Michigan Department of Transportation
RESEARCH Administration

RESEARCH SPOTLIGHT

Project Information

REPORT NAME: Development of Guidelines for the Use of Intermediate Diaphragms on Precast Concrete Beam Superstructures

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Measuring the effect and value of intermediate diaphragms on bridges

A diaphragm is a structural element that can provide lateral bracing across bridge girders, and there is little consensus on the need for such bracing on straight, precast concrete beam bridges. Given the time and resources needed for constructing and maintaining intermediate diaphragms over a bridge's life span, the Michigan Department of Transportation (MDOT) wanted to understand their benefits for the state's bridges. In-depth research showed that while many variables impact bridge stability, intermediate diaphragms can provide needed bracing in some circumstances but are not likely to in others.

PROBLEM

Bridge girders require lateral support during construction when decks are being placed. During service, vehicular loads are typically distributed across the bridge to avoid overloading a single girder. Intermediate diaphragms, or structural supports between girders at intervals over the bridge, can serve both purposes.

Diaphragms placed at intermediate locations (the members running left to right in this image) can help transfer loads; this research helped determine when they are needed. (Image courtesy of John A. Weeks III)

While federal design specifications require the use of diaphragms at abutments, piers and hinge joints on most structures, there is little guidance on when to use them along the span at intermediate locations. Moderately or significantly curved bridges may need additional bracing, but straighter low-skew bridges – where the span is at an angle less than 30 degrees from the abutment – experience lower twisting stress and need less lateral bracing.

If intermediate diaphragms don't provide a significant benefit on some bridges, eliminating them from those designs would save time and money during construction and longer-term maintenance.

(continued)

"This comprehensive analysis of the impact of intermediate diaphragms on bridges under construction and in service provided MDOT with useful data and guidelines on how and when to best use them."

John Nadjarian
Project Manager

MDOT wanted to better understand the need for intermediate diaphragms on under-construction and in-service bridges.

RESEARCH

The goal of this research was to examine the effect of intermediate diaphragms on precast concrete girder bridges with various beam types. Looking both at construction and in-service scenarios, researchers analyzed a broad spectrum of bridges in MDOT's inventory.

After reviewing previous research related to guidelines for the use of intermediate diaphragms with bridges, researchers surveyed other state DOTs to document current practices. The research team turned to finite element analysis, an engineering modeling method to analyze structural issues, to assess the performance of intermediate diaphragms on bridges under construction and already in service.

To examine bridges under construction, researchers modeled two indicators of stability: girder rollover and lateral torsional buckling (sudden lateral displacement and twisting). To determine the effect of intermediate diaphragms on vehicular loading on in-service bridges, researchers modeled the change in distribution factor, which is the proportion of vehicular weight going to a single girder to that being distributed across the bridge. For both scenarios, they examined a variety of beams, bridge geometries, spans, skews, girder spacing, and load configurations.

RESULTS

Modeling results were generally consistent with the literature researchers reviewed and the survey results. Past studies showed that intermediate diaphragms are primarily used to stabilize girders during construction but there was no clear consensus on their need on straighter, in-service bridges. Likewise, most surveyed states require intermediate diaphragms for stabilization during construction on low-skew, low-curvature precast concrete bridges, though placement and specific requirements vary significantly. Only a few of the states consider intermediate diaphragms useful for in-service load distribution.

Bridge Construction

Modeling revealed there are many variables that impact girder stability before and during bridge deck placement. A few specific characteristics, however, appeared most likely to predict when intermediate diaphragms would be most effective in providing stability. To guard against girder rollover before any loads are placed, researchers found that longer girders and those with narrower bearings and smaller, lower flange widths are more susceptible to rollover without bracing. To prevent lateral torsional buckling once loads are placed, the type and length of girders best determined the need for lateral bracing.

In-Service Bridges

Researchers found that bridges with more flexible decks and stiffer girders appear to benefit most from intermediate diaphragms for live load distribution. Given the construction and characteristics of bridges in MDOT's inventory, the research indicates that for most bridges, once in service, intermediate diaphragms are not generally needed for load distribution.

IMPLEMENTATION

This research shows it is unlikely that intermediate diaphragms on most of Michigan's in-service bridges add meaningful benefit. While such diaphragms on bridges under construction may be useful, the significant number of variables impacting girder stability complicate the development of general guidance. Further research might help in understanding when intermediate diaphragms can provide stability in the construction of bridges with a wider range of design parameters. In the meantime, MDOT bridge designers can use these results to understand the behavior of different beam types when braced with intermediate diaphragms. The research results will be very helpful in informing bridge design and construction on a case-by-case basis.

Research Administration

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