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Field Verification for the Effectiveness of Continuity Diaphragms for Skewed Continuous P/C P/S Concrete Girder Bridges

INTRODUCTION

The majority of highway bridges are built as cast-in-place reinforced concrete slabs and prestressed concrete girders. The simple-span precast, prestressed concrete girders made continuous through cast-in-place decks and diaphragms have been widely used in the United States since 1960's. Shear connectors on the top of the girders assure composite action between the slabs and girders. The design guidelines for bridges in AASHTO Standard Design Specifications Section 8.12 indicate that diaphragms should be installed for T-girder spans and may be omitted where structural analysis shows adequate strength. Similar discussions are presented in Load Resistance Factor Design (LRFD) Bridge Design Code (AASHTO 2004). The advantages of continuity diaphragms are the reduced expansion joint installation and maintenance costs, the improved riding quality, and the enhanced structural redundancy. Furthermore, the effects of diaphragms are not accounted for in the proportioning of the girders. Therefore, the use of diaphragms should be investigated.

In 2004, the Louisiana Transportation Research Center (LTRC) sponsored the theoretical investigation on the effects of continuity diaphragms for skewed continuous span precast prestressed concrete girder bridges. The results of the research were published in LTRC Report 383. The research team, Saber et al., reported that continuity diaphragms used in the prestressed girder bridges on skewed bents cause difficulties in detailing and construction. Details for small skewed bridges (> 30° from perpendicular) have not been a problem for the Louisiana Department of Transportation and Development (LADOTD), but as the skew angle increases or the girder spacing decreases, the connection and the construction become more difficult. Also, results of the research indicated that the continuity diaphragms could be eliminated without any significant effects on the stresses or deflections in the bridge girders. One of the objectives of this research was to conduct field verification for the analytical results reported in LTRC Report 383.

OBJECTIVE

The objectives of this research were to: (1) perform field load testing on the BNSS overpass and compare measured strains with those determined through the theoretical analyses, and (2) determine the effects of continuity diaphragms in the load transfer mechanism in prestressed concrete skewed bridges.

LTRC Report 440

Read online summary or final report:
www.ltrc.lsu.edu/publications.html

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SCOPE

The scope of the study was to perform live load tests that will verify the strains in the continuity diaphragms and bridge girders on the BNSF (Burlington Northern Santa Fe)Overpass Bridge and to study the effects of continuity diaphragms on the stresses and deflections from truck loading on continuous slab and girder bridges.

METHODOLOGY

The current design concept of continuity diaphragms was examined to determine the effectiveness of the diaphragms in skewed bridges. The bridge parameters that were considered include skew angle, length of the span, beam spacing, the ratio of beam spacing to span (aspect ratio), and the ratio of the stiffness of the girder to that of the slab. A prestressed concrete bridge with continuity diaphragms and skewed angle of 48° was selected by a team of engineers from the LADOTD, LTRC, Federal Highway Administration (FHWA), and principal investigator on this research project, Dr. Saber.

The BNSF Overpass Bridge is located on US-90 in Jennings, Louisiana. The field verification was performed using a comprehensive instrumentation plan and live load tests as described in this report. The field and theoretical results from this study provided a fundamental understanding of the load transfer mechanism through these diaphragms of skewed, continuous span bridges. The findings in this study on stresses, strains, and deflections in the bridge girders and deck indicated that the effects of the continuity diaphragms on skewed continuous span precast prestressed concrete girder bridges were negligible.

CONCLUSIONS

The results presented in this report also confirmed the theoretical findings published in LTRC Report 383. Continuity diaphragms used in prestressed concrete girder bridges on skewed bents provided additional redundancy in the bridge but caused difficulties in detailing and construction. As the skew angle increases or the girder spacing decreases, the construction becomes more difficult and the effectiveness of the diaphragms becomes questionable.

RECOMMENDATIONS

Therefore, it is recommended that the use of continuity diaphragms be evaluated based on the need for the enhanced structural redundancy, the reduced expansion joint installation and maintenance costs, and the associated construction difficulties and costs. The outcome of this research will reduce the construction and maintenance costs of bridges throughout the state of Louisiana and United States.