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FINITE ELEMENT APPROACH ON MINIMIZATION OF CRACKS AT I-GIRDER ENDS INDUCED BY PRESTRESS

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By

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ABSTRACT

FINITE ELEMENT APPROACH ON

MINIMIZATION OF CRACKS AT I-GIRDER ENDS INDUCED BY PRESTRESS

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The University of Texas at Arlington, 2022

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Prestressed I-girders are one of the very commonly and widely used girders for bridges. It is produced at precast plant and transported to bridge site. To produce a prestressed I-girder, strands are first pulled and concrete is poured in I-girder's formwork. Once the concrete reaches a desired strength, strands are released which induce prestress in I-girder. There are mainly two types of design for I-girders-one that requires debonding of strands at the end of I-girders and another that requires harping of strands at the end of I-girders. The debonding and harping of strands are done to reduce tension at the top flange of I-girder as required strength for moment at the end of I-girders are much less than at mid-span of I-girders. The requirement of de-bonding criteria limits its utilization for all design cases as different bridges have different span length and girder depth requirements. This study focuses on I-girder with harped strand case as it is very commonly used and cracks at the girder ends are commonly observed. Reinforcement bars are used at the ends of I-girders to limit the width of the cracks. However, sometimes the cracks are wider and can result in rejection of the I-girder by quality control personnel. When wider

cracks are observed, spacing of vertical reinforcements are reduced to reduce crack width, but the spacing can be reduced only to certain extent due to congestion of the reinforcement. Therefore, the cracks width cannot be minimized to desired level in all cases by reducing the spacing of vertical bars. Moreover, a corrective action is required if wider cracks are observed on a repetitive basis that exceeds the limit provided on fabrication notes. The wider cracks can allow moisture to reach the reinforcements and strands easily resulting in corrosion, which can reduce the durability of I-girders. Previous studies have shown that increasing area of reinforcement bars will not further help in significantly minimizing the crack width. In this study, a non-linear finite element modeling (FEM) approach was used to show that using a prestressing strand in I-girder web in vertical direction at the girder ends can significantly minimize the cracks. The FEM modeling assumptions were validated by comparing with experimental data available in the literature. In addition, sensitivity analysis was performed and non-linear regression equation was developed.

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CHAPTER 1. INTRODUCTION

1.1 Overview

Prestressed concrete I-girders are widely used in constructing bridges, where their durability is an important factor. To produce a prestressed I-girder, strands are pulled to jacking stress limit and concrete is poured in I-girder's formwork. Relaxation loss in strands occurs from the time strands are pulled to when it is cut. When an I-girder's concrete strength has reached the desired value at the precast facility, prestress force is applied by cutting the prestressing strands. At this stage, the strands again experience loss in stress due to elastic shortening of the girder. The I-girder cambers upward due to the eccentricity of the strands, and the girder is supported at its ends. The gravity forces them downward, in the opposite direction of the camber. A state of equilibrium is reached by the transfer of stress from the strands to the I-girder. The transfer of prestressing force from strands to I-girder causes spalling and bursting cracks at the I-girder end as shown in Figure 1. The horizontal cracks in the girder web are spalling cracks and the vertical crack in the bottom flange is bursting crack. The horizontal crack at the junction between web and bottom flange sometime meet with vertical crack in the bottom flange and forms Y or T shape and it is also called Y or T crack. Reinforcement bars are currently used at the girder ends to limit the width of the cracks, but they do not prevent the cracks from occurring completely in all design cases. Depending on the design and number of strands used, the cracks width may be large or small. The cracks can cause the prestressing strands and reinforcement bars to corrode, which leads to a durability concern, and if they are severe enough, the cracks can propagate enough to cause the prestressing strands to debond, resulting in reduced shear and flexure capacity. If a crack width is small, it can be repaired; however, if it is large, the girder may be rejected by quality control personnel.
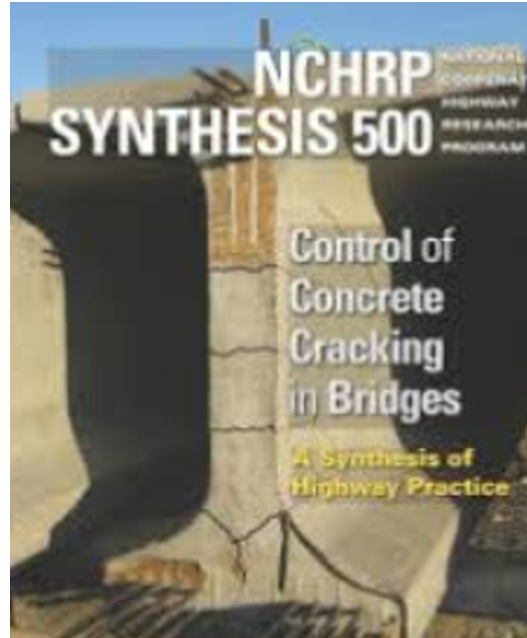
Figure 1.1: Typical cracking pattern in I-girder end

1.2 Goals and objectives

In this study, a bridge was assumed and designed using PGSuper program, which is developed and used by Texas Department of Transportation (TxDOT) in collaboration with other states' Department of Transportation (DOT). One of very commonly used I-girder type in Texas is TX54, and it was used in the bridge design. A non-linear analysis approach was used to construct a three-dimensional finite element model (FEM) of TX54 girder with TxDOT specifications including reinforcements and strands using Abaqus program to analyze it. The FEM modeling approach was validated by modeling another TX54 girder and applying modeling assumptions to it whose experimental data was available in the literature. The concrete strain obtained in the FEM model is in good agreement with the experimental data. The designed I-girder's end region was analyzed. Cracks were observed at the I-girder ends; therefore, a modification to the current

reinforcement detailing practice is proposed at the girder ends to significantly minimize the cracks. The modification requires replacement of first pairs of vertical reinforcement bars in I-girder web with a prestressing strand. This also allows placement of horizontal reinforcements at I-girder's bottom flange closer to the girder end which is better. This proposed method can significantly minimize the wider cracks induced by prestressing in the I-girder end region.

The proposed method is a better crack control method, and it can be easily implemented without impacting design of I-girder. By utilizing the proposed method, the risk of having wider cracks is extremely less. This reduces the risk of rejection of I-girder by quality personnel and reduces risk of wasting girders caused by it. Since each I-girder design can be different, crack width can be wider or smaller depending on design. The proposed method can minimize or eliminate the cracks, and reduce waste of girders. In addition. this proposed method will allow using more strands in an I-girder in the future. This will help increasing spacing of girders in a bridge and use less girders. As a result, this will save cost and make design of bridges more economical. This will also help to use strands with higher allowable jacking stress in the future.

CHAPTER 2. LITERATURE REVIEW

The girder end zone cracks have been discussed and analyzed by previous researchers. [1] (Okumus and Olivia 2013), [2], [3] and [4]. They found that strand cutting order doesn't eliminate Y cracking in the girder end. They also found that lowering harped strands is not effective in controlling web cracks. Moreover, lowering harped strands may reduce number of straight strands that can be used in the bottom flange and this method may be inefficient for heavily prestressed girders and is not recommended in such cases because it decrease girder capacity. They also said it is not recommended to increase the vertical reinforcement area alone in the girder end region as it doesn't eliminate cracking, though it helps to reduce crack width. Since the girder end web region is already congested, it is not practical to place more bars in this area. According to [5] (Hasenkamp et al. 2012), the reinforcement in the girder end is used to limit cracks width at girder end, and the cracks are coated with a sealant or injected with grout, depending on their width. Previous research has focused on minimizing cracks' widths by better distribution of mild reinforcement bars and debonding strands. Placing half of the reinforcement bars from the end of an I-girder to one eighth of the girder depth, and distributing the remaining half between one eighth and a half the girder depth helps control girder end cracks [6] (Tuan et al. 2004) [7] (Arab et al. 2011) [8] (Arab 2012) [9] (Arab et al. 2014). Placing the reinforcement bars near an I-girder end may also help in limiting the crack width [10] (Steensels et al. 2019), but clear cover requirements limit how far they can be moved. [1] (Okumus and Olivia 2013) espoused that increasing the vertical reinforcement in the end zone, even as much as three times, does not eliminate cracking. Mild reinforcement bars at I-girder ends are expected to help limit the crack width rather than prevent cracks from occurring [1] (Okumus and Olvia 2013) [11] (Hamilton et al. 2019) [12] (Ross et al 2014). [1] (Okumus and Olivia 2013) suggested

debonding the strands helps to eliminate cracks, but the suggested debonding percentage exceeds the limit established by the American Association of State Highway and Transportation Officials [13] (AASHTO 2017), Section 5.9.4.3-3. Debonded prestressing strands also reduce I-girder's shear strength in the end zone and consequently interfere with the I-girder's design. In addition, this approach is not beneficial for owners or states where a harped strand pattern is preferred over a debonded strand pattern. TXDOT current standard practice is to use straight and harped strands for the design. Despite a significant amount of research, eliminating I-girder end cracks in prestressed I-girders is still a challenge.

Cracks can be sealed by using Pressure-Injected Epoxy or Surface Sealing to avoid water, chorides or other contaminants infiltration. According to TxDOT Concrete Repair Manual (CRM) [14], cracks as narrow as 0.002 inch can be injected with epoxy resin depending on the epoxy resin material. However, it is often difficult to effectively fill cracks that are narrower than 0.005 inches. TxDOT Type IX low-viscosity epoxy resin (ASTM C 881 Type IV, Grade 1) typically consists of two liquid components that are combined automatically during the pressure injection process. The repair procedure involves surface preparation, mixing, application and finishing. According to CRM, injecting concrete cracks with epoxy resin takes a great deal of skill and expertise, and the repair crew should receive hands-on training from a technical representative from the resin manufacturer before proceeding with the work, or the contractor should retain a specialty firm to perform the work. Cracks can also be sealed using Surface sealing method, but this method only cover sealing the cracks at the outer surface of the concrete. Surface sealing involves simple application of adhesive directly over the crack to prevent infiltration of water, chlorides and other contaminants. A preapproved Type VIII or Type X epoxy that meets TxDOT standard can be applied for surface crack sealing. According to CRM,

surface sealing can be applied to minor cracks of prestressed members that occurs as a result of fabrication. Repair of cracks increase time and cost of girder production. Moreover, if cracks in I-girder are wider than 0.005 inch on repetitive basis, it requires corrective action according to TxDOT specification [15] and TxDOT IGD [16]. It is not uncommon to exceed the cracks width more than 0.005-inch. In some cases, crack width can be reduced by reducing spacing of bars, but requirement of clear spacing between bars limits the extent of closer spacing. Debonding may help minimize the cracks, but some designs may not meet the debonding criteria. An example of debonding design attempt is provided in Appendix E of this paper. Wider cracks in I-girder can result in rejection of the girder by a quality control personnel. There is a risk of girder rejection and girder waste due to cracks. Therefore, it is beneficial to minimize anticipated cracks by applying preventative measures than corrective measures.

To minimize cracks in a structure, it is important to understand material behavior. Also, conducting experiments based on hit and trial method to find a better crack control method will not be economically feasible. FEM modeling using computer programs have been widely used in research for analysis of concrete girders. In this study, non-linear FEM was done using Abaqus program to do analysis of prestressed I-girder end region and recommend a better crack control method. The details of FEM including material modeling is discussed in Finite Element Modeling chapter of this paper. In order to have a girder design details for FEM modeling, a bridge was designed using prestressed I-girder.

3. GIRDER DESIGN AND DETAILING

3.1 Prestressed concrete girder

It is a well-known fact that concrete is weak in tension and strong in compression. When a simply supported girder is loaded, it experiences tension at the bottom and compression at the top of girder. Since concrete is weak in tension, the bottom of girder requires reinforcement to take tension caused by load. If load is very small or span of the girder is small, it can be reinforced with bars. But, when loads are high or span length is large, reinforcement bars may not be enough to prevent cracking at the bottom of girder. Steel girders could be an option, but it is expensive. In those cases, the bottom of the concrete girder can be prestressed in such a way that the compression induced by strands are enough to overcome tension caused by external load. Since prestressed girder are cheaper compared to steel girders, it is commonly used in bridges.

Figure 3.1 shows a simply supported beam of length l with uniformly distributed load, w. The moment diagram is shown in Figure 3.2. The maximum moment location is at mid span with zero moment at supports. The beam tends to deflect in downward direction and the bottom part of the beam experience tension force.
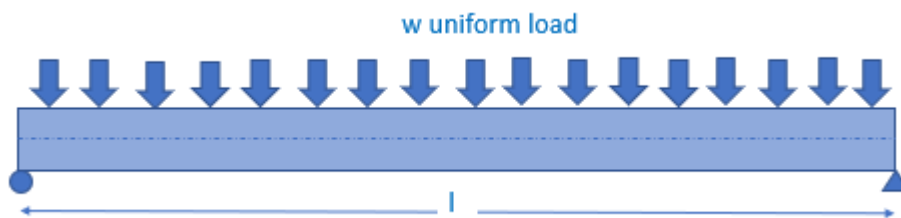
Figure 3.1 Simply supported beam with uniform loading
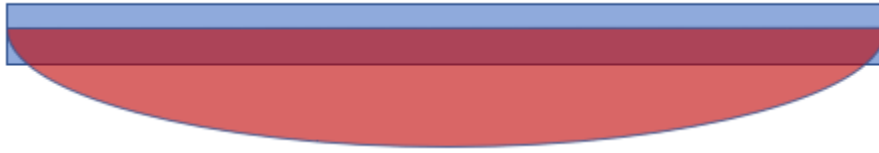
Figure 3.2 Simply supported beam moment diagram

Maximum moment at mid span,

$$M = \frac{wl^2}{8}$$
Eq 3.1

$$\sigma_w = \frac{M}{S}$$
Eq 3.2

Where S is section modulus of the girder, M is moment due to the uniform load, and σw is tension stress developed at the bottom face of the girder.

In prestressed girder, prestress force is applied by using prestressing strand to resist the tension force caused by external load. Figure 3.3 shows prestress force P is applied at eccentricity e from the neural axis of the girder.

Figure 3.4 shows the moment diagram due to prestress force. Since the eccentricity is constant along the length of the girder, the moment is constant along the girder. This prestress force causes compression at the bottom of girder.

Figure 3.3 Simply supported beam with prestress force
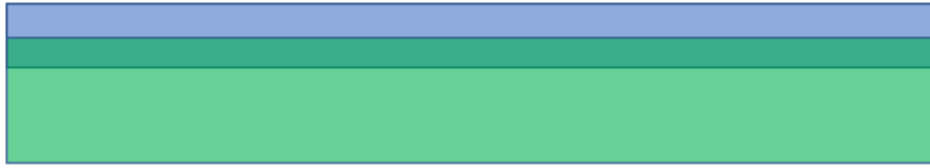
Figure 3.4

$$Mp = Pxe \qquad\qquad \text{Eq 3.3}$$

$$\sigma_p = \frac{M_p}{S} + \frac{P}{A} \qquad\qquad \text{Eq 3.4}$$

Where S is section modulus of the girder, A is cross section area of girder, Mp is moment due to prestress force, and σp is compression stress due to the prestress at bottom face of girder.

If σ_p, which is stress at the bottom face of the girder due to prestress, and σ_w, which is stress due to the uniform load at the bottom face of the girder, are equal, the net stress at the mid span will be zero. Therefore, tension force caused by external loading in concrete can be offset by prestress force without using reinforcement bars. This advantage has made prestressing concept very popular in structures including bridges.

As shown in the Figure 3.2, the demand which is caused by the uniform load is not constant along the girder unlike the capacity provided by the prestress force, which can be seen in Figure 3.4. This causes unnecessary prestress force near supports where prestress force exceeds the demand. When the upward deflection caused by prestress force is greater than the downward deflection caused by the uniform load, it creates net tension at the top face of the girder near supports.

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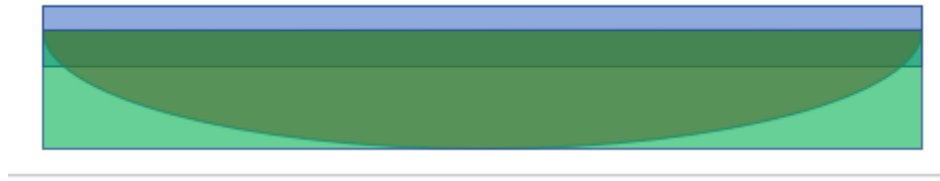
Figure 3.5 Overlapping diagram of demand and capacity

Figure 3.5 shows overlapping diagram of demand and capacity. The demand and capacity are equal at the mid-span and has zero net tension at the bottom face of the girder. But, the excess capacity due to prestress causes tension at the top of the girder away from the mid-span with maximum excess near supports. This requires adjustment of eccentricity of strands away from the mid-span so that the capacity can be reduced and tension at the top flange can be brought to zero or within the allowable limit.

This adjustment of eccentricity can be done by depressing the strands away from the mid span. Figure 3.6 shows the profile of stand with depressed or harped strand. The strand is kept horizontal for a few feet in mid span region and then is sloped linearly to the girder end. Some strands in the girder are kept horizontal throughout the length and some strands are harped to achieve desired demand at mid span and near supports. The number of straight and harped strands depends on the span length and spacing of girders which is part of a bridge design.

Figure 3.6 Harped strand profile in girder

3.2 I-girder design

In Texas, one of common types of girders used for bridges is TX54, which has a total girder depth of 54 inches. To obtain a design for TX54 girder, a bridge with 125.5ft span as shown in Figure 3.6 was assumed with girder spacing of 8ft. For TX54 girder, economical span is about 125ft. I-girder length is typically 6 inch less than span length due to clearance of 3 inch on each end. The TX54 girder length was 125 ft; 46 strands were used, with 8 of them harped strands. Figure 3.7 shows the longitudinal view of the I-girder with strands, and Figure 3.8 shows the strand pattern at the I-girder's end and mid-span. The assumed strand, a low relaxation strand, has a nominal diameter of 0.6 inch and 270 Ksi tensile strength [13], AASHTO 2017 Table 5.4.4.1-1. The initial applied prestress was 75% of the tensile strength; the initial concrete strength was 6 Ksi, which is the maximum allowable in a standard TX prestressed I-girder at release. More details of the design are in Appendix A.

Span = 125.5 ft
Girder Spacing = 8ft

Bridge plan

Bridge cross section
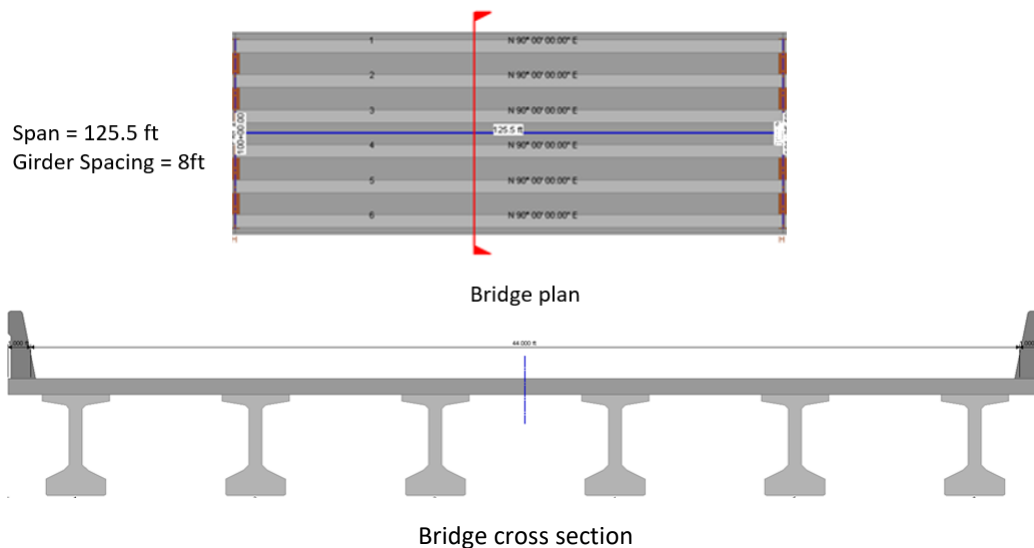
Figure 3.7 Bridge with TX54 girders
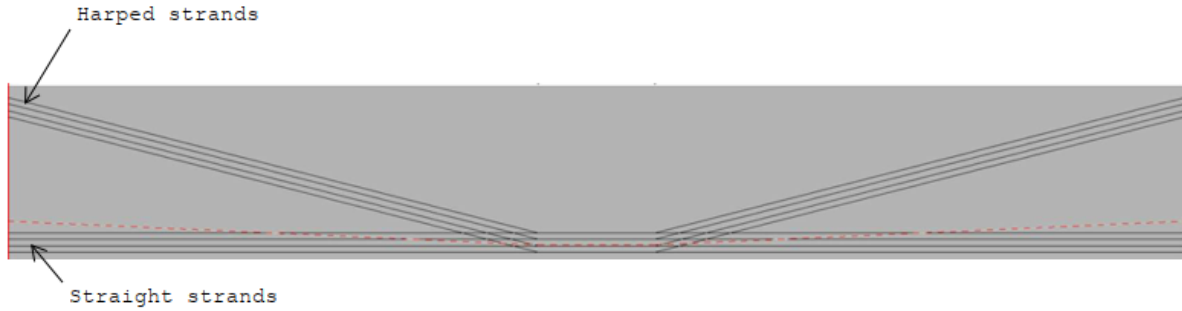
Figure 3.8 Longitudinal view of I-girder with strands
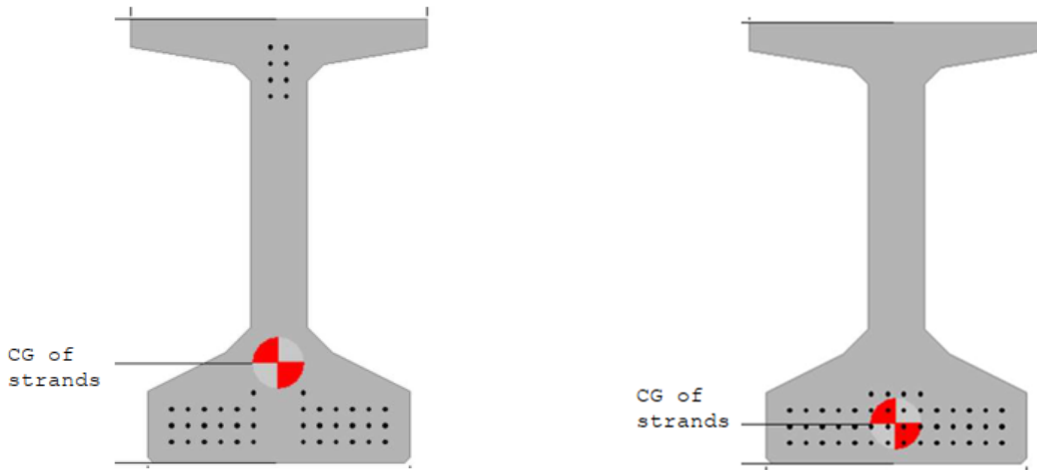
Figure 3.9 Strand pattern at I-girder end (Left) and at mid-span (Right)

3.3 I-girder end reinforcement detailing

The girder cross section, reinforcement bars and its location at girder end are shown in Figures 3.9 – 3.10. These details are per the prestressed concrete I-girder specifications of the Texas Department of Transportation's (TXDOT's) bridge standard [17] and it is in Appendix B of this paper.
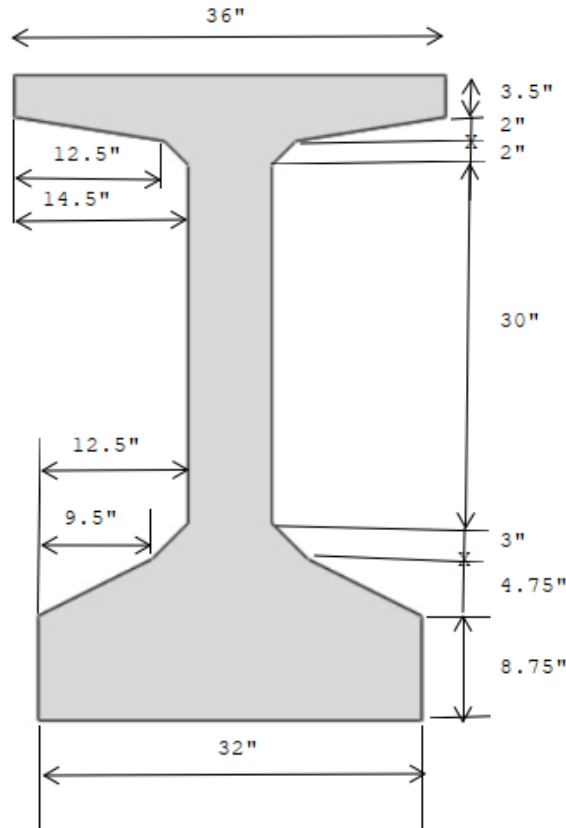
Figure 3.10 Cross section of TX54 girder

Bars S, T C and CH are placed vertically, and bars U, A and T are placed horizontally as shown in Figure 3.10. Bars S is placed in the girder web that extends into bottom flange and top flange. Bar R is placed in the web as well and it extends above the top flange. The purpose of the portion above the top flange outside the girder is to connect it to the bridge deck. Bars C and CH are placed in the girder bottom flange to provide confinement. U bars are placed in between rows of strands. A bar is placed in the top flange transversely. T bar is placed in the top flange longitudinally. More details of the bars placement is in Appendix B.
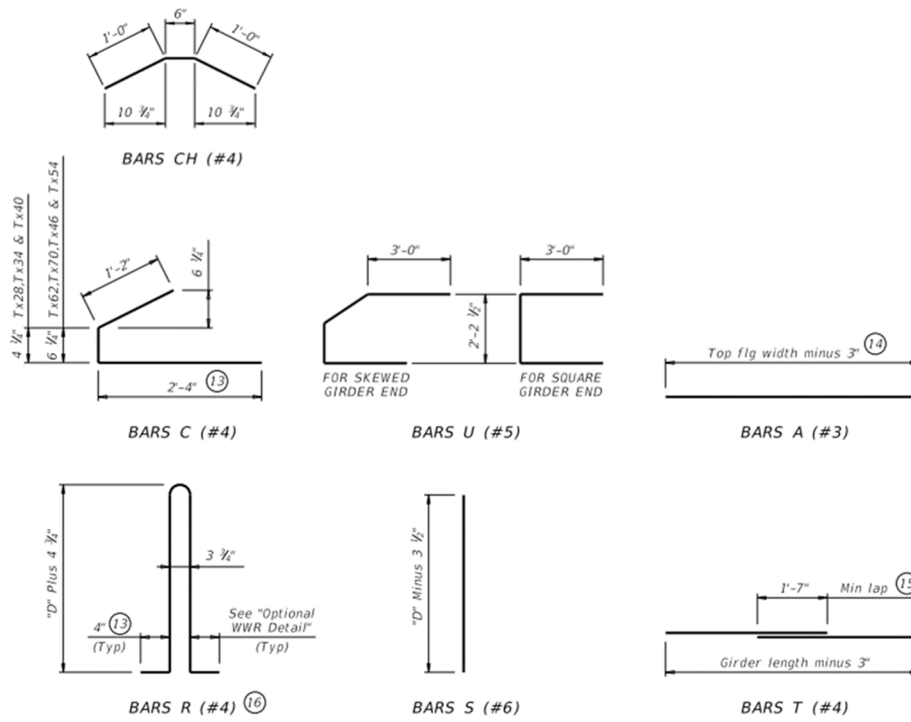
Figure 3.11 Reinforcement bars at I-girder end
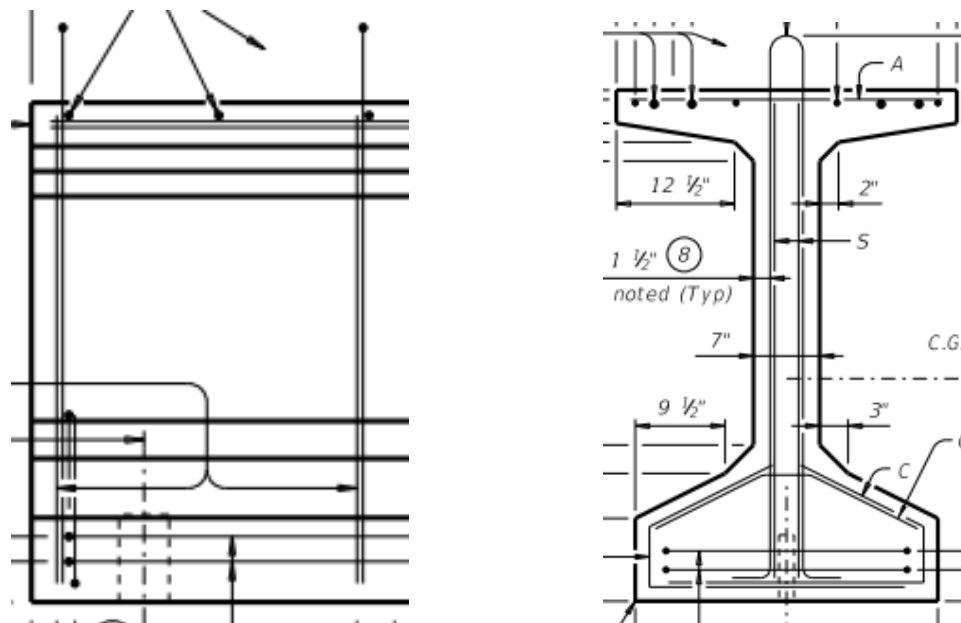
Figure 3.12 Reinforcement bars at I-girder end

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3.4 I-girder fabrication

Fabrication of girder should be in accordance with TxDOT Standard Specification for Construction and maintenance of Highways, Streets, and Bridges [15]. It requires qualified personnel in accordance with DMS-7300. It requires bottom and side of form made of steel. If timber form is used, it must meet certain requirements as specified in the standard. A form must conform to the profiles, dimensions, tolerances and should be free from dents, grease, or other foreign materials. The form thickness, external bracing and stiffeners should be able to withstand the forces generated during concrete placement and consolidation.

The prestressing is done by use of hydraulic jacks with sufficient capacity and should be equipped with instruments for monitoring the hydraulic pressure. The tension in the stands is released after concrete strength requirements are met using flame de-tensioning. Each strand is flame-released simultaneously at both ends.

4. FINITE ELEMENT MODELING AND VALIDATION

4.1 Modeling of I-girder

The Abaqus program was used for the I-girder modeling and nonlinear analysis in this study. A 125-foot long TX54 girder was modeled for the analysis.

4.1.1 Concrete Modeling

It is well known fact that concrete is very good in compression and weak in tension. There are situations where concrete undergoes tension and development of crack plays a significant role such as in prestressed I-girder end during prestress. This type of problem is solved by considering plasticity theory in compression zone and analyzing tensile zone where at least one principal stress is tensile using fracture mechanics theory such as smeared crack modeling [18] (Rashid, 1968) or fictitious crack model [19] (Hillerborg et al., 1976) or crack band theory [20] (Bazant and Oh, 1983). But, according to [21] Onate et al. (1986), those modeling techniques to deal with tension zones in concrete have several drawbacks, such as unable to use a quite arbitrary shear retention factor to ensure some shear resistance along the crack and unable to attain equilibrium at cracking point when multiple cracks are expected. [22] Lubliner et al. (1989) mentioned that those limitations can be overcome by defining the single constitutive model that governs the nonlinear behavior of concrete including failure in both compression and tension, which is called concrete plasticity theory. [22] Lubliner et al. proposed the theory based on an internal variable formulation of plasticity theory and new yield criteria, which matches the experimental data for concrete.

[22] Lubliner et al. (1989) replaced the hardening variable of classical theory by plastic damage variable. This yield surface adopted by these authors is defined by Figure 4.1.

$$F(\sigma) = \frac{1}{1-\alpha}[\sqrt{3J_2} + \alpha I_1 + \beta <\sigma_{max}> -\gamma <-\sigma_{max}>]$$

$$\frac{1}{1-\alpha}(\bar{q} - 3\alpha\bar{p} + \beta\,\widehat{\bar{\sigma}_2}) = \sigma_{co}$$

Uniaxial tension

Biaxial tension

$\widehat{\sigma_2}$

$\widehat{\sigma_1}$

Uniaxial compression

Biaxial compression

$$\frac{1}{1-\alpha}(\bar{q} - 3\alpha\bar{p} + \beta\widehat{\bar{\sigma}_1}) = \sigma_{co}$$

$(\sigma_\infty, \sigma_\infty)$

σ_∞

$$\frac{1}{1-\alpha}(\bar{q} - 3\alpha\bar{p}) = \sigma_\infty$$
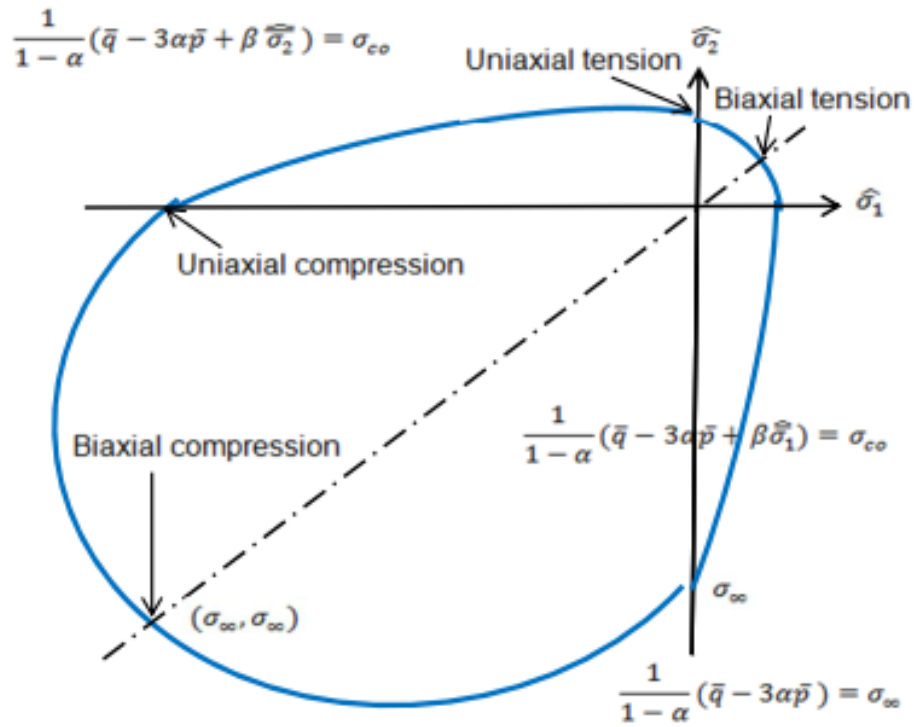
Figure 4.1 Concrete yield surface in plane stress
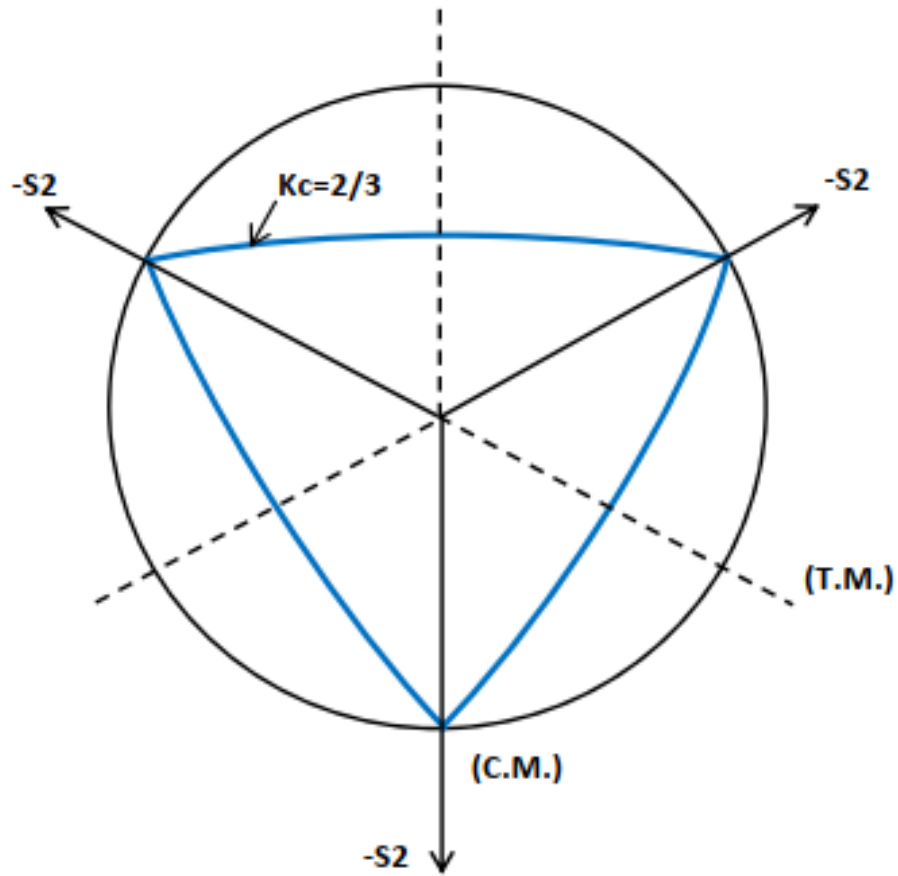
Figure 4.2 Yield surfaces in deviatoric plane corresponding to different value of Kc

In the above equation α, β, and γ are dimensionless constants. In biaxial compression, σ max = 0. The value of α 0.08 and 0.12 based on experiments. The parameter γ is valid only for triaxial compression or the state of being σ max < 0. In the Figure 4.2, (T.M.) and (C.M.) represents tensile and compression meridian respectively.

For tensile meridian (σ1 > σ2 = σ3),

$$\sigma max = \frac{1}{3}(I1 + 2\sqrt{3J2}) \qquad\qquad \text{Eq 4.1}$$

For triaxial compression,

$$(2\gamma + 3)\sqrt{3J2} + (\gamma + 3\alpha)I1 = (1-\alpha)\ fc \qquad \text{Eq 4.2}$$

For compressive meridian ($\sigma_1 = \sigma_2 > \sigma_3$),

$$\sigma max = \frac{1}{3}(I1 + 2\sqrt{3J2}) \qquad \text{Eq 4.3}$$

For triaxial compression,

$$(\gamma + 3)\sqrt{3J2} + (\gamma + 3\alpha)I1 = (1-\alpha)\ fc \qquad \text{Eq 4.4}$$

Where fc is the critical stress in uniaxial compression

The multiaxial behavior of concrete with degradation behavior states that bulk modulus depends primarily on the volume strain, and shear modulus on the octahedral shear strain as reported by [23] Cedolin et al. (1977). The bulk and shear moduli are given by the equation below

$$K = (1 - d_1)K_0 \qquad \text{Eq 4.5}$$

$$G = (1 - d_2)G_0 \qquad \text{Eq 4.6}$$

The 6 x 6 stiffness matrix of an isotropic solid is given below.

$$D = KII^T + GU_{dev} \qquad \text{Eq 4.7}$$

In the above equation,

$$I = (1,1,1,0,0,0)$$

$$dev = 1 - \frac{1}{3}II^T$$

$$U = \begin{bmatrix} 2 & 0 & 0 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

[24] (Okumus et.al 2012] used non-linear FEM to simulate the prestressed I-girder and used non-linear concrete material properties. They recommended tetrahedral elements for the non-linear analysis. [25] (Yapar et al. 2015) performed lab experiments as the basis for their non-linear FEM analysis of a prestressed girder and included strands in the model. Both [12] (Ross et al. 2014) and [25] (Yapar et al. 2015) used concrete plasticity damage for their concrete modeling.

