



# Testing Structural Behavior of Alternative Dowel Bars

tech transfer summary

Accurate test methods for determining the modulus of dowel support can assist in decisions regarding optimal dowel shape and material.

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RESEARCH PROJECT TITLE

Laboratory Study of Structural Behavior of Alternative Dowel Bars

SPONSORS

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## Objectives

The primary objective of this study was to investigate and improve the current AASHTO T253 test method for determining the modulus of dowel support,  $k_D$ . The feasibility of a new simplified cantilever dowel test was also analyzed as a means of verifying the modified AASHTO procedure.

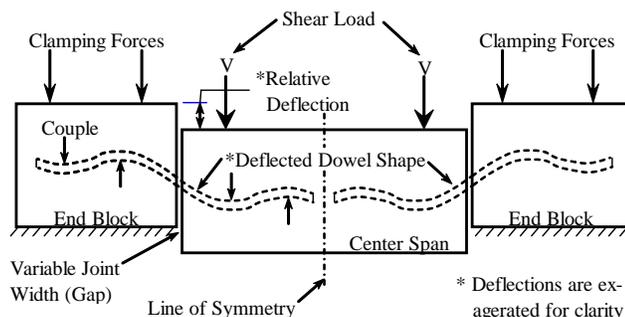
## Problem Statement

There are flaws with the round steel bars traditionally used to bear and transfer load in concrete pavement. These flaws include corrosion of the dowel and erosion of the surrounding concrete. This erosion, called oblonging, reduces the bar's ability to handle load transfer. In order to select the optimal bar shape and material for the design of concrete pavements, the modulus of dowel support ( $k_D$ ) must be accurately determined. The modified AASHTO T253 test was pursued as a replacement for the Iosipescu shear dowel test, since the load apparatus for this conventional test is difficult and time-consuming to build.

## Research Description

Research involved testing 78 different dowel specimens and evaluating the stress-bearing performance of six different dowel bar types subjected to two different shear load laboratory test methods. The six dowel types tested were

- Round GFRP
- Elliptical GFRP
- Small elliptical steel (epoxy-coated)
- Large elliptical steel (epoxy-coated)
- Round steel (epoxy-coated)
- Stainless steel



Modified AASHTO T253 test

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The first load test was a modified version of the AASHTO T253 method. The second procedure was an experimental cantilevered dowel test. The modified AASHTO specimens were also subjected to a small-scale fatigue test in order to simulate long-term dowel behavior with respect to concrete joint damage. Loss on ignition tests were also performed on the GFRP dowel specimens to determine the resin content percentage.

### Key Findings

- The modified AASHTO T253 test method is recommended for future testing of dowel bar structural behavior. The modified AASHTO test specimens yielded scattered results but were more consistent than those numbers obtained during the cantilever test. The modified AASHTO test demonstrates improvement over the traditional AASHTO T253 method.
- The cantilever test was less reliable than the modified AASHTO T253 test and less reliable than predicted due to several factors. The base support beam experienced small deflections, which dictated the need for a more sophisticated clamping mechanism. The necessitated clamping method allowed undesirable effects such as large normal forces on the dowel and small, unpredictable rotations. As a result, the  $k_o$  results obtained from the cantilever test were inconsistent and not accurate with respect to the current accepted ranges of  $k_o$  values. The cantilever test was not an effective alternative to the modified AASHTO test.
- The fatigue test yielded largely inconclusive results. Because of the limited number of cycles and exaggerated load values necessitated by time and budget constraints, this fatigue test did not allow an accurate comparison to the millions of wheel loads withstood by an actual concrete slab. Although subsequent inspection of the dowel holes revealed a fine white powder, the fatigue test resulted in no visible oblonging of the dowel holes. Because no significant elongation of the dowel holes occurred, the fatigue test was inconclusive in demonstrating which dowel bar will cause the least amount of deterioration after a long period of time.
- The soft epoxy coating on the steel bars resulted in more initial dowel dis-

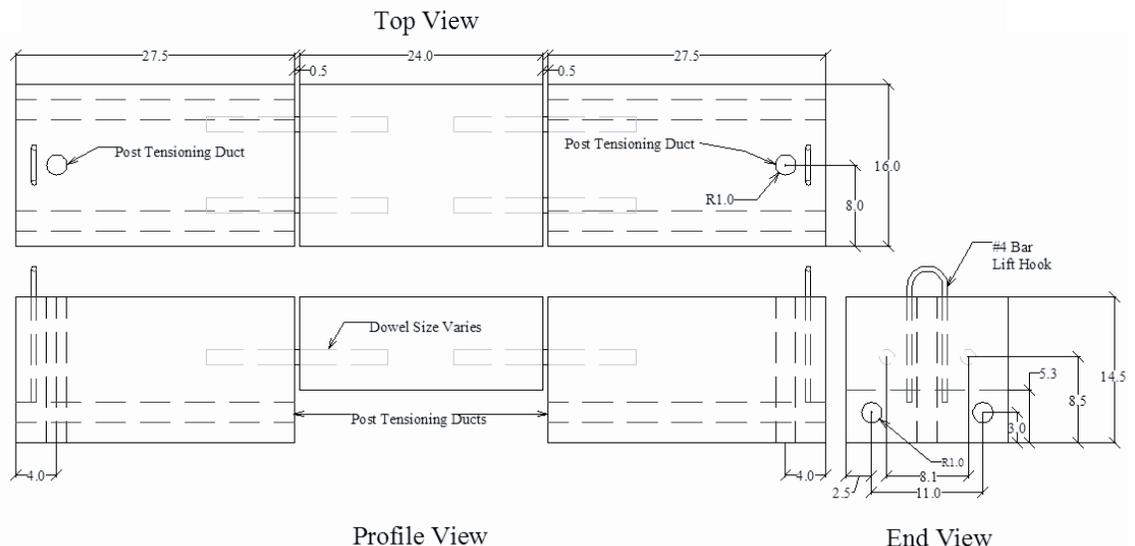
placement at lower loads than the non-coated stainless steel bars. Not surprisingly, the GFRP dowels produced lower  $k_o$  values than the epoxy-coated steel dowels and the stainless steel dowels.

### Implementation Benefits

The modified AASHTO T253 test is a relatively economical and accurate method for evaluating the value of  $k_o$ . Performance of the modified AASHTO method demonstrates an improvement over older methods used in previous research. With further improvement, the modified AASHTO test procedure can more accurately determine  $k_o$ , which is necessary for evaluating the bar shape and material best suited to the construction of new concrete pavement.

### Implementation Readiness

- Although the AASHTO T253 test modifications increased the accuracy of the test method, further improvements are desired in order to calculate the value of  $k_o$  even more precisely. The modified AASHTO test completed in this study does not accurately replicate actual roadway conditions. Recommendations for future research include building a replica in a controlled environment of pavement over a soil subbase. This replica would allow observation and close monitoring of dowel behavior in a more realistic setting.
- The fatigue test requires significant modification to yield more conclusive results. A more sophisticated fatigue testing mechanism should be developed to more accurately test specimens by applying a load more comparable to a wheel load. The number of load application cycles should also be increased to more adequately model the performance of a dowel over the useful life of a pavement.
- Additional modification and verification of the cantilever test is required before it can be accepted as an adequate tool to determine  $k_o$ .



***Suggestions for future refinement of the modified AASHTO T253 test***