THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

Technical Memorandum

To:	Martin Dassi, TxDOT Project Manager
From:	Oguzhan Bayrak, Project Supervisor
Subject:	P12 TxDOT Project 0-7090: Evaluate the Deployment of High Strength Reinforcing Steel in Texas
Date:	10/30/2024

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1. Introduction

This document provides design recommendations for the employment of high-strength reinforcing steel in bridge superstructure components, specifically concrete deck slab and prestressed girder. These recommendations are based on the research findings from Task 3 (Example Calculations & Designs), Task 8 (Superstructures—Pretensioned Girders), Task 9 (Superstructures—Decks), and Task 11 (Numerical Structural Performance Assessment) of Project 0-7090, with detailed results previously submitted in technical memorandums. This document focuses on practical design considerations, starting with a summary of current design recommendations, followed by proposed design recommendations based on the research results, and concluding with comparative examples with design drawings.

2. Design Recommendations

2.1. Current Recommendations

For concrete deck slabs, the TxDOT design manual—LRFD (2024) specifies the use of the Empirical Design of Article 9.7.2 of the AASHTO LRFD Bridge Design Specifications. The reinforcement details require that the top and bottom mat reinforcement utilize No. 4 bars with a maximum spacing of 9 inches (0.27 sq. in./ft.) in both transverse and longitudinal directions.

2.2. Proposed Recommendations

Deck strip tests were conducted on CIP-PCP deck specimens. The experimental results showed that using high-strength steel in the current mat reinforcement layout provides greater load-carrying capacity compared to normal-strength steel. Furthermore, it was confirmed that a modified layout with reduced high-strength steel reinforcement maintains the same load-carrying capacity as the current layout with normal-strength steel, while satisfying serviceability requirements for crack control.

The research team conducted large-scale tests and numerical analyses on prestressed concrete girders using Grade 100 high-strength steel. For both Tx-girders and box beams, the girders maintained their shear strength even when high-strength shear reinforcement was spaced wider than current design specifications. Additionally, the crack width at service levels remained within acceptable limits. This indicates that the spacing of shear reinforcement can be increased in proportion to its strength, applicable to both the B-region and D-region.

For Tx-girders, high-strength shear reinforcement can be effectively utilized with both straight and harped strands. In the case of box beams, the effectiveness of high-strength shear reinforcement is not affected by the number, size, or location of the supports. However, for Tx-girders, the maximum spacing of high-strength shear reinforcement must comply with the limits established by the AASHTO LRFD Bridge Design Specifications.

These findings suggest that the use of high-strength reinforcement can significantly reduce the mat reinforcement in concrete deck slab and shear reinforcement congestion in Texas standard prestressed girders, enhancing constructability and reducing material usage.

2.3. Design Examples: Current design (Normal-strength steel) and proposed design (High-strength steel)

The design examples compare conventional design using normal-strength steel and with those utilizing high-strength steel, incorporating the proposed design recommendations. For concrete deck slab, 5XB28 and Tx62 deck details were used. Additionally, Texas standard prestressed girders (Tx-62 and Box) drawings were included, with comparative drawings provided.

Table 2-1. Rebar details of slab of 5XB28

Grade	Bottom transverse reinforcement			Top transverse reinforcement		
	Layout	Weight [lb/ft]	Remark	Layout	Weight [lb/ft]	Remark
60	#5@6"	95.96	-	#5@6"	95.96	-
100	#5@10"	57.57	↓40%	#5@10"	57.57	↓40%
Grade	Bottom longitudinal reinforcement			Top longitudinal reinforcement		
	Layout	Weight [lb/ft]	Remark	Layout	Weight [lb/ft]	Remark
60	5-#5 btw. girders	26.08	-	#4@9"	40.97	-
100	4-#4 btw. girders	13.36	↓49%	#3@9"	23.06	↓44%
Grade	Total					
	Weight [lb/ft]			Remark		
60	258.96			-		
100	151.57			↓41%		

