



C E N T E R F O R
P O R T L A N D C E M E N T C O N C R E T E
P A V E M E N T T E C H N O L O G Y

Field Evaluation of Elliptical Fiber Reinforced Polymer Dowel Performance

Construction Report
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Department of Civil, Construction, and Environmental Engineering

IOWA STATE UNIVERSITY

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16. Abstract <p>Fiber composite materials (FRP) are making an entry into the construction market in both buildings and pavements. The application to pavements comes in the form of joint reinforcement (dowels and tie bars) to date. FRP resistance to salt corrosion in dowels has made it an alternative to standard epoxy coated dowels for pavements. Iowa State University has completed a large amount of laboratory research into the determination of diameter, spacing, and durability of FRP dowels.</p> <p>This report documents the installation of a series of FRP elliptical-shaped dowel joints (including instrumented units) in a field situation and the beginning of a two-year study to compare laboratory results to in-service pavements. Ten joints were constructed for each of three dowel spacings of 10, 12, and 15 inches (254, 305, and 381 mm) with one instrumented joint in each test section. The instrumented bars will be load tested with a loaded truck and FWD testing.</p>					
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INTRODUCTION

Background

Typically, in the field of concrete paving, circular dowel bars are used to transfer load across the transverse joints. Traditional epoxy-coated steel dowels have provided that load transfer.

Doweled joints have been shown to deteriorate in terms of steel corrosion from the chloride ion exchange. Fiber reinforced polymer (FRP) materials have been shown in research to be resistant to the typical steel corrosion deterioration due to road salts and other de-icer solutions distributed on the pavements. In addition, deterioration occurs from hollowing or oblonging of the hole location at the dowel bars due to excessive bearing stresses under cyclic loading.

Problem Statement

To date, all FRP dowel bar related research in the United States has centered on the chemical makeup of the materials in the bars and their laboratory evaluation. Current research in Iowa has moved that research out to the field installations for round dowels. Recent work in Iowa indicates that elliptical-shaped dowels could offer improvements in reduced bearing stresses and performance. Current work in Iowa is evaluating the performance of elliptical-shaped epoxy-coated steel dowels.

This research provides the opportunity to compare elliptical-shaped FRP bars in a roadway section immediately adjacent (but separate in construction) to a roadway segment with round and elliptical-shaped steel bars under IPRF Task 7. This comparison means that the same traffic will most likely use both segments of roadway and the environmental conditions will be very similar over the research period. This can result in one measure of the relative stiffness, durability, cost, and strength of each material installed.

Objectives

The goal of this project is the evaluation of elliptical-shaped FRP dowels and elliptical dowel bar basket assemblies to provide for transfer of load across the concrete pavement joints. The advantage of FRP over conventional steel dowels is the long-term performance against corrosion. In addition, the benefits of an elliptical shape over circular are the reduction of the bearing contact stress between the concrete and the dowel bar.

DESCRIPTION OF DOWEL BARS

The FRP dowel bars used in this project were manufactured and donated by Hughes Brothers of Seward, Nebraska. The bars are elliptical shaped and are 18 inches (457 mm) in length. As seen in Figure 1, the major and minor axes have dimensions of 2.25 and 1.94 inches (57.15 mm and 49.28 mm), respectively.