To reduce the computational cost, only end zone of I-girder was fine meshed since this study is focused on analysis cracking of I-girder end. To analyze the I-girder end, 3.5 ft of the girder, measured from the girder one end, was assigned tetrahedral elements with a 3-inch fine mesh size. Hexahedral element with a 6 inch-transition mesh was assigned to the middle1 ft section, and the remaining length of the girder was assigned hexahedral element with 60-inch coarse mesh size as shown in Figure 4.3. Since this study focuses on the end region of the I-girder, tetrahedral elements were assigned only to the fine mesh region. A tie constraint was used between the fine and the transition interface, and between the transition and the coarse interface. Concrete plasticity damage was used for the material modeling of the I-girder, and the elastic and plastic properties were assigned for the concrete. For concrete tension stiffening, it was assumed that strain softening after failure reduces the stress linearly to zero at a total strain of 10 times the strain at failure. In the absence of experimental data, this is a reasonable assumption for concrete with good amount of reinforcement [26] (Abaqus 2014). The other data for the concrete plasticity damage model were taken from Abaqus default values, which are 0.1 for flow potential

eccentricity (Є), 1.16 for the ratio of the initial equibiaxial compression yield stress to the initial uniaxial compressive yield stress (fb0/fc0 or σb0/σc0), and 0.67 for the ratio of the second stress invariant on the tensile meridian to that on the compressive meridian at initial yield (K), 31 degrees dilation angle (ψ), and zero for the viscosity parameter (μ). These default values in Abaqus are taken from a range of experimental data mentioned by Lubliner et al [18] and was also validated by research performed by Yapar et al [25]. The concrete design compressive strength (f'cm) at release of strands was 6 Ksi, which is the maximum allowable by TxDOT specification. The tensile cracking strength limit was assumed to be 0.24 √(f'cm) [13] (AASHTO 2017) [27] (TxDOT Bridge Design Manual-LRFD). The Poisson's ratio was assumed to be 0.2 [13] (AASHTO 2017), and the modulus of elasticity was assumed to be 120,000 $Wc^2 f'cm^{0.33}$ [13] (AASHTO 2017), where Wc is the unit weight of concrete in Kcf and f'cm is the design concrete compressive strength in Ksi.
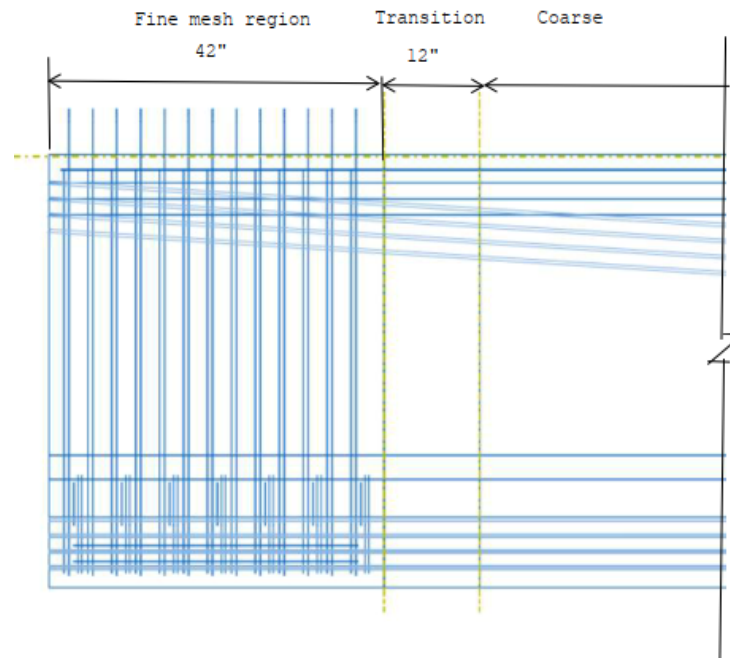
Figure 4.3: I-girder model with fine, transition and coarse mesh region

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Figure 4.4 shows a stress-strain diagram of concrete in compression. The behavior was assumed to be linear up to the allowable limit for compression provided in the TXDOT Bridge Design Manual [27] (TxDOT Bridge Design Manual-LRFD). This linear behavior is also observed in experimental study [28] (Schnittker and Bavrak). After reaching the allowable limit for compression, non-linear behavior of concrete was assumed [29] (Xuo and Tadros 1997). Figure 4.5 shows a stress-strain diagram of concrete in tension.
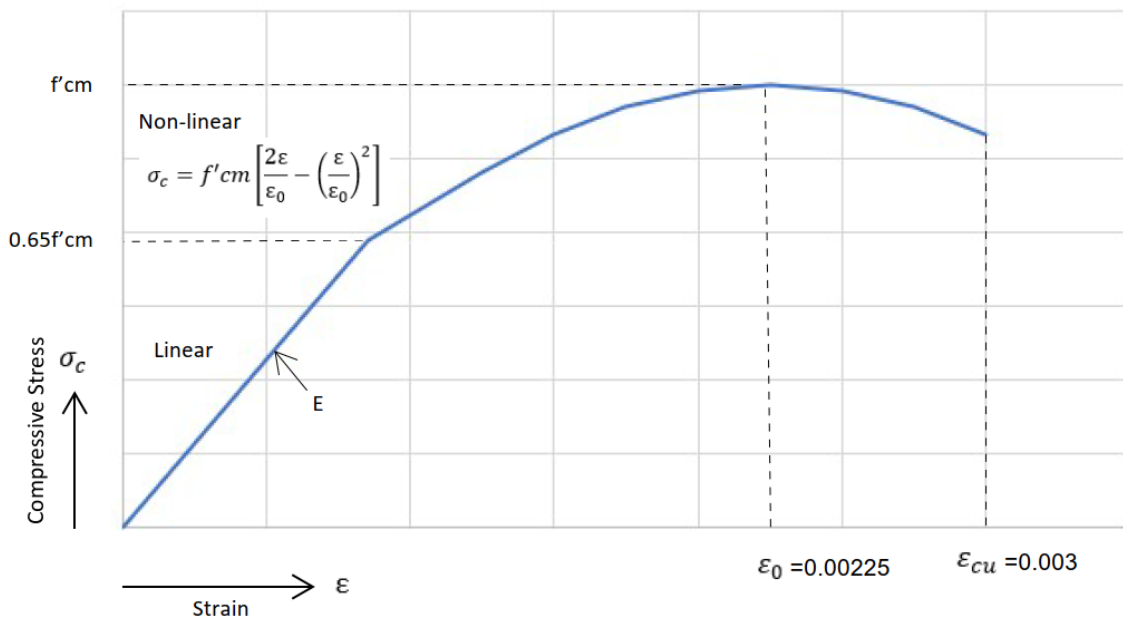
Figure 4.4 Concrete compressive stress-strain diagram

$$f'tm = 0.24\sqrt{f'cm}$$
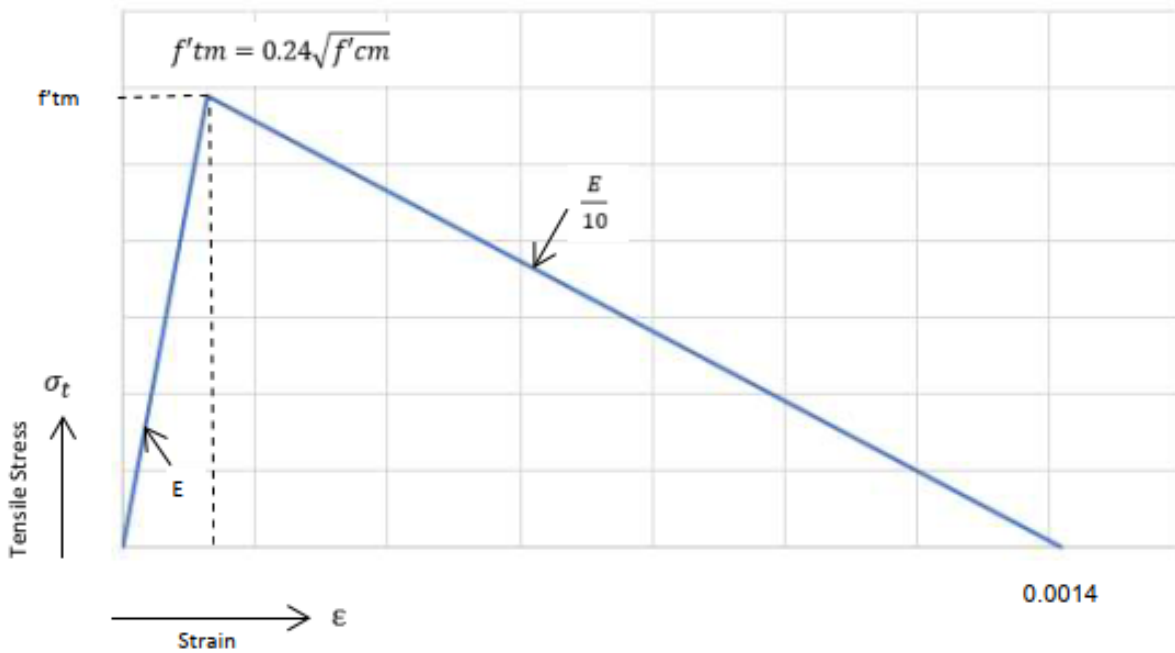
Figure 4.5 Concrete tensile stress-strain diagram

4.1.2 Strand Modeling

A 3D element with circular cross section equivalent to an area of 0.217 in² was modeled for the strand. Yapar et al. used an equivalent area method to model the strand [25] (Yapar et al. 2015). Okumus et al. applied the prestress loads directly on the concrete as surface loads [24] (Okumus et al. 2012). For this research, the strands were modeled as 3D element so that the Hoyer's effect can be captured. The strands were modeled as embedded in the I-girder to simulate the bond between the strands and the concrete. This modeling approach to analyze the behavior of prestressed concrete has been validated by experimental research performed by [30] (Rauniyar 2013). The modulus of elasticity was assumed to be 28500 ksi [13] (AASHTO 2017), section 5.4.4.2. The strands were expected to remain within the elastic limit. Figure 4.6 shows the

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modeled strands, and Figure 4.7 shows the location of the straight and harped strands at the I-girder ends.
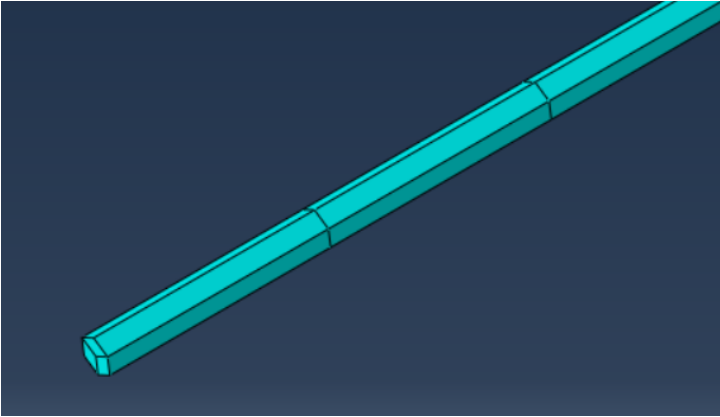
Figure 4.6 Modeled prestressing strand
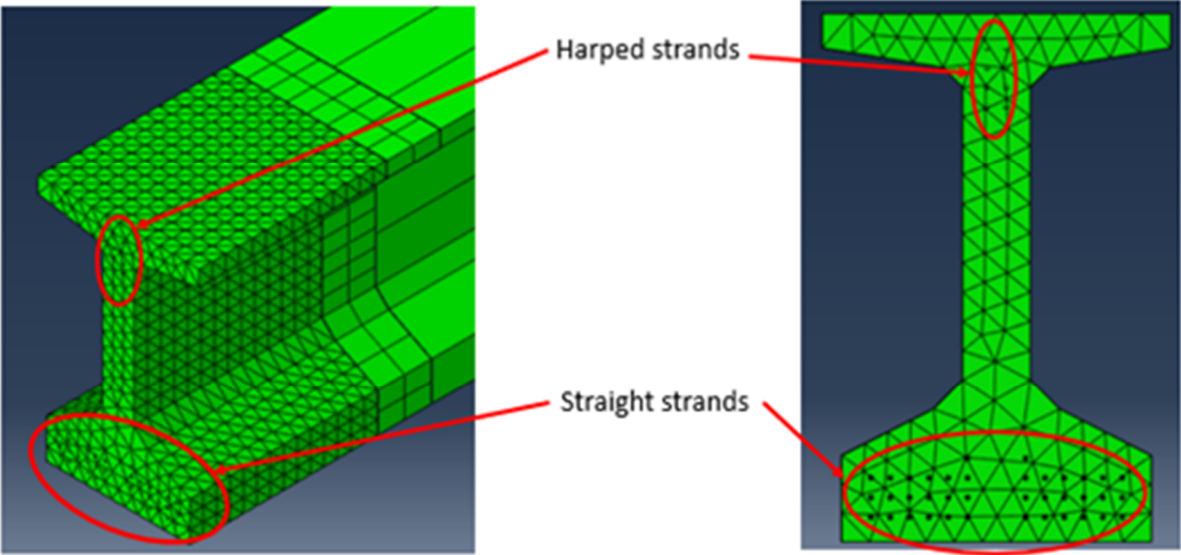
Figure 4.7 I-girder model with straight and harped strands

4.1.3 Reinforcement bars modeling

The reinforcement bars were modeled as truss element with cross section properties based on the diameter of the bars. Figure 4.8 to Figure 4.16 shows the modeled bars in Abaqus. The bars were modeled as embedded in the girder to simulate a bond between the bars and the concrete. The yield stress was asssumed to be 60 ksi [17] (TXDOT Bridge Standard IGD), and the modulus of elasticty was assumed to be 29000 ksi [13] (AASHTO 2017), section 5.4.3.2. The reinforcement bars were expected to remain within the elastic limit. Figure 4.17 shows the modeled reinforcement bars and strands at I-girder end.

Figure 4.8 Modeled A bar

Figure 4.9 Modeled C bar

Figure 4.10 Modeled CH bar
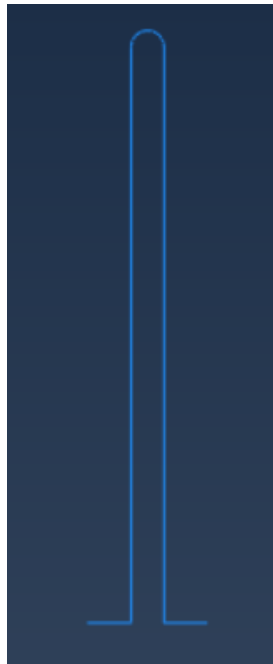
Figure 4.11 Modeled R bar
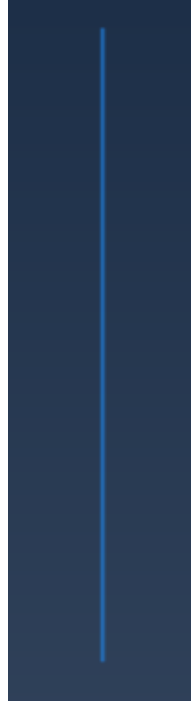
Figure 4.12 Modeled S bar

Figure 4.13 Modeled T bar
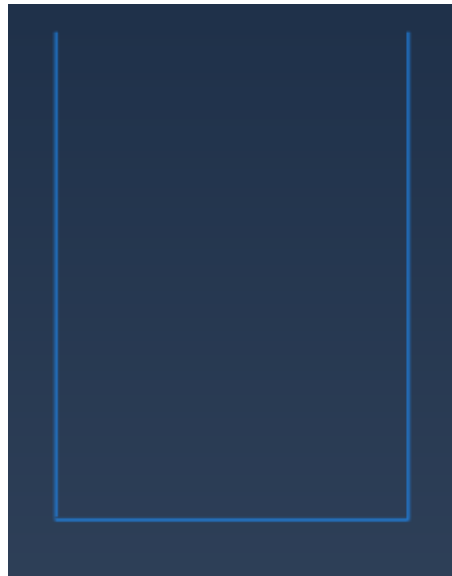
Figure 4.14 Modeled U bar
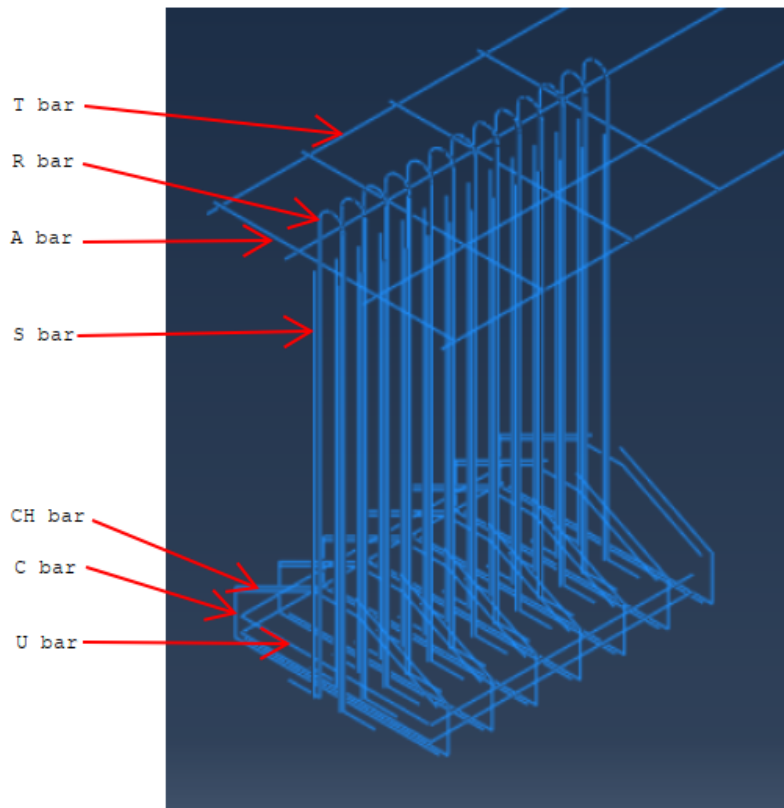
Figure 4.15 Modeled bars in I-girder end
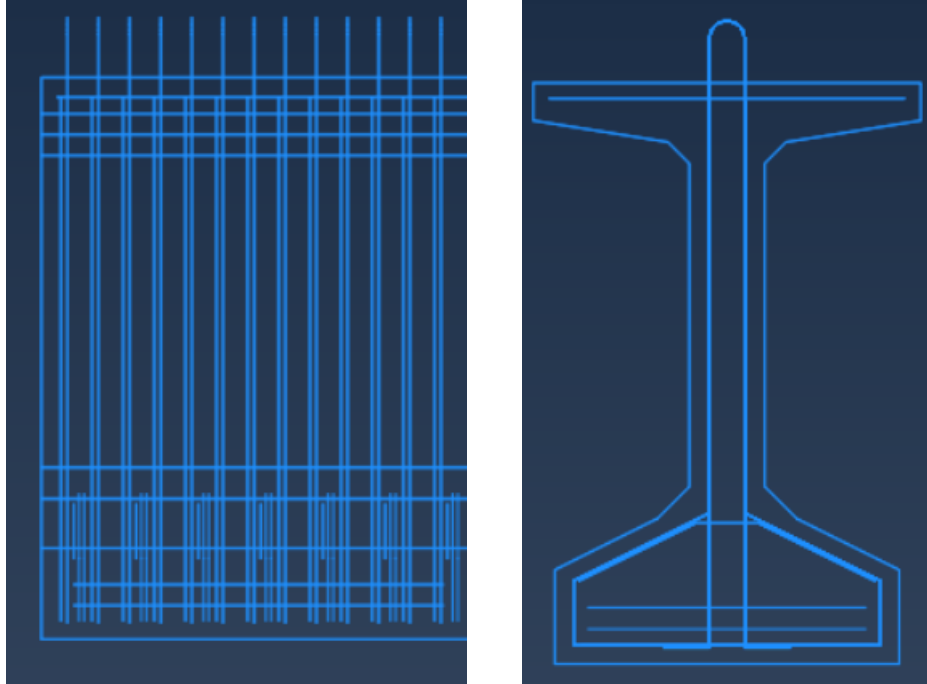
Figure 4.16 Longitudinal view (left) and cross section view (right) of I-girder end with bars
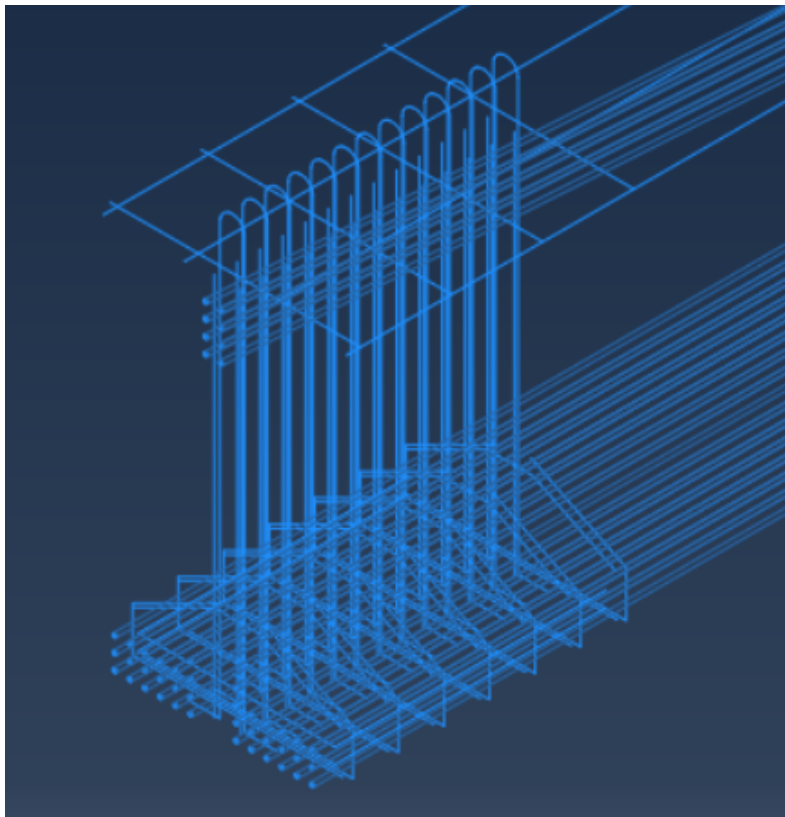
Figure 4.17 Modeled reinforcement bars and strands in I-girder end

4.1.4 Support Modeling

Supports were assigned at the ends of the I-girder at the bottom flange as knife-edge support. Only the translation degree of freedom in the vertical direction was restrained at the fine-meshed end of the I-girder. At the other end, the translation degree of freedom was restrained in all three directions and all rotational degrees of freedom were free. Figure 4.18 shows the support conditions at the ends of the I-girder: X is the horizontal direction along the cross section of I-girder, Y is the vertical direction, and Z is the horizontal direction along the length of the I-girder.
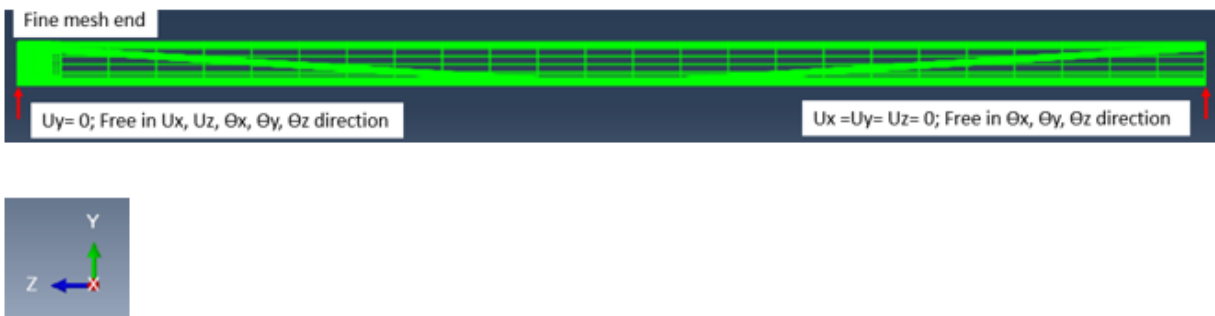
Figure 4.18 Support conditions at ends of I-girder

Ux, Uy, and Uz are the translation degrees of freedom in the X, Y and Z directions, respectively, and Θx, Θy, and Θz are the rotational degrees of freedom in the X, Y and Z directions, respectively. The prestress and gravity loads were applied simultaneously.

4.1.5. Gravity Load Modeling

The gravity load was applied to the model as 386.4 in/s^2 acceleration in a downward direction, which is a commonly used method.

4.1.6 Prestress force Modeling

In order to apply prestress in girder, strands are pulled to the stress limit during jacking. Once the concrete is hardened, strands are released. When prestress force is applied in girder, elastic shortening occurs. In the finite element model, this is automatically captured and any prestress loss due to elastic shortening is included in the model.

Jacking stress or stress limit [13] (AASHTO 2017),

$$fpbt = 0.75\ fpu \qquad\qquad\qquad \text{Eq 4.8}$$

$$= 0.75\text{x}270$$

$$= 202.5\ \text{Ksi}$$

Where fpu is ultimate stress of strand.

Assuming strands are released 1 day or 24 hours after jacking.

Stress in strand before release [31] (Nieto C D 2014),

$$fps(t) = fpbt\ [1 - \frac{log10(t)}{k}\ (\frac{fpbt}{fpy} - 0.55)] \qquad\qquad \text{Eq 4.9}$$

$$= fpbt\ [1 - \frac{log10(t)}{k}\ (\frac{fpbt}{fpy} - 0.55)]$$

$$= 202.5\ [1 - \frac{log10(24)}{30}\ (\frac{fpu\ x\ 0.75}{fpu\ x\ 0.9} - 0.55)]$$

$$= 199.86\ ksi$$

where k =30 for low relaxation strands, t is duration of loading in hours and fpy is yield stress of strand, which is 90% of ultimate stress.

Relaxation loss of strand,

$$fps\ (RL) = 202.5 - 199.86\ \text{Ksi} \qquad\qquad \text{Eq 4.10}$$

$$= 2.64\ \text{Ksi}$$

The prestress in the strands was assigned as initial stress in Abaqus. This modeling technique has

been validated by experimental research [30] (Rauniyar 2013). The value of initial stress is equal

to stress in strand before release. The stress is assigned along the longitudinal direction of the

strand. Another method to apply stress in FEM is by using fictitious temperature, but it requires

known final stress after equilibrium. Therefore, temperature method was not used.

4.2. Results

The results obtained from 125 ft FEM model is presented and discussed below. Figure 4.19

shows the principal plastic strain at the girder end. Cracks in the girder web and bottom flange

were observed.
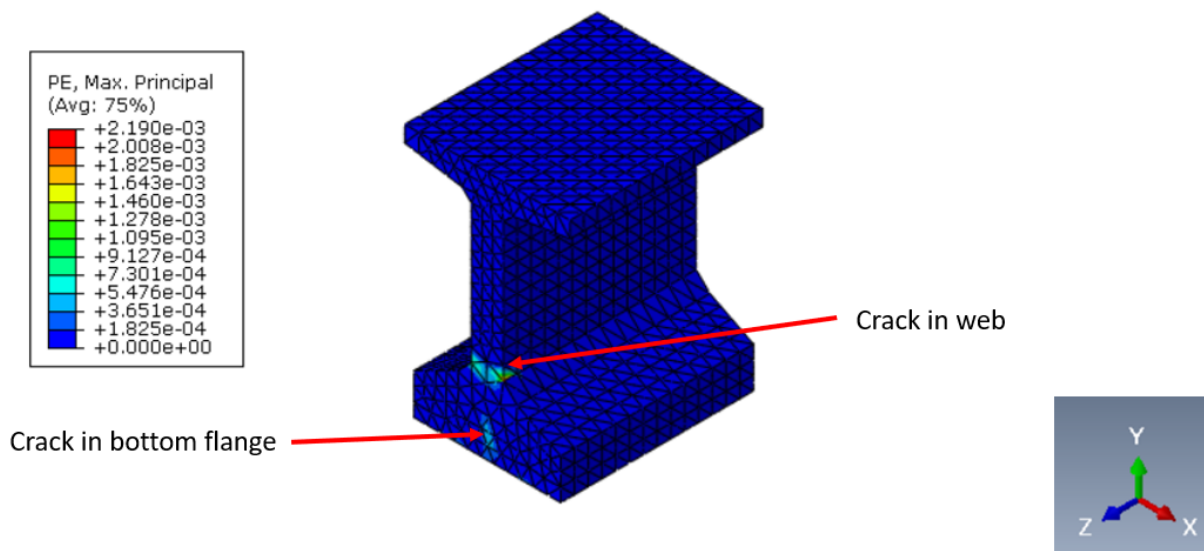
Figure 4.19 Principal plastic strain contour at the I-girder end after prestress

The maximum plastic strain in the I-girder occurred at the junction between the girder web and the bottom flange, which is the section where cross section area suddenly changes. This indicates the stress concentration at that location. In the research study done by [7] (Arab et al. 2011) and [24] (Okumus et al. 2012) also, the FEM results shows the stress concentration at the junction between web and bottom flange.

The prestress force in straight strands and harped strands causes bending on the girder end surface. As a result, the girder web experience tension or spalling stress in vertical direction as shown in Figure 4.20. This causes horizontal cracks in the girder web at the girder end. The stress is concentrated at the junction between girder web and bottom flange. Also, the group of straight strands at the bottom flange on each side creates horizontal stress or bursting stress that causes vertical crack at center of bottom flange as shown in Figure 4.20.
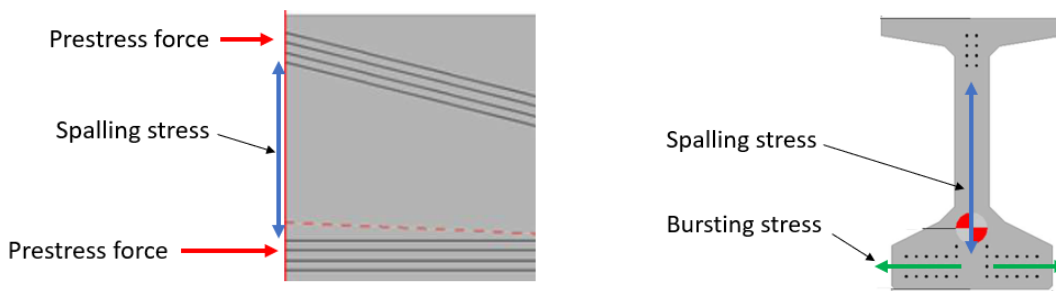
Figure 4.20 Depicting spalling and bursting stress due to straight and harped strands

More figures and contours of the results are in Appendix C.

4.3 Validation of finite element modeling

In order to validate the modeling assumptions of the FEM, a TX54 girder with straight and harped strands pattern available in the literature [31] (Nieto 2014) that has experimental data available was modeled. This girder length was 110ft and strands type were 0.5" low lax strands, which has area of 0.153 in^2. The total number of strands was 78 including 24 harped strands. The concrete strength at release was 6.408 ksi.

This girder was modeled as 3D element. The 3.5 ft length of girder from end was assigned 3-inch fine mesh with tetrahedral element. After that 1ft length was assigned 6-inch transition mesh with hexahedral element and remaining length of the girder was assigned 60-inch coarse mesh with hexahedral element.

The prestressing strand was modeled as 3D element with circular cross section and area of 0.153 in2. The prestressing strand was modeled as embedded in concrete to simulate bond between the strand and girder.

The reinforcement bars are modeled as truss element with area based on its size. The bars are modeled as embedded in concrete to simulate bond between the bars and concrete.

All the modeling assumptions including load and prestress application, support modeling, and material properties were applied to this girder as described in the previous section. The girder with modeled reinforcement bars and strands is shown in Figure 4.21. The cross section of the FEM model is shown in Figure 4.22. The strain gauge location and strain obtained from FEM model is shown in Figure 4.23. The strain value obtained from FEM is shown in Figure 4.24. The comparison of strain value between experiment and FEM model is shown in Figure 4.25.
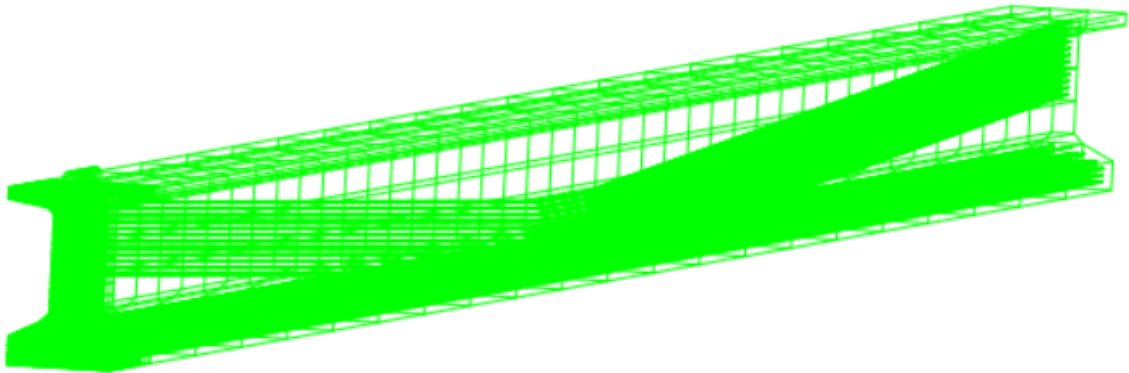
Figure 4.21 Modeled 110ft girder with reinforcement bars and strands
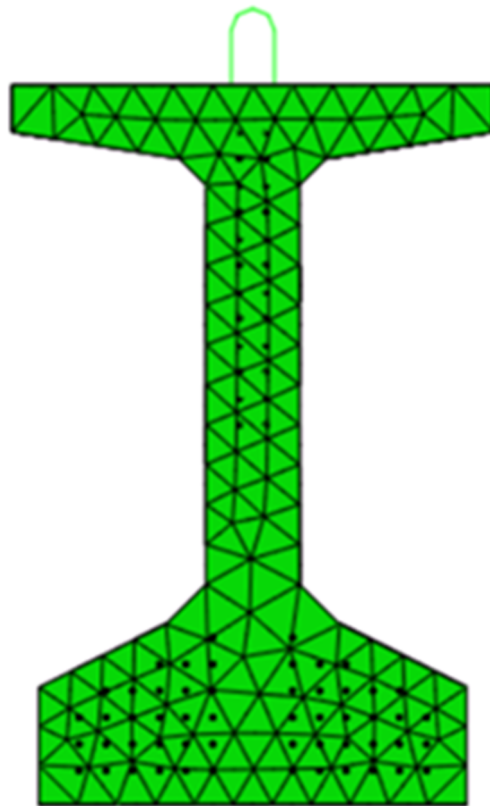
Figure 4.22 Cross section of modeled 110ft I-girder
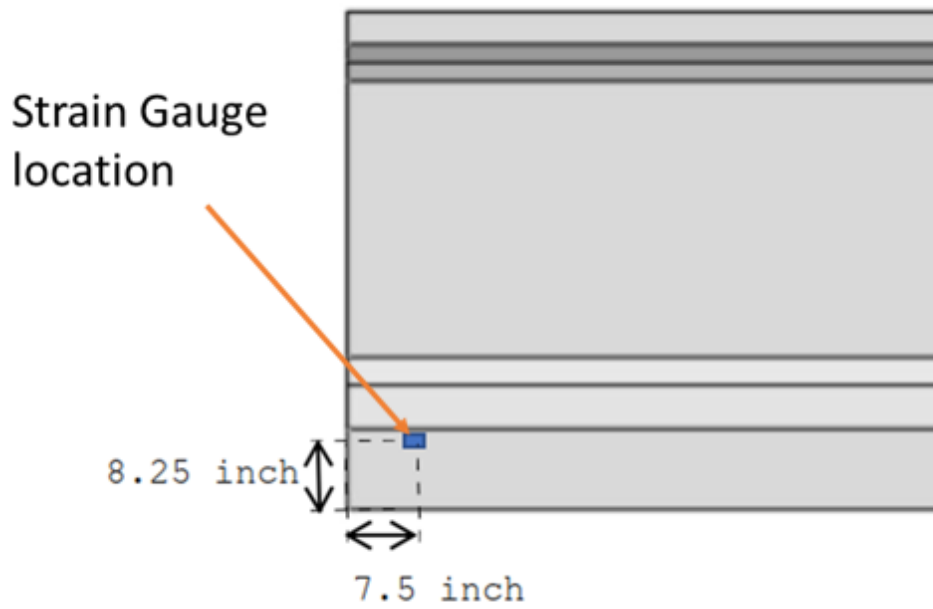
Figure 4.23 Strain gauge location
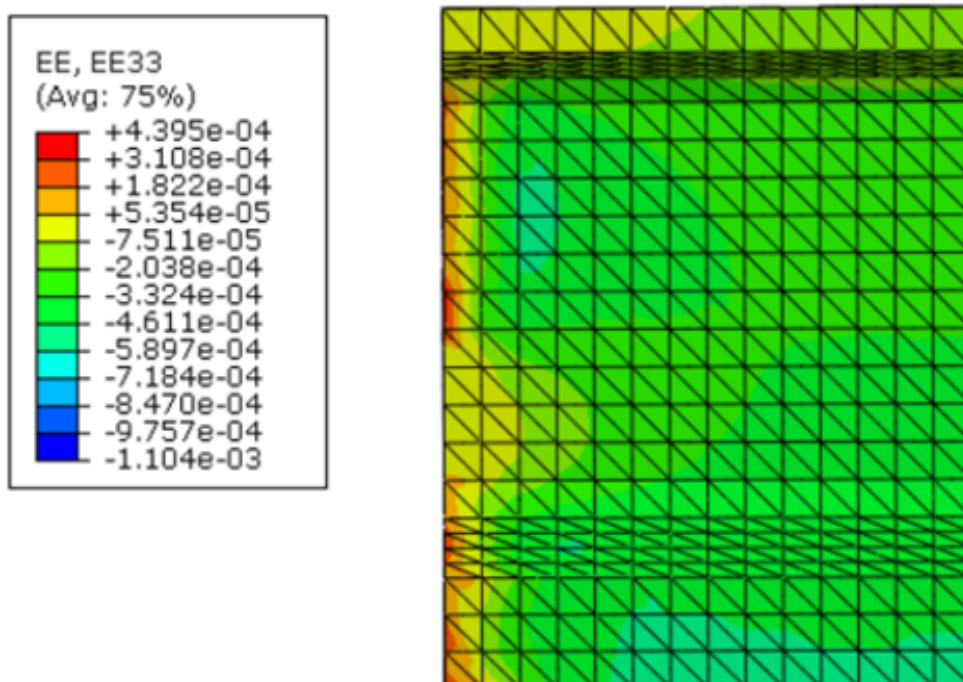
Figure 4.24 Strain in FEM model
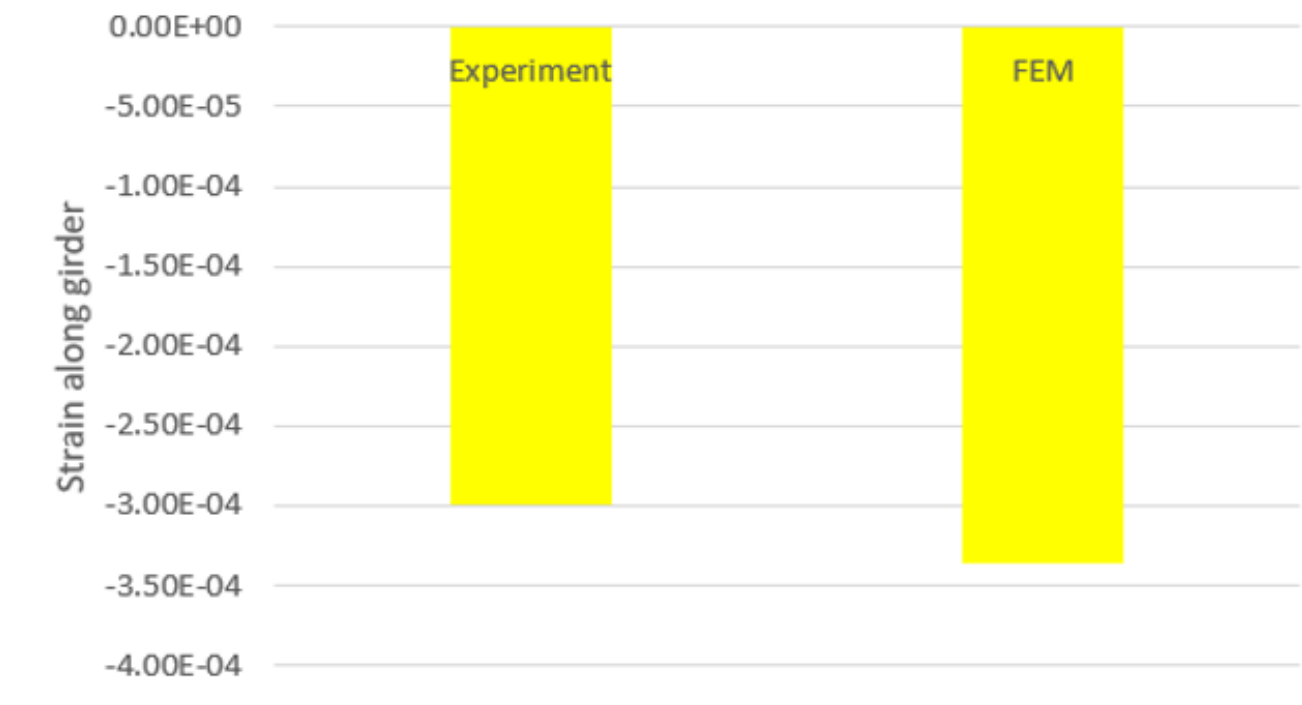
Figure 4.25 Comparison between the experiment and FEM strain value

The concrete strain obtained from FEM is slightly higher compared to experimental value and the difference is about 12%. The result from FEM is slightly conservative for analysis.

5. PROPOSED I-GIRDER END REGION DETAILING

In the current practice, S bars, which are vertical bars in the girder web resist stress in girder web. R bars also helps in resisting stress although its main purpose is to resist horizontal shear between interface of deck and girder when placed on a bridge span. C and CH bars provides confinement of bottom flange. The maximum spalling and bursting stress are at the very end of the girder. Therefore, maximum benefit of reinforcement bars can be taken when it is placed closest to the girder end. However, clear cover requirements prevent it from further moving it closer to the girder end. Also, cracks caused by spalling stress in girder web are of main concern as it could be wider depending on number of harped strands and its position from the bottom of girder. [16] TxDOT IGND sheet, which is a sheet where girder design details are shown when a bridge is designed, states when wider cracks are observed in a girder end at fabrication plant, spacing of S and R bars can be reduced to reduce the crack width. However, there is a limit on how much spacing can be reduced as it will start creating congestion of reinforcement. It also states that if the crack width wider than 0.005 inch starts appearing on a repetitive basis, it will require a corrective action. Therefore, more focus has been put on minimization of spalling cracks in girder web in this study.

