Chapter 6

End Seals, Wing Walls and Bulkheads

End Seals, Wing Walls and Bulkheads

When the Snap-Tite® Liner is in place, after it has been pulled or pushed inside the culvert pipe, the annular space between the culvert and the liner must be sealed in order to stop leakage from the old pipe. When the Snap-Tite® Liner is installed and the ends are sealed, the flow of water will stop; soil and backfill will remain in place.

The above picture shows sliplining through a wing wall. An end seal with fill pipes is under construction.

End seals can be made in many different ways. The most common way to make end seals is to pack relative dry cement mix around the ends of the liner between the host culvert and the Snap-Tite® liner. Another method is to build a form and pour concrete in the form. If this method is used, it is important that concrete mix extend between the host culvert and the liner for 12 to 18 inches. This length of contact is needed for a good seal to form in this area.

Dry mix must be packed into the annular space between the host culvert and the Snap-Title® Liner to get a good seal and structural soundness. The mix shall be packed 12 to 24 inches into the annular space. The size of the liner and pressure in the annular space determine the exact depth.

When there is erosion at the ends of the existing culvert, headwalls are cast at the end of the culvert pipe and around the liner. When headwalls are used, the wall must be designed to handle soil loads, hydrostatic pressure, expansion and contraction and other forces from the roadbead. The design must include sealing of the liner to the headwall plus stopping flow from any French drain effect around the old culvert. For sections of liner 80 or more feet in length, it is important to extend the liner through the wall at least six inches on each end to allow for possible contraction.

The final step in finishing an end seal or headwall is to remove the fill pipes and seal over these areas.

Cast in place headwall

Chapter 7
Annular Space Grouting

Purpose

When rehabilitating culverts, the primary goals of annular space grouting are to stop the leakage of water, stop movement of road backfill materials, secure the liner in place and reinforce the old culvert. Grouting the annular space is a key process in reaching these goals. Proper grouting of the annular space ensures a long life for the pipe system, and the road above. This can be critical to provide a total-systems approach for culvert rehabilitation.

When the existing culvert has deteriorated to such an extent that bedding material has infiltrated into the culvert, resulting in voids beneath the road base, grout can be used to help fill these voids. This effectively stabilizes the surrounding soils and eliminates the potential for settlement or collapse of the roadway.

The grout around the liner provides extra support for the liner. This support increases the collapse strength of the liner. With no grout, if the host culverts begin to collapse, there is a danger of point loads, localized deflection, and possible impingement occurring on the Snap-Tite® liner. The grout supports the old culvert and helps to evenly distribute backfill and vehicle loads. As Chapter 8 discusses in greater detail, the grout becomes the primary structural component of a rehabilitated pipe system, and therefore the liner is not required to be a significant portion of the structural system. The primary role of the liner is to provide a smooth hydraulic surface, often with a pipe that has improved flow characteristics when compared to the original host pipe.

Need for Grout

Not every sliplined culvert requires grouting. If there is a very small annular space resulting from the sliplining, and the host pipe is structurally sound, grouting of the annular space may not provide enough benefits to justify the cost and effort required. Additionally, injecting grout into a small annular space may require pressure injection which could cause joint leakage or damage to the Snap-Tite® liner.

However, if the host pipe has failed or is in the process of failing, often evidenced by corrosion of a metal pipe or joint separation of a metal or concrete culvert (box structure or pipe), then grouting a sliplined culvert is recommended.

Types of Grout

Grout has traditionally been defined as "a thin, coarse mortar used for filling masonry joints." In recent years the definition of grout has been expanded to cover a wide range of concrete and organic compounds used to fill masonry joints or space in or around pipes or liners. In Snap-Tite® culvert lining applications, both non-cellular and cellular grouts can be used to fill the annular space in a rehabilitated culvert system. But cellular grouts with lower densities are normally preferred since they limit hydrostatic loads on the liner when being placed.

