Ohio Department of Transportation
Research Project Fact Sheet

Re-rounding of Deflected Thermoplastic Conduit

<table>
<thead>
<tr>
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The Problem

Flexible pipes, such as high-density polyethylene (HDPE) pipe, require proper installation for long-term function. HDPE pipe is reliant upon the backfill material and compaction for structural stability. A method of remediating excessive deflection, called “re-rounding”, has been used throughout the midwestern United States. The re-rounding process as evaluated utilizes an eccentric pneumatic compactor with expanding curved plates which vibrate and exert pressure against the pipe interior on the crown and invert, pushing out the deflection in the pipe and redistributing the surrounding backfill. Despite the existence of the technology for over 30 years there is a lack of comprehensive mechanistic data on the process and little known about its impacts on thermoplastic pipe. The literature consists of a 1982 report from a re-rounding vendor and a 2009 report by a thermoplastic pipe manufacturer.

Research Approach

Five HDPE pipes, two of diameter 18 in (0.45 m) and three of diameter 36 in (0.9 m), were instrumented with pressure cells, accelerometers, and/or soil stiffness device and then purposely installed to induce deflection (minimum -10%), sometimes with the help of a horizontal expansion device. Different backfill materials were used: ODOT Structural Backfill Type 1 (ODOT Item 304 crushed stone aggregate), Type 2 (sand), and Type 3 (AASHTO #57 crushed stone aggregate). Gradation and uniformity of aggregate were measured before and after re-rounding.

Each pipe was installed, measured by collecting profiles at ten cross-sections along its length, and allowed to rest and settle for a month or more. Then the pipe profile was measured and other data collected. The vendor operated the re-rounder following their procedure, and the pipe profiled and data collected afterwards. This process was repeated if needed until the pipe shape was sufficiently restored as determined by the vendor’s mandrel or until it was determined further passes would not provide any benefit. The pipe then rested again for a month or more. A final set of profiles and data were collected and the pipe excavated and examined for any damage. Profile data were analyzed to determine the vertical deflection before and after re-rounding. Other data collected included soil pressures, soil stiffness, acceleration of backfill particles, corrugation depth, and soil characteristics.

Findings

Here is a table summarizing the deflection data in this experiment. Underlined deflection percentages exceed ODOT 7.50% criterion for repair or replacement.

<table>
<thead>
<tr>
<th>Test Pipe</th>
<th>Structural backfill material (ODOT Type)</th>
<th>Nominal diameter</th>
<th>Re-rounder passes</th>
<th>Maximum vertical deflection before re-rounding</th>
<th>Deflection of above after re-rounding</th>
<th>Maximum deflection in pipe after re-rounding</th>
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<tbody>
<tr>
<td></td>
<td>Item 304 (1)</td>
<td>36 in (0.9 m)</td>
<td>3</td>
<td>-13.91%</td>
<td>-7.20%</td>
<td>-8.62%</td>
</tr>
<tr>
<td></td>
<td>sand (2)</td>
<td></td>
<td>2</td>
<td>-9.89%</td>
<td>-8.57%</td>
<td>-8.57%</td>
</tr>
<tr>
<td></td>
<td>#57 (3)</td>
<td></td>
<td>1</td>
<td>-10.18%</td>
<td>-2.52%</td>
<td>-2.52%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>-16.67%</td>
<td>-6.17%</td>
<td>-6.17%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>-14.50%</td>
<td>-6.21%</td>
<td>-7.47%</td>
</tr>
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</table>

- After three passes of the re-rounder in Test Pipe 1, the re-rounder became so hot, the vendor said further use would permanently damage their device, so the re-rounding was stopped.
- Re-rounding had the best success in reshaping the pipe to acceptable levels in the open-graded aggregate Type 3 backfill. However, during the first installation of Pipe 3, the backfill did not provide sufficient resistance for the pipe to retain the induced deflection during installation. Hence it was necessary to use the pipe deflector device to maintain the desired level of initial deflection during the second installation of a replacement Pipe 3. Both the difficulty in maintaining the intended deflection

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during construction and the ease with which the pipe was re-rounded can be attributed to a lack of aggregate interlock in the AASHTO #57 aggregate used as Structural Backfill Type 3.

