

Dowel Basket Anchoring Methods



U.S. Department of Transportation
Federal Highway Administration

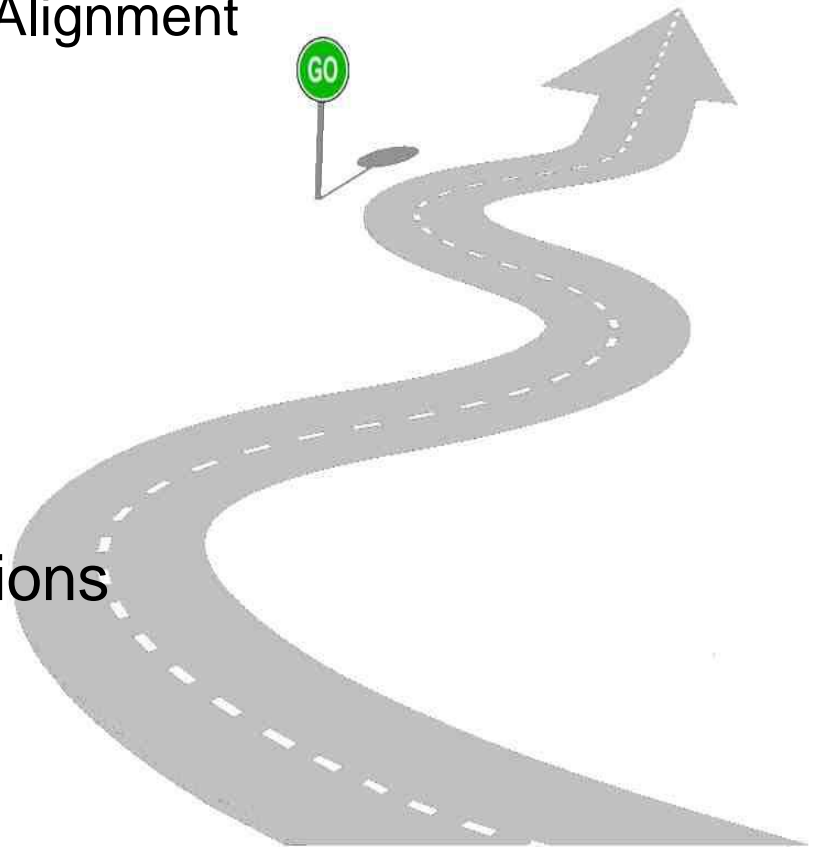
National Concrete Pavement
Technology Center



IOWA STATE UNIVERSITY
Institute for Transportation

Outline

- Dowel Alignment and Placement
 - Dowels 101 – The Basics
 - The Importance of Location and Alignment
 - Placement Methods
- Anchoring Dowel Baskets
 - Basket Stakes
 - Basket Clips
 - Typical Practices
- Additional Support/Bracing Options
- Conclusions



Reference

Tech Brief

DOWEL BASKET ANCHORING METHODS

Best Practices for Jointed Concrete Pavements

MAY 2016

FHWA-HIF-16-003

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).

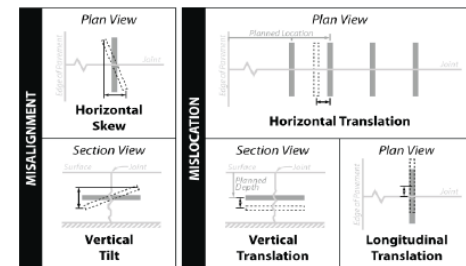
DOWEL ALIGNMENT AND PLACEMENT

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.



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Snyder 2012 after Tayeb 1986 and FHWA 2007

Figure 1. Five types of dowel bar misalignment and mislocation

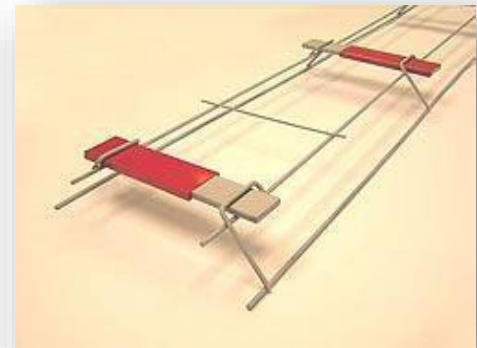
<http://www.fhwa.dot.gov/pavement/concrete/pubs/hif16021.pdf>

DOWELS 101 – THE BASICS

Introduction

- Dowels are the most commonly used means for mechanical load transfer in concrete pavement joints.
- To perform optimally over many years of pavement life dowels need to be:
 - Oriented appropriately
 - Within tolerable location limits
- Proper placement ensures optimal performance.
- Attention to dowel placement and securing dowels is an important quality control activity.

There Are Many Different Types of Dowels



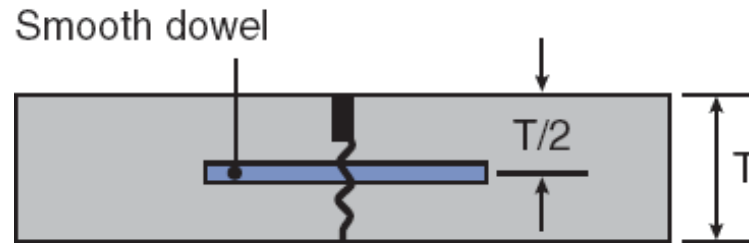
Typical Dowel Specifications

- AASHTO M254 - Standard Specification for Corrosion-Resistant Coated Dowel Bars
- ASTM A1078 - Standard Specification for Epoxy-Coated Steel Dowels for Concrete Pavement



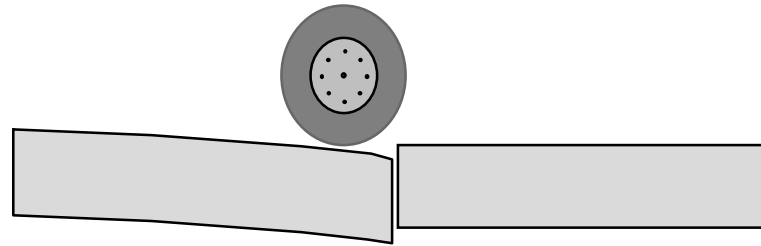
Goal of Dowel Placement

- ***Adequate Alignment*** such that they impose no intolerable restraint on joint opening/closing.
- ***Location within Tolerance*** such that they provide adequate long-term load transfer.

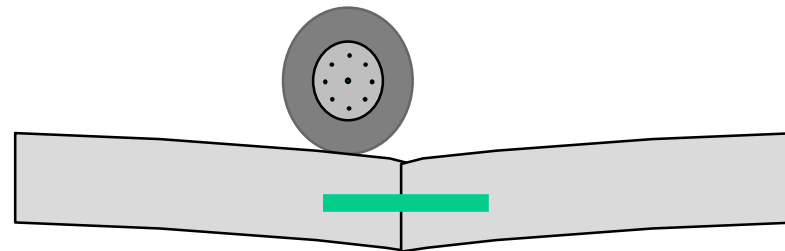


The Purpose of Dowel Bars

0% Load Transfer Efficiency



100% Load Transfer Efficiency



Problems From Poor Load Transfer

Pumping of fine-grained materials from beneath the joints.



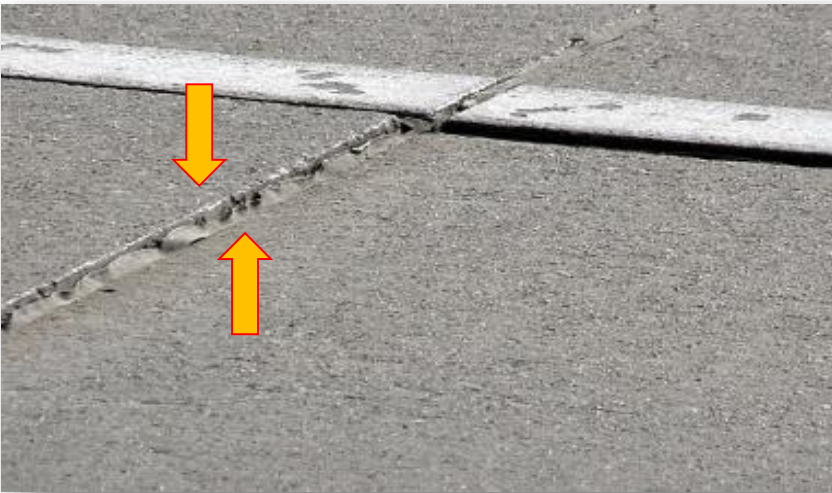
Water expulsion under wheel load



Shoulders stained from fine base materials

Problems From Poor Load Transfer

Faulting and corner breaks are common manifestations from pumping



Faulted Joint



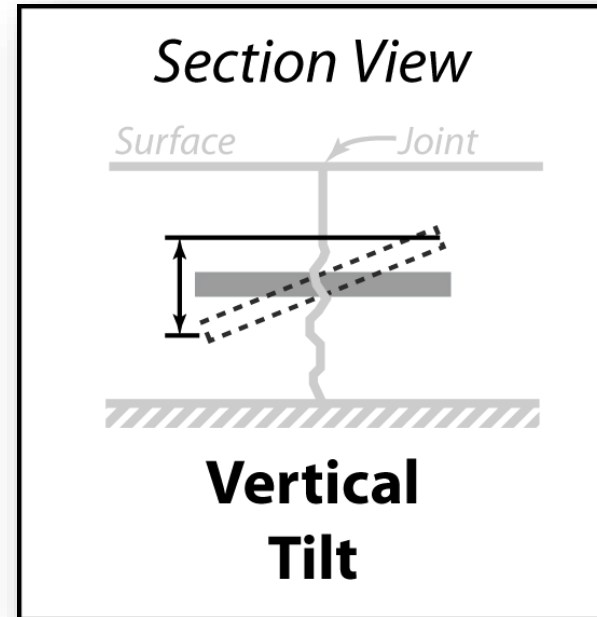
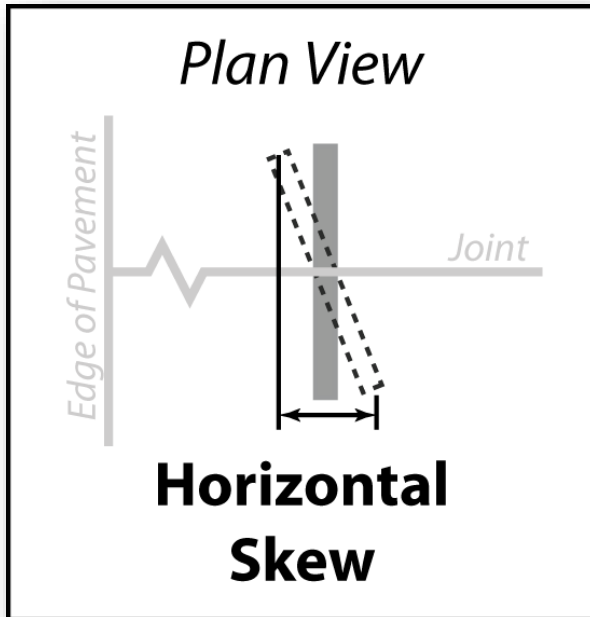
Corner Breaks

