Tech Brief

DOWEL BASKET ANCHORING METHODS

Best Practices for Jointed Concrete Pavements

INTRODUCTION

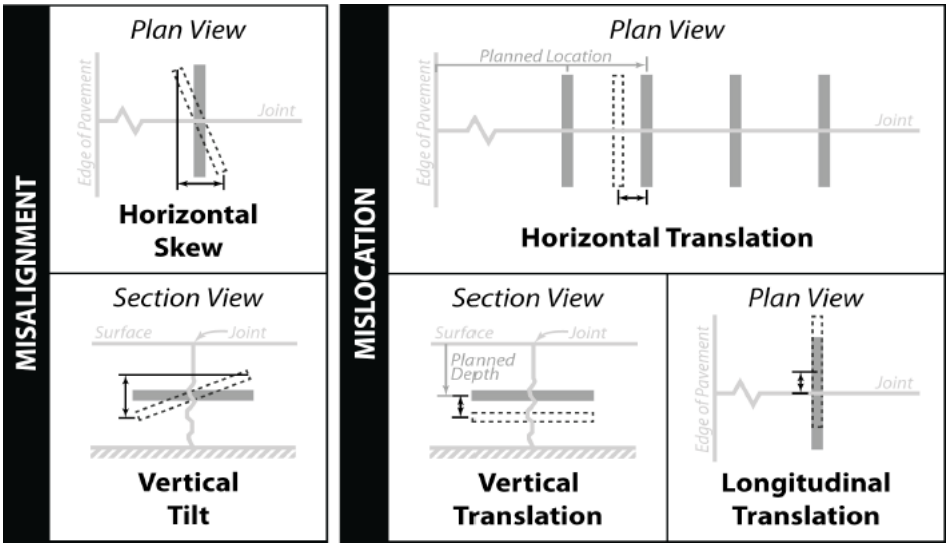
Dowels are the most common form of load transfer in concrete pavements. They come in various sizes, shapes, and materials, but to perform optimally over the course of the pavement life, they need to be oriented appropriately and within tolerable location limits in the slab. Proper placement ensures optimal load transfer with minimal added stress to the pavement. For this reason, attention to dowel placement during paving is important, and ensuring that dowel placement accuracy is maintained through paving is a necessary quality control activity.

Dowel basket fasteners, such as basket clips and stakes, are commonly used to secure dowel baskets for the paving process. This tech brief summarizes the purpose and recommendations for ensuring that dowels placed using baskets maintain their position and elevation through the paving process. Additional details can be found in the *Guide to Dowel Load Transfer Systems for Jointed Concrete Roadway Pavements* (Snyder 2011).

DOWEL ALIGNMENT AND PLACEMENT

The location and alignment of dowel bars is important to achieve intended performance. This is true regardless of whether dowels are placed using a mechanical dowel bar inserter (DBI) or placed before paving with baskets, which is the subject of this tech brief.

Pavement specifications typically include placement tolerances. These tolerances call for dowels to be placed reasonably close to parallel with the pavement centerline and the pavement surface. This also results in the dowels being parallel to each other. Specifications also require that dowels be located within mid-depth of the slab. Dowels that are significantly misaligned or mislocated (as illustrated in Figure 1) may not function as intended and, if well out of tolerance, can cause detrimental pavement damage.



Snyder 2012 after Tayabii 1986 and FHWA 2007

Figure 1. Five types of dowel bar misalignment and mislocation

U.S. Department of Transportation
Federal Highway Administration

When dowels are placed and aligned prior to paving, dowel bar assemblies or dowel baskets (sometimes also called cages) of sufficient rigidity are required. The dowel baskets must be anchored well. If they are not properly secured or anchored to the subgrade or subbase, the basket may slide, tip, pull apart, or be crushed under the pressure of the paving machine. If this happens, the dowels may likely fall out of the required tolerances and, in extreme cases, cause joint problems (see Figures 2 and 3).

Technologies such as ground penetrating radar (GPR) and the MIT-SCAN2-BT have made it possible to view dowel positions within the pavement after the concrete hardens. This capability may help contractors improve methods of placing dowels and engineers better relate as-built dowel alignment to discrete joint problems and long-term joint performance.

ANCHORING DOWEL BASKETS

Once the baskets are properly positioned either prior to paving operations or directly in front of the paver, they need to be secured to withstand the pressures from the plastic concrete during paving. Failures to properly anchor dowel baskets have resulted in tipping and sliding movements of baskets during paving operations, and subsequently the need for costly remediation.

Snyder 2012

Figure 2. Mislocated dowel too close to the surface causing joint deterioration (spalling)

Figure 3. Misaligned dowel bars causing surface distress

Contractors may use a variety of dowel fasteners, such as stakes, pins, nails, and/or clips to secure baskets and provide sufficient support to prevent baskets from being dislodged. Contractors may also adjust their concrete placement techniques in order to relieve some of the pressure induced during the paving process.

