Uniform Soil Groups For Pipe Installation

The language in pipe installation specifications should be as clear, concise and consistent as possible. The engineer often relies on American Water Works Association (AWWA) and American Standards of Testing and Measurement (ASTM) standards and manuals to prepare the project documents. However, there is currently little agreement between these publications as to terminology for soil groups for pipeline construction. When describing soils for use in pipeline installation, the various ASTM standards and AWWA manuals all use different tables of soil categories and different names for the soils in the categories.

The following example illustrates the confusion that different terminology may create. Pea gravel is a common material used for pipe installation. In general, pea gravel is gravel particles about the size of peas (3/8 inch). If a designer wanted to specify pea gravel for a project involving different types of pipe and use current AWWA manuals and ASTM standards, the project specification would have to resemble the following:

"PVC sewer pipe embedment shall be Class II soil. The concrete pipe storm drain shall be embedded in Category I soil. Install the ductile iron water pipe in Type 4 laying condition. Steel pipe shall be embedded with coarse-grained soils with little or no fines. The PE storm drain embedment shall be Class II soil. Clay pipe shall be embedded with Class II material. Embedment for CMP shall be structural backfill. The low-head concrete pipe shall use granular soil with less than 5 percent fines. The embedment for the pre-stressed concrete cylinder pipe shall be compacted back-fill material free from large clogs or rocks.”

In this specification paragraph, pea gravel is referred to with seven different terms (shown in bold). This complicates the specifications, confuses the contractor, and burdens the inspector.

Jane the designer has to refer to seven different soil descriptions in 10 different standards to see how to refer to the soil. As a result, the one soil type would have to be described seven different ways in her written specifications.

Joe the contractor wants to bid on the project. However, he is from an adjoining state and is unfamiliar with the soils locally available for the project. He may assume that seven different soil types are required and bids accordingly. He may also assume that different types of soil compactors are required when actually only one method of compacting the soil is needed.

Jack the inspector has to have 10 different standards available so he can check to be sure the right soil is being used for the embedment material for all the different pipe types.

Jane, Joe and Jack have all wasted time and money describing, bidding and checking one soil type. Life for Jane, Joe and Jack would be much simpler if only one soil categorization system was used for all the pipe types. Time and money would be saved. More importantly, a uniform system for all pipe types could lead to a better understanding and communication about what the job requirements are.

The specifications and project manuals may be simplified by using consistent language in the installation standards. There should only be one method to describe the soils, such as the Uniform Soil Group table as shown in Table 1. This table is based on soil stiffness and is applicable for all types of pipe. The system has been recently adopted into several ASTM standards and AWWA manuals. Efforts are currently underway to amend other standards accordingly.

Using the recommended soil groups, the above specification paragraph would simply say: “The embedment soil shall be Class II material.”

The groups in Table 1 are based on the soil properties when the soil is compacted. The strength or stiffness of the embedment varies with the grouping (Howard 2009).

<table>
<thead>
<tr>
<th>Class</th>
<th>Crushed rock</th>
<th>Clean sands/gravels</th>
<th>Silty/clayey sands/gravels</th>
<th>Silts and Clays</th>
<th>Highly plastic/compressible silts and clays, organic soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>100 percent passing 1-1/2-in sieve, ≤ 25 percent passing 2-1/8-in sieve, ≤ 15 percent passing No. 4 sieve, ≤ 12 percent fines</td>
<td>GW, GP SW, SP</td>
<td>GM, GC SM, SC</td>
<td>ML, CL</td>
<td>MH, CH OL, OH, Pt</td>
</tr>
<tr>
<td>II</td>
<td>any soil beginning with one of these symbols (can contain up to 12 percent fines) (Note 1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Sandy or gravelly silt/clay with ≥ 30 percent retained on No. 200 sieve</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Silts and Clays with &lt; 30 percent retained on No. 200 sieve</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Uniform Soil Groups

Notes:
1. Uniform fine sands (SP) and SP-SC (SP-SM) with more than 50 percent passing a No. 100 sieve shall be treated as Class III material.
2. Soil classification in accordance with ASTM D 2487 or D 2488.
3. Fines are soil particles that pass a No. 200 sieve.
4. Class I: crushed rock particles shall have all fractured faces.
5. Recycled concrete, slag and shells should be considered Class II.

Class I is the stiffest soil when compacted, and Class V is the least stiff. Class I provides the best support for pipe, and Class V the least. The percent of fines (silt and clay) increase with class number.

Typically, as the amount of silt and clay in a soil increases, the stiffness decreases.

The crushed rock designation for Class I is a common expression for a processed construction material that is the result of crushing cobbles, gravel, or boulders. For Class I, the particles should be between ¾-inch and 1½-inch in size. Fractured faces provide the maximum interlocking of particles.

Class II contains clean, cohesionless sands and gravels such as GW, GP, SW, and SP. Class II also includes the dual symbol soils that begin with one of these symbols, such as SP-SM. So this group includes soils that contain up to 12 percent fines. These soils are predominantly cohesionless so they are best compacted using vibration. However, Poorly Graded Sands (SP) (SP-SC) (SP-SM) that are primarily fine sand (more than 50 percent pass the No. 100 sieve) can be extremely difficult to compact and should be considered a Sandy Silt (ML), a Class III material, if they are used as pipe embedment. At high moisture levels, the soil may pump (move around like jello) and be hard to compact. Fine sand consists of particles that pass the No. 40 sieve and may be described as table salt or sugar size.

Class II would also include broken shells, slag and recycled concrete. Recycled concrete should have less
than 5 percent waste metal and should not have any debris, toxic or deleterious material.

Class III soils are sands and gravel that contain 13 to 49 percent fines. The soils are:
- GM Silty Gravel
- SM Silty Sand
- GC Clayey Gravel
- SC Clayey Sand
- Class III also includes silt and clay soils that contain 30 to 70 percent sand and/or gravel. These soils are:
  - ML Sandy Silt
  - CL Sandy Lean Clay
  - ML Gravelly Silt
  - CL Gravelly Lean Clay

Altogether, Class III includes soils that have from 13 to 70 percent fines. Although these soils have significant amount of fines, the sand and/or gravel acts as rebar resulting in much higher stiffness than Class IV.

Class IV soils are silts and clays that contain less than 30 percent sand and/or gravel. These soils would be:
- ML Silt
- CL Lean Clay (And the dual symbol soil CL-ML, Silty Clay.)

Class V soils are not suitable for pipe bedding or embedment because these soils are difficult to compact. Class V should also not be used as compacted backfill under pavements for roads or parking lots. They may be used as uncompacted backfill and the organic soils used as topsoil. These soils include:
- MH Elastic Silt
- OH Organic Clay
- CH Fat Clay
- OL Organic Silt
- Pt Peat

To date, the ASTM standards that use the Uniform Soil Groups include:
- C 12, Standard Practice for Installing Vitrified Clay Pipe;
- D 2321 Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications;
- D 2774 Standard Recommended Practice for Underground Installation of Thermo-Plastic Pressure Piping; and
- D 3839 Standard Practice for Underground Installation of Fiberglass (Glass Fiber Reinforced Thermosetting Resin) Pipe

Also, the AWWA manual uses the Uniform Soil Groups: M45 Fiberglass Pipe Design Manual, 2nd Edition.

Unnecessary complexity and confusion can lead to poor construction and future pipe failures and leaks. If you think Uniform Soil Groups would promote better pipeline installation, ask your firm or agency to start including them in their specifications, and encourage the ASTM and AWWA committees to adopt their use.

REFERENCES
ASTM D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2488 Description and Identification of Soils (Visual Manual Procedure)

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