Table 2-2. Rebar details of slab of Tx-62

Grade	Top transverse reinforcement			Top longitudinal reinforcement		
	Layout	Weight [lb/ft]	Remark	Layout	Weight [lb/ft]	Remark
60	#4@9"	40.97	-	#4@9"	40.97	-
100	#4@15"	24.58	↓40%	#4@15"	24.58	↓40%
Grade	Total					
	Weight [lb/ft]			Remark		
60	81.94			-		
100	49.16			↓40%		

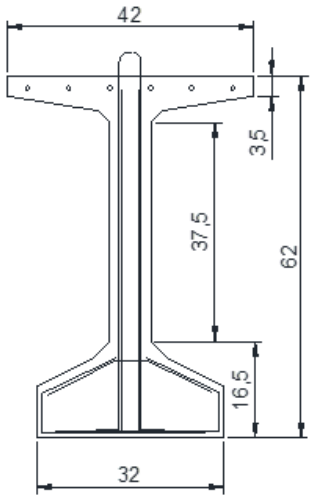
Table 2-3. Rebar quantity of Tx-girder for 45 ft length

Type		Grade	No. of rebar	Weight (lb)	Compare
Vertical	R bar	60	83	680	-
		100	64	525	↓23%
	S bar	60, 100	26	190	Same
Confinement	C bar	60, 100	32	86	Same
	CH bar	60, 100	16	27	Same
Top longitudinal	U bar	60, 100	2	17	Same
	T bar	60, 100	6	180	Same
Top confinement	A bar	60, 100	45	55	Same
Total		60	-	1,235	-
		100	-	1080	↓13%

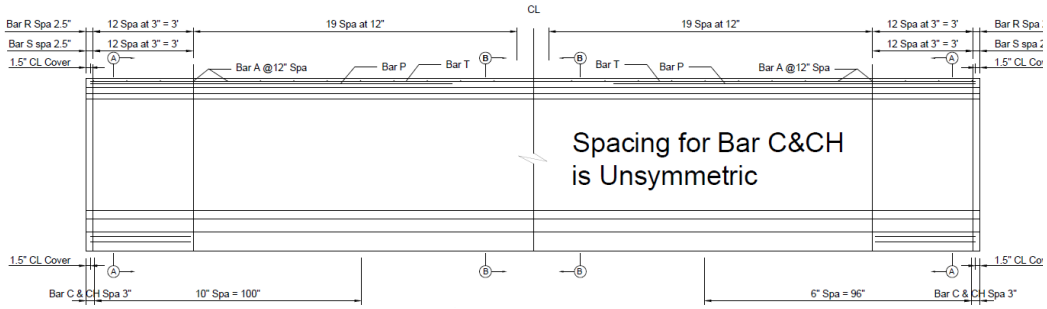
Table 2-4. Rebar quantity of box beam for 40 ft length

Type		Grade	No. of rebar	Weight (lb)	Compare
Vertical	C bar	60	82	542	-
		100	52	344	↓36%
	A bar	60	76	384	-
		100	46	232	↓40%
End block	M bar	60, 100	6	19	Same
	N bar	60, 100	6	15	Same
Confinement	U bar	60, 100	88	251	Same
Top longitudinal	D bar	60, 100	8	350	Same
Top confinement	B bar	60, 100	81	234	Same
Total		60	-	1795	-
		100	-	1445	↓19%

