‘Self-Compacting’ Soils

February 2016, Vol. 71 No. 2

Similar to an urban myth, the words ‘self-compacting’ soils have unfortunately taken on an aura of acceptability. Clean gravels and crushed rock are sometimes referred to as “self-compacting,” meaning that if they are dumped in beside a pipe, the material will have a high density. Owners, engineers, contractors and inspectors have been known to use this expression. Some even claim that dumping in gravel and crushed rock will result in 95 percent compaction meaning that the density of the dumped soil is 95 percent of the maximum density for that soil. In reality, the dumped density is only about 80 percent of the maximum density. The support for a buried pipe depends on the embedment soil stiffness. The stiffness of dumped soil is typically less than half of the stiffness of compacted soil.

Claims of “self-compacting” can be verified. The in-place density can be measured and compared to a laboratory maximum density. There are two tests to determine the maximum density of clean gravels and crushed rock:

ASTM D 4253 Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory
Table; and (Preferred) ASTM D 7382 Test Method for Dry Density of Granular Soils Using a Vibratory Hammer.

The dumped density will be about 80 percent of the maximum density because typically the density will be close to the minimum density of the soil. The dumped density can even be compared to the laboratory minimum density. Yes, there is a test to measure the minimum density: ASTM D 4254 Test Methods for Minimum Index Density of Soils and Calculation of Relative Density.

The dumped in-place density will be close to the minimum density laboratory value since the soil is placed loosely in both cases. Several sources have compiled data on the laboratory minimum density of a soil and the laboratory maximum density of the same soil. The data show that the minimum density is generally 75 to 85 percent of the maximum density with 80 percent being a representative average. These studies are discussed in the Technical Note “Self-Compacting Soils” – Not! on the download page on the website Pipeline-Installation.com. Applied to pipeline installation, dumped gravel around a pipe is more likely about 80 to 85 percent of the maximum density.

Note that laboratory vibratory tests are used to determine the maximum density. As stated in their ASTM standards, standard and modified Proctor tests are not applicable for gravels and crushed rock.

In all of the pipe installation manuals/standards/documents published by AWWA, ASTM and ASCE, there is no mention of dumping soils to get a high density. Neither is there any such mention in any of the pipe installation guides published by the pipe trade associations. The author has not found any technical data published that demonstrates that gravel is densified by dumping. However, there are numerous claims in Internet discussion boards by some that gravels are “self-compacting,” but geotechnical engineer contributors generally disagree.

The amount of soil support for buried pipe is directly related to the stiffness of the soil. Increasing the density of gravels from 85 percent of their maximum density to 95 percent can easily double the stiffness.

**Stiffness**

Recent large scale compression tests on crushed rock and gravel have demonstrated that the stiffness (e.g. modulus of deformation, constrained modulus) can easily double when the density increases from 85 to 95 percent compaction (Gemperline and Gemperline 2011). This increased soil stiffness reduces the settlement beneath a loaded structure, reduces the deflection of buried flexible pipe, and increases the support of haunch embedment for rigid pipe.

Other published comparisons of stiffness (or strength) show increases up to 600% when cohesionless soils, such as gravels, are compacted to high densities (Howard 2006). In the American Concrete Pipe Association (ACPA) Design Data No. 9, the bedding factor for concrete pipe more than doubles when the gravel density goes from uncompacted to 95 percent compaction. In effect, this doubles the allowable backfill height over the pipe (ACPA 2013).
Installation
The installation design for buried pipe is often based on achieving a high level of soil support. That support depends on the embedment soil being properly compacted. Misconceptions about soil compaction may prevent attaining the necessary pipe support. A new buried pipeline is an investment in our future. That future should be protected by proper installation.

NOTES: Raining cohesionless soils (pluviation) in a laboratory testing is sometimes used to create high densities for research projects. Dumping gravel into a trench, however, is not the same as in a laboratory. In the laboratory, individual soil particles fall vertically without interference onto other particles resting on the surface and the resulting impact results in compaction. This is not the case in the field. Particles that are dumped into place ride, slide, and collide reducing the compaction. Dumped gravel typically impacts the pipe and the trench walls in addition to particles hitting each other. Consequently, the resulting density is substantially reduced.

Self Consolidating Concrete (SCC) is sometimes referred to as self compacting concrete. Self consolidating concrete is an acceptable and valid term for using superplasticisers and stabilisers in a concrete mix to significantly increase the fluidity. SCC does not require vibration. It fills the formwork by means of its own weight without any segregation of the coarse aggregate or void around reinforcement.

Acknowledgements:
1. ASTM D 4253 Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
2. ASTM D 4254 Test Methods for Minimum Index Density of Soils and Calculation of Relative Density
3. ASTM D 7382 Test Method for Dry Density of Granular Soils Using a Vibratory Hammer
4. ACPA (2013) Standard Installation and Bedding Factors for the Indirect Design Method, Design Data No. 9, American Concrete Pipe Association
7. Howard, Amster (2015), Pipeline Installation 2.0, Relativity Publishing

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For more information:
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