Investigation of Improved Utility Cut Repair Techniques to Reduce Settlement in Repaired Areas, Phase II

tech transfer summary

Improved selection of materials and better construction techniques can minimize trench settlement and improve pavement patch longevity.

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RESEARCH PROJECT TITLE
Investigation of Improved Utility Cut Repair Techniques, Phase II

SPONSORS
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The mission of SUDAS is to develop and maintain urban design standards and standard specifications for the State of Iowa that will be recognized, adopted, and used by state and local government, contractors, and consulting engineers as the acceptable standards for construction of urban public environments.

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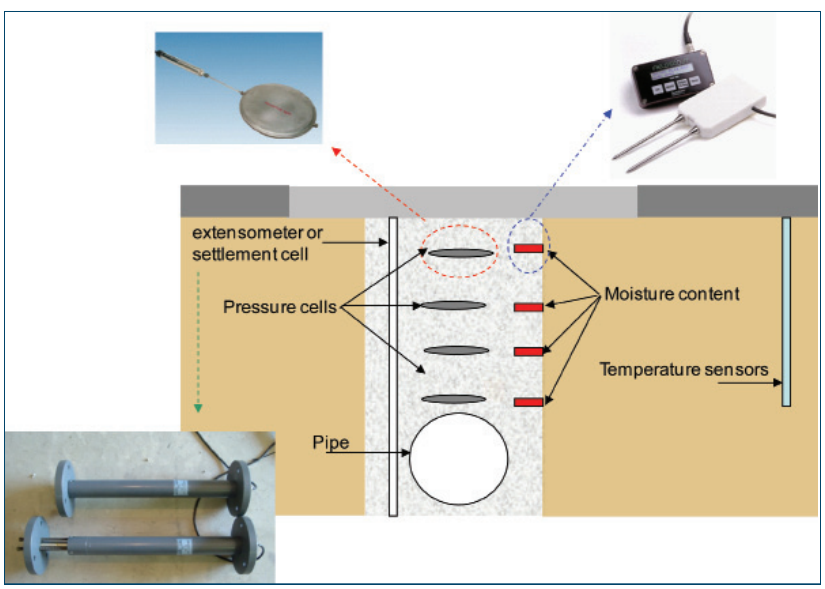
Objectives

This investigation is part of a multiphase research project that aims to improve long-term performance of utility cut restoration trenches. The goal of this research is to improve pavement patch life and reduce the maintenance of the repaired areas.

More specifically, these were the objectives of Phase II:

- Correlate the long-term performance of trench restorations with the in-situ properties of the backfill during construction and the engineering properties in laboratory testing.
- Continue the monitoring of the utility cut restorations constructed during Phase I.
- Construct recommended trenches and monitor their long-term performance.
- Research and identify the principles of trench subsurface settlement and load distribution in utility cut restoration areas using three new instrumented trenches.
- Update the recommendations made during Phase I and recommend the best practices for utility cut restoration repair techniques for the Statewide Urban Design and Specifications (SUDAS) Program.



Instrumentation used to monitor trench restoration performance

Problem Statement

The common procedure of installing utilities, such as gas, water, telecommunications, and sanitary and storm sewers, requires excavation to install the pipes or lines. Utility cut restoration has a significant effect on pavement performance. It is often observed that the pavement within and around utility cuts fails prematurely, increasing maintenance costs.

For example, early distress in a pavement may result in the formation of cracks where water can enter the base course, in turn leading to deterioration of the pavement. The resulting effect has a direct influence on the pavement integrity, life, and aesthetic value, as well as driver safety.

The magnitude of the effect depends upon the pavement patching procedures, backfill material condition, climate, traffic, and pavement condition at the time of patching. While new pavement should last between 15 and 20 years, once a cut is made, the pavement life is reduced to about eight years. Furthermore, several cuts in a roadway can lower the road life by 50%.

Poor performance of pavements around utility trenches on local streets and state highway systems often causes continual maintenance due to improper backfill placement, such as improper backfill material, under compacted, too dry, too wet, and so forth. The cost of repairing poorly-constructed pavements can be reduced with an understanding of proper material selection and construction practices. Current utility cut and backfill practices vary widely across Iowa, which results in a range of maintenance issues.

Research Description

Phase I was an initial investigation into utility cut restoration failures to document the occurrence and frequency of failures and to determine the failure mechanisms. Activities conducted during Phase I included a survey of utility cut restoration practices, testing of backfill materials, and evaluating trench restoration performance with falling weight deflectometer (FWD) testing.

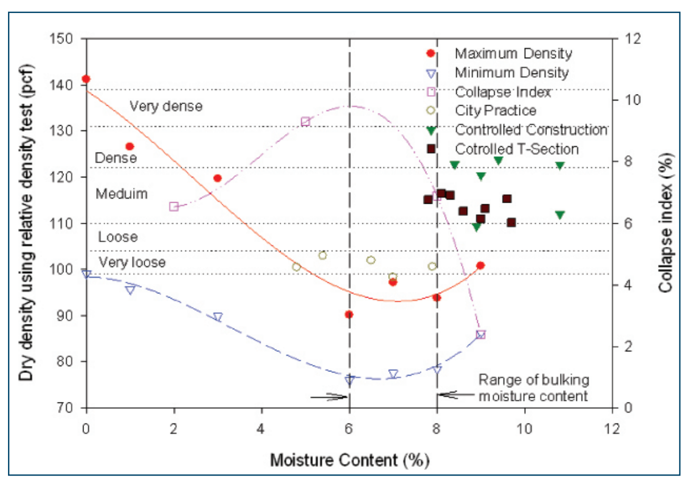
Based on the results of Phase I, Phase II was initiated to further investigate the influences of compaction, moisture content and density of the backfill, and "zone of influence" on the performance of utility cut trench restorations through these four tasks:

1. Continue monitoring the utility cut restorations constructed during Phase I.
2. Construct new trenches using six recommended practices.
3. Instrument three new trenches to understand the mechanisms of trench backfill settlement and load distribution.
4. Evaluate and summarize the data collected.