Non-cellular grouts are the traditional Portland cement formulations, typically referred to as flowable fill. These products are well known and are used for many applications, including grouting liners in place. The Department of Transportation for most states has some type of specification established for flowable fill grout.

<u>Flowable Fill Grout</u>

This is comprised of a mixture of cement, sand, and water, sometimes with chemical admixtures put in to affect certain properties of the grout mix. A portion of the cement component can be replaced with fly ash. Fly ash is a cementitous material, usually at a lower cost than cement, which can improve certain properties of the resulting grout mix. Fly ash may not be available in all locations.

Flowable fills are sometimes used to fill the annular space or as backfill around pipe. The unit weight, or density, of a flowable fill grout mix typically ranges from 130 to 135 pounds per cubic foot (pcf). Project specifications may call for a 3-sack, 4-sack, or 5-sack flowable fill, referring to the amount of cement added to each cubic yard of the grout mix. One sack of cement weighs 94 pounds. Thus a 3-sack mix will have 282 pounds of cement mixed into each cubic yard batch; while a 5-sack mix will include 470 pounds of cement per cubic yard.

The extent to which a flowable fill grout can travel within the annular space is limited and based on viscosity. An annular space within a culvert that is longer than 40 – 50 feet may not be completely filled with such a grout mix. In such applications, by lowering the density, or unit weight, of the grout mix, the viscosity of the grout will also decrease and flowability of the mix will typically increase.

Reduced Density Flowable Fill

Certain chemical admixtures are available commercially to reduce the density of a flowable fill grout mix. The grout unit weight may be lowered to a value in the vicinity of 100 pcf, depending on the type of sand and cement used and the percentage of the various components in the mix design. These in plant or on site "bag mixtures" use a chemical reaction to introduce gas bubbles and voids into a flowable fill mix. A cellular grout that is under 100 lb/ft^3 for a wet cast density is very difficult to achieve using this formulation method. The chemical reactions are limited in the amount of air that can be introduced as off gases in the formulation of a cellular grout. And without the use of a foaming generator it is difficult to introduce enough air into a flowable fill mix to create a target wet cast density between 40 lb/ft^3 and 75 lb/ft^3.

While the annular space can physically be filled with these higher density grouts, the risk of hydrostatically overstressing the HDPE liner will increase as the density of the grout increases. Additionally, some admixtures are exothermic, which will further raise the curing temperature of the grout. The heat of hydration for the selected grouting agent should always be considered. Increased curing temperatures will result in a decrease on the allowable loads recommended for the liner. Expansive grouts are not recommended.

It is suggested that grout mixtures, which are utilized to fill the annulus where the wet cast density exceeds 75 lb/ft^3, should be independently evaluated for suitability of use by the owner or the installer. Direct consultation with the commercial admixture manufacturer is recommended in these instances. Increased grout densities will increase the likelihood that the annular space grouting will need to be performed in lifts to limit stresses in the liner.

Consideration to hydrostatic pressures on the liner should always be considered prior to creating or injecting the selected grout, regardless of actual grout density being used.

Cellular Grout

Cellular grout is a low density grout mix comprised of cement and water (or cement, fly ash, and water) with a foaming agent added to inject a large volume of macroscopic air bubbles into the grout mix. This admixture greatly reduces the density, or unit weight, of the grout mix, and often will result in 40% or greater air content in the finished product. A foam generator unit is normally required to obtain such a high percentage of air and to reduce grout density. Most additive manufacturers report a maximum of 20% to

To produce cellular grout, a concentrated foaming agent is required in combination with various types of foam generating equipment. This equipment may generate foam via air pressure or water pressure.

30% air when using additive products that do not utilize a foam generation unit. This is because the churning action of the truck mixer alone is relied upon to entrain air into the grout. Therefore cellular grouts made with additive products that do not utilize a foam generation unit are often higher density grouts than those created using foam generators.