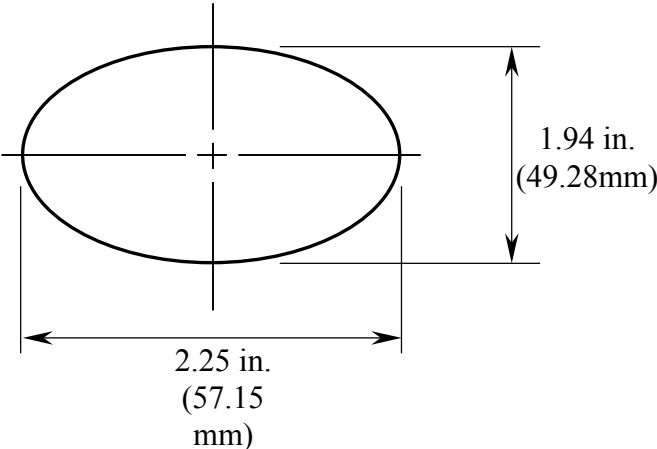


Figure 1. Elliptical FRP Dowel Bar Geometry

PROJECT CONSTRUCTION

Dowel Bar Placement/Layout

Field installation of the elliptical FRP dowel bars took place just west of Melbourne, Iowa, on Highway 330. This project was completed using the metric system; therefore, stationing was measured in meters. Dowel bars were placed in the northbound lanes at 30 joint locations, each 19.69 feet (6 meters) apart, starting at Station 1371+09, heading north, and ending at Station 1372+83. All 30 joints were constructed normal to the edge of the concrete pavement. Three different dowel bar spacings of 10, 12, and 15 inches (254, 305, and 381 mm) center to center were used. The bars from Station 1371+09 to Station 1371+63 were spaced at 10 inches (254 mm), the bars from Station 1371+69 to Station 1372+23 were spaced at 12 inches (305 mm), and the bars from Station 1372+29 to Station 1372+83 were spaced at 15 inches (381 mm). Figures 2 through 4 illustrate the layout of the dowel bars.



Figure 2. Layout of Elliptical FRP Dowel Bars

All dowel bars were attached to specially built elliptical dowel bar basket assemblies elevating the center of the bar 5 inches (127 mm) from the subgrade, placing the dowel in the center of the 10-inch (254 mm) slab pavement. Problems were encountered while trying to attach the bars to the basket. The use of FRP material caused an inability to use the conventional method of welding steel dowel bars to the baskets. Therefore, the dowels were attached to the baskets using plastic ties and epoxy. Special care was taken to make sure that, when dried, the epoxy was strong enough to hold the bars in position during the concrete placement, yet brittle enough to crack and allow the bar to move in the longitudinal direction after the concrete had set. Figure 3 shows a closer view of the dowel bar basket configuration.



Figure 3. Dowel Bar Placement, One Joint (10 inch [254 mm] spacing)