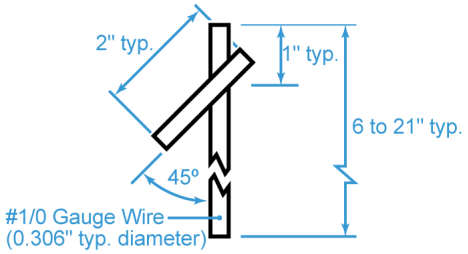
Basket Stakes

Basket stakes (also called pins or spikes) are the most commonly used fastener for dowel baskets. While they are most often used for securing baskets to granular materials and soil, they can be used with nearly all foundation materials. Basket stakes are typically manufactured in lengths from 6 in. (150 mm) to 21 in. (530 mm). A schematic of a typical anchor pin is shown in Figure 4.

Different foundation types may require different stake lengths, with the longer lengths necessary for weaker subbase or subgrade materials. Stake diameters can also vary, but most are about 0.30 in. (7.6 mm). The stakes must be strong enough to withstand being pounded into place without bending.

Stakes are typically driven manually or with an electric pneumatic/air tool. When pins are placed through a stabilized subbase, holes are first drilled in order to effectively drive the pins through the harder material. This process can be very time and labor intensive.

Figure 5 illustrates a stake placed on the leave side of the basket and basket wire to ensure the basket is properly anchored.



After Iowa DOT 2016

Figure 4. Basket stake/anchor pin schematic with typical dimensions

Figure 5. Stake anchoring a dowel basket in place

Basket Clips

The other primary method of anchoring dowel baskets is by using basket clips that are power nailed into the support layers. Basket clips are typically used with stiffer foundations (asphalt or lean concrete bases) and are considered less labor-intensive than pre-drilling holes for basket stakes.

The two types of basket clips are wrap-around clips (shown in Figure 6), which encompass the basket support wire, and nail-down clips (shown in Figure 7), which clasp the basket wire to the roadbed.

Masten 2012

Figure 6. Wrap-around dowel basket clip

Masten 2012

Figure 7. Nail-down basket clip

Keith Thomas, Hilti, from Reid 2012

Figure 8. Nail-down clip installation using pneumatic tool

Privrat 2012

Figure 9. Nail-down clip installation using a powder-actuated gun

Contractors use a few different types of tools to install the fasteners or nails. Either pneumatic tools (Figure 8), which are powered by air or compressed gas, or powder-actuated installers (Figure 9), can expedite the installation process significantly.

Typical Practices

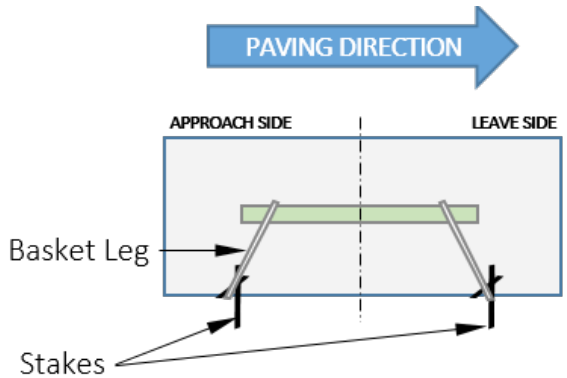
Type, location, number, and length of anchors are typically dependent on field conditions, state requirements and contractor preferences. Some agencies have moved to requiring a quality control plan, leaving the anchoring method to the contractor, but assuring that the issue is of importance for quality assurance.

For example, the Minnesota Department of Transportation (MnDOT) requires that baskets be fastened to the substrate surface so they do not move more than 1/4 in. (6 mm) in the vertical or horizontal direction. Contractors must be able to demonstrate that their anchoring method works at the beginning of each day (MnDOT 2016).

While practices vary by state requirement, contractor preference, and past experience, a minimum of eight fasteners is typically used for a standard lane 10 to 12 ft (3 to 3.6 m) wide. Additional fasteners are added for baskets in widened lanes that extend past 12 ft. Regardless of the number, the fasteners should be evenly spaced with half being placed on each side of the basket.

Weaker subbases and subgrades may require additional fasteners to provide the necessary restraint to resist vertical and horizontal shifting. Conversely, a basket placed on a stabilized subbase may only require six fasteners as long as the trials indicate that the baskets hold fast during paving. For pavements designed with mini baskets (where dowels are being placed only in the wheelpaths), four fasteners is typical, with two on each side of the basket.

While basket stakes and pins are placed on both the approach and leave sides of the basket, it is recommended to have the pins placed on the leave side of the basket wire. Anchoring on the leave side of the basket wire ensures that the basket is not pushed by the head of concrete in the direction of paving (see Figure 10).



