Elliptical Fiber Reinforced Polymer Dowel Performance

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Objectives

- Evaluate the load transfer capabilities of elliptical-shaped fiber reinforced polymer (FRP) dowels and basket assemblies across concrete pavement joints.
- Estimate the performance of the individual dowel configurations in terms of stiffness, durability, modulus of dowel support, and deflection predictions.
- Compare the performance of elliptical FRP dowels to that of conventional 1.5-inch diameter circular epoxy-coated steel dowels, the performance of FRP dowels to conventional steel dowels with respect to long-term corrosion resistance, and the effect of an elliptical versus circular shape in reducing the bearing contact stress between the concrete and the dowel bar.

Problem Statement

The most commonly used load transfer devices in transverse concrete pavement joints are epoxy-coated steel dowels, which are usually round with a diameter of 1.25 or 1.5 inches. These dowels can cause corrosion and oblonging within the joint, leading to chipping and spalling in the surrounding concrete, freezing or locking of the joint, and loosening of the connection between the dowel and the pavement.

FRP dowels, an alternative to steel dowels, have been studied for the chemical composition of the bars' materials and for the bars' laboratory strength. Research is underway to evaluate field installations for round FRP dowels. A recent study has indicated that elliptical-shaped dowels can reduce bearing stresses above and below the dowel and thus alleviate some of the problems experienced with round-shaped dowels. Other research has suggested that corrosion deterioration comparisons between FRP and steel dowels require longer term evaluation than studies to date have performed. Also, steel has generally been shown to provide higher load transfer efficiency than FRP for round dowels of the same size and at the same spacing.

Because combinations of size, shape, and spacing affect the load transfer efficiency of dowels, studies are needed of the performance of larger FRP dowels with varied spacing between bars for improving load transfer efficiency.

Research Description

Elliptical-shaped FRP bars in a roadway segment were compared to round and elliptical-shaped steel bars in an adjacent (but separately constructed) roadway segment. The testing, performed biannually during similar times of day, included the following procedures to monitor pavement performance:

- Falling weight deflectometer (FWD)
- Strain gage analysis under two conditions
- Load application with a standard DOT dump (crawl) truck
- Load application with FWD
- Joint faulting measurement
- Joint widening measurement
- Visual distress survey

The comparison yielded a measure of the relative stiffness, durability, cost, and strength of the installations in both roadway segments.

Key Findings

- FRP dowels at each variable spacing provide adequate load transfer across the joints.
- FRP dowel bars provide adequate rider comfort for vehicles crossing joints containing FRP dowel bars.
- Faulting and joint opening measurements demonstrated that the joints operated properly.

Implementation Benefits

FRP dowels have the potential to reduce or eliminate the corrosion and resulting deterioration often associated with conventional steel dowels.
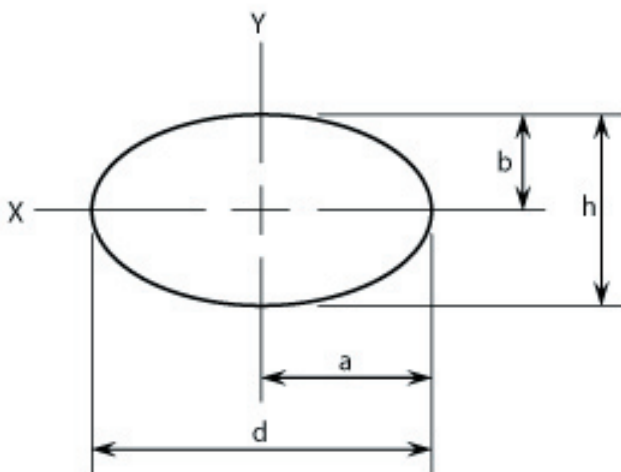
Elliptical steel dowel bar detail

Implementation Readiness

- Because faulting and joint opening data are valuable for determining long-term dowel bar performance, further long-term testing is suggested to study the true behavior of FRP dowel bars more accurately. Additional test sections would also create a wider, and thus more valuable, range of data to be analyzed.
- Corrosion and other long-term problems may affect FRP dowel bar performance over time and should be monitored and analyzed over a longer testing period.
- Slabs with multiple dowel bars should be fully tested in the laboratory to more accurately determine the effects of dowel spacing on load distribution. Fatigue testing should also be performed to better evaluate the long-term capabilities of elliptical FRP dowels subjected to cyclical loadings.
- Because expansion joints are placed where pavement meets a fixed structure, FRP dowel bars within expansion joints should be analyzed, designed, and tested thoroughly.
- For all types of joints, additional research can determine the effects of gap sizes other than 0.125 inches; the additional effects of deflection due to flexure is crucial in joints containing larger gaps.
- The polymer matrix of a fiber composite is hygroscopic, which means that it can potentially absorb water and subsequently swell, thus affecting the slippage mechanism of concrete pavement joints over time. This phenomenon should therefore be investigated more fully.