NCC Dowel Bar Task Force 2.0 Progress Report

Fall 2015 NCC Meeting

Milwaukee, WI

Tom Burnham, Minnesota DOT – Co-Chair

Mark Snyder, Engineering Consultant – Co-Chair

NCC Dowel Bar Task Force 2.0

(formed Spring 2014, Jacksonville, FL NCC Meeting)

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Steve Tritsch, JC Supply
Tom Yu, FHWA

Current AASHTO Dowel Specs

- M 254 – Standard Specification for Corrosion-Resistant Coated Dowel Bars
  - "… specification covers the materials, manufacture and installation of coated dowel bars to be used where corrosion-resistant performance is essential … [t]he dowel shall consist of a steel core covered by an organic coating."
- T 253 – Standard Method of Test for Coated Dowel Bars
  - "..methods to test the qualifications of the organic coating of corrosion-resistant dowel bars to withstand the effects of weathering, de-icing chemicals, and the abrading and loading stresses experienced in field joints."

For "organically coated" (epoxy- or plastic-coated) dowels, 1.25-in diameter, 20-30 mils coating (Type A) or 5-9 mils (Type B).

Dowels qualified as individual products, not systems.

Limitations of Current AASHTO Specs

- Not applicable to many dowel products being used and developed today
  - Plate dowels
  - Hollow/Tube dowels (with or without coatings)
  - Composite dowels (FRP/steel, zinc/steel, etc.)
  - Elliptical dowels
  - No ability to evaluate structural performance potential (differential deflection) of nonstandard dowel spacing
  - Technically, not applicable to epoxy/plastic coatings currently being used in many states
  - Many more …

There is a need for a specification and associated suite of structural and corrosion tests that can:

- Provide *manufacturers* with targets for *innovative improvements*, and
- Provide *agencies* with *objective measures of* the relative *performance potential* of competing products.

Without the ability to fairly and objectively quantify the relative performance benefits of various dowel materials and system designs, it is difficult for agencies to justify the additional costs of better-performing systems.

Task Force Objective

- Establish specifications and tests that can be used by agencies for acceptance/rejection of *all* dowel systems
- Provide indications of performance potential
  - Structural adequacy
    - Shear, relative deflection
  - Corrosion resistance
    - Durability of coating, if any
- Use existing T 253/M 254 as basis of development

Fall 2015 Status Update

- Draft documents now available:
  - **Standard Specification** for Corrosion-Resistant Dowel Bars
  - **Standard Method of Test** for Corrosion-Resistant Dowel Bars
- To be posted to NCC site for review and comment (October 2015?)

Draft

Standard Specification for Corrosion-Resistant Dowel Bars

Scope

- Dowel bar types
  - ➢ Type A: One metallic material
    - *MMFX, stainless steel, tube systems*
  - ➢ Type B: One non-metallic material
    - *GFRP*
  - ➢ Type C: Metallic-based core, coated or clad with metallic-based material
    - *Zinc-clad steel, stainless steel-clad steel, sleeved systems*
  - ➢ Type D: Metallic-based core, coated or clad with non-metallic-based material
    - *Epoxy coated steel, plastic coated steel, GFRP cladding on steel core*

Physical Requirements

- **Performance tests to ensure corrosion resistance:**
  - Pullout
    - Ensure slippage, no critical damage to coating
  - Abrasion
    - Resistance to abrasion during service
  - Corrosion
  - Chemical Resistance
    - Resistance to deicing chemicals or other solutions
  - Cathodic disbonding
  - Impact resistance
    - Resistance to shipping/paving impact forces
  - Delamination resistance
    - For clad or sleeved systems
  - Exposure
    - UV/moisture damage during storage

Physical Requirements

- **Performance tests to ensure structural capacity:**
  - Load testing (described later …)

