Introduction

Flowable fill (soil-cement slurry) is a combination of soil, cementitious material, and water that is used as a replacement method of embedment and backfill during the installation of thermoplastic pipe, including high density polyethylene (HDPE) and polypropylene (PP). Flowable fill has many names such as "CLSM" (controlled low strength material); soil-cement grout, unshrinkable fill, flowable mortar, and controlled density fill. This mixture is pourable, self-leveling and provides adequate strength needed for the embedment, especially where in-situ soils are not suitable for installation. The use of flowable fill is also utilized when cost or availability of other backfill material is limited through construction.

While flowable fill is a viable alternative to traditional soil or stone backfill, full assessments of the design consideration are warranted before beginning any project. For more information, visit www.prinsco.com or contact your local Prinsco representative.

Applications

The strength of the embankment material is primary factor of the pipe/soil structure for buried pipe. The flowable fill can be used as a partial or full replacement of bedding and embedment backfill material. As shown in Figure 1, the slurry is poured in between the trench wall and pipe instead of a compacted alternative backfill. The use of flowable fill is highly cost-effective if narrow trench widths are encountered, or if the compaction equipment is not available for compacting the backfill. With these applications, there is also design constraints that should be considered.

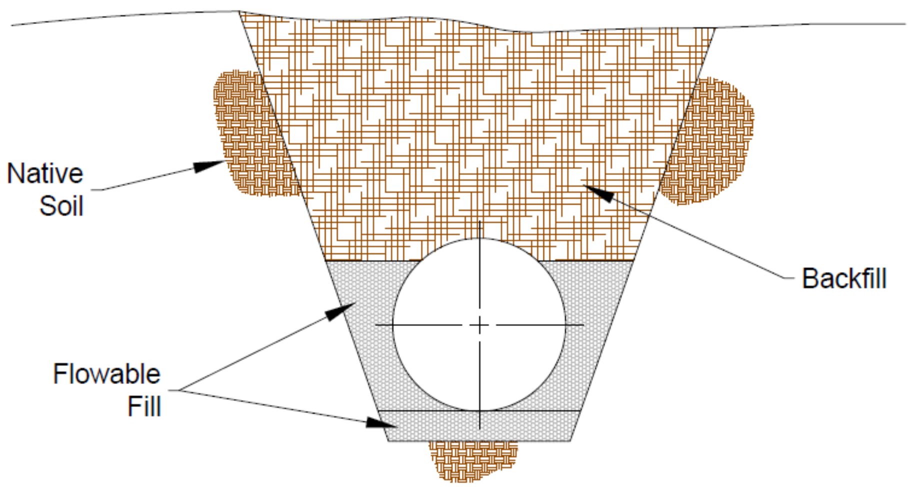

Figure 1: Flowable Fill Backfill

Benefits

- Increased strength distribution between pipe and soil
- Less native material disturbance due to narrower trench
- Reduced personnel, equipment and time required for installation
- No compaction of flowable fill needed
- Reduced trench width and excavation cost depending on soil conditions

Design Constraints

- Set time, mixing time, and material/slurry transportation time, if not produced on site, can increase costs
- Difficulty in future excavations dependent on fill composition
- Anchoring required due to potential for pipe flotation
- Abiotic factors of environment (temperature, humidity, rainfall, etc.)
- Uneven placement of fill can cause pipe stress or movement
- Cannot be stockpiled unlike other backfill materials

Flowable fill Mixing Design

The mix design for flowable fill can widely vary and depends on the properties of the ingredients, desired strength, and flowability. The design shall ensure the mix delivers suitable strength yet is still soft enough for future excavations. Flowable fill is usually a combination of water, soil, and Portland cement. Cementitious fly ash may be used in place of cement. At seven days, the hardened mixture should result in 50 to 100 psi (350 to 700 kN/m^2) compressive strength. Exceeding these strengths could increase difficulties in future excavations. The mixture must also have a consistency that completely fills the spaces between the native soil and pipe but can range from a fluid to a high-slump material. Laboratory tests on the flowable fill should be performed prior to installation. Small composition adjustments may need to be made in order to achieve the proper mix because of environmental factors. Batching and mixing can be done either on site or off-site. On-site, material excavated from the trench can be used in the flowable fill by means of a trench-side portable batch plant. Off-site commercial ready-mix plants use traditional concrete sand and can be transported to the construction site.

Installation

Trench Widths

Trench widths must be wide enough to allow the flowable fill to adequately flow around the pipe. According to ASTM D2321, minimum trench width shall not be less than the greater of either the pipe outside diameter plus 16 in. or the pipe outside diameter times 1.25, plus 12 in. Table 1 depicts the recommended trench widths for Prinsco pipe.

