Texas Department of Transportation

CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY REPORT

0-7090: Evaluate the Deployment of High Strength Reinforcing Steel in Texas

Background

High-strength reinforcing steel has been incorporated into design specifications and permitted under certain provisions of concrete building and bridge design codes, highlighting its growing recognition in construction. The employment of high-strength reinforcing bars offers several potential advantages, including reduced reinforcement quantities, cost savings, decreased congestion, and improved workability. Despite these benefits, specific design code provisions still restrict the use of high-strength rebar, and its application in Texas bridges remains limited. This limited adoption arises from the need for empirical validation to bridge the knowledge gap surrounding its practical implementation. This research project aims to address these challenges and promote the use of high-strength rebar in Texas bridge designs.

What the Researchers Did

The research team undertook a comprehensive study combining experimental programs, numerical analysis, and practical applications through example calculations based on actual bridge structures.

The experimental program encompassed 44 large-scale structural tests to evaluate the applicability of high-strength reinforcing bars in various bridge components, including CIP-PCP decks, prestressed girders (Box beams and Tx girders), bent caps (rectangular and inverted T deep beams), and drilled shaft footings. Additionally, the program addressed related issues such as cracking behavior in lap splices and uniaxial tension. This was investigated through tests on 20 concrete prisms and 4 RC beams (included in the 44 structural tests), filling knowledge gaps and identifying opportunities for innovation.

Numerical analyses and example calculations based on actual bridge structures supplemented the experimental findings. These efforts enhanced the understanding of the behavior of bridge systems under realistic conditions and validated the applicability of high-strength rebar for practical use.

What They Found

Researchers investigated the impact of high-strength reinforcing bar on the load and crack control performance of various structural members, leading to several key findings:

CIP-PCP Decks: The application of high-strength rebar enhanced the load capacity. Even when the quantity of high-strength rebar was reduced in proportion to the strength ratio relative to normal-strength rebar, comparable load capacity was achieved. Crack control performance was found to be similar to that of normal-strength rebar when high-strength rebar was used.

Prestressed Girders: High-strength shear reinforcement maintained the shear capacity of prestressed girders even when the reinforcement quantity was reduced. This result is consistent across different strand layouts and support conditions. However, crack formation areas and crack widths increased as rebar spacing increased due to reduced reinforcement quantities.

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Despite this, crack widths under service conditions remained within the limits specified by the current AASHTO specification.

Bent Caps (Deep Beams): In terms of shear capacity, a reduction in high-strength reinforcement was found to be acceptable. The strut-and-tie method outlined in the current AASHTO specification provided a reasonable estimation of shear capacity. While the minimum web reinforcement ratio of 0.3% proposed by AASHTO was effective for high-strength steel, high-strength steel demonstrated similar crack control performance at a reduced ratio of 0.2%.

Drilled Shaft Footings: The use of high-strength rebar as mat reinforcement allowed for effective reductions in quantity without compromising load performance. However, reducing the side surface reinforcement below current standards resulted in increased strain, poor strain redistribution, and premature failure.
Tension Lap Splice: The AASHTO lap splice length equation was effective for high-strength rebar, ensuring sufficient stress transfer. Beams with high-strength spliced rebar adhered to AASHTO crack width control standards.

Uniaxial Tension: The maximum crack width was minimally affected by steel grade up to the yield point. High-strength steel specimens exhibited more uniform stress distribution and a greater number of smaller cracks, resulting in reduced maximum crack width compared to normal-strength steel specimens.

In conclusion, this research validates the application of high-strength rebar to bridge components, confirming that current design standards remain applicable. Additionally, experimental results indicate that high-strength steel may offer improved crack control compared to normal-strength steel. While the use of high-strength rebar is recommended, further research is needed to explore its crack control advantages and refine design guidelines.

What This Means

This research provides an extensive experimental database on the application of high-strength rebar to various bridge elements, offering a valuable reference for future research in this area.

By integrating experimental results with numerical analyses and computational examples, this project bridges the gap between theory and practice, supporting both practical applications and further research to set new standards for using high-strength rebar in bridge construction.

The findings have significant implications for the future of bridge construction in Texas. They highlight the benefits of high-strength rebar, and the research results will help engineers apply it effectively in real-world applications. The use of high-strength rebar is expected to contribute to safer, more efficient bridge construction across the state.

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