Draft

Standard Method of Test for Corrosion-Resistant Dowel Bars

Performance Tests

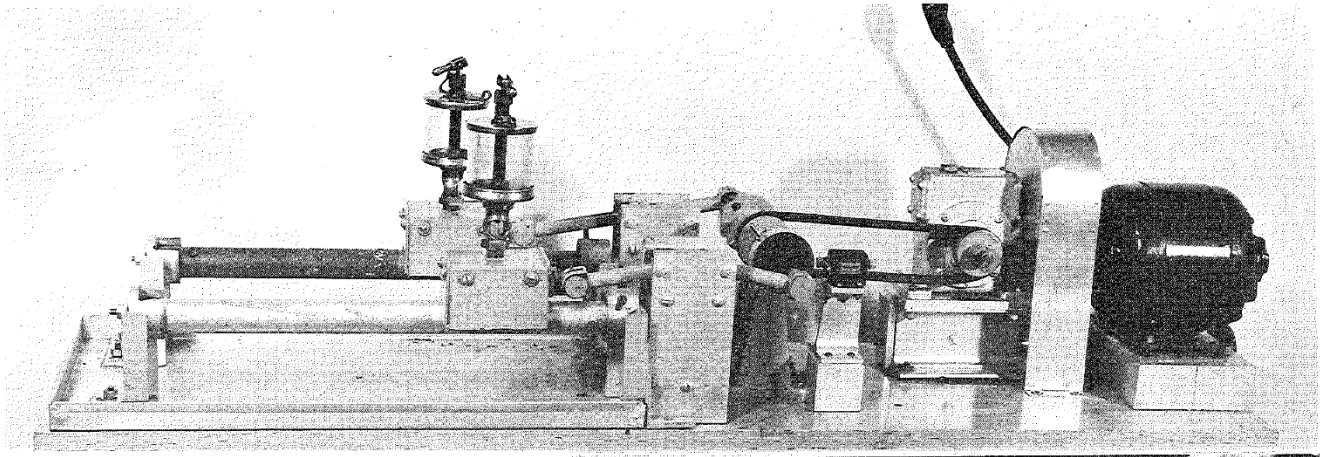
- Tests provide results
- Different tests apply to different dowel types
- Agencies determine limit values and how they are categorized for service life and/or climate
- Expert commentary guidance to be provided to aid agencies

Performance Tests

- Pullout Test
  - Ensure slippage
  - Similar to existing AASHTO T253 procedure
  - Questions
    - Should calcium or magnesium chloride solutions be added or substituted for sodium chloride?
    - Should freeze thaw cycles be increased or adjusted based on service life?
    - How to handle zinc coatings?

Performance Tests

- Corrosion-Abrasion Test
  - Resistance to abrasion from joint movement
  - Similar to existing AASHTO T253 procedure
  - Abradometer
  - Questions
    - Should number of strokes be increased or adjusted based on service life?
    - Should abraded dowels be placed in calcium or magnesium chloride solutions?
    - How to handle zinc coatings?



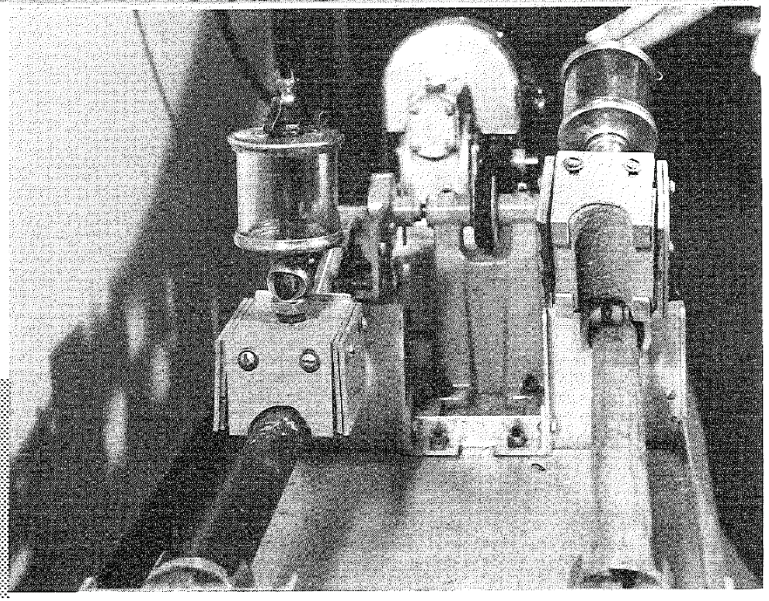


Figure 2. Two views of laboratory-fabricated abradometer device including detail (right) of abrading block holder with two dowels in place for testing.

Performance Tests

- Chemical Resistance Test
  - Resistance to immersion in various chemical solutions
  - Similar to existing AASHTO T253 procedure
  - Questions
    - Should length of immersion be increased or adjusted based on service life?
    - Should a magnesium chloride solution be added?

Performance Tests

- Impact Resistance Test
  - Resistance to damage during handling/paving
  - Applicable to non-metallic surfaces
  - Similar to existing AASHTO T 253 procedure
  - ASTM G-14 Falling Weight Test

