DETENTION, RETENTION AND RECHARGE STRUCTURES

Introduction

Foundation, trenchwall, bedding and backfill considerations for multiple barrel detention systems are not unlike those for conventional CSP installations. However, placement and compaction considerations differ substantially. Construction often must proceed in a dif- ferent manner making the use of different materials and methods advisable to achieve a sound, economical result. While this design manual covers many of the procedures that must be followed, there may be cases that require additional considerations. It is always good practice to consult with the manufacturer prior to the installation of these systems.

The following are areas that should be considered and planned for each system installed:

- Foundation
- Bedding
- In-situ trench wall
- Backfill material
- Backfill placement
- Construction loading

Foundation Considerations

A stable foundation must be constructed prior to the placement of the bedding material (Figure 10.32). It is important that the foundation is not only capable of supporting the design load applied by the pipe and it's adjacent backfill weight, but is also capable of maintaining its integrity during the construction sequence.

When soft or unsuitable soils are encountered, corrective measures must be taken. The unsuitable material needs to be removed down to a suitable depth and then built up to the appropriate elevation with a suitable structural backfill material.

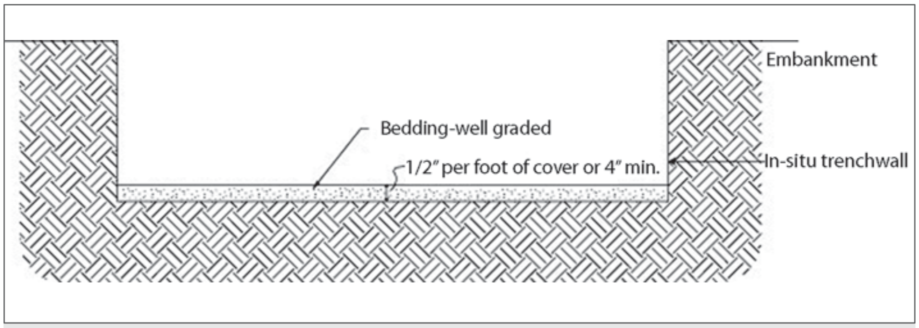
It is important to make sure that this added structural fill material has a gradation that will not allow the migration of fines, causing possible settlement of the detention system or the pavement above. In cases where the structural fill material is not compatible with the underlying soils, an engineering fabric can be used as a separator.

Figure 10.33 Detention system installation.

The foundation subgrade should be graded to a uniform or slightly sloping grade prior to the placement of the bedding material. If the subgrade is a clay or is relatively non-porous and the construction sequence will last for an extended period of time, it is best to slope the grade to one end of the system. This will enable excess water to be drained quickly, preventing saturation of the subgrade.

Bedding Considerations

A well-graded granular material placed a minimum of 4 to 6 inches in depth works best for the bedding (Figure 10.34). If construction equipment is expected to operate for an extended period of time on the bedding, an engineering fabric can be used to make sure the bedding material maintains its integrity.

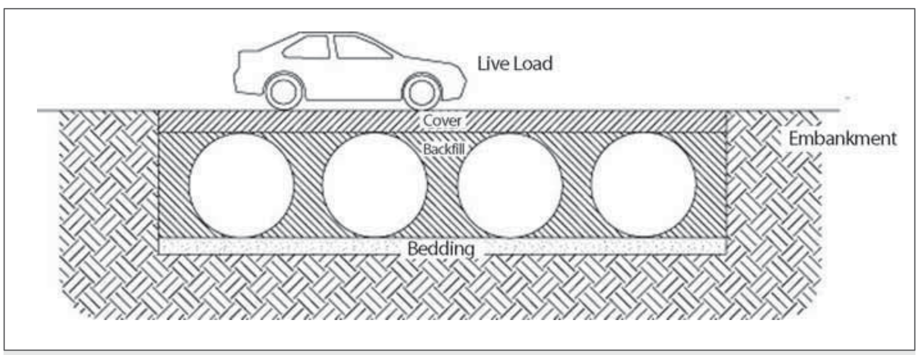


■ **Figure 10.34** Bedding considerations

The use of an open graded bedding material is acceptable; however, an engineering fabric separator is required between the bedding and the subgrade. The bedding should be graded to a smooth consistent uniform grade to allow for the placement of the pipe on the proper line and grade.

