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HUB ASSEMBLIES FOR THE NEXT GENERATION OF BASCULE BRIDGES

PROBLEM STATEMENT

Bascule bridge designs used in Florida have changed over the years as bridge sizes have increased to handle higher traffic demands. Designing large bascule bridges capable of handling up to four lanes of traffic creates new challenges that are not addressed in the current design guidelines. For example, some recent bascule bridges utilize box girders for the main girders instead of plate girders. Such box girder designs utilize two hubs per girder instead of the single hub found on simple trunnion or Hopkins frame designs of the past. Assembly requirements of such designs place constraints on the hub size. As a result, many of these bridges deviate from current AASHTO and FDOT guidelines on hub geometry and hub assembly designs. The impact of deviations from current guidelines with respect to hub geometry needs to be investigated to ensure that such deviations do not adversely affect the strength and serviceability of bascule bridges. The hub geometry also impacts stresses developed during shrink-fit assembly process and hub casting quality.

OBJECTIVES

The overall goal of this research is to update the current guidelines used to design bascule bridge hub assemblies. Specific objectives include the following:

1. To determine how hub geometry influences the structural performance of a bridge in service
2. To investigate the impact of hub geometry on the assembly process (given the hub failures that have been experienced during the hub-girder shrink fitting procedure)
3. To study design aspects that influence the quality and the cost of hub castings. The finding may be used to update current guidelines used for design of bascule bridge hub assemblies.

FINDINGS AND CONCLUSIONS

Simplified design equations and linear finite element analysis results indicated that the tensile hoop stresses that developed in the hub due to the interference fit with the trunnion may exceed the allowable static stress limits in hub designs based on current FDOT guidelines. A parameter study of a hub design based on AASHTO guidelines demonstrated tensile hoop stresses within allowable limits when using an FN2 fit (i.e., a medium drive force fit) between trunnion and hub. Hub hoop stresses always exceed the allowable limit if the FN2 fit is replaced with an FN3 fit (i.e., a heavy drive force fit).

Researchers identified performance and strength requirements for hub assembly and developed a MathCAD worksheet into which these requirements were incorporated. The worksheet was developed to assist in the preliminary design of hub assemblies. Review of preliminary designs

based on bridge loading of representative bridges revealed that it is possible to obtain satisfactory designs based on current FDOT design guidelines with the methodology used in the worksheet.

Linear three-dimensional finite element models were developed to provide a better understanding of the stresses developed in hub assemblies as a result of the interference fit and service loads. The analysis highlighted regions in the hub with stresses that exceed the allowable limits.

Using a finite element model, researchers performed thermal analysis of the current shrink fit procedure and found that the thermal stresses resulting from the current procedure of heating the hub were within acceptable limits.

BENEFITS

This research has resulted in a variety of benefits to the Department, including the following:

- recommendations regarding the castability of hub geometry
- preliminary recommendations for hub casting acceptance criteria, which ultimately should ensure more uniform and higher quality hub castings
- MathCAD and Excel files that can be used to rapidly develop and visualize preliminary hub design
- an updated specification that may lead to optimum design of the geometry of the trunnion-hub-girder assembly and, thus, more economical designs
- development of bascule hub assemblies with a smaller change of failure during assembly (i.e., compared to current design)

In addition, the Department, its consultants, and hub manufacturers can use the developed model to evaluate future designs.

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