defines the design curve, by the following equation:

$$w = W_0 \times (P_0)^{-1/3} \times (P_0 - p)^{1/3}$$

Where:

P_0 = the internal pressure required to overcome all compression in the core concrete

W_0 = nine tenths (0.9) of the 3-edge bearing load producing incipient cracking in the core with no internal pressure

p = maximum design pressure in combination with 3-edge bearing load, w, equivalent to the maximum earth load divided by the bedding factor

w = maximum 3-edge bearing load, equivalent to load, in combination with design pressure p

a) W_0 is computed based upon the equation below. The information that is needed to solve this equation comes from the pipe manufacturer's specification/data sheets for each project and from the manufacturer's catalogue. The specification/data sheets can generally be found by researching the available contract documents and correspondence contained on microfilm or original construction files, which are available from WSSC.

$$W_0 = 0.9 \times W_{0.001}$$

$$W_{0.001} = \left(\left((17.94 \times T_w^2) \div D_m\right) \times (f_{cr} + 600)\right) - (0.91 \times W_t)$$

Where:

T_w = wall thickness of pipe, inches

W_t = weight of pipe, pounds per linear foot

D_m = mean pipe diameter

= ID + T_w, inches

f_{cr} = resultant compression in concrete, psi

b) For embedded-cylinder (SP-12) pipe, P_0 is plotted as the x-intercept and W_0 is plotted as the y-intercept).

c) For lined-cylinder (SP-5) pipe, 0.8 x P_0 is plotted as the x-intercept.

d) Once the design curve is plotted, plot the operating point of the section of pipe under consideration. The abscissa of the operating point consists of the internal operating pressure of the pipe at the elevation of the pipe under analysis and the ordinate consists of the amount of proposed earth load over the pipe. The amount of earth load should reflect the increase or decrease in fill over the pipe, depending on the proposed grading. The proposed earth load should reflect the same assumptions made for large diameter sewer pipe. If the operating point falls within or on the W_0 P_0 parabolic curve, then the pipe with revised grading is adequate for operating conditions.

e) Next, the transient and first-crack curves must be plotted. For the pipe to be adequate for transient conditions, the transient point must fall within these curves. The transient curve is also a parabolic curve, but with y-intercept equal to ($1.2 \times W_0$) and x-intercept equal to ($1.1 \times P_0$). The first-crack curve, likewise, is a parabolic curve with y-intercept at $W_{0.001}$ and the x-intercept at $[P_0 \times (f_{cr} + 300) \div f_{cr}]$, where f_{cr} is the resultant concrete core stress which is given in the PCCP manufacturer's specification/data sheet.

f) The plotting and graphing numbers on the abscissa are generally expressed as a fraction of P_0 and the numbers on the ordinate are usually expressed as fractions of W_0 (earth and live loads are divided by the bedding factor and then expressed as a fraction of W_0).

3) Information required for analysis.

a) Determine pipe soil cover from the proposed design and the existing pipe invert from the as-built plans. If there is evidence that the pipe may be at an elevation significantly different than that shown on the as-builts or if the proposed depth of cover is within one (1) foot of the maximum or minimum allowable, then perform test pit(s) to determine the actual elevation of the pipe.

b) <u>Working and surge pressures</u>, see Part One, Section 5 (Total Internal and Transient Pressures).

c) <u>Pipe specifications and class of pipe</u>.

d) <u>Earth and live loads</u>.

(1) Compute the earth load using the Marston method of design for determining loads on rigid conduits, see ANSI A21.1-1972 or the Concrete Pipe Handbook (1988) for the design method. In addition, the “SAMM” computer program (September 1990), distributed by American Concrete Pipe Association, can also be used for this purpose. In cases where a proposed surcharge fill is being added over an existing pipe which was originally installed under a ditch (trench) condition, consider the negative projection embankment condition, to evaluate the earth load on the rigid pipe due to the proposed fill. Determine the earth load using the following parameters:

(a) Unit weight of soil (γ).
Assume $\gamma = 120 \text{ lb/ft}^3$, unless actual soil samples are taken to prove otherwise

(b) Trench width at top of pipe. When calculating earth loads on PCCP, assume a <u>transition width</u> trench.