In-Situ Trench Wall Considerations

In the event that excavation is required to get the pipe placed on the proper line and grade, consideration needs to be given to the quality of the surrounding in-situ soil (Figure 10.35). The trench wall must be stable and capable of supporting the load that the pipe sheds as the system is loaded. Soils that are weak and not capable of supporting these loads will allow the pipe to deflect excessively. A simple soil pressure check will provide the designer with the applied loads that can be used to determine the limits of excavation required beyond the spring line of the outermost pipes. It should be noted that in most cases, the requirements for providing a safe work environment and enough space for proper backfill placement and compaction, take care of this concern.



■ **Figure 10.35** In-Situ trench considerations

Backfill Material Considerations

All other considerations aside, the best backfill material is an angular, clean, well-graded granular fill meeting the requirements of AASHTO A-1-a. However, other backfill types can be used (consult the manufacturer). If a uniformly graded (particles all one size) bedding is used, then a geotextile separation fabric should be used to prevent the migration of fines (Figure 10.36).

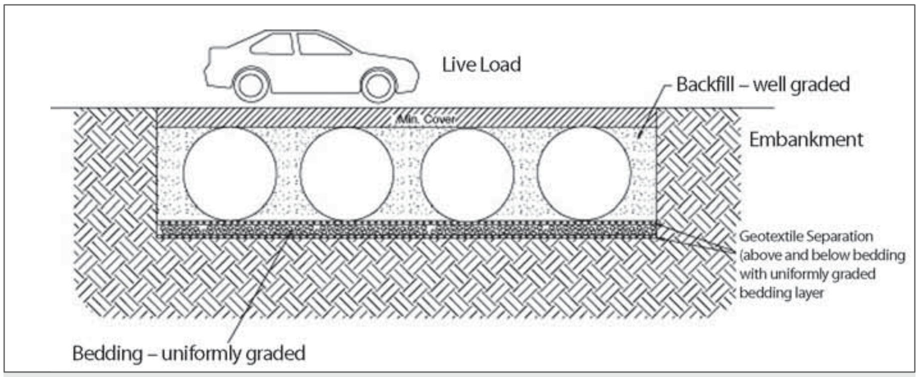


Figure 10.36 Backfill considerations

Depending on the size of the pipe and the spacing, it is at times desirable to use a uniformly graded material for the first 18 to 24 inches. This type of material is easier to place under the haunches of the pipe and requires little compaction effort. In the event that this type of material is used, then a separation geotextile should be used above and below these initial lifts, depending again on the bedding material (Figure 10.37).

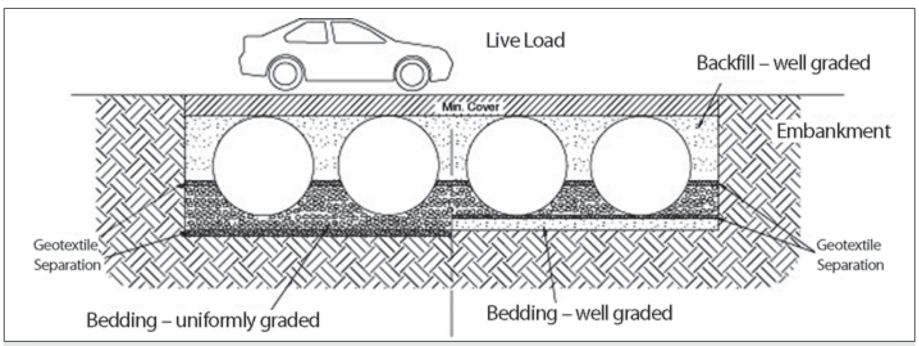
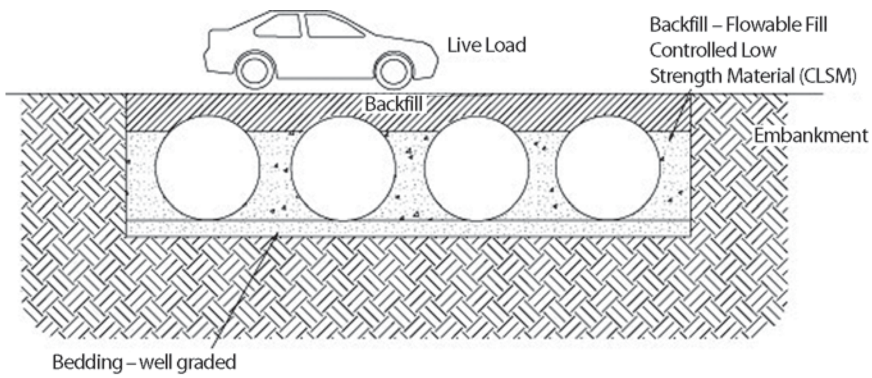


