Saturday, January 11, 2003

Hancor Design Aids Section

Products
Markets
Design Aids
Ducks Unlimited
Ordering
About Hancor
Contact Us
Monthly Drawing
Featured Products
Case Studies
Installation Video
Co-op Advertising
Hot News

2-3 DESIGN CRITERIA – Installation Conditions and Soil Factors

The structural performance of pipe depends on the interaction between the embedment, or backfill envelope, and the pipe, and is commonly referred to as pipe/soil interaction. The backfill envelope must provide structural and drainage characteristics appropriate for the application. Structural considerations of the backfill include the type of material and compaction level, dimensions of the backfill envelope, and native soil conditions. The information presented here is, with few exceptions, consistent with requirements established in ASTM D2321 “Recommended Practice for Underground Installation of Flexible Thermoplastic Sewer Pipe.” Additional information regarding dimensions of the backfill envelope and native soil considerations are discussed in more detail in Section 6.

The type of material (sand, gravel, clay, etc.) and compaction level (standard Proctor density) determine overall strength of the backfill. As a general rule, material particles that are relatively large and angular require less compaction than particles that are smaller and rounder to produce structures having equal strength.

The strength of the backfill can be described using different parameters. One way is by describing it in terms of the modulus of soil reaction (E’), which is an empirical value developed by the Bureau of Reclamation to calculate deflection. Table 2-3 presents the E’ values that result from different materials and compaction levels. Another parameter used to describe backfill strength is the secant constrained soil modulus (M_S). Although this property can be measured in the laboratory, values appropriate for design are shown in Table 2-4. This value must be used in the wall thrust calculations.

The native soil and other locally available materials should be considered for backfill. If they meet the criteria of Table 2-3 and Table 2-4, they may be acceptable materials and should be considered to minimize material and hauling costs. When in doubt about the appropriate material to use in an installation, consult a Hancor engineer.

Mechanical compaction is not always necessary; some backfill materials can be dumped and others can meet minimum compaction criteria simply by being walked over. On the other hand, mechanical compaction can make placement of some backfill materials much faster. Additional information regarding the types of mechanical compactors available and the soil types with which they work best is located in Section 6.

Another backfill material that has gained in application over the past few years is flowable fill. This material is similar to a very low strength concrete. It is poured around the pipe and hardens to form a structure with an estimated E’ and M_s value of 3000 psi (20,700 kPa) within two days and 25,000 psi (172,000 kPa) after seven days. In order to take advantage of the strength of this material, the width of the trench should be at least twice the pipe diameter and the E’ of the native material must be at least 1000 psi. The major disadvantages of this material are that it can be very costly both in terms of material costs and installation time, and it will cause the

pipe to float if precautions are not taken. Properly designed and installed, however, it can be used as an alternative to typical granular backfill. Hancor engineers and some textbooks can provide additional guidance in the use of this material.

Table 2-3
Modulus of Soil Reaction, E'

Table 2-4
Secant Constrained Soil Modulus, M_S

The way the pipe is seated into the bedding also influences pipe behavior. The bedding constant term, K, is used to account for the support that the bedding is providing to the pipe. It is a function of the bedding angle as shown in Figure 2-1. Table 2-5 lists bedding constants for various bedding angles. Very commonly, a value of 0.1 is assumed in design.

Figure 2-1 – Bedding Angle

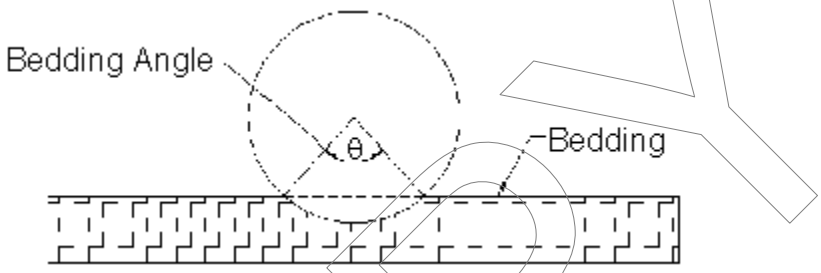

Table 2-5 – Bedding Constants, K

Bedding Angle, degrees	Bedding Constant
0	0.110
30	0.108
45	0.105
60	0.102
90	0.096
120	0.090
180	0.083

Another soil property used in design, the shape factor (D_f), is a function of pipe stiffness, type of backfill material, and the compaction level. The shape factor relates deflection and bending behaviors. Table 2-6 lists shape factors for a variety of typical installation conditions.

Table 2-6 – Shape Factors, D_f

	Gravel GW, GP, GW-GC, GW-GM, GP-GC and GP-GM (includes crushed stone)			Sand SW, SP, SM, SC, GM, GC or mixtures
Pipe Stiffness, PS (1) pii (N/m/mm)	Dumped to Slight (< 85% SPD)	Moderate to High (↵ 85% SPD)	Dumped to Slight (< 85% SPD)	Moderate to High (↵ 85% SPD)
14 (97)	4.9	6.2	5.4	7.2
16 (110)	4.7	5.8	5.2	6.8

18 (125)	4.5	5.5	5.0	6.5
20 (140)	4.4	5.4	4.9	6.4
22 (150)	4.3	5.3	4.8	6.3
28 (195)	4.1	4.9	4.4	5.9
34 (235)	3.9	4.6	4.1	5.6
35 (240)	3.8	4.6	4.1	5.6
40 (275)	3.7	4.4	3.9	5.4
42 (290)	3.7	4.4	3.9	5.3
50 (345)	3.6	4.2	3.8	5.1

Notes: 1. Interpolate for intermediate pipe stiffness values.
2. For other backfill materials, use the highest shape factor for the pipe stiffness.
3. Modified from AWWA Manual M45, p. 42.