Performance Tests

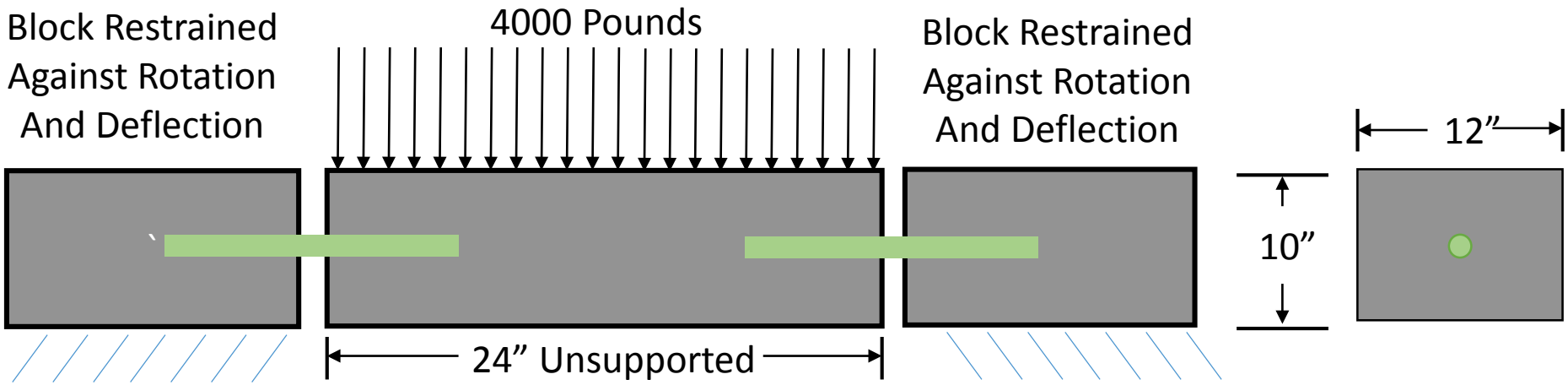
- Cathodic Disbonding Test
  - Behavior following breach of coating/cladding during ASTM G14
  - Similar to existing AASHTO T253 procedure
  - Questions
    - Should test period be increased or adjusted based on service life?

Performance Tests

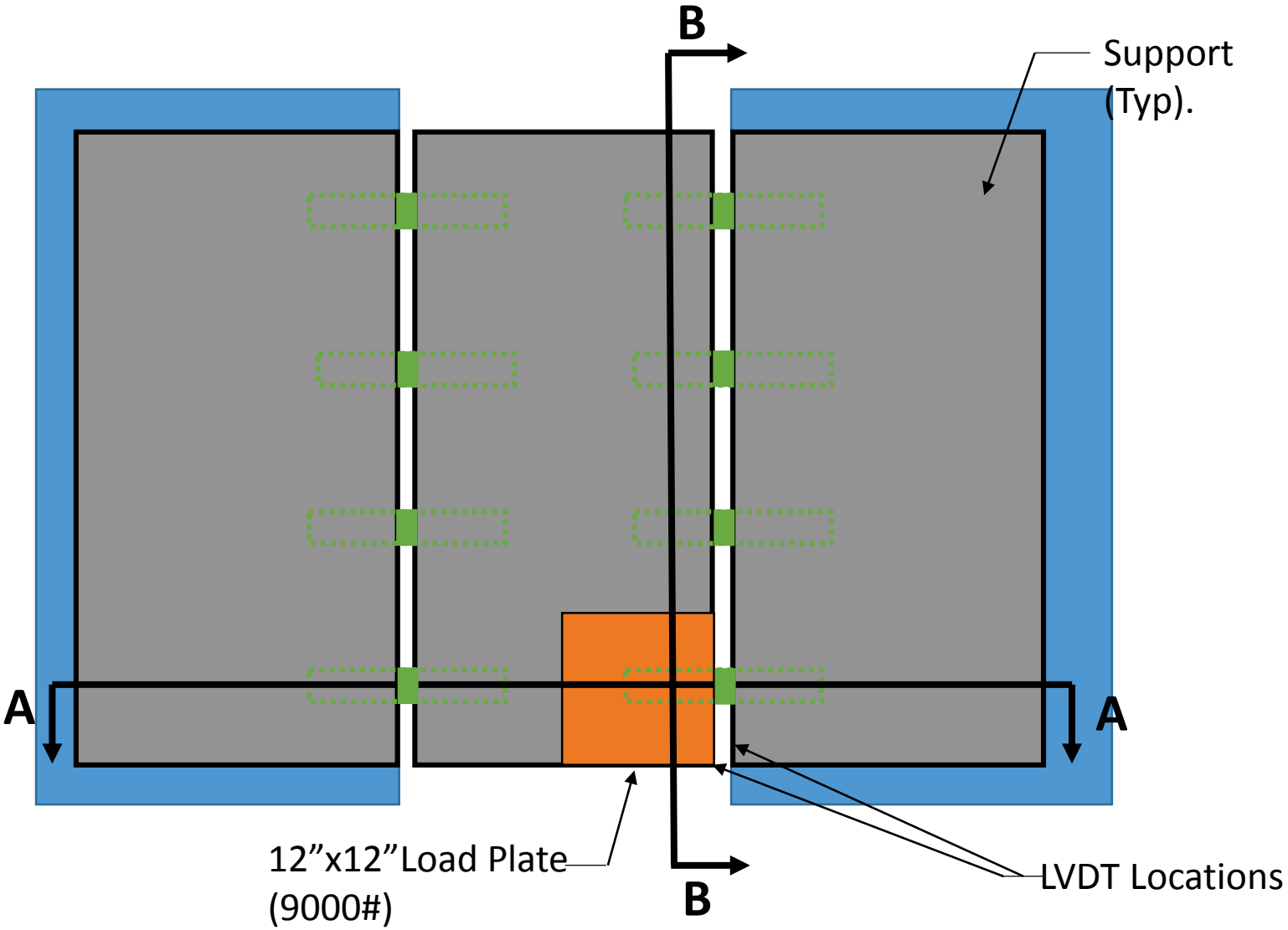
- Ultraviolet Light and Exposure Resistance Test
  - Determine limits on exterior storage practices(?)
  - ASTM G 155 water spray and ultraviolet light
  - Questions
    - How long should test duration be?