5.1 Proposed modification

For the 125ft TX54 girder, a FEM model was created with the modifications shown in the proposed case in Figure 5.1 and Figure 5.2. The first pair of S bars are replaced with a 0.6-inch low lax vertical prestressing strand (V strand). The applied prestress was same as prestress in the longitudinal strands. This also allows reduction in clear cover for U bars which is better for bottom flange region.
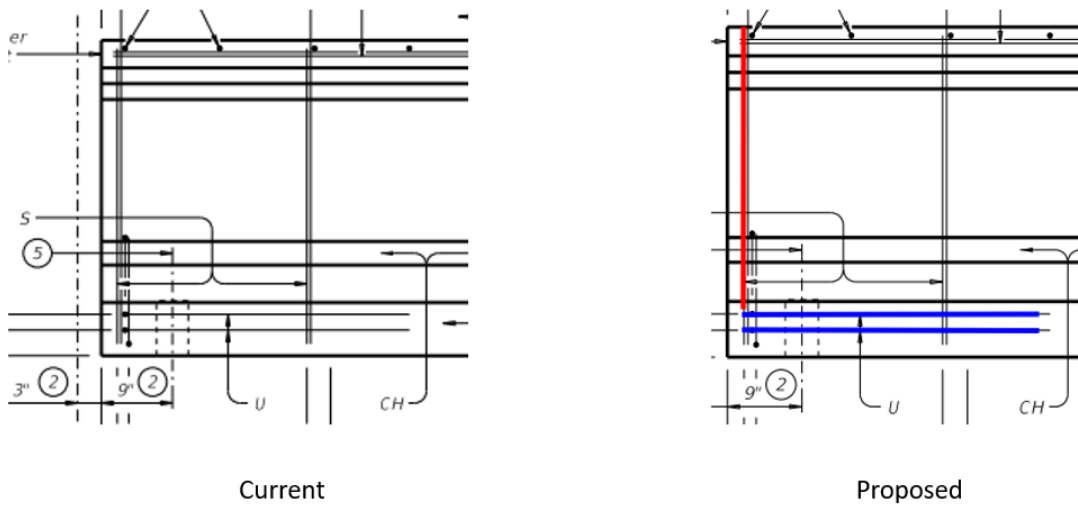
Figure 5.1 Girder end elevation view with current (left) and proposed (right) case
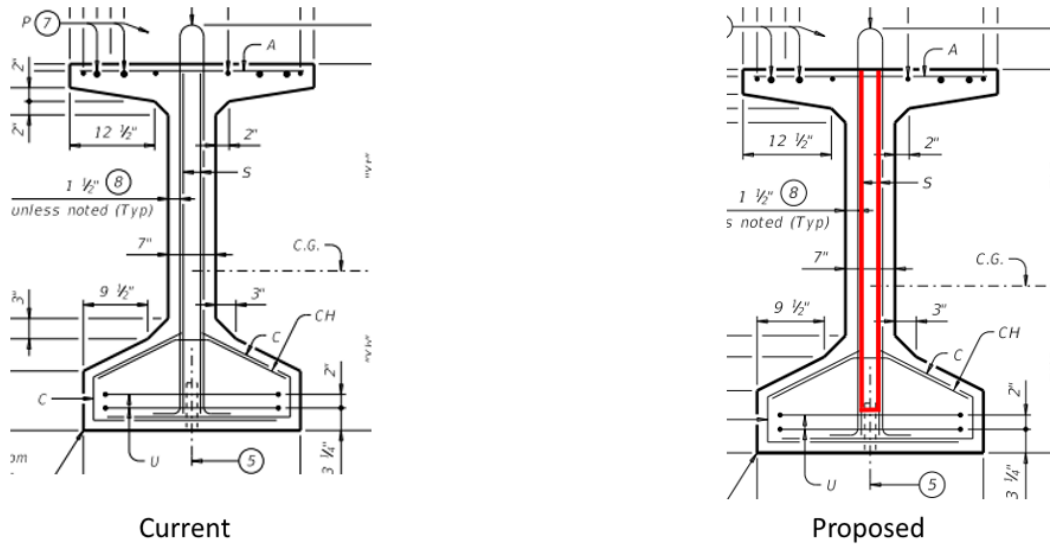
Figure 5.2 I-girder end cross section view with current (left) and proposed (right) case

5.2 Results of proposed case

Figure 5.3 shows the principal plastic strain contour for the current and the proposed modification case. This proposed method significantly reduces the cracks at the girder ends. Additional figures and contours are in Appendix D.
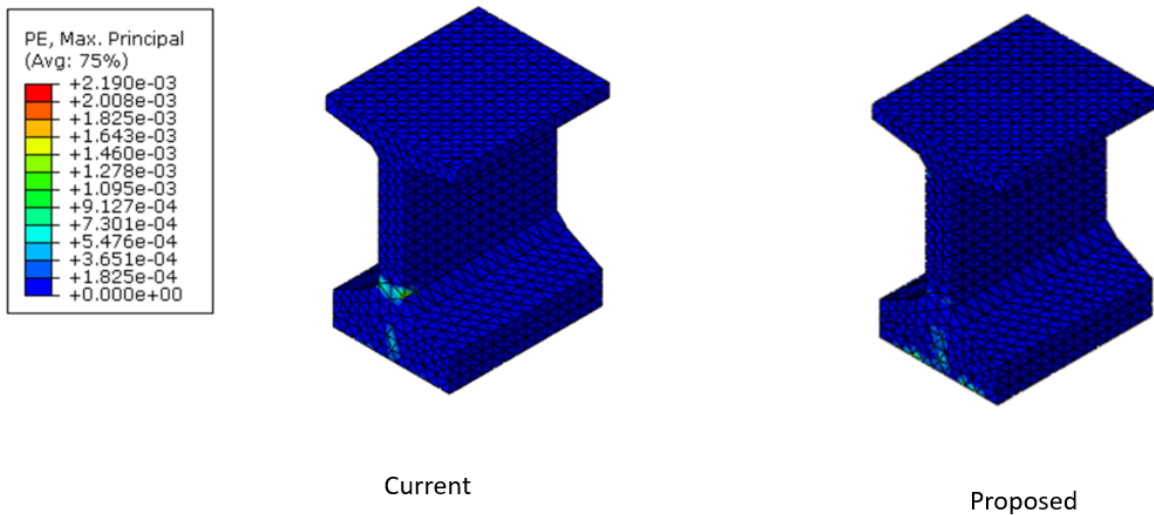
Current   Proposed

Figure 5.3 Principal Plastic strain contour for the current (Left) and Proposed (Right) case

Also, when an I-girder is placed in a bridge span, it is typically supported at 9 inches from the girder ends rather than at the girder ends as shown in Figure 5.4. As shown in Figure 5.4, the centerline of bearing is 9 inches from the girder end, and 5 inches of the girder from its end is outside of the bearing pad. The modified portion of the girder detailing is outside of the supports. Therefore, the prestress in vertical direction will not interfere with the design of the girder.
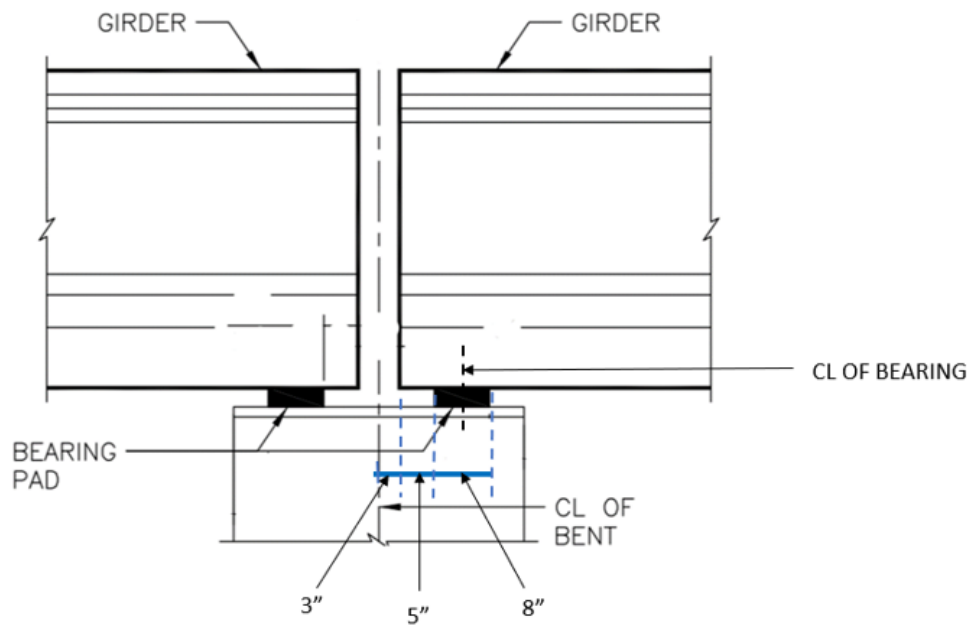
Figure 5.4 Typical I-girder support in a bridge

5.3 Fabrication of I-girder with proposed modifications

At the fabrication yard, this modification can be accomplished by holding down at the bottom of the vertical strand similar to that is done for harped strand near mid-span and pulling the strands vertically as shown in Figure 5.5.
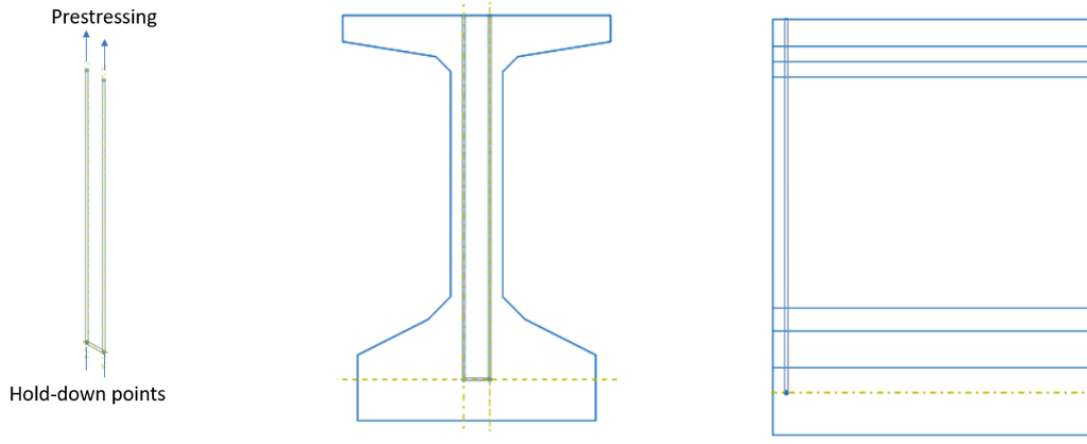
Figure 5.5 Prestressing vertical strand vertically

The prestress in the vertical strand can also be applied by pulling it horizontally with the help of pully system as shown in Figure 5.6. The hold-down points will remain same.
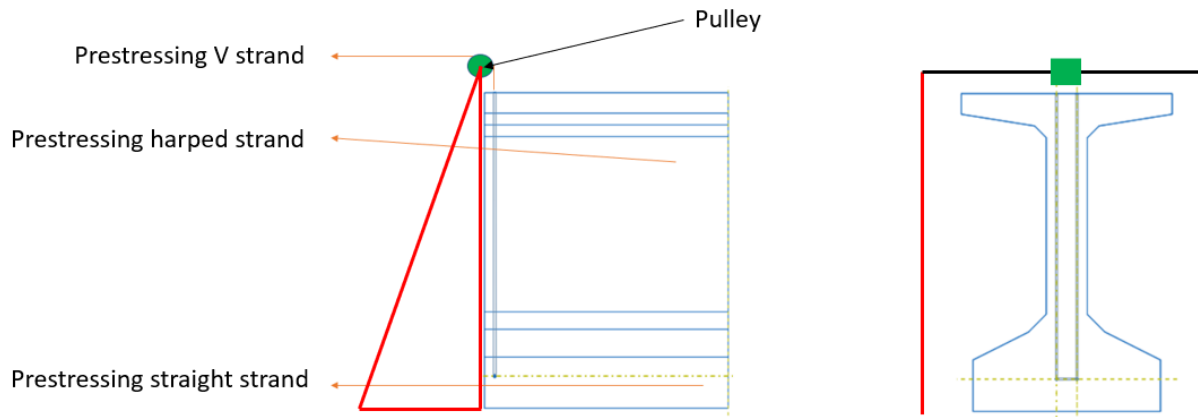
Figure 5.6 Prestressing vertical strand horizontally with pulley system

At the fabrication yard, sometimes more than one girder is fabricated in the production line if the design is identical. For those cases also, prestressing of vertical strand can be done by pulling in horizontal direction as shown in Figure 5.7.
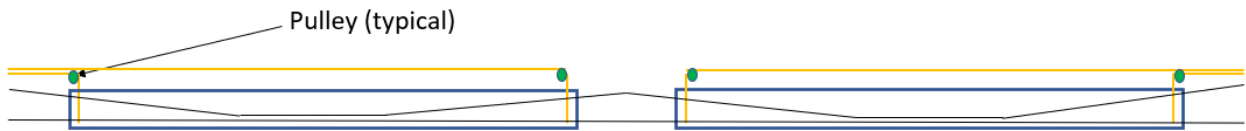
Figure 5.7 Prestressing vertical strand horizontally with pulley system for more than one girder

6. SENSITIVITY ANALYSIS AND NONLINEAR REGRESSION

Sensitivity analysis and nonlinear regression were done for V strand, U bar, C bar, CH bar, and R bar at girder ends. These bars are in I-girder web and bottom flange, which are the regions of cracks. Figure 6.1 shows V strand and bars that were analyzed for sensitivity.
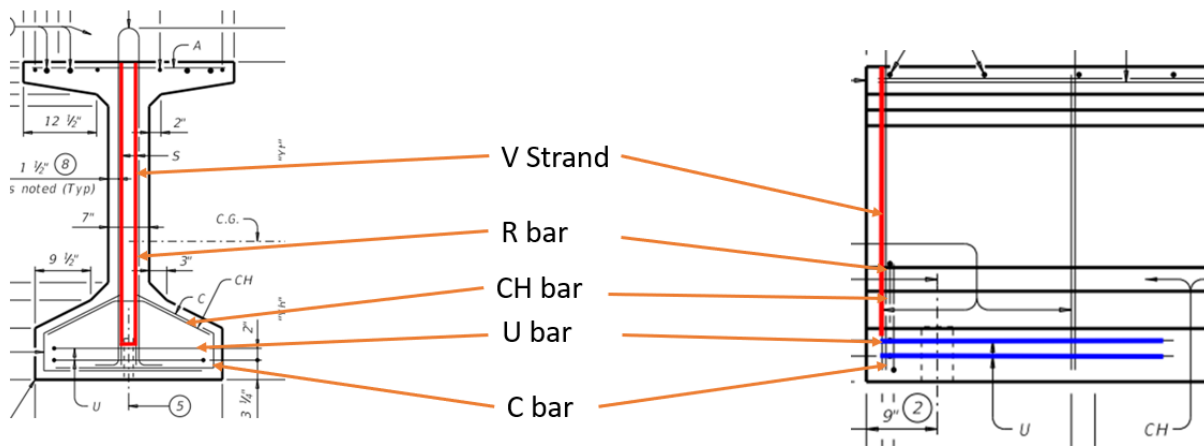
Figure 6.1 Variables of sensitivity analysis

6.1 Sensitivity of V strand

Sensitivity of V strand was done by changing its inclination to the horizontal, which is shown as angle Ө in Figure 6.2. M indicates Medium case when angle is 90 degree. L indicates Low case when angle is less than 90 degree. H indicates High case when angle is greater than 90 degree. For Low case, the strand was rotated by keeping the top of the strand point fixed. For High case, the strand was rotated by keeping the bottom of the strand location fixed. Slight rotation of the

vertical strand due to movement at top could occur during the placement of the strand or during pulling of the strand. The chance of rotation of the vertical strand due to movement at bottom is less as the bottom is hold-down point.
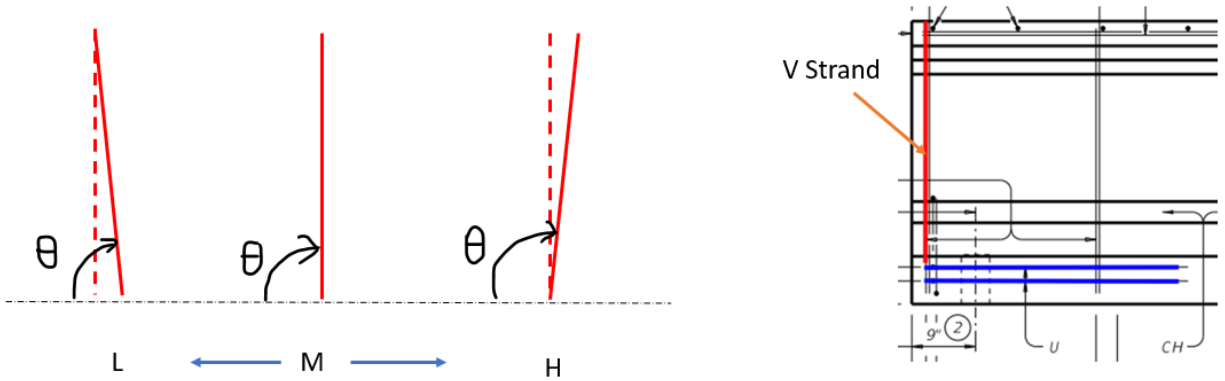
Figure 6.2 V strand variable for sensitivity analysis

One degree rotation causes about three quarter of an inch translation movement of the strand at one end. The sensitivity results are shown in Figures 6.3-6.5. As shown in Figure 6.5, the vertical strand is very sensitive for Low side rotation up to one degree rotation. Beyond one degree rotation, it makes negligible difference. Also, moving the top of the strand away from the girder end has very small effect. At I-girder ends, the cracks are near bottom flange area, and this makes the location of bottom of the strand more sensitive compared to the location of top of the strand.
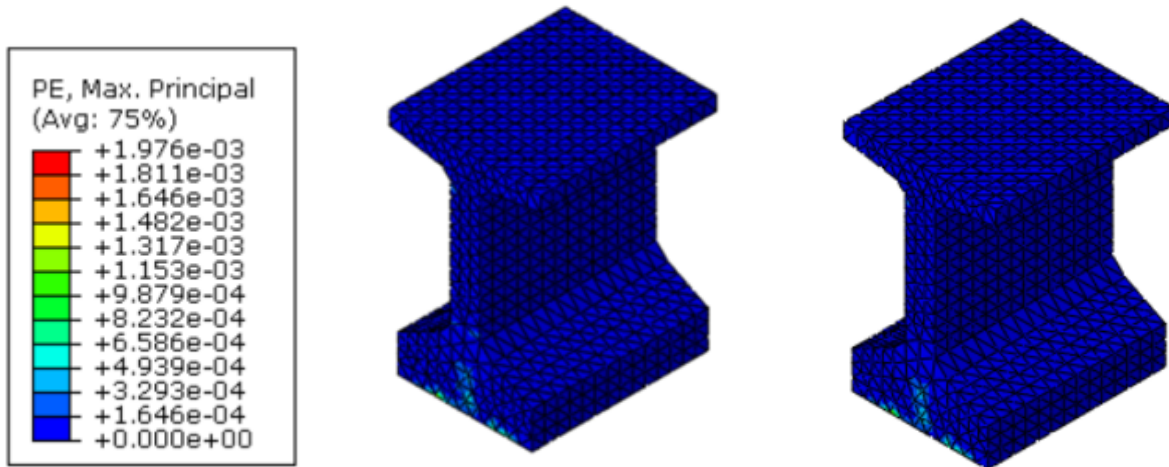
Figure 6.3 Plastic strain contour for Medium case (Left) and High case (Right)
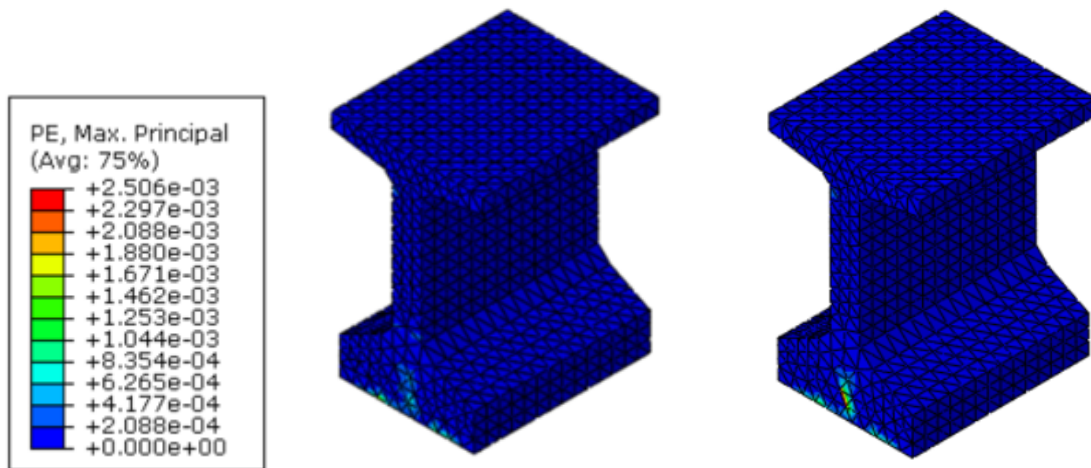
Figure 6.4 Plastic strain contour for Medium case (Left) and Low case (Right)
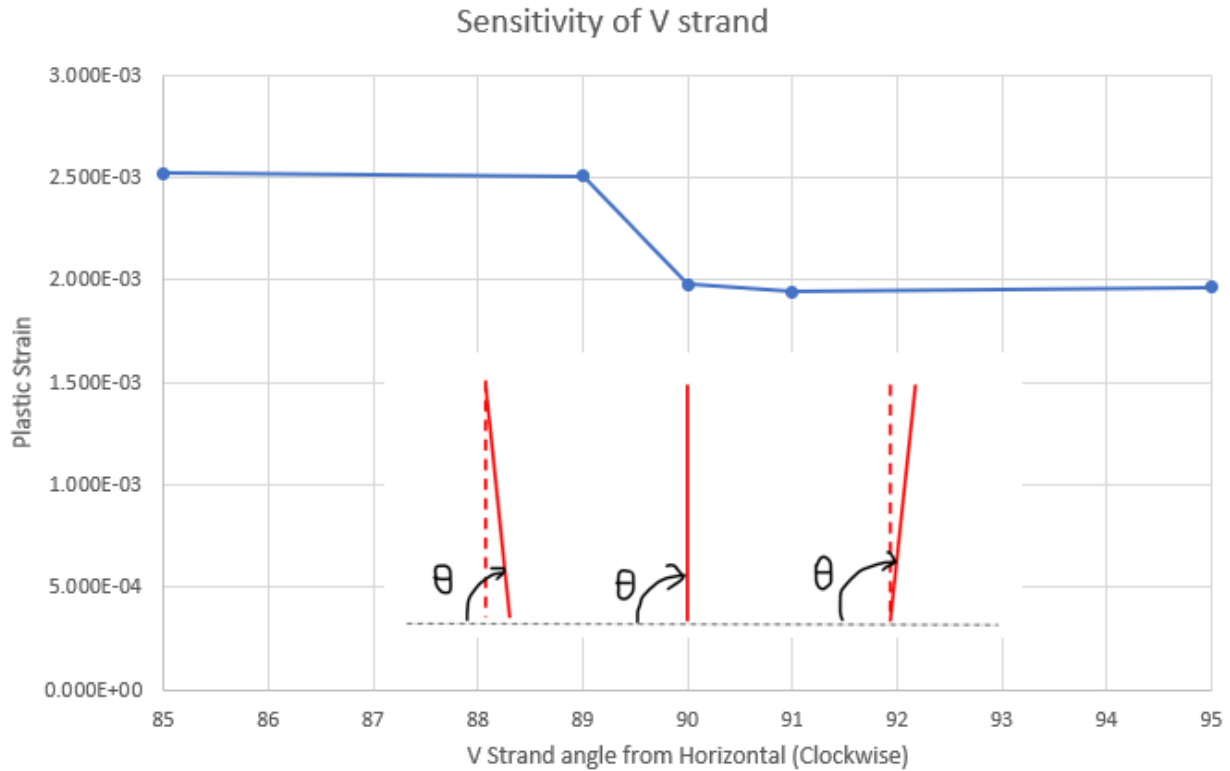
Figure 6.5 Sensitivity of V strand

6.2 Sensitivity of U bar

Sensitivity of U bar was done by changing the size of the bar. For Medium case, the size of the

bar is the size in current detailing practice, which is #5. For Low case, the size of the bar was #4,

which is one size less than the current size. For High case, the size of the bar was #6, which is

one size greater than the current size. The bar sizes for L, M and H are shown in Figure 6.8.
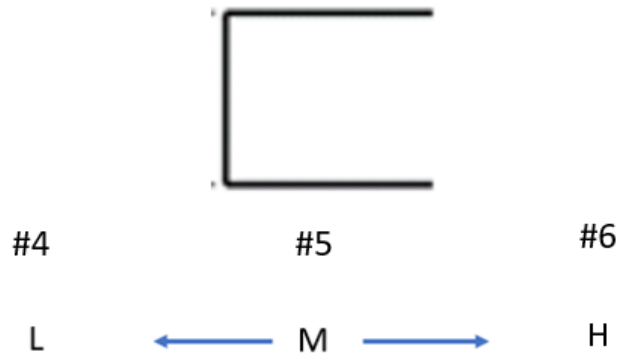
Figure 6.6 U bar variable for sensitivity analysis

The sensitivity results are shown in Figure 6.9-6.11. The results show that changing the bar size of U bar impacts end zone cracks. High case is slightly more sensitive than Low case.
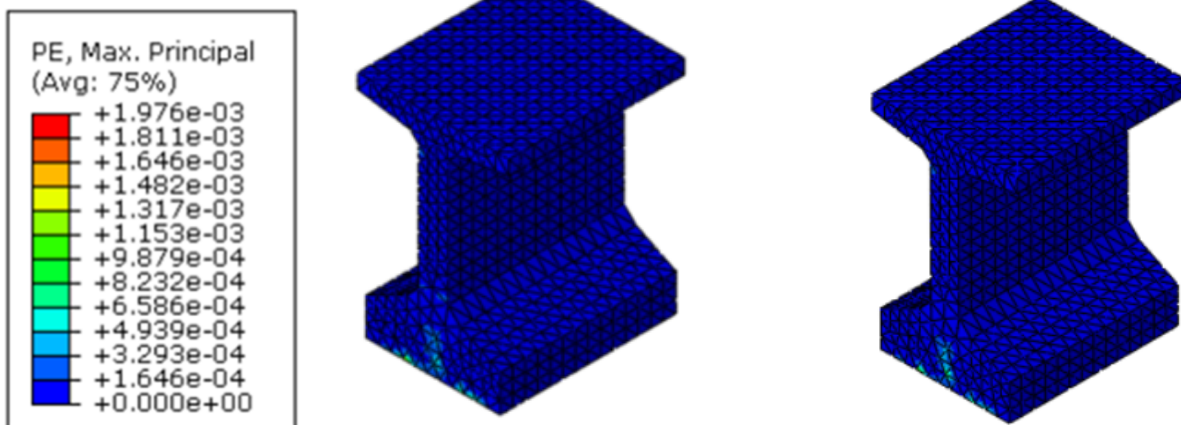
Figure 6.7 Plastic strain contour for Medium case (Left) and High case (Right)
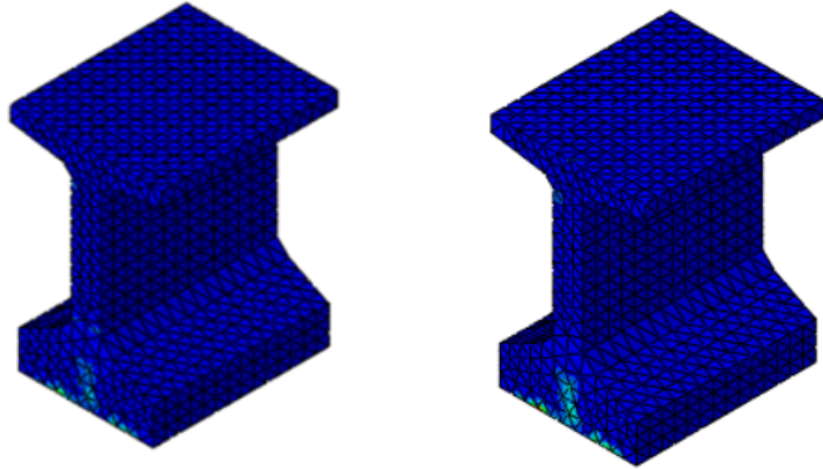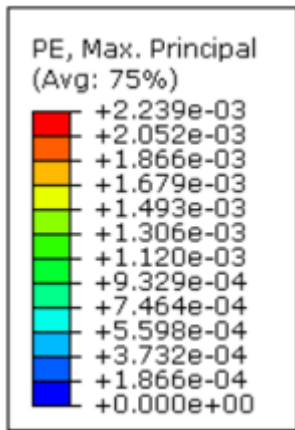
Figure 6.8 Plastic strain contour for Medium case (Left) and Low case (Right)
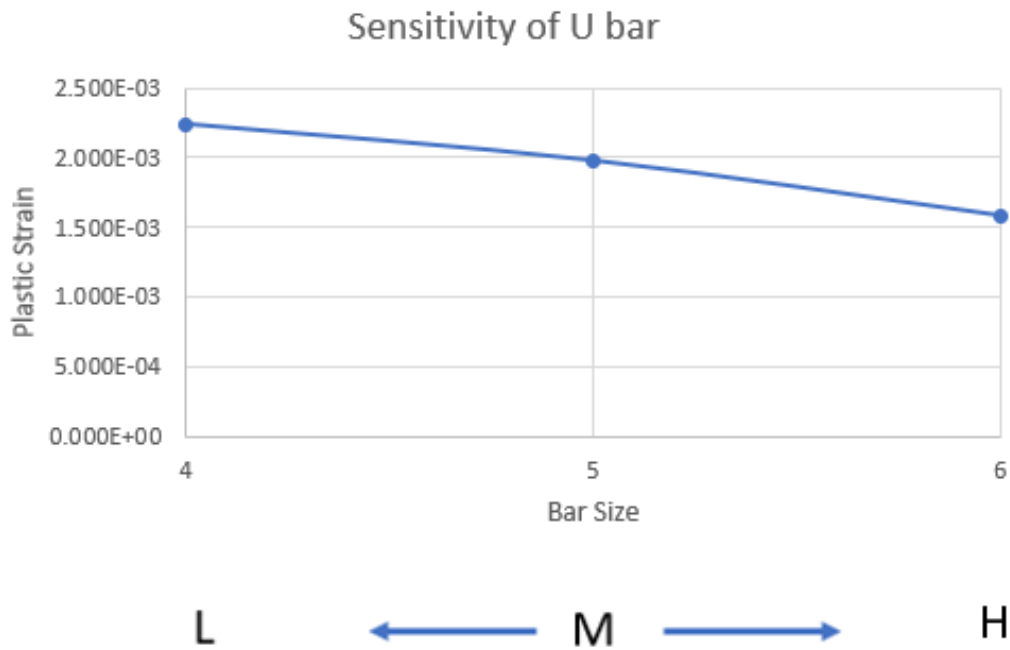
Figure 6.9 Sensitivity of U bar

6.3 Sensitivity of C bar

Sensitivity of C bar were done by changing the size of the bar. For Medium case, the size of the bar is the size in current detailing practice, which is #4. For Low case, the size of the bar was #3, which is one size less than the current size. For High case, the size of the bar was #5, which is one size greater than the current size. The bar sizes for L, M and H are shown in Figure 6.12.
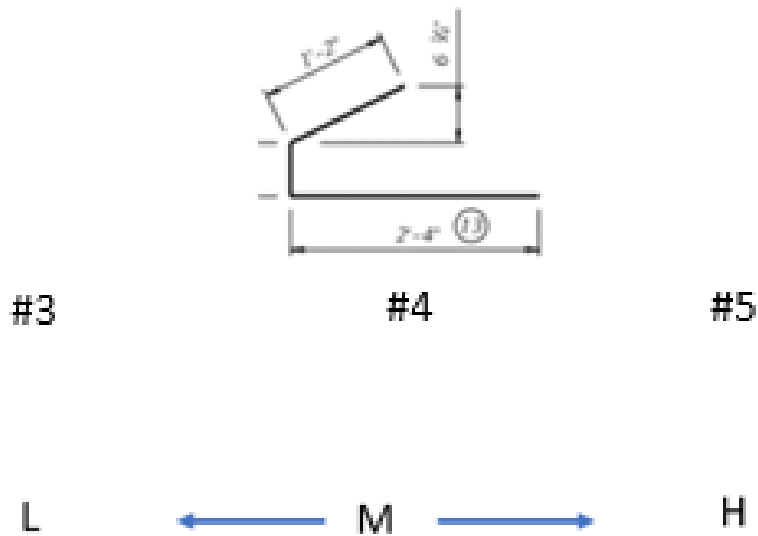
Figure 6.10 C bar variable for sensitivity analysis

The sensitivity results are shown in Figure 6.13-6.15. The results show that changing the bar size of C bar impacts end zone cracks. High case is slightly more sensitive than Low case.
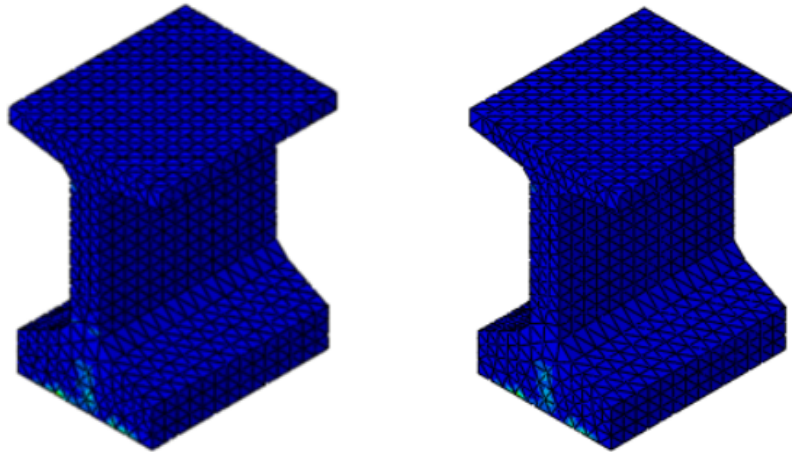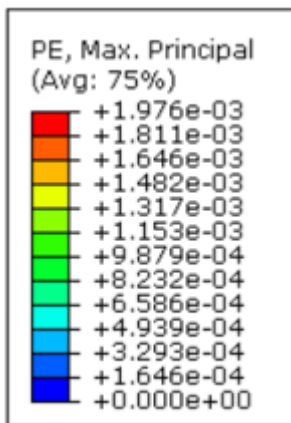
Figure 6.11 Plastic strain contour for Medium case (Left) and High case (Right)
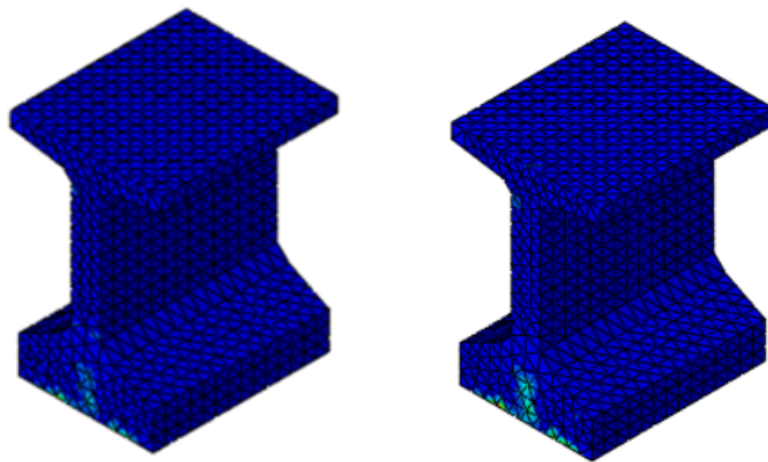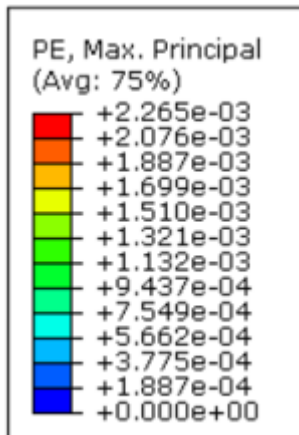
Figure 6.12 Plastic strain contour for Medium case (Left) and Low case (Right)
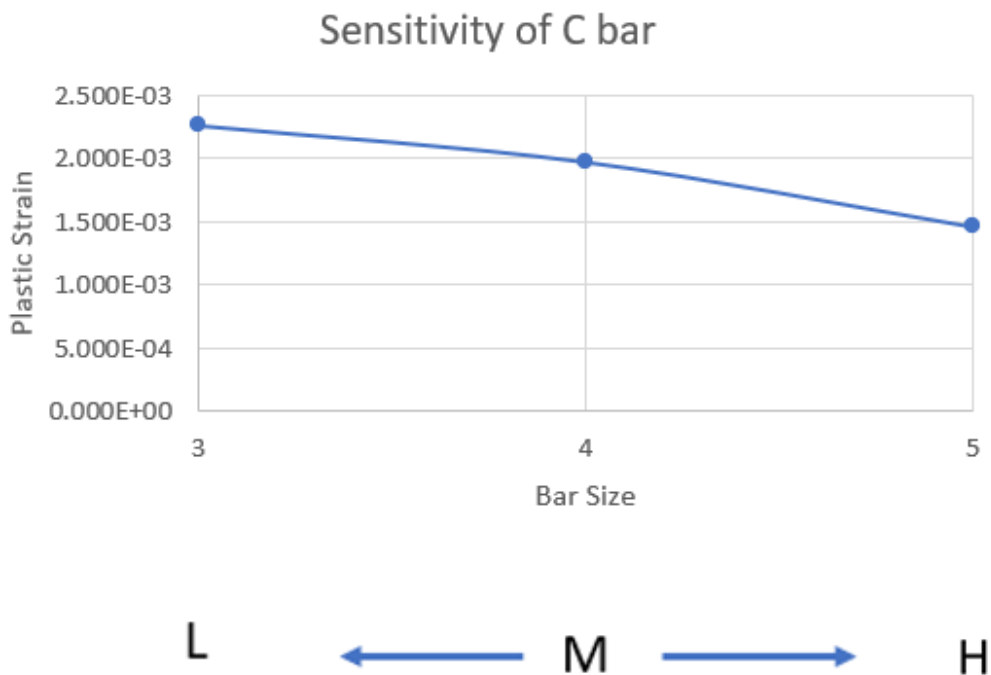
Figure 6.13 Sensitivity of C bar

6.4 Sensitivity of CH bar

Sensitivity of CH bar were done by changing the size of the bar. For Medium case, the size of the bar is the size in current detailing practice, which is #4. For Low case, the size of the bar was #3, which is one size less than the current size. For High case, the size of the bar was #5, which is one size greater than the current size. The bar sizes for L, M and H are shown in Figure 6.16.
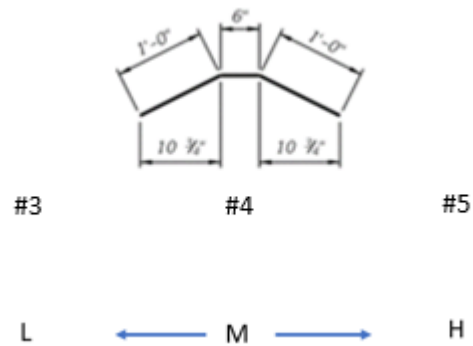
Figure 6.14 CH bar variable for sensitivity analysis

The sensitivity results is shown in Figures 6.17-6.19. The results show that changing the bar size of CH bar has negligible impacts on end zone cracks. Both High case sensitivity is similar to Low case sensitivity.
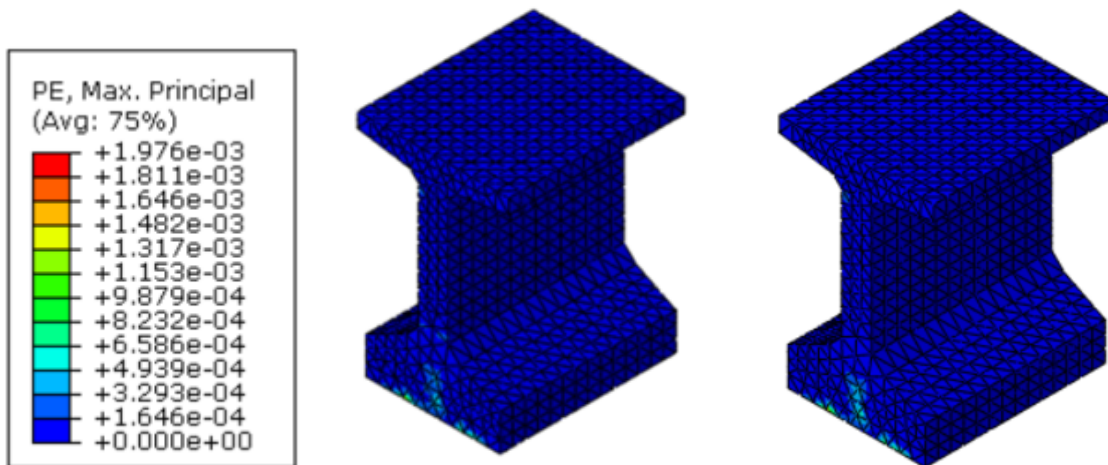
Figure 6.15 Plastic strain contour for Medium case (Left) and High case (Right)
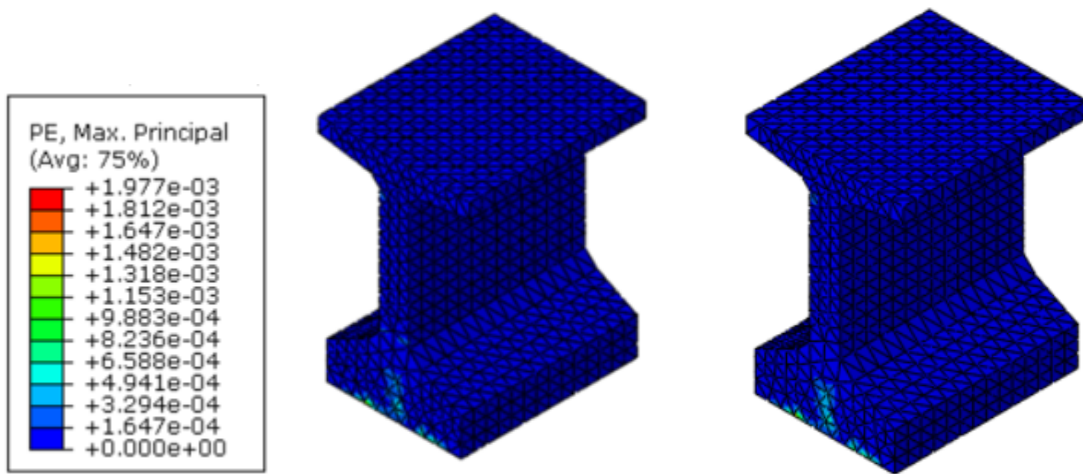
Figure 6.16 Plastic strain contour for Medium case (Left) and Low case (Right)
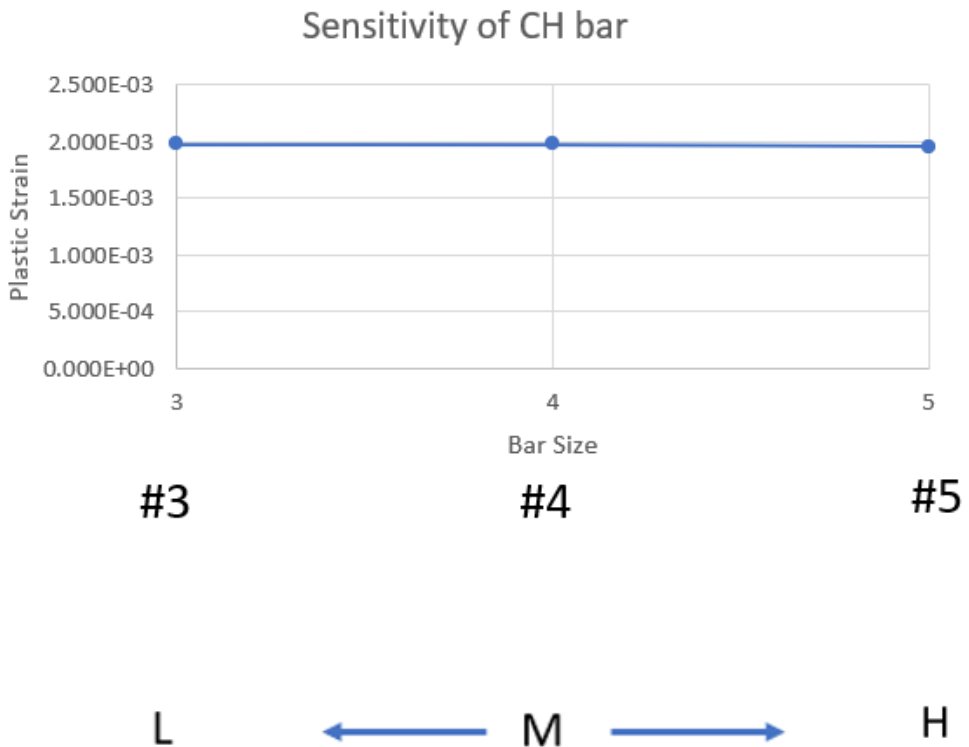
Figure 6.17 Sensitivity of CH bar

6.5 Sensitivity of R bar

Sensitivity of R bar was analyzed by changing the size of the bar. For Medium case, the size of the bar is the size in current detailing practice, which is #4. For Low case, the size of the bar was #3, which is one size less than the current size. For High case, the size of the bar was #5, which is one size greater than the current size. The bar sizes for L, M and H are shown in Figure 6.20.
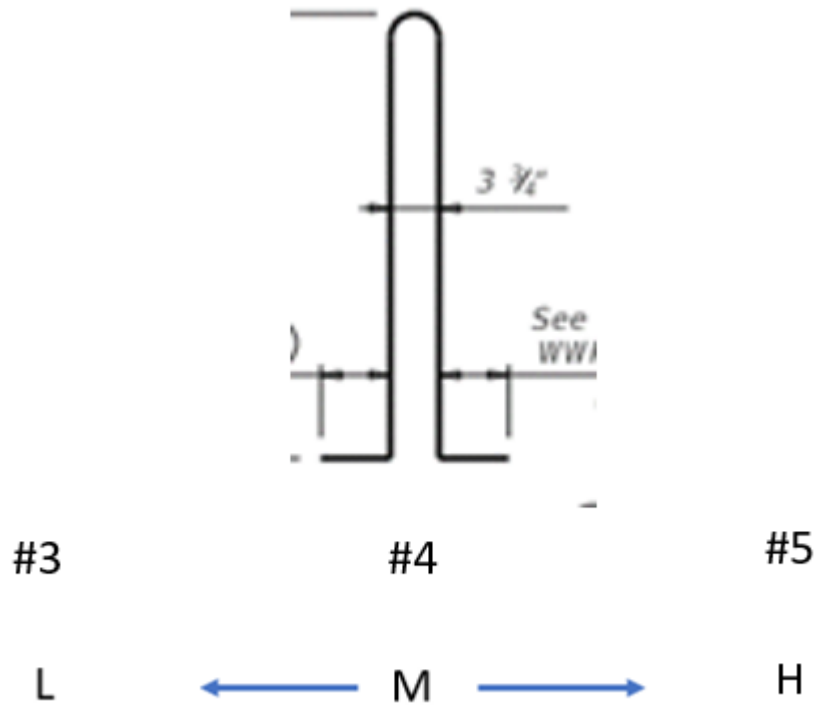
Figure 6.18 R bar variable for sensitivity analysis