Jerry Voigt, American Concrete Pavement Association

Figure 10. Anchor pins placed on the leave side of the basket wire on both the approach and leave side of the basket

Many state recommendations require stakes to penetrate at least 12 in. (300 mm) into the subgrade or subbase. However, the required depth really depends on the strength of the support layers. A dense stabilized subbase may only require a stake to be embedded 4 in. (100 mm) and a treated permeable subbase may only require 6 in. (150 mm) of embedment. If deviations are made from a standard or specification, the contractor should demonstrate and verify their method with the engineer before paving.

If baskets are dislodged during test sections or at the beginning of a project or day of operation, the contractor should either add more fasteners or increase the embedment depth of each stake or nail until the baskets hold fast under the paving conditions. When encountering a new application or subbase material, the contractor is encouraged to consult their basket supplier for any additional fastener recommendations.

ADDITIONAL SUPPORT AND BRACING

Typically, when dowel baskets are properly anchored, the basket has little risk of sliding, tipping, or pulling apart. However, it is still possible for the baskets to collapse or pull apart under the initial load of the plastic concrete during paving, as shown in Figure 11.

One method of limiting this risk is to leave the shipping wires (sometimes called basket tie wires) intact on the dowel baskets. These wires add support and rigidity to the basket. A cut tie wire can be seen in the earlier Figure 5.

Leaving the tie wires intact does not adversely affect joint formation, joint opening, or long-term pavement performance as long as the contractor maintains attention to proper saw-cut timing (ACPA 2005). However, the tie wires may reduce the accuracy of dowel location measurements when using magnetic tomography-type systems (e.g., the MIT-SCAN2-BT).

Masten 2012

Figure 11. Crew addressing a collapsed dowel basket during paving, a very difficult challenge once the paving is underway, underscoring the need for proper anchoring and basket stability

A recent survey of state practices conducted by the American Concrete Pavement Association (ACPA) found that 78% of states do not have specific requirements for the contractor to cut shipping wires on baskets. A few of these states allow the wires to remain intact while acknowledging that it may impact readings with an MIT-SCAN2-BT device for dowel bar location verification. These agencies are opting to accept some limitation on verification testing to avoid a risk of misalignment from flimsy dowel baskets and loose bars.

If a placer or a side-belt spreader (as shown in Figure 12) is being used, the contractor may better control concrete placement to avoid damaging or dislodging the baskets. Placing concrete using a placer or side-belt spreader also helps ensure that the concrete head in front of the paver does not induce undue pressure on the basket.

In paving operations where dowel baskets are placed just ahead of the paver, careful end-dumping of some of the concrete directly from haul trucks onto the dowel baskets (as shown in Figure 13) may help reduce sliding and tipping of dowel baskets; but, unless performed carefully, may also increase the likelihood of the baskets being pulled apart.

Peter Taylor

Figure 12. Side-belt placer operation

Privrat 2012

Figure 13. Haul truck end-dumping concrete directly onto dowel basket

Jim Thomas, The Harper Company

Figure 14. KY Brace before being rotated into place

Jim Thomas, The Harper Company

Figure 15. KY Brace in place

Care should be taken to minimize the dump height and to avoid dumping the whole concrete load directly onto the baskets as both actions may deform the assembly.

The KY Brace is a newer option that can be used to provide added support for a dowel basket assembly. The KY Brace is an extra triangular metal wire frame that begins in-plane with the basket support legs (as shown in Figure 14), and is rotated into the direction of paving after the anchors are applied (as shown in Figure 15).

The extra bracing is spaced at about 2 ft (600 mm) intervals along each side of the basket and provides additional rigidity to the basket to prevent dislodging and rotation even when shipping wires are cut. Therefore, another benefit of the KY Brace is that it does not significantly interfere with dowel bar verification devices like the MIT-SCAN2-BT.

SUMMARY

Dowel alignment and location are important to pavement performance in jointed concrete pavements. Dowel baskets must be fabricated and secured to withstand the pressures of the plastic concrete while it is being placed. Because of their importance to pavement quality, agencies and contractors should take the necessary care to ensure fastening methods work well for each project situation.

The most common anchors are basket stakes and basket clips, which are secured by fasteners or power nails. The roadbed foundation impacts which anchor should be used, the required embedment depth for the anchor, and the number of anchors required to properly secure the basket assembly. Contractors should test and adjust their chosen method of securing baskets regularly to avoid mislocation and/or misalignment problems.

Notwithstanding the primary importance of properly fastening the baskets, additional strategies may also be employed to secure baskets and avoid crushing or deforming the baskets during paving. These considerations include carefully discharging the concrete directly on the baskets where end-dumping is utilized, leaving basket tie wires intact, and using additional bracing, such as the KY Brace.

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This Tech Brief was developed under Federal Highway Administration (FHWA) contract DTFH16-14-D-0005. For more information contact:

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Key Words— anchor pin placement, anchoring methods, jointed concrete pavement, dowel bar alignment, dowel baskets

MAY 2016 FHWA-HIF-16-021