Table 1: Minimum Trench Widths (ASTM D2321)

Prinsco Pipe Diameter in. (mm)	Minimum Trench Width in. (mm)
12 (300)	30 (750)
15 (375)	34 (850)
18 (450)	39 (975)
24 (600)	47 (1175)
30 (750)	56 (1500)
36 (900)	63 (1575)
42 (1050)	72 (1800)
48 (1200)	80 (2000)
60 (1500)	96 (2400)

Trench Walls

Under stable working conditions, the trench must be free of water and at widths designated by the contract documents. The sides and bottom of the trench exposed to flowable fill must not be frozen. In using flowable fill, a trench box can be raised vertically with the slurry placed at the bottom of the trench. However, it is also important to keep in mind that pipe floatation can still occur. Flowable fill can be used in a rough-cut trench in order to provide necessary support for the pipe while reducing the cost of installation

Flowable Fill Placement

During flowable fill installation, ambient temperature shall not be below 40ºF (4ºC) and the temperature of the mix shall not be below 50ºF (10ºC). Placement of the flowable fill is not recommended if precipitation is expected or if expected temperatures do not meet requirements. Backfill should not be placed over the slurry until it has been set. If the backfill is not placed within eight hours of slurry placement, 6” (15 cm) of moist earth should be placed in order for the moisture to assist in curing. It is recommended to cover the fill with an insulated blanket prior to set, in addition to soil post-set, as to prevent freezing. Fill shall be evenly distributed on both sides of the pipe to minimize pipe-stress or movement of pipe as shown in Figure 2.

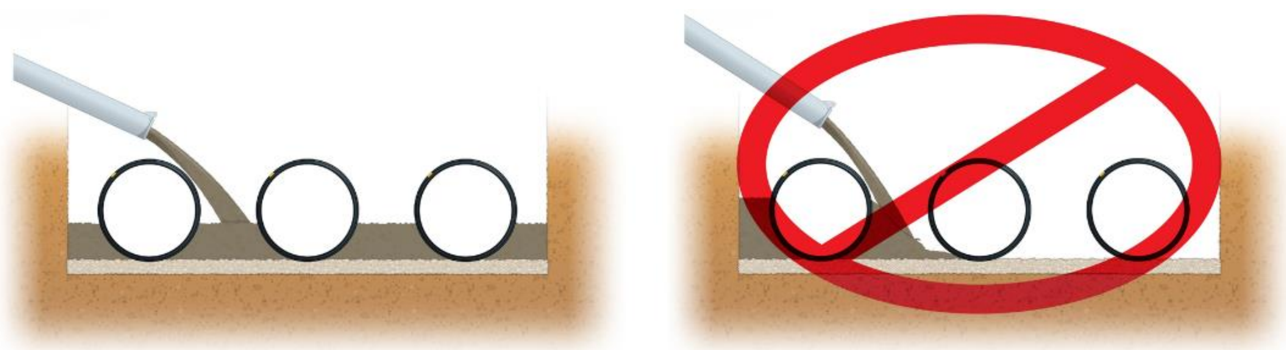

Figure 2: Flowable Fill Placement Recommendation

Flotation

Pipe floatation shall be considered when installing flowable fill. HDPE and PP pipe are typically less dense than the flowable fill and may result in pipe floatation. The pipe must be anchored to maintain the intended grade and alignment. Some common methods of anchoring include placing sandbags on top of the pipe or bracing the pipe with re-bar. Anchoring systems such as geotextile wrapping, concrete collar utilization, and screw anchor assemblies may also be applied. Testing small sections on the job site could be useful in determining which method provides the best results. Figure 3 displays the flotation that could occur and how to prevent such action. Once the fill has set, any weights or rebar can be removed.

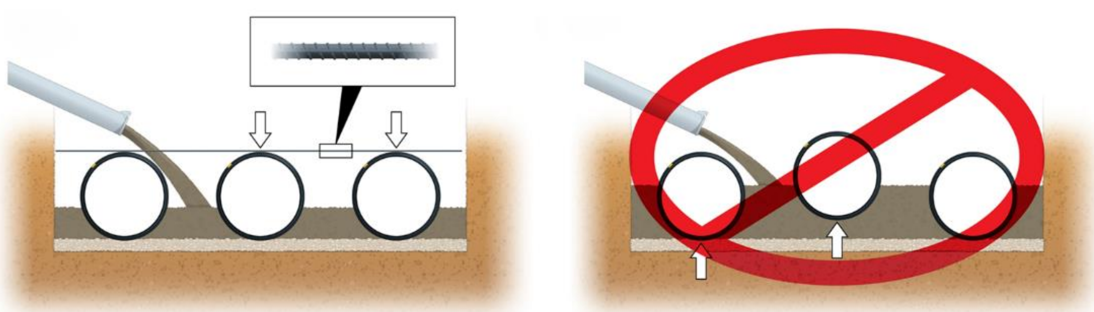

Figure 3: Pipe Anchoring to Prevent Floatation

In order to accommodate for the uplift force caused by flowable fill, a hold-down force is needed in order to counteract the uplift force. Table 2 displays minimum forces required to offset the uplift. The values in the table assume hold-down forces for one continuous fill application assuming the unit weight of the flowable fil is 155 lb/ft^3.

Table 2: Required Hold-Down Force

Prinsco Pipe Diameter in. (mm)	Require Hold-Down Force lb/ft (kg/m)
12 (300)	178 (265)
15 (375)	259 (385)
18 (450)	391 (582)
24 (600)	687 (1022)
30 (750)	1036 (1542)
36 (900)	1421 (2115)
42 (1050)	1907 (2838)
48 (1200)	2474 (3682)
60 (1500)	3795 (5648)

Lifts

Flowable fill can also be placed through incremental lifts. After calculating the point where floatation will occur, the initial lift can be filled just below the point of floatation. The second and each successive lift can be placed after the flowable fill has set. Anchoring of the pipe is till recommended to ensure that the required line and grade of the pipe is maintained.