The sensitivity results are shown in Figures 6.21-6.23. The results show that changing the bar size of R bar impacts end zone cracks. It can be seen that increasing the bar size of R bar significantly helps in minimization of cracks in the bottom flange.
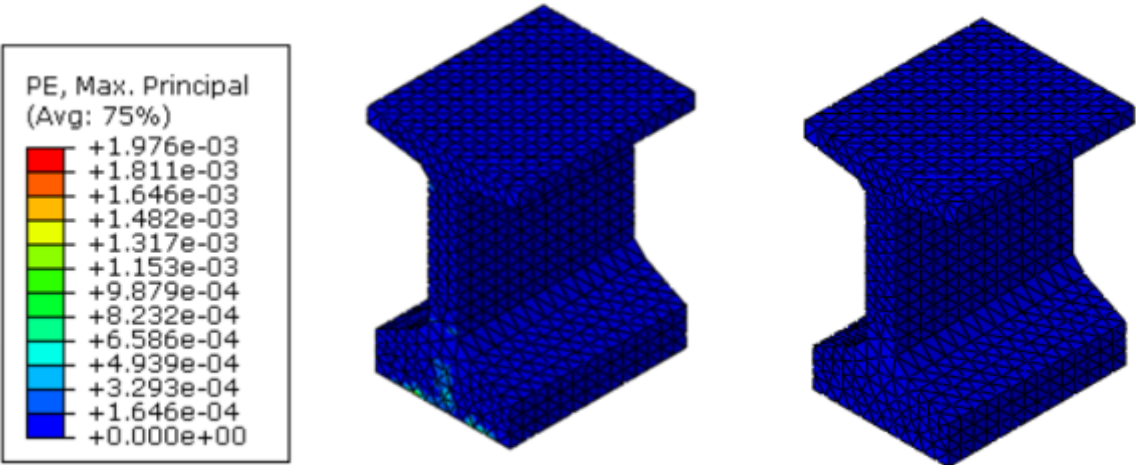
Figure 6.19 Plastic strain contour for Medium case (Left) and High case (Right)
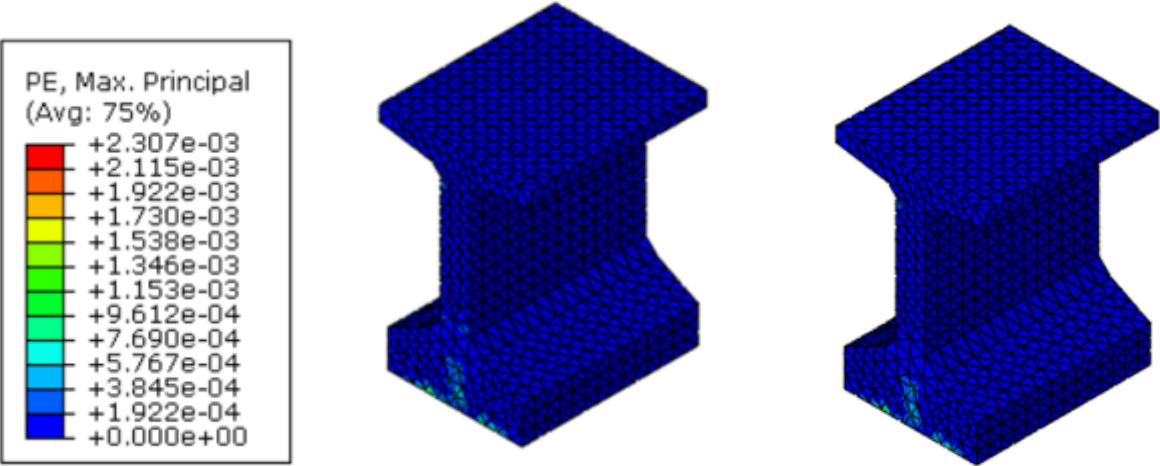
Figure 6.20 Plastic strain contour for Medium case (Left) and Low case (Right)

Sensitivity of R bar

Plastic Strain vs Bar Size
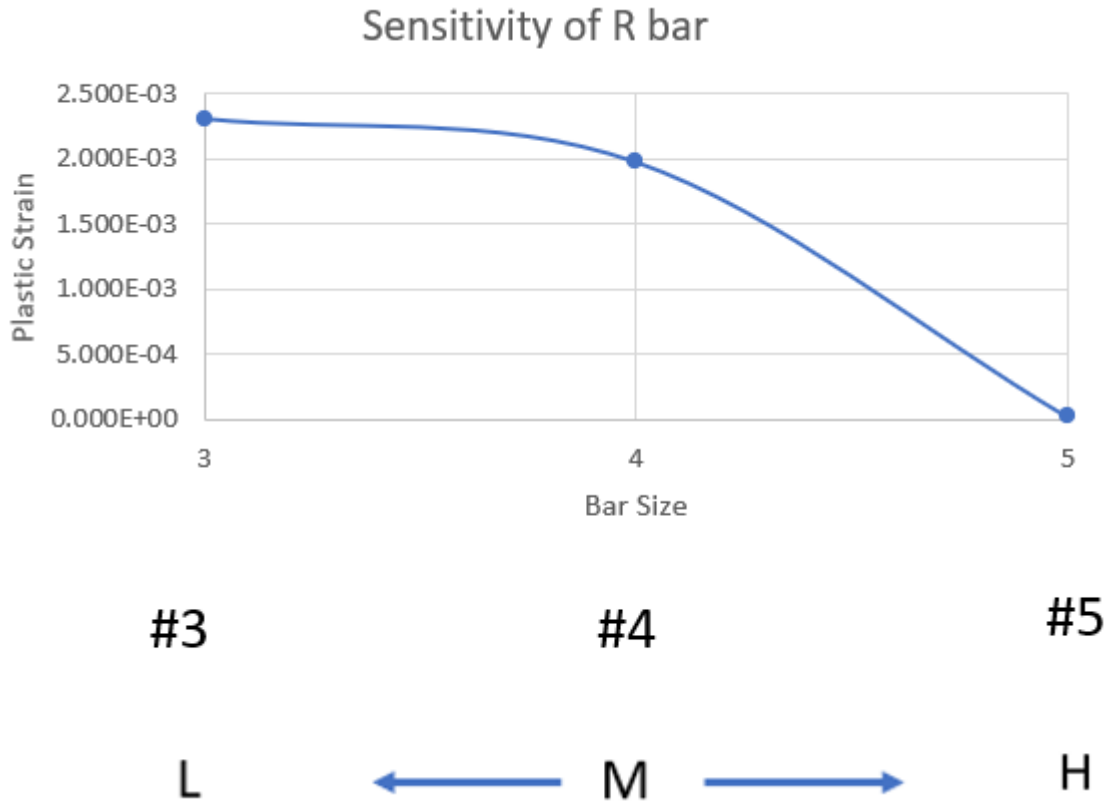
Figure 6.21 Sensitivity of R bar

6.6 Sensitivity comparison

Figure 6.24 shows plots of sensitivity of V strand, U bar, C bar, CH bar and R bar. The crack width in vertical axis is based on plastic strain and element size. It can be seen that V strand is more sensitive compared to others in Low case. This indicates bottom of V strand location is very important in minimizing cracks. In High case, R bar is more sensitive compared to others. Increasing R bar size significantly helps in further minimization of cracks mainly in bottom flange.
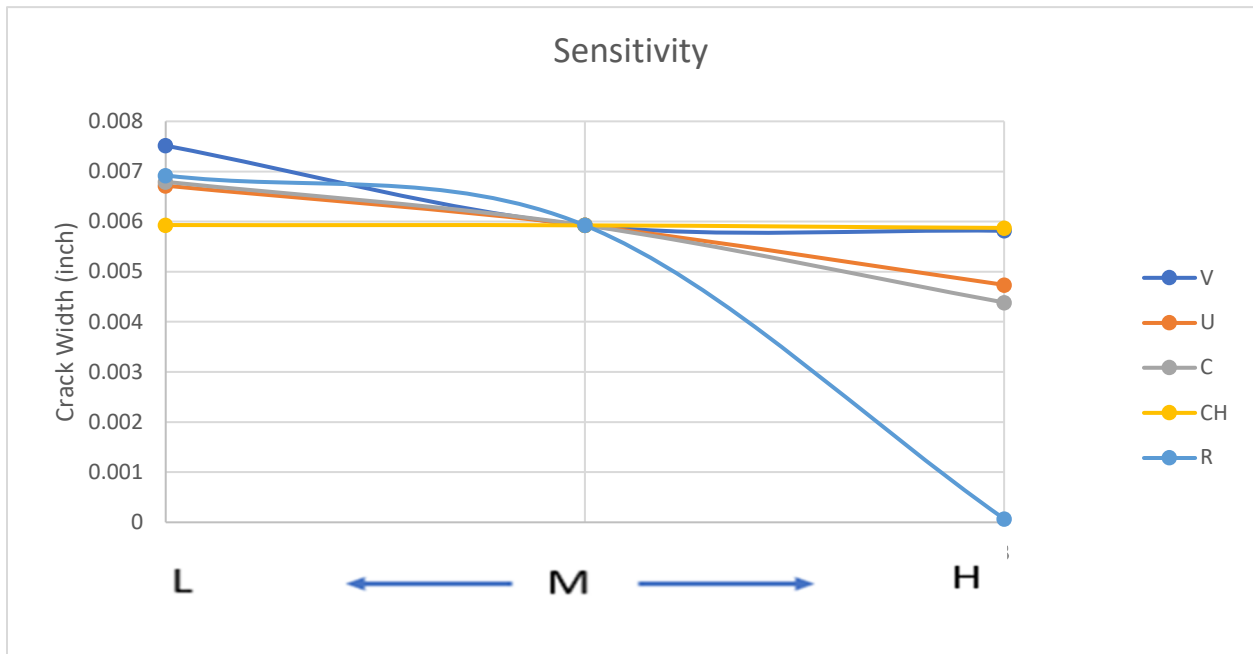
Figure 6.22 Sensitivity comparison

6.7 Nonlinear regression

The sensitivity analysis data has been presented in Table 6.1 by varying only one parameter at a time. The last column shows concrete crack width , and each row shows combination of the parameters value. In each row only one variable has been changed at a time. Vertical strand angle (V), U bar size (U), C bar size (C), CH bar size (CH) and R bar size (R) are independent variable, and concrete crack width (CRw) is dependent variable.

Table 6.1 Independent and dependent variables for regression analysis

V (Degree)	U (Bar Size)	C (Bar Size)	CH (Bar Size)	R (Bar Size)	CRw (Crack Width in inch)
90	5	4	4	4	0.006
89	5	4	4	4	0.008
91	5	4	4	4	0.006
90	4	4	4	4	0.007
90	6	4	4	4	0.005
90	5	3	4	4	0.007
90	5	5	4	4	0.004
90	5	4	3	4	0.006
90	5	4	5	4	0.006
90	5	4	4	3	0.007
90	5	4	4	5	0.0001

The relation between the dependent and independent variables are given by the nonlinear regression equation below.

$$CRw = K.V^{\alpha 1}\ U^{\alpha 2}\ C^{\alpha 3}\ CH^{\alpha 4} R^{\alpha 5}$$
<div align="right">Eq 6.1</div>

where α1, α2, α3, α4, α5 are sensitivity coefficients of V, U, C, CH and R respectively. K is a constant.

The following equation, Eq 6.2 is natural log Eq 6.1.

$$Ln(CRw) = Ln(K.V^{\alpha 1}\, U^{\alpha 2}\, C^{\alpha 3} CH^{\alpha 4}\, R^{\alpha 5})$$ Eq 6.2

$$= Ln(K) + Ln\,(V^{\alpha 1}) + Ln(\,U^{\alpha 2}) + Ln(\,C^{\alpha 3}) + Ln(\,CH^{\alpha 4}) + Ln(\,R^{\alpha 5})$$

$$= Ln(K) + \alpha 1. Ln\,(V) + \alpha 2. Ln\,(U) + \alpha 3. Ln\,(C) + \alpha 4. Ln\,(CH) + \alpha 5. Ln\,(R)$$

To determine the sensitivity coefficients α1, α2, α3, α4, α5 and the constant, Microsoft excel regression function was used. The data for the excel input is shown in Table 6.2 below. This is generated using data from Table 6.1 above with natural logarithm.

Table 6.2 Logarithmic independent and dependent variables for regression analysis

ln (V)	ln (U)	ln (C)	ln (CH)	ln (R)	ln (CRw)
4.500	1.609	1.386	1.386	1.386	-5.128
4.489	1.609	1.386	1.386	1.386	-4.890
4.511	1.609	1.386	1.386	1.386	-5.146
4.500	1.386	1.386	1.386	1.386	-5.003
4.500	1.792	1.386	1.386	1.386	-5.352
4.500	1.609	1.099	1.386	1.386	-4.992
4.500	1.609	1.609	1.386	1.386	-5.429
4.500	1.609	1.386	1.099	1.386	-5.128
4.500	1.609	1.386	1.609	1.386	-5.137
4.500	1.609	1.386	1.386	1.099	-4.973
4.500	1.609	1.386	1.386	1.609	-9.571

$$CRw = 9.3 \ x \ 10^{26}. V^{-11.8} \ U^{-1.0} C^{-1.0} CH^{-0.2} \ R^{-8.0} \hspace{4cm} \text{Eq 6.3}$$

$$CRw = K. V^{\alpha1} \ U^{\alpha2} \ C^{\alpha3} CH^{\alpha4} \ R^{\alpha5} \hspace{5cm} \text{Eq 6.4}$$

Where $\alpha1$= -11.8, $\alpha2$= -1.0, $\alpha3$= -1.0, $\alpha4$= -0.2, $\alpha4$= -8.0, K= $9.3 \ x \ 10^{26}$

If $\beta1$ = -$\alpha1$, $\beta2$ = -$\alpha2$, $\beta3$ = -$\alpha3$, $\beta4$ = -$\alpha4$ and $\beta5$ = -$\alpha5$

$$CRw = \frac{K}{V^{\beta1} \ U^{\beta2} \ C^{\beta3} CH^{\beta4} \ R^{\beta5}} \hspace{5cm} \text{Eq 6.5}$$

Where $\beta1$= 11.8, $\beta2$= 1.0, $\beta3$= 1.0, $\beta4$= 0.2, $\beta5$= 8.0, K= $9.3 \ x \ 10^{26}$

In the above equation, $\beta1$ has the maximum sensitivity value followed by $\beta5$. $\beta1$ is the sensitivity of vertical strand angle and $\beta5$ is the sensitivity of R bar.

7. SUMMARY

It is very common for I-girders to have end cracks at fabrication plant during prestressing. When there are more harped strands in an I-girder, there is more chances of having wider cracks at I-girder ends. Harped strands are required in I-girder to reduce the tension at top flange, and it is a part of I-girder design. When I-girder end cracks are wider, it can be rejected by a quality control personnel. As per the current TxDOT standard practice, if the cracks are wider than 0.005-inch, corrective action is required. Previous research has shown that increasing area of reinforcement will not make significant difference in controlling I-girder end cracks. Moreover, I-girder end region reinforcement bars in the current practice are already closely spaced. Therefore, in this research, a study to improve I-girder end crack control was done. The crack control study was performed using FEM approach.

In order to develop a FEM of a prestressed girder, design parameters of girder is required. A bridge of span 125.5ft span length with TX54 type Texas prestressed I-girder was designed. The economical length of TX54 girder is about 125ft. Since I-girder length is typically 6 inch less than bridge span length, the bridge span length was chosen to obtain whole number for the girder length. The designed girder has 0.6-inch low lax type 46 strands in which 8 of them are harped or draped. The strand has tensile strength of 270 ksi and initial applied prestress was 75% of tensile strength. The initial concrete strength (f'cm) was 6ksi, which is maximum allowable strength per TxDOT Bridge Design Manual.

The Tx54 girder was used for FEM modeling and analysis. Since this study was focused on analysis of girder end cracks due to prestress, only 3.5ft from the girder end was fine meshed. In the fine mesh region, tetrahedral elements of 3-inch mesh size were used. Tetrahedral elements are recommended by previous researchers for non-linear analysis. After that 1ft section of girder

was assigned transition mesh and remaining length of the girder was assigned coarse mesh. In the transition and coarse mesh region, hexahedral elements with 6-inch and 60-inch size respectively were used. A tie constraint was used between the fine and the transition interface, and between the transition and the coarse interface. Concrete plasticity damage was used for the material modeling. For concrete compression, the behavior was assumed to be linear up to the allowable limit for compression, which is 0.65 f'cm per TXDOT Bridge Design Manual. After the allowable limit, the behavior was assumed to be non-linear. The tensile cracking strength was assumed to be 0.24√(f'cm). the poisson's ratio was assumed to be 0.2 and modulus of elasticity was assumed to 120,000 $Wc^2f'cm^{0.33}$, where Wc is the unit weight of concrete.

The prestressing strand was modeled as 3D element with cross section equivalent to an area of 0.217 in^2, which is the area of a 0.6-inch low lax strand. The strands were modeled as embedded in I-girder to simulate bond between the strands and the concrete. The modulus of elasticity was assumed to be 28500 Ksi. The reinforcement bars were modeled as truss element and cross section properties were assigned based on bar size. The bars details were based on TXDOT standard detailing IGD sheet. TXDOT bars A, C, CH, R, S, T and U were modeled as embedded in the girder to simulate bond between the bars and the concrete. The modulus of elasticity was assumed to be 29000 Ksi.

Supports were assigned in FEM model at the ends of the girder at the bottom flange as knife-edge support. At the fine-meshed end, only translation degree of freedom in the vertical direction was restrained. At the other end, only translation degree of freedom was restrained in all three directions. Gravity load was applied to the model as 386.4 in/s^2 acceleration in a downward direction. The prestress in the strands were modeled by assigning initial stress, which is equal to strand stress before strands are released.

Cracks were observed at the end of the girder in web and bottom flange in FEM model. The type of cracks observed were similar to typical cracks seen in prestressed I-girder at fabrication yard after prestress. The cracks in web are caused by spalling stress and in bottom flange are caused by bursting stress.

To validate the FEM assumptions, another TX54 girder whose full-scale experimental data was available in the literature was modeled. This girder length was 110ft and strand type were 0.5-inch low lax strands, which has area of 0.153 in^2. The 3.5ft length of girder was assigned 3-inch mesh size with tetrahedral element. After that 1ft length was assigned 6-inch transition mesh with hexahedral elements and remaining length of the girder was assigned 60-inch coarse mesh with hexahedral element. All FEM assumptions including concrete material modeling, prestressing stand modeling, reinforcement bars modeling, support modeling, load modeling and prestress force modeling were identical to modeling technique explained in previous paragraphs. The FEM result of concrete strain was compared with the strain gauge value obtained from the full-scale experiment. The value obtained from FEM was slightly higher than experimental value with 12% margin.

After the validation of FEM assumptions, the designed TX54 FEM model was analyzed by making modification to the girder end detailing. When the first pair of S bars were replaced with a 0.6-inch low lax strand placed vertically, it significantly minimized the girder end cracks mainly in the girder web. This also helps to place the U bars closer to the girder end, which is better for crack control. In addition, when R bar size was changed from #4 to #5, it significantly minimized cracks in the bottom flange. The vertical strand can be pulled horizontally in the fabrication yard by using pulley system, which has been explained in this paper. Also, when girders have identical design, they are usually fabricated in the same production line. In this

paper, fabrication of multiple girders by using the vertical strand has also been explained. When I-girder is placed on bents of a bridge, the end 5 inch of girder are usually outside of bearing pad or supports. In other words, the proposed modification falls outside the supports when it is under service. Therefore, it doesn't interfere with the design of girder. This will make implementation of the proposed modification easier.

In addition, a sensitivity analysis and nonlinear regression were done for elements in web and bottom flange, which are regions of cracks. Sensitivity analysis of vertical strand, U bar, C bar, CH bar and R bar were done. For vertical strand, sensitivity of its angle from horizontal was analyzed, and for the reinforcement bars sensitivity of bar size was analyzed. The results showed that the location of bottom of strand is very sensitive for crack control because moving the bottom of the strand away from girder end by keeping the top of strand fixed makes girder end cracks worse. But, when top of the strand was moved away from girder end by keeping the bottom of strand fixed, it makes negligible difference. This is because the end cracks in I-girder are near bottom of girder. Also, sensitivity analysis of R bar showed that increasing the bar size helps in significantly minimizing the cracks in I-girder bottom flange. Bars U, C and CH are less sensitive compared to other parameters. The angle of vertical strand and the bars size were independent variable and concrete plastic strain was dependent variable. Only one independent variable was changed at a time for the sensitivity analysis. A nonlinear regression equation was developed based on the sensitivity analysis.

8. CONCLUSION

8.1 Conclusion

The following conclusions were drawn from this study.

- A bridge span with TX54 girders, which is a Texas prestressed I-girder, was designed using straight and harped strands.

- A nonlinear finite element model (FEM) of the TX54 girder was successfully created by modeling concrete girder, prestressing strands and girder end zone reinforcement bars.

- In the FEM model, typical cracks induced due to prestress were observed at the I-girder end.

- Another TX54 girder FEM model whose experimental data was available in the literature was created using identical FEM assumptions. The FEM and experimental results were compared, and the difference was about 12%.

- The end zone reinforcements were modified by replacing first pair of S bars with a 0.6-inch low lax vertical strand and moving U bars closer to the girder end. This modification significantly minimizes girder end cracks mainly in girder web. Furthermore, if size of R bar is increased from #4 size to #5 size, it helps in further minimization of cracks mainly in bottom flange.

- A sensitivity study was conducted by varying vertical angle of the vertical strand and size of reinforcement bars.

- The girder end cracks were very sensitive when angle of vertical strand is changed by moving the bottom of the strand location away from the girder end. It increased the cracks because girder end cracks are closer to bottom of girder and having bottom of

strand closer to girder end helps in controlling the cracks. However, when the angle was change by moving the top of the strand away from the girder end, it had negligible effect on the girder end cracks. This is because there are no cracks near top of girder.

- The girder end cracks were sensitive when U bar size was changed. The end cracks increased when the bar size was decreased, and the cracks decreased when the bar size increased.

- The girder end cracks were sensitive when C bar size was changed. The end cracks increased when the bar size was decreased, and the cracks decreased when the bar size increased.

- The girder end cracks were not sensitive when CH bar size was changed. When CH bar size was decreased or increased, it had negligible effect on the girder end crack.

- The girder end cracks were sensitive when R bar size was decreased. It increased the cracks. The girder end cracks were very sensitive when R bar size was increased. It significantly decreased the end cracks mainly in bottom flange.

- A non-linear regression equation for girder end crack was developed based on the variable parameters of the sensitivity study. The regression equation has girder end crack or plastic strain as dependent variable, and strand vertical angle, size of bars U, C, CH and R as independent variables. The independent variable with higher power coefficient in the equation indicates more sensitivity and lower power coefficient indicates less sensitivity.

- The power coefficient in the regression equation was found to be 11.8, 1.0, 1.0, 0.2 and 8.0 for vertical strand angle, U bar size, C bar size, CH bar size and R bar size

respectively. This indicates the stand angle is most sensitivity and CH bar is least sensitive for the girder end cracks.

- The proposed modification, which are replacing first pair of S bars with a 0.6-inch prestressing strand, moving U bars closer to girder end and increasing R bar size, can be applied when wider cracks are observed in I-girder end at the fabrication plant to bring the cracks within acceptable limit.

- Horizontal pulling of vertical stand can be done using pulley system and it has been explained in this paper. It is also explained for a case when more than one girder are fabricated in production line for identical design cases.

- Since the proposed modification eliminates risk of wider end cracks, it could save girder repair cost due to sealant or grout injection.

- In the current practice, if the cracks are wider than 0.005-inch, corrective action is required. The proposed modification can be applied brig the cracks within acceptable limit. Moreover, the proposed modification doesn't impact girder design and will be easy to implement it.

- In the current practice, girder with wider end cracks may be rejected by quality personnel. If the proposed modification is implemented, it will reduce waste of girders as the proposed modification significantly minimizes the cracks.

- If the proposed modification is implemented, more harped can be used in a girder design as end cracks will be significantly less. Since harped strands are required in I-girder to reduce the tension in top flange, allowing to use more harped strands will increase total number of strands in an I-girder. When total number of strands are more at mid span, it

can take more loads and consequently span length can be increased. Consequently, shallower girder can be used where vertical clearance is tight at roadway under a bridge.

- Higher girder capacity due to increased number of strands can allow to increase span length and may help eliminate number of bents or intermediate support of bridge. This could help in cost saving for bridge design.

- Higher girder capacity due to increased number of strands can allow to increase spacing between girders and may help use less number of girders. This could help in cost saving for bridge design.

- In the future, if strands with higher allowable stress are used, the proposed modification will be very helpful to control I-girder end cracks as strands with higher allowable stress will have higher prestress force at girder end.

Hence, this study presented a better crack control method for prestressed I-girder end without impacting the design of girder. The proposed modification falls outside the supports of girder when a girder is placed on bridge bents or abutments. The proposed modification will be easy to implement. This research will have broader impact as it not only eliminates risk of rejection of girder by minimizing I-girder end cracks significantly, but also will save cost of bridge design by allowing use of more harped strands in I-girder.

8.2 Future recommendations

It is recommended to implement the proposed modification in prestressed I-girder as it provides better crack control at I-girder end.

APPENDIX A. I-GIRDER DESIGN REPORT

Bridge Geometry Report

August 13, 2022 5:03:39 pm

PGSuper™ (x64)

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Version 6.1.0 - Built on May 12 2021

**Washington State
Department of Transportation**

Texas
Department
of Transportation

Project Properties

Bridge Name	
Bridge ID	
Company	
Engineer	
Job Number	
Comments	
File	D:\PHD work\Research papers\TX54\PG super(Tx54)-1.pgs

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Configuration

Configuration Server: TxDOT
Configuration Name: TxDOT
Configuration Source: ftp://ftp.dot.state.tx.us/pub/txdot-info/brg/pgsuper/version_6.1.0/txdot.pgz
Configuration Date Stamp: January 6, 2021 3:35:03 pm

Library	Entry	Source
Girders		Project Library
Traffic Barriers	SSTR	Master Library
Project Criteria	TxDOT 2017 based on AASHTO LRFD Bridge Design Specification, 8th Edition 2017	Master Library
Load Rating Criteria	Default based on The Manual for Bridge Evaluation, First Edition 2008, with 2010 interim provisions	Project Library
Haul Trucks	Old Haul Truck -0	Project Library

Analysis Controls

Structural Analysis Method: Simple Span
Section Properties: Gross
Losses: Refined estimate per TxDOT Research Report 0-6374-2

Notes

Symbol	Definition
L_r	Span Length of Girder at Release
L_l	Span Length of Girder during Lifting
L_{st}	Span Length of Girder during Storage
L_h	Span Length of Girder during Hauling
L_e	Span Length of Girder after Erection
L_s	Length of Span
Debond	Point where bond begins for a debonded strand
PSXFR	Point of prestress transfer
FoS	Face of Support in final bridge configuration
ST	Section Transitions
STLF	Section Transitions, Left Face
STRF	Section Transitions, Right Face
SDCR	Start of Deck Casting Region
EDCR	End of Deck Casting Region
Diaphragm	Location of a precast or cast in place diaphragm
Bar Cutoff	End of a reinforcing bar in the girder
Deck Bar Cutoff	End of a reinforcing bar in the deck
CS	Critical Section for Shear
SZB	Stirrup Zone Boundary
H	H from end of girder or face of support
1.5H	1.5H from end of girder or face of support
HP	Harp Point
Pick Point	Support point where girder is lifted from form
Bunk Point	Point where girder is supported during transportation

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Bridge: Job: 8/13/2022

Alignment

Alignment Details
Direction: N 90° 00' 00.00" E
Ref. Point: 0+00.00 (E (X) 0.000, N (Y) 0.000)

Profile Details
Station: 0+00.00
Elevation: 0.000 ft
Grade: 0%

Roadway Cross Sections
Each Roadway Cross Section Template contains 2 segments per section.
Ridge Point #1 is the controlling ridge point. It defines the slope sign convention and coincides with the horizontal alignment, profile grade, and superelevation pivot location.

Template	Station	Segment 1 Slope (ft/ft)	Segment 2 Slope (ft/ft)
1	0+00.00	0	0

Roadway Elevations

Deck Elevations over Girder Webs
Web Offset is measured from and normal to the centerline girder at top of girder
Station, Offset, and Elev are given for 10th points between bearings along the girder webs

Span 1

Girder	Web		CL Brg	0.1L$_s$	0.2L$_s$	0.3L$_s$	0.4L$_s$	0.5L$_s$	0.6L$_s$	0.7L$_s$	0.8L$_s$	0.9L$_s$	CL Brg
1	1	Web Offset (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Station	100+01.00	100+13.35	100+25.70	100+38.05	100+50.40	100+62.75	100+75.10	100+87.45	100+99.80	101+12.15	101+24.50
		Offset (ft)	20.000 L	20.000 L	20.000 L	20.000 L	20.000 L	20.000 L	20.000 L	20.000 L	20.000 L	20.000 L	20.000 L
		Elev (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	1	Web Offset (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Station	100+01.00	100+13.35	100+25.70	100+38.05	100+50.40	100+62.75	100+75.10	100+87.45	100+99.80	101+12.15	101+24.50
		Offset (ft)	12.000 L	12.000 L	12.000 L	12.000 L	12.000 L	12.000 L	12.000 L	12.000 L	12.000 L	12.000 L	12.000 L
		Elev (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	1	Web Offset (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Station	100+01.00	100+13.35	100+25.70	100+38.05	100+50.40	100+62.75	100+75.10	100+87.45	100+99.80	101+12.15	101+24.50
		Offset (ft)	4.000 L	4.000 L	4.000 L	4.000 L	4.000 L	4.000 L	4.000 L	4.000 L	4.000 L	4.000 L	4.000 L
		Elev (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	1	Web Offset (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Station	100+01.00	100+13.35	100+25.70	100+38.05	100+50.40	100+62.75	100+75.10	100+87.45	100+99.80	101+12.15	101+24.50
		Offset (ft)	4.000 R	4.000 R	4.000 R	4.000 R	4.000 R	4.000 R	4.000 R	4.000 R	4.000 R	4.000 R	4.000 R
		Elev (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	1	Web Offset (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Station	100+01.00	100+13.35	100+25.70	100+38.05	100+50.40	100+62.75	100+75.10	100+87.45	100+99.80	101+12.15	101+24.50
		Offset (ft)	12.000 R	12.000 R	12.000 R	12.000 R	12.000 R	12.000 R	12.000 R	12.000 R	12.000 R	12.000 R	12.000 R
		Elev (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	1	Web Offset (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		Station	100+01.00	100+13.35	100+25.70	100+38.05	100+50.40	100+62.75	100+75.10	100+87.45	100+99.80	101+12.15	101+24.50
		Offset (ft)	20.000 R	20.000 R	20.000 R	20.000 R	20.000 R	20.000 R	20.000 R	20.000 R	20.000 R	20.000 R	20.000 R
		Elev (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Pier Geometry

Pier Layout

	Station	Bearing	Skew Angle	Alignment Intersection East (X)	North (Y)	Elev (ft)
Abutment 1	100+00.00	N 0° 00' 00.00" E	0° 00' 00.00" L	10000.000	0.000	0.000
Abutment 2	101+25.50	N 0° 00' 00.00" E	0° 00' 00.00" L	10125.500	0.000	0.000

Girder Geometry

Girder Points
Girder points are measured at top CL of girders.

Span 1

Girder	Start of Girder Abutment Line East (X)	North (Y)	Deck Elev (ft)	Girder End East (X)	North (Y)	Deck Elev (ft)	CL Bearing East (X)	North (Y)	Deck Elev (ft)	End of Girder CL Bearing East (X)	North (Y)	Deck Elev (ft)	Girder End East (X)	North (Y)	Deck Elev (ft)	Abutment Line East (X)	North (Y)	Deck Elev (ft)
1	10000.000	20.000	0.000	10000.250	20.000	0.000	10001.000	20.000	0.000	10124.500	20.000	0.000	10125.250	20.000	0.000	10125.500	20.000	0.000
2	10000.000	12.000	0.000	10000.250	12.000	0.000	10001.000	12.000	0.000	10124.500	12.000	0.000	10125.250	12.000	0.000	10125.500	12.000	0.000
3	10000.000	4.000	0.000	10000.250	4.000	0.000	10001.000	4.000	0.000	10124.500	4.000	0.000	10125.250	4.000	0.000	10125.500	4.000	0.000
4	10000.000	-4.000	0.000	10000.250	-4.000	0.000	10001.000	-4.000	0.000	10124.500	-4.000	0.000	10125.250	-4.000	0.000	10125.500	-4.000	0.000

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Girder	Start of Girder									End of Girder								
	Abutment Line			Girder End			CL Bearing			CL Bearing			Girder End			Abutment Line		
	East (X)	North (Y)	Deck Elev (ft)	East (X)	North (Y)	Deck Elev (ft)	East (X)	North (Y)	Deck Elev (ft)	East (X)	North (Y)	Deck Elev (ft)	East (X)	North (Y)	Deck Elev (ft)	East (X)	North (Y)	Deck Elev (ft)
5	10000.000	-12.000	0.000	10000.250	-12.000	0.000	10001.000	-12.000	0.000	10124.500	-12.000	0.000	10125.250	-12.000	0.000	10125.500	-12.000	0.000
6	10000.000	-20.000	0.000	10000.250	-20.000	0.000	10001.000	-20.000	0.000	10124.500	-20.000	0.000	10125.250	-20.000	0.000	10125.500	-20.000	0.000

Girder Offsets

Offsets are measured at top CL of girders.

Span 1

Girder	Start of Girder									End of Girder								
	Abutment Line			Girder End			CL Bearing			CL Bearing			Girder End			Abutment Line		
	Station	Offset (ft)	Deck Elev (ft)	Station	Offset (ft)	Deck Elev (ft)	Station	Offset (ft)	Deck Elev (ft)	Station	Offset (ft)	Deck Elev (ft)	Station	Offset (ft)	Deck Elev (ft)	Station	Offset (ft)	Deck Elev (ft)
1	100+00.00	20.000 L	0.000	100+00.25	20.000 L	0.000	100+01.00	20.000 L	0.000	101+24.50	20.000 L	0.000	101+25.25	20.000 L	0.000	101+25.50	20.000 L	0.000
2	100+00.00	12.000 L	0.000	100+00.25	12.000 L	0.000	100+01.00	12.000 L	0.000	101+24.50	12.000 L	0.000	101+25.25	12.000 L	0.000	101+25.50	12.000 L	0.000
3	100+00.00	4.000 L	0.000	100+00.25	4.000 L	0.000	100+01.00	4.000 L	0.000	101+24.50	4.000 L	0.000	101+25.25	4.000 L	0.000	101+25.50	4.000 L	0.000
4	100+00.00	4.000 R	0.000	100+00.25	4.000 R	0.000	100+01.00	4.000 R	0.000	101+24.50	4.000 R	0.000	101+25.25	4.000 R	0.000	101+25.50	4.000 R	0.000
5	100+00.00	12.000 R	0.000	100+00.25	12.000 R	0.000	100+01.00	12.000 R	0.000	101+24.50	12.000 R	0.000	101+25.25	12.000 R	0.000	101+25.50	12.000 R	0.000
6	100+00.00	20.000 R	0.000	100+00.25	20.000 R	0.000	100+01.00	20.000 R	0.000	101+24.50	20.000 R	0.000	101+25.25	20.000 R	0.000	101+25.50	20.000 R	0.000

Girder Spacing

Girder spacing is measured at top CL of girders.

Span 1

Girder	Start of Girder				Angle with CL Pier	End of Girder				Angle with CL Pier
	Spacing at CL Pier		Spacing at CL Brg			Spacing at CL Brg		Spacing at CL Pier		
	⊥ to Alignment (ft)	Along CL Pier (ft)	⊥ to Alignment (ft)	Along CL Brg (ft)		⊥ to Alignment (ft)	Along CL Brg (ft)	⊥ to Alignment (ft)	Along CL Pier (ft)	
1					90° 00' 00.00"					90° 00' 00.00"
	8.000	8.000	8.000	8.000		8.000	8.000	8.000	8.000	
2					90° 00' 00.00"					90° 00' 00.00"
	8.000	8.000	8.000	8.000		8.000	8.000	8.000	8.000	
3					90° 00' 00.00"					90° 00' 00.00"
	8.000	8.000	8.000	8.000		8.000	8.000	8.000	8.000	
4					90° 00' 00.00"					90° 00' 00.00"
	8.000	8.000	8.000	8.000		8.000	8.000	8.000	8.000	
5					90° 00' 00.00"					90° 00' 00.00"
	8.000	8.000	8.000	8.000		8.000	8.000	8.000	8.000	
6					90° 00' 00.00"					90° 00' 00.00"

⊥ to Alignment: spacing is measured along a line that is normal to the alignment at the CL Pier and passes through the point where the CL Pier or CL Brg intersect the alignment.

Girder End Distances

Span 1

Girder	Start of Girder					End of Girder				
	CL Pier to CL Brg		CL Pier to Girder End		CL Brg to Girder End	CL Pier to CL Brg		CL Pier to Girder End		CL Brg to Girder End
	⊥ to Pier (ft)	Along Girder (ft)	⊥ to Pier (ft)	Along Girder (ft)	Along Girder (ft)	⊥ to Pier (ft)	Along Girder (ft)	⊥ to Pier (ft)	Along Girder (ft)	Along Girder (ft)
1	1.000	1.000	0.250	0.250	0.750	1.000	1.000	0.250	0.250	0.750
2	1.000	1.000	0.250	0.250	0.750	1.000	1.000	0.250	0.250	0.750
3	1.000	1.000	0.250	0.250	0.750	1.000	1.000	0.250	0.250	0.750
4	1.000	1.000	0.250	0.250	0.750	1.000	1.000	0.250	0.250	0.750
5	1.000	1.000	0.250	0.250	0.750	1.000	1.000	0.250	0.250	0.750
6	1.000	1.000	0.250	0.250	0.750	1.000	1.000	0.250	0.250	0.750

Girder Lengths

C-C Pier = Abutment/Pier Line to Abutment/Pier Line length measured along the girder
C-C Bearing = Centerline bearing to centerline bearing length measured along the girder centerline
Girder Length, Plan = End to end length of the girder projected into a horizontal plane

Girder Length, Along Grade = End to end length of girder measured along grade of the girder (slope adjusted) = $L_g\sqrt{1 + grade^2}$

Span 1

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Bridge: Job: 8/13/2022

Girder	C-C Pier (ft)	C-C Bearing (ft)	Girder Length		Grade (ft/ft)	Direction
			Plan (ft)	Along Grade (ft)		
1	125.500	123.500	125.000	125.000	0.0000	N 90° 00' 00.00" E
2	125.500	123.500	125.000	125.000	0.0000	N 90° 00' 00.00" E
3	125.500	123.500	125.000	125.000	0.0000	N 90° 00' 00.00" E
4	125.500	123.500	125.000	125.000	0.0000	N 90° 00' 00.00" E
5	125.500	123.500	125.000	125.000	0.0000	N 90° 00' 00.00" E
6	125.500	123.500	125.000	125.000	0.0000	N 90° 00' 00.00" E

Bearing Seat Elevations

Abutment 1, Ahead

Girder	Bearing #	Top Bearing Elev (ft)	Bearing Seat Elev (ft)
1	1	-5.208	-5.208
2	1	-5.208	-5.208
3	1	-5.208	-5.208
4	1	-5.208	-5.208
5	1	-5.208	-5.208
6	1	-5.208	-5.208

Abutment 2, Back

Girder	Bearing #	Top Bearing Elev (ft)	Bearing Seat Elev (ft)
1	1	-5.208	-5.208
2	1	-5.208	-5.208
3	1	-5.208	-5.208
4	1	-5.208	-5.208
5	1	-5.208	-5.208
6	1	-5.208	-5.208

Bearing Seat Elevation Details
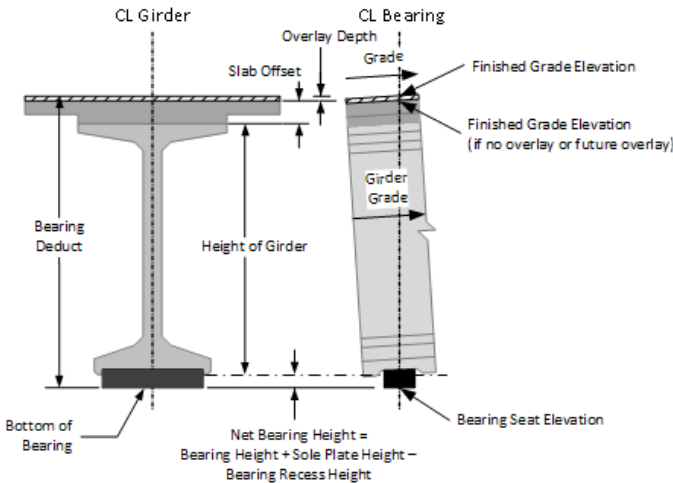
NOTE: Vertical height dimensions listed in the tables below are adjusted for girder and roadway grade and orientation.
NOTE: Bearing Deduct is a nominal value rounded to 1/8"

Abutment 1 Ahead

Girder	Bearing* #	Station	Offset (ft)	Finish Grade Elev (ft)	Profile Grade (ft/ft)	Cross Slope (ft/ft)	Girder Grade (ft/ft)	Girder Orientation (ft/ft)	Slab Offset (in)	Net Height of Girder (in)	Top Bearing Elev (ft)	Net Bearing Height (in)	Bearing Seat Elev (ft)	Bearing Deduct (in)
1	1	100+01.00	20.000 L	0.000	0	0	0	0	8.500	54.000	-5.208	0.000	-5.208	62.500
2	1	100+01.00	12.000 L	0.000	0	0	0	0	8.500	54.000	-5.208	0.000	-5.208	62.500
3	1	100+01.00	4.000 L	0.000	0	0	0	0	8.500	54.000	-5.208	0.000	-5.208	62.500
4	1	100+01.00	4.000 R	0.000	0	0	0	0	8.500	54.000	-5.208	0.000	-5.208	62.500
5	1	100+01.00	12.000 R	0.000	0	0	0	0	8.500	54.000	-5.208	0.000	-5.208	62.500
6	1	100+01.00	20.000 R	0.000	0	0	0	0	8.500	54.000	-5.208	0.000	-5.208	62.500

Bridge: Job: 8/13/2022

* Note that reported bearing locations are physical 3D locations of bearings adjusted for girder depth, slope and orientation. 'CL' is location of bearing seat at intersection of CL girder and bearing line. Roadway elevations at bearing line - work line intersections can be found in other tables in the Bridge Geometry report.

