Florida Department of Transportation
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EFFECTS OF BOUNDARY CONDITIONS ON BRIDGE PERFORMANCE

PROBLEM STATEMENT

Reinforced elastomeric bearing pads generally support precast concrete bridge girders. The condition of the bearing pads and the pad-bridge interface define the support boundary conditions of the bridge super-structure. The interface between bearing pads and bridge girders affect the performance of the superstructure and the substructure. The pads are designed to carry vertical loads and to accommodate horizontal movements of the bridge girders. They are also designed to deflect horizontally under shearing-type forces. Girder movement can be caused by several factors including temperature and longitudinal thrust. In addition to the horizontal movement, the bearing pads maintain a rotational stiffness to accommodate the end rotations of the girders under load. In the design of the bridge girders, simple support conditions are normally assumed with no horizontal bearing restraint forces imparted on the girders.

Due to the nature of the elastomeric material and its resistance to shearing, horizontal forces are present under service load conditions as the horizontal movement of the bridge girders apply load and deform the bearing pads. The effects of these forces on the performance of the bridge girders are unknown, as are the effects of other bridge parameters in conjunction with the bearing pad effect. It is possible that forces existing as a result of the boundary conditions could improve or alter the performance of bridge girders. LRFD AASHTO specifications for highway bridges do not address the resistance effect of bearing pad construction in its design specification for bridge girders.

OBJECTIVES

A parametric study on the interaction of the support boundary conditions and bridge girders was performed in this project. The performance of bridge superstructures under various combinations of parameters was explored. Parameters affecting the superstructure performance and included in this study are:

- Type of bridge girder
- Girder length and spacing
- Bearing pad type
- Static loading
- Skewness of bridge
- Presence of intermediate diaphragms
- Temperature effects

Specific objectives included the following:

1. To determine the material and stiffness properties of typical elastomeric bearing pads.

2. To utilize a commercial finite element analysis (FEA) program to model the Florida Bulb Tee 78 girder, and to analyze the loading response and girder performance under the established boundary conditions.

3. To determine the effects of the various parameters on the bridge superstructure performance.

4. To compare girder performance with simple support conditions corresponding to the current FDOT design.

5. To provide recommendations regarding the effect of the boundary conditions on the performance of the girders.

FINDINGS AND CONCLUSIONS

The following conclusions may be made based upon the parametric analysis of currently specified FDOT type bearing pad specifications and theoretical modeling of the Florida Bulb Tee 78 precast concrete bridge girders.

1. Increasing the bearing stiffness has the overall benefit of reducing the midpoint deflections and tensile stresses of the bridge. However, during negative temperature changes this effect is reversed.

2. The skew angle of a bridge has a significant effect on bridge performance. A greater skew angle results in higher deflection and tensile stresses for the same pad stiffness. Higher skew angles need bearing pads with higher shear modulus to reduce midpoint deflection.

3. Lower skew angles may cause an uplift effect at the end girder supports, causing possible loss of contact with the bearing pads. This effect decreases as the skew angle increases. The uplift is generally confined to the external girders only.

4. Intermediate diaphragms have the effect of reducing the overall midpoint deflections and maximum stresses for the bridge system, which promotes the application of the intermediate diaphragms. However, the reductions are smaller for increasing skew angles. Deflection may decrease by about 17% for straight bridges, but only about 5% for a 60° skew.

5. The application of the intermediate diaphragms has the added effect of eliminating the loss of girder contact with the bearing pads. This beneficial effect was apparent for all stiffnesses and skew angles.

6. The expansion of the bridge due to a positive temperature change decreases midpoint deflections and tensile stresses as a result of the bearing pad effects. As the bearing stiffness increases, a camber-like effect occurs that benefits the bridge system.

7. The contraction of the bridge due to a negative temperature change has the effect of increasing the midpoint deflection and tensile stresses when using bearing pads. Due to the combined live and temperature loads, the results indicate that as the temperature decreases, the shear modulus of the bearing pad should be reduced to decrease midpoint deflections.

This study has shown that ordinary bearing pads provide adequate horizontal movement with minimal restraining forces applied to the girder. The effect of increasing the bearing stiffness has been shown to be both beneficial and detrimental to the bridge system--depending on the conditions. Laminated neoprene bearing pads provide an economic girder support system.

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