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HUB-GIRDER BOLT ASSEMBLY WITHOUT AN INTERFERENCE FIT IN BASCULE BRIDGES

PROBLEM STATEMENT

A bascule bridge is a type of movable bridge that can be opened or closed to facilitate the movement of water-borne traffic such as ships or yachts. A bascule bridge opens like a lever on a fulcrum. The fulcrum that is fit into the girder of the bridge is made of a trunnion and a hub. Hub failures occurred during manufacture of the trunnion-hub-girder (THG) assemblies of the Miami Avenue Bridge and the Brickell Avenue Bridge.

THG assemblies of bascule bridges are currently assembled using shrink fits. Currently, there are two conventional methods for assembling THGs, both of which employ interference fits. In the first method, a trunnion-hub assembly is cooled in liquid nitrogen and shrink-fitted into the girder; when it warms up and expands, it establishes an interference fit. The problem with this process is that there is a high probability that cracks will develop in the hub (and possible catastrophic failure) during the assembly procedure (specifically, after the trunnion is shrink fitted into the hub and the trunnion-hub assembly is subsequently shrink fitted into the girder). The second method uses the same cooling-heating process but reverses the assembly process. The problem with this approach is that it is not conducive to assembly, since it requires that the girders be shipped to the hub machine shop for assembly of the hub and trunnion. An alternative to these methods would be to utilize an assembly method that does not rely on interference fit at the hub-girder interface. The 17th Street Bridge in Ft. Lauderdale, designed and constructed utilizing a slip-critical bolted THG assembly, provides an example of the alternative method. The issue is whether this method is a viable alternative.

OBJECTIVES

The purpose of this study was twofold: first, to confirm that the design used on the 17th Street bridge was satisfactory, and second, to establish whether the slip-critical design should be considered a viable alternative to the interference fit.

FINDINGS AND CONCLUSIONS

By eliminating the interference fit at the hub-girder, new problems arise because the bolts would transmit most of the loads from the bridge girder through the hub and backing ring into the trunnion, and then to the bearings. Numerous parameters need to be studied and defined or specified in order for the hub and bolts to be able to transmit the load. The proposed design scheme utilizes slip-critical bolted connection between the hub, the girder, and a backing ring. The bolted connection design utilizes turned bolts with locational clearance (LC) fit. Loads to be resisted by the connection are identified and computed individually and subsequently combined to arrive at the net required slip resistance. Using this value, the bolt size and number of bolts are determined using a spreadsheet developed for this purpose. In addition to slip resistance, the bolted connection is also checked for bolt shear strength and bearing stresses on the bolted members.

The design procedure developed was refined using results from an axisymmetric finite element model. The model proved useful in highlighting the behavior of friction force resulting from the interference fit between the backing ring and the hub.

Six representative bridges were analyzed using this design scheme. The analysis revealed that the proposed design is unlikely to adversely impact practice since most THG assemblies utilize more bolts than required for achieving a slip-critical connection. This may be the case because the hub flange dimension ratio to trunnion size is dictated by American Association of State Highway and Transportation Officials (AASHTO) and Florida Department of Transportation (FDOT) standards, and it results in sufficient room on the hub flange to accommodate extra bolts.

BENEFITS

The slip-critical design method is an improvement over the first conventional FDOT-approved THG assembly method, in that the risk of the hub cracking during chilling of the trunnion-hub assembly is eliminated. It is also easier to construct than either of the currently approved methods. This research allows FDOT, consultants, and trunnion-hub-girder manufacturers to predict the mechanical behavior of a slip-critical bolted THG assembly (i.e., without a hub-girder interference fit) to evaluate future designs that use the slip-critical method in order to ensure safe assemblies and structural integrity. An optimum design of the geometry of the hub-girder assembly using a slip-critical bolted assembly of the hub and girder would be more economical than the current designs. Thus, both cost savings and safety enhancement can result from this research.

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