Abutment 2 Back

Girder	Bearing* #	Station	Offset (ft)	Finish Grade Elev (ft)	Profile Grade (ft/ft)	Cross Slope (ft/ft)	Girder Grade (ft/ft)	Girder Orientation (ft/ft)	Slab Offset (in)	Net Height of Girder (in)	Top Bearing Elev (ft)	Net Bearing Height (in)	Bearing Seat Elev (ft)	Bearing Deduct (in)
1	1	101+24.50	20.000 L	0.000	0	0	0	0	8.500	54.000	-5.208	0.000	-5.208	62.500
2	1	101+24.50	12.000 L	0.000	0	0	0	0	8.500	54.000	-5.208	0.000	-5.208	62.500
3	1	101+24.50	4.000 L	0.000	0	0	0	0	8.500	54.000	-5.208	0.000	-5.208	62.500
4	1	101+24.50	4.000 R	0.000	0	0	0	0	8.500	54.000	-5.208	0.000	-5.208	62.500
5	1	101+24.50	12.000 R	0.000	0	0	0	0	8.500	54.000	-5.208	0.000	-5.208	62.500
6	1	101+24.50	20.000 R	0.000	0	0	0	0	8.500	54.000	-5.208	0.000	-5.208	62.500

* Note that reported bearing locations are physical 3D locations of bearings adjusted for girder depth, slope and orientation. 'CL' is location of bearing seat at intersection of CL girder and bearing line. Roadway elevations at bearing line - work line intersections can be found in other tables in the Bridge Geometry report.

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Bridge: Job: 8/13/2022

TxDOT Girder Schedule Report

For Span 1 (Girder 1,2,3,4,5,6)

August 13, 2022 5:05:24 pm

PGSuper™ (x64)

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Version 6.1.0 - Built on May 12 2021

Washington State Department of Transportation

Texas Department of Transportation ®

Project Properties

Bridge Name	
Bridge ID	
Company	
Engineer	
Job Number	
Comments	
File	D:\PHD work\Research papers\TX54\PG super(Tx54)-1.pgs

Configuration

Configuration Server: TxDOT
Configuration Name: TxDOT
Configuration Source: ftp://ftp.dot.state.tx.us/pub/txdot-info/brg/pgsuper/version_6.1.0/txdot.pgz
Configuration Date Stamp: January 6, 2021 3:35:03 pm

Library	Entry	Source
Girders		Project Library
Traffic Barriers	SSTR	Master Library
Project Criteria	TxDOT 2017 based on AASHTO LRFD Bridge Design Specification, 8th Edition 2017	Master Library
Load Rating Criteria	Default based on The Manual for Bridge Evaluation, First Edition 2008, with 2010 interim provisions	Project Library
Haul Trucks	Old Haul Truck -0	Project Library

Analysis Controls

Structural Analysis Method: Simple Span
Section Properties: Gross
Losses: Refined estimate per TxDOT Research Report 0-6374-2

Girder Schedule

The Specification Check was Successful

TxDOT Girder Schedule

Span	1	1	1	1	1	1
Girder	1	2	3	4	5	6
Girder Type						

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Prestressing Strands						
NO. ($N_h + N_s$)	46	46	46	46	46	46
Size	0.600 in Dia.	0.600 in Dia.	0.600 in Dia.	0.600 in Dia.	0.600 in Dia.	0.600 in Dia.
Strength	Grade 270 Low Relaxation	Grade 270 Low Relaxation	Grade 270 Low Relaxation	Grade 270 Low Relaxation	Grade 270 Low Relaxation	Grade 270 Low Relaxation
Eccentricity @ CL	18.660 in	18.660 in	18.660 in	18.660 in	18.660 in	18.660 in
Eccentricity @ End	11.356 in	11.356 in	11.356 in	11.356 in	11.356 in	11.356 in
Prestressing Strands	**Depressed**	**Depressed**	**Depressed**	**Depressed**	**Depressed**	**Depressed**
NO. (# of Depressed Strands)	8	8	8	8	8	8
Y_b of Topmost Depressed Strand(s) @ End	50.500 in	50.500 in	50.500 in	50.500 in	50.500 in	50.500 in
Y_b of Topmost Depressed Strand(s) @ CL	8.500 in	8.500 in	8.500 in	8.500 in	8.500 in	8.500 in
Concrete						
Release Strength f'_{ci}	6.000 KSI	6.000 KSI	6.000 KSI	6.000 KSI	6.000 KSI	6.000 KSI
Minimum 28 day compressive strength f'_c	7.300 KSI	7.300 KSI	7.300 KSI	7.300 KSI	7.300 KSI	7.300 KSI
Optional Design						
Design Load Compressive Stress (Top CL)	4.554 KSI	4.732 KSI	4.732 KSI	4.732 KSI	4.732 KSI	4.554 KSI
Design Load Tensile Stress (Bottom CL)	-4.381 KSI	-4.554 KSI	-4.554 KSI	-4.554 KSI	-4.554 KSI	-4.381 KSI
Required minimum ultimate moment capacity	8464.49 kip-ft	8717.70 kip-ft	8717.70 kip-ft	8717.70 kip-ft	8717.70 kip-ft	8464.49 kip-ft
Live Load Distribution Factor for Moment (Strength and Service Limit States)	0.61509	0.61509	0.61509	0.61509	0.61509	0.61509
Live Load Distribution Factor for Shear (Strength and Service Limit States)	0.81433	0.81433	0.81433	0.81433	0.81433	0.81433
Live Load Distribution Factor for Moment (Fatigue Limit States)	0.35339	0.35339	0.35339	0.35339	0.35339	0.35339

NOTE: Stresses show in the above table reflect the following sign convention: Compressive Stress is positive. Tensile Stress is negative

Camber and Deflections

Camber and Deflection

Span	1	1	1	1	1	1
Girder	**1**	**2**	**3**	**4**	**5**	**6**
Unfactored Design Camber	0.363 ft	0.363 ft	0.363 ft	0.363 ft	0.363 ft	0.363 ft
Factored Design Camber, Δ_4**	0.363 ft	0.363 ft	0.363 ft	0.363 ft	0.363 ft	0.363 ft
Deflection (Prestressing)	0.520 ft	0.520 ft	0.520 ft	0.520 ft	0.520 ft	0.520 ft
Deflection (Girder)	-0.272 ft	-0.272 ft	-0.272 ft	-0.272 ft	-0.272 ft	-0.272 ft
Deflection (Deck and Diaphragms)*	-0.216 ft	-0.247 ft	-0.247 ft	-0.247 ft	-0.247 ft	-0.216 ft
Deflection (Traffic Barrier)	-0.014 ft	-0.014 ft	-0.014 ft	-0.014 ft	-0.014 ft	-0.014 ft
Deflection (Overlay)	0.000 ft	0.000 ft	0.000 ft	0.000 ft	0.000 ft	0.000 ft
Deflection (User Defined DC)	-0.033 ft	-0.033 ft	-0.033 ft	-0.033 ft	-0.033 ft	-0.033 ft
Deflection (User Defined DW)	0.000 ft	0.000 ft	0.000 ft	0.000 ft	0.000 ft	0.000 ft
Screed Camber, C**	0.199 ft	0.224 ft	0.224 ft	0.224 ft	0.224 ft	0.199 ft
Computed Excess Camber, Δ_4 - C	0.164 ft	0.139 ft	0.139 ft	0.139 ft	0.139 ft	0.164 ft

Bridge: Job: 8/13/2022

Live Load Deflection (HL93 - Per Lane)	-0.209 ft	-0.201 ft	-0.201 ft	-0.201 ft	-0.201 ft	-0.209 ft
Optional Live Load Deflection (LRFD 3.6.1.3.2)	-0.056 ft	-0.056 ft	-0.056 ft	-0.056 ft	-0.056 ft	-0.056 ft

* Deflection due to haunch weight is not included in this value
** Refer to the Camber Details tables in the Details report for more information

Bridge: Job: 8/13/2022

Bridge Analysis Report

For Girder Line 2

August 13, 2022 5:09:10 pm

PGSuper™ (x64)

Version 6.1.0 - Built on May 12 2021

Washington State Department of Transportation

Texas Department of Transportation

Project Properties

Bridge Name	
Bridge ID	
Company	
Engineer	
Job Number	
Comments	
File	D:\PHD work\Research papers\TX54\PG super(Tx54)-1.pgs

Configuration

Configuration Server: TxDOT
Configuration Name: TxDOT
Configuration Source: ftp://ftp.dot.state.tx.us/pub/txdot-info/brg/pgsuper/version_6.1.0/txdot.pgz
Configuration Date Stamp: January 6, 2021 3:35:03 pm

Library	Entry	Source
Girders		Project Library
Traffic Barriers	SSTR	Master Library
Project Criteria	TxDOT 2017 based on AASHTO LRFD Bridge Design Specification, 8th Edition 2017	Master Library
Load Rating Criteria	Default based on The Manual for Bridge Evaluation, First Edition 2008, with 2010 interim provisions	Project Library
Haul Trucks	Old Haul Truck -0	Project Library

Analysis Controls

Structural Analysis Method: Simple Span
Section Properties: Gross
Losses: Refined estimate per TxDOT Research Report 0-6374-2

Notes

Symbol	Definition
L_r	Span Length of Girder at Release
L_l	Span Length of Girder during Lifting
L_{st}	Span Length of Girder during Storage
L_h	Span Length of Girder during Hauling
L_e	Span Length of Girder after Erection
L_s	Length of Span
Debond	Point where bond begins for a debonded strand
PSXFR	Point of prestress transfer
FoS	Face of Support in final bridge configuration
ST	Section Transitions
STLF	Section Transitions, Left Face
STRF	Section Transitions, Right Face
SDCR	Start of Deck Casting Region
EDCR	End of Deck Casting Region
Diaphragm	Location of a precast or cast in place diaphragm
Bar Cutoff	End of a reinforcing bar in the girder
Deck Bar Cutoff	End of a reinforcing bar in the deck
CS	Critical Section for Shear
SZB	Stirrup Zone Boundary
H	H from end of girder or face of support
1.5H	1.5H from end of girder or face of support
HP	Harp Point
Pick Point	Support point where girder is lifted from form
Bunk Point	Point where girder is supported during transportation

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Bridge: Job: 8/13/2022

Simple Span

Load Responses - Bridge Site

Moments

Location from Left Support (ft)	Girder (kip-ft)	Diaphragm (kip-ft)	Slab (kip-ft)	Haunch (kip-ft)	Railing System (kip-ft)	* Design Live Load		* Fatigue Live Load	
						Max (kip-ft)	Min (kip-ft)	Max (kip-ft)	Min (kip-ft)
Span 1 Girder 2, 0.000	0.00	0.00	0.00	0.00	0.00	0.00 (D0)	0.00 (D0)	0.00 (F0)	0.00 (F0)
Span 1 Girder 2, (0.0L$_s$) 0.000	0.00	0.00	0.00	0.00	0.00	0.00 (D0)	0.00 (D0)	0.00 (F0)	0.00 (F0)
Span 1 Girder 2, (PSXFR) 2.250	116.13	0.00	115.95	0.00	17.10	282.55 (D0)	0.00 (D0)	155.42 (F0)	0.00 (F0)
Span 1 Girder 2, (CS) 4.876	246.21	0.00	245.82	0.00	36.25	598.28 (D0)	0.00 (D0)	328.21 (F0)	0.00 (F0)
Span 1 Girder 2, (0.1L$_s$) 12.350	584.34	0.00	583.40	0.00	86.02	1414.26 (D0)	0.00 (D0)	769.44 (F0)	0.00 (F0)
Span 1 Girder 2, (0.2L$_s$) 24.700	1038.82	0.00	1037.15	0.00	152.93	2494.38 (D0)	0.00 (D0)	1334.37 (F0)	0.00 (F0)
Span 1 Girder 2, (0.3L$_s$) 37.050	1363.45	0.00	1361.26	0.00	200.72	3240.36 (D0)	0.00 (D0)	1726.06 (F0)	0.00 (F0)
Span 1 Girder 2, (0.4L$_s$) 49.400	1558.23	0.00	1555.73	0.00	229.39	3681.99 (D0)	0.00 (D0)	1935.31 (F0)	0.00 (F0)
Span 1 Girder 2, (0.5L$_s$) 61.750	1623.16	0.00	1620.55	0.00	238.95	3804.37 (D0)	0.00 (D0)	1940.05 (F0)	0.00 (F0)
Span 1 Girder 2, (0.6L$_s$) 74.100	1558.23	0.00	1555.73	0.00	229.39	3681.99 (D0)	0.00 (D0)	1935.31 (F0)	0.00 (F0)
Span 1 Girder 2, (0.7L$_s$) 86.450	1363.45	0.00	1361.26	0.00	200.72	3240.36 (D0)	0.00 (D0)	1726.06 (F0)	0.00 (F0)
Span 1 Girder 2, (0.8L$_s$) 98.800	1038.82	0.00	1037.15	0.00	152.93	2494.38 (D0)	0.00 (D0)	1334.37 (F0)	0.00 (F0)
Span 1 Girder 2, (0.9L$_s$) 111.150	584.34	0.00	583.40	0.00	86.02	1414.26 (D0)	0.00 (D0)	769.44 (F0)	0.00 (F0)
Span 1 Girder 2, (CS) 118.624	246.21	0.00	245.82	0.00	36.25	598.28 (D0)	0.00 (D0)	328.21 (F0)	0.00 (F0)
Span 1 Girder 2, (PSXFR) 121.250	116.13	0.00	115.95	0.00	17.10	282.55 (D0)	0.00 (D0)	155.42 (F0)	0.00 (F0)
Span 1 Girder 2, (1.0L$_s$) 123.500	0.00	0.00	0.00	0.00	0.00	0.00 (D0)	0.00 (D0)	0.00 (F0)	0.00 (F0)
Span 1 Girder 2, 123.500	0.00	0.00	0.00	0.00	0.00	0.00 (D0)	0.00 (D0)	0.00 (F0)	0.00 (F0)

* Live Load values are per lane and include impact.
(D0) LRFD Design Truck + Lane
(D1) LRFD Design Tandem + Lane
(F0) LRFD Fatigue Truck

Moment due to User Defined Loads in Interval 10: Cast Deck, Apply User Defined Loads

Location from Left Support (ft)	User DC (kip-ft)	User DW (kip-ft)	User LL+IM (kip-ft)
Group 1 Girder 2 Segment 1, 0.000	0.00	0.00	0.00
Group 1 Girder 2 Segment 1, (0.0L$_e$) 0.000	0.00	0.00	0.00
Group 1 Girder 2 Segment 1, (PSXFR) 2.250	15.41	0.00	0.00
Group 1 Girder 2 Segment 1, (0.1L$_e$) 12.350	77.56	0.00	0.00
Group 1 Girder 2 Segment 1, (0.2L$_e$) 24.700	137.88	0.00	0.00
Group 1 Girder 2 Segment 1, (0.3L$_e$) 37.050	180.97	0.00	0.00
Group 1 Girder 2 Segment 1, (0.4L$_e$) 49.400	206.82	0.00	0.00
Group 1 Girder 2 Segment 1, (0.5L$_e$) 61.750	215.44	0.00	0.00
Group 1 Girder 2 Segment 1, (0.6L$_e$) 74.100	206.82	0.00	0.00
Group 1 Girder 2 Segment 1, (0.7L$_e$) 86.450	180.97	0.00	0.00
Group 1 Girder 2 Segment 1, (0.8L$_e$) 98.800	137.88	0.00	0.00

Bridge: Job: 8/13/2022

Location from Left Support (ft)	User DC (kip-ft)	User DW (kip-ft)	User LL+IM (kip-ft)
Group 1 Girder 2 Segment 1, (0.9L$_e$) 111.150	77.56	0.00	0.00
Group 1 Girder 2 Segment 1, (PSXFR) 121.250	15.41	0.00	0.00
Group 1 Girder 2 Segment 1, (1.0L$_e$) 123.500	0.00	0.00	0.00
Group 1 Girder 2 Segment 1, 123.500	0.00	0.00	0.00

Shears

Location from Left Support (ft)	Girder (kip)	Diaphragm (kip)	Slab (kip)	Haunch (kip)	Railing System (kip)	* Design Live Load Max (kip)	* Design Live Load Min (kip)	* Fatigue Live Load Max (kip)	* Fatigue Live Load Min (kip)
Span 1 Girder 2, 0.000	0.00	0.00	0.00	0.00	0.00	0.00 (D0)	0.00 (D0)	0.00 (F0)	0.00 (F0)
Span 1 Girder 2, (0.0L$_s$) 0.000	53.21 52.57	0.00	53.12 52.49	0.00	7.83 7.74	128.04 (D0)	0.00 (D0)	70.58 (F0)	0.00 (F0)
Span 1 Girder 2, (CS) 4.876	48.42	0.00	48.34	0.00	7.13	121.20 (D0)	-1.74 (D0)	67.31 (F0)	-1.45 (F0)
Span 1 Girder 2, (0.1L$_s$) 12.350	42.06	0.00	41.99	0.00	6.19	110.96 (D0)	-5.97 (D1)	62.30 (F0)	-3.68 (F0)
Span 1 Girder 2, (0.2L$_s$) 24.700	31.54	0.00	31.49	0.00	4.64	94.66 (D0)	-13.80 (D1)	54.02 (F0)	-7.36 (F0)
Span 1 Girder 2, (0.3L$_s$) 37.050	21.03	0.00	20.99	0.00	3.10	79.16 (D0)	-25.05 (D0)	45.74 (F0)	-13.14 (F0)
Span 1 Girder 2, (0.4L$_s$) 49.400	10.51	0.00	10.50	0.00	1.55	64.45 (D0)	-37.39 (D0)	37.46 (F0)	-20.90 (F0)
Span 1 Girder 2, (0.5L$_s$) 61.750	0.00	0.00	0.00	0.00	0.00	50.52 (D0)	-50.52 (D0)	29.18 (F0)	-29.18 (F0)
Span 1 Girder 2, (0.6L$_s$) 74.100	-10.51	0.00	-10.50	0.00	-1.55	37.39 (D0)	-64.45 (D0)	20.90 (F0)	-37.46 (F0)
Span 1 Girder 2, (0.7L$_s$) 86.450	-21.03	0.00	-21.00	0.00	-3.10	25.05 (D0)	-79.16 (D0)	13.14 (F0)	-45.74 (F0)
Span 1 Girder 2, (0.8L$_s$) 98.800	-31.54	0.00	-31.49	0.00	-4.64	13.80 (D1)	-94.66 (D0)	7.36 (F0)	-54.02 (F0)
Span 1 Girder 2, (0.9L$_s$) 111.150	-42.06	0.00	-41.99	0.00	-6.19	5.97 (D1)	-110.96 (D0)	3.68 (F0)	-62.30 (F0)
Span 1 Girder 2, (CS) 118.624	-48.42	0.00	-48.34	0.00	-7.13	1.74 (D0)	-121.20 (D0)	1.45 (F0)	-67.31 (F0)
Span 1 Girder 2, (1.0L$_s$) 123.500	-52.57 -53.21	0.00	-52.49 -53.13	0.00	-7.74 -7.83	0.00 (D0)	-128.04 (D0)	0.00 (F0)	-70.58 (F0)
Span 1 Girder 2, 123.500	0.00	0.00	0.00	0.00	0.00	0.00 (D0)	0.00 (D0)	0.00 (F0)	0.00 (F0)

* Live Load values are per lane and include impact.

(D0) LRFD Design Truck + Lane
(D1) LRFD Design Tandem + Lane
(F0) LRFD Fatigue Truck

Shears due to User Defined Loads in Interval 10: Cast Deck, Apply User Defined Loads

Location from Left Support (ft)	User DC (kip)	User DW (kip)	User LL+IM (kip)
Group 1 Girder 2 Segment 1, 0.000	0.00	0.00	0.00
Group 1 Girder 2 Segment 1, (0.0L$_e$) 0.000	6.98	0.00	0.00
Group 1 Girder 2 Segment 1, (0.1L$_e$) 12.350	5.58	0.00	0.00
Group 1 Girder 2 Segment 1, (0.2L$_e$) 24.700	4.19	0.00	0.00
Group 1 Girder 2 Segment 1, (0.3L$_e$) 37.050	2.79	0.00	0.00
Group 1 Girder 2 Segment 1, (0.4L$_e$) 49.400	1.40	0.00	0.00
Group 1 Girder 2 Segment 1, (0.5L$_e$) 61.750	0.00	0.00	0.00
Group 1 Girder 2 Segment 1, (0.6L$_e$) 74.100	-1.40	0.00	0.00
Group 1 Girder 2 Segment 1, (0.7L$_e$) 86.450	-2.79	0.00	0.00

Bridge: Job: 8/13/2022

Location from Left Support (ft)	User DC (kip)	User DW (kip)	User LL+IM (kip)
Group 1 Girder 2 Segment 1, (0.8L$_e$) 98.800	-4.19	0.00	0.00
Group 1 Girder 2 Segment 1, (0.9L$_e$) 111.150	-5.58	0.00	0.00
Group 1 Girder 2 Segment 1, (1.0L$_e$) 123.500	-6.98	0.00	0.00
Group 1 Girder 2 Segment 1, 123.500	0.00	0.00	0.00

Girder Line Pier Reactions

	Girder (kip)	Diaphragm (kip)	Slab (kip)	Haunch (kip)	Railing System (kip)	* Design Live Load		* Fatigue Live Load	
						Max (kip)	Min (kip)	Max (kip)	Min (kip)
Abutment 1	53.21	0.00	53.13	0.00	7.83	128.04 (D0)	0.00 (D0)	70.58 (F0)	0.00 (F0)
Abutment 2	53.21	0.00	53.12	0.00	7.83	128.04 (D0)	0.00 (D0)	70.58 (F0)	0.00 (F0)

* Live Load values are per lane and include impact.

(D0) LRFD Design Truck + Lane
(D1) LRFD Design Tandem + Lane
(F0) LRFD Fatigue Truck

Girder Bearing Reactions

	Girder (kip)	Diaphragm (kip)	Slab (kip)	Haunch (kip)	Railing System (kip)	* Design Live Load		* Fatigue Live Load	
						Max (kip)	Min (kip)	Max (kip)	Min (kip)
Abutment 1 - Ahead	53.21	0.00	53.13	0.00	7.83	128.04 (D0)	0.00 (D0)	70.58 (F0)	0.00 (F0)
Abutment 2 - Back	53.21	0.00	53.12	0.00	7.83	128.04 (D0)	0.00 (D0)	70.58 (F0)	0.00 (F0)

* Live Load values are per lane and include impact.

(D0) LRFD Design Truck + Lane
(D1) LRFD Design Tandem + Lane
(F0) LRFD Fatigue Truck

Girder Line Pier Reactions due to User Defined Loads in Interval 10: Cast Deck, Apply User Defined Loads

	User DC (kip)	User DW (kip)	User LL+IM (kip)
Abutment 1	6.98	0.00	0.00
Abutment 2	6.98	0.00	0.00

Girder Bearing Reactions due to User Defined Loads in Interval 10: Cast Deck, Apply User Defined Loads

	User DC (kip)	User DW (kip)	User LL+IM (kip)
Abutment 1 - Ahead	6.98	0.00	0.00
Abutment 2 - Back	6.98	0.00	0.00

Deflections

Location from Left Support (ft)	Girder (in)	Diaphragm (in)	Slab (in)	Haunch (in)	Railing System (in)	* Design Live Load		* Fatigue Live Load	
						Max (in)	Min (in)	Max (in)	Min (in)
Span 1 Girder 2, 0.000	0.000	0.000	0.000	0.000	0.000	0.000 (D0)	0.000 (D0)	0.000 (F0)	0.000 (F0)
Span 1 Girder 2, (0.0L$_s$) 0.000	0.000	0.000	0.000	0.000	0.000	0.000 (D0)	0.000 (D0)	0.000 (F0)	0.000 (F0)
Span 1 Girder 2, (0.1L$_s$) 12.350	-1.024	0.000	-0.932	0.000	-0.052	0.000 (D0)	-0.742 (D0)	0.000 (F0)	-0.391 (F0)
Span 1 Girder 2, (0.2L$_s$) 24.700	-1.937	0.000	-1.763	0.000	-0.098	0.000 (D0)	-1.413 (D0)	0.000 (F0)	-0.745 (F0)
Span 1 Girder 2, (0.3L$_s$) 37.050	-2.652	0.000	-2.414	0.000	-0.134	0.000 (D0)	-1.945 (D0)	0.000 (F0)	-1.024 (F0)

Bridge: Job: 8/13/2022

Location from Left Support (ft)	Girder (in)	Diaphragm (in)	Slab (in)	Haunch (in)	Railing System (in)	* Design Live Load		* Fatigue Live Load	
						Max (in)	Min (in)	Max (in)	Min (in)
Span 1 Girder 2, (0.4L$_s$) 49.400	-3.106	0.000	-2.827	0.000	-0.157	0.000 (D0)	-2.292 (D0)	0.000 (F0)	-1.201 (F0)
Span 1 Girder 2, (0.5L$_s$) 61.750	-3.262	0.000	-2.969	0.000	-0.165	0.000 (D0)	-2.408 (D0)	0.000 (F0)	-1.261 (F0)
Span 1 Girder 2, (0.6L$_s$) 74.100	-3.106	0.000	-2.827	0.000	-0.157	0.000 (D0)	-2.292 (D0)	0.000 (F0)	-1.201 (F0)
Span 1 Girder 2, (0.7L$_s$) 86.450	-2.652	0.000	-2.414	0.000	-0.134	0.000 (D0)	-1.945 (D0)	0.000 (F0)	-1.024 (F0)
Span 1 Girder 2, (0.8L$_s$) 98.800	-1.937	0.000	-1.763	0.000	-0.098	0.000 (D0)	-1.413 (D0)	0.000 (F0)	-0.745 (F0)
Span 1 Girder 2, (0.9L$_s$) 111.150	-1.024	0.000	-0.932	0.000	-0.052	0.000 (D0)	-0.742 (D0)	0.000 (F0)	-0.391 (F0)
Span 1 Girder 2, (1.0L$_s$) 123.500	0.000	0.000	0.000	0.000	0.000	0.000 (D0)	0.000 (D0)	0.000 (F0)	0.000 (F0)
Span 1 Girder 2, 123.500	0.000	0.000	0.000	0.000	0.000	0.000 (D0)	0.000 (D0)	0.000 (F0)	0.000 (F0)

* Live Load values are per lane and include impact.

(D0) LRFD Design Truck + Lane
(D1) LRFD Design Tandem + Lane
(F0) LRFD Fatigue Truck

Deflections due to User Defined Loads in Interval 10: Cast Deck, Apply User Defined Loads

Location from Left Support (ft)	User DC (in)	User DW (in)	User LL+IM (in)
Group 1 Girder 2 Segment 1, 0.000	0.000	0.000	0.000
Group 1 Girder 2 Segment 1, (0.0L$_e$) 0.000	0.000	0.000	0.000
Group 1 Girder 2 Segment 1, (0.1L$_e$) 12.350	-0.124	0.000	0.000
Group 1 Girder 2 Segment 1, (0.2L$_e$) 24.700	-0.234	0.000	0.000
Group 1 Girder 2 Segment 1, (0.3L$_e$) 37.050	-0.321	0.000	0.000
Group 1 Girder 2 Segment 1, (0.4L$_e$) 49.400	-0.376	0.000	0.000
Group 1 Girder 2 Segment 1, (0.5L$_e$) 61.750	-0.395	0.000	0.000
Group 1 Girder 2 Segment 1, (0.6L$_e$) 74.100	-0.376	0.000	0.000
Group 1 Girder 2 Segment 1, (0.7L$_e$) 86.450	-0.321	0.000	0.000
Group 1 Girder 2 Segment 1, (0.8L$_e$) 98.800	-0.234	0.000	0.000
Group 1 Girder 2 Segment 1, (0.9L$_e$) 111.150	-0.124	0.000	0.000
Group 1 Girder 2 Segment 1, (1.0L$_e$) 123.500	0.000	0.000	0.000
Group 1 Girder 2 Segment 1, 123.500	0.000	0.000	0.000

Rotations

	Girder (rad)	Diaphragm (rad)	Slab (rad)	Haunch (rad)	Railing System (rad)	* Design Live Load		* Fatigue Live Load	
						Max (rad)	Min (rad)	Max (rad)	Min (rad)
Abutment 1 - Ahead	-0.00704	0.00000	-0.00641	0.00000	-0.00036	0.00000 (D0)	-0.00509 (D0)	0.00000 (F0)	-0.00268 (F0)
Abutment 2 - Back	0.00704	0.00000	0.00641	0.00000	0.00036	0.00509 (D0)	0.00000 (D0)	0.00268 (F0)	0.00000 (F0)

* Live Load values are per lane and include impact.

(D0) LRFD Design Truck + Lane
(D1) LRFD Design Tandem + Lane
(F0) LRFD Fatigue Truck

Rotations due to User Defined Loads in Interval 10: Cast Deck, Apply User Defined Loads

	User DC (rad)	User DW (rad)	User LL+IM (rad)

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	User DC (rad)	User DW (rad)	User LL+IM (rad)
Abutment 1 - Ahead	-0.00085	0.00000	0.00000
Abutment 2 - Back	0.00085	0.00000	0.00000

Design Live Load Individual Vehicle Response

Live Load Results for LRFD Design Truck + Lane

	X (ft)	Moment Max (kip-ft)	Moment Max Config	Moment Min (kip-ft)	Moment Min Config	Shear Max (kip)	Shear Max Config	Shear Min (kip)	Shear Min Config	Deflection Max (in)	Deflection Max Config	Deflection Min (in)	Deflection Min Config
Span 1 Girder 2, 0.000	0.000	0.00		0.00		0.00		0.00		0.000		0.000	
Span 1 Girder 2, (0.0L_s) 0.000	0.000	0.00		0.00		128.04	8.00 kip @ 28.000 ft 32.00 kip @ 14.000 ft 32.00 kip @ 0.000 ft	0.00		0.000		0.000	
Span 1 Girder 2, (CS) 4.876	4.876	598.28	8.00 kip @ 32.876 ft 32.00 kip @ 18.876 ft 32.00 kip @ 4.876 ft	0.00		121.20	8.00 kip @ 32.876 ft 32.00 kip @ 18.876 ft 32.00 kip @ 4.876 ft	-1.74	32.00 kip @ 4.876 ft	0.000		-0.297	8.00 kip @ 35.250 ft 32.00 kip @ 49.250 ft 32.00 kip @ 63.250 ft
Span 1 Girder 2, (0.1L_s) 12.350	12.350	1414.26	8.00 kip @ 40.350 ft 32.00 kip @ 26.350 ft 32.00 kip @ 12.350 ft	0.00		110.96	8.00 kip @ 40.350 ft 32.00 kip @ 26.350 ft 32.00 kip @ 12.350 ft	-4.65	32.00 kip @ 12.350 ft	0.000		-0.742	8.00 kip @ 35.250 ft 32.00 kip @ 49.250 ft 32.00 kip @ 63.250 ft
Span 1 Girder 2, (0.2L_s) 24.700	24.700	2494.38	8.00 kip @ 52.700 ft 32.00 kip @ 38.700 ft 32.00 kip @ 24.700 ft	0.00		94.66	8.00 kip @ 52.700 ft 32.00 kip @ 38.700 ft 32.00 kip @ 24.700 ft	-13.78	32.00 kip @ 24.700 ft 32.00 kip @ 10.700 ft	0.000		-1.413	8.00 kip @ 35.450 ft 32.00 kip @ 49.450 ft 32.00 kip @ 63.450 ft
Span 1 Girder 2, (0.3L_s) 37.050	37.050	3240.36	8.00 kip @ 65.050 ft 32.00 kip @ 51.050 ft 32.00 kip @ 37.050 ft	0.00		79.16	8.00 kip @ 65.050 ft 32.00 kip @ 51.050 ft 32.00 kip @ 37.050 ft	-25.05	8.00 kip @ 9.050 ft 32.00 kip @ 23.050 ft 32.00 kip @ 37.050 ft	0.000		-1.945	8.00 kip @ 75.750 ft 32.00 kip @ 61.750 ft 32.00 kip @ 47.750 ft
Span 1 Girder 2, (0.4L_s) 49.400	49.400	3681.99	8.00 kip @ 35.400 ft 32.00 kip @ 49.400 ft 32.00 kip @ 63.400 ft	0.00		64.45	8.00 kip @ 77.400 ft 32.00 kip @ 63.400 ft 32.00 kip @ 49.400 ft	-37.39	8.00 kip @ 21.400 ft 32.00 kip @ 35.400 ft 32.00 kip @ 49.400 ft	0.000		-2.292	8.00 kip @ 77.250 ft 32.00 kip @ 63.250 ft 32.00 kip @ 49.250 ft
Span 1 Girder 2, (0.5L_s)	61.750	3804.37	8.00 kip @ 47.750 ft	0.00		50.52	8.00 kip @ 89.750 ft	-50.52	8.00 kip @ 33.750 ft	0.000		-2.408	8.00 kip @ 81.920 ft 32.00 kip

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	X (ft)	Moment Max (kip-ft)	Moment Max Config	Moment Min (kip-ft)	Moment Min Config	Shear Max (kip)	Shear Max Config	Shear Min (kip)	Shear Min Config	Deflection Max (in)	Deflection Max Config	Deflection Min (in)	Deflection Min Config
61.750			32.00 kip @ 61.750 ft 32.00 kip @ 75.750 ft				32.00 kip @ 75.750 ft 32.00 kip @ 61.750 ft		32.00 kip @ 47.750 ft 32.00 kip @ 61.750 ft				@ 67.920 ft 32.00 kip @ 53.920 ft
Span 1 Girder 2, (0.6Lₛ) 74.100	74.100	3681.99	8.00 kip @ 88.100 ft 32.00 kip @ 74.100 ft 32.00 kip @ 60.100 ft	0.00		37.39	8.00 kip @ 102.100 ft 32.00 kip @ 88.100 ft 32.00 kip @ 74.100 ft	-64.45	8.00 kip @ 46.100 ft 32.00 kip @ 60.100 ft 32.00 kip @ 74.100 ft	0.000		-2.292	8.00 kip @ 46.250 ft 32.00 kip @ 60.250 ft 32.00 kip @ 74.250 ft
Span 1 Girder 2, (0.7Lₛ) 86.450	86.450	3240.36	8.00 kip @ 58.450 ft 32.00 kip @ 72.450 ft 32.00 kip @ 86.450 ft	0.00		25.05	8.00 kip @ 114.450 ft 32.00 kip @ 100.450 ft 32.00 kip @ 86.450 ft	-79.16	8.00 kip @ 58.450 ft 32.00 kip @ 72.450 ft 32.00 kip @ 86.450 ft	0.000		-1.945	8.00 kip @ 47.750 ft 32.00 kip @ 61.750 ft 32.00 kip @ 75.750 ft
Span 1 Girder 2, (0.8Lₛ) 98.800	98.800	2494.38	8.00 kip @ 70.800 ft 32.00 kip @ 84.800 ft 32.00 kip @ 98.800 ft	0.00		13.78	32.00 kip @ 98.800 ft 32.00 kip @ 112.800 ft	-94.66	8.00 kip @ 70.800 ft 32.00 kip @ 84.800 ft 32.00 kip @ 98.800 ft	0.000		-1.413	8.00 kip @ 88.050 ft 32.00 kip @ 74.050 ft 32.00 kip @ 60.050 ft
Span 1 Girder 2, (0.9Lₛ) 111.150	111.150	1414.26	8.00 kip @ 83.150 ft 32.00 kip @ 97.150 ft 32.00 kip @ 111.150 ft	0.00		4.65	32.00 kip @ 111.150 ft	-110.96	8.00 kip @ 83.150 ft 32.00 kip @ 97.150 ft 32.00 kip @ 111.150 ft	0.000		-0.742	8.00 kip @ 88.250 ft 32.00 kip @ 74.250 ft 32.00 kip @ 60.250 ft
Span 1 Girder 2, (CS) 118.624	118.624	598.28	8.00 kip @ 90.624 ft 32.00 kip @ 104.624 ft 32.00 kip @ 118.624 ft	0.00		1.74	32.00 kip @ 118.624 ft	-121.20	8.00 kip @ 90.624 ft 32.00 kip @ 104.624 ft 32.00 kip @ 118.624 ft	0.000		-0.297	8.00 kip @ 88.250 ft 32.00 kip @ 74.250 ft 32.00 kip @ 60.250 ft
Span 1 Girder 2, (1.0Lₛ) 123.500	123.500	0.00		0.00		0.00		-128.04	8.00 kip @ 95.500 ft 32.00 kip @ 109.500 ft 32.00 kip @ 123.500 ft	0.000		0.000	
Span 1	123.500	0.00		0.00		0.00		0.00		0.000		0.000	

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	X (ft)	Moment Max (kip-ft)	Moment Max Config	Moment Min (kip-ft)	Moment Min Config	Shear Max (kip)	Shear Max Config	Shear Min (kip)	Shear Min Config	Deflection Max (in)	Deflection Max Config	Deflection Min (in)	Deflection Min Config
Girder 2, 123.500													

* Live Load values are per lane and include impact.

Live Load Reactions and Rotations for LRFD Design Truck + Lane

	Reaction Max (kip)	Reaction Max Config	Reaction Min (kip)	Reaction Min Config	Rotation Max (rad)	Rotation Max Config	Rotation Min (rad)	Rotation Min Config
Abutment 1	128.04	8.00 kip @ 28.000 ft 32.00 kip @ 14.000 ft 32.00 kip @ 0.000 ft	0.00		0.00000		-0.00509	8.00 kip @ 35.250 ft 32.00 kip @ 49.250 ft 32.00 kip @ 63.250 ft
Abutment 2	128.04	8.00 kip @ 95.500 ft 32.00 kip @ 109.500 ft 32.00 kip @ 123.500 ft	0.00		0.00509	8.00 kip @ 88.250 ft 32.00 kip @ 74.250 ft 32.00 kip @ 60.250 ft	0.00000	

* Live Load values are per lane and include impact.

Live Load Results for LRFD Design Tandem + Lane

	X (ft)	Moment Max (kip-ft)	Moment Max Config	Moment Min (kip-ft)	Moment Min Config	Shear Max (kip)	Shear Max Config	Shear Min (kip)	Shear Min Config	Deflection Max (in)	Deflection Max Config	Deflection Min (in)	Deflection Min Config
Span 1 Girder 2, 0.000	0.000	0.00		0.00		0.00		0.00		0.000		0.000	
Span 1 Girder 2, (0.0L$_s$) 0.000	0.000	0.00		0.00		104.94	25.00 kip @ 0.000 ft 25.00 kip @ 4.000 ft	0.00		0.000		0.000	
Span 1 Girder 2, (CS) 4.876	4.876	491.28	25.00 kip @ 4.876 ft 25.00 kip @ 8.876 ft	0.00		99.26	25.00 kip @ 4.876 ft 25.00 kip @ 8.876 ft	-1.61	25.00 kip @ 4.876 ft 25.00 kip @ 0.876 ft	0.000		-0.242	25.00 kip @ 49.450 ft 25.00 kip @ 53.450 ft
Span 1 Girder 2, (0.1L$_s$) 12.350	12.350	1165.11	25.00 kip @ 12.350 ft 25.00 kip @ 16.350 ft	0.00		90.78	25.00 kip @ 12.350 ft 25.00 kip @ 16.350 ft	-5.97	25.00 kip @ 12.350 ft 25.00 kip @ 8.350 ft	0.000		-0.604	25.00 kip @ 55.575 ft 25.00 kip @ 51.575 ft
Span 1 Girder 2, (0.2L$_s$) 24.700	24.700	2068.36	25.00 kip @ 24.700 ft 25.00 kip @ 28.700 ft	0.00		77.42	25.00 kip @ 24.700 ft 25.00 kip @ 28.700 ft	-13.80	25.00 kip @ 24.700 ft 25.00 kip @ 20.700 ft	0.000		-1.150	25.00 kip @ 55.575 ft 25.00 kip @ 51.575 ft
Span 1 Girder 2, (0.3L$_s$) 37.050	37.050	2709.73	25.00 kip @ 37.050 ft 25.00 kip @ 41.050 ft	0.00		64.84	25.00 kip @ 37.050 ft 25.00 kip @ 41.050 ft	-22.43	25.00 kip @ 37.050 ft 25.00 kip @ 33.050 ft	0.000		-1.583	25.00 kip @ 55.580 ft 25.00 kip @ 51.580 ft
Span 1 Girder 2, (0.4L$_s$) 49.400	49.400	3089.23	25.00 kip @ 49.400 ft 25.00 kip @ 53.400 ft	0.00		53.05	25.00 kip @ 49.400 ft 25.00 kip @ 53.400 ft	-31.85	25.00 kip @ 49.400 ft 25.00 kip @ 45.400 ft	0.000		-1.865	25.00 kip @ 55.580 ft 25.00 kip @ 59.580 ft
Span 1 Girder 2, (0.5L$_s$) 61.750	61.750	3206.87	25.00 kip @ 61.750 ft 25.00 kip @ 65.750 ft	0.00		42.05	25.00 kip @ 61.750 ft 25.00 kip @ 65.750 ft	-42.05	25.00 kip @ 61.750 ft 25.00 kip @ 57.750 ft	0.000		-1.962	25.00 kip @ 61.750 ft 25.00 kip @ 65.750 ft

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Bridge: Job: 8/13/2022

	X (ft)	Moment Max (kip-ft)	Moment Max Config	Moment Min (kip-ft)	Moment Min Config	Shear Max (kip)	Shear Max Config	Shear Min (kip)	Shear Min Config	Deflection Max (in)	Deflection Max Config	Deflection Min (in)	Deflection Min Config
Span 1 Girder 2, (0.6Ls) 74.100	74.100	3089.23	25.00 kip @ 74.100 ft 25.00 kip @ 70.100 ft	0.00		31.85	25.00 kip @ 74.100 ft 25.00 kip @ 78.100 ft	-53.05	25.00 kip @ 74.100 ft 25.00 kip @ 70.100 ft	0.000		-1.865	25.00 kip @ 67.920 ft 25.00 kip @ 63.920 ft
Span 1 Girder 2, (0.7Ls) 86.450	86.450	2709.73	25.00 kip @ 86.450 ft 25.00 kip @ 82.450 ft	0.00		22.43	25.00 kip @ 86.450 ft 25.00 kip @ 90.450 ft	-64.84	25.00 kip @ 86.450 ft 25.00 kip @ 82.450 ft	0.000		-1.583	25.00 kip @ 67.920 ft 25.00 kip @ 71.920 ft
Span 1 Girder 2, (0.8Ls) 98.800	98.800	2068.36	25.00 kip @ 98.800 ft 25.00 kip @ 94.800 ft	0.00		13.80	25.00 kip @ 98.800 ft 25.00 kip @ 102.800 ft	-77.42	25.00 kip @ 98.800 ft 25.00 kip @ 94.800 ft	0.000		-1.150	25.00 kip @ 67.925 ft 25.00 kip @ 71.925 ft
Span 1 Girder 2, (0.9Ls) 111.150	111.150	1165.11	25.00 kip @ 111.150 ft 25.00 kip @ 107.150 ft	0.00		5.97	25.00 kip @ 111.150 ft 25.00 kip @ 115.150 ft	-90.78	25.00 kip @ 111.150 ft 25.00 kip @ 107.150 ft	0.000		-0.604	25.00 kip @ 67.925 ft 25.00 kip @ 71.925 ft
Span 1 Girder 2, (CS) 118.624	118.624	491.28	25.00 kip @ 118.624 ft 25.00 kip @ 114.624 ft	0.00		1.61	25.00 kip @ 118.624 ft 25.00 kip @ 122.624 ft	-99.26	25.00 kip @ 118.624 ft 25.00 kip @ 114.624 ft	0.000		-0.242	25.00 kip @ 74.050 ft 25.00 kip @ 70.050 ft
Span 1 Girder 2, (1.0Ls) 123.500	123.500	0.00		0.00		0.00		-104.94	25.00 kip @ 123.500 ft 25.00 kip @ 119.500 ft	0.000		0.000	
Span 1 Girder 2, 123.500	123.500	0.00		0.00		0.00		0.00		0.000		0.000	

* Live Load values are per lane and include impact.