(c) Assume soil type as ordinary clay, unless actual soil samples are taken to prove otherwise.

(2) Evaluate truck and superimposed live loads on rigid pipe, using the method presented in the Concrete Pipe Design Manual, 1992 and/or the Concrete Pipe Handbook, 1988 both by the American Concrete Pipe Association which is based on Holl's integration of Boussineq's equations. In addition, the “SAMM” computer program (September 1990), distributed by American Concrete Pipe Association, can also be used for this purpose. The maximum highway wheel load used for analysis is the maximum of those specified by AASHTO in "Standard Specification for Highway Bridges" for H20 and HS20 plus impact for a single dual wheel, two (2) passing HS20 trucks and alternate loads in the passing mode. When the depth of cover over the pipe exceeds nine (9) feet, the live load can be neglected.

e) Standard pipe laying condition.

(1) To determine the actual pipe laying condition and Bedding Factor (B_f), see Figure "C" in this section. Information on bedding and backfill for the pipe may be found in the Specifications and Standard Details in effect at the time of the pipe installation to determine the laying condition used.

(2) If the actual laying condition cannot be determined from researching the available contract documents and correspondence contained on microfilm or orginal construction files, which are available through WSSC or applicable Specifications and Standard Details or by test pit (i.e. presence and extent of any granular bedding), then use class D, flat subgrade with loose backfill, $B_f = 1.1$ for analysis.

f. Asbestos Cement Pipe (ACP) Water Pipelines.

1) ACP was used for water mains on a very limited basis when indicated in the special provisions according to the 1968 WSSC Specifications. Small diameter (4-inch through 16-inch) water pipe was produced according to ANSI/AWWA C400. The supporting strength of existing ACP water pipelines shall be determined using ANSI/AWWA C401, AWWA Standard Practice for the Selection of Asbestos-Cement Distribution Pipe 4-inch through 16-inch for Water and Other Liquids.

g. Polyvinyl Chloride (PVC) Pipe Sewer Pipelines.

1) PVC pipe is a flexible pipe, which interacts with the surrounding soil to create a pipe-soil system which act together to support the over burden loading. The deflection of the PVC pipe at the springline transfers a portion of the load to the surrounding soil. PVC pipe interacts with the surrounding soil to support the load, bedding/backfill properties are very important.

2) The maximum allowable soil cover over existing PVC gravity sewers is twenty-two (22) feet in accordance with Standard Detail M/8.2. Installation of the existing PVC gravity sewers, is to be in accordance with Standard Detail M/8.2 and the Specifications. The minimum allowable cover over gravity sewers in general is three (3) feet.

h. Ductile Iron Pipe (DIP) Sewer Pipelines.

1) DIP is considered a flexible pipe, therefore, the method of thickness design is based on flexible pipe principles. The required thickness is determined by considering internal pressure and trench load separately. For DIP gravity sewers, there is no internal pressure, only trench load. Evaluate the proposed change in soil cover by calculating the required thickness class using ANSI A21.50/AWWA C150. Compare the required thickness for the proposed conditions with the actual pipe class provided. The minimum allowable cover for gravity sewers in general is three

(3) feet. The maximum deflection of cement lined DIP gravity sewers, not exceed to three (3%) percent.

2) Information required to evaluate existing DIP sewers is the same as DIP water mains, except working and surge pressure are not required. See requirements in Ductile Iron Pipe (DIP) Water Pipelines, in this section.

i. Vitrified Clay Pipe Extra Strength (VCPX), Concrete Sewer Pipe Extra Strength (CSPX), and Asbestos Cement Pipe (ACP) Sewer Pipelines.