IMPORTANCE OF LOCATION AND ALIGNMENT

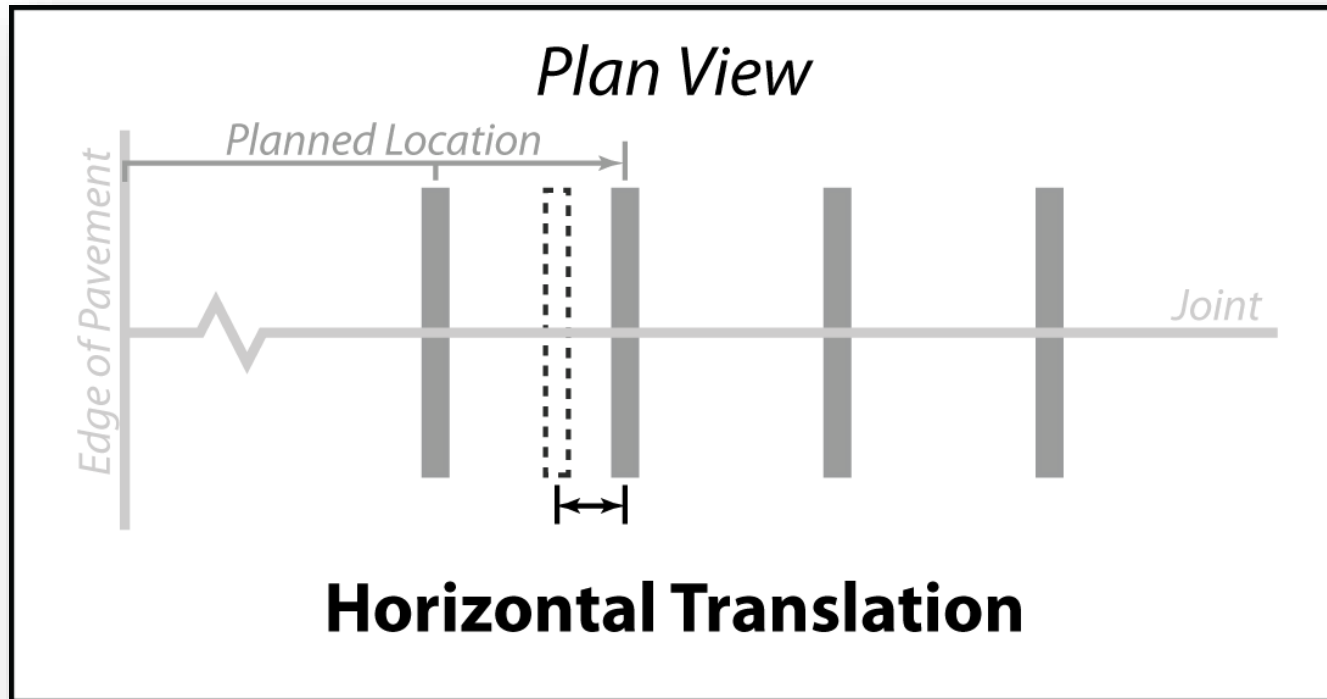
Dowel Alignment and Location

- Dowel location and alignment are important to maximizing long-term performance
- Good alignment allows joints to open and close as slabs expand/contract with temperature cycling
- Good location ensures there is enough connection to provide load transfer between slabs
- Dowels baskets need to be positioned and fastened well

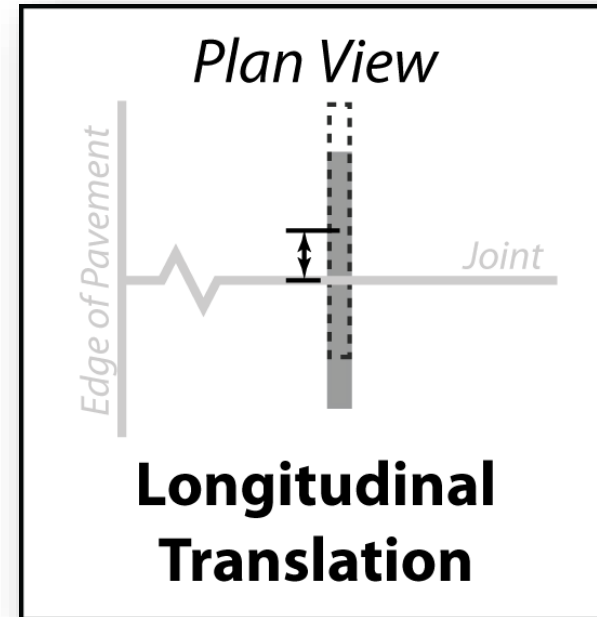
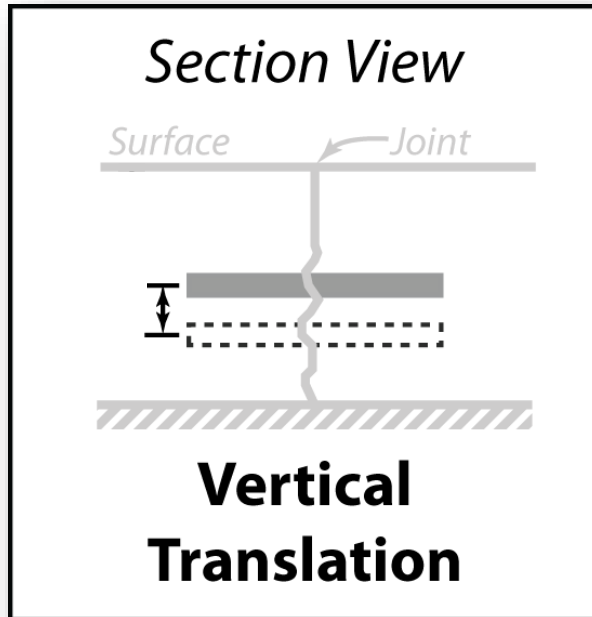
Dowel Alignment – Skew and Tilt



Dowel Alignment - Translation



Dowel Alignment - Translation



Dowels & Dowel Alignment 101

- Typical dowel bar installation results in a combination of skew, tilt and translation of some bars.
- The key is keeping the bars within reasonable tolerances.

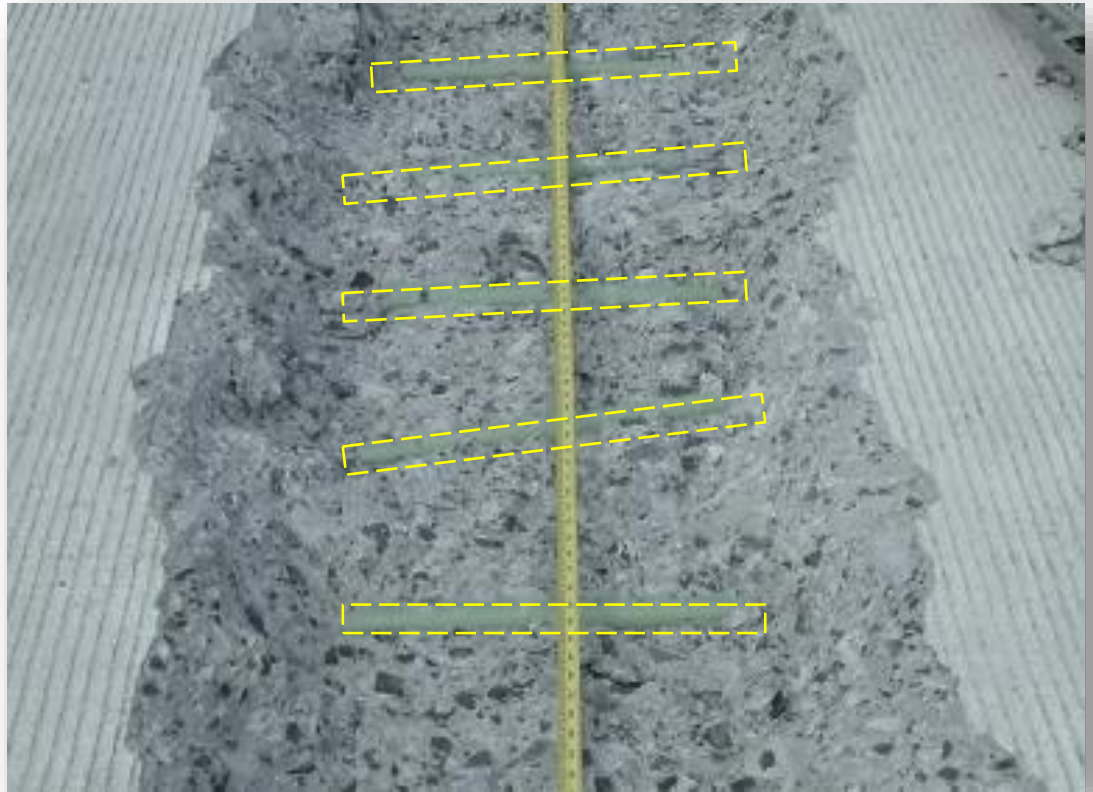
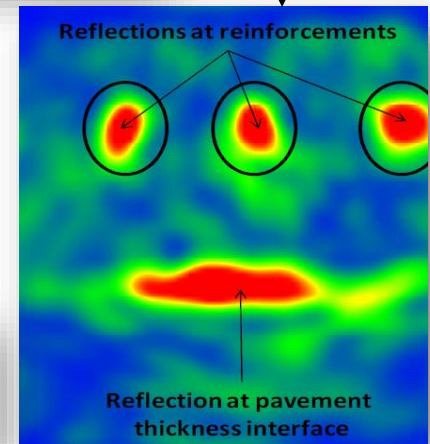
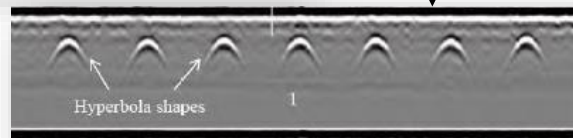




Photo Credit to ACPA

Dowels & Dowel Alignment 101

- Dowel bar imaging has provided a method to detect bar location and alignment without damaging the slab



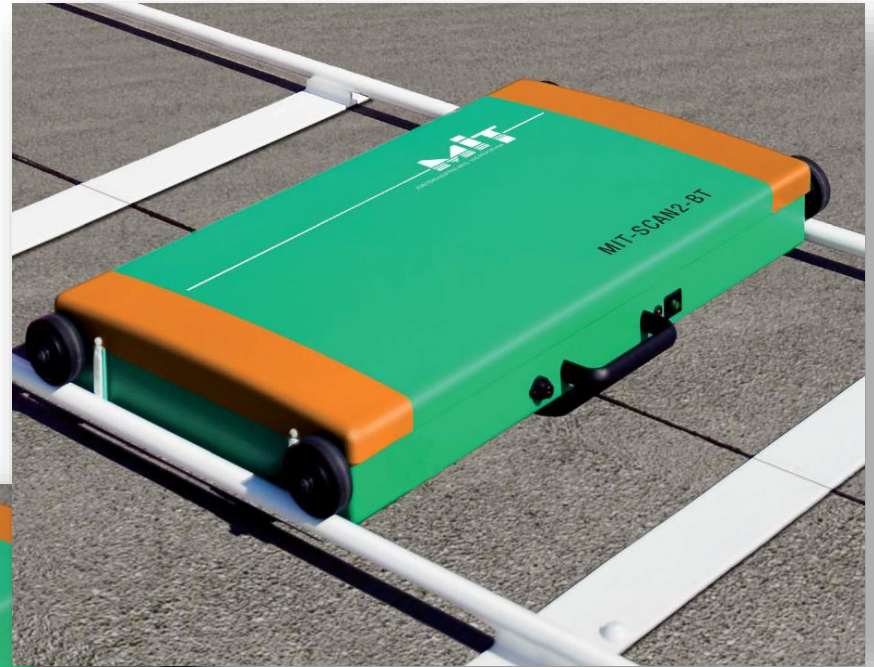
Dowels & Dowel Alignment 101

- MIT Scan2 B.
- Consists of a compact rail-guided measuring device.
- GRP (glass fiber reinforced plastic) rail system.
- Unit is pulled along rails while measuring.