Live Load Reactions and Rotations for LRFD Design Tandem + Lane

	Reaction Max (kip)	Reaction Max Config	Reaction Min (kip)	Reaction Min Config	Rotation Max (rad)	Rotation Max Config	Rotation Min (rad)	Rotation Min Config
Abutment 1	104.94	25.00 kip @ 0.000 ft 25.00 kip @ 4.000 ft	0.00		0.00000		-0.00415	25.00 kip @ 49.450 ft 25.00 kip @ 53.450 ft
Abutment 2	104.94	25.00 kip @ 123.500 ft 25.00 kip @ 119.500 ft	0.00		0.00415	25.00 kip @ 74.050 ft 25.00 kip @ 70.050 ft	0.00000	

* Live Load values are per lane and include impact.

Fatigue Live Load Individual Vehicle Response

Live Load Results for LRFD Fatigue Truck

	X (ft)	Moment Max (kip-ft)	Moment Max Config	Moment Min (kip-ft)	Moment Min Config	Shear Max (kip)	Shear Max Config	Shear Min (kip)	Shear Min Config	Deflection Max (in)	Deflection Max Config	Deflection Min (in)	Deflection Min Config
Span 1 Girder 2,	0.000	0.00		0.00		0.00		0.00		0.000		0.000	

Bridge: Job: 8/13/2022

	X (ft)	Moment Max (kip-ft)	Moment Max Config	Moment Min (kip-ft)	Moment Min Config	Shear Max (kip)	Shear Max Config	Shear Min (kip)	Shear Min Config	Deflection Max (in)	Deflection Max Config	Deflection Min (in)	Deflection Min Config
0.000													
Span 1 Girder 2, (0.0L$_s$) 0.000	0.000	0.00		0.00		70.58	8.00 kip @ 44.000 ft 32.00 kip @ 30.000 ft 32.00 kip @ 0.000 ft	0.00		0.000		0.000	
Span 1 Girder 2, (CS) 4.876	4.876	328.21	8.00 kip @ 48.876 ft 32.00 kip @ 34.876 ft 32.00 kip @ 4.876 ft	0.00		67.31	8.00 kip @ 48.876 ft 32.00 kip @ 34.876 ft 32.00 kip @ 4.876 ft	-1.45	32.00 kip @ 4.876 ft	0.000		-0.156	8.00 kip @ 80.750 ft 32.00 kip @ 66.750 ft 32.00 kip @ 36.750 ft
Span 1 Girder 2, (0.1L$_s$) 12.350	12.350	769.44	8.00 kip @ 56.350 ft 32.00 kip @ 42.350 ft 32.00 kip @ 12.350 ft	0.00		62.30	8.00 kip @ 56.350 ft 32.00 kip @ 42.350 ft 32.00 kip @ 12.350 ft	-3.68	32.00 kip @ 12.350 ft	0.000		-0.391	8.00 kip @ 81.461 ft 32.00 kip @ 67.461 ft 32.00 kip @ 37.461 ft
Span 1 Girder 2, (0.2L$_s$) 24.700	24.700	1334.37	8.00 kip @ 68.700 ft 32.00 kip @ 54.700 ft 32.00 kip @ 24.700 ft	0.00		54.02	8.00 kip @ 68.700 ft 32.00 kip @ 54.700 ft 32.00 kip @ 24.700 ft	-7.36	32.00 kip @ 24.700 ft	0.000		-0.745	8.00 kip @ 81.461 ft 32.00 kip @ 67.461 ft 32.00 kip @ 37.461 ft
Span 1 Girder 2, (0.3L$_s$) 37.050	37.050	1726.06	8.00 kip @ 23.050 ft 32.00 kip @ 37.050 ft 32.00 kip @ 67.050 ft	0.00		45.74	8.00 kip @ 81.050 ft 32.00 kip @ 67.050 ft 32.00 kip @ 37.050 ft	-13.14	32.00 kip @ 7.050 ft 32.00 kip @ 37.050 ft	0.000		-1.024	8.00 kip @ 81.461 ft 32.00 kip @ 67.461 ft 32.00 kip @ 37.461 ft
Span 1 Girder 2, (0.4L$_s$) 49.400	49.400	1935.31	8.00 kip @ 35.400 ft 32.00 kip @ 49.400 ft 32.00 kip @ 79.400 ft	0.00		37.46	8.00 kip @ 93.400 ft 32.00 kip @ 79.400 ft 32.00 kip @ 49.400 ft	-20.90	8.00 kip @ 5.400 ft 32.00 kip @ 19.400 ft 32.00 kip @ 49.400 ft	0.000		-1.201	8.00 kip @ 35.250 ft 32.00 kip @ 49.250 ft 32.00 kip @ 79.250 ft
Span 1 Girder 2, (0.5L$_s$) 61.750	61.750	1940.05	8.00 kip @ 47.750 ft 32.00 kip @ 61.750 ft 32.00 kip @ 91.750 ft	0.00		29.18	8.00 kip @ 105.750 ft 32.00 kip @ 91.750 ft 32.00 kip @ 61.750 ft	-29.18	8.00 kip @ 17.750 ft 32.00 kip @ 31.750 ft 32.00 kip @ 61.750 ft	0.000		-1.261	8.00 kip @ 88.050 ft 32.00 kip @ 74.050 ft 32.00 kip @ 44.050 ft
Span 1 Girder 2, (0.6L$_s$) 74.100	74.100	1935.31	8.00 kip @ 88.100 ft 32.00 kip	0.00		20.90	8.00 kip @ 118.100 ft 32.00 kip	-37.46	8.00 kip @ 30.100 ft 32.00 kip	0.000		-1.201	8.00 kip @ 88.250 ft 32.00 kip @ 74.250 ft

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Bridge: Job: 8/13/2022

	X (ft)	Moment Max (kip-ft)	Moment Max Config	Moment Min (kip-ft)	Moment Min Config	Shear Max (kip)	Shear Max Config	Shear Min (kip)	Shear Min Config	Deflection Max (in)	Deflection Max Config	Deflection Min (in)	Deflection Min Config
			@ 74.100 ft 32.00 kip @ 44.100 ft				32.00 kip @ 104.100 ft 32.00 kip @ 74.100 ft		@ 44.100 ft 32.00 kip @ 74.100 ft				32.00 kip @ 44.250 ft
Span 1 Girder 2, (0.7L$_s$) 86.450	86.450	1726.06	8.00 kip @ 100.450 ft 32.00 kip @ 86.450 ft 32.00 kip @ 56.450 ft	0.00		13.14	32.00 kip @ 116.450 ft 32.00 kip @ 86.450 ft	-45.74	8.00 kip @ 42.450 ft 32.00 kip @ 56.450 ft 32.00 kip @ 86.450 ft	0.000		-1.024	8.00 kip @ 42.039 ft 32.00 kip @ 56.039 ft 32.00 kip @ 86.039 ft
Span 1 Girder 2, (0.8L$_s$) 98.800	98.800	1334.37	8.00 kip @ 54.800 ft 32.00 kip @ 68.800 ft 32.00 kip @ 98.800 ft	0.00		7.36	32.00 kip @ 98.800 ft	-54.02	8.00 kip @ 54.800 ft 32.00 kip @ 68.800 ft 32.00 kip @ 98.800 ft	0.000		-0.745	8.00 kip @ 42.039 ft 32.00 kip @ 56.039 ft 32.00 kip @ 86.039 ft
Span 1 Girder 2, (0.9L$_s$) 111.150	111.150	769.44	8.00 kip @ 67.150 ft 32.00 kip @ 81.150 ft 32.00 kip @ 111.150 ft	0.00		3.68	32.00 kip @ 111.150 ft	-62.30	8.00 kip @ 67.150 ft 32.00 kip @ 81.150 ft 32.00 kip @ 111.150 ft	0.000		-0.391	8.00 kip @ 42.039 ft 32.00 kip @ 56.039 ft 32.00 kip @ 86.039 ft
Span 1 Girder 2, (CS) 118.624	118.624	328.21	8.00 kip @ 74.624 ft 32.00 kip @ 88.624 ft 32.00 kip @ 118.624 ft	0.00		1.45	32.00 kip @ 118.624 ft	-67.31	8.00 kip @ 74.624 ft 32.00 kip @ 88.624 ft 32.00 kip @ 118.624 ft	0.000		-0.156	8.00 kip @ 42.750 ft 32.00 kip @ 56.750 ft 32.00 kip @ 86.750 ft
Span 1 Girder 2, (1.0L$_s$) 123.500	123.500	0.00		0.00		0.00		-70.58	8.00 kip @ 79.500 ft 32.00 kip @ 93.500 ft 32.00 kip @ 123.500 ft	0.000		0.000	
Span 1 Girder 2, 123.500	123.500	0.00		0.00		0.00		0.00		0.000		0.000	

* Live Load values are per lane and include impact.

Live Load Reactions and Rotations for LRFD Fatigue Truck

	Reaction Max (kip)	Reaction Max Config	Reaction Min (kip)	Reaction Min Config	Rotation Max (rad)	Rotation Max Config	Rotation Min (rad)	Rotation Min Config
Abutment 1	70.58	8.00 kip @ 44.000 ft 32.00 kip @ 30.000 ft	0.00		0.00000		-0.00268	8.00 kip @ 80.750 ft 32.00 kip @ 66.750 ft

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Bridge: Job: 8/13/2022

	Reaction Max (kip)	Reaction Max Config	Reaction Min (kip)	Reaction Min Config	Rotation Max (rad)	Rotation Max Config	Rotation Min (rad)	Rotation Min Config
		32.00 kip @ 0.000 ft						32.00 kip @ 36.750 ft
Abutment 2	70.58	8.00 kip @ 79.500 ft 32.00 kip @ 93.500 ft 32.00 kip @ 123.500 ft	0.00		0.00268	8.00 kip @ 42.750 ft 32.00 kip @ 56.750 ft 32.00 kip @ 86.750 ft	0.00000	

* Live Load values are per lane and include impact.

Combined Results - Interval 2: Prestress Release

Moment

Location from Left Support (ft)	DC (kip-ft)	DW (kip-ft)	ΣDC (kip-ft)	ΣDW (kip-ft)	Service I (kip-ft)
Span 1 Girder 2, (STRF) -0.750	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (FoS) 0.542	68.02	0.00	68.02	0.00	68.02
Span 1 Girder 2, (Bar Develop.) 1.471	116.07	0.00	116.07	0.00	116.07
Span 1 Girder 2, (PSXFR) 2.250	155.80	0.00	155.80	0.00	155.80
Span 1 Girder 2, (Bar Cutoff) 2.375	162.13	0.00	162.13	0.00	162.13
Span 1 Girder 2, (SZB) 2.461	166.48	0.00	166.48	0.00	166.48
Span 1 Girder 2, (CS) 4.876	285.88	0.00	285.88	0.00	285.88
Span 1 Girder 2, (H) 5.042	293.90	0.00	293.90	0.00	293.90
Span 1 Girder 2, (1.5H) 7.292	400.37	0.00	400.37	0.00	400.37
Span 1 Girder 2, 11.750	598.62	0.00	598.62	0.00	598.62
Span 1 Girder 2, (SZB) 12.461	628.68	0.00	628.68	0.00	628.68
Span 1 Girder 2, (SZB) 22.461	1005.74	0.00	1005.74	0.00	1005.74
Span 1 Girder 2, 24.250	1064.21	0.00	1064.21	0.00	1064.21
Span 1 Girder 2, 36.750	1396.77	0.00	1396.77	0.00	1396.77
Span 1 Girder 2, (SZB) 37.461	1411.70	0.00	1411.70	0.00	1411.70
Span 1 Girder 2, 49.250	1596.31	0.00	1596.31	0.00	1596.31
Span 1 Girder 2, (HP) 55.575	1646.59	0.00	1646.59	0.00	1646.59
Span 1 Girder 2, (0.5L$_s$) 61.750	1662.83	0.00	1662.83	0.00	1662.83
Span 1 Girder 2, (HP) 67.925	1646.59	0.00	1646.59	0.00	1646.59
Span 1 Girder 2, 74.250	1596.31	0.00	1596.31	0.00	1596.31
Span 1 Girder 2, (SZB) 86.039	1411.70	0.00	1411.70	0.00	1411.70
Span 1 Girder 2, 86.750	1396.77	0.00	1396.77	0.00	1396.77
Span 1 Girder 2, 99.250	1064.21	0.00	1064.21	0.00	1064.21
Span 1 Girder 2, (SZB) 101.039	1005.74	0.00	1005.74	0.00	1005.74
Span 1 Girder 2, (SZB) 111.039	628.68	0.00	628.68	0.00	628.68
Span 1 Girder 2, 111.750	598.62	0.00	598.62	0.00	598.62
Span 1 Girder 2, (1.5H) 116.208	400.37	0.00	400.37	0.00	400.37
Span 1 Girder 2, (H) 118.458	293.90	0.00	293.90	0.00	293.90
Span 1 Girder 2, (CS) 118.624	285.88	0.00	285.88	0.00	285.88
Span 1 Girder 2, (SZB) 121.039	166.48	0.00	166.48	0.00	166.48
Span 1 Girder 2, (Bar Cutoff) 121.125	162.13	0.00	162.13	0.00	162.13
Span 1 Girder 2, (PSXFR) 121.250	155.80	0.00	155.80	0.00	155.80
Span 1 Girder 2, (Bar Develop.) 122.029	116.07	0.00	116.07	0.00	116.07
Span 1 Girder 2, (FoS) 122.958	68.02	0.00	68.02	0.00	68.02
Span 1 Girder 2, (STLF) 124.250	0.00	0.00	0.00	0.00	0.00

Shear

Location from Left Support (ft)	DC (kip)	DW (kip)	ΣDC (kip)	ΣDW (kip)	Service I (kip)
Span 1 Girder 2, (STRF) -0.750	53.21	0.00	53.21	0.00	53.21
Span 1 Girder 2, (FoS) 0.542	52.11	0.00	52.11	0.00	52.11
Span 1 Girder 2, (Bar Develop.) 1.471	51.32	0.00	51.32	0.00	51.32
Span 1 Girder 2, (PSXFR) 2.250	50.66	0.00	50.66	0.00	50.66
Span 1 Girder 2, (Bar Cutoff) 2.375	50.55	0.00	50.55	0.00	50.55
Span 1 Girder 2, (SZB) 2.461	50.48	0.00	50.48	0.00	50.48

Bridge: Job: 8/13/2022

Location from Left Support (ft)	DC (kip)	DW (kip)	ΣDC (kip)	ΣDW (kip)	Service I (kip)
Span 1 Girder 2, (CS) 4.876	48.42	0.00	48.42	0.00	48.42
Span 1 Girder 2, (H) 5.042	48.28	0.00	48.28	0.00	48.28
Span 1 Girder 2, (1.5H) 7.292	46.36	0.00	46.36	0.00	46.36
Span 1 Girder 2, 11.750	42.57	0.00	42.57	0.00	42.57
Span 1 Girder 2, (SZB) 12.461	41.96	0.00	41.96	0.00	41.96
Span 1 Girder 2, (SZB) 22.461	33.45	0.00	33.45	0.00	33.45
Span 1 Girder 2, 24.250	31.93	0.00	31.93	0.00	31.93
Span 1 Girder 2, 36.750	21.28	0.00	21.28	0.00	21.28
Span 1 Girder 2, (SZB) 37.461	20.68	0.00	20.68	0.00	20.68
Span 1 Girder 2, 49.250	10.64	0.00	10.64	0.00	10.64
Span 1 Girder 2, (HP) 55.575	5.26	0.00	5.26	0.00	5.26
Span 1 Girder 2, (0.5L$_s$) 61.750	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (HP) 67.925	-5.26	0.00	-5.26	0.00	-5.26
Span 1 Girder 2, 74.250	-10.64	0.00	-10.64	0.00	-10.64
Span 1 Girder 2, (SZB) 86.039	-20.68	0.00	-20.68	0.00	-20.68
Span 1 Girder 2, 86.750	-21.28	0.00	-21.28	0.00	-21.28
Span 1 Girder 2, 99.250	-31.93	0.00	-31.93	0.00	-31.93
Span 1 Girder 2, (SZB) 101.039	-33.45	0.00	-33.45	0.00	-33.45
Span 1 Girder 2, (SZB) 111.039	-41.96	0.00	-41.96	0.00	-41.96
Span 1 Girder 2, 111.750	-42.57	0.00	-42.57	0.00	-42.57
Span 1 Girder 2, (1.5H) 116.208	-46.36	0.00	-46.36	0.00	-46.36
Span 1 Girder 2, (H) 118.458	-48.28	0.00	-48.28	0.00	-48.28
Span 1 Girder 2, (CS) 118.624	-48.42	0.00	-48.42	0.00	-48.42
Span 1 Girder 2, (SZB) 121.039	-50.48	0.00	-50.48	0.00	-50.48
Span 1 Girder 2, (Bar Cutoff) 121.125	-50.55	0.00	-50.55	0.00	-50.55
Span 1 Girder 2, (PSXFR) 121.250	-50.66	0.00	-50.66	0.00	-50.66
Span 1 Girder 2, (Bar Develop.) 122.029	-51.32	0.00	-51.32	0.00	-51.32
Span 1 Girder 2, (FoS) 122.958	-52.11	0.00	-52.11	0.00	-52.11
Span 1 Girder 2, (STLF) 124.250	-53.21	0.00	-53.21	0.00	-53.21

Combined Results - Interval 10: Cast Deck, Apply User Defined Loads

Moment

Location from Left Support (ft)	DC (kip-ft)	DW (kip-ft)	ΣDC (kip-ft)	ΣDW (kip-ft)	Service I (kip-ft)
Span 1 Girder 2, (STRF) -0.750	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, 0.000	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (0.0L$_s$) 0.000	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (FoS) 0.542	32.07	0.00	60.42	0.00	60.42
Span 1 Girder 2, (Bar Develop.) 1.471	86.41	0.00	162.81	0.00	162.81
Span 1 Girder 2, (PSXFR) 2.250	131.36	0.00	247.49	0.00	247.49
Span 1 Girder 2, (Bar Cutoff) 2.375	138.51	0.00	260.97	0.00	260.97
Span 1 Girder 2, (SZB) 2.461	143.44	0.00	270.26	0.00	270.26
Span 1 Girder 2, (CS) 4.876	278.50	0.00	524.71	0.00	524.71
Span 1 Girder 2, (H) 5.042	287.57	0.00	541.79	0.00	541.79
Span 1 Girder 2, (1.5H) 7.292	408.00	0.00	768.70	0.00	768.70
Span 1 Girder 2, (0.1L$_s$) 12.350	660.96	0.00	1245.29	0.00	1245.29
Span 1 Girder 2, (SZB) 12.461	666.24	0.00	1255.26	0.00	1255.26
Span 1 Girder 2, (SZB) 22.461	1092.74	0.00	2058.82	0.00	2058.82
Span 1 Girder 2, (0.2L$_s$) 24.700	1175.03	0.00	2213.85	0.00	2213.85
Span 1 Girder 2, (0.3L$_s$) 37.050	1542.23	0.00	2905.68	0.00	2905.68
Span 1 Girder 2, (SZB) 37.461	1551.93	0.00	2923.96	0.00	2923.96
Span 1 Girder 2, (0.4L$_s$) 49.400	1762.55	0.00	3320.78	0.00	3320.78
Span 1 Girder 2, (HP) 55.575	1817.63	0.00	3424.56	0.00	3424.56
	1835.99	0.00	3459.15	0.00	3459.15

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Location from Left Support (ft)	DC (kip-ft)	DW (kip-ft)	ΣDC (kip-ft)	ΣDW (kip-ft)	Service I (kip-ft)
Span 1 Girder 2, (0.5L$_s$) 61.750					
Span 1 Girder 2, (HP) 67.925	1817.63	0.00	3424.56	0.00	3424.56
Span 1 Girder 2, (0.6L$_s$) 74.100	1762.55	0.00	3320.78	0.00	3320.78
Span 1 Girder 2, (SZB) 86.039	1551.93	0.00	2923.96	0.00	2923.96
Span 1 Girder 2, (0.7L$_s$) 86.450	1542.23	0.00	2905.68	0.00	2905.68
Span 1 Girder 2, (0.8L$_s$) 98.800	1175.03	0.00	2213.85	0.00	2213.85
Span 1 Girder 2, (SZB) 101.039	1092.74	0.00	2058.82	0.00	2058.82
Span 1 Girder 2, (SZB) 111.039	666.24	0.00	1255.26	0.00	1255.26
Span 1 Girder 2, (0.9L$_s$) 111.150	660.96	0.00	1245.29	0.00	1245.29
Span 1 Girder 2, (1.5H) 116.208	408.00	0.00	768.70	0.00	768.70
Span 1 Girder 2, (H) 118.458	287.57	0.00	541.79	0.00	541.79
Span 1 Girder 2, (CS) 118.624	278.50	0.00	524.71	0.00	524.71
Span 1 Girder 2, (SZB) 121.039	143.44	0.00	270.26	0.00	270.26
Span 1 Girder 2, (Bar Cutoff) 121.125	138.51	0.00	260.97	0.00	260.97
Span 1 Girder 2, (PSXFR) 121.250	131.36	0.00	247.49	0.00	247.49
Span 1 Girder 2, (Bar Develop.) 122.029	86.41	0.00	162.81	0.00	162.81
Span 1 Girder 2, (FoS) 122.958	32.07	0.00	60.42	0.00	60.42
Span 1 Girder 2, (1.0L$_s$) 123.500	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, 123.500	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (STLF) 124.250	0.00	0.00	0.00	0.00	0.00

Shear

Location from Left Support (ft)	DC (kip)	DW (kip)	ΣDC (kip)	ΣDW (kip)	Service I (kip)
Span 1 Girder 2, (STRF) -0.750	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, 0.000	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (0.0L$_s$) 0.000	60.10 59.47	0.00	113.31 112.04	0.00	113.31 112.04
Span 1 Girder 2, (FoS) 0.542	58.94	0.00	111.05	0.00	111.05
Span 1 Girder 2, (Bar Develop.) 1.471	58.05	0.00	109.37	0.00	109.37
Span 1 Girder 2, (PSXFR) 2.250	57.30	0.00	107.95	0.00	107.95
Span 1 Girder 2, (Bar Cutoff) 2.375	57.18	0.00	107.73	0.00	107.73
Span 1 Girder 2, (SZB) 2.461	57.10	0.00	107.57	0.00	107.57
Span 1 Girder 2, (CS) 4.876	54.77	0.00	103.19	0.00	103.19
Span 1 Girder 2, (H) 5.042	54.61	0.00	102.89	0.00	102.89
Span 1 Girder 2, (1.5H) 7.292	52.44	0.00	98.81	0.00	98.81
Span 1 Girder 2, (0.1L$_s$) 12.350	47.57	0.00	89.63	0.00	89.63
Span 1 Girder 2, (SZB) 12.461	47.47	0.00	89.43	0.00	89.43
Span 1 Girder 2, (SZB) 22.461	37.84	0.00	71.28	0.00	71.28
Span 1 Girder 2, (0.2L$_s$) 24.700	35.68	0.00	67.22	0.00	67.22
Span 1 Girder 2, (0.3L$_s$) 37.050	23.79	0.00	44.81	0.00	44.81
Span 1 Girder 2, (SZB) 37.461	23.39	0.00	44.07	0.00	44.07
Span 1 Girder 2, (0.4L$_s$) 49.400	11.89	0.00	22.41	0.00	22.41
Span 1 Girder 2, (HP) 55.575	5.95	0.00	11.20	0.00	11.20
Span 1 Girder 2, (0.5L$_s$) 61.750	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (HP) 67.925	-5.95	0.00	-11.20	0.00	-11.20
Span 1 Girder 2, (0.6L$_s$) 74.100	-11.89	0.00	-22.41	0.00	-22.41
Span 1 Girder 2, (SZB) 86.039	-23.39	0.00	-44.07	0.00	-44.07
Span 1 Girder 2, (0.7L$_s$) 86.450	-23.79	0.00	-44.81	0.00	-44.81
Span 1 Girder 2, (0.8L$_s$) 98.800	-35.68	0.00	-67.22	0.00	-67.22
Span 1 Girder 2, (SZB) 101.039	-37.84	0.00	-71.28	0.00	-71.28
Span 1 Girder 2, (SZB) 111.039	-47.47	0.00	-89.43	0.00	-89.43

Bridge: Job: 8/13/2022

Location from Left Support (ft)	DC (kip)	DW (kip)	ΣDC (kip)	ΣDW (kip)	Service I (kip)
Span 1 Girder 2, (0.9L$_s$) 111.150	-47.57	0.00	-89.63	0.00	-89.63
Span 1 Girder 2, (1.5H) 116.208	-52.44	0.00	-98.81	0.00	-98.81
Span 1 Girder 2, (H) 118.458	-54.61	0.00	-102.89	0.00	-102.89
Span 1 Girder 2, (CS) 118.624	-54.77	0.00	-103.19	0.00	-103.19
Span 1 Girder 2, (SZB) 121.039	-57.10	0.00	-107.57	0.00	-107.57
Span 1 Girder 2, (Bar Cutoff) 121.125	-57.18	0.00	-107.73	0.00	-107.73
Span 1 Girder 2, (PSXFR) 121.250	-57.30	0.00	-107.95	0.00	-107.95
Span 1 Girder 2, (Bar Develop.) 122.029	-58.05	0.00	-109.37	0.00	-109.37
Span 1 Girder 2, (FoS) 122.958	-58.94	0.00	-111.05	0.00	-111.05
Span 1 Girder 2, (1.0L$_s$) 123.500	-59.47 -60.10	0.00	-112.04 -113.31	0.00	-112.04 -113.31
Span 1 Girder 2, 123.500	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (STLF) 124.250	0.00	0.00	0.00	0.00	0.00

Girder Line Pier Reactions

	DC (kip)	DW (kip)	ΣDC (kip)	ΣDW (kip)
Abutment 1	60.10	0.00	113.31	0.00
Abutment 2	60.10	0.00	113.31	0.00

Girder Bearing Reactions

	DC (kip)	DW (kip)	ΣDC (kip)	ΣDW (kip)
Abutment 1 - Ahead	60.10	0.00	113.31	0.00
Abutment 2 - Back	60.10	0.00	113.31	0.00

Combined Results - Interval 16: Open to Traffic

Moment and Shear

Location from Left Support (ft)	Strength/Service			Fatigue/Special Permit Rating		
	+M	-M	V	+M	-M	V
Span 1 Girder 2, 0.000	0.615	---	0.814	0.353	---	0.567
Span 1 Girder 2, (0.0L$_s$) 0.000	0.615	---	0.814	0.353	---	0.567
Span 1 Girder 2, (0.1L$_s$) 12.350	0.615	---	0.814	0.353	---	0.567
Span 1 Girder 2, (0.2L$_s$) 24.700	0.615	---	0.814	0.353	---	0.567
Span 1 Girder 2, (0.3L$_s$) 37.050	0.615	---	0.814	0.353	---	0.567
Span 1 Girder 2, (0.4L$_s$) 49.400	0.615	---	0.814	0.353	---	0.567
Span 1 Girder 2, (0.5L$_s$) 61.750	0.615	---	0.814	0.353	---	0.567
Span 1 Girder 2, (0.6L$_s$) 74.100	0.615	---	0.814	0.353	---	0.567
Span 1 Girder 2, (0.7L$_s$) 86.450	0.615	---	0.814	0.353	---	0.567
Span 1 Girder 2, (0.8L$_s$) 98.800	0.615	---	0.814	0.353	---	0.567
Span 1 Girder 2, (0.9L$_s$) 111.150	0.615	---	0.814	0.353	---	0.567
Span 1 Girder 2, (1.0L$_s$) 123.500	0.615	---	0.814	0.353	---	0.567
Span 1 Girder 2, 123.500	0.615	---	0.814	0.353	---	0.567

Note that the lever rule used to compute distribution factors if the range of applicability requirements are exceeded.

Moment

Location from Left Support (ft)	DC (kip-ft)	DW (kip-ft)	ΣDC (kip-ft)	ΣDW (kip-ft)
Span 1 Girder 2, (STRF) -0.750	0.00	0.00	0.00	0.00
Span 1 Girder 2, 0.000	0.00	0.00	0.00	0.00
Span 1 Girder 2, (0.0L$_s$) 0.000	0.00	0.00	0.00	0.00
Span 1 Girder 2, (FoS) 0.542	0.00	0.00	64.59	0.00
Span 1 Girder 2, (Bar Develop.) 1.471	0.00	0.00	174.06	0.00
Span 1 Girder 2, (PSXFR) 2.250	0.00	0.00	264.59	0.00

Bridge: Job: 8/13/2022

Location from Left Support (ft)	DC (kip-ft)	DW (kip-ft)	ΣDC (kip-ft)	ΣDW (kip-ft)
Span 1 Girder 2, (Bar Cutoff) 2.375	0.00	0.00	279.00	0.00
Span 1 Girder 2, (SZB) 2.461	0.00	0.00	288.93	0.00
Span 1 Girder 2, (CS) 4.876	0.00	0.00	560.96	0.00
Span 1 Girder 2, (H) 5.042	0.00	0.00	579.22	0.00
Span 1 Girder 2, (1.5H) 7.292	0.00	0.00	821.80	0.00
Span 1 Girder 2, (0.1L$_s$) 12.350	0.00	0.00	1331.32	0.00
Span 1 Girder 2, (SZB) 12.461	0.00	0.00	1341.97	0.00
Span 1 Girder 2, (SZB) 22.461	0.00	0.00	2201.04	0.00
Span 1 Girder 2, (0.2L$_s$) 24.700	0.00	0.00	2366.78	0.00
Span 1 Girder 2, (0.3L$_s$) 37.050	0.00	0.00	3106.40	0.00
Span 1 Girder 2, (SZB) 37.461	0.00	0.00	3125.94	0.00
Span 1 Girder 2, (0.4L$_s$) 49.400	0.00	0.00	3550.18	0.00
Span 1 Girder 2, (HP) 55.575	0.00	0.00	3661.12	0.00
Span 1 Girder 2, (0.5L$_s$) 61.750	0.00	0.00	3698.10	0.00
Span 1 Girder 2, (HP) 67.925	0.00	0.00	3661.12	0.00
Span 1 Girder 2, (0.6L$_s$) 74.100	0.00	0.00	3550.18	0.00
Span 1 Girder 2, (SZB) 86.039	0.00	0.00	3125.94	0.00
Span 1 Girder 2, (0.7L$_s$) 86.450	0.00	0.00	3106.40	0.00
Span 1 Girder 2, (0.8L$_s$) 98.800	0.00	0.00	2366.78	0.00
Span 1 Girder 2, (SZB) 101.039	0.00	0.00	2201.04	0.00
Span 1 Girder 2, (SZB) 111.039	0.00	0.00	1341.97	0.00
Span 1 Girder 2, (0.9L$_s$) 111.150	0.00	0.00	1331.32	0.00
Span 1 Girder 2, (1.5H) 116.208	0.00	0.00	821.80	0.00
Span 1 Girder 2, (H) 118.458	0.00	0.00	579.22	0.00
Span 1 Girder 2, (CS) 118.624	0.00	0.00	560.96	0.00
Span 1 Girder 2, (SZB) 121.039	0.00	0.00	288.93	0.00
Span 1 Girder 2, (Bar Cutoff) 121.125	0.00	0.00	279.00	0.00
Span 1 Girder 2, (PSXFR) 121.250	0.00	0.00	264.59	0.00
Span 1 Girder 2, (Bar Develop.) 122.029	0.00	0.00	174.06	0.00
Span 1 Girder 2, (FoS) 122.958	0.00	0.00	64.59	0.00
Span 1 Girder 2, (1.0L$_s$) 123.500	0.00	0.00	0.00	0.00
Span 1 Girder 2, 123.500	0.00	0.00	0.00	0.00
Span 1 Girder 2, (STLF) 124.250	0.00	0.00	0.00	0.00

Moment - Design Vehicles

Location from Left Support (ft)	Live Load			
	* LL+IM Design		* LL+IM Fatigue	
	Max (kip-ft)	Min (kip-ft)	Max (kip-ft)	Min (kip-ft)
Span 1 Girder 2, (STRF) -0.750	0.00	0.00	0.00	0.00
Span 1 Girder 2, 0.000	0.00	0.00	0.00	0.00
Span 1 Girder 2, (0.0L$_s$) 0.000	0.00	0.00	0.00	0.00
Span 1 Girder 2, (FoS) 0.542	42.46	0.00	13.44	0.00
Span 1 Girder 2, (Bar Develop.) 1.471	114.37	0.00	36.17	0.00
Span 1 Girder 2, (PSXFR) 2.250	173.80	0.00	54.92	0.00
Span 1 Girder 2, (Bar Cutoff) 2.375	183.25	0.00	57.90	0.00
Span 1 Girder 2, (SZB) 2.461	189.77	0.00	59.96	0.00
Span 1 Girder 2, (CS) 4.876	368.00	0.00	115.99	0.00
Span 1 Girder 2, (H) 5.042	379.95	0.00	119.73	0.00
Span 1 Girder 2, (1.5H) 7.292	538.46	0.00	169.28	0.00
Span 1 Girder 2, (0.1L$_s$) 12.350	869.90	0.00	271.91	0.00
Span 1 Girder 2, (SZB) 12.461	876.81	0.00	274.04	0.00
Span 1 Girder 2, (SZB) 22.461	1429.10	0.00	440.73	0.00

Bridge: Job: 8/13/2022

Location from Left Support (ft)	Live Load			
	* LL+IM Design		* LL+IM Fatigue	
	Max (kip-ft)	Min (kip-ft)	Max (kip-ft)	Min (kip-ft)
Span 1 Girder 2, (0.2L$_s$) 24.700	1534.28	0.00	471.55	0.00
Span 1 Girder 2, (0.3L$_s$) 37.050	1993.13	0.00	609.97	0.00
Span 1 Girder 2, (SZB) 37.461	2004.87	0.00	613.60	0.00
Span 1 Girder 2, (0.4L$_s$) 49.400	2264.77	0.00	683.92	0.00
Span 1 Girder 2, (HP) 55.575	2328.10	0.00	693.79	0.00
Span 1 Girder 2, (0.5L$_s$) 61.750	2340.05	0.00	685.60	0.00
Span 1 Girder 2, (HP) 67.925	2328.10	0.00	693.79	0.00
Span 1 Girder 2, (0.6L$_s$) 74.100	2264.77	0.00	683.92	0.00
Span 1 Girder 2, (SZB) 86.039	2004.87	0.00	613.60	0.00
Span 1 Girder 2, (0.7L$_s$) 86.450	1993.13	0.00	609.97	0.00
Span 1 Girder 2, (0.8L$_s$) 98.800	1534.28	0.00	471.55	0.00
Span 1 Girder 2, (SZB) 101.039	1429.10	0.00	440.73	0.00
Span 1 Girder 2, (SZB) 111.039	876.81	0.00	274.04	0.00
Span 1 Girder 2, (0.9L$_s$) 111.150	869.90	0.00	271.91	0.00
Span 1 Girder 2, (1.5H) 116.208	538.46	0.00	169.28	0.00
Span 1 Girder 2, (H) 118.458	379.95	0.00	119.73	0.00
Span 1 Girder 2, (CS) 118.624	368.00	0.00	115.99	0.00
Span 1 Girder 2, (SZB) 121.039	189.77	0.00	59.96	0.00
Span 1 Girder 2, (Bar Cutoff) 121.125	183.25	0.00	57.90	0.00
Span 1 Girder 2, (PSXFR) 121.250	173.80	0.00	54.92	0.00
Span 1 Girder 2, (Bar Develop.) 122.029	114.37	0.00	36.17	0.00
Span 1 Girder 2, (FoS) 122.958	42.46	0.00	13.44	0.00
Span 1 Girder 2, (1.0L$_s$) 123.500	0.00	0.00	0.00	0.00
Span 1 Girder 2, 123.500	0.00	0.00	0.00	0.00
Span 1 Girder 2, (STLF) 124.250	0.00	0.00	0.00	0.00

* Live Load values are per girder and include impact.

Moment, Mu

Location from Left Support (ft)	Design					
	Service I (kip-ft)	Service III (kip-ft)	Fatigue I (kip-ft)	Strength I		
				Max (kip-ft)	Min (kip-ft)	* Deck (kip-ft)
Span 1 Girder 2, (STRF) -0.750	0.00	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, 0.000	0.00	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (0.0L$_s$) 0.000	0.00	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (FoS) 0.542	107.06	98.56	52.46	155.05	58.13	58.13
Span 1 Girder 2, (Bar Develop.) 1.471	288.43	265.56	141.29	417.72	156.65	156.65
Span 1 Girder 2, (PSXFR) 2.250	438.38	403.62	214.68	634.88	238.13	238.13
Span 1 Girder 2, (Bar Cutoff) 2.375	462.25	425.60	226.36	669.44	251.10	251.10
Span 1 Girder 2, (SZB) 2.461	478.69	440.74	234.40	693.25	260.04	260.04
Span 1 Girder 2, (CS) 4.876	928.96	855.36	454.46	1345.20	504.86	504.86
Span 1 Girder 2, (H) 5.042	959.17	883.18	469.21	1388.94	521.30	521.30
Span 1 Girder 2, (1.5H) 7.292	1360.26	1252.57	664.83	1969.56	739.62	739.62
Span 1 Girder 2, (0.1L$_s$) 12.350	2201.22	2027.24	1073.53	3186.48	1198.18	1198.18
Span 1 Girder 2, (SZB) 12.461	2218.77	2043.41	1082.04	3211.87	1207.77	1207.77
Span 1 Girder 2, (SZB) 22.461	3630.13	3344.31	1761.61	5252.21	1980.93	1980.93
Span 1 Girder 2, (0.2L$_s$) 24.700	3901.06	3594.21	1890.72	5643.47	2130.11	2130.11
Span 1 Girder 2, (0.3L$_s$) 37.050	5099.53	4700.90	2468.16	7370.97	2795.76	2795.76
Span 1 Girder 2, (SZB) 37.461	5130.81	4729.84	2483.37	7415.95	2813.35	2813.35
Span 1 Girder 2, (0.4L$_s$) 49.400	5814.94	5361.99	2800.97	8401.06	3195.16	3195.16
Span 1 Girder 2, (HP) 55.575	5989.22	5523.60	2871.25	8650.57	3295.01	3295.01
	6038.15	5570.14	2877.44	8717.70	3328.29	3328.29

Bridge: Job: 8/13/2022

Location from Left Support (ft)	Design					
	Service I (kip-ft)	Service III (kip-ft)	Fatigue I (kip-ft)	Strength I		
				Max (kip-ft)	Min (kip-ft)	* Deck (kip-ft)
Span 1 Girder 2, (0.5L$_s$) 61.750						
Span 1 Girder 2, (HP) 67.925	5989.22	5523.60	2871.25	8650.57	3295.01	3295.01
Span 1 Girder 2, (0.6L$_s$) 74.100	5814.94	5361.99	2800.97	8401.06	3195.16	3195.16
Span 1 Girder 2, (SZB) 86.039	5130.81	4729.84	2483.37	7415.95	2813.35	2813.35
Span 1 Girder 2, (0.7L$_s$) 86.450	5099.53	4700.90	2468.16	7370.97	2795.76	2795.76
Span 1 Girder 2, (0.8L$_s$) 98.800	3901.06	3594.21	1890.72	5643.47	2130.11	2130.11
Span 1 Girder 2, (SZB) 101.039	3630.13	3344.31	1761.61	5252.21	1980.93	1980.93
Span 1 Girder 2, (SZB) 111.039	2218.77	2043.41	1082.04	3211.87	1207.77	1207.77
Span 1 Girder 2, (0.9L$_s$) 111.150	2201.22	2027.24	1073.53	3186.48	1198.18	1198.18
Span 1 Girder 2, (1.5H) 116.208	1360.26	1252.57	664.83	1969.56	739.62	739.62
Span 1 Girder 2, (H) 118.458	959.17	883.18	469.21	1388.94	521.30	521.30
Span 1 Girder 2, (CS) 118.624	928.96	855.36	454.46	1345.20	504.86	504.86
Span 1 Girder 2, (SZB) 121.039	478.69	440.74	234.40	693.25	260.04	260.04
Span 1 Girder 2, (Bar Cutoff) 121.125	462.25	425.60	226.36	669.44	251.10	251.10
Span 1 Girder 2, (PSXFR) 121.250	438.38	403.62	214.68	634.88	238.13	238.13
Span 1 Girder 2, (Bar Develop.) 122.029	288.43	265.56	141.29	417.72	156.65	156.65
Span 1 Girder 2, (FoS) 122.958	107.06	98.56	52.46	155.05	58.13	58.13
Span 1 Girder 2, (1.0L$_s$) 123.500	0.00	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, 123.500	0.00	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (STLF) 124.250	0.00	0.00	0.00	0.00	0.00	0.00

* Deck moment (Mu) is for negative moment deck design.

