CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-7015: Analyze Shear Capacity of Texas Standard Prestressed Beams from Strut-and-Tie Models of Beams Ends

Background

Texas bridge designers have been facing difficulties, in some instances, due to the *0.18* f'_c shear stress limit at the end regions specified in Article 5.7.3.2 of the American Association of State Highway and Transportation Officials Load and Resistance Factor Design (AASHTO LRFD). If a bridge beam exceeds the *0.18* f'_c shear stress limit, the effective area of members can be increased (e.g., decreasing the beam spacing, providing additional members, or increasing the size of members), or an appropriate Strut-and-Tie Method (STM) can be developed to justify the load transfer mechanisms at the end regions. In other words, the *0.18* f'_c shear stress limit can be exceeded if appropriate STMs can justify load transfer into the supports.

However, the development of STMs might be a cumbersome procedure due to difficulties associated with standard pre-tensioned girders, such as harped strands, debonded strands, support conditions, specific geometric details (e.g., solid end blocks U-beam, box beam, X-beam, and decked-slab beam) and so on. Therefore, the appropriate STMs for the end region of Texas standard prestressed beams should be studied considering geometry and boundary conditions. Furthermore, additional expected failure modes should be confirmed whether they limit the shear strength when the shear stress exceeded the *0.18* f'_c shear stress limit.

When the appropriate STMs are developed for the end region of Texas standard prestressed beams and additional expected failure modes of the girder are considered, the feasibility of increasing the *0.18* f'_c shear stress limit without creating design issues with respect to structural safety or performance issues concerning serviceability of prestressed concrete bridges can be studied.

What the Researchers Did

This study investigates the shear failure mechanisms of the end regions of pre-tensioned girders and develops appropriate STMs for Texas standard prestressed beams. The shear strengthes of six different types of the Texas beam's (Tx-girder, box beam, X-beam, U-beam, decked-slab beam, and slab beam) end region are calculated by the proposed STMs and anchorage capacity, which can prevent the anchorage zone distress. Also, other expected failure modes, in addition to the anchorage zone distress, are considered depending on the geometry of the beams.

The shear stress capacity of the Texas standard prestressed beam's end region is estimated using the proposed STMs and additional expected failure modes. The final purpose of this project is to check whether the end region of the Texas beams can exceed the *0.18* f'_c shear stress limit and the extent to which the stress limit can be relaxed. Furthermore, the analytical results are compared with existing experimental results to determine whether the analytical method applied in this study is conservative in calculating shear strength. Finally, the different results and conclusions for each type of Texas standard prestressed beams are yielded.

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What They Found

When comparing Tx-girder and AASHTO Type I-girder using the database for shear strength of prestressed beams, the *0.18* f'_c shear stress limit might be overly conservative for the Tx-girder because it can contain a greater number of strands, and thus a greater shear capacity than the AASHTO Type I-girder. Therefore, it is appropriate to calculate the shear stress limit of the end region of the Texas standard prestressed beams instead of using the *0.18* f'_c shear stress limit. Therefore, the 0-7015 project determines whether the shear stress in the end region of the Texas standard prestressed beams can exce the *0.18* f'_c shear stress limit when using STM and anchorage capacity as suggested in NCHRP 579, and this outcome is achieved for every size of Tx-girder and decked-slab beam. Among other types of beams, there are beams with a size that can relax the shear stress limit, but the effects are insignificant.

The shear stress of the Tx-girder and decked-slab beam's end region can exceed the *0.18* f'_c shear stress limit through the analytical method. Even when the shear stress exceeds the *0.18* f'_c shear stress limit, other expected failure modes do not limit the capacity. Since the maximum shear stress capacity varies depending on the size of the beams, different shear stress limits recommended by this project should be specified according to the sizes of the beams. Also, the analytical method utilized in this study is conservative in calculating the shear strength of Tx-girder and decked-slab beams. The table below shows the shear stress limits for Tx-girder and decked-slab beam suggested in this project.

Table 1. Shear stress limit for Tx-girder and decked-slab beam

Proposed shear stress limit (f'_c)						
Tx-28	**Tx-34**	**Tx-40**	**Tx-46**	**Tx-54**	**Tx-62**	**Tx-70**
0.22	*0.22*	*0.23*	*0.23*	*0.22*	*0.21*	*0.20*

6DS20	**6DS23**	**7DS20**	**7DS23**	**8DS20**	**8DS23**
0.23	*0.22*	*0.23*	*0.23*	*0.23*	*0.24*

What This Means

Based on the analytical result of this project, the *0.18* f' shear stress limit applied in the design of the bridge end is too conservative to the two types of Texas standard prestressed beams. The end regions of Tx-girders and decked slab beams can withstand the shear stress until the proposed shear stress limit in Table 1 without expected failures. Finally, it is justifiable to relax the shear stress limit of every size of the Tx-girder and decked-slab beam, allowing for a more economical design of bridges as the shear stress limit of the girder increases. In addition, applying the analytical method proposed in this study, the possibility of relaxing the *0.18* f'_c shear stress limit of the end region of prestressed beams other than Texas beams can be confirmed.

For More Information

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