- Re-rounding had an intermediate success in the ODOT Structural Backfill Type 2 (sand), requiring two passes of the re-rounder in both sizes of pipe, 36 in (0.9 m) (Pipe 1) and 18 in (0.45 m) (Pipe 5) but the re-rounding did not completely restore the pipe shape to meet operational criteria.
- The well-graded Item 304 aggregate used as ODOT Structural Backfill Type 1 proved highly resistant to re-rounding due to aggregate interlock. This backfill required the least amount of added effort to maintain initial deflection during construction.
- The 18 in (0.45 m) pipes generally followed the same general trends as the 36 in (0.9 m) pipes.
- During re-rounding, backfill particles migrated and pressure redistributed. In Type 1 backfill, fine material from crown and springline moved downward toward the haunch area around the pipe. The movement of the particles was enhanced by the re-rounder pushing the crown and invert out, allowing the sides to move in. These factors also reduced the soil pressure at the crown and springline. Direct measurement of the redistribution of the more uniformly graded backfill material was not possible.
- It is difficult to successfully reduce deflection in HDPE pipes in ODOT Structural Backfill Type 1 (Item 304 aggregate) by re-rounding. The amount of energy involved is extreme and ability to move particles appears limited. Based on evaluation of the gradation measurements during exhumation, only the fine materials appeared to move vertically during re-rounding. However, the extreme energy required to mobilize the backfill material can be seen as a benefit to the long-term suitability of re-rounded HDPE pipes installed in ODOT Structural Backfill Type 1 (Item 304 aggregate).
- The research findings indicate HDPE pipes installed in the field with Type 1 backfill may still perform long-term without major distresses under deflections greater in magnitude than -7.5%, assuming the backfill material is adequately compacted. In Type 1 backfill, if the initial deflection before re-rounding is more than -7.5%, the pipe installation may still be safe and durable. However, typical strain limit states must also be verified.
- Installing the pipes with excess deflection proved a significant challenge, as all the pipes required significant deliberate effort to reach sufficient deflection. It proved necessary to resort to creating a device to hold the pipe in a deflected state during backfilling.
- Re-rounding may be successful at reducing deflections to acceptable levels for pipes in Type 2 backfill (sand). However, it is well established that the sand must be sufficiently confined. Sand which is open and exposed will migrate, particularly under water pressure.
- Pipes in Type 3 backfill were easy to re-round. However, it is possible a change in environmental conditions and/or dynamic loading may create a change in the stress path leading to excessive deflection and reversing the effects of re-rounding. Consolidation in the embankment may be problematic, creating a loss of backfill height. This may be due to re-rounding or by service conditions.

**Recommendations**

- Re-rounding can be used as a mechanism for reducing vertical deflection in thermoplastic pipe exceeding the minimum acceptable deflection. However, since the re-rounding machine used operates on the vertical axis, its effectiveness against racked pipes is unknown.
- When pipe is installed in Type 3 backfill (AASHTO #57 aggregate), the re-rounding is effective at reducing vertical deflection. However, this is because the backfill material was easily mobilized under the dynamic loading of the re-rounder. Further study is needed to confirm if condition changes or dynamic loads during service after re-rounding, particularly in shallow cover, could reverse the re-rounding and create deflection problems.
- The use of fine material above Type 3 backfill should be used with caution as this can result in voids above the pipe crown.
- Further evaluation is needed to determine whether the re-rounding process and associated migration of material above the pipe leads to cracking in pavement, particularly when there is shallow cover.
- It remains to be determined what are the limit states (maximum peak particle velocity) to ensure the stresses from re-rounding vibrations do not cause any negative impacts to pavements or surrounding underground structures.

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