Shear

Location from Left Support (ft)	DC (kip)	DW (kip)	ΣDC (kip)	ΣDW (kip)
Span 1 Girder 2, (STRF) -0.750	0.00	0.00	0.00	0.00
Span 1 Girder 2, 0.000	0.00	0.00	0.00	0.00
Span 1 Girder 2, (0.0L$_s$) 0.000	0.00	0.00	121.15 119.78	0.00
Span 1 Girder 2, (FoS) 0.542	0.00	0.00	118.73	0.00
Span 1 Girder 2, (Bar Develop.) 1.471	0.00	0.00	116.92	0.00
Span 1 Girder 2, (PSXFR) 2.250	0.00	0.00	115.41	0.00
Span 1 Girder 2, (Bar Cutoff) 2.375	0.00	0.00	115.17	0.00
Span 1 Girder 2, (SZB) 2.461	0.00	0.00	115.00	0.00
Span 1 Girder 2, (CS) 4.876	0.00	0.00	110.32	0.00
Span 1 Girder 2, (H) 5.042	0.00	0.00	110.00	0.00
Span 1 Girder 2, (1.5H) 7.292	0.00	0.00	105.63	0.00
Span 1 Girder 2, (0.1L$_s$) 12.350	0.00	0.00	95.82	0.00
Span 1 Girder 2, (SZB) 12.461	0.00	0.00	95.61	0.00
Span 1 Girder 2, (SZB) 22.461	0.00	0.00	76.21	0.00
Span 1 Girder 2, (0.2L$_s$) 24.700	0.00	0.00	71.87	0.00
Span 1 Girder 2, (0.3L$_s$) 37.050	0.00	0.00	47.91	0.00
Span 1 Girder 2, (SZB) 37.461	0.00	0.00	47.11	0.00
Span 1 Girder 2, (0.4L$_s$) 49.400	0.00	0.00	23.96	0.00
Span 1 Girder 2, (HP) 55.575	0.00	0.00	11.98	0.00
Span 1 Girder 2, (0.5L$_s$) 61.750	0.00	0.00	0.00	0.00
Span 1 Girder 2, (HP) 67.925	0.00	0.00	-11.98	0.00
Span 1 Girder 2, (0.6L$_s$) 74.100	0.00	0.00	-23.96	0.00
Span 1 Girder 2, (SZB) 86.039	0.00	0.00	-47.11	0.00
Span 1 Girder 2, (0.7L$_s$) 86.450	0.00	0.00	-47.91	0.00
Span 1 Girder 2, (0.8L$_s$) 98.800	0.00	0.00	-71.87	0.00

Bridge: Job: 8/13/2022

Location from Left Support (ft)	DC (kip)	DW (kip)	ΣDC (kip)	ΣDW (kip)
Span 1 Girder 2, (SZB) 101.039	0.00	0.00	-76.21	0.00
Span 1 Girder 2, (SZB) 111.039	0.00	0.00	-95.61	0.00
Span 1 Girder 2, (0.9L$_s$) 111.150	0.00	0.00	-95.82	0.00
Span 1 Girder 2, (1.5H) 116.208	0.00	0.00	-105.63	0.00
Span 1 Girder 2, (H) 118.458	0.00	0.00	-110.00	0.00
Span 1 Girder 2, (CS) 118.624	0.00	0.00	-110.32	0.00
Span 1 Girder 2, (SZB) 121.039	0.00	0.00	-115.00	0.00
Span 1 Girder 2, (Bar Cutoff) 121.125	0.00	0.00	-115.17	0.00
Span 1 Girder 2, (PSXFR) 121.250	0.00	0.00	-115.41	0.00
Span 1 Girder 2, (Bar Develop.) 122.029	0.00	0.00	-116.92	0.00
Span 1 Girder 2, (FoS) 122.958	0.00	0.00	-118.73	0.00
Span 1 Girder 2, (1.0L$_s$) 123.500	0.00	0.00	-119.78 -121.15	0.00
Span 1 Girder 2, 123.500	0.00	0.00	0.00	0.00
Span 1 Girder 2, (STLF) 124.250	0.00	0.00	0.00	0.00

Shear - Design Vehicles

Location from Left Support (ft)	Live Load			
	* LL+IM Design		* LL+IM Fatigue	
	Max (kip)	Min (kip)	Max (kip)	Min (kip)
Span 1 Girder 2, (STRF) -0.750	0.00	0.00	0.00	0.00
Span 1 Girder 2, 0.000	0.00	0.00	0.00	0.00
Span 1 Girder 2, (0.0L$_s$) 0.000	104.27	0.00	39.99	0.00
Span 1 Girder 2, (FoS) 0.542	103.65	-0.15	39.79	-0.09
Span 1 Girder 2, (Bar Develop.) 1.471	102.58	-0.42	39.44	-0.25
Span 1 Girder 2, (PSXFR) 2.250	101.69	-0.64	39.14	-0.38
Span 1 Girder 2, (Bar Cutoff) 2.375	101.54	-0.68	39.09	-0.40
Span 1 Girder 2, (SZB) 2.461	101.45	-0.70	39.06	-0.42
Span 1 Girder 2, (CS) 4.876	98.70	-1.42	38.14	-0.82
Span 1 Girder 2, (H) 5.042	98.51	-1.47	38.08	-0.85
Span 1 Girder 2, (1.5H) 7.292	95.98	-2.43	37.22	-1.23
Span 1 Girder 2, (0.1L$_s$) 12.350	90.36	-4.86	35.30	-2.09
Span 1 Girder 2, (SZB) 12.461	90.23	-4.91	35.26	-2.10
Span 1 Girder 2, (SZB) 22.461	79.45	-10.04	31.46	-3.79
Span 1 Girder 2, (0.2L$_s$) 24.700	77.09	-11.24	30.61	-4.17
Span 1 Girder 2, (0.3L$_s$) 37.050	64.46	-20.40	25.92	-7.45
Span 1 Girder 2, (SZB) 37.461	64.05	-20.72	25.76	-7.58
Span 1 Girder 2, (0.4L$_s$) 49.400	52.48	-30.45	21.23	-11.84
Span 1 Girder 2, (HP) 55.575	46.73	-35.71	18.88	-14.19
Span 1 Girder 2, (0.5L$_s$) 61.750	41.14	-41.14	16.54	-16.54
Span 1 Girder 2, (HP) 67.925	35.71	-46.73	14.19	-18.88
Span 1 Girder 2, (0.6L$_s$) 74.100	30.45	-52.48	11.84	-21.23
Span 1 Girder 2, (SZB) 86.039	20.72	-64.05	7.58	-25.76
Span 1 Girder 2, (0.7L$_s$) 86.450	20.40	-64.46	7.45	-25.92
Span 1 Girder 2, (0.8L$_s$) 98.800	11.24	-77.09	4.17	-30.61
Span 1 Girder 2, (SZB) 101.039	10.04	-79.45	3.79	-31.46
Span 1 Girder 2, (SZB) 111.039	4.91	-90.23	2.10	-35.26
Span 1 Girder 2, (0.9L$_s$) 111.150	4.86	-90.36	2.09	-35.30
Span 1 Girder 2, (1.5H) 116.208	2.43	-95.98	1.23	-37.22
Span 1 Girder 2, (H) 118.458	1.47	-98.51	0.85	-38.08
Span 1 Girder 2, (CS) 118.624	1.42	-98.70	0.82	-38.14
Span 1 Girder 2, (SZB) 121.039	0.70	-101.45	0.42	-39.06

99

Location from Left Support (ft)	Live Load			
	* LL+IM Design		* LL+IM Fatigue	
	Max (kip)	Min (kip)	Max (kip)	Min (kip)
Span 1 Girder 2, (Bar Cutoff) 121.125	0.68	-101.54	0.40	-39.09
Span 1 Girder 2, (PSXFR) 121.250	0.64	-101.69	0.38	-39.14
Span 1 Girder 2, (Bar Develop.) 122.029	0.42	-102.58	0.25	-39.44
Span 1 Girder 2, (FoS) 122.958	0.15	-103.65	0.09	-39.79
Span 1 Girder 2, (1.0L$_s$) 123.500	0.00	-104.27	0.00	-39.99
Span 1 Girder 2, 123.500	0.00	0.00	0.00	0.00
Span 1 Girder 2, (STLF) 124.250	0.00	0.00	0.00	0.00

* Live Load values are per girder and include impact.

Shear, Vu

Location from Left Support (ft)	Design				
	Service I (kip)	Service III (kip)	Fatigue I (kip)	Strength I	
				Max (kip)	Min (kip)
Span 1 Girder 2, (STRF) -0.750	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, 0.000	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (0.0L$_s$) 0.000	225.42 224.05	204.56 203.19	120.56 119.88	333.90 332.19	109.03 107.80
Span 1 Girder 2, (FoS) 0.542	222.37	201.64	119.05	329.79	106.59
Span 1 Girder 2, (Bar Develop.) 1.471	219.50	198.99	117.61	325.67	104.50
Span 1 Girder 2, (PSXFR) 2.250	217.10	196.76	116.41	322.22	102.75
Span 1 Girder 2, (Bar Cutoff) 2.375	216.71	196.40	116.22	321.66	102.47
Span 1 Girder 2, (SZB) 2.461	216.45	196.16	116.09	321.28	102.27
Span 1 Girder 2, (CS) 4.876	209.02	189.28	112.37	310.62	96.80
Span 1 Girder 2, (H) 5.042	208.51	188.81	112.12	309.89	96.43
Span 1 Girder 2, (1.5H) 7.292	201.61	182.41	108.65	300.00	90.81
Span 1 Girder 2, (0.1L$_s$) 12.350	186.18	168.11	100.86	277.90	77.73
Span 1 Girder 2, (SZB) 12.461	185.84	167.79	100.69	277.42	77.44
Span 1 Girder 2, (SZB) 22.461	155.65	139.76	85.30	234.29	51.02
Span 1 Girder 2, (0.2L$_s$) 24.700	148.95	133.54	81.85	224.74	45.01
Span 1 Girder 2, (0.3L$_s$) 37.050	112.37	99.48	62.83	172.70	7.42
Span 1 Girder 2, (SZB) 37.461	111.17	98.36	62.20	170.98	6.14
Span 1 Girder 2, (0.4L$_s$) 49.400	76.44	65.94	43.82	121.79	-31.72
Span 1 Girder 2, (HP) 55.575	58.71	49.36	34.31	96.75	-51.72
Span 1 Girder 2, (0.5L$_s$) 61.750	41.14	32.91	24.80	72.00	-72.00
Span 1 Girder 2, (HP) 67.925	23.74	16.59	15.30	51.72	-96.75
Span 1 Girder 2, (0.6L$_s$) 74.100	6.49	0.40	5.79	31.72	-121.79
Span 1 Girder 2, (SZB) 86.039	-26.39	-30.54	-12.18	-6.14	-170.98
Span 1 Girder 2, (0.7L$_s$) 86.450	-27.51	-31.59	-12.79	-7.42	-172.70
Span 1 Girder 2, (0.8L$_s$) 98.800	-60.62	-62.87	-29.68	-45.01	-224.74
Span 1 Girder 2, (SZB) 101.039	-66.17	-68.18	-32.42	-51.02	-234.29
Span 1 Girder 2, (SZB) 111.039	-90.69	-91.67	-44.65	-77.44	-277.42
Span 1 Girder 2, (0.9L$_s$) 111.150	-90.96	-91.93	-44.78	-77.73	-277.90
Span 1 Girder 2, (1.5H) 116.208	-103.20	-103.69	-50.97	-90.81	-300.00
Span 1 Girder 2, (H) 118.458	-108.53	-108.82	-53.72	-96.43	-309.89
Span 1 Girder 2, (CS) 118.624	-108.90	-109.18	-53.92	-96.80	-310.62
Span 1 Girder 2, (SZB) 121.039	-114.30	-114.44	-56.88	-102.27	-321.28
Span 1 Girder 2, (Bar Cutoff) 121.125	-114.49	-114.63	-56.98	-102.47	-321.66
Span 1 Girder 2, (PSXFR) 121.250	-114.77	-114.90	-57.14	-102.75	-322.22
Span 1 Girder 2, (Bar Develop.) 122.029	-116.51	-116.59	-58.09	-104.50	-325.67
Span 1 Girder 2, (FoS) 122.958	-118.57	-118.60	-59.23	-106.59	-329.79
Span 1 Girder 2, (1.0L$_s$) 123.500	-119.78 -121.15	-119.78 -121.15	-59.89 -60.57	-107.80 -109.03	-332.19 -333.90

Bridge: Job: 8/13/2022

Location from Left Support (ft)	Design				
	Service I (kip)	Service III (kip)	Fatigue I (kip)	Strength I	
				Max (kip)	Min (kip)
Span 1 Girder 2, 123.500	0.00	0.00	0.00	0.00	0.00
Span 1 Girder 2, (STLF) 124.250	0.00	0.00	0.00	0.00	0.00

Girder Line Pier Reactions

	DC (kip)	DW (kip)	∑DC (kip)	∑DW (kip)
Abutment 1	0.00	0.00	121.15	0.00
Abutment 2	0.00	0.00	121.15	0.00

Girder Bearing Reactions

	DC (kip)	DW (kip)	∑DC (kip)	∑DW (kip)
Abutment 1 - Ahead	0.00	0.00	121.15	0.00
Abutment 2 - Back	0.00	0.00	121.15	0.00

Girder Bearing Reactions - Design Vehicles (With Impact)

	Live Load			
	* LL+IM Design		* LL+IM Fatigue	
	Max (kip)	Min (kip)	Max (kip)	Min (kip)
Abutment 1 - Ahead	54.42	0.00	39.99	0.00
Abutment 2 - Back	54.42	0.00	39.99	0.00

* Live Load values are per girder and include impact.

Girder Bearing Reactions (With Impact)

	Design				
	Service I (kip)	Service III (kip)	Fatigue I (kip)	Strength I	
				Max (kip)	Min (kip)
Abutment 1 - Ahead	175.56	164.68	120.56	246.67	109.03
Abutment 2 - Back	175.56	164.68	120.56	246.67	109.03

Live Load Reactions Without Impact

Girder Bearing Reactions - Design Vehicles (Without Impact)

	Live Load			
	* LL Design		* LL Fatigue	
	Max (kip)	Min (kip)	Max (kip)	Min (kip)
Abutment 1 - Ahead	45.08	0.00	34.78	0.00
Abutment 2 - Back	45.08	0.00	34.78	0.00

* Live Load values are per girder and do not include impact.

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Bridge: Job: 8/13/2022

APPENDIX B. I-GIRDER STANDARD DETAILING

GIRDER ELEVATION

Bars R Spa ~ 2 ½"

12 Spa at 3" = 3'-0"	30 Spa at 8" = 20'-0"	15 Spa at 12" = 15'-0"	Spa at 18" Max	Showing Type Tx62 & Tx70 Girders
12 Spa at 3" = 3'-0"	20 Spa at 6" = 10'-0"	15 Spa at 8" = 10'-0"	15 Spa at 12" = 15'-0"	Spa at 18" Max	Showing Type Tx40, Tx46 & Tx54 Girders
12 Spa at 3" = 3'-0"	15 Spa at 4" = 5'-0"	10 Spa at 6" = 5'-0"	15 Spa at 8" = 10'-0"	Spa at 12" Max	Showing Type Tx28 & Tx34 Girders

Face of abut bkwl, inverted-T stem or ℄ interior bent

Do not blockout top of girders for thickened slab ends.

Face of abut bkwl, inverted-T stem or ℄ interior bent

Symmetrical about ℄

End of girder for payment

End of girder for payment

Optional ¾" Chamfer vertically (Typ)

C.G. of girder

C.G. of depressed strands

"e"

90° at int bents, plumb ends at abut bkwl & inverted-T

C.G. of straight strands

C.G. of all strands

Hold down point

3'-3" Bars parallel to girder end

Bars perpendicular to bottom of girder ③

Bars S Cl Cov 1 ½"

Bars S Spa ① 12 Spa at 3" = 3'-0"

Bars C & CH Spa ~ 3" (Bundle)

6" Max Spa = 1.5 x "D" (Min)

Bundle with Bars R when vertical clearance is less than or equal to 20'

L/2 (One half span length)

L/2 (One half span length)

Notes

① Bundle with Bars R.

② Measured along ℄ Girder at interior bents; perpendicular to abutment bkwl or inverted-T stem.

③ The average of the top and bottom spacing of Bars R cannot exceed the required spacing.

④ L/20, but not less than 5'-0" (-0,+2').

⑤ ℄ 4" x 1 ½" Vertical Slotted Hole at doweled girder end [labeled (D) on Bridge Layout]. Required for outside girder only or as shown on substructure details. Anchorage holes may be tapered (4 ¾" x 1 ⅝") at base. If holes are formed with sheet metal, forms may be left in place.

⑥ Bars P (#6 x 15'-0") required in Tx62 and Tx70 girders. At the fabricator's option bars larger than #6 may be used. When L is less than 50 ft, Bars P are to be the same length as Bars T.

⑦ Bars P (#6 x 15'-0") are only required in Tx28, Tx34, Tx40, Tx46, and Tx54 girders when "e" at girder ends exceeds 0.25 x "D". At the fabricator's option bars larger than #6 may be used. When L is less than 50 ft, Bars P are to be the same length as Bars T.

⑧ 1 ⅜" Clear Cover to Bars S.

⑨ Space Bars A at 6" Max for girders requiring overhang bracket hangers. Space at 12" Max for all other girders. Tie to Bars R as necessary. See standard IGMS for "Deck Forming Notes".

⑩ Based on 155 pcf total weight of concrete and reinforcing steel.

⑪ Smooth trowel finish on the slab overhang side of exterior girder.

GIRDER DIMENSIONS AND SECTION PROPERTIES

Girder Type	"D" (in.)	"B" (in.)	"Yt" (in.)	"Yb" (in.)	Area (in.²)	"Ix" (in.⁴)	"Iy" (in.⁴)	Weight ⑩ (plf)
Tx28	28	6	15.02	12.98	585	52,772	40,559	630
Tx34	34	12	18.49	15.51	627	88,355	40,731	675
Tx40	40	18	21.90	18.10	669	134,990	40,902	720
Tx46	46	22	25.90	20.10	761	198,089	46,478	819
Tx54	54	30	30.49	23.51	817	299,740	46,707	880
Tx62	62	37 ½	33.72	28.28	910	463,072	57,351	980
Tx70	70	45 ½	38.09	31.91	966	628,747	57,579	1,040

GENERAL NOTES:

Designed according to AASHTO LRFD Bridge Design Specifications.
Provide Class H concrete.
Provide Grade 60 reinforcing steel.
An equal area of deformed Welded Wire Reinforcement (WWR) (ASTM A1064) may be substituted for Bars A, C, R or T unless otherwise noted.
It is permissible for bars or strands to come in contact with materials used in forming anchor holes.

Cover dimensions are clear dimensions, unless noted otherwise.
Reinforcing bar dimensions shown are out-to-out of bar.

Cross Sections

TYPE Tx62 & Tx70

42"
Bars T at 5 Eq Spa

TYPE Tx46 & Tx54

36"
Bars T at 3 Eq Spa

TYPE Tx28, Tx34 & Tx40

36"
Bars T at 3 Eq Spa

HL93 LOADING   SHEET 1 OF 2

Texas Department of Transportation   Bridge Division Standard

PRESTRESSED CONCRETE I-GIRDER DETAILS

IGD

FILE: igdstds1-19.dgn   DN: TxDOT   CK: JMH   DW: JTR   CK: TAR

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REVISIONS
10-19: Added Bars C and CH full length for VC<= 20'

CONT | SECT | JOB | HIGHWAY

DIST | COUNTY | SHEET NO.

103

Face of abut bkwl, inverted-T stem or ℄ interior bent

Skew angle

Showing top flg reinf

Showing bott flg reinf

A

R

T   S

U   S

C & CH
R
R
C & CH

2 ½"
Bar R

0° SKEW

3"
Bar R

15° SKEW

4"
Bar R

30° SKEW

5 ½"
Bar R

45° SKEW

Bar R 7 ½"

60° SKEW

PLAN OF GIRDER ENDS (12)

To control top flange cracking that may occur during form removal, additional top flange reinforcing may be placed as shown in girder ends at the Fabricator's option.

1 ½" Clear

1 ½" Clear
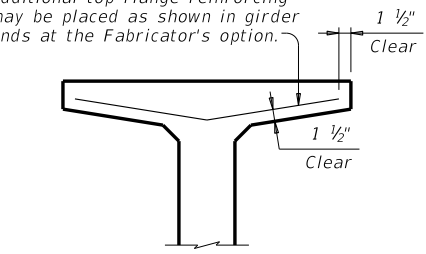
**OPTIONAL TOP FLANGE
REINFORCING DETAIL**

Longitudinal wire area must be 40 % or greater of vertical deformed wire's area

Vertical WWR leg

$0.25 \times "D"$ Max

2" Min
2 ½" Max

1 ½" Min

Bottom of girder
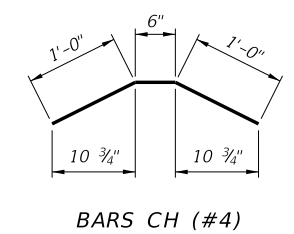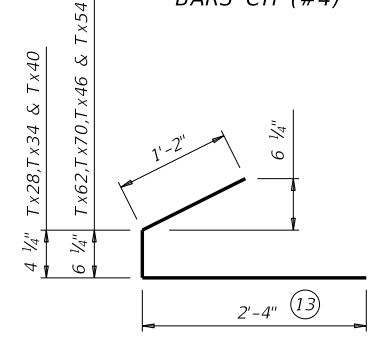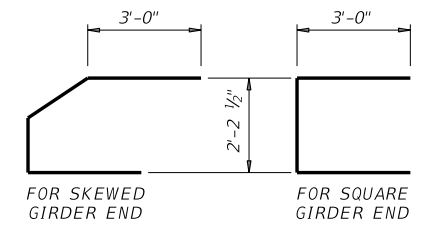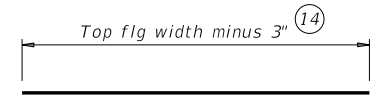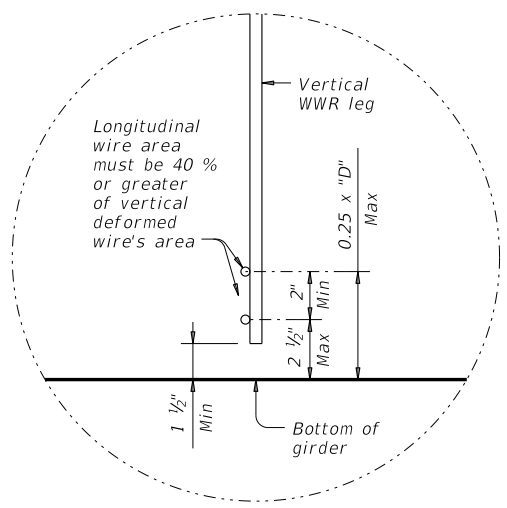
**OPTIONAL WELDED WIRE
REINFORCEMENT (WWR) DETAIL**

1'-0"   6"   1'-0"

10 ¾"   10 ¾"

BARS CH (#4)

Tx28,Tx34 & Tx40
Tx62,Tx70,Tx46 & Tx54

1'-2"
6 ¼"
4 ¼"
6 ¼"
2'-4" (13)

BARS C (#4)

3'-0"   3'-0"

2'-2 ½"

FOR SKEWED GIRDER END

FOR SQUARE GIRDER END

BARS U (#5)

Top flg width minus 3" (14)

BARS A (#3)

"D" Plus 4 ¾"

4" (13) (Typ)

3 ¾"

See "Optional WWR Detail" (Typ)

BARS R (#4) (16)

"D" Minus 3 ½"

BARS S (#6)

1'-7"   Min lap (15)

Girder length minus 3"
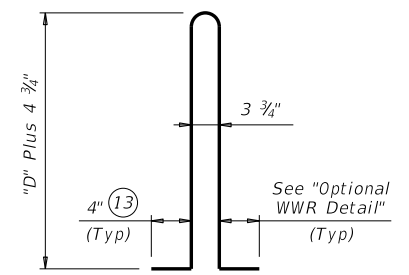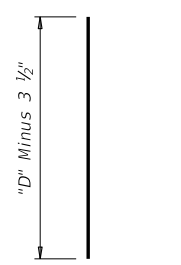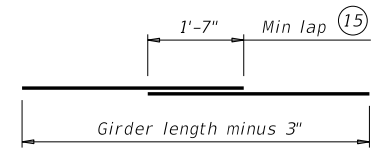
BARS T (#4)

(12) Reinforcing patterns shown are provided as guides to determine reinforcement placement in skewed ends. Place Bars S as close to girder end as cover requirements permit, which may prevent them to be bundled with Bars R.

(13) Bars may be cut or bent at skewed end as required.

(14) Increase as necessary for bars at skewed end.

(15) No portion of bar less than 10 ft.

(16) For Welded Wire Reinforcement (WWR) option, area of Bars R may be reduced in proportion to the increase in reinforcement yield strength over 60 ksi. Yield strength of WWR is limited to 75 ksi.

HL93 LOADING   SHEET 2 OF 2

Texas Department of Transportation

Bridge Division Standard

**PRESTRESSED CONCRETE
I-GIRDER DETAILS**

IGD

FILE: igdstds1-19.dgn   DN: TxDOT   CK: JMH   DW: JTR   CK: TAR

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CONT   SECT   JOB   HIGHWAY

REVISIONS

10-19: Added Bars C and CH full length for VC<= 20'

DIST   COUNTY   SHEET NO.

104

APPENDIX C. PLOTS OF I-GIRDER END REGION OF CURRENT CASE
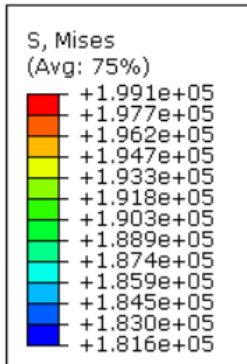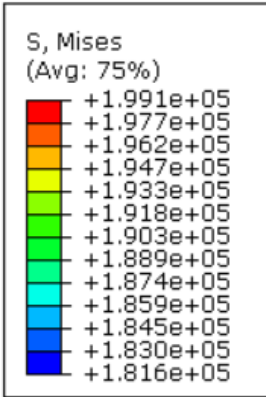
Figure C.1 Stress in strands in I-girder end region

S, S11
(Avg: 75%)
+3.559e+03
+2.202e+03
+8.458e+02
-5.108e+02
-1.867e+03
-3.224e+03
-4.581e+03
-5.937e+03
-7.294e+03
-8.650e+03
-1.001e+04
-1.136e+04
-1.272e+04
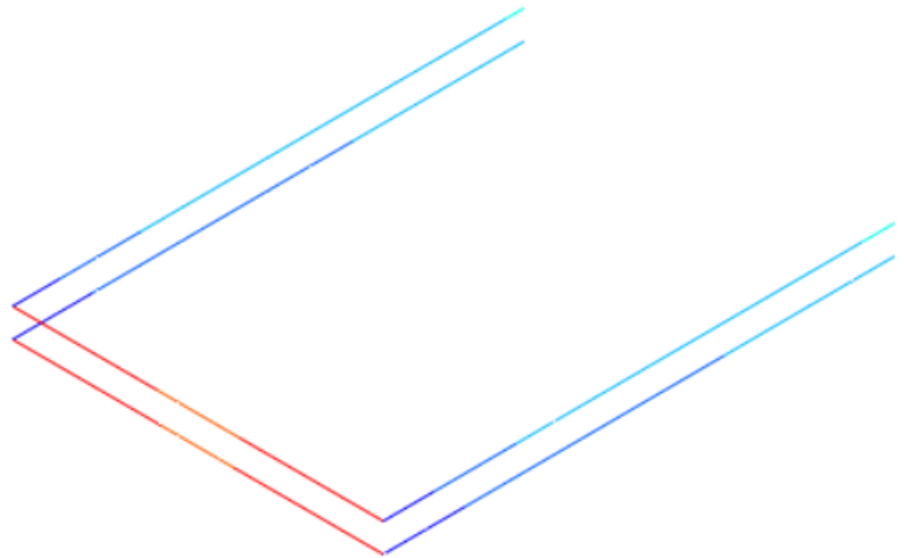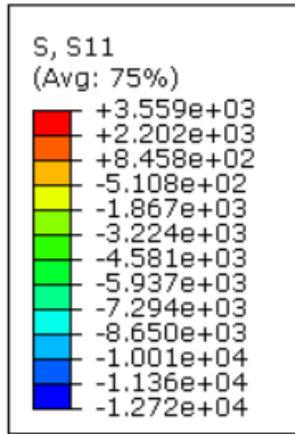
Figure C.2 Stress in U bars in I-girder end region

S, S11
(Avg: 75%)
+4.396e+03
+4.090e+03
+3.785e+03
+3.480e+03
+3.174e+03
+2.869e+03
+2.563e+03
+2.258e+03
+1.953e+03
+1.647e+03
+1.342e+03
+1.036e+03
+7.308e+02
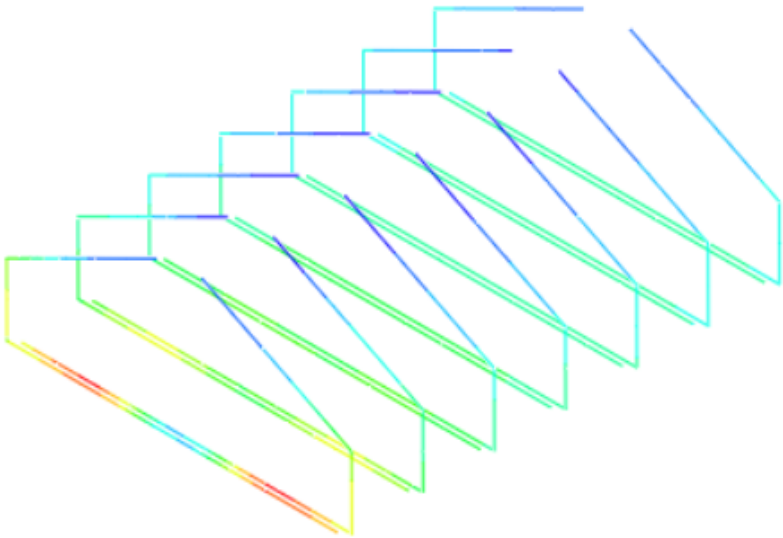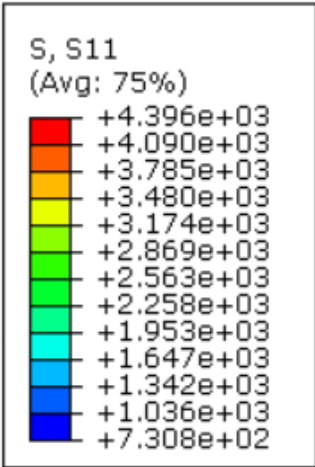
Figure C.3 Stress in C bars in I-girder end region

S, S11
(Avg: 75%)
+2.334e+03
+2.206e+03
+2.077e+03
+1.948e+03
+1.819e+03
+1.690e+03
+1.562e+03
+1.433e+03
+1.304e+03
+1.175e+03
+1.046e+03
+9.175e+02
+7.887e+02
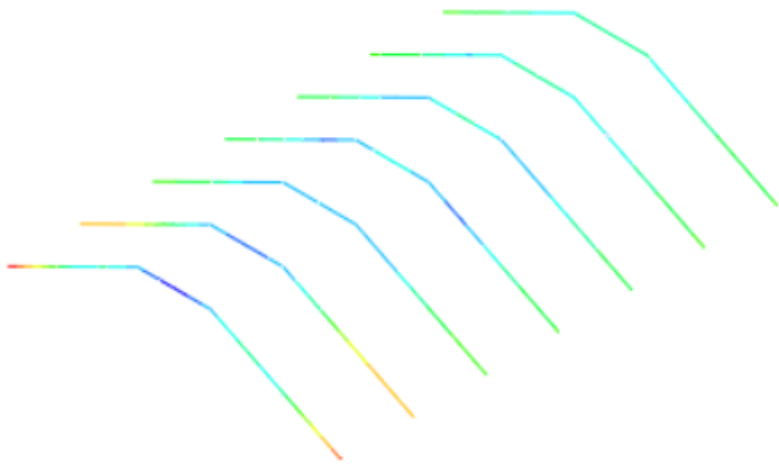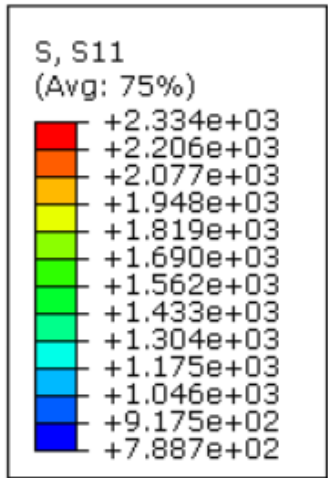
Figure C.4 Stress in CH bars in I-girder end region

S, S11
(Avg: 75%)
+5.571e+03
+5.054e+03
+4.537e+03
+4.019e+03
+3.502e+03
+2.985e+03
+2.467e+03
+1.950e+03
+1.433e+03
+9.154e+02
+3.981e+02
-1.192e+02
-6.365e+02
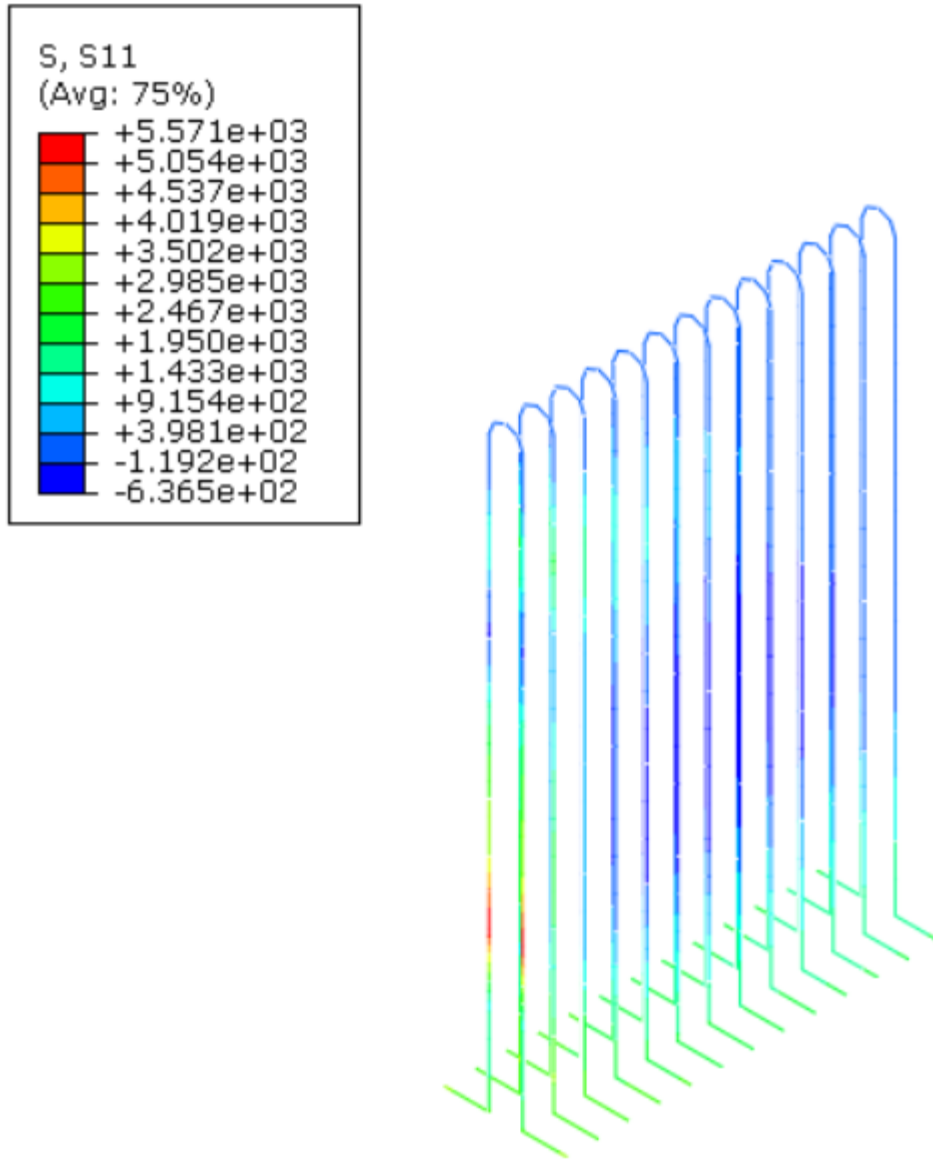
Figure C.5 Stress in R bars in I-girder end region
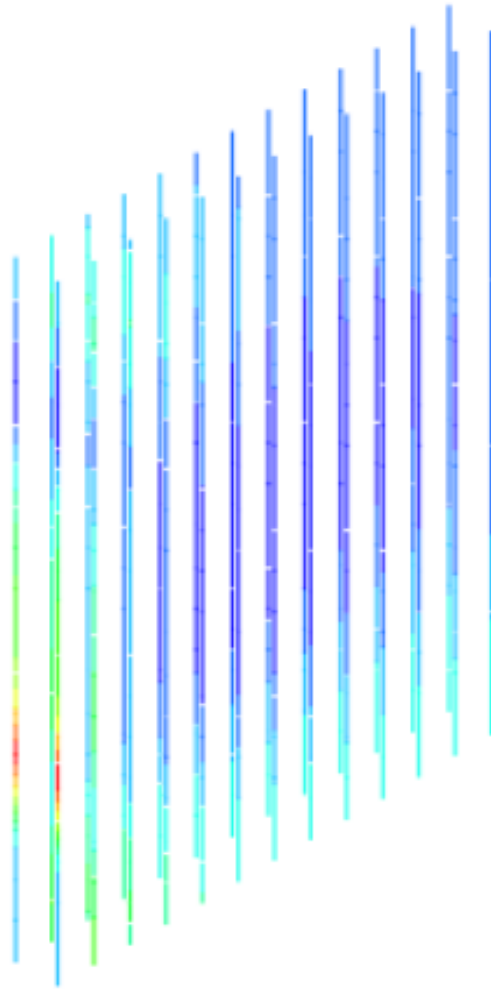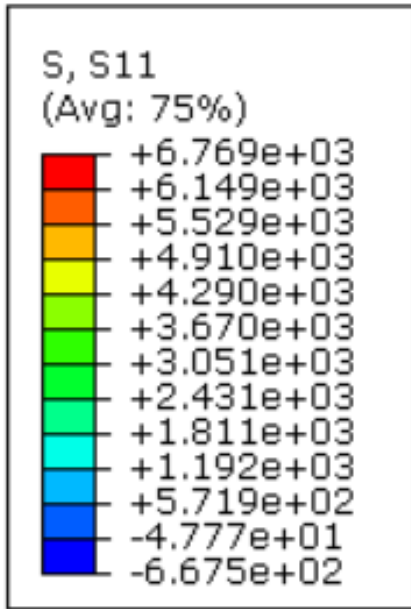
Figure C.6 Stress in S bars in I-girder end region
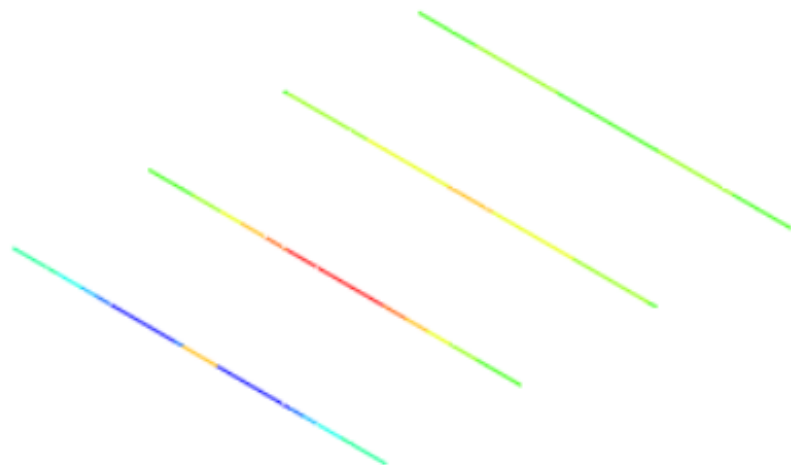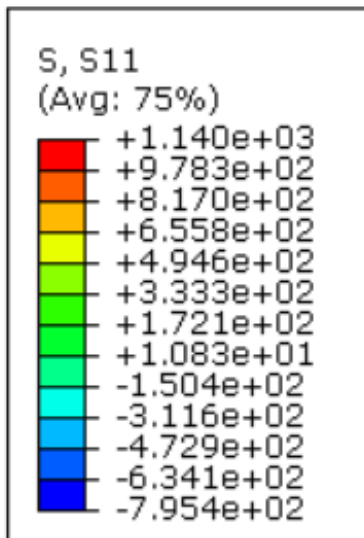
Figure C.7 Stress in A bars in I-girder end region

S, S11
(Avg: 75%)
-3.813e+02
-6.525e+02
-9.238e+02
-1.195e+03
-1.466e+03
-1.737e+03
-2.009e+03
-2.280e+03
-2.551e+03
-2.822e+03
-3.094e+03
-3.365e+03
-3.636e+03
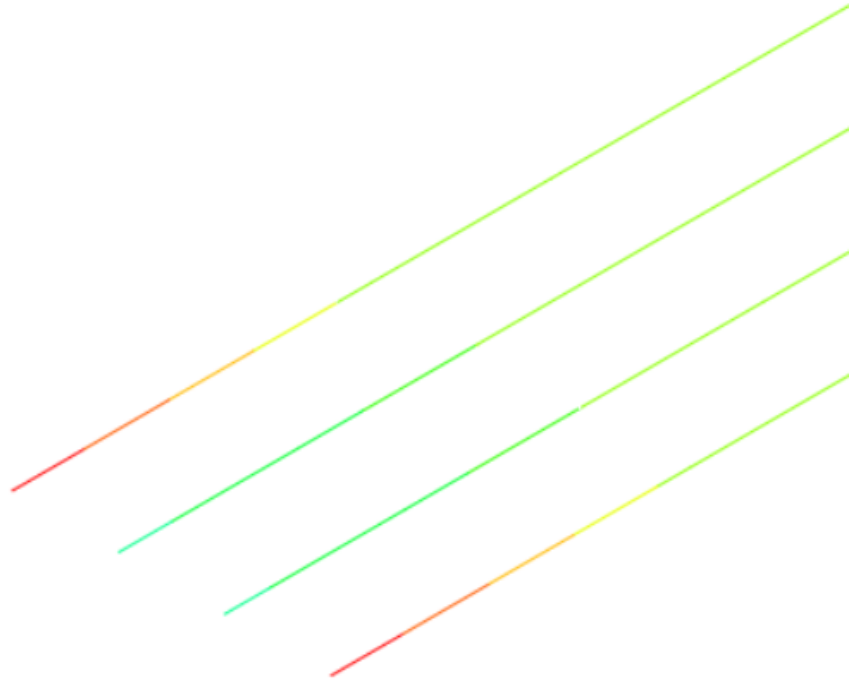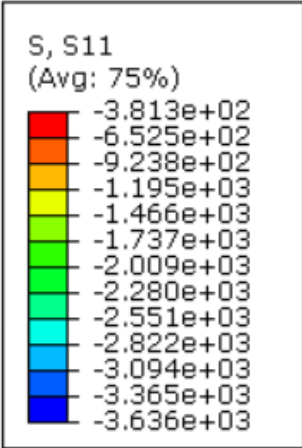
Figure C.8 Stress in T bars in I-girder end region
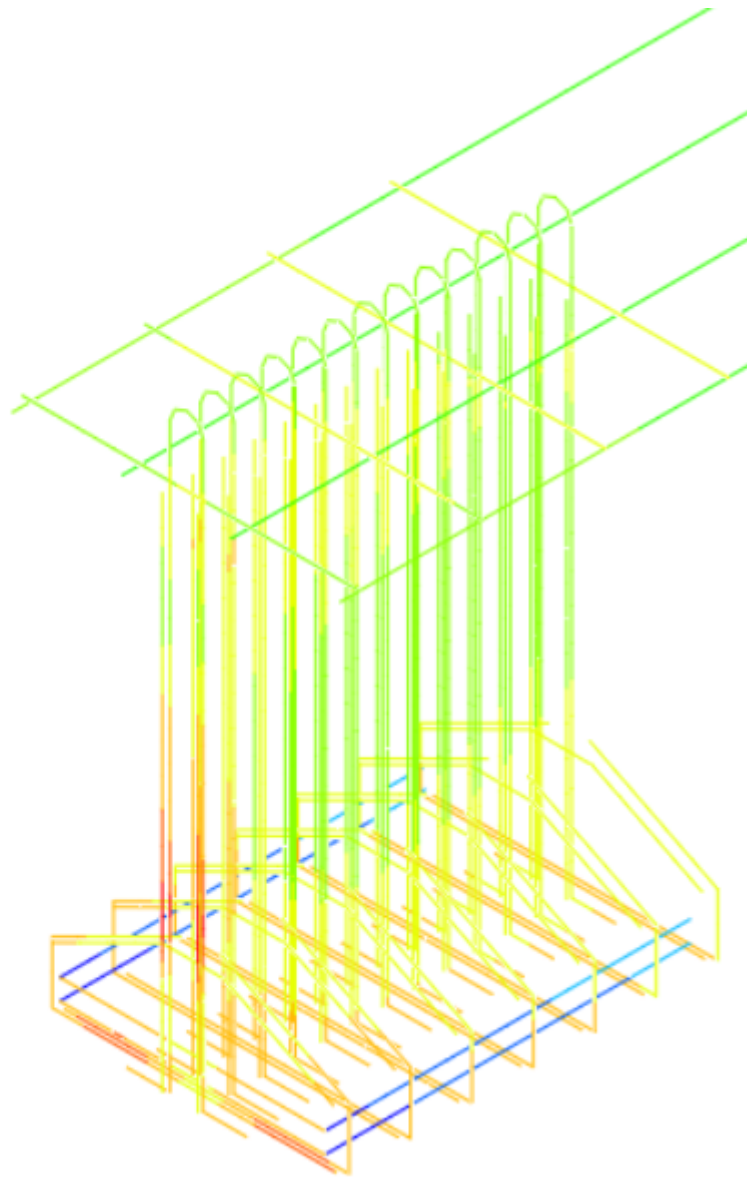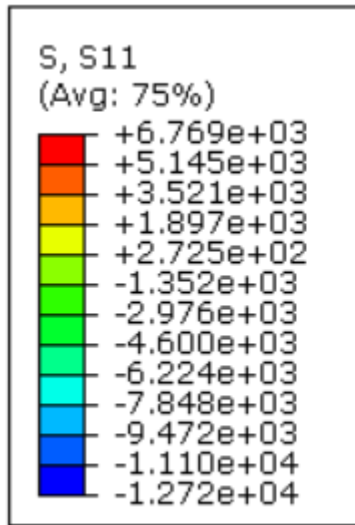
Figure C.9 Stress in reinforcement bars in I-girder end region