In cellular grouts, the air bubbles stay in suspension long enough for the cement paste to coat them and begin to hydrate, or "set," and the air bubbles replace the aggregates commonly found in products such as concrete. Once hardened, the grout mix has a compressive strength that can range from 200 psi to well over 1,000 psi. These values are higher than that of the bedding soil that was originally around the host pipe.

Cellular grouts can be designed to have wet densities, while still in the "plastic" stage, ranging from 30 pcf to 80 pcf. With this lower unit weight the grout applies less hydrostatic pressure on the Snap-Tite® liner than with a denser product. An additional benefit is that the grout is able to travel longer distances within the sliplined pipe system while also flowing through the holes or separated joints of the host pipe, filling the voids in the surrounding bedding materials. These voids were originally caused by the soil infiltrating into the host pipe through separated joints or holes in the pipe. The voids are thus filled with the grout flowing through these same openings.

Grout Properties

Density or Unit Weight

The density of a grout mix is the weight, in pounds, of a defined volume of the grout, for instance one cubic foot of material. Density is often reported in units such as "pounds per cubic foot (pcf)." The unit weight is measured by collecting a sample of the grout mix and filling a container of a pre-determined volume. Typically a one-half cubic foot metal unit weight bucket is used. After completely filling the bucket and striking off the surface, the bucket is weighed. The weight of the empty bucket is subtracted from this value and the resulting number is multiplied by two (using a one-half cubic foot bucket) to obtain the density of the grout mix (pcf).

Air Content

The air content is the amount of air introduced into the grout mixture; this is reported as a percentage of the total volume. Certain chemical admixtures have the ability to entrain air around sand particles in the mix. These are macroscopic air bubbles and typically add 3-5% of air to the mix. The advantages of having air bubbles in a grout mix are that they provide for better flow of the material and give greater resistance to the damaging effects of a freeze/thaw environment.

Foam generators can introduce up to 70% air to create highly-designed and consistent air incorporation. These air bubbles are attached to the cementitious particles in the grout. The resulting grout mix can appear to have a foam consistency. The larger air content in the material greatly enhances the ability of the grout mix to flow longer distances and through smaller spaces.

Viscosity

The viscosity is the thickness of a liquid or "a measure of a fluid's resistance to flow." A low viscosity is desirable for grout mixes in a Snap-Tite® application. The viscosity of a grout mix is measured by use of a flow cone as described by ASTM C939. A slump test is not applicable in determining the flow of a grout mix.

Compressive Strength

The compressive strength of grout is the amount of compressive force that the material can resist after the grout material is allowed to set. This is determined by obtaining a grout sample and filling a cylindrical container, typically a mold 4” in diameter and 8” in height, and testing the sample in a compressive strength test apparatus. This test is conducted in pre-determined time increments, such as sample ages of 1-day, 3-days, or 7-days after the grout mix is batched. ASTM C1019 describes this testing process.

While compressive strength is commonly specified for concrete and grout used in other applications, this is not an important property for grout used to fill the annular space after sliplining a culvert. Practically any grout used will have compressive strength values greater than the original soil surrounding the host culvert. The significant property of the grout mix is the density of the material. However, as a general rule, as grout density is increased, so is the compressive strength of the grout.

Applications & Grout Selection

The Snap-Tite® liner system is used in a variety of culvert and gravity-flow pipe applications. There are many types of grout available. A thorough analysis of the existing culvert pipe is needed before making liner and grout selections. Engineering analysis and/or consultation may additionally be required.

Condition of Host Pipe

The condition of the pipe to be lined is important in determining the liner and grout requirements. Grout will fill the space between the liner and the pipe, and assist in maintaining a pipe seal. If the existing pipe has lost its ability to handle soil and highway loads, a liner and a grout must be selected to handle these loads. In most situations, a liner with a DR of 32.5 and a low-density foam grout with unit weight values of 40 pcf or greater will be suitable.

If the host pipe is in good condition, i.e., without corrosion holes or separation of the pipe joints, then grouting of the annular space may or may not be needed. In this application, the remaining site conditions should be evaluated to determine the long term advantages and disadvantages of grouting.