Dowels & Dowel Alignment 101

- MIT Scan2 BT requires calibration for accurate results



Dowels & Dowel Alignment 101

- MIT-SCAN2 typical output provides:
 - Graphical presentations
 - Numerical data
- Each bar included.
- Easy to interpret.

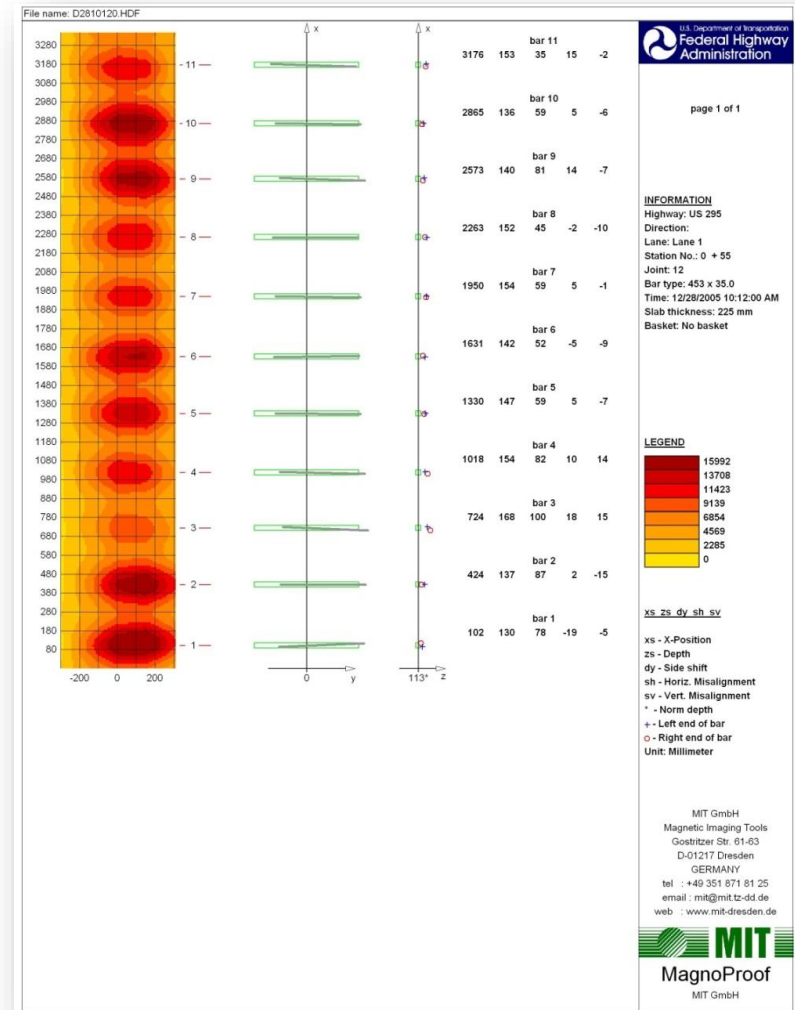
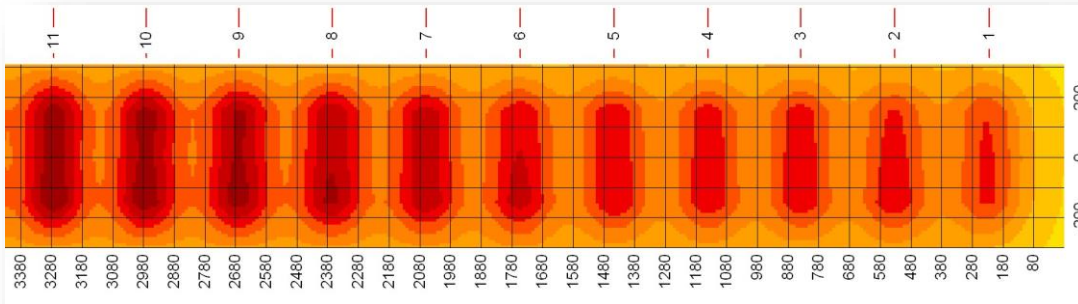
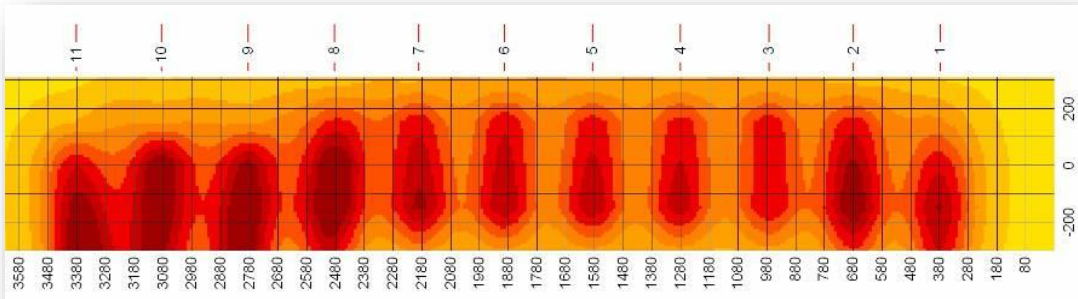


Photo Credits to KSE Testing Equipment

Dowels & Dowel Alignment 101

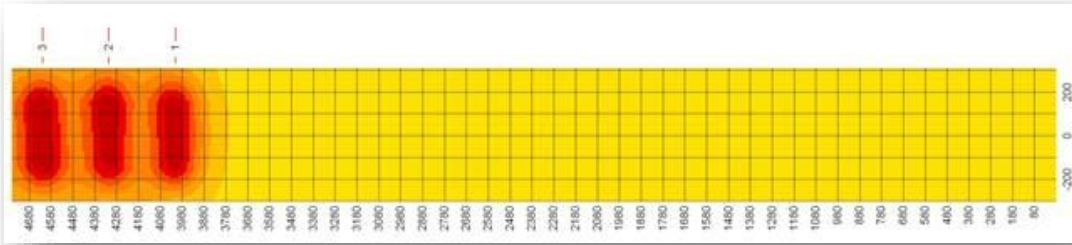


Scan from typical joint
showing bars in good position

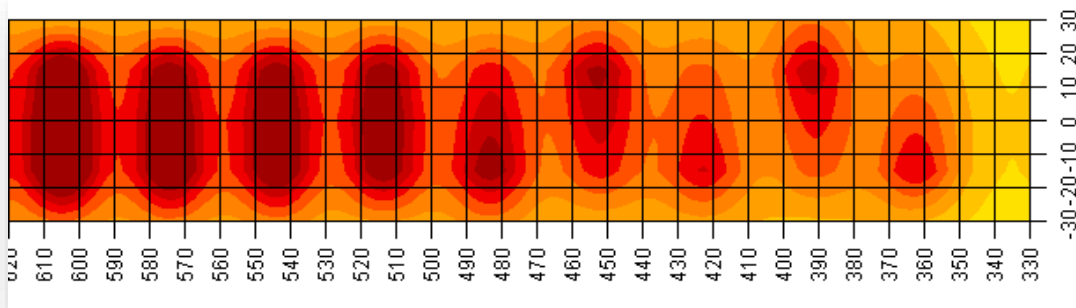


Scan from joint indicating an
anchoring Issue

Dowels & Dowel Alignment 101



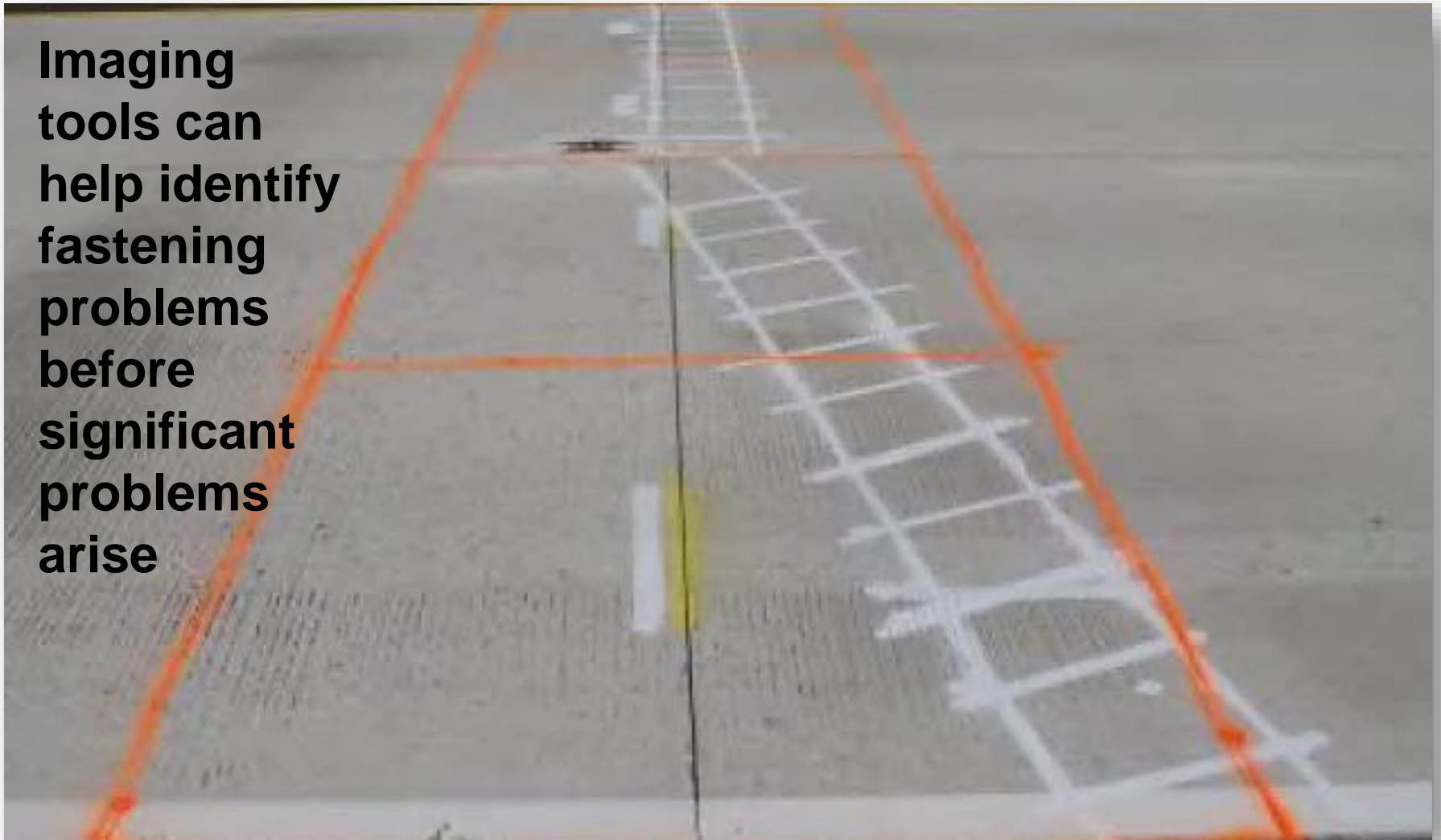
Scan from joint with missing
dowel bars



Scan from joint where the
basket opened & dowels
tilted

Dowels & Dowel Alignment 101

Imaging tools can help identify fastening problems before significant problems arise



Dowels & Dowel Alignment 101



Dowel too close to surface

Dowels tipped and too close to surface ►



Dowels & Dowel Alignment 101



▲ Dowel too close to corner.