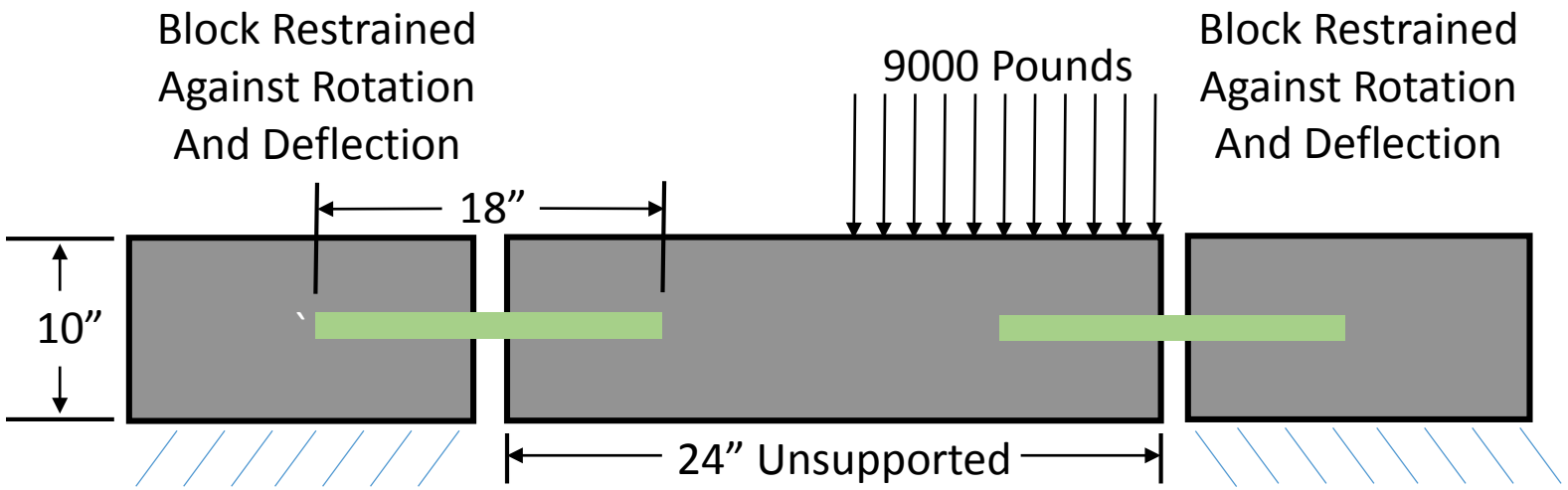
Structural Capacity of Dowel Systems

AASHTO T253 Test Setup



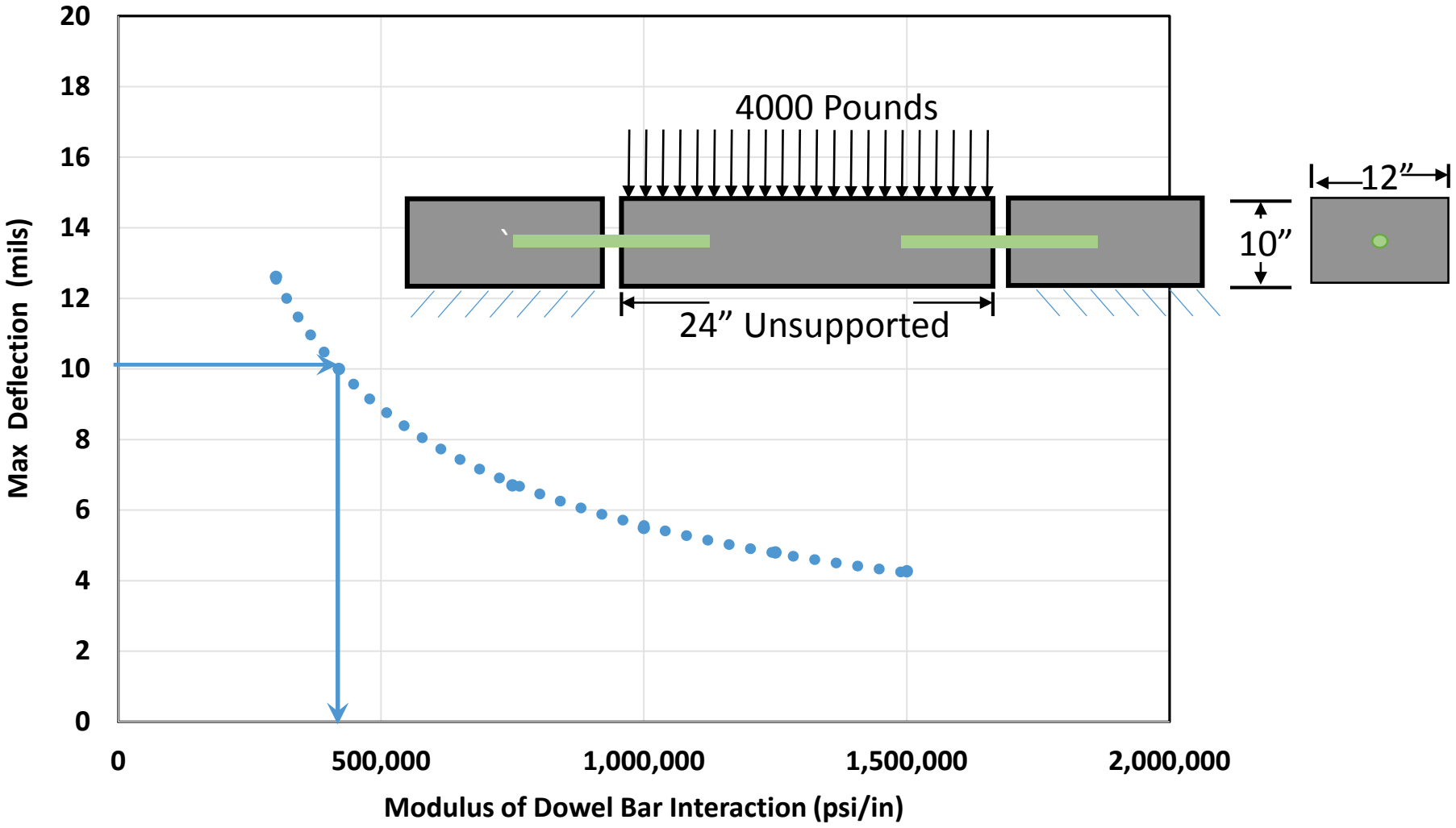
Proposed Test Setup For Dowel Bar System Equivalency Evaluation