Figure 10.37 Geotextile separator recommendations

It is not desirable to use an open graded fill beyond the initial 18 to 24 inches because the proposed fill often does not provide adequate confining restraint to the pipes in these types of systems.

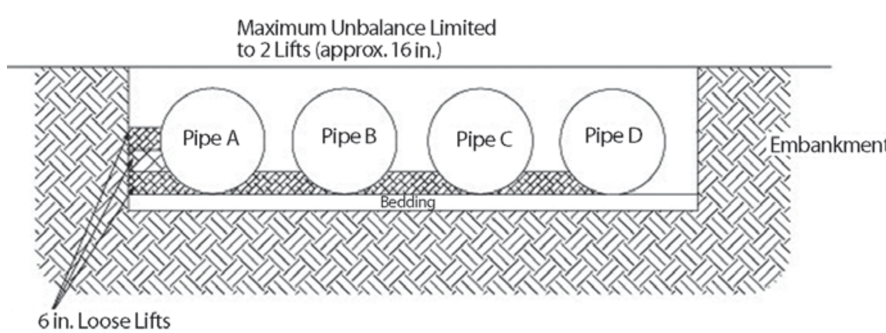


■ **Figure 10.38** Backfill with CLSM

Figure 10.38 shows backfill with CLSM, another suitable material.

Backfill Placement Considerations

The backfill should be placed in 6 inch loose lifts and compacted to 90% AASHTO T99 standard proctor density (Figure 10.39). The backfill must be placed in a balanced manner making sure that no more than a two-lift differential is present from one pipe side to the other during the backfilling process. Excessive backfill differential heights from one side of the pipe to the other can cause pipe distortion or lateral movement.



■ **Figure 10.39** Backfill placement

As backfill is placed between the pipes it must be kept balanced from side to side as well as advanced at the same rate along the length of the detention system. In other words, if you place the first lift between pipe A and B for a distance of 25 feet along the length of the system, then 25 feet of fill needs to be placed between pipes B and C and so forth until all pipes are backfilled equally (Figure 10.40).

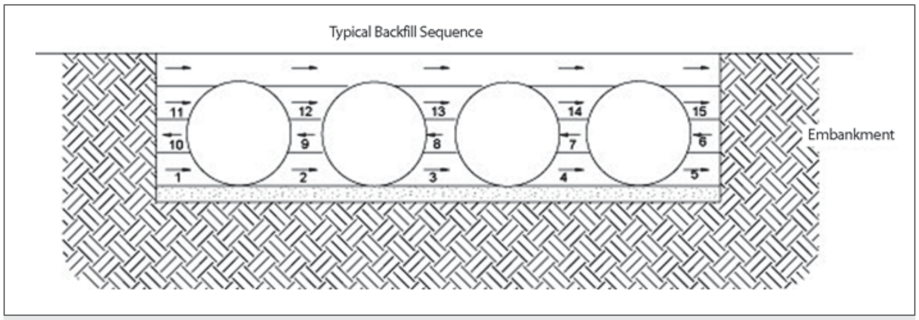


Figure 10.40 Backfill placement sequence

For large systems, conveyor systems have been used to place the fill effectively. Backhoes with long reaches or draglines with stone buckets have also been used effectively to place the fill along the pipe lengths until minimum cover is reached for construction loading across the entire width of the system. On long parallel sections of pipe, the contractor may need to backfill in stages along the pipe lengths. Once the required cover is reached on the initial section, then the equipment advances forward to the end of the recently placed fill and the sequence begins over again until the system is completely backfilled. This type of construction sequence will provide room for stockpiled backfill directly behind the backhoe as well as for the movement of construction traffic. Material stockpiles on top of the backfilled detention system should be limited to 8-10 feet maximum height and must provide balanced loading across all barrels. To determine the proper cover over the pipes to allow the movement of construction equipment, see the section that follows, **Construction Loading Considerations**.