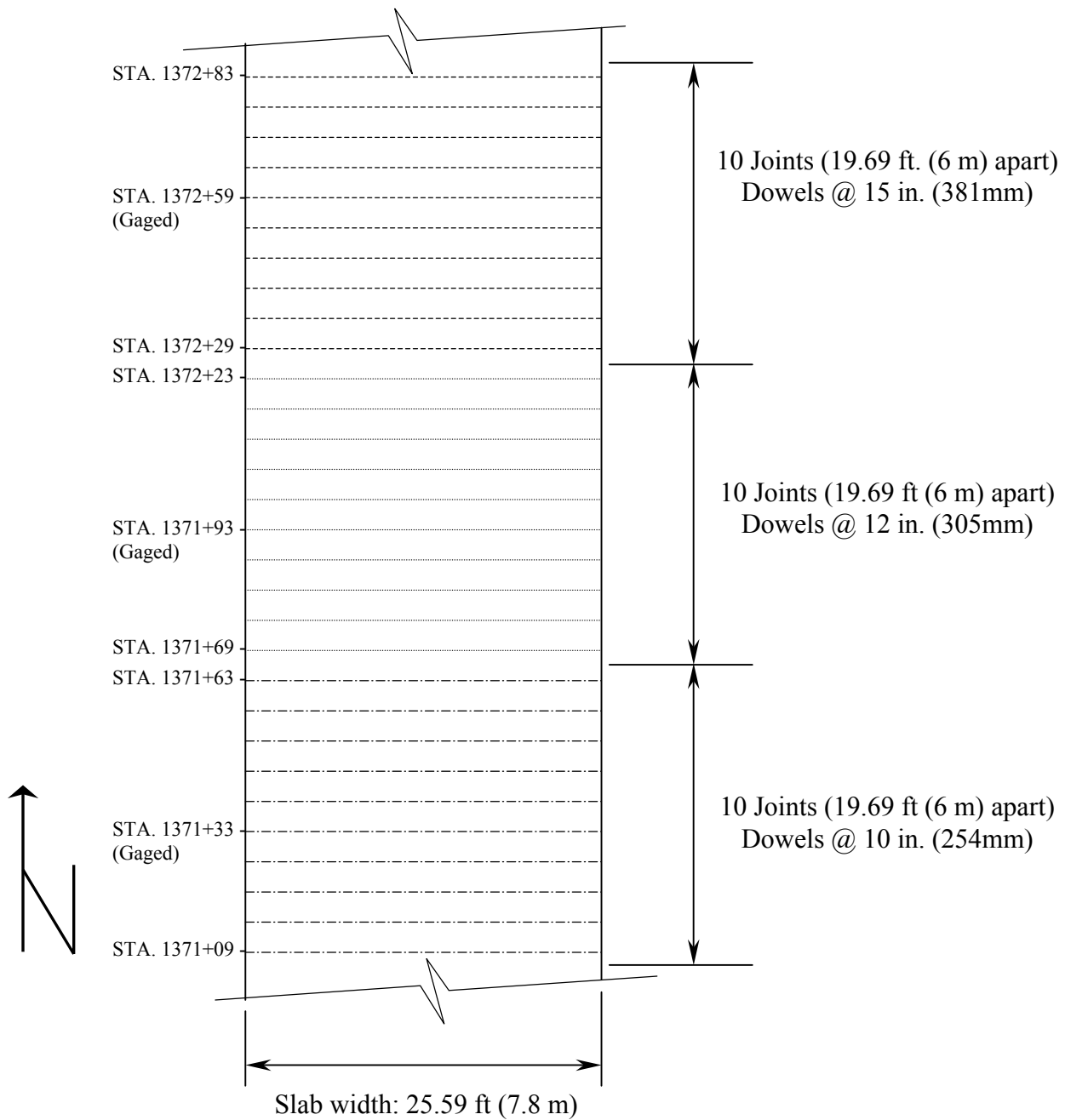


Figure 4. Layout and Placement of Elliptical FRP Dowel Bar Site

Strain Gage Placement

In order to determine the stresses on the dowel bars at different spacings, one dowel bar from each of the 10, 12 and 15-inch (254, 305 and 381 mm) spacings were fitted with eight strain gages. The strain-gauged dowel bars were located as follows:

- 10-inch (254 mm) spacing: at Station 1371+33 on the fifth bar in from the right edge of pavement (46 inches [1,168 mm] from edge of pavement)
- 12-inch (305 mm) spacing: at Station 1371+93 on the fifth bar in from the right edge of pavement (54 inches [1,372 mm] from the edge of pavement)
- 15-inch (381 mm) spacing: at Station 1372+59 on the fourth bar in from the right edge of pavement (51 inches [1,295 mm] from edge of pavement)

Four gages were placed on the top and bottom of each dowel bar. Strain gages were located at a distance of 1.5 and 4.5 inches (38 and 114 mm) from the centerline of the 18-inch (457 mm) long dowel bars as shown in Figures 5 and 6. These distances were chosen to be the same as the strain gages placed on the coinciding elliptical steel dowel bar project so that a comparison between the two types of bars would be made easier. Gages were glued to the bars and strain gage wire was then soldered to each strain gage. The gage and wires were then covered to prevent damage before installation. Gages were labeled A through H as according to Figure 5.

