

## Compaction Control in Keyholes

### Introduction

Soil compaction control in Keyholes (12 to 18-inch diameter controlled holes in the pavement to access buried utilities) is important to insure integrity of the restored section.

This Technical Note identifies compaction procedures and the technologies that are used for QC/QA of compaction.

### Backfilling

#### Backfill Material

Granular Material as commonly used as a backfill in keyholes. The type and gradation of the granular backfill should be according to the construction specifications and provisions of the highway and should be placed at moisture condition within  $\pm 2$  percent of its Optimum Moisture Content.

The excavated base and/or subbase soils may be reused if they are managed in the site to prevent contamination, and have their moisture condition within  $\pm 2$  percent of their Optimum Moisture Content.

#### Compaction

The backfill material should be placed in lifts with a maximum lift height of 10 inches. The first lift should be placed on the top of a maximum of 4 inch sand cover over of the utility pipe.

The backfill shall be compacted to 95 percent of its maximum Standard Proctor Density as per ASTM D698 (1) , or 90 percent of its Modified Proctor Density as per ASTM D1557 (2), according to the roadway compaction specifications. Compaction may be performed using a Pneumatic Jumping Jack as in Figure 1.



Figure 1- Use of "jumping jack" to compact backfill in keyhole

### Compaction Control

The use of the Nuclear Density Gauge (NDG) in compaction measurements of backfill in keyholes is not appropriate due to the small size of keyholes and boundary effects of the surrounding soil on the NDG measurements; resulting in inaccurate measurements of soil moisture and density (1) (2).

Soil compaction may be measured using the 5-lb Dynamic Cone Penetrometer (DCP) Test according to ASTM D7380 (5) . The number of drops required to drive the cone a distance of 3.25 inches is used as a criterion to determine compaction pass or fail.

The Utility-DCP is a simple device capable of being handled and operated by a single operator in field conditions. It was developed for use by the utility companies for evaluating the compaction of backfill in confined cuts and trenches and in utility pavement restoration work. It is typically used as Quality Control (QC) of layer-by-layer compaction by the construction crew.

The Utility-DCP is used to determine the pass or fail of soil compaction based on the number of

drops of a 5-lb drop-weight which is required to drive the cone a distance of 3.25 inches in the soil. Calibration tests should be performed on the backfill prior to keyhole operation to determine the number of drops which indicates an acceptable soil compaction effort.

An extension rod is commonly used with the DCP in soil compaction in keyhole excavations. The extension allows for monitoring the depth of penetration from the surface when the cone tip is not visible in the keyhole. Figure 2 shows a schematic of the device with the extension rod.

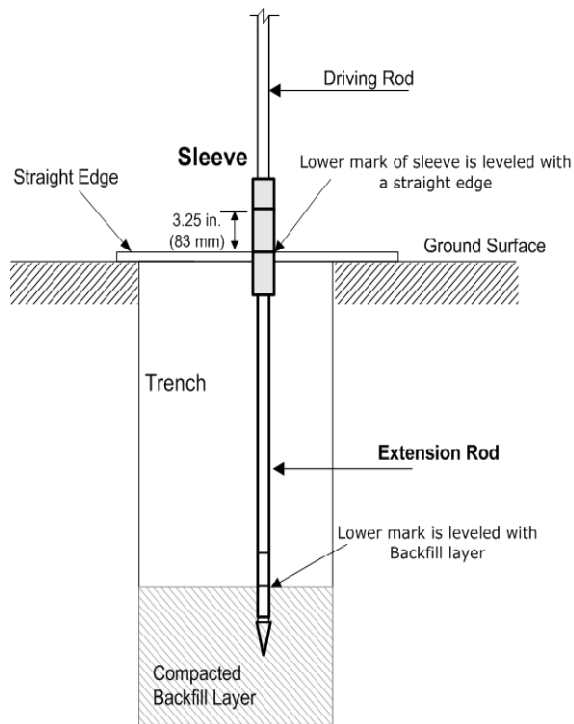


Figure 2 - DCP in the keyhole compaction control

Soil compaction control is also performed using the Soil Compaction Supervisor (SCS). The SCS device consists of a sensor placed at the bottom of the hole and a readout box (Figure 3). The sensor produces a voltage signal in response to the waves transmitted through the soil from the compactor. During compaction, the voltage signal levels off and the device produces a red

signal when soil reaches its maximum achievable compaction.



Figure 3 - Soil Compaction Supervisor

## References

1. ASTM 698, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft (600 kN-m/m))*, 2007.
2. ASTM 1557, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft (2,700 kN-m/m))*, 2007.
3. *Surface Moisture-Density Gauge, Model 3440-Operation Manual*, Troxler Electronic Labs, NC, 2002.
4. *Evaluation of Soil Compaction Measuring Devices*, Gas Technology Institute, Report GRI-04/0067, 2004.
5. ASTM D7380, *Standard Test Method for Soil Compaction Determination at Shallow Depths using 5-lb Dynamic Cone Penetrometer*.