The trench width and pipe spacing requirements were established to allow the full range of backfill materials to be used. These spacings can be reduced when special backfill and special care is used. The limit is where the difficulty of access for assembly and backfill compaction becomes uneconomical.

Reducing the spacing between pipes can be especially helpful where the multiple runs often involved with detention, retention and recharge systems are encountered. These are typically low cover applications where the strength of the backfill is less important and high compaction not as critical. Clean, non-plastic, easily flowing backfill materials have higher strengths than other backfill materials, even at lower compaction levels.

Spacings of 24 inches are generally not objectionable. A spacing of 18 inches or less can be used with backfill materials such as crushed rock, # 57 stone or pea gravel. These materials are more easily placed into the haunch. When necessary, concrete vibrators can be used to move and consolidate the backfill much like they do fluid concrete, to assure there are no voids left. Alternatively conventional vibratory compaction plates have been used inside the pipe invert to help move and consolidate these materials against the outside of the pipe.

Low strength grout, controlled low strength materials (CLSM), etc. allow spacing of as little six inches if the pipes can be joined. However, flotation becomes a special consideration and may require the pipe to be weighted (Figure 10.41).

Flotation

When CSP reline pipes or those backfilled with grout are installed, a primary consideration is the need to control flotation. Fluid grout, which may have a density of 120 pcf or greater can develop greater buoyancy forces than water. To minimize flotation problems, grout is typically placed in thin lifts from side to side of the pipes in a balanced manner.

Direct burial pipes typically are more difficult to hold down. Methods that have been used to provide a degree of hold down restraint include placing timbers over the pipe with each end wedged into the trench wall, or placing tension straps over the pipe crown tied to earth anchors in the foundation. Where feasible, pipe have been filled with water or weighted down with concrete blocks placed on roller dollies in the invert.

Where the hold down restraints are intermittent, support spacing limits apply such as discussed for aerial spans in Chapter 8. However, it must be recognized that the aerial span limits apply to water filled pipes whereas inundating the entire pipe with grout could develop roughly twice the uplift, due to the higher grout density.

One way to reduce the buoyant forces is the use of lightweight cementitious backfill materials. These are often simply portland cement, water and a foaming agent that, at 30 to 40 pounds per cubic foot, provide excellent backfill and lower buoyancy forces than low strength grout. While these special backfill are more costly, the closer pipe spacings reduce the necessary quantity.

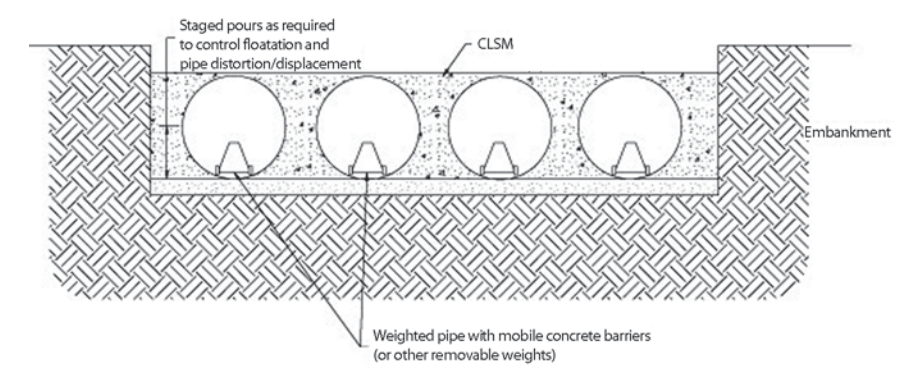


Figure 10.41 Stage pours for CLSM placement

Box culvert with construction equipment loading on top of the structure.

Construction Loading Considerations

Typically, the minimum cover specified for the project is for standard AASHTO H-20 live loads. Construction loads can greatly exceed those loads for which the pipe is designed in its completed state. In many cases, increased temporary minimum cover requirements are necessary to facilitate construction loading (Figures 10.26 and 10.42). Since construction equipment varies from job to job, it is best to discuss the minimum cover requirements during construction with the contractor at the preconstruction meeting. Table 10.1 provides guidelines.

