Background

At longitudinal construction joints (LCJs), short pieces of reinforcing steel are used across the joints to keep the two adjoining slabs from separating, to keep the surface across the joints flat, and to provide continuity and support for the steel reinforcing mat. Figure 1 shows the tie bars extending into the adjacent placement.

Figure 1. Longitudinal Construction Joint

TxDOT Specification Item 360 and Statewide Standard Details allow either single piece tie bars or multiple piece tie bars at longitudinal construction joints (See Figure 2).

From Item 360 4.3. Reinforcing Steel and Joint Assemblies:

Use multiple-piece tie bars, drill and epoxy grout tie bars, or, if approved, mechanically-inserted single-piece tie bars at longitudinal construction joints.

Figure 2. LCJ Detail for Single Layer CRCP (top) and Double Layer CRCP (bottom)

All three methods for LCJ tie bar construction (multiple-piece, single piece: drill and epoxy, and single piece: mechanically inserted) produce identical results when installed correctly. Because the stresses in tie bars under LCJs can be 10-20 times higher than the stresses in the transverse steel, it is very important to a long-lasting, well-performing CRCP that the tie bars perform as intended.
In the past, single piece tie bars were often bent to keep the tie bars from interfering with traffic or construction. After the concrete set, the bent tie bars were straightened to the proper position. This practice is no longer allowed. Field bending can weaken the tie bar especially if field practices do not follow the requirements of ACI 318. This weakening, caused by bending and straightening, led to serious issues with tie bar ruptures and lane separations.

Installation Techniques

**Mechanical Insertion of Single Piece Tie Bars**

Mechanical insertion of tie bars occurs in the concrete that is still confined by the slip-form paver, with equipment that can be either pneumatic or hydraulic. Some systems insert the bar very rapidly; some systems vibrate the area while the bar is being inserted.

Check tie bar insertion depth and locations during paving operations to ensure proper placement. Because steel location tolerances still apply for mechanically inserted tie bars, caution is needed to avoid hitting the reinforcing mat during insertion into the side of the fresh concrete. It is recommended to insert tie bars a few inches away from the transverse bar locations to avoid displacing the mat.

Figure 3 shows several different types of mechanical inserters.

**Issues requiring special attention:**

Care must be taken to prevent any movement of the tie bars after placement and before the concrete sets. Ensure that equipment and the finishing crew do not knock or drag the protruding bars.

Note the plastic sleeves in Figure 5 on the protruding half of the inserted tie bar. The sleeves prevent curing compound from adhering to the bar surface, which would negatively impact the bond development of the concrete placed in the adjoining lane.

Insertion by hand (not allowed under current TxDOT specifications) often causes the edge of the plastic concrete to drop down and requires constant remedial work seen shown in Figure 6. Drop down of mechanically inserted bars can also occur in localized areas where the concrete is too wet or where the bar hit the mat when inserted.

The contractor must demonstrate, to the Engineer’s satisfaction, that the mechanical insertion process results in an acceptable final product. Multi-piece tie bars or drilled-and-epoxied single piece tie bars will be required if mechanical insertion results in steel misalignment or improper location, poor concrete consolidation, or other inadequacies.
Drill and Epoxy of Single Piece Tie Bars

There are some instances where it can be advantageous to drill and epoxy single piece tie bars into the pavement (See Figure 7). Widening an existing concrete pavement is usually accomplished in this manner. However, any instance where limited numbers of tie bars need to be inserted or repaired will also use this technique and can be accomplished with single or multi-gang drills.

The contractor will need to perform pull out testing to demonstrate that the resulting bond strength of the epoxy-grouted tie bars is acceptable.

Issues requiring special attention:

- Epoxy does not adhere well when an excess of concrete powder remains in the drilled holes, so the requirements for cleaning the holes must take place as per the epoxy manufacturer’s instructions.
- Also, the epoxy must fill the entire tie bar hole or there will be insufficient bond strength. Figure 8 shows the result of not completely filling the drilled hole with epoxy before inserting the bar.

Figure 7. Drilling tie bar holes

Multiple Piece Tie Bars

Multiple piece tie bars are threaded in the middle to allow the two halves of the tie bar to be separated and then reconnected prior to the casting of the adjacent pavement (See Figure 9).

The female side of the multiple-piece tie bar is wired to the steel mat, and its location is marked with spray paint or other means as shown in Figure 10. The coupler portion of the tie bar should have a plastic insert to prevent concrete from clogging the threads during paving.

After the paver passes, the concrete covering the coupler portion of the tie bar should be removed with a relatively minimal disruption to the fresh concrete (See Figure 11).

Issues requiring special attention:

- The second (male) piece of the multiple-piece tie bar must be screwed into the coupler so that there is full thread engagement. This requires more than hand tightening, as small amounts of rust and sand may be present on the machined threads. A lack of thread engagement will cause slippage within the multiple-piece tie bar, rendering it ineffective.
Table 1: Rough Cost Estimates for LCJ Tie Bar Options

<table>
<thead>
<tr>
<th></th>
<th>Mechanical Insertion</th>
<th>Drill and Epoxy</th>
<th>Multi-Piece Tie Bar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Costs</td>
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<tr>
<td></td>
<td>(pneumatic systems)</td>
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<td>$20,000 - $24,000</td>
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<td></td>
<td>(hydraulic systems)</td>
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<tr>
<td>Material and Labor Cost (each bar)</td>
<td>$2.80</td>
<td>$2.80 + $1.30 + $2.15</td>
<td>$3.00 + $1.65</td>
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<tr>
<td>Material and Labor Cost per lane mile of single mat CRCP LCJ</td>
<td>$7,392</td>
<td>$16,500</td>
<td>$12,276</td>
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</tbody>
</table>

1 These figures are generic and approximate and should not be used for precise estimating purposes.

Cost Comparison

Each of the three approaches to reinforcing a longitudinal construction joint have their unique advantages and disadvantages. They also have their own cost structure as shown in Table 1.

Summary

For typical main lane paving projects, mechanical insertion of tie bars is the most economical, especially after the capital costs of the equipment purchase have been fully offset.

References


TxDOT Funded Research: 0-5444 – Longitudinal Joint Separation, 0-5832 - TxCRCP-ME Design

Contact Information

If you have any questions about the content of this article, please contact the Rigid Pavements and Concrete Section of the Materials and Tests Division.