CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-7016: Develop Guidance for Structural Behavior of Tall Haunches in TxDOT Beam and Girder Bridges

Background

Deck haunches are commonly required with both prestressed concrete (PSC) and structural steel girder bridges primarily to maintain a uniform deck thickness, accounting for camber and cross-slope. Due to design errors, construction errors, or unusual geometrical demands, steel or PSC girder bridges sometimes require tall haunches (≥ 6 in.) in the field, leading to shear connectors of insufficient heights and potential strength and ductility issues.

The purpose of this study was to evaluate the impact of haunch geometry and structural detailing on the ultimate strength of both steel and PSC girder bridges, and the development of design guidelines. The effectiveness of currently used tall haunch details was investigated through full-scale push-out tests.

What the Researchers Did

The research study focused on the influence of haunch geometry and reinforcement detailing on the shear capacity of steel and PSC bridge girders, and included laboratory testing and parametric studies using finite element (FE) analyses to account for haunches up to 12 in. for PSC girders and 15 in. for steel girders. The following major tasks were completed on this project:

1. A literature review was conducted and (considering TxDOT construction practices) a matrix of full-scale tests were developed to investigate and identify limitations of current design specifications and previous research relevant to the shear connectors in steel and PSC girders.
2. A self-reacting test frame was designed and fabricated to perform push-out shear tests on steel and PSC girder specimens. The testing frame had the capacity to load up to 1100 kips. Instrumentation was provided to measure applied load, relative slip at shear interfaces, and strain values in steel sections and reinforcing bars.
3. Modified push-out steel (34 total) and PSC girder (36 total) specimens with tall haunches were fabricated and tested. The steel girder specimens accounted for full cast-in-place decks (CIP), while the PSC girder specimens accounted for full CIP decks and decks with partial-depth-precast concrete deck panels (PCPs). The maximum haunch height tested for steel girder specimens was 15 in. and PSC girder specimens were tested with haunches up to 12 in. tall. A total of 34 steel girder specimens and 36 PSC girder specimens were tested.
4. FE models were developed and validated with results from the experimental push-out experiments. The numerical analyses were conducted using Abaqus/Explicit. Parametric studies were carried out on the validated models. Based on the experimental results and the parametric studies, the influence of different haunch parameters on the ultimate capacity of steel and PSC girder specimens was identified.
5. Design guidelines are proposed to account for tall haunch behavior in determining the ultimate shear capacity of steel and PSC bridge girders.

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Project Completed:
5-31-2023

What They Found

The results for the experiments on both steel and PSC girder specimens are summarized below. More detail is provided in the Project 0-7016 final report.

1. Steel Girder Specimens

   1.1. Both shear stud failure and concrete failure were observed during the push-out tests. Shear stud failure resulted in a relatively large capacity and ductility compared to cases where failures initiated in the concrete.

   1.2. Haunch depth significantly affects the behavior of the shear connectors with failures varying in the concrete or shear studs depending on geometry.

   1.3. Stud penetration impacts tall haunch behavior. The specimens with shear studs penetrating into the decks by at least 2 in. showed larger ultimate strength compared to other cases.

   1.4. The minimum stud pitch required in tall haunch cases should be larger compared to girders with normal haunch depths.

   1.5. Confined longitudinal rebar near the bottom of a haunch can effectively increase the ductility of the shear connectors.

2. PSC Girder Specimens

   2.1. The behavior of haunches in PSC girder specimens depends upon the type of deck used, interface roughness, shear reinforcement, and concrete properties.

   2.2. The weakest shear interface for PSC girder specimens with CIP decks was between the girder and the haunch. For specimens with PCP decks, the weakest interface was between the PCPs and the haunch.

   2.3. Specimens with PCP decks and a shear connector penetration depth less than 5.5 in. had a concrete pull-out failure resulting in a lower capacity than debonding failure. The reinforcing bar details also impacted the strength.

What This Means

The researchers provide reinforcing recommendations to improve ductility for both steel and concrete girder systems. For steel girder systems, steel studs should penetrate at least 2 in. into the concrete deck and details are recommended to improve ductility and strength. For PS concrete girder systems, the PCP-haunch interface was found to be weaker compared to the girder-haunch interface, a modification to the design equation is suggested to account for the contact area and cohesion factor at the weakest interface.

For More Information

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Keyword: Research