Utility Cut Restoration

A. General

Utility cuts are made in existing pavement sections to install a myriad of utilities and to repair those that experience maintenance needs. Once a utility cut is made in the pavement, the restoration materials and process will have a significant impact on the life of the pavement patch. When a utility cut is made, the native material surrounding the perimeter of the trench is subjected to loss of lateral support. This leads to loss of material under the pavement and bulging of the soil on the trench sidewalls into the excavation. Subsequent refilling of the excavation does not necessarily restore the original strength of the soils in this weakened zone. The weakened zone around a utility cut excavation is called the “zone of influence.” Poor performance of pavements over and around utility trenches on local and state systems often causes unnecessary maintenance problems due to improper backfill placement (i.e., under compacted, too wet, too dry). It has been reported that the life of a utility cut replacement patch is only 2 to 3 years. The costs of repairing poorly performing utility cut restorations can potentially be avoided with a better understanding of proper material selection and construction practices. In addition to the resources spent by the public agency to maintain the pavement patch area, there is a significant impact to the traveling public due to rough streets and the traffic interruptions that occur frequently when maintenance activities are occurring.

The improper use and placement of backfill materials and failure to provide for the loss of lateral support of the trench walls are the primary causes of pavement patch failure.

While planning of utility modifications can be accommodated as part of a larger project, frequently these excavations occur at odd-hours and with no advance notice to repair a facility (i.e., water main break). It is therefore important to plan ahead to help ensure that desirable methods are used to restore utility trenches, even when weather, timing, or other factors may be less than ideal.

B. Background

The Iowa Highway Research Board (IHRB) commissioned two projects focusing on how best to reconstruct utility trenches. The goal of the projects has been to mitigate the negative effects utility trenches have on the surrounding roadway pavement. The two studies are described below.

- IHRB Project TR-503 (2005) Utility Cut Repair Techniques - Investigation of Improved Cut Repair Techniques to Reduce Settlement in Repaired Areas
- IHRB Project TR-566 (2010) Utility Cut Repair Techniques - Investigation of Improved Utility Cut Repair Techniques to Reduce Settlement in Repaired Areas, Phase II

The above reports can be accessed at the following websites:

- www.intrans.iastate.edu
- https://iowadot.gov/research/research/reports-library

The research identified the following problems with current trench restoration methods:

- Large equipment bearing on the trench edges (causing damage to the trench sidewalls and the remaining pavement)

- 2 to 4 foot lifts of backfill material
- Sporadic compaction of the backfill lifts
- Utilizing native, saturated material in the excavation in an attempt to clean the excavation site
- General lack of density and moisture quality control

The research identified three modes of failure for the utility trenches.

- Settlement of utility cut restoration, caused by poor compaction and wet/frozen conditions
- A “bump” forming over the restoration, resulting from uplift or settlement of surrounding soil
- Weakening of the surrounding soils

Many of the studied patches showed signs of failure within 2 years.

C. Factors Affecting Patch Performance

1. **Compaction:** Proper compaction of the non-manufactured backfill material is a critical element of good trench construction. Use of granular backfill has previously been thought of as a means to achieve an acceptable level of trench compaction with a minimal level of effort; however, that is not the case. Even with granular materials, the material should be placed in lifts not exceeding 12 inches in thickness. Each lift of granular material should receive an appropriate level of compactive effort to achieve a minimum relative density of 65%. If cohesive soils are used in the top 2 feet to match existing subgrade materials, the soil should be placed in 8 inch lifts and compacted to 95% of Standard Proctor Density for that soil.

   Backfill materials are often compacted using large compaction equipment, which is placed close to the edges of the cut, resulting in damage to pavement surfaces around the perimeter of the excavation. Note Figure 9D-1.01. It is important to keep equipment away from the edges of the trench.