Length of Host Pipe

The length of the pipe is a very important consideration when grouting. If the host pipe is short, i.e., less than sixty linear feet in length, almost any mix discussed can be used as long as low-pressure is utilized for installation. Availability and economic factors play a larger role in grout selection in these applications.

Elevation can be used to assist with grouting short runs of pipe using the effects of gravity, depending upon the flow rate or viscosity of the grout. As the length of pipe increases, the amount of pressure required for grouting the annular space may also increase, unless the viscosity of the grout is changed.

Volume of Annular Space

Annular space is the area between the liner and the existing pipe. If there is only a small space resulting after sliplining Snap-Tite® into the existing pipe, it will be more difficult to fill this space compared to a sliplining situation where a large annular space is the result. More pressure may be required to fill a small annular space compared to a larger annular space. The density of the grout should be reduced as much as possible to reduce the risk of hydrostatic collapse to the liner during the grouting operations.

When the annular space is small, a high flow, low-density grout under low-pressure (less than five feet of head or 2 psi) will fill this space. Portland cement grouts containing fine aggregate, such as sand, often require higher pressure than is desired to flow the length of the pipe. Additionally, the sands can at times begin to settle out of the grout mix and accumulate in the fill tubes. This can possibly lead to constricting or clogging the fill tube. If this type of grout must be used, it is recommended that multiple grout insertion pipes are placed at various lengths within the annular space. This will lower the force required to place the grout within the area.

If there is a large difference between the diameter of the liner and the existing pipe, a grout with a higher density will apply more pressure to the liner during installation. A lower density grout is once again preferred in this situation as well.

Flotation

Why is flotation a concern? During the grouting operation, the polyethylene pipe will float in the grout material and rise to the top of the host pipe, unless it is restrained or held down in some way. This may change the grade of the liner, affecting the water flow through the lined pipe. The selection of the grout can affect the flotation concern. Lower density grouts create lower resulting buoyant forces.

There are numerous methods that can help control this problem. One method is to attach wood, plastic or metallic blocks inside the culvert, along the top of the host pipe or the liner itself, to minimize the flotation. This technique is commonly referred to as bridging or blocking. Runners attached to the bottom of the liner are also used to center the liner.

Sand bags, or other materials, can be used to weigh the liner down and counter the buoyancy factor to prevent the liner from floating, along with the possibility having the liner partially or fully filled with water to help neutralize any buoyant force. Underwater lining applications have been successfully completed with Snap-Tite® and in these installations the liner has almost neutral buoyancy, since the HDPE pipe has a density that is very close to that of fresh water.

Elevation Change

When there are large changes in elevation between the ends of a pipe being lined with Snap-Tite®, the grout will exert additional pressure on the liner material, and additionally on the bulkhead positioned on the down stream end of the lined host culvert. When the elevation difference is greater than five feet, the method of grout installation must be evaluated to prevent hydrostatic collapse of the liner. Grouting in lifts is usually the best method to prevent liner collapse, leakage at the bulkhead and other potential problems.

Elevation, or gravity, can be used to provide pressure for grouting short runs of pipe, depending upon the flow rate of the grout. As the length of pipe increases, the amount of pressure required for grouting the annular space increases.

Unconstrained Buckle & Grouting Pressures

The following equation can be used to assist the designer to evaluate an allowable load on the HDPE liner.

Equation 7-1

$$P_{WU} = \frac{f_0}{N_S} \frac{2E}{(1 - \mu^2)} \left(\frac{1}{DR - 1} \right)^3$$

Where:

