NATIONAL CORRUGATED STEEL PIPE ASSOCIATION **ISSUED: June 2006**

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Technote

NCSPA Technical Notes are prepared by the NCSPA Technical Advisory Committee to provide up-to-date technical information about drainage structures and their proper use and application. User comments or questions are welcome. ■ *Technical Notes are not intended for detailed design purposes.*

Corrugated Steel Pipe Backfill Alternatives

GENERAL

Corrugated steel pipe is a flexible conduit and is structurally dependent upon the backfill selected and placed around it. This Technote supercedes CSP STRUCTURE BACKFILL ALTERNATIVES, August, 1987, distributed by the National Corrugated Steel Pipe Association (NCSPA). Technote No. 204 will provide guidance to the engineer or designer on alternative backfill materials that can provide competent quality.

BACKFILL ALTERNATIVES

Requirements for selecting and placing backfill material around and near the conduit are similar to those for selecting a roadway embankment fill. The main differences in requirements is that the conduit generates more lateral pressure than would the earth within the embankment if no structure existed. The backfill material must be placed and compacted around the conduit without distorting its shape beyond acceptable limits. However, in the end, the quality of the backfill may be dictated by the need to support the pavement over the conduit.

The quality of the backfill depends on its stiffness, which results from the nature of the material itself in combination with its degree of compaction. The best backfill materials are non-plastic sands and gravels (GW, GP, SW, SP, etc.) compacted to a minimum 90 percent of their standard Proctor density. The use of these, or other clean, well graded materials, not only provide excellent pipe support but reduces the compaction effort required to achieve density.

Often, the backfill material may be selected from the available materials at hand. Highly plastic or organic soils are unsuitable. However, materials with some degree of plasticity (SM GM, etc.) can be used in most instances. The stiffness of corrugated steel pipe allows these materials to be placed and compacted to the density necessary to support the pipe. For hydraulic structures, if the backfill trench wall or embankment materials contain fine sands or silts, an appropriately graded backfill material is necessary to control soil migration or piping. Alternatively, soil migration can be controlled by using a geotextile fabric as a separator.

The height of final soil cover, as well as the stiffness of the pipe itself, dictate which materials are suitable. The soil load that must be carried by the pipe often depends upon the quality (stiffness) of the backfill. Higher covers dictate better backfill materials that not only reduce the loads on the pipe, but also provide better support and improved structural strength.

As the cover increases, the choice of backfill materials becomes more important. The American Association of State Highway and Transportation Officials (AASHTO) allow corrugated metal pipes to reach their full design strength when backfill materials meet AASHTO M 145 requirements for A1, A2 or A3 materials, compacted to a minimum 90 percent of their standard proctor density. Table 1 provides a comparison of AASHTO and the Unified Soil Classification system.

TABLE 1 Soil Types by USCS and AASHTO Classifications

USCS Soil Classification	AASHTO M 145 Classification		Description
	Group	Subgroup	
	A1		
GW GP SP		A1-a	Well graded gravel
GM SM SP SM		A1-b	Gravelly sand
	A2		
GM SM ML SPGP		A2-4	Sand and gravel with low plasticity silt
SC GC GM		A2-5	Sand and gravels with elastic silt
SC GC		A2-6	Sands with clay fines
SC GC		A2-7	Sands with highly plastic clay fines
SP SM SW	A3		Fine sands, such as beach sand
ML CL OL	A4		Low compressibility silts
MH OH ML OL	A5		High compressibility silts
CL ML CH	A6		Low to medium compressibility silts
OL OH CH MH CL	A7		High compressibility silts and clays
PT OH	A8		Peat and organics not suitable as backfill

As pipes get larger and become more flexible, the choice of materials and degree of compaction becomes more important. The backfill must be compacted sufficiently to provide the necessary pipe support. Well-graded (densely graded), clean, non-plastic materials compact more easily. Because their jagged shape provides a degree of mechanical lock between the particles, angular materials such as crushed rock typically offer excellent support with relatively minimum compaction efforts. Round or subround material can be used provided the installer can compact sufficiently to provide the necessary pipe support.

A typical specification for pipe backfill under highway pavement may read:

> Backfill material to a distance of 12 inches above the pipe shall meet the requirements of AASHTO M 145 for A1, A2 or A3 materials. It shall be placed in 8 to 12 inch lifts and compacted to 90% standard Proctor (90% AASHTO T 99) density.

All state Departments of Transportation have backfill specifications for the use of CSP under roadways. They recognize local conditions and will provide guidance for the engineer.

The required trench width or the minimum backfill width in a normal highway embankment depends on the backfill material and the compaction equipment used. In trench installations, the backfill must extend from trench wall to trench wall. In sound trench conditions or highway embankment applications, the backfill only needs to be wide enough to allow the material to be placed under the haunch and compacted to the specified density. While trench widths often call for two feet on either side of the pipe, crushed stone and flowable gravels can be placed in a narrower width. Round or subround aggregates have been used successfully under limited fill height conditions and when measures are implemented to assure that the material is adequately confined and compacted. Rounded materials can typically attain specified density through use of concrete vibrators or other vibratory equipment. ASTM A 798, covering the installation of corrugated steel pipe, points out that cementitious slurries and foam materials can be placed with a spacing as narrow as 6 inches. While cement stabilized sand provides excellent support, it must be used in a width adequate to allow it to be placed and compacted.