1) VCPX, CSPX and ACP are non-reinforced rigid pipes. The supporting strengths are specified in the ASTM standards in terms of the minimum ultimate strength (crushing strength) by the standard Three Edge Bearing (TEB) laboratory test. To compute the required three edge bearing strength of these non-reinforced pipes under a certain loading condition, use the following equation:

Required TEB Strength $= [(W_l + W_e) \times FS] \div B_f$

Where:

TEB = Three Edge Bearing crushing load for the pipe in lbs/ft
W_e = earth load on the pipe in lbs/ft
W_l = live load on the pipe in lbs/ft
B_f = bedding factor, the ratio between the actual supporting strength of the buried field installed pipe to the strength of the pipe determined in the TEB laboratory test
FS = factor of safety, WSSC standard is 1.5

2) The information required to evaluate VCPX, CSPX and ACP sewer pipe is as follows:

a) Pipe soil cover. Determine pipe soil cover from the proposed design and the existing pipe invert from the as-built plans. If there is evidence that the pipe may be at an elevation significantly different than that shown on the as-builts or if the proposed depth of cover is within one (1) foot of the maximum or minimum allowable, then perform test pit(s) to determine the actual elevation of the pipe.

b) Three edge bearing strengths.

(1) ANSI/ASTM standards. The minimum three edge bearing strengths shall be obtained from the ANSI/ASTM standards under which the particular pipe was manufactured. ANSI/ASTM standards are periodically revised and updated, therefore the pipe strengths must be obtained from the applicable specification at the time the pipe was manufactured. If uncertain if the specification is applicable or if it is not available, then obtain the standards for several years before and after the pipe was installed. If the minimum TEB strength of the pipe remained unchanged, then it may be used for analysis.

(2) The applicable pipe specifications (for information only) are as follows, unless otherwise indicated or modified by the applicable Specifications or special provisions for the contract in question:

VCPX - ASTM C200, Extra Strength Clay Pipe, replaced in 1973 by ASTM C700, Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.

CSPX - ASTM C14, Concrete Sewer, Storm Drain, and Culvert Pipe.

ACP - ASTM C428, Asbestos-Cement Non-Pressure Pipe and ASTM C644, Asbestos-Cement Non-Pressure Small Diameter Sewer Pipe

(3) Standard pipe laying condition.

(a) To determine the actual pipe laying condition and Bedding Factor (B_f), see Figure "C" in this section. Information on bedding and backfill for the pipe may be found in the Specifications and Standard Details in effect at the time of the pipe installation to determine the laying condition used.

(b) If the actual laying condition cannot be determined from researching the available contract documents and correspondence contained on microfilm or orginal construction files, which are available through WSSC or applicable Specifications and Standard Details or by test pit (i.e. presence and extent of any granular bedding), then use class D, flat subgrade with loose backfill, $B_f = 1.1$ for analysis.

(4) Type of pipe.

(a) The type of pipe used is typically indicated on the as-built drawings in either the General Notes or on the as-built plans under "As-Built Data". If not indicated on the as-builts, it may be found by researching the available contract documents and correspondence contained on microfilm or orginal construction files, which are available through the WSSC.

(b) If the type of pipe cannot be determined by researching the contract documents, then it may be possible to determine the type of pipe by going into a manhole or doing a test pit on the run of pipe in question; by visual inspection and verification of type/class by measuring the pipe wall thickness, outside diameter and/or inside diameter and comparing findings to pipe specifications.

(c) Existing sewers 24-inch and larger, are typically Reinforced Concrete Pipe (RCP), although some large diameter ACP and VCPX sewers exist in the system.

(d) If an option of several different pipe types is given on contract drawings and there is no indication on the as-builts which was used i.e., in the "As-Built Data", and all other means of determining the type of pipe have proven unsuccessful, then base the analysis upon the weakest pipe.

(5) Earth and truck loads.