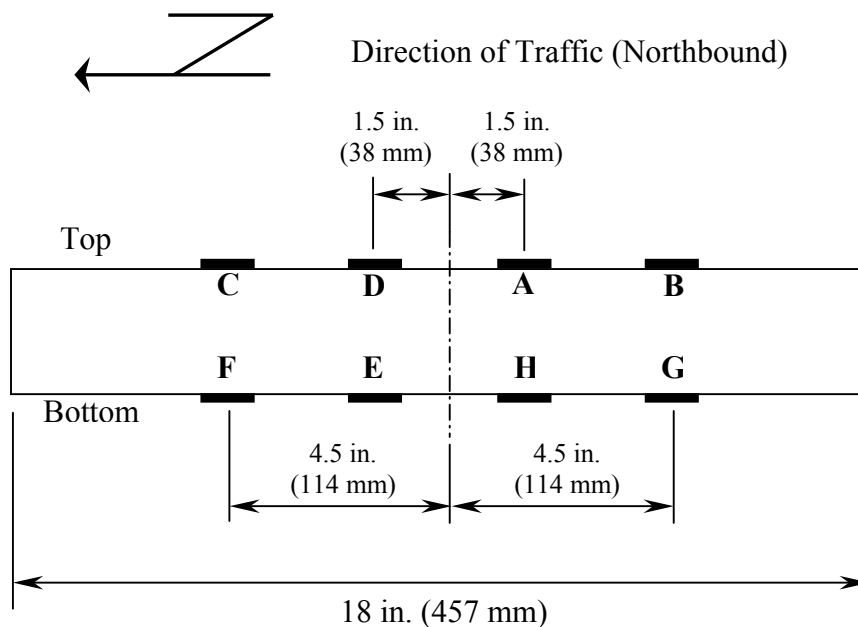


Figure 5. Location of Strain Gages on Elliptical FRP Dowel Bar



Figure 6. Gaged Dowel Bar in Field

Construction Placement

All dowel bar baskets were placed and staked 6 inches (152 mm) in from the edge of the pavement. Strain gage wires were buried under the subgrade at the shoulder locations as to not interfere with paving construction. After paving was complete the wires were dug up and strung through protective PVC pipe buried under the shoulder.

During the paving process, a few dowel bars had to be removed. Dowel bar baskets were placed beyond the right edge of pavement, causing the concrete paver to contact the right end dowel bar baskets. The right end bars and baskets located at Stations 1371+09,15,21,87 and 1372+65 were clipped off to prevent the paver from contacting and skewing the baskets and, in turn, the dowel bars. Figures 7 and 8 show the slip-form paver and dowel bars during construction. Note the closeness of the dowel bars to the edge of the paver. Strain gage wires for the bars at the 10-inch (254 mm) spacing, location at Station 1371+33, were also destroyed during shoulder work. Initial strain gage readings, however, were recorded.



Figure 7. Slip-Form Paver and Dowel Bars



Figure 8. Paving Over Elliptical FRP Dowel Bars

TESTING PROCEDURE

The testing for this project involves both mechanical and visual tests for the two-year period and beyond. During the contract period of two years, the following tests are being conducted:

- Visual distress surveys using Strategic Highway Research Program protocols will be conducted twice per year (spring and fall).
- Joint openings and faulting of the joints in each test section will be measured twice each year (spring and fall).
- Deflection testing using the Iowa Department of Transportation (Iowa DOT) falling weight deflectometer (FWD) will be conducted in the outer wheel path twice per year (spring and fall).
- Profiles of the outer wheel path will be developed with the Iowa DOT version of the South Dakota Profiler each spring and fall.
- Load testing using a loaded Iowa DOT tandem axle truck and Iowa DOT FWD at the instrumented sites was accomplished in the fall of 2002 and will be conducted under winter conditions in the winter of 2003.

The research staff intends to continue this testing for five years in conjunction with and adjacent project involving elliptical steel dowels to make comparisons over five years. Load testing will be considered in the future only as the wiring to the test bars on both projects continues to function.

CONCLUSIONS

The following conclusions were drawn from the project:

- The FRP elliptical dowels can be placed on metal baskets and successfully placed in concrete pavements.
- Testing of the FRP dowel locations indicates no specific differences with the steel dowels on an adjacent project.

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