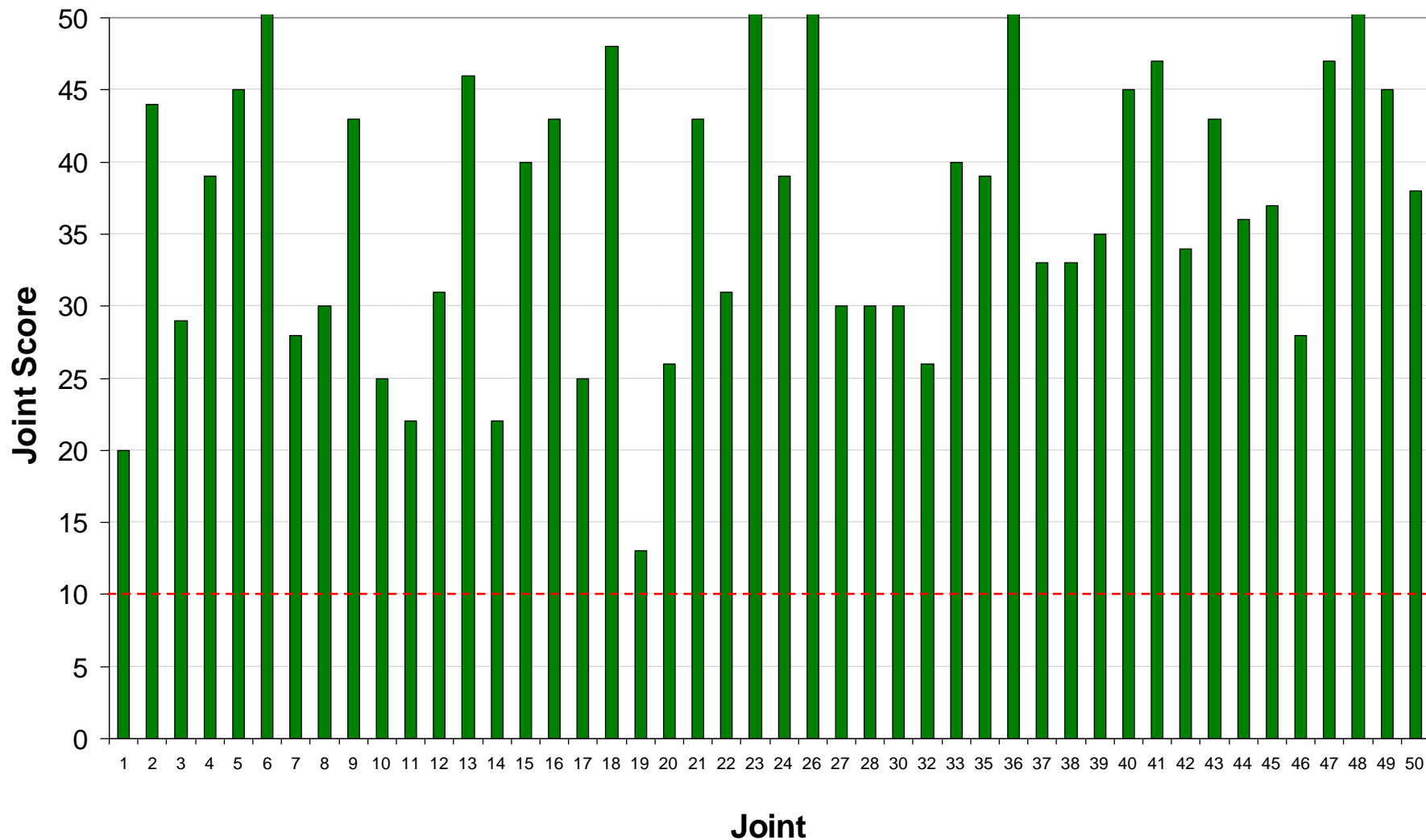
Dowel tipped and too close to surface ►



Dowels & Dowel Alignment 101

- No perfect measure exists to correlate the degree of misalignment and joint distress or loss of load transfer.
- Engineers are still trying to create a reasonable tolerance and specification measure to take advantage of new measuring devices.
- Joint Score is one approach.

Joint Score for the GA Section





30-yr old pavement section with extremely poor
dowel alignment

Photo Credit to ACPA

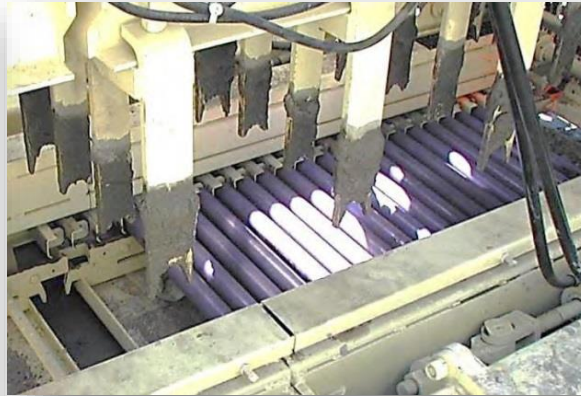
DOWEL PLACEMENT

Dowel Placement

- Two methods:
 - Dowel Bar Insertion
 - Dowel Basket Assemblies



Dowel Bar Insertion

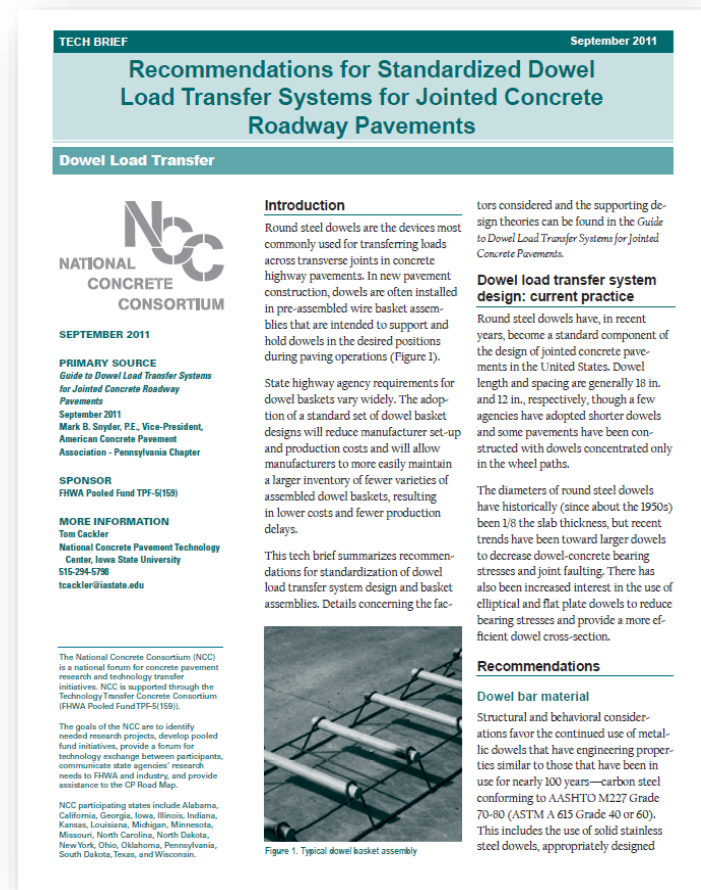


Dowel Basket Assemblies

- Consist of multiple components.
- Typically made of steel.
- Typically use the dowels as part of the basket.
- Often alternate affixing the dowel to the basket frame on each side.
- Sometimes called “cages”.
- There is no one standard for the frame design.