Figure 9D-1.01: Cracking Pavement Surrounding the Utility Cut Area Because of Construction Equipment Getting Too Close to the Edge of the Open Cut

Source: IHRB Project TR-566

Figure 9D-1.02: Large Lift Thicknesses Used in Utility Cut Trench Backfill Material Placement

Source: IHRB Project TR-566

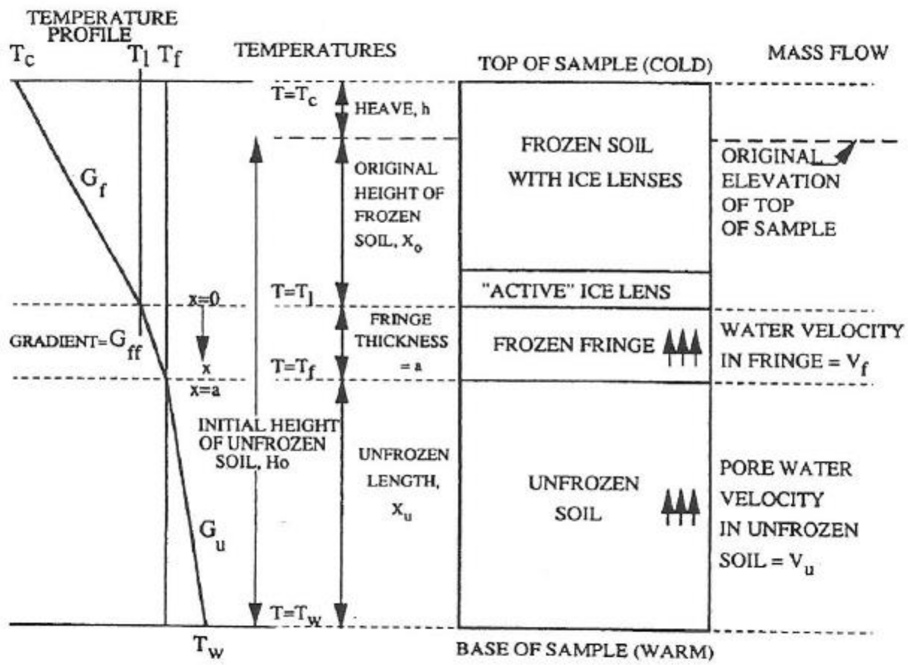
2. **Use of Appropriate Backfill Material:** Class I and Class II backfill material, according to SUDAS Specifications Section 3010, should be used to place backfill material in the trench. The Engineer can change the gradation to meet locally acceptable materials, including crushed concrete pavement. Backfill materials classified as SM (silty sands) or GC (clayey gravel) with less than 35% sand will achieve relative densities of dense to very dense without a significant amount of compaction. In addition to non-manufactured soils, manufactured products such as flowable mortar and controlled low strength material (CLSM) can be used. These manufactured products do not require compaction, but they do cost more.

3. **Frost Heave:** One of the major impacts to trench performance is seasonal effects such as frost heave. Frost is known to cause two main problems. First, frost changes the stiffness of the soil structure during freeze and thaw cycles. As frost forms, the pavement structure stiffens. When frost thaws, the increase in water content in the soil causes the pavement structure to weaken. Second, displacements are caused by the formation of ice lens and the pressure on related structures, which are normal to the growth of the lens.

   As frost forms in a soil, a frozen fringe develops (see Figure 9D-1.03). This fringe develops at freezing temperatures and extends downward. The frozen fringe forms below where an active ice lens is forming. As freezing temperatures penetrate deeper in a soil, the frozen fringe and zone of active lens formation also migrate downward. The active ice lens layer in the soil is also a boundary where the permeability of the soil decreases because the pores begin filling with ice. This boundary prevents water from traveling upward beyond the active lens zone. Because of this, no additional ice lens will form above the active ice lens zone. The downward movement of the frozen fringe affects the size of the ice lens. When the front advances rapidly through a soil, the lens will be thin; however, when the frozen fringe remains at a stationary point because of the heat flow balance, a larger lens will form.

   As ice lenses form, they exert an outward pressure on the pore. When the pressures are greater than the overburden pressures, the soil will heave. The heave (expansion of soil) occurs at the frost line, which is assumed to be at freezing. Frozen soils above the frost line do not expand because there is no influx of moisture.

Figure 9D-1.03: Frost Heave in Idealized One-Dimensional Soil Column



Source: IHRB Project TR-566

Soils do not need to be saturated to experience frost formation. Conversely, when a soil is at freezing temperatures, not all of the water is frozen.