P_{WU} = allowable unconstrained pipe wall buckling pressure, psi

DR = Dimensional Ratio

E = apparent modulus of elasticity of pipe material, psi

f_0 = Ovality Correction Factor, Figure 7-1

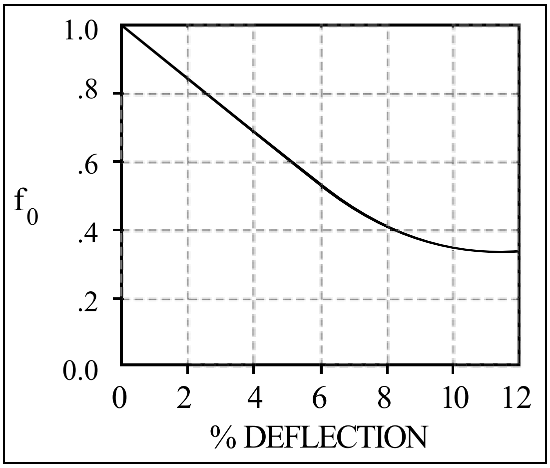
N_S = safety factor

I = Pipe wall moment of inertia, in4/in

μ = Poisson's ratio

D_I = pipe inside diameter, in

Figure 7-1



Ovality Compensation Factor, f_e

**Ovality compensation factors and buckle equation presented in PPI Handbook of Polyethylene.*

An approach often utilized by designers is to use a 10-hour pipe modulus based on a 73 degree Fahrenheit temperature. This modulus is used since the heat of hydration for the cementations fill usually does not increase until the grout material begins to set up. When the grout materials begin to set up, they also begin to provide support to the liner nearly simultaneously. The Plastics Pipe Institute provides an industry established modulus for a PE3408 material of 62,000 psi. based on a 10-hour load at 73 degrees Fahrenheit. Most grouts will provide structural support due to curing within this 10-hour time span.

It is also an industry standard to base calculations on a 0.45 Poisson's ratio and an assumed deflection of 3% existing in the HDPE liner. This would result in an ovality factor of 0.76 using Figure 7-1.

If a 2 to 1 safety factor is used with the approach described above, an HDPE liner made with a DR 32.5 pipe wall would have an allowable external pressure of 2 psi. This is consistent with the allowable load suggested by ISCO's Snap-Tite® Division for RPS liners.

Culvert Circumstances

The specific culvert circumstances have the greatest impact on the type of grout that should be used to fill the annular space. Table 7-1 is provided to assist in this determination. This is an aid only; it should not be considered a definitive recommendation of what type of grout to use for any particular application.

Grouting Operation

Preparation

The preparation for the grouting operation begins before installing Snap-Tite® pipe into the existing culvert pipe. The existing culvert should be inspected to determine the following factors:

- Point of entry for grout
- Length and slope of culvert
- Existence of corrosion holes or separated joints in culvert
- Evidence of voids in the road bedding and fill materials
- Available workspace
- Traffic control
- Protection of environment and existing conditions

Table 7-1

		Condition of Host Pipe		Length of Host Pipe (LF)			Culvert Circumstances	
	Density Range (pcf)	Good	Failed or Failing	< 50	50 – 125	> 125	Light Traffic	Heavy Traffic
3-Sack Flowable Fill	130-135	x		x			x	x
Reduced Density Flowable Fill	90-120	x	x	x	x		x	x
Cellular Grout	40 – 80	x	x	x	x	x	x	x

Point of Entry for Grout

There are many ways that grout can be placed into the annular space of a rehabilitated culvert. It can be pumped in, under low-pressure, or allowed to flow in by gravity. This can be done through injection ports placed through the bulkheads or through a hole or holes cut into the top of a metal culvert pipe, behind the bulkhead. The grout may flow into the annular space though these holes, on one end or in both ends of the culvert.

Length and Slope of Culvert

Elevation is normally used (provided there is less than a ten foot elevation change) to provide static head pressure for grouting short runs of pipe up to sixty to eighty feet in length, depending upon the flow rate of the grout. As the length of pipe increases, the amount of pressure required for grouting the annular space may also increase.

Measure the elevation change and the total distance between the inlet and the outlet and determine the total length the grout must flow. This information will help in the selection of the grout, affect the number of fill or vent tubes, and influence the method of grout injection.