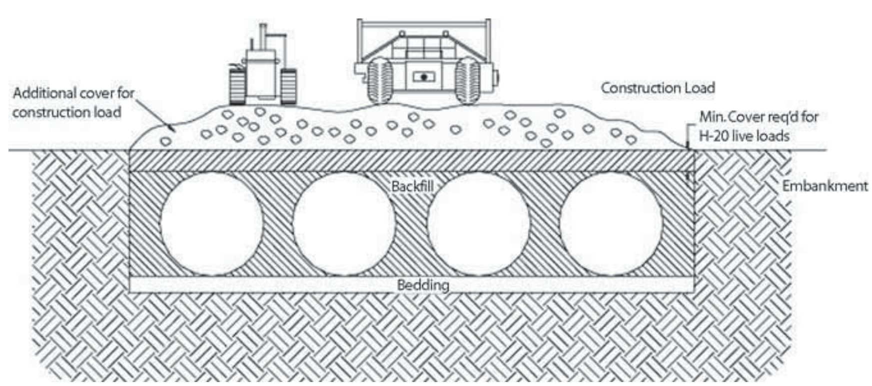


Figure 10.42 Additional cover for construction loading

from construction equipment. When construction equipment with heavy wheel loads, greater than those for which the pipe was designed, is to be driven over or close to the structure, it is the responsibility of the installer to provide the additional cover needed to prevent pipe damage. Table 10.1 provides minimum cover guidelines. Steel box culverts are especially vulnerable to damage from excessive live loads and may require additional temporary cover.

Table 10.1

Guidelines for minimum cover for heavy off-road construction equipment.

Span (in)	Min. Cover (ft) for Axle Loads (kips) 18-50	50-75	75-110	110-150
12-42	2.0	2.5	3.0	3.0
48-72	3.0	3.0	3.5	4.0
78-120	3.0	3.5	4.0	4.0
126-144	3.5	4.0	4.5	4.5

1) Min. crossing width of twice the span is recommended.
2) Additional cover may be needed depending on local conditions.

The amount of additional fill needed depends on the equipment axle loads as well as rutting and frequency of use. Figure 10.26 provides safe minimum cover limits for typical structure sizes, axle loads and construction use. This figure does not apply to steel box culverts. The additional temporary cover shown in Figure 10.26 must be maintained so that rutting, surface grading, etc. does not reduce its effect. A minimum crossing width of twice the structure span (or total width for multiple structures) is recommended for typical equipment.

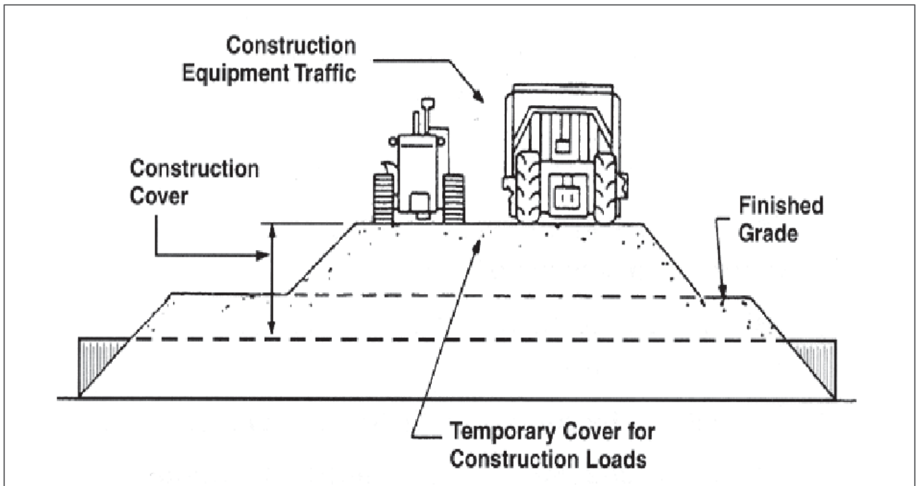


Figure 10.26 Minimum cover for construction loads. (See also Figure 10.42.)