Key Findings

Phase I survey results indicated that many restored utility cut restorations fail in less than two years. Field and laboratory tests of backfill indicated inadequate compaction, moisture content, and density of the backfill are factors that contribute to utility cut trench restoration failures. FWD tests indicated weakened subgrade soil around the utility cut trench restorations. This weakened soil is known as the zone of influence.

Cracks on temporary patch covering city practice trench indicating settlement (collapse) due to rain



Vibratory compaction test, collapse index, and measured moisture content from instrumented trenches

Based on the monitoring of the trenches constructed during Phase I, the six recommended trenches during Phase II, and the three instrumented trenches constructed during Phase II, the conclusions and recommendations of this research follow.

Material Selection

- Relative density test (i.e., vibrating table compaction) is recommended for any potential granular backfill.
- Simple column test is recommended to determine the collapse potential (i.e., reduction in volume or settlement) of different backfill materials.
- The range of moisture content around the smallest density and highest collapse potential is known as the bulking moisture content. Backfill materials installed at moisture content higher than the bulking moisture content and at relative density of medium to dense show good performance in the field.
- Lift thicknesses should be limited to less than 1 foot.
- Using the 3/8 inch minus backfill material installed with proper construction practices showed minimum settlement during spring/summer and a heave comparable to surrounding pavement, avoiding the formation of a bump at the utility cut location.
- Avoid using backfill soils that have high silt content, which are susceptible to frost heave.
- One inch clean limestone or other clean backfill with limited fines do not experience collapse and are least susceptible to frost heave. The use of 1 inch clean limestone improves the performance of the trenches. It stiffens the response of the trench in FWD testing, and the settlement within the trench is less.

Construction Practices

- The use of a concrete patch with dowels improved the performance at the utility cut location.
- Remove at least 2 feet of pavement around the perimeter and compact the soil if a T-section is not constructed.
- When comparing trenches constructed with 1 inch clean, the trench constructed with highest relative density showed the smallest settlement and highest uplift movement. The trench with the lowest relative density showed the highest settlement.
- When comparing FWD test results, the trenches with T-sections showed reduced measured deflections within the zone of influence. However, the T-section may have caused a shift of the zone of influence.
- Smaller settlement was measured in trenches with higher relative densities, and smaller FWD deflections corresponded to higher California Bearing Ratio (CBR) values estimated from the dynamic cone penetration (DCP) test.
- The T-section could be modified to use walls that are beveled outward to facilitate compaction of backfill. Beveled edges may reduce the amount of disturbance to the surrounding soil and eliminate the vertical excavation; however, it may make compacting the backfill at the edges difficult. This is expected to prevent the zone of influence from migrating outside of the T-section.
- Construction equipment should be kept away from the edges of the open trench to reduce its effects on the zone of influence. FWD testing showed that damage caused by equipment during construction had a long-term impact on trench performance.
- The use of geogrid in the trenches did not improve the performance of the trenches compared to the trenches constructed without the geogrid for the trenches using 3/8 inch minus limestone.

Watering backfill material to increase the moisture content beyond the bulking moisture content

Compaction to achieve relative desnity higher than 35% (medium to dense material)

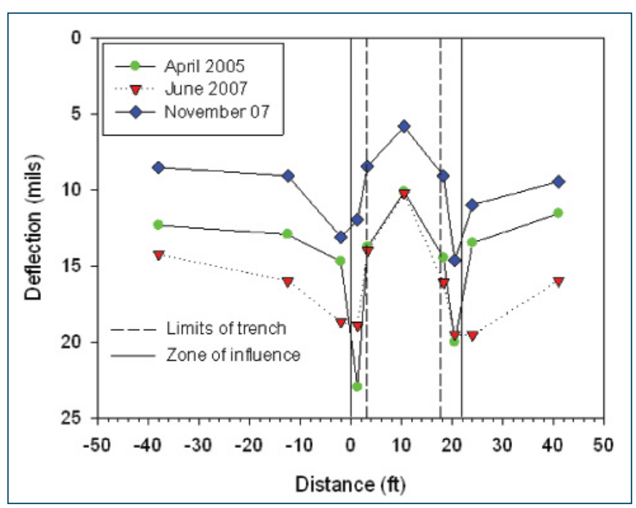
Quality Management

- Quality control measures should be implemented in the field to ensure that compaction requirements are met. This includes achieving at least medium-to-dense relative density with moisture content above the bulking moisture content for cohesionless soils and above 95% of Standard Proctor Density and +/-2% of optimum moisture content for cohesive soils.
- An educational program should be established to educate city maintenance crews on the importance of proper construction practices. A program including demonstrations will help solidify the importance of moisture control during trench construction.

FWD equipment used to test and monitor trench restoration performance

Future Research Needs

- Continue FWD testing on the trenches.
- Evaluate pavement surface roughness in utility cut areas using the International Roughness Index (IRI) data to assess the ride quality and determine the effect on pavement maintenance and methods to improvement smoothness in these areas.



Zone of influence using FWD