Existence of Corrosion Holes or Separated Joints

If either of these factors is observed during the culvert investigation, the possibility exists that there are voids in the soil bedding around the original culvert structure. An additional volume of grout will be required, beyond the calculated annular space volume, to fill these voids. An estimation of this additional volume (10%, 20%, etc.) should be made at this point. If corrosion or separated joints have created obstructions along the ID of the pipe, these obstructions should be removed to prevent interference during the sliplining process.

Blocking

As discussed before, flotation of the liner is of concern when a liner is to be grouted or there is ground water present. To prevent flotation, using blocks or skids around the pipe can center the Snap-Tite® culvert liners. Blocks or skids are typically installed in a staggered pattern. Spaces are left between the blocks or skids to allow grout to flow under and around the liner.

Blocks are installed in the top 120 degrees of the culvert. For culverts 48" in diameter or larger, blocks are attached to the old culvert. The first block is often installed at 11 o'clock, and then a space of four feet is left before the second block is installed at the 12 o'clock position. Then a space is left and the third block is installed at 1 o'clock. These blocks are usually four to eight feet in length. The thickness is determined by the difference in the ID of the culvert and the liner. The upper skids must have structural strength adequate to resist the buoyant force created as the liner is grouted in place. Wood and solid plastic will work. Styrofoam does not have adequate compressive strength to work for many liner sizes.

To prevent the Snap-Tite® liner from moving off-center during the grouting operation, grout may be placed in a staggered sequence, using multiple grout injection points on each side of the liner. This will help assure an even distribution of grout on both sides of the Snap-Tite® pipe.

Blocking can also be used to bridge any gaps created by separated joints in the existing host pipe. This can help to prevent the Snap-Tite® liner from catching on the gaps in the disjointed sections, and aid in the sliplining process.

<u>Vent Ports</u>

Vent ports should be located at strategic positions though the bulkhead or in the top of the host pipe, depending on the site conditions. A minimum of one vent port, in addition to the grout injection ports, is recommended, unless the grout is inserted into the annular space

through a hole large enough to serve as both. Vent ports help to prevent pressure buildup in the annular space and also serve as grout verification points. Preparations must be made to adequately close off the opening once grout begins to flow out of the area. A vent port placed at the bottom of the bulkhead will help drain water that may exist in the annular space during the grouting operations.

<u>Bulkheads</u>

The purpose of the bulkhead is to retain the grout within the annular space until hydration occurs and the grout material hardens. Many different materials can be used to accomplish this task, such as a low-slump concrete mix, a stiff grout mix, wood, Oakum water-activated urethane rope, soil, etc. The conditions at the site, the type of grout selected, and what substances are available at the time will dictate what bulkhead material is best for an application.

<u>Grout Injection</u>

Grout should be placed into the annular space slowly and patiently. The material must be

given time to flow along the pipeline and run out though any holes that may be in the host pipe, or through separated joints in the line.

When possible, gravity should be used to place grout into the annular space. A low density or cellular grout material will flow along the space, exiting out through holes in the host pipe, or separated pipe joints, and replace lost bedding soil around the host pipe. Once the voids are filled, the grout will continue to flow down the pipe length and slowly fill the annular space between the liner and host pipe. Again, patience is critical with the grouting operation.

Grout pumping may be necessary in some applications. The pump pressure is used to move the grout from the mixing tank, through the injection port, into the annular space. For long culverts, multiple sections of injection pipes in varying lengths can be used to place the grout further into the culvert to efficiently fill the space.

At the point where the grout exits the injection pipe, the pressure quickly dissipates to zero. If a back pressure is noted by the pump operator, the pumping should immediately be stopped. Many pump truck pressure gauges don't have the sensitivity to perceive a low-pressure (2 psi). Exerting unnecessary pressure within the annular space, on the outside of the culvert liner, can cause unwanted problems, from grout leaking through the joints to a catastrophic collapse of the liner pipe. Although this occurrence is rare, careful planning, patience, and close observation should be used during the grout injection operation to help mitigate any potential damage to the liner or the bulkheads.