(a) Compute the earth loads using the Marston method of design for determining loads on rigid conduits, see ANSI A21.1-1972 or the Concrete Pipe Handbook (1988) for the design method. In addition, the "SAMM" computer program (September 1990), distributed by American Concrete Pipe Association, can also be used for this purpose. In cases where a proposed surcharge fill is being added over an existing pipe which was originally installed under a ditch (trench) condition, consider the negative projection embankment condition, to evaluate the earth load on the rigid pipe due to the proposed fill. Determine the earth load on the following parameters:

[1] Unit weight of soil (γ).
Assume γ = 120 lb/ft^3, unless actual soil samples are taken to prove otherwise

[2] Trench width at top of pipe.

[a] For pipes smaller than 16-inch in diameter, use 30-inch or the trench width found in the applicable Standard Detail or Specification used for construction, whichever is greater.

[b] For 14-inch diameter pipe, use the trench width for a 15-inch pipe indicated in the applicable Standard Detail used for the construction. If evidence of a wider trench width exists, then use wider width.

[c] For pipes 16-inch and larger, calculate earth loads assuming original installation was in a transition width trench.

[3] Assume soil type, ordinary clay, unless actual soil samples are taken to prove otherwise.

(b) Evaluate truck and superimposed live loads on rigid pipe, using the method presented in the Concrete Pipe Design Manual, 1992 and/or the Concrete Pipe Handbook, 1988 both by the American Concrete Pipe Association which is based on Holl's integration of Boussineq's equations. In addition, the “SAMM” computer program (September 1990), distributed by American Concrete Pipe Association, can also be used for this purpose. The maximum highway wheel loads used for analysis is the as the maximum of those specified by AASHTO in "Standard Specification for Highway Bridges" for H20 and HS20 plus impact for a single dual wheel, two (2) passing HS20 trucks and alternate loads in the passing mode. When the depth of cover over the pipe exceeds nine (9) feet, the live load can be neglected.

j. Reinforced Concrete Pipe (RCP), Reinforced Concrete Sewer Pipe (RCSP), Reinforced Concrete Culvert Pipe Standard Strength (RCCP), Reinforced Concrete Culvert Pipe Extra Strength (RCCPX) Sewer Pipelines.

1) RCP, RCSP, RCCP, and RCCPX are rigid steel reinforced concrete pipes. The strengths for reinforced concrete pipes are specified in the ASTM standards in terms of the ultimate strength (crushing strength) and/or the 0.01 inch crack strength as determined by the Three Edge Bearing (TEB) laboratory test. The 0.01 inch crack strength is the maximum TEB test load supported by a concrete pipe before a crack occurs having a width of 0.01 inch measured at close intervals, throughout a length of at least one foot.

Use the 0.01 inch crack strength criteria, when evaluating existing reinforced concrete pipes for a change in loading conditions, not the ultimate or crushing strength.

2) RCP strengths to produce a 0.01 inch crack are specified in ASTM standard in one of two ways:

a) Three edge bearing strength. The specific load in lb/ft required to produce a 0.01 crack for each individual pipe diameter and class by the TEB test; designated this way in the earlier versions of the ASTM standards. Use the following equation to evaluate the supporting strength of reinforced concrete pipe when specified as above:

TEB to produce 0.01 inch crack $= [(W_l + W_e) \times FS] \div B_f$

b) D-load strength. Because reinforced concrete pipe was later available in numerous sizes and classes, the pipe strengths were classified by the "D-load" concept in the newer versions of the ASTM standards. The D-load concept provides strength classifications independent of pipe diameter. For reinforced circular pipe the TEB test load in lb/ft to produce the 0.01 inch crack equals the D-load, designated as $D_{0.01}$, as indicated in the ASTM standards, multiplied by the nominal inside pipe diameter.