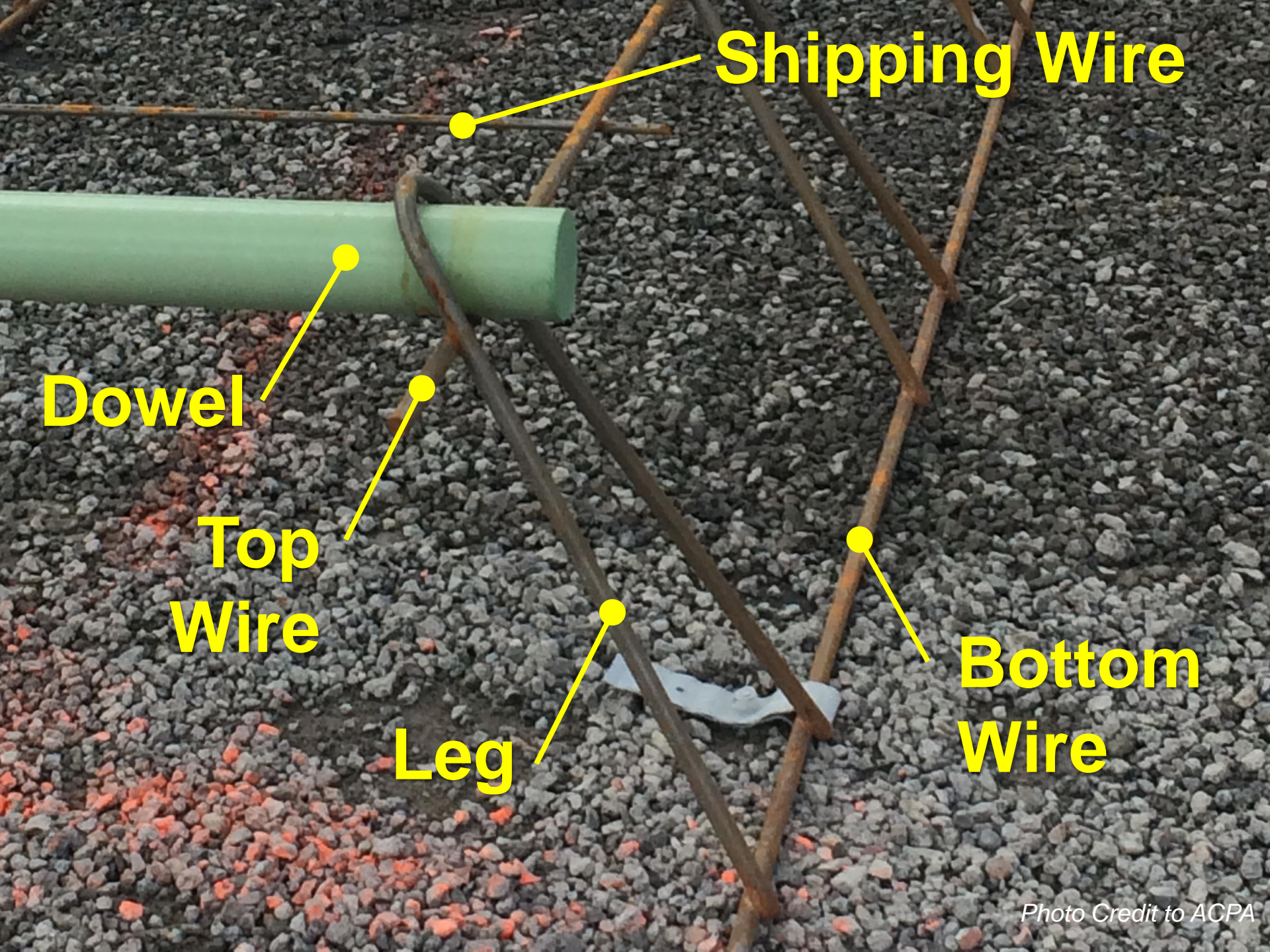
Dowel Basket Standardization Goal

- National Concrete Consortium goal for more than a decade.
- Among other recommendations:
 - Basket rail wire should be:
 - 0.306 in. min. diameter (1/0 gauge).
 - Loop wires should be:
 - “U” or “V” style.
 - 0.243 in. min. diameter (3 gauge).
 - Spacer or tie wires should be:
 - 0.177 in. dia. (7 gauge).
 - 4 used per standard-width basket.



Dowel Basket Assemblies





Shipping Wire

Dowel

Top Wire

Leg

Bottom Wire



Dowels stacked and Stored for Use

The Variety of Dowels

- Variables:
 - Shape
 - Size
 - Length
 - Material
 - Ends (cut & treatment)
 - Coating (type & thickness)

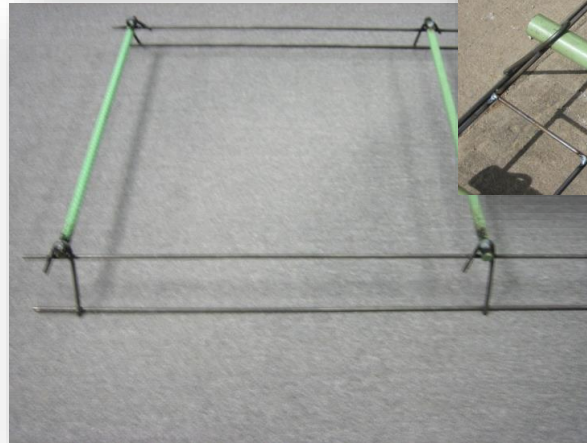
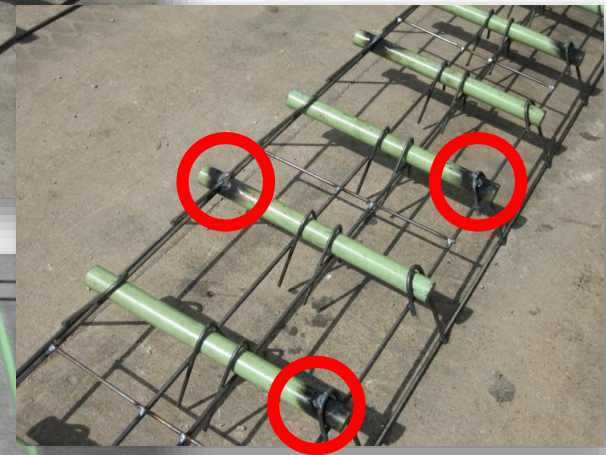
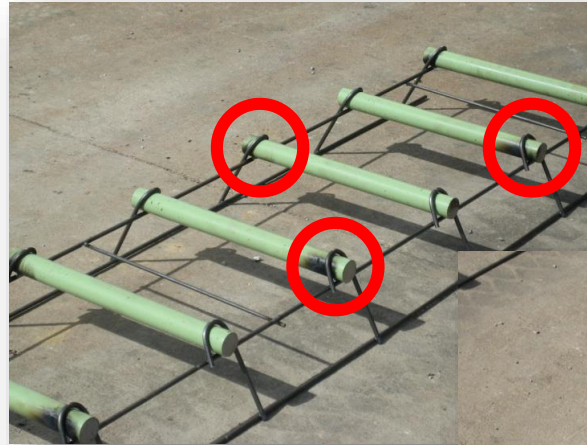


DOT Epoxy Coating Mil Thickness Variation

AL 5-9	IN 7 min	NY 10-18	SD 5-10
AZ 8-12	IA 6 min	NV 8-12	TN 8-12
AR 8-12	KS 8-12	NC 7-13	TX 8-12
CO 5-9	KY 9-15	NM 6-10	UT 8-12
DE 5-9	MI 8-12	ND 8-12	VA 8-12
FL 7-12	MN 8-12	OH 5-9	WA 8-12
GA 10-14	MO 5 min	OK 7-12	WV 7 min
ID 5-9	MT 8-12	PA 8-12	WI 5-9
IL 7-12	NE 5-9	SC None	WY 5-9

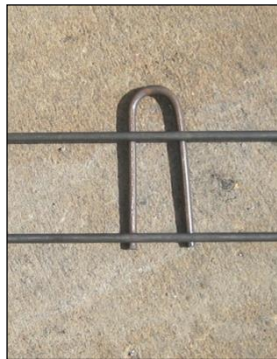
Types of Dowel Basket Assemblies

- Contraction joint
 - Conventional
 - Half-width
 - Tapered baskets
 - Skewed baskets
 - Stepped baskets
- Expansion joint
- Rebar baskets
 - Tied joint
 - Hing-joint baskets



Dowel Basket Assembly Variations

- Design of basket
- Wire gauges
- Number of shipping wires
- Number of dowels
- Spacing of dowels
- Dowel height
- Leg Style



Dowel Basket Leg Styles

- “J”
- “U”
- “V”
- “R”
- Choked “V”



Dowel Basket Assembly – Typical Dowel Spacing

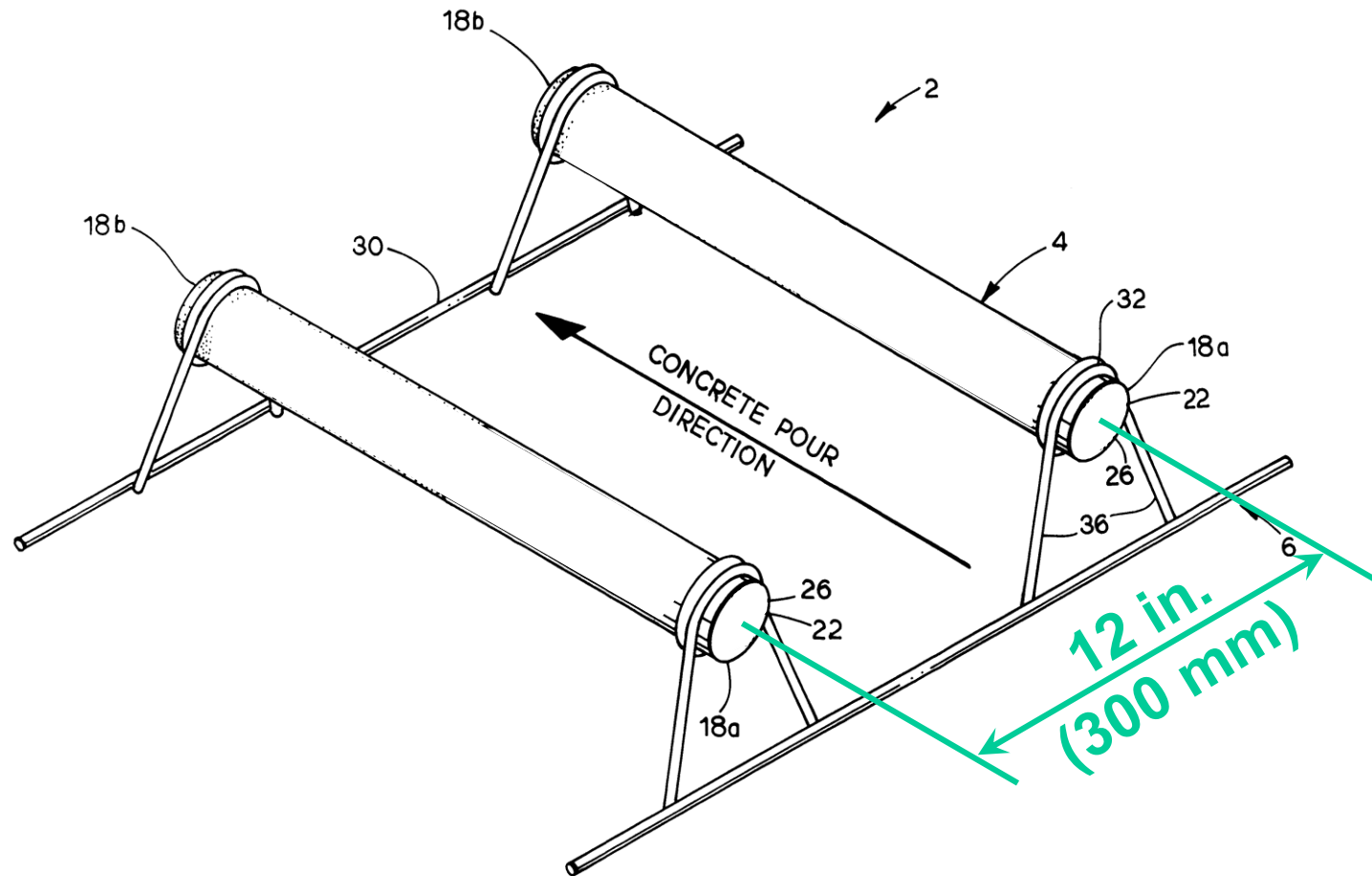




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ANCHORING BASKET ASSEMBLIES

Types of Anchors

- Pins
- Stakes
- Spikes
- Clips

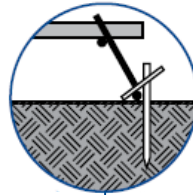


Number of Anchors

- Practice varies by:
 - Specification requirement (sometimes)
 - Contractor experience
 - Base type
- Recommended minimums:
 - 8 per basket (12-ft lane)
 - 10 per basket (14-15 ft. lane)
 - Same number on each side
- Make Adjustments as Needed!

Number of Anchors per Basket

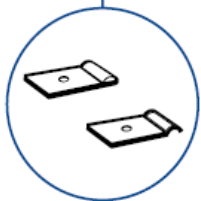
STAKES FOR UNBOUND
BASE LAYERS



Dowels spaced per plan
(12 in. typ.)