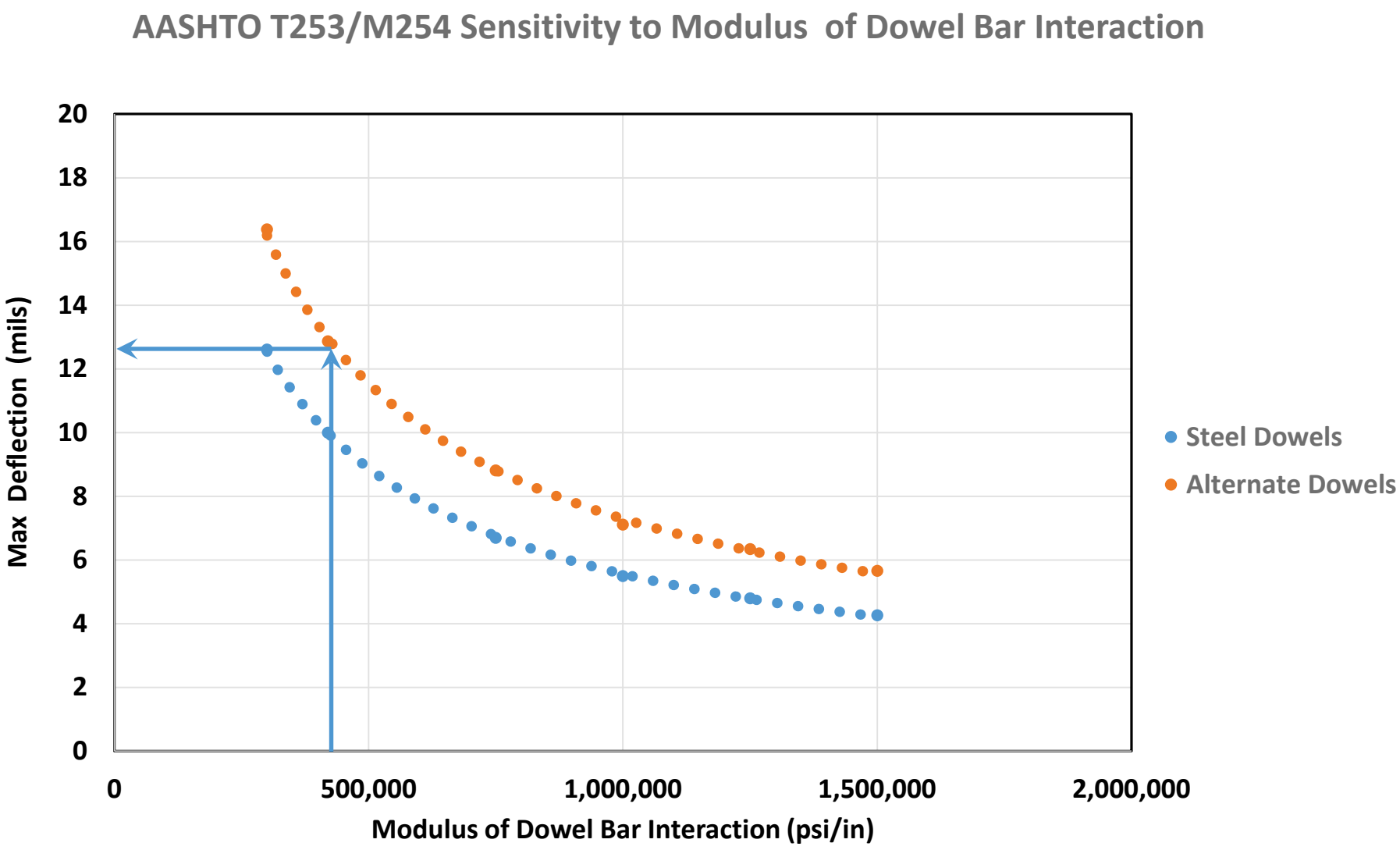


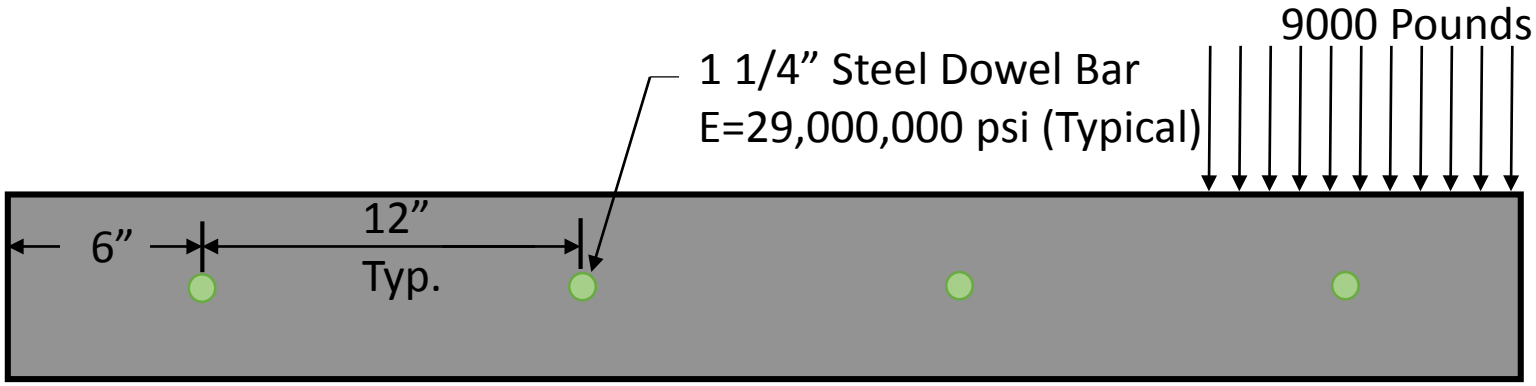

Block Restrained
Against Rotation
And Deflection
9000 Pounds
Block Restrained