Grout Verification

As mentioned in the preparation section, grout verification ports can be placed to monitor the grouting operation. Short pieces of pipe can be placed through the bulkheads to serve initially as vent ports for escaping air in the system and later as grout verification ports, during the installation process. When grout begins to flow from these lines, a cap can be placed over the pipe to stop the flow. A verification pipe with a threaded terminating end that extends from the bulkhead can easily be sealed as it will accept a threaded cap to terminate the pipe.

Quality Control & Testing

The primary property to identify for QA/QC is the unit weight or mass of the grout that is being placed. The density (unit weight) of the material has a greater effect on the performance of the culvert rehabilitation than the compressive strength value of the grout.

Practically any grout selected will be stronger when compared by compressive strength than the bedding material around the host pipe. And this is the material that the grout is intended to replace and serve in its absence.

The equipment required to determine density is a calibrated unit weight bucket, a tool to strike off or level the surface, and a scale. Testing, ASTM C138, of the mix prior to insertion into the annular space of the sliplined culvert is needed.

The density (unit weight) of the material has a greater effect on the performance of the culvert rehabilitation than the compressive strength value of the grout. Practically any grout selected will be stronger than the bedding material around the host pipe. This is the material that the grout is intended to replace and serve in its absence.

Grout can be seen exiting from the PVC port

Trouble Shooting Bulkhead leaks

When grouting the annular space of a sliplined pipe, the grout is placed within a closed space and exerts pressure on the bulkheads of end walls constructed at each end of the culvert. The best prevention against bulkhead leaks is to construct an end wall strong enough to withstand the internal hydrostatic pressure exerted on it by the grout. A bulkhead with a thickness of 18” to 24” is typically adequate for most culvert relining projects.

If a cementitious material, be it a concrete mix or a stiff grout mix, is used for the end walls, then drying/shrinkage of the material is a concern. To protect against grout leaks in this instance, a quick-set, non-shrink grout material should be on site on the day of the grouting operation.

A preventive maintenance procedure is to apply this material in a thin layer over the cured bulkhead or end wall prior to starting the grouting operation. This material typically sets in15 minutes and will help plug any cracks in the bulkhead or gaps between the end wall and grout insertion tubes and vent ports.

Material Sources

Grout Supplier

A concrete ready mix supplier, or batch plant, local to the project site is a source for the grout and for a material that can be used to construct the culvert bulkheads. These facilities have supplies of cement, sand, and water as well as the equipment to measure and adequately mix the components. A mix design may be submitted to the batch personnel to assure a material with appropriate density is obtained.

In some locations, grouting contractors are available that have all-inclusive units and can provide appropriate grout mixtures, as well as pumping apparatus, to place the grout into the culverts. These contractors are skilled in all types of grout needs and should serve the project well. Similar services can be additionally obtained directly through ISCO and our Snap-Tite® division. Your Snap-Tite® representative can assist you with obtaining grouting services from ISCO.

Admixtures

There are numerous manufacturers of chemical admixtures utilized in grout formulation. The admixtures include macro air-entraining agents, retarders to delay the hydration of the cement in the mix, and foaming agents to inject increased volumes of air into the grout mix. Cellular concrete or “foamed” concrete mixes use wetting agents as a type of admixtures.

There are also many regional manufacturers for foaming agents, such as Vermillion & Associates, Cellular Concrete Solutions, Cellular Concrete Technologies and Elastizell. Many of these companies can also provide foam generation equipment for use in creating cellular grouts. The admixture manufacturer should be contacted for support on proper use of their specific foaming agents.

There are chemical admixture manufacturers that distribute nationwide, such as BASF (Master Builder's product line) and W.R Grace. Rheocell Rheofill, manufactured by BASF, is a ready-to-use, self-contained product for use in various flowable fill applications where a limited reduced density grout may be desirable. Direct contact with the chemical admixture manufacturer is recommended when these additive packages are selected for grout formulation.