Dowels affixed on alternate sides

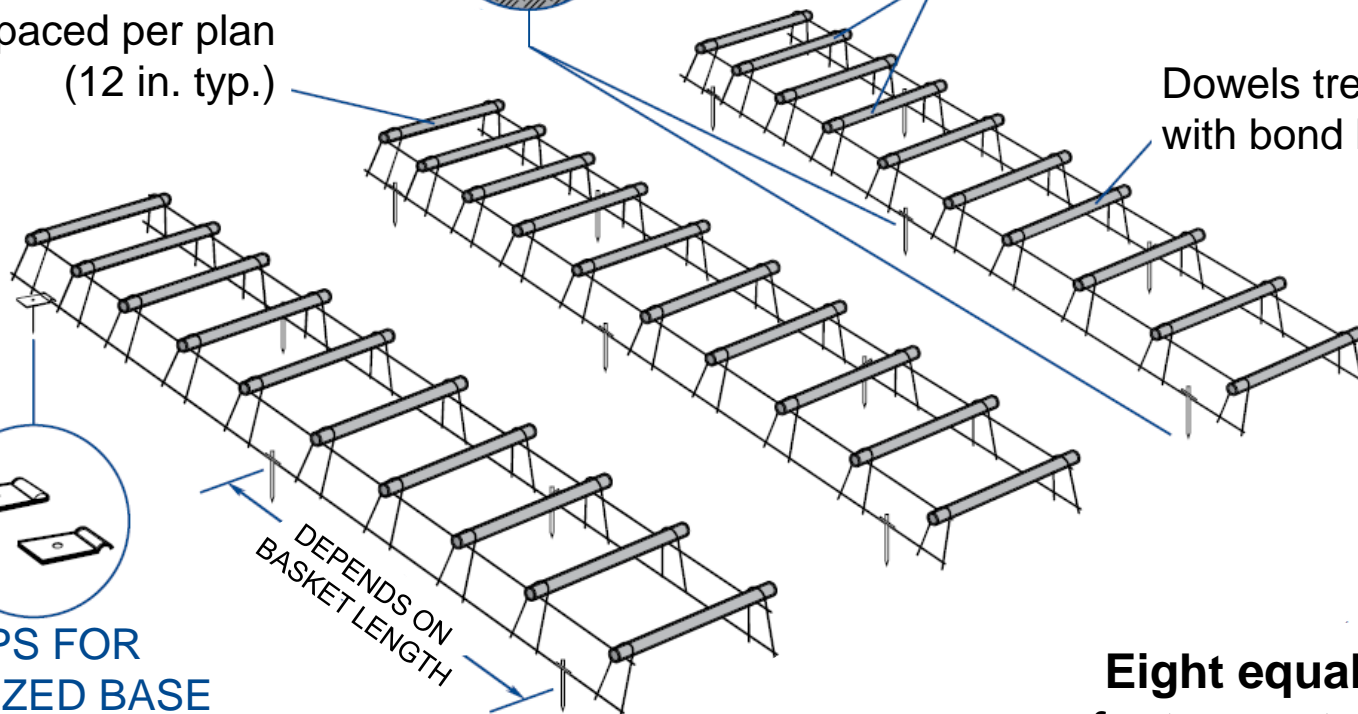
Dowels treated
with bond breaker



CLIPS FOR
STABILIZED BASE
LAYERS

DEPENDS ON
BASKET LENGTH

**Eight equal-spaced
fasteners typical per
12-ft lane basket**



Anchoring Depth

- Granular Base
 - Most states require minimum of 12 in. (300 mm)
- Dense-Graded Stabilized Base
 - 4 in. (100 mm) usually sufficient
- Open-Graded Stabilized Base
 - 6 in. (150 mm) depth to hold
- Make Adjustments as Needed!

Anchoring on Leave Side of Joint

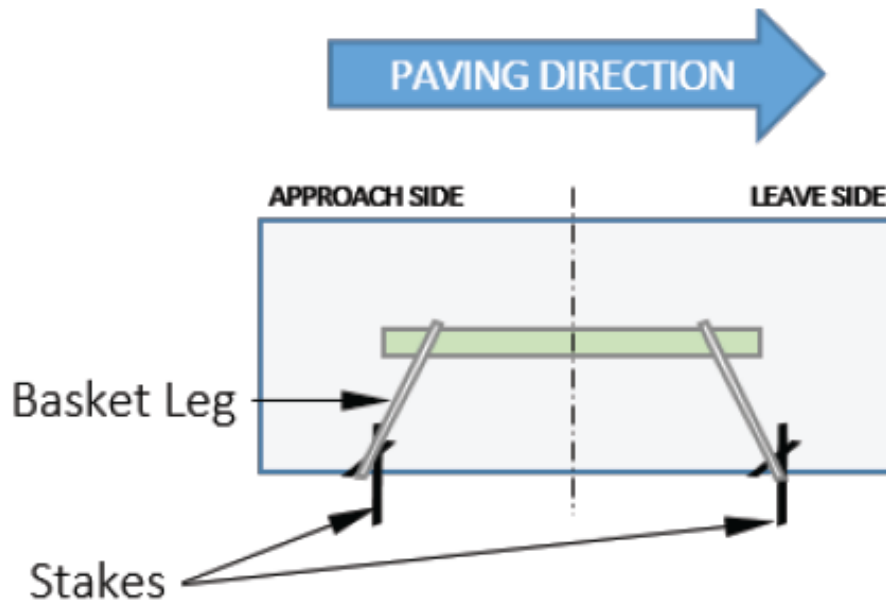
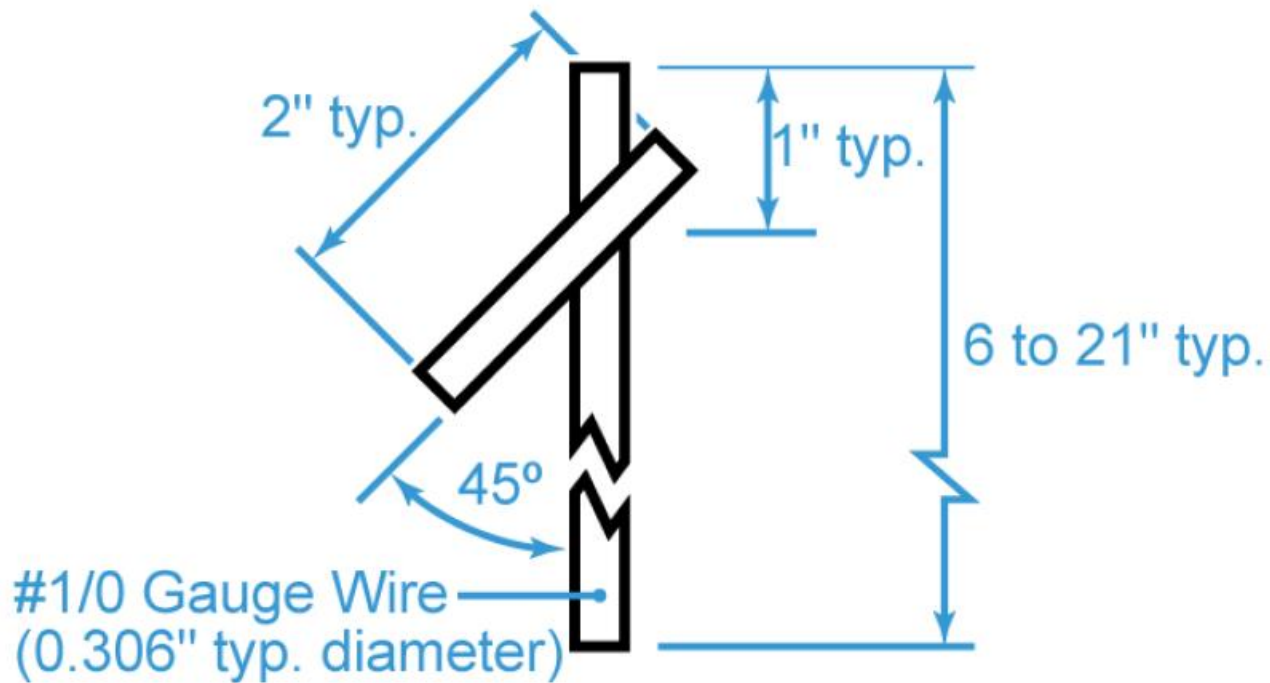


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Anchoring Dowel Baskets – Basket Stakes