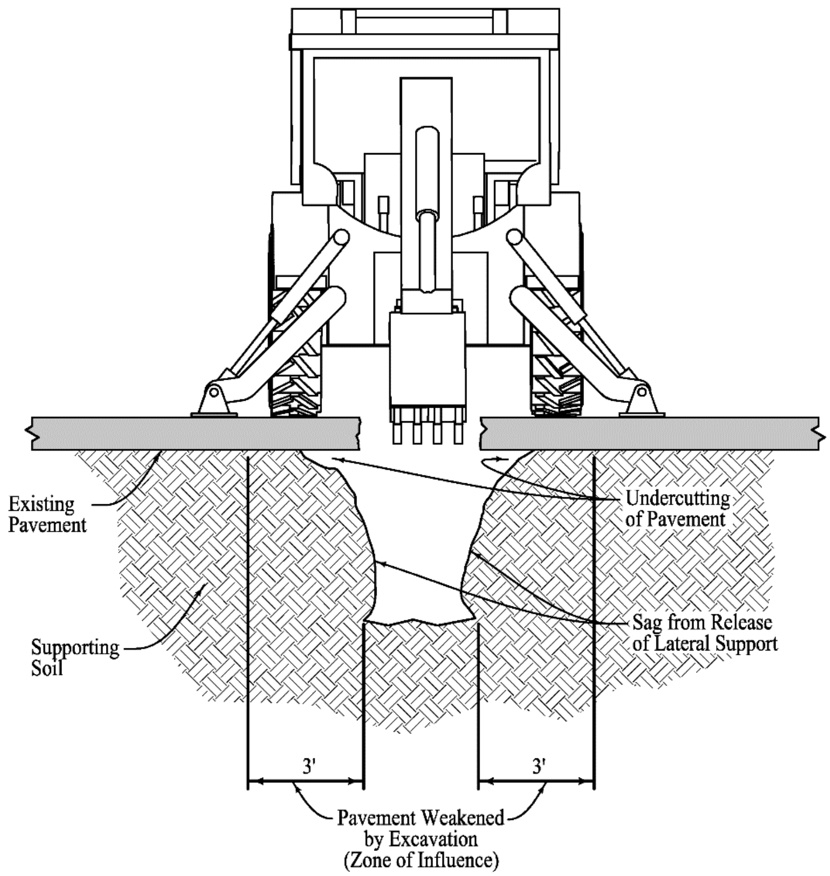
The frost susceptibility of a soil is a function of particle and void size. Gravels have large voids and large particles. This allows water to flow freely through the soil. When water does freeze in gravel, the void size is large enough so that as the frozen fringe passes through, the lens cannot grow large enough to displace the particles. Clays, at the other end of the gradation chart, have very small particles and small voids. Less force is required to displace smaller soil particles than larger particles, such as gravels. This make soils with high percentages of fines more susceptible to frost.

4. **Zone of Influence:** The zone of influence is an area immediately adjacent to and outside the trench where the soils are adversely affected by the nearby excavation. The effects in this zone are caused by changes to the soil that remains in place during a trench excavation. The trench walls, usually close to vertical, are not capable of withstanding their normal loads and tend to experience sloughing due to loss of lateral support. In all cases, there is subsidence that creates a weakened plane in the soil. This weakened plane, if it is not addressed, is one of the primary reasons for trench/pavement patch failure. This can lead to undercutting of the existing pavement that was original planned to remain in place. These effects are detailed in Figure 9D-1.04. The damage to the supporting nature of the soils is very difficult to repair and results in an isolated weak column of soil surrounding the entire excavation.

The research has pointed out that the zone of influence can extend between 2 and 3 feet from the top of the trench wall. Thus, prior to replacement of the pavement, the area should be cut back a minimum of 3 feet and to a depth of 2 feet. This top area should then be filled with backfill materials matching the existing subgrade/subbase to provide uniform pavement support.