Against Rotation
And Deflection
18”
10”
24” Unsupported

Section A-A

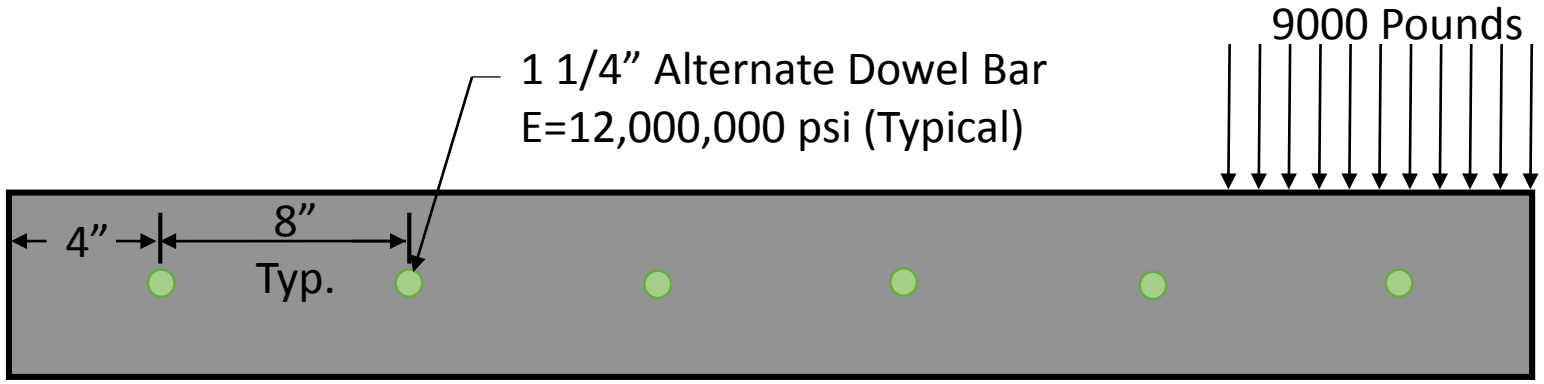
AASHTO T253/M254 Sensitivity to Modulus of Dowel Bar Interaction



