

12. Related Design and Analysis.

a. Methods to Increase the Strength of Pipe Due to a Change in Loading Conditions.

- 1) An analysis of proposed loading conditions on existing pipe will sometimes reveal that the pipe is either adequate or inadequate to handle the load, see Part Three, Section 11 (Loading Analysis of Existing Pipelines). If the existing pipe is found to be inadequate for the proposed loading, several methods are available and permissible by WSSC to mitigate the proposed loading without replacing or relocating the pipe.
- 2) Methods.
 - a) Revise the proposed grading. The first alternative should always be to make every effort to revise the proposed grading or loading to reduce the load on the pipe. Reduce the proposed grade or loading over the existing pipeline to the extent that the pipe is no longer overloaded.
 - b) Upgrade the pipe bedding conditions.
 - (1) As indicated in Part Three, Section 11 (Loading Analysis of Existing Pipelines), the pipe bedding factor or lay condition plays a large part in determining the load carrying capacity of the pipe.
 - (2) Prior to performing a design to upgrade the existing pipe bedding, refer to Part Three, Section 13 (Concrete Encasement, Arches and Cradles), for restrictions on the use of concrete encasements, arches and cradles.
 - (3) Type of pipe.
 - (a) Rigid gravity sewer pipelines, (cast iron, clay, plain concrete, reinforced concrete and asbestos cement pipe) upgrade the bedding to increase the bedding factor and the load carrying capacity as follows:
 - [1] For all diameters, use concrete cradle according to Standard Detail M/9.0, or concrete arch according to Figure "C". The concrete can be plain or reinforced depending on the bedding factor required, see Figure "C", in Part Three, Section 11 (Loading Analysis of Existing Pipelines), for configuration and corresponding bedding factor for plain and reinforced cradles and arches.
 - [2] For diameters less than 24-inch, re-bed the pipe with a higher class granular bedding, see Figure "C", in Part Three, Section 11 (Loading Analysis of Existing Pipelines), for configuration and corresponding bedding factor.
 - (b) Rigid pressure pipe, (prestressed concrete cylinder pipe, cast iron), see rigid gravity sewer pipe except concrete arches and concrete encasement are not permitted. In order to cradle or re-bed pressure pipe, the pipeline must be depressurized before excavation around the pipe takes place. WSSC must be contacted to see what time and seasonal restrictions may limit depressurizing the pipeline. In some instances, the pipeline may not be able to be put out of service and this method of increasing load capacity of the pipe may be impossible to implement.



(c) Flexible pipe, (ductile iron, PVC), both gravity and pressure service, provide upgraded laying condition.

[1] DIP, see Part Three, Section 11 (Loading Analysis of Existing Pipelines) and AWWA C150 for the relationship between lay condition and pipe load capacity and derive the lay condition that will allow the pipe to carry the proposed additional load.

[2] PVC pipe, the lay condition (type of soil and degree of compaction) must be modified to provide a modulus of soil reaction, E' , that will allow the pipe to carry the load. Generally, the Modified Iowa Formula, as rewritten in the Uni-Bell Handbook of PVC Pipe is used to analyze PVC, with a deflection lag factor of 1.5 and an allowable deflection of five (5%) percent.

c) Relocate or replace the pipe using a pipe material or pipe class capable of handling the additional load.

b. Field Investigations to Verify Assumptions Made in Analysis.

1) Assumptions.

a) Part Three, Section 11 (Loading Analysis of Existing Pipelines), has established criteria and procedures for evaluating the impact of changing the grade or loading over existing water and sewer pipelines. The results of these evaluations will indicate whether a pipeline, or section of pipeline, is adequate to handle existing and additional proposed loading. Certain assumptions are made in these evaluations.

b) The following assumptions are typically made from the best available record information: Amount of existing earth cover over the pipe, Whether or not pipe bedding was used and the extent of bedding, Whether or not the pipe was installed in a wide or narrow trench, Surge allowance for waterlines and forcemains, Pipe material and class, Unit weight and type of soil. The assumptions for these parameters provide for a conservative, expeditious analysis.

2) Field investigations. Occasionally, the need may arise for a more exact pipe loading analysis. Such needs may arise, for example, when the cost to relocate an existing inadequate pipe due to excess proposed fill is prohibitive. In such cases, the developer, highway authority, WSSC, etc., may propose a field, or other program to verify the assumptions made in the analysis.

a) Example case to verify existing earth cover. The amount of proposed additional fill in conjunction with existing earth cover may be shown in an analysis to overload an existing pipe. The relocation of the pipe may be extensive, disruptive, and expensive. In doing the analysis to see whether the pipe is overloaded, the amount of existing cover over the pipe is generally taken from the as-built drawings. The accuracy of the as-builts, however, is questionable in some cases. If the as-builts show more cover than actually exists, then the analysis may be more conservative than necessitated by actual conditions.

Therefore, participants in the project may recommend that test pits be done to verify actual cover. If it is found that the existing pipeline was built at a higher elevation than shown on the as-builts (and therefore has less cover than originally expected), the pipe may actually be adequate for the proposed additional fill and not need be relocated.