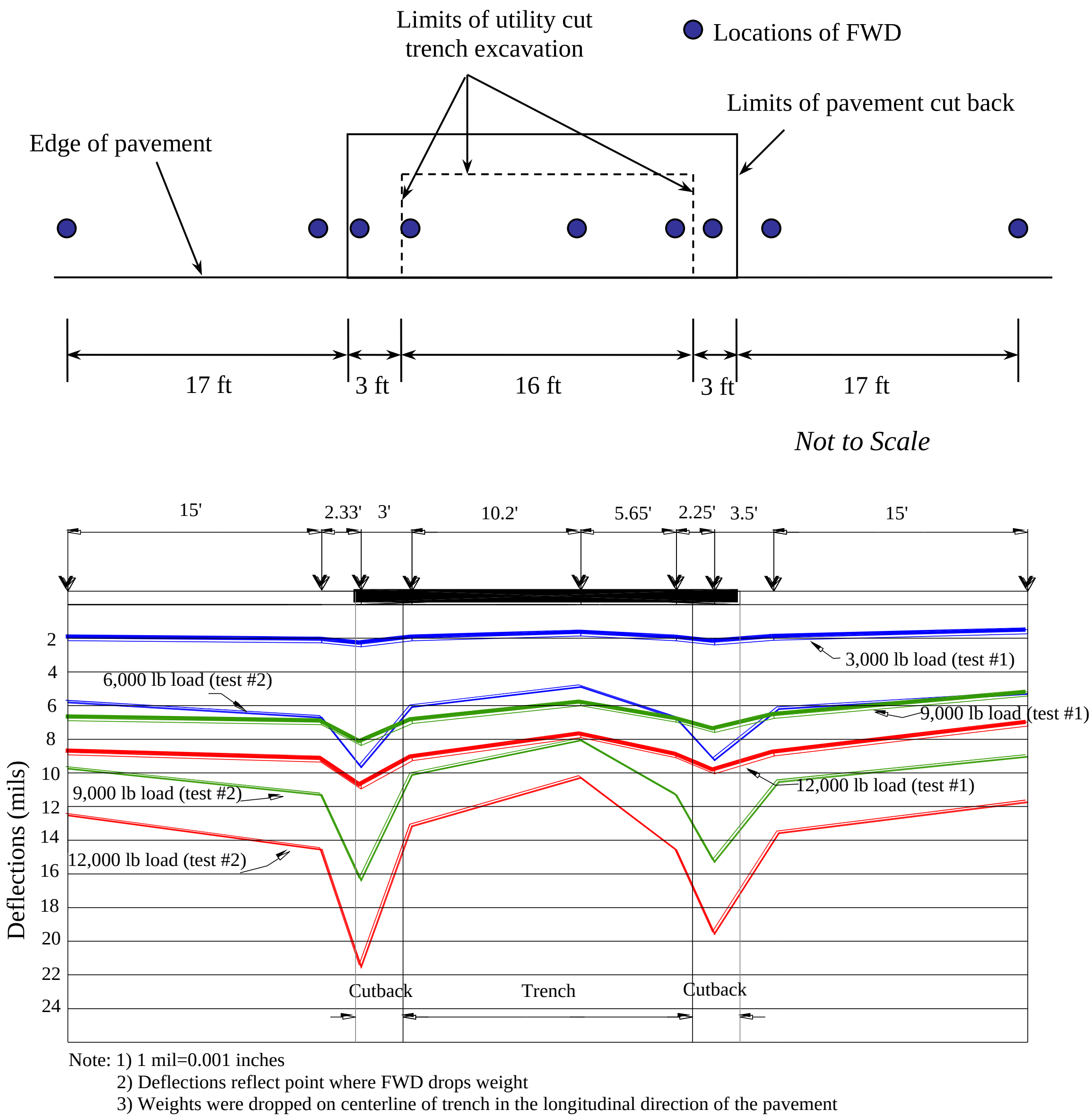
As can be seen in Figure 9D-1.05, the zone of influence, in this case approximately five to six feet in width, performed significantly poorer than both the existing, undisturbed pavement section, and the properly constructed trench backfill. This increased deflection implies that the pavement is moving relative to the surrounding pavement, increasing the likelihood of crack formation and premature pavement deterioration.

Figure 9D-1.04: Overstressing of the Pavement and Natural Materials Adjacent to the Trench



Source: IHRB Project TR-503

Figure 9D-1.05: Locations and Results of FWD Tests Performed at a Utility Cut Location Showing Deflection Within the Zone of Influence



Source: IHRB Project TR-566

The charts above were recorded using a Falling Weight Deflectometer (FWD). This tool, providing a non-destructive measurement, drops a weight from a controlled height and measures the resulting pavement deflection using an array of sensors placed along a line. This line is usually orientated along the direction of travel for the roadway. Figure 9D-1.07 shows the Iowa DOT's FWD.