Example of D-load Strength:

ASTM C 76, Class IV RCP is manufactured to a D-load of 2000 lb/ft/ft of diameter, with the D-load designated as 2000D, to produce the 0.01 inch crack and 3000 lb/ft/ft of diameter (3000D) to produce the ultimate or crushing load. Therefore, a 48 inch diameter Class IV RCP (ASTM C 76) would have a minimum laboratory strength of (2000 lb/ft/ft × 4ft) or 8000 lb/ft to produce the 0.01 inch crack and (3000 lb/ft/ft × 4ft) or 12,000 lb/ft at the ultimate or crushing strength.

Use the following equation, when evaluating the strength of reinforced concrete pipes expressed as D-loads:

$$D_{0.01} = [(\text{Field Load}) \times (\text{Safety Factor})] \div [(\text{Bedding Factor}) \times (\text{Nominal Diameter})]$$

$$D_{0.01} = [(W_l + W_e) \times FS] \div [(B_f \times D)]$$

Where:

$D_{0.01}$ = D-load to produce 0.01 inch crack in lb/ft
W_l = live load on pipe in lb/ft
W_e = earth load on pipe in lb/ft
B_f = bedding factor
FS = factor of safety, WSSC standard is 1.0 for reinforced concrete pipe when the 0.01 inch crack strength is used as the strength criteria.
D = nominal inside diameter of circular pipe

3) Information required for analysis.

a) Determine pipe soil cover from the proposed design and the existing pipe invert from the as-built plans. If there is evidence that the pipe may be at an elevation significantly different than that shown on the as-builts or if the proposed depth of cover is within one (1) foot of the maximum or minimum allowable, then perform test pit(s) to determine the actual elevation of the pipe.

b) Pipe strength to produce 0.01 inch crack by the TEB method:

(1) ASTM/ANSI standards. The minimum pipe strength to produce a 0.01 inch crack shall be obtained from the applicable ASTM/ANSI standards for the pipe. Use the ASTM/ANSI standard that was in effect at the time the original pipe was manufactured.

(2) The applicable pipe specifications (for information only) are as follows, unless otherwise indicated or modified by the applicable Specifications or special provisions for the contract in question:

RCP, RCCP and RCCPX - ASTM C76 Reinforced Concrete Culvert, Storm Drain and Sewer Pipe.
RCSP - ASTM C 75 Reinforced Concrete Sewer Pipe.

(3) Pipe laying condition.

(a) To determine the actual pipe laying condition and Bedding Factor (B_f), see Figure "C", herein. Information on bedding and backfill for the pipe may be found in the Specifications and Standard Details in effect at the time of the pipe installation to determine the laying condition used.

(b) If the actual laying condition cannot be determined from researching the available contract documents and correspondence contained on microfilm or orginal construction files, which are available through the WSSC or applicable Specifications and Standard Details or by test pit (i.e. presence and extent of any granular bedding), then use B_f = 1.1 for analysis (class D, flat subgrade with loose backfill).

(4) Type and class of pipe.

(a) The type of pipe used is typically indicated on the as-built drawings in either the General Notes or on the as-built plans under "As-Built Data". If not indicated on the as-builts, it may be found by researching the available contract documents and correspondence contained on microfilm or original construction files, which are available through WSSC.

(b) If the type of pipe cannot be determined by researching the contract documents, then it may be possible to determine the type of pipe by going into a manhole or doing a test pit on the run of pipe in question; by visual inspection and verification of type/class by measuring the pipe wall thickness, outside diameter and/or inside diameter and comparing findings to pipe specifications.

(c) If an option of several different pipe types is given on contract drawings and there is no indication on the as-builts which was used i.e., in the "As-Built Data", and all other means of determining the type of pipe have proven unsuccessful, then base the analysis upon the weakest pipe.

(5) Earth and truck load.

(a) Compute the earth loads using the Marston method of design for determining loads on rigid conduits, see ANSI A21.1-1972 or the Concrete Pipe Handbook (1988) for the design method. In addition, the “SAMM” computer program (September 1990), distributed by American Concrete Pipe Association, can also be used for this purpose. In cases where a proposed surcharge fill is being added over an existing pipe which was originally installed under a ditch (trench) condition, consider the negative projection embankment condition to evaluate the earth load on the rigid pipe due to the proposed fill. Determine the earth load on the following parameters:

[1] Unit weight of soil (γ).
Assume γ = 120 lb/ft^3 unless actual soil samples are taken to prove otherwise

[2] Trench width at top of pipe.

[a] For pipes smaller than 16-inch in diameter, use 30-inch or the trench width found in the applicable Standard Detail or Specification used for construction, whichever is greater.

[b] For 14-inch diameter pipe, use the trench width for a 15-inch pipe indicated in the applicable Standard Detail used for the construction. If evidence of a wider trench width exists, then use the wider trench.

[c] For pipes 16-inch and larger, calculate earth loads assuming original installation was in a transition width trench.

[3] Assume soil type, ordinary clay, unless actual soil samples are taken to prove otherwise.

(b) Evaluate truck and superimposed live loads on rigid pipe, using the method presented in the Concrete Pipe Design Manual, 1992 and/or the Concrete Pipe Handbook, 1988 both by the American Concrete Pipe Association which is based on Holl's integration of Boussineq's equations. In addition, the "SAMM" computer program (September 1990), distributed by American Concrete Pipe Association, can also be used for this purpose. The maximum highway wheel load used for analysis is the as the maximum of those specified by AASHTO in "Standard Specification for Highway Bridges" for H20 and HS20 plus impact for a single dual wheel, two (2) passing HS20 trucks and alternate loads in the passing mode. When the depth of cover over the pipe exceeds nine (9) feet, the live load can be neglected.

k. Ductile Iron Pipe (DIP) Force Mains.

1) DIP used for sewage force mains is evaluated similar to DIP water pipelines. The required thickness of DIP is determined by considering internal pressure and trench load separately, both of which are applicable to force mains. Evaluate the proposed change in grade by calculating the required pipe thickness class using ANSI A21.50 (AWWA C150). Compare the required thickness for the proposed condition with the actual pipe class existing.

2) Information required for analysis. To evaluate an existing DIP force main for a change in loading conditions the information required using A21.50 is the same as for DIP water pipelines, except that the working and surge pressures are obtained from contract drawings and/or contract specifications.

l. Cast Iron Pipe (CIP) Force Mains.

1) CIP used for sewage force mains is evaluated similar to CIP water pipelines. The required thickness of CIP is determined by considering internal pressure and trench load combined, both of which are applicable to force mains. Evaluate the proposed change in load by calculating the required pipe thickness class using ASA/USAS A21.1, (AWWA H1). Compare the required thickness for the proposed condition with the actual pipe class existing.

2) Information required for analysis. To evaluate an existing CIP force main for a change in loading conditions the information required using ASA/USAS A21.1 is the same as for CIP water pipelines, except that the working and surge pressure are obtained from contract drawings and/or contract specifications.

m. Polyvinyl Chloride (PVC) Small Diameter Pressure Sewers.

1) Small diameter PVC pressure sewer pipe in accordance with the Specifications, sizes 1 1/4-inch to 4-inch, are used on a limited basis for mainline pressure sewers and pressure sewer house connections as part of a grinder pump sewer system. Due to the limited use of PVC pressure sewer pipe, a detailed method of evaluating the pipe for additional earth loading is not presented

is this manual. In general, the method used shall be based upon the Modified Iowa Formula presented in the third edition of the Handbook of PVC Pipe, by the Uni-Bell PVC Pipe Association, limiting the maximum allowable pipe deflection to five (5%) percent and using a deflection lag factor of 1.5.

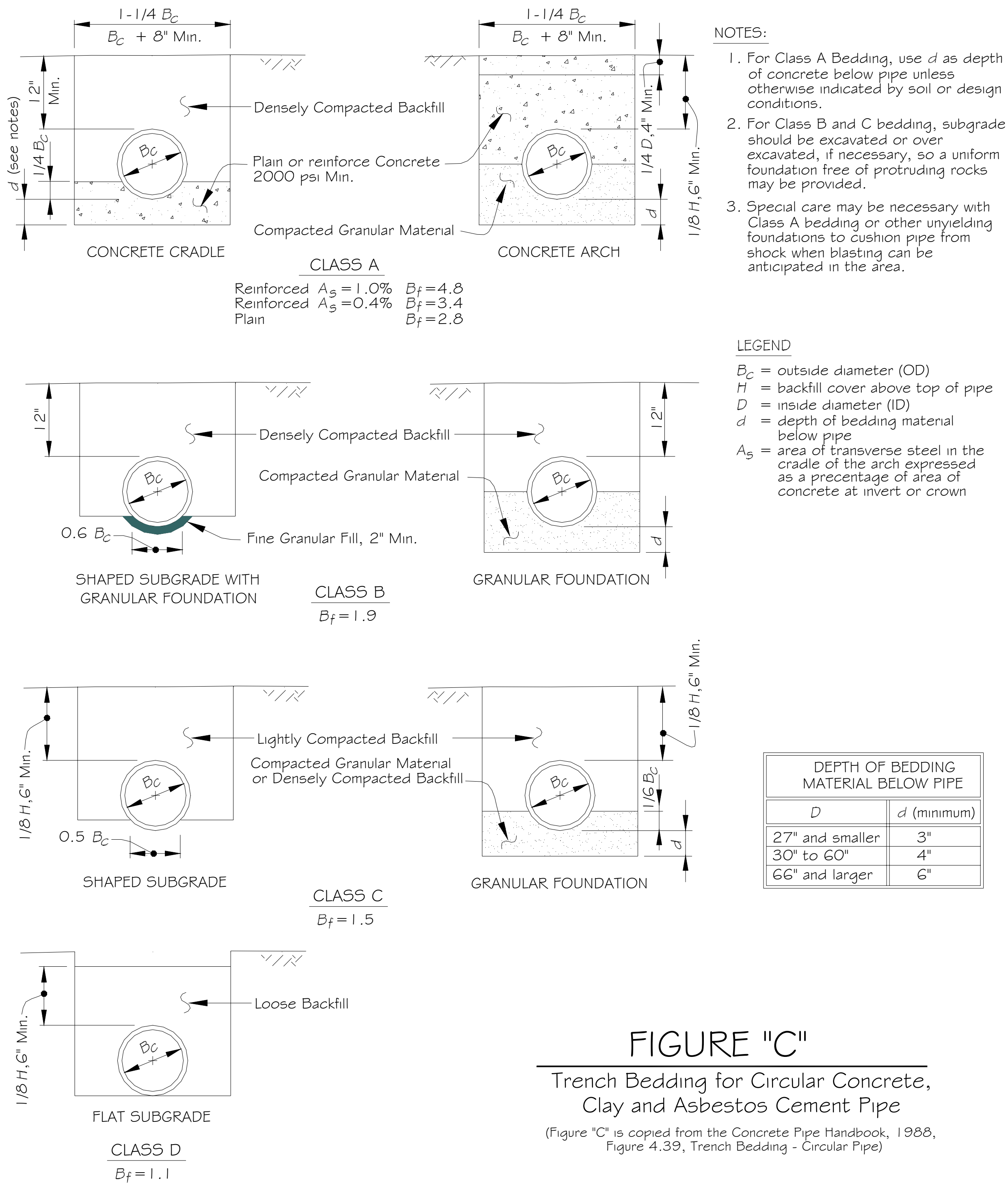

FIGURE "C"

Trench Bedding for Circular Concrete, Clay and Asbestos Cement Pipe

(Figure "C" is copied from the Concrete Pipe Handbook, 1988, Figure 4.39, Trench Bedding - Circular Pipe)