APPENDIX D. PLOTS OF I-GIRDER END REGION OF PROPOSED CASE
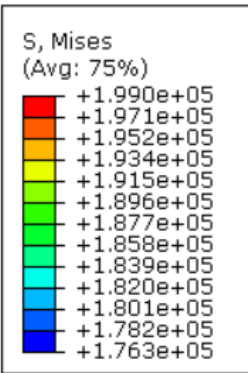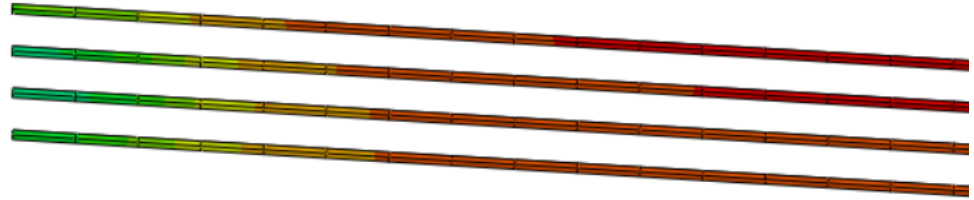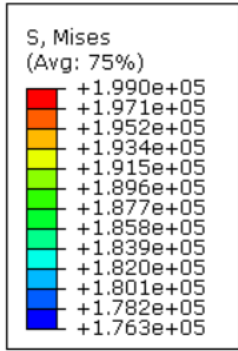
Figure D.1 Stress in strands in I-girder end region
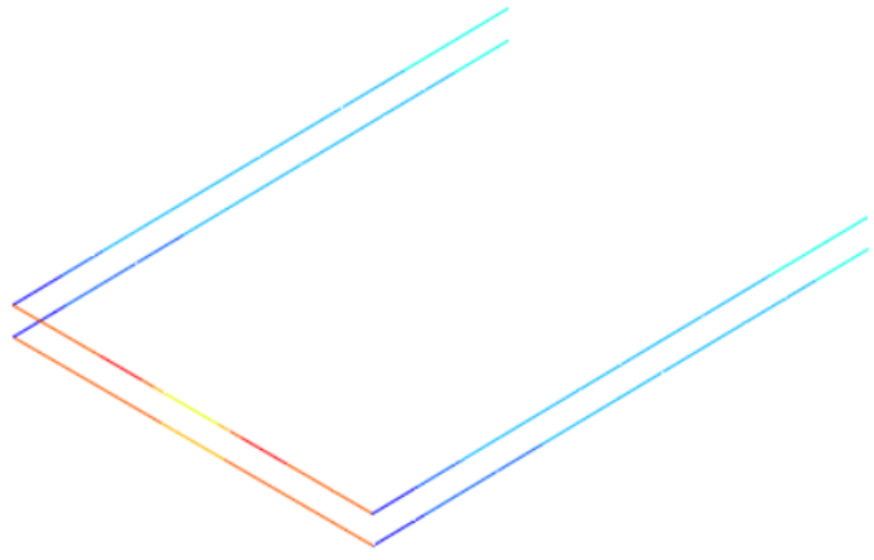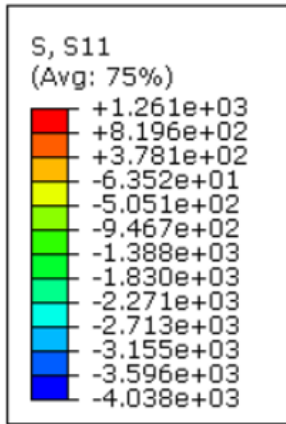
Figure D.2 Stress in U bars in I-girder end region

S, S11
(Avg: 75%)
+1.114e+03
+1.038e+03
+9.607e+02
+8.838e+02
+8.069e+02
+7.301e+02
+6.532e+02
+5.763e+02
+4.994e+02
+4.226e+02
+3.457e+02
+2.688e+02
+1.919e+02
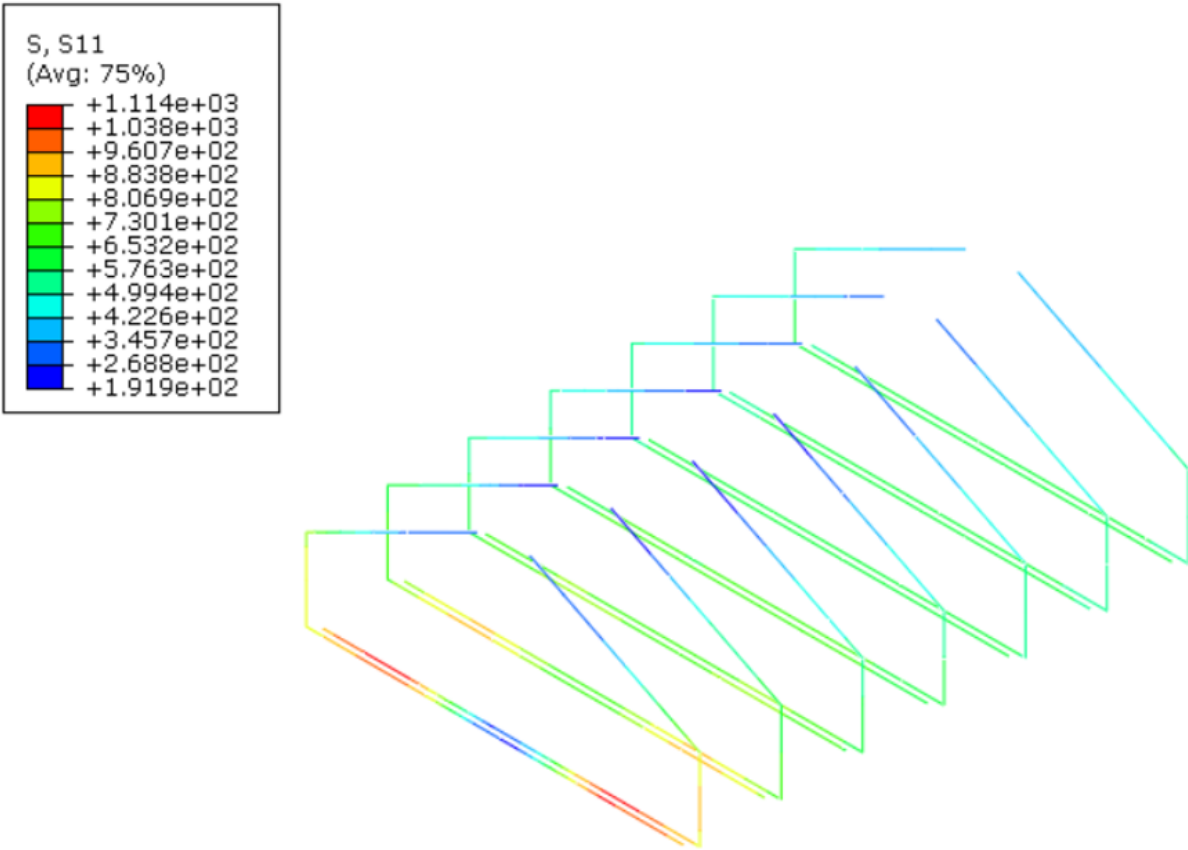
Figure D.3 Stress in C bars in I-girder end region
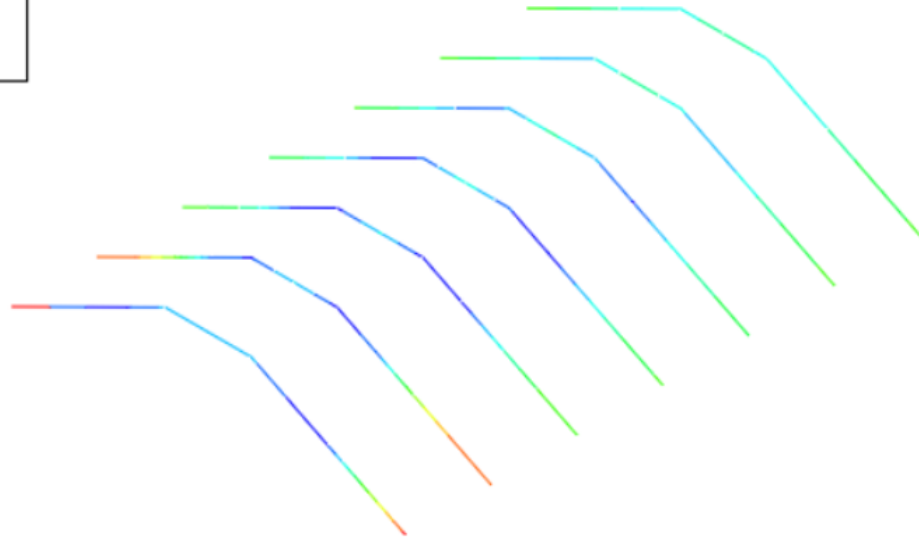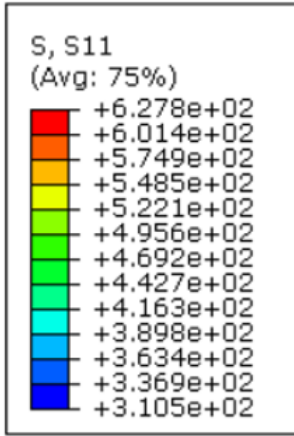
Figure D.4 Stress in CH bars in I-girder end region
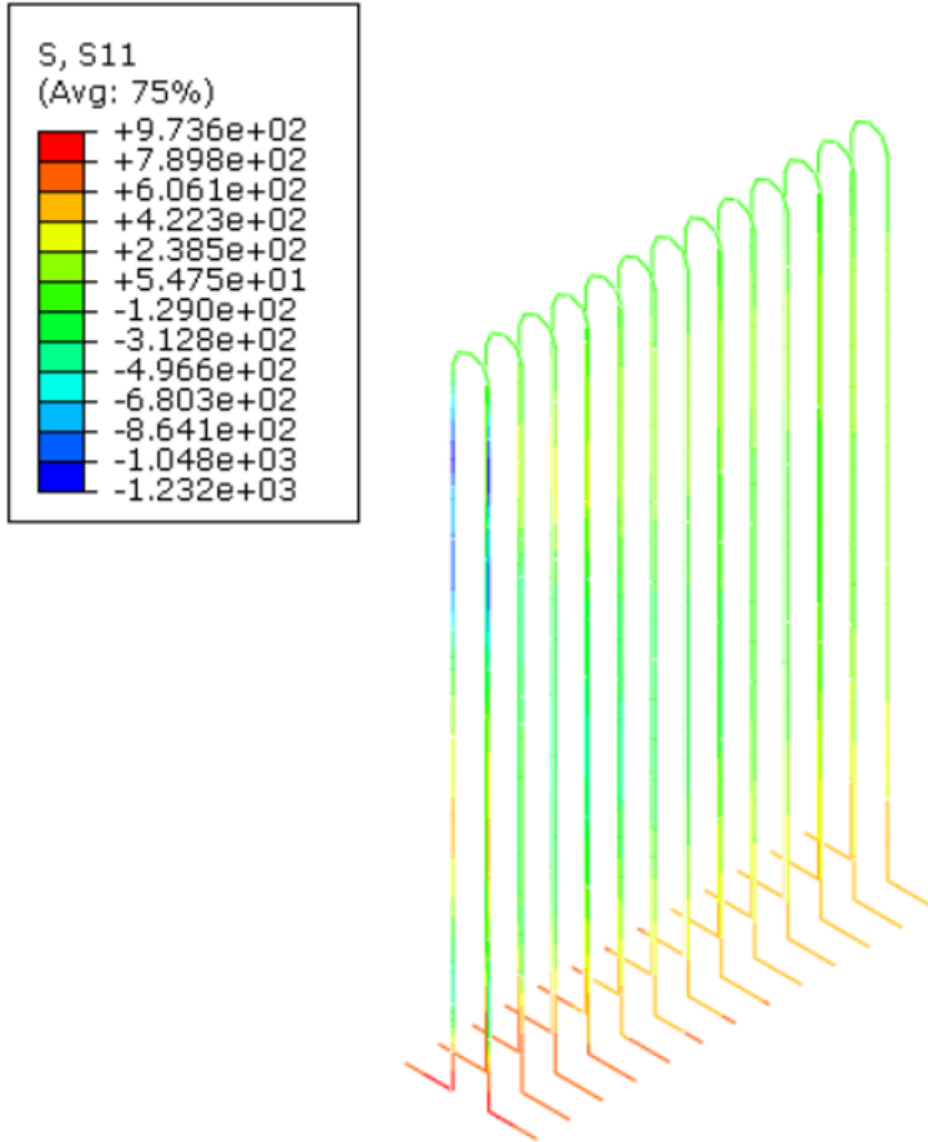
Figure D.4 Stress in R bars in I-girder end region
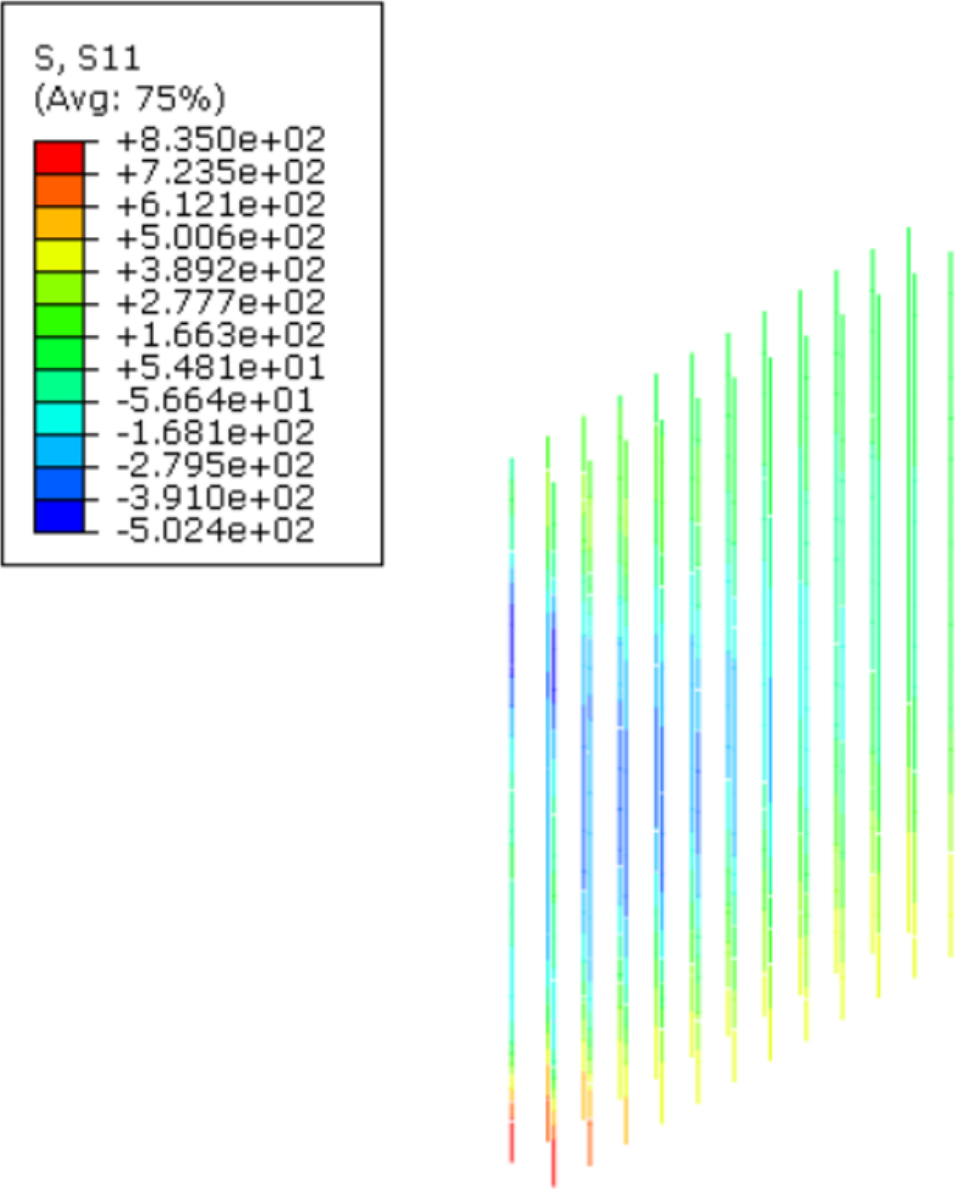
Figure D.5 Stress in S bars in I-girder end region

S, S11
(Avg: 75%)
+2.654e+02
+2.270e+02
+1.885e+02
+1.501e+02
+1.117e+02
+7.324e+01
+3.481e+01
-3.615e+00
-4.204e+01
-8.047e+01
-1.189e+02
-1.573e+02
-1.958e+02
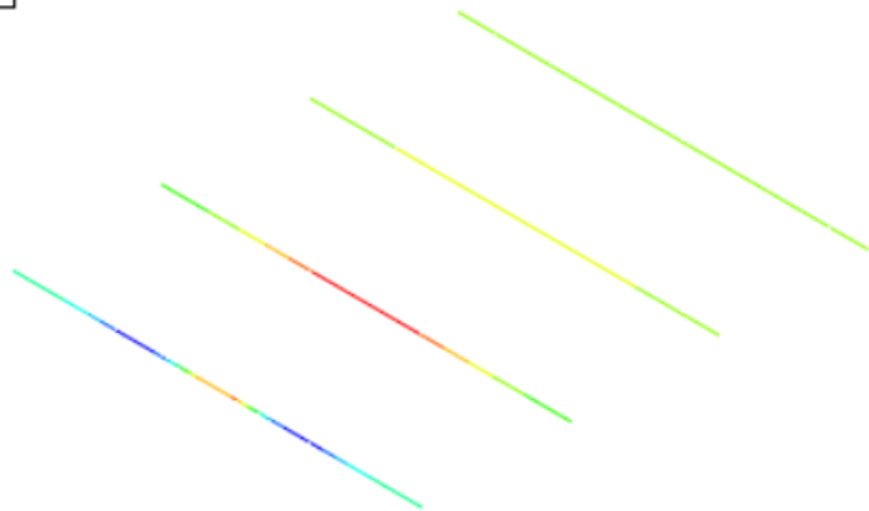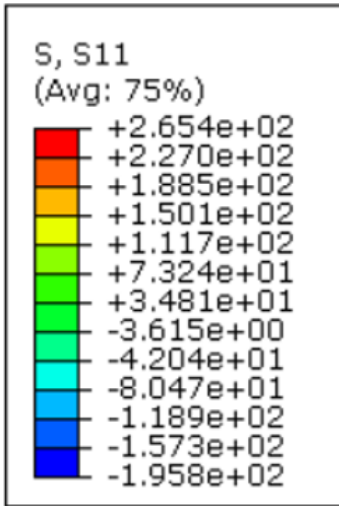
Figure D.6 Stress in A bars in I-girder end region
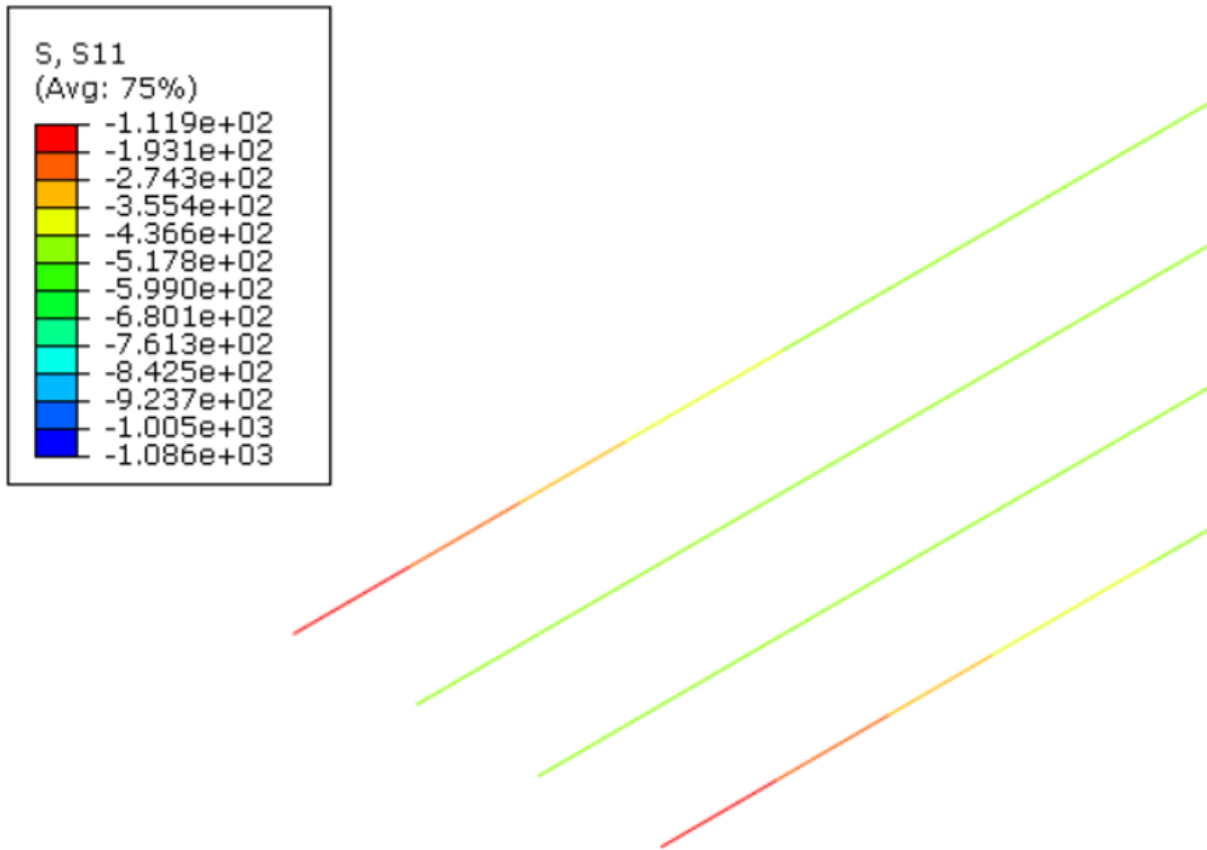
Figure D.7 Stress in T bars in I-girder end region
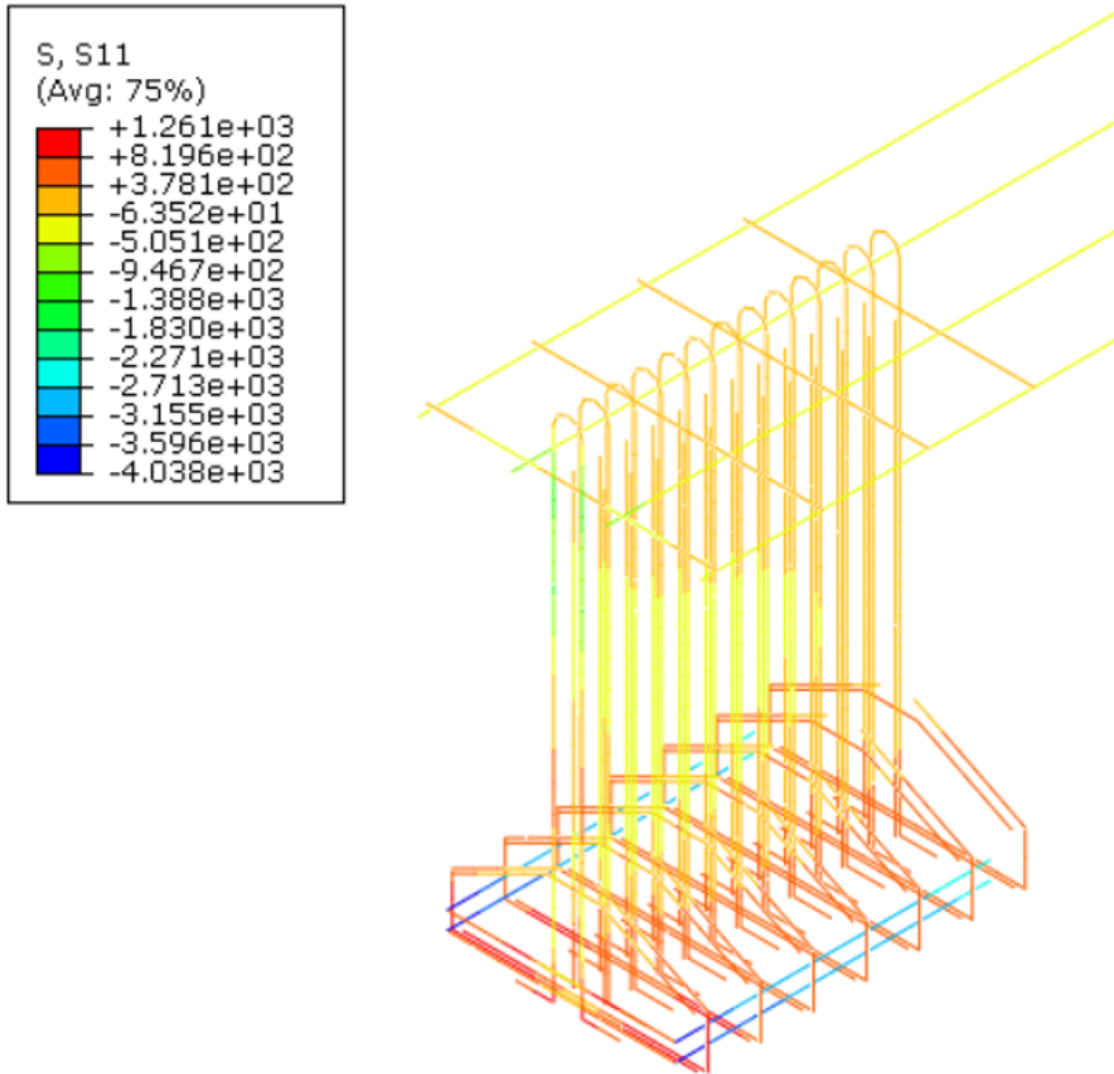
Figure D.8 Stress in reinforcement bars in I-girder end region
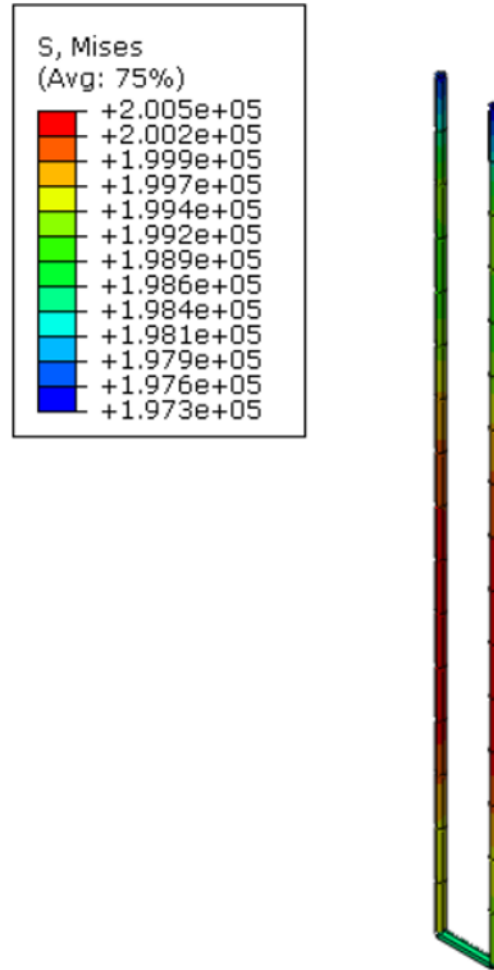
Figure D.8 Stress in reinforcement bars in I-girder end region

APPENDIX E. AN EXAMPLE OF DEBONDED DESIGN ATTEMPT

TxDOT Girder Schedule Report

For Span 1 (Girder 1,2,3,4,5,6)

October 11, 2022 11:47:03 pm

PGSuper™ (x64)

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Version 6.1.0 - Built on May 12 2021

Washington State Department of Transportation

Texas Department of Transportation

Project Properties

Bridge Name	
Bridge ID	
Company	
Engineer	
Job Number	
Comments	
File	D:\PHD work\Research papers\TX54\Test1.pgs

Configuration

Configuration Server: TxDOT
Configuration Name: TxDOT
Configuration Source: ftp://ftp.dot.state.tx.us/pub/txdot-info/brg/pgsuper/version_6.1.0/txdot.pgz
Configuration Date Stamp: January 6, 2021 3:35:03 pm

Library	Entry	Source
Girders	Tx54 (Copy 1)	Project Library
Traffic Barriers	SSTR	Master Library
Project Criteria	TxDOT 2017 based on AASHTO LRFD Bridge Design Specification, 8th Edition 2017	Master Library
Load Rating Criteria	Default based on The Manual for Bridge Evaluation, First Edition 2008, with 2010 interim provisions	Project Library
Haul Trucks	Old Haul Truck -0	Project Library

Analysis Controls

Structural Analysis Method: Simple Span
Section Properties: Gross
Losses: Refined estimate per TxDOT Research Report 0-6374-2

Girder Schedule

The Specification Check Was Not Successful
Note: A Non-Standard Strand Fill Was Used For Span 1 Girder 1
Note: A Non-Standard Strand Fill Was Used For Span 1 Girder 2
Note: A Non-Standard Strand Fill Was Used For Span 1 Girder 3
Note: A Non-Standard Strand Fill Was Used For Span 1 Girder 4
Note: A Non-Standard Strand Fill Was Used For Span 1 Girder 5
Note: A Non-Standard Strand Fill Was Used For Span 1 Girder 6

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TxDOT Girder Schedule

Span	1	1	1	1	1	1
Girder	1	2	3	4	5	6
Girder Type	Tx54 (Copy 1)	Tx54 (Copy 1)	Tx54 (Copy 1)	Tx54 (Copy 1)	Tx54 (Copy 1)	Tx54 (Copy 1)
Prestressing Strands						
NO. ($N_h + N_s$)	46	46	46	46	46	46
Size	0.600 in Dia.	0.600 in Dia.	0.600 in Dia.	0.600 in Dia.	0.600 in Dia.	0.600 in Dia.
Strength	Grade 270 Low Relaxation	Grade 270 Low Relaxation	Grade 270 Low Relaxation	Grade 270 Low Relaxation	Grade 270 Low Relaxation	Grade 270 Low Relaxation
Eccentricity @ CL	18.660 in	18.660 in	18.660 in	18.660 in	18.660 in	18.660 in
Eccentricity @ End	18.436 in	18.436 in	18.436 in	18.436 in	18.436 in	18.436 in
Prestressing Strands	**Straight**	**Straight**	**Straight**	**Straight**	**Straight**	**Straight**
NO. (# of Debonded Strands)	18	18	18	18	18	18
Concrete						
Release Strength f'_{ci}	6.000 KSI	6.000 KSI	6.000 KSI	6.000 KSI	6.000 KSI	6.000 KSI
Minimum 28 day compressive strength f'_c	7.300 KSI	7.300 KSI	7.300 KSI	7.300 KSI	7.300 KSI	7.300 KSI
Optional Design						
Design Load Compressive Stress (Top CL)	4.554 KSI	4.732 KSI	4.732 KSI	4.732 KSI	4.732 KSI	4.554 KSI
Design Load Tensile Stress (Bottom CL)	-4.381 KSI	-4.554 KSI	-4.554 KSI	-4.554 KSI	-4.554 KSI	-4.381 KSI
Required minimum ultimate moment capacity	8464.49 kip-ft	8717.70 kip-ft	8717.70 kip-ft	8717.70 kip-ft	8717.70 kip-ft	8464.49 kip-ft
Live Load Distribution Factor for Moment (Strength and Service Limit States)	0.61509	0.61509	0.61509	0.61509	0.61509	0.61509
Live Load Distribution Factor for Shear (Strength and Service Limit States)	0.81433	0.81433	0.81433	0.81433	0.81433	0.81433
Live Load Distribution Factor for Moment (Fatigue Limit States)	0.35339	0.35339	0.35339	0.35339	0.35339	0.35339

NOTE: Stresses show in the above table reflect the following sign convention:
Compressive Stress is positive. Tensile Stress is negative

Debonded Strand Pattern for Span 1 Girder 1

Dist from Bottom	# of Strands		# of Strands Debonded At									
	Total	Debonded	3 ft	6 ft	9 ft	12 ft	15 ft	18 ft	21 ft	24 ft	27 ft	30 ft
2.500 in	14	6	0	0	0	0	6	0	0	0	0	0
4.500 in	14	6	0	0	0	2	4	0	0	0	0	0
6.500 in	14	6	0	0	0	6	0	0	0	0	0	0

Debonded Strand Pattern for Span 1 Girder 2

Dist from Bottom	# of Strands		# of Strands Debonded At									
	Total	Debonded	3 ft	6 ft	9 ft	12 ft	15 ft	18 ft	21 ft	24 ft	27 ft	30 ft
2.500 in	14	6	0	0	0	0	6	0	0	0	0	0
4.500 in	14	6	0	0	0	2	4	0	0	0	0	0
6.500 in	14	6	0	0	0	6	0	0	0	0	0	0

Debonded Strand Pattern for Span 1 Girder 3

Bridge: Job: 10/11/2022

Dist from Bottom	# of Strands		# of Strands Debonded At										
	Total	Debonded	3 ft	6 ft	9 ft	12 ft	15 ft	18 ft	21 ft	24 ft	27 ft	30 ft
2.500 in	14	6	0	0	0	0	6	0	0	0	0	0
4.500 in	14	6	0	0	0	2	4	0	0	0	0	0
6.500 in	14	6	0	0	0	6	0	0	0	0	0	0

Debonded Strand Pattern for Span 1 Girder 4

Dist from Bottom	# of Strands		# of Strands Debonded At										
	Total	Debonded	3 ft	6 ft	9 ft	12 ft	15 ft	18 ft	21 ft	24 ft	27 ft	30 ft
2.500 in	14	6	0	0	0	0	6	0	0	0	0	0
4.500 in	14	6	0	0	0	2	4	0	0	0	0	0
6.500 in	14	6	0	0	0	6	0	0	0	0	0	0

Debonded Strand Pattern for Span 1 Girder 5

Dist from Bottom	# of Strands		# of Strands Debonded At										
	Total	Debonded	3 ft	6 ft	9 ft	12 ft	15 ft	18 ft	21 ft	24 ft	27 ft	30 ft
2.500 in	14	6	0	0	0	0	6	0	0	0	0	0
4.500 in	14	6	0	0	0	2	4	0	0	0	0	0
6.500 in	14	6	0	0	0	6	0	0	0	0	0	0

Debonded Strand Pattern for Span 1 Girder 6

Dist from Bottom	# of Strands		# of Strands Debonded At										
	Total	Debonded	3 ft	6 ft	9 ft	12 ft	15 ft	18 ft	21 ft	24 ft	27 ft	30 ft
2.500 in	14	6	0	0	0	0	6	0	0	0	0	0
4.500 in	14	6	0	0	0	2	4	0	0	0	0	0
6.500 in	14	6	0	0	0	6	0	0	0	0	0	0

Non-Standard Strand Pattern for Span 1 Girder 1

Row From Bottom (in)	Strands
3	ABCDEFG (14)
5	ABCDEFG (14)
7	ABCDEFG (14)
9	AB (4)

Non-Standard Strand Pattern for Span 1 Girder 2

Row From Bottom (in)	Strands
3	ABCDEFG (14)
5	ABCDEFG (14)
7	ABCDEFG (14)
9	AB (4)

Non-Standard Strand Pattern for Span 1 Girder 3

Row From Bottom (in)	Strands
3	ABCDEFG (14)
5	ABCDEFG (14)
7	ABCDEFG (14)

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Bridge: Job: 10/11/2022

Row From Bottom (in)	Strands
9	AB (4)

Non-Standard Strand Pattern for Span 1 Girder 4

Row From Bottom (in)	Strands
3	ABCDEFG (14)
5	ABCDEFG (14)
7	ABCDEFG (14)
9	AB (4)

Non-Standard Strand Pattern for Span 1 Girder 5

Row From Bottom (in)	Strands
3	ABCDEFG (14)
5	ABCDEFG (14)
7	ABCDEFG (14)
9	AB (4)

Non-Standard Strand Pattern for Span 1 Girder 6

Row From Bottom (in)	Strands
3	ABCDEFG (14)
5	ABCDEFG (14)
7	ABCDEFG (14)
9	AB (4)

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TxDOT Summary Report (Long Form)

For Span 1 Girder 2

October 11, 2022 11:43:46 pm

PGSuper™ (x64)

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Version 6.1.0 - Built on May 12 2021

Project Properties

Bridge Name	
Bridge ID	
Company	
Engineer	
Job Number	
Comments	
File	D:\PHD work\Research papers\TX54\Test1.pgs

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Configuration

Configuration Server: TxDOT
Configuration Name: TxDOT
Configuration Source: ftp://ftp.dot.state.tx.us/pub/txdot-info/brg/pgsuper/version_6.1.0/txdot.pgz
Configuration Date Stamp: January 6, 2021 3:35:03 pm

Library	Entry	Source
Girders	Tx54 (Copy 1)	Project Library
Traffic Barriers	SSTR	Master Library
Project Criteria	TxDOT 2017 based on AASHTO LRFD Bridge Design Specification, 8th Edition 2017	Master Library
Load Rating Criteria	Default based on The Manual for Bridge Evaluation, First Edition 2008, with 2010 interim provisions	Project Library
Haul Trucks	Old Haul Truck -0	Project Library

Analysis Controls

Structural Analysis Method: Simple Span
Section Properties: Gross
Losses: Refined estimate per TxDOT Research Report 0-6374-2

Notes

Symbol	Definition
L_r	Span Length of Girder at Release
L_l	Span Length of Girder during Lifting
L_{st}	Span Length of Girder during Storage
L_h	Span Length of Girder during Hauling
L_e	Span Length of Girder after Erection
L_s	Length of Span
Debond	Point where bond begins for a debonded strand
PSXFR	Point of prestress transfer
FoS	Face of Support in final bridge configuration
ST	Section Transitions
STLF	Section Transitions, Left Face
STRF	Section Transitions, Right Face
SDCR	Start of Deck Casting Region
EDCR	End of Deck Casting Region
Diaphragm	Location of a precast or cast in place diaphragm
Bar Cutoff	End of a reinforcing bar in the girder
Deck Bar Cutoff	End of a reinforcing bar in the deck
CS	Critical Section for Shear
SZB	Stirrup Zone Boundary
H	H from end of girder or face of support
1.5H	1.5H from end of girder or face of support
HP	Harp Point
Pick Point	Support point where girder is lifted from form
Bunk Point	Point where girder is supported during transportation

Status Items

Level	Description
Warning	Span 1, Girder 2: Either the Jacking stress is not equal to 0.75Fpu, or Debonded strands are present, or Temporary strands are present, or the girder is Not Prismatic. Therefore, for the calculation of elastic shortening; an iterative solution was used to find Fcgp after release rather than assuming 0.7*Fpu per the TxDOT design manual.

Bridge: Job: 10/11/2022

Level	Description
Information	The Lever Rule has been used for all cases where Ranges of Applicability for Live Load Distribution Factor Equations are exceeded. Otherwise, factors are computed using the Equations.

Girder Summary

Note: A Non-Standard Strand Fill Was Used For Span 1 Girder 2

TxDOT Girder Schedule

Span	1
Girder	**2**
Girder Type	Tx54 (Copy 1)
Prestressing Strands	**Total**
NO. ($N_h + N_s$)	46
Size	0.600 in Dia.
Strength	Grade 270 Low Relaxation
Eccentricity @ CL	18.660 in
Eccentricity @ End	18.436 in
Prestressing Strands	**Straight**
NO. (# of Debonded Strands)	18
Concrete	
Release Strength f'_{ci}	6.000 KSI
Minimum 28 day compressive strength f'_c	7.300 KSI
Optional Design	
Design Load Compressive Stress (Top CL)	4.732 KSI
Design Load Tensile Stress (Bottom CL)	-4.554 KSI
Required minimum ultimate moment capacity	8717.70 kip-ft
Live Load Distribution Factor for Moment (Strength and Service Limit States)	0.61509
Live Load Distribution Factor for Shear (Strength and Service Limit States)	0.81433
Live Load Distribution Factor for Moment (Fatigue Limit States)	0.35339

NOTE: Stresses show in the above table reflect the following sign convention:
Compressive Stress is positive. Tensile Stress is negative

Debonded Strand Pattern for Span 1 Girder 2

Dist from Bottom	# of Strands		# of Strands Debonded At										
	Total	Debonded	3 ft	6 ft	9 ft	12 ft	15 ft	18 ft	21 ft	24 ft	27 ft	30 ft
2.500 in	14	6	0	0	0	0	6	0	0	0	0	0
4.500 in	14	6	0	0	0	2	4	0	0	0	0	0
6.500 in	14	6	0	0	0	6	0	0	0	0	0	0

Non-Standard Strand Pattern for Span 1 Girder 2

Row From Bottom (in)	Strands
3	ABCDEFG (14)
5	ABCDEFG (14)
7	ABCDEFG (14)
9	AB (4)

Girder Line Geometry

Girder Type	Tx54 (Copy 1)
Span Length, CL Bearing to CL Bearing	123.500 ft
Girder Length	125.000 ft
Number of Girders	6
Girder Spacing Datum Start of Span	Measured normal to alignment at abutment line
Left Girder Spacing Start of Span	8.000 ft

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Right Girder Spacing Start of Span	8.000 ft
Girder Spacing Datum End of Span	Measured normal to alignment at abutment line
Left Girder Spacing End of Span	8.000 ft
Right Girder Spacing End of Span	8.000 ft
Slab Thickness for Design	8.500 in
Slab Thickness for Construction	8.500 in
Slab Offset at Start ("A" Dimension)	8.500 in
Slab Offset at End ("A" Dimension)	8.500 in
Overlay	0.000 KSF
Left Traffic Barrier	SSTR
Right Traffic Barrier	SSTR
Traffic Barrier Weight (per girder)	0.125 kip/ft
Connection Geometry at Abutment 1	Bearing Offset: 1.000 ft Measured From Abutment Line and Along Girder Centerline End Distance: 0.250 ft Measured From Abutment Line and Along Girder Centerline
Connection Geometry at Abutment 2	Bearing Offset: 1.000 ft Measured From Abutment Line and Along Girder Centerline End Distance: 0.250 ft Measured From Abutment Line and Along Girder Centerline

Loading Details

Span 1, Girder 2

Uniform Loads Applied Along the Entire Girder

Load Type	w (kip/