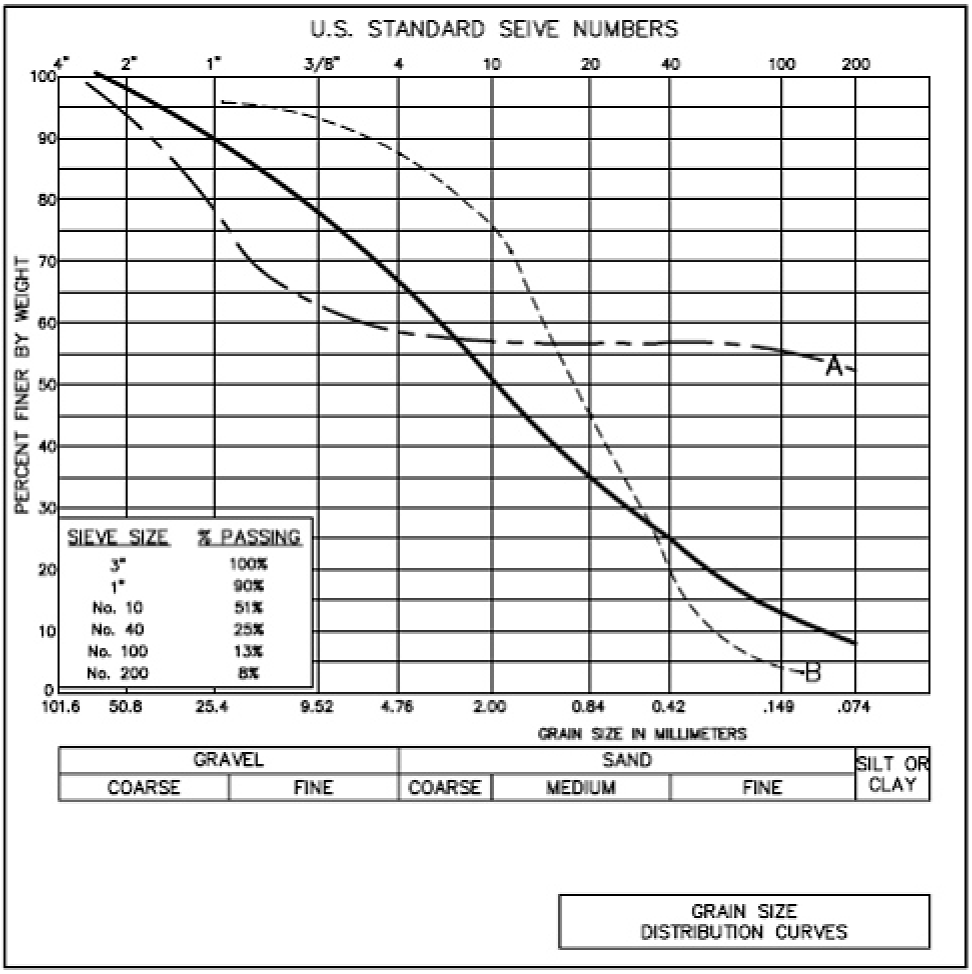
Unlike in concrete and other rigid pipes, steel pipes are often designed to carry the soil prism above the pipe. There is no concern that excessively wide trenches increase the load on the pipe.

Backfill typically extends to 12-inches above the pipe.

Spiral rib pipes actually assume three installation types. These include the standard embankment and trench conditions as Type I and II as well as Type III, a trench installation using only special, easily compacted, backfill materials.

When the designer is determining the acceptability of available backfill materials, one method of evaluating the gradation of a granular sil is to plot its sieve analysis results as shown in the semi-log plots of Figure 1. The slope and shape of the resulting curve describes the gradation.

FIGURE 1



The solid line in Figure 1 indicates a well graded granular material. The approximate 1:! (45 degree) slope indicates a material that is well graded. This slope indicates that the material contains approximately the same of material for each particle size across the range. This material is considered clean since it contains less than 10% silt or clay (less than 10% passing the #200 sieve) and consists primarily of sand and gravel. This gradation size and range provides a high density material that is often referred to as densely graded.

In Figure 1, Plot A would indicate a mixture of gravel and clay or gravel and silt. The curve initially slopes downward from the left at approximately a 45 degree angle, indicating that this portion is fairly well graded. However, beyond this point the plot becomes level, indicating that materials in this particle size range (#4 to #200 sieve) are not present. This shows that there is little or no sand in the material. Everything passing the #200 sieve (about half the material in this example) is either clay or silt. Materials similar to those in Plot A are called gap graded due to the large "gap" in the solid particle sizes in the mix. The more vertical the slope of the plot, the more limited the particle size range. Common beach sand, classified by AASHTO as an A3 material, typically consists of 0.074 to 0.149 mm (#100 to #200 sieve size) particles. Its gradation plots as a near vertical line between these two adjacent sieve sizes.

The more vertical the slope of the plot, the more limited the particle size range. The third plot (labeled as material B) indicates a clean sand material containing little clay or silt. The sieve analysis indicates that only about 10% is retained on the #4 and larger sieves (gravel particle sizes), while about 5% passes the #200 sieve (comprised of clay or silt). Thus, about 85% of this material is fine to course sand. Since the slope of the curve does not approach a 45 degree angle, this material is not as well graded. However, because it has a relatively broad particle size range, this material is a sand that is much easier to compact than some others sands.

Beach sand, classified by AASHTO as A3 materials, typically consists of 0.074 to 0.149 mm (#100 to #200 sieve size) particles. Its gradation plots as a near vertical line between these two adjacent sieve sizes. Because the particles are nearly all the same size, these materials can not achieve the density and do not compact as easily as better graded materials.