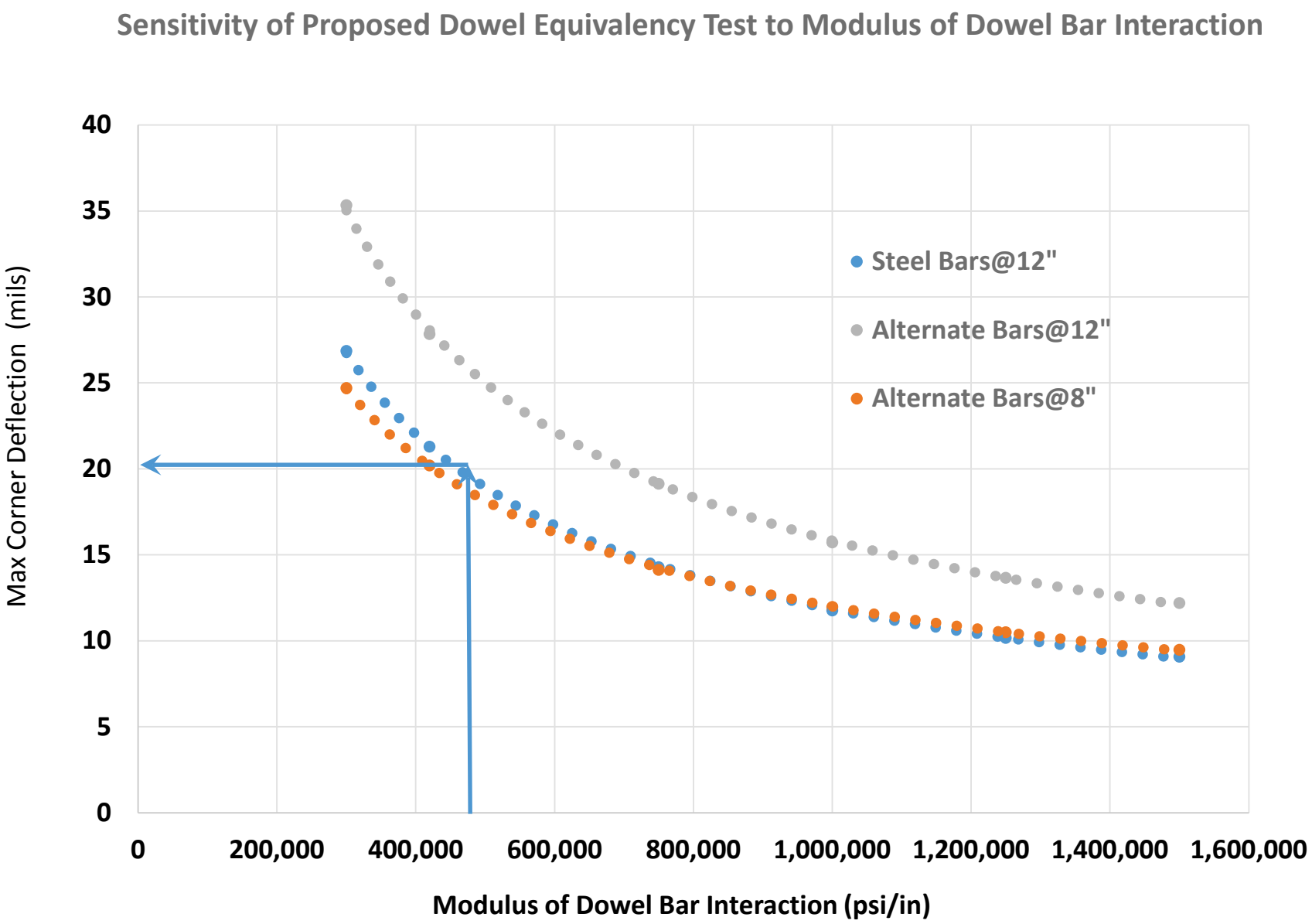

AASHTO T253/M254 Sensitivity to Modulus of Dowel Bar Interaction
Max Deflection (mils)
20
18
16
14
12
10
8
6
4
2
0
0
500,000
1,000,000
1,500,000
2,000,000
Modulus of Dowel Bar Interaction (psi/in)
Steel Dowels
Alternate Dowels