Grout Pump Equipment

The pumping apparatus best suited for grouting annular space should be rotor/stator or squeeze pumps. Other pump types, such as piston pumps, can be used but these may force some of the air out of the grout mixture. With less air in the mix the resulting density will increase.

Mix designs

The mix design for grout used to fill the annular space created in a Snap-Tite® culvert lining project will vary depending on the type of grout selected for the application, i.e., flowable fill, reduced density flowable fill, or cellular grout.

Flowable Fill

As stated earlier, flowable fill is comprised of a mixture of cement, sand and water. A portion of the cement may be substituted with fly ash, and chemical admixtures may be used to affect certain properties of the mix.

Different sources of materials will have an impact on the specific gravities of the materials. This is especially true with sand and fly ash. The specific gravity value of the material is used to calculate its absolute volume in the mix. The volume value is used to calculate the total yield of the batch. The quality control manager for the ready-mix supplier can help formulate a flowable fill mix based on their specific materials.

Reduced Density Flowable Fill

To reduce the density of a flowable fill an admixture may be considered by the owner or installing contractor for incorporation into the grout formulation mix. Two such admixture products are Rheocell Rheofill, manufactured by BASF, and DaraFill, produced by Grace Construction Products.

The addition of the specialty, density-lowering admixture is made at the mix plant or at the jobsite depending on product being used. The admixtures are added directly into the concrete mixer after batching. They are designed to generate air contents from 15% to 25% in the grout mix. Typically these grouting mixtures exceed a density of 100 lb/ft^3.

Cellular Grout

Cellular grout may be produced with a grout mixture containing sand, cement and water or with a mixture of cement and water only. In both cases a portion of the cement may be replaced with fly ash to reduce the cost of the grout.

The addition of the liquid foaming agent is made at the jobsite. The foam is manufactured using an air-foaming generator and dispensed directly into the concrete mixer. To determine the amount of foaming required, unit weight measurements should be taken until the desired unit weight of the grout mix is obtained.

It is unlikely that a cellular grout can be manufactured with a density below 100 lbs/ft^3 if a foaming generator is not used in the formulation process.

Table 7-2
Cellular Grout Mix - 40 lb/ft³ using Foam Generator

Component		Units	Weight (lbs)	Volume (Yd³)
Type III Portland Cement	6,950	lbs	6,950	1.4
Water	418	Gallons	3,488	2.0
Foam	179	Cu./Ft.	716	6.6
		Mix Totals	11,154	10.0
		Net Wet Cast Density =	**41.3**	**lb/ft³**

Foam Instructions

Component	
Varimax HS-320	61.71 Oz
Water	82.87 Gallons

Mix together and run through foam generator for 8 minutes and 8 seconds.

Table 7-3
Cellular Grout Mix - 55 lb/ft³ using Foam Generator

Component		Units	Weight (lbs)	Volume (Yd³)
Type III Portland Cement	9,700	lbs	9,700	1.8
Water	584	Gallons	4,877	2.9
Foam	143	Cu./Ft.	572	5.3
		Mix Totals	15,149	10.0
		Net Wet Cast Density =	**56.1**	**lb/ft³**

Foam Instructions

Component	
Varimax HS-320	49 Oz
Water	66.2 Gallons

Mix together and run through foam generator for 6 minutes and 30 seconds.

Table 7-4
Cellular Grout Mix - 70 lb/ft³ using Foam Generator

Component		Units	Weight (lbs)	Volume (Yd³)
Type III Portland Cement	13,368	lbs	13,368	2.5
Water	805	Gallons	6,720	4.0
Foam	95	Cu./Ft.	380	3.5
		Mix Totals	20,468	10.0
		Net Wet Cast Density =	**75.8**	**lb/ft³**

Foam Instructions

Component	
Varimax HS-320	35.75 Oz
Water	43.98 Gallons

Mix together and run through foam generator for 4 minutes and 51 seconds.

[1]Mix Ratios provided by Vermillion and Associates.
[2]Construction Specifications are available on www.culvert-rehab.com