Baskets Stake – Typical Dimensions

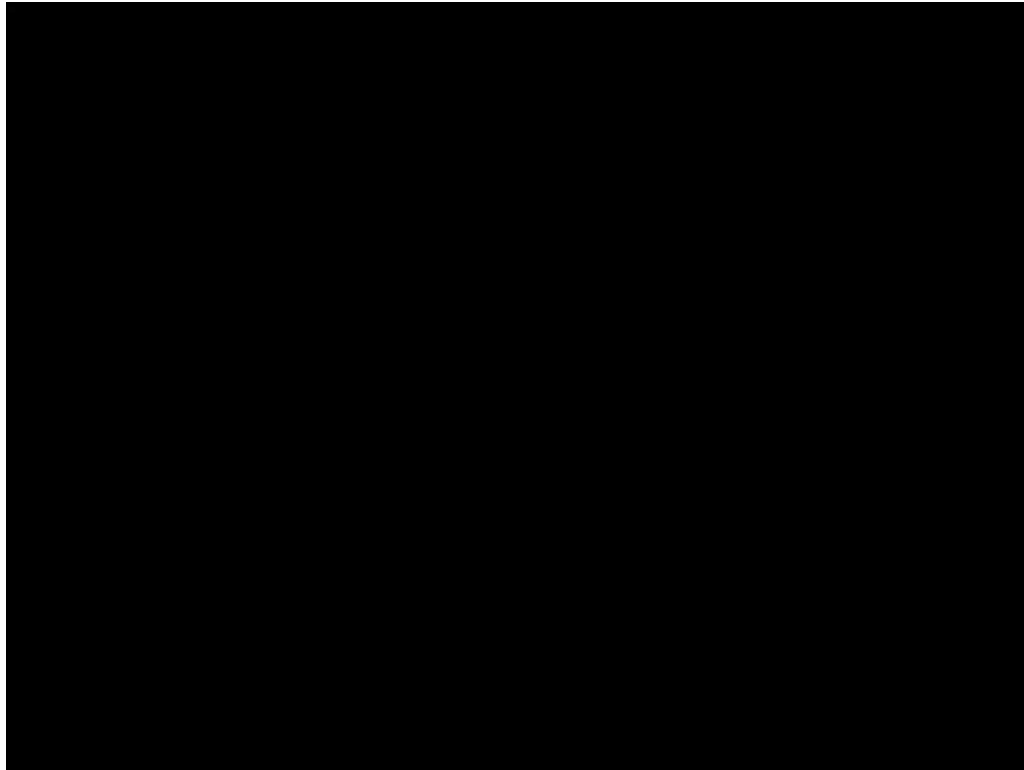


Basket Stakes – Driving into Grade

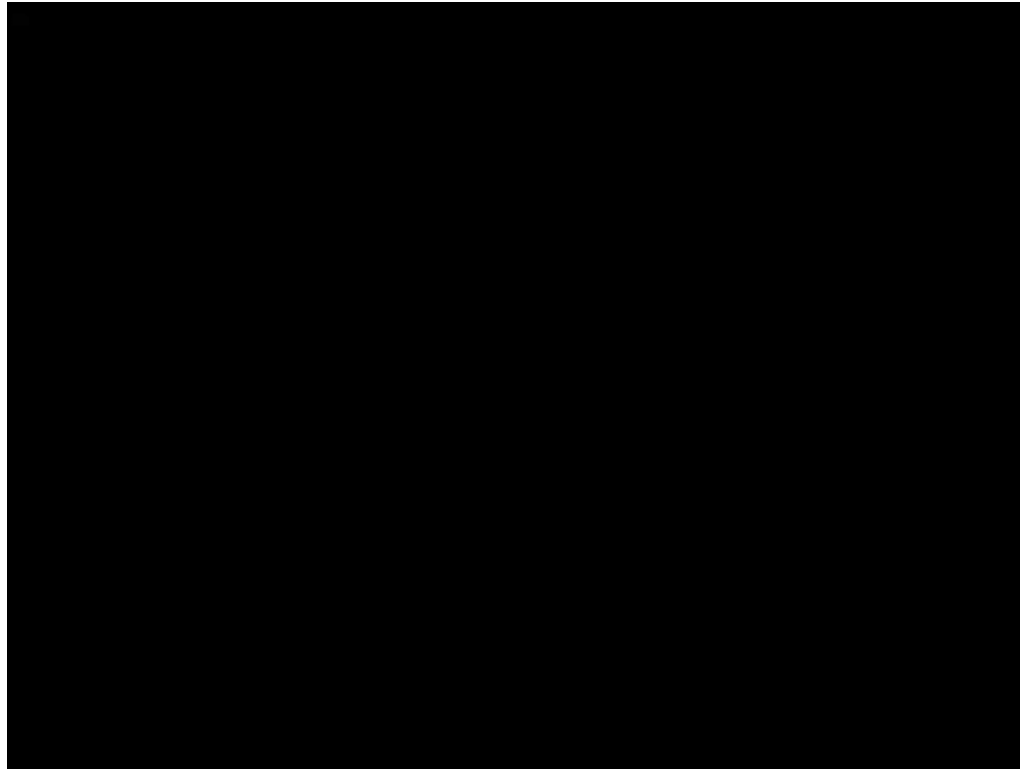


Photo Credits to Hilti North America (L) and ACPA (R)

Basket Stakes – Driving by Hand



Basket Stakes – Driving with Pneumatic Hammer



Basket Clips – Wrap-Around Type



Basket Clips – Nail Down Type



Photo Credits to MnDOT (top L), Hilti North America (top R), and Dayton Superior

Basket Clips – Nailing into Place

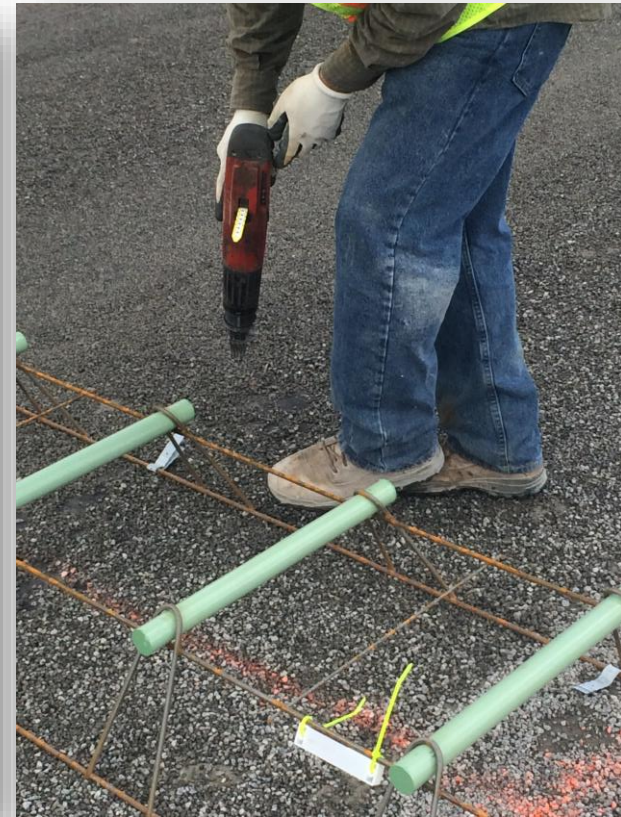
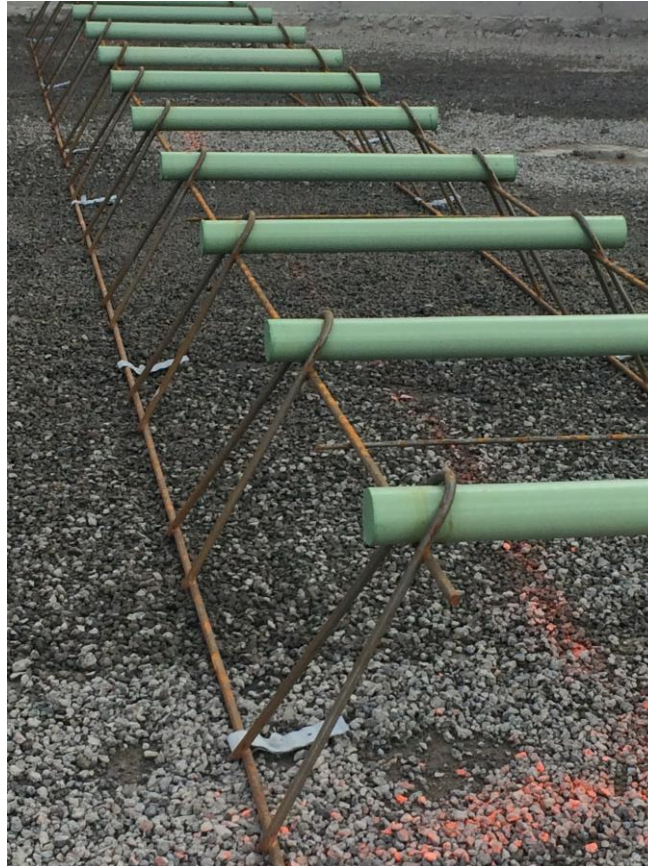


Photo Credits to Hilti North America (L), Duit Construction Company (C), and ACPA

Nailing Tool and Pins



Anchoring Best Practices



Anchoring Dowel Baskets – Installation



CONCRETE PLACEMENT CONSIDERATIONS

Discharging on Baskets w/ Placer or Spreader

- Placer or Side Spreader placement provides good control to avoid damaging baskets.
- This method preferable on projects where haul road is available to deliver concrete.
- Ensures that the concrete head in front of the paver does not induce undue pressure on the basket.

Placer/Spreader



Placer/spreader with side belt to receive and distribute concrete from haul trucks.



Placer spreads concrete ahead of paver
(nighttime construction).

Discharging on Baskets

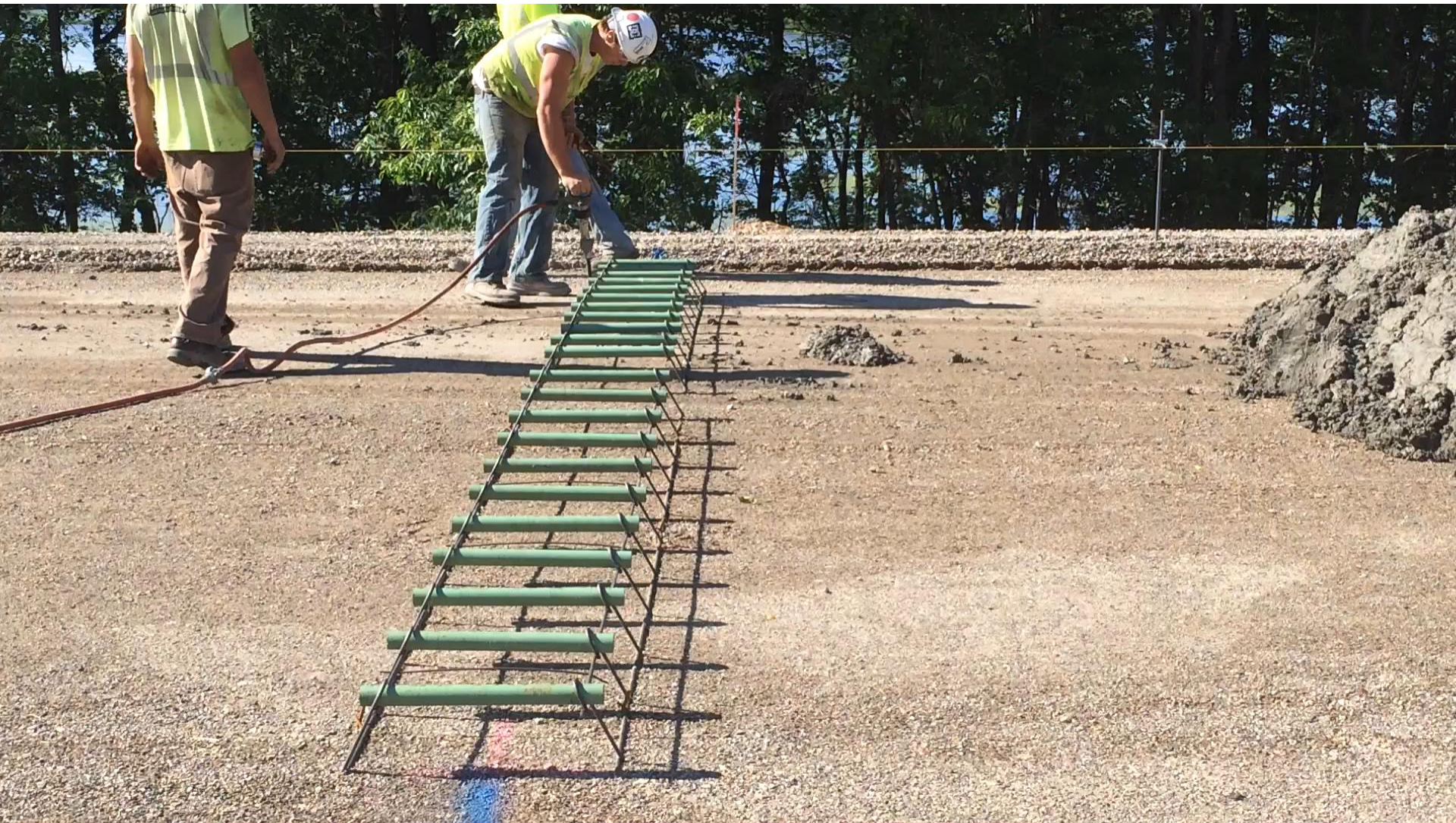
- End dumping requires special attention to fastening
- Minimize the dump height if possible to avoid deforming the baskets.