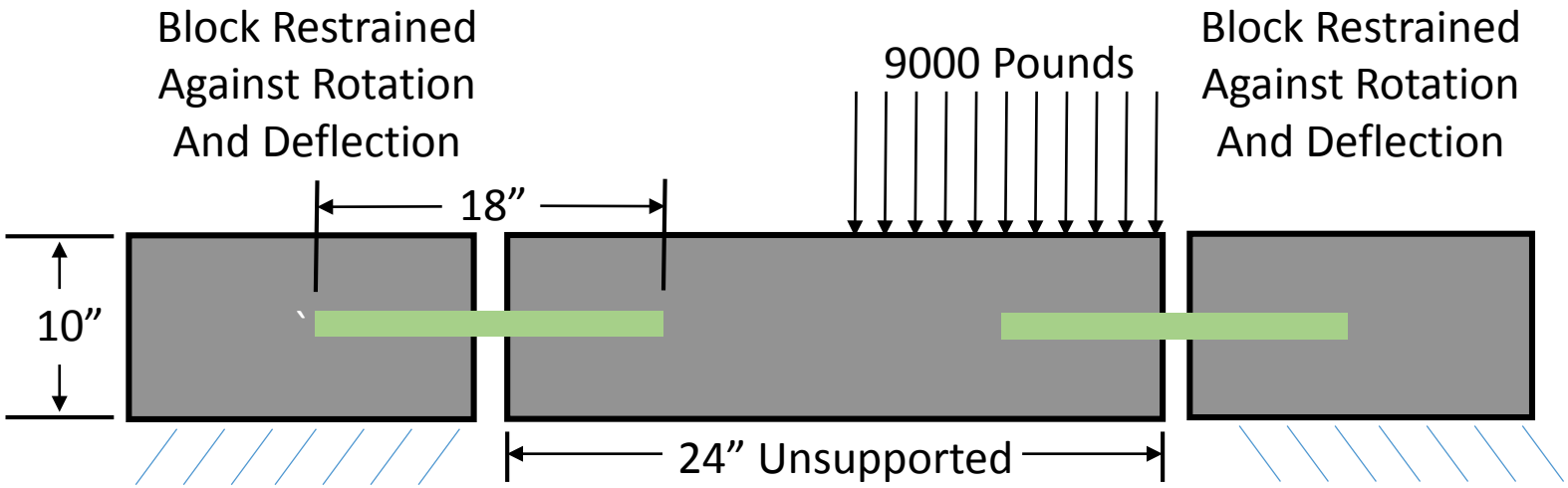


Section B-B
Steel Dowels @12”



Section B-B
Alternate Dowels @8”


Sensitivity of Proposed Dowel Equivalency Test to Modulus of Dowel Bar Interaction
Max Corner Deflection (mils)
40
35
30
25
20
15
10
5
0
0
200,000
400,000
600,000
800,000
1,000,000
1,200,000
1,400,000
1,600,000
Modulus of Dowel Bar Interaction (psi/in)
Steel Bars@12"
Alternate Bars@12"
Alternate Bars@8"



- Proposed configuration allows up to 4 replicate measures from a single specimen
- Specification to fix concrete parameters
- Primary Performance Evaluation Criterion: Differential Deflection (but consider bearing stress in design …)
- Possible test modifications that have been evaluated analytically:
  - Modified support conditions to allow ultimate load testing – no impact on differential deflections
  - Variation in distance to edge from outside dowel (to standardize test specimen width at 48”, regardless of LT device spacing) – no significant impact on differential deflections
- Analytical work should be validated through lab tests!

Concepts for NCC Dowel Test Validation Program - Objectives

- Validate structural models of dowel system (multi-dowel) behavior and acceptance thresholds when compared with current AASHTO T253 single-dowel behavior and acceptance threshold.
- Determine effects of variations in test parameters (e.g., test slab thickness, distance from outside dowel to free edge, etc.) on test results.
- Collect replicate test data for precision and bias statements (determination of test result variability and impact on test interpretation).

Concepts for NCC Dowel Test Validation Program - Approach

1. Single dowel tests of standard 1.25-in diameter cylindrical metallic dowels in current AASHTO T253 test (3 replicates, minimum);
2. Tests of standard 1.25-in diameter cylindrical metallic dowels in proposed NCC test (3 replicates, minimum);
3. Similar to phase 2 (standard dowels) except with range of slab thickness (one thinner, one thicker) and widths (1 ft added width) to determine sensitivity of test results to parameter variations that might be necessary to accommodate some dowel configurations (e.g., use of plate dowels in thin pavements, use of wide slab to accommodate systems with greater dowel spacing, etc.) – replicate requirements to be determined based on results of previous phases.
4. Tests of a limited number (say, three) of alternate dowels (e.g., nonspecific FRP cylindrical dowels, short metallic dowels, nonspecific plate dowel, hollow dowel, standard dowels of larger or smaller diameter, etc.) to validate expected behavior relative to standard dowel behavior in NCC test and the evaluate suitability of acceptance threshold.

Discussion Topics

- Final product?
  - NCC guide specs and tests?
  - Formatted for AASHTO or ASTM adoption?
    - State Champion for AASHTO adoption?
- Which option?
  - One specification and suite of tests for all dowels?
  - Keep current AASHTO and create new one for long-life dowels?
- How to develop recommendations for project-specific test criteria (for varying exposure, climate, etc.) for use in commentary document or guide?
- Pooled fund research?