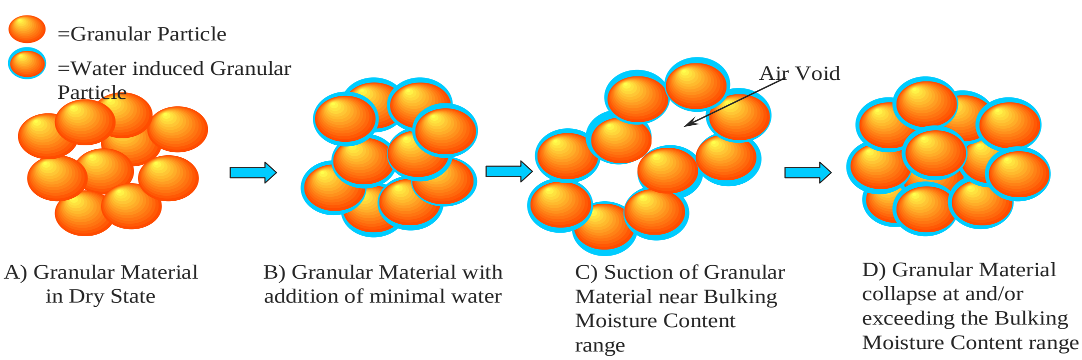
Figure 9D-1.06: Iowa DOT FWD Equipment Showing Sensor Configuration

Source: IHRB Project TR-566

5. **Moisture Content of Backfill Material and Collapse Potential:** It is critical that the bulking moisture content of the granular material be exceeded in order to achieve a dense backfill condition. Bulking is a phenomena that occurs in most granular materials in which the capillary action between soil particles that are surrounded by water hold the particles together in a honeycombed structure as noted below. The material starts out dry. With the addition of some water, the soil particles are surrounded. As more water is introduced, generally to a moisture content of approximately 6% to 10%, suction forms between the soil particles that creates tension and air voids. With the addition of more water, generally above 10%, the tension is released. This rearrangement of particles is referred to as collapse of granular materials. This phenomena is shown in Figure 9D-1.07.

   When the tension releases, the collapse occurs, leading to a denser material, and reduced trench settling. Thus, it is very important that the granular backfill materials be placed in the trench above the bulking moisture content. The bulking moisture content range (i.e., the range of moisture contents to avoid can be determined in the laboratory and the range is defined as the moisture content for the maximum collapse potential plus or minus 2%.

Figure 9D-1.07: Bulking Moisture Content



Source: IHRB Project TR-503

6. **Quality Control:** If granular materials are used for the primary backfill material as recommended, the level of density must be checked and compared to the relative density of the material. Use of Standard Proctor Density does not provide an appropriate level of results for the density of granular materials. See Chapter 6 - Geotechnical for more information on relative density and Proctor density. Use of the Dynamic Cone Penetrometer (DCP), which involves measurements of penetration of the rod into the backfill material, is another method of determining density. The greater the number of blows to penetrate a given depth, the stiffer the material. The Clegg Hammer operates on the same general principle.

D. Recommended Utility Trench

The recommended trench configuration and recommended best practices to increase performance of pavement patches over utility trench repairs are shown below. It is important to note that all of these recommendations must be implemented in order to have improved pavement life.

1. **Equipment:**
   - Throughout construction of the trench, including excavation and placement of backfill material, keep equipment and materials as far away from the trench area as possible to minimize trench wall sloughing.
   - The smallest equipment which can satisfactorily perform the job should be used to minimize the adverse effects caused by equipment loading near the edges of the excavation.

2. **Trench Excavation:**
   - Soils excavated from the trenches or other soils should not be mixed with the granular backfills unless previous laboratory testing yielding a range of recommended moisture content and densities to be achieved in the field are conducted.
   - The T-section should be modified to use walls that are beveled outward to facilitate compaction of backfill. Beveled edges will reduce the amount of disturbance to the surrounding soil and also eliminate the vertical excavation, which makes compacting the backfill more difficult.
   - Refrain from using saturated material from the excavation.

3. **Backfill:**
   - Reduce lift thickness to 8 inches to 12 inches for backfill materials
   - The standard vertical-walled cross-section with 1 inch clean limestone is recommended as a construction practice.
   - Quality control measures should be implemented in the field. These should include methods to ensure compaction and moisture requirements are met. This includes achieving at least medium relative density with moisture contents above the bulking moisture content for cohesionless soils and above 95% of Standard Proctor and ± 2% of optimum moisture content for cohesive soils.
   - Place geotextiles in the bottom of the cutback area prior to placement of subgrade/subbase material.

4. **Pavement Surfacing:**
   - Saw the pavement full depth to create the cutback area three feet from edge of the original trench.
   - Recompact the top 12 inches of trench backfill material after removal of cutback materials.
   - PCC patches seem to perform better regardless of the existing pavement type. This is due in part to the difficulties in completing uniform compaction of HMA in relatively small areas.

Figure 9D-1.08: Recommended Trench Reconstruction