Anchoring Dowel Baskets



Anchoring Dowel Baskets



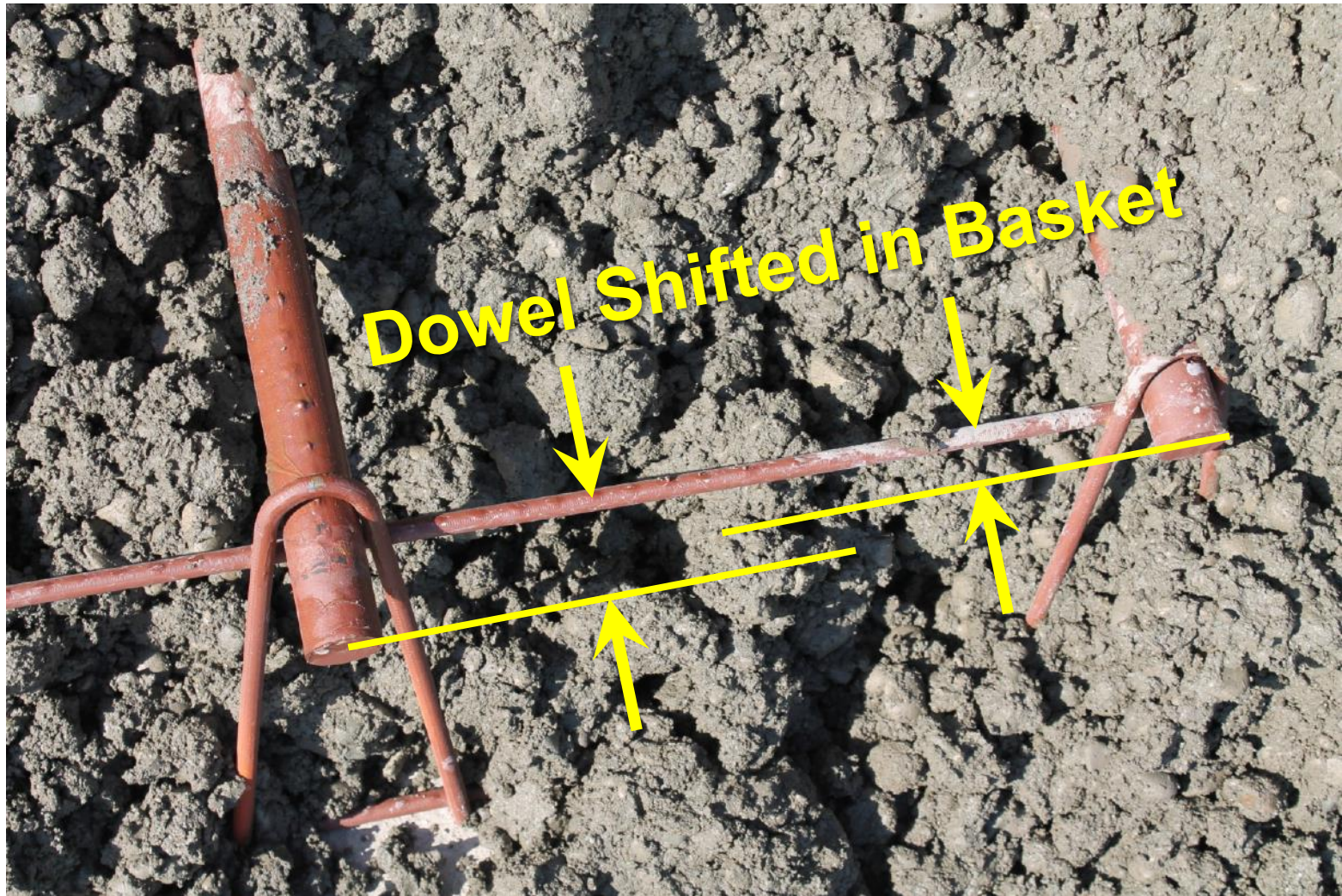
Video Credit to ACPA

ADDITIONAL SUPPORT AND BRACING CONSIDERATIONS

Basket Rigidity and Tie Wires

- With well-made and properly anchored baskets:
 - Dowel bars should not skew, tilt or translate
- Cutting basket tie wires reduces basket rigidity.
- ACPA recommends against this practice:
 - No proof of problems in field.
 - Engineering analysis indicates tie-wire welds will yield far before joint is restrained.

Basket Rigidity Important to Avoid Collapse



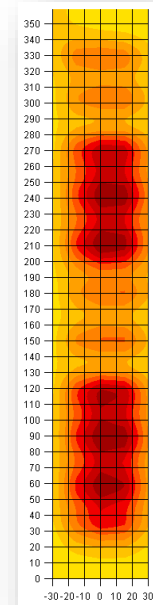
Basket Rigidity Important to Avoid Collapse



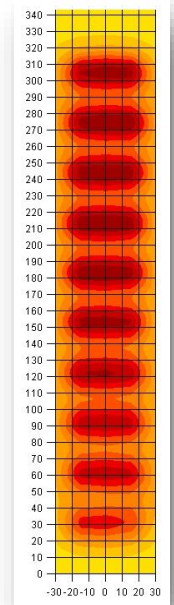
Basket Rigidity – Shipping Wires



Cutting tie wires to facilitate MIT-Scan measurement can be counterproductive.



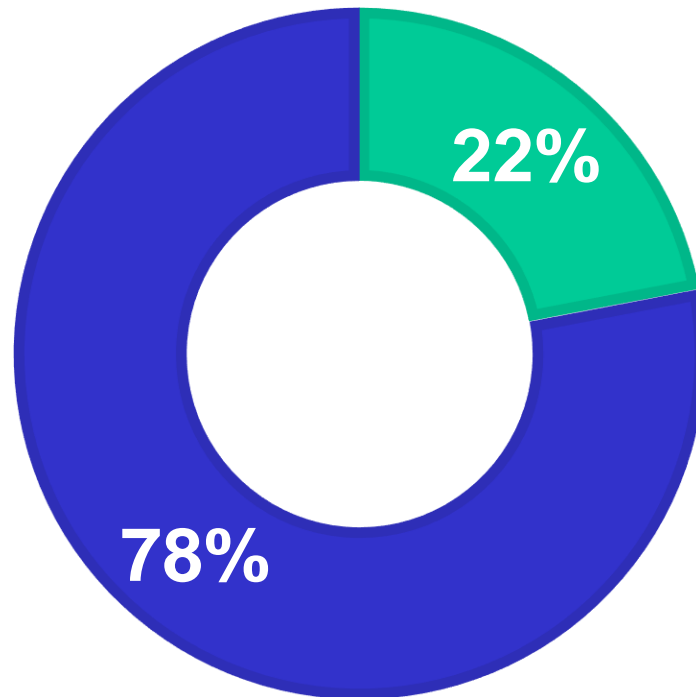
Erroneous Scan
with Wires Intact



Better Scan
with Wires Cut

Basket Rigidity – Shipping Wires

■ Require Cutting Wires ■ No Requirement



Basket Rigidity – KY Brace

- Provides additional leg stability
- Manufactured as part of the basket frame.
- Tool is used to rotate into position.



Basket Rigidity – KY Brace



Basket Rigidity – Sand Plates



CONCLUSIONS & ADDITIONAL RESOURCES

Conclusions

- Dowels, placement, and alignment are critical to pavement performance
- Baskets must be secured properly with stakes or clips (typically 8 per basket)
- The type, number and depth of stakes or clips depends on the base type
- Anchoring on leave side of lower frame wire usually considered best

Conclusions

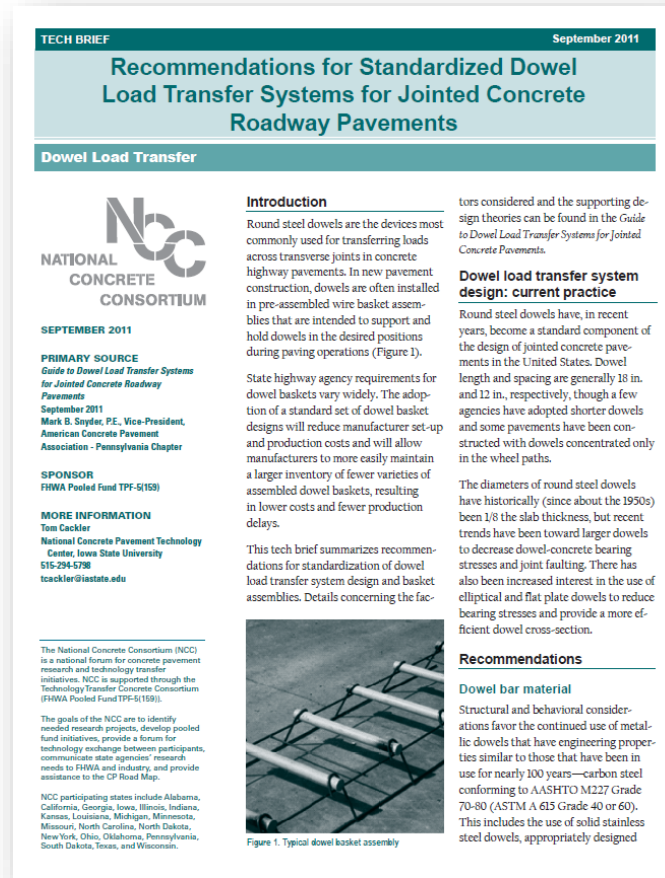
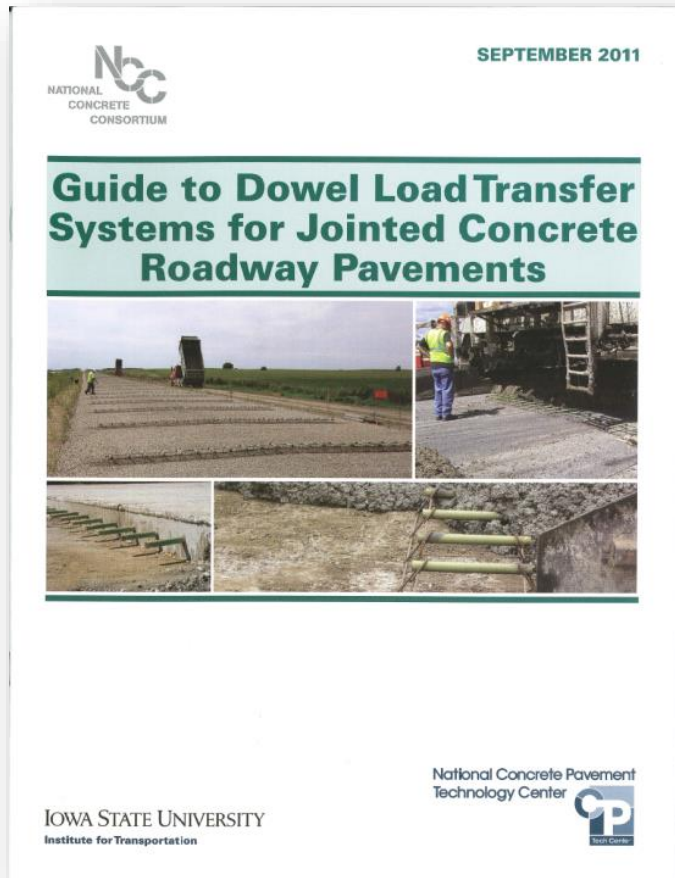
- Additional basket rigidity is important to prevent dowels from dislodging
- Rigidity can be provided by:
 - Not cutting shipping wires
 - Using the KY Brace
 - Using care in discharging concrete onto baskets
 - Using sand plates on weaker or looser base layer materials

Additional Resources



www.acpa.org

Additional Resources



www.cptechcenter.org

Questions and Discussion?