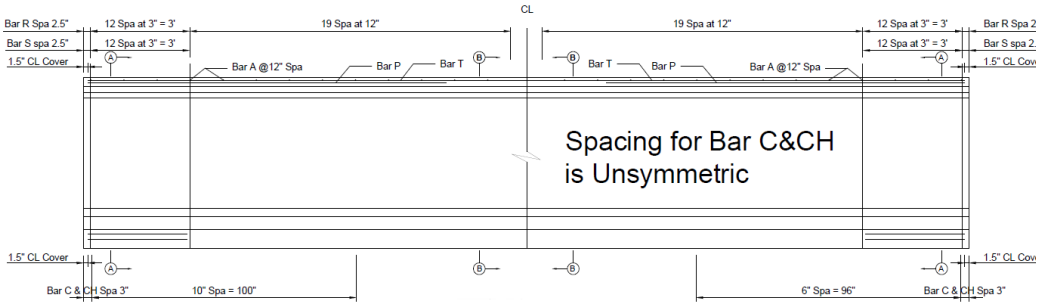
2.3.1. Drawing of Tx-girder



(a) Cross-section for Tx-62 example



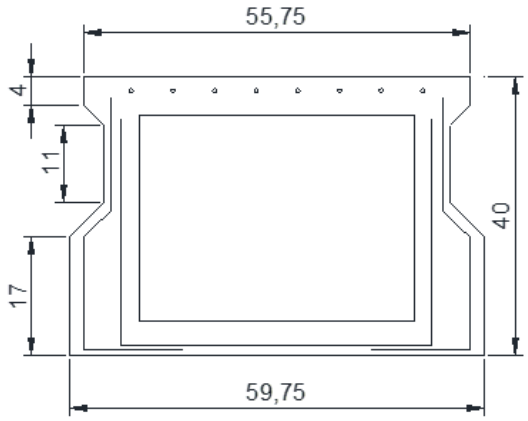
(b) Rebar layout for Tx-62 example using normal-strength



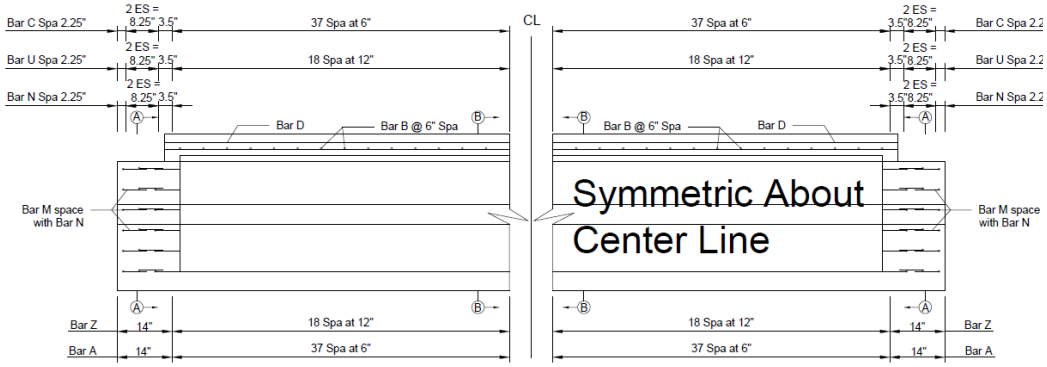
(c) Rebar layout for Tx-62 example using high-strength

Figure 2-1. Shear reinforcement layout comparison when using different strength of rebar for Tx-girder

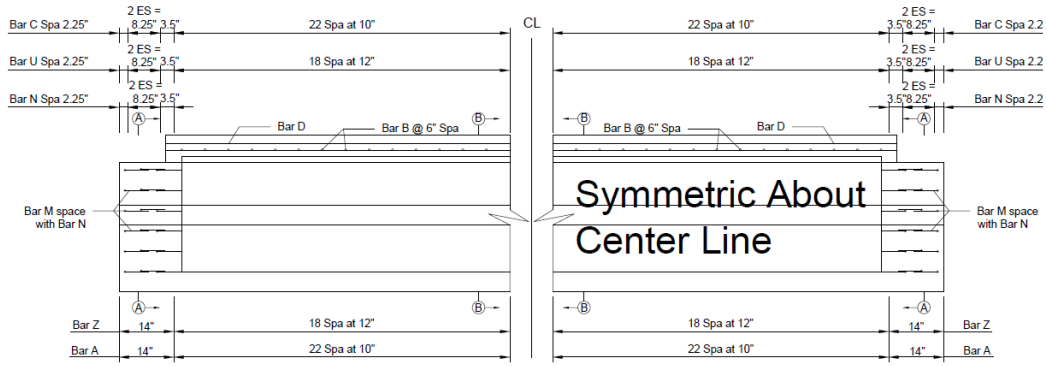
2.3.2. Drawing of Box beam



(a) Cross-section for box beam example



(b) Rebar layout for box beam example using normal-strength



(c) Rebar layout for box beam example using high-strength

Figure 2-2. Shear reinforcement layout comparison when using different strength of rebar for Box beam