- b) Example case to verify existing pipe bedding. Another example would be where a pipe analysis makes the assumption that the pipe was installed in a flat-bottom trench. This assumption may minimize the earth loading capacity of the pipe. As in the previous example, if the pipe analysis assuming a flat-bottom trench, shows additional cover will overload the pipe, relocation may be required. Again, the required relocation may be expensive, extensive and disruptive. Participants may recommend that test pits be performed to confirm actual bedding conditions. Better bedding will increase the load-carrying capacity of the pipe and possibly eliminate the need for relocation.
- 3) For methods to increase the load carrying capacity of the pipe without having to relocate or replace, see Methods to Increase the Strength of Pipe Due to a Change in Loading Conditions, in this section.

c. Necessity for Pipeline Relocations.

- 1) The design of water and sewer pipeline relocations can be costly and lengthy. They are typically more involved than standard designs due to the often limited allowable shutdown time (usually eight (8) hours) for the existing pipeline. Special designs are often required for items such as special thrust restraint and suggested construction sequencing in order to maintain service or minimize disruption to existing services. In addition, construction of the relocation requires additional coordination and construction efforts resulting in higher construction costs.
- 2) Situations which may result in relocations including the design of new roads, storm drains, road improvements, new developments, etc., should be closely coordinated with existing WSSC water and sewer pipelines during the design of these facilities. Whenever possible, consider alternate facility designs that will eliminate the need for water or sewer pipeline relocation. The following situations may require relocation of an existing pipeline:
 - a) Proposed stormwater management pond too close to an existing WSSC pipeline.
 - b) Proposed grading that adds fill that overloads the existing pipe.
 - c) Proposed grading that removes cover over an existing pipe to the extent it may be damaged by construction equipment, impact and point loading, etc. For minimum permissible earth cover over water pipelines see Part One, Section 4 (Selection of Pipe Material) and Section 11 (Vertical Alignment - Profiles), and over sewer pipelines, see Part Two, Section 3, (Selection of Pipelines Material - Gravity Sewers) and Section 8 (Vertical Alignment - Profiles).
 - d) Proposed placement of a new structure too close to an existing pipeline. The proposed structure location may be such that the existing pipeline will fall within the influence of the new footing or the new structure may be placed such that maintenance of the existing pipeline is too difficult.
 - e) Conflicts with proposed storm drain piping and structures.
 - f) Conflicts with new roads, road improvements, or new developments.



d. Methods to Protect Pipelines During Construction.

- 1) Often new construction or grading will take place over or adjacent to existing pipelines. When this occurs, it may be necessary to add requirements under the contract documents to protect existing WSSC facilities. The pipeline may be damaged during construction operations by circumstances such as:
 - a) Overloading the pipe by crossing over it with construction vehicles, producing a live load greater than AASHTO H20/HS20.
 - b) Overloading the pipe by stockpiling soils or other materials above the pipe.
 - c) Overloading the pipe by crossing it with heavy construction equipment at locations where the soil has been cut to less than the minimum allowable.
 - d) The location of the existing thrust blocking and the passive soil wedge resisting the block's movement may have to be staked in the field, if the contractor's work might possibly adversely impact the block's stability.
- 2) Examples.
 - a) A WSSC right of way containing a 96-inch water pipeline goes through a site on which a developer is going to build a residential community. The developer's grading plan requires him to move large amounts of fill from one part of the site to another using heavy earth moving equipment driving over the existing 96-inch water pipeline. The WSSC finds the pipe is almost overloaded without the additional construction loads. The pipeline needs to be protected during construction. Methods of protection that should be considered include:
 - (1) Designate certain locations as crossing points over the existing pipeline. To keep vehicular and equipment traffic off the pipeline at other locations, the right of way can be fenced off.
 - (2) At the designated crossing point, provide a means of crossing the pipeline without overloading it. This might include use of a temporary bridge over the pipe or designating a crossing point. If the bridge is used, the bridge abutments would have to be placed so they don't transfer any load to the pipe. In some cases, augered caissons (augered to below the pipe invert) have been used for abutments to support the bridge. Timber mats may be used to spread a load, however provide calculations to show that the weight of the heaviest vehicle, when crossing the mat, is reduced to a load no greater than that produced by an AASHTO H20/HS20 configuration.
 - b) To avoid overloading a pipe due to stockpiling of material, provide notes indicating the minimum clearances between the toe of the stockpile and the centerline of the existing pipe.
 - c) For locations where the soil cover will be cut below the minimum allowable during construction, the method of protection that should be considered includes restricting all work above the pipeline to be performed using manual equipment and restricting construction vehicles from working close to the pipe until adequate soil cover is placed manually.



e. Submittal Information Required for the Proposed Grading over WSSC Pipelines.

- 1) Submit the following information.
 - a) Scaled profile of the proposed grading drawn on the as-built plans of the existing pipeline.
 - b) If the scaled profile cannot be drawn on a copy of the as-built plans, then the existing pipeline invert, with stations and elevations should be transferred to a new profile.
 - c) Information about the existing pipeline.
 - (1) Type of existing pipe material and type of existing pipe joint (mechanical joint, push-on joint, etc.).
 - (2) Strength class of the existing pipeline.
 - (3) Internal pressure of the existing pipeline.
 - (4) Pipe bedding information on the existing pipeline.
 - (5) If the above information is not 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 is available through the WSSC.
 - (a) WSSC Construction Files must be retrieved and reviewed to extract the information from delivery tickets, correspondence, specifications, inspection reports, or other contract documents that may be in these files.
 - (b) Where Prestressed Concrete Cylinder Pipe (PCCP) was installed, the pipe specification, design curves and lay schedule must be retrieved because PCCP is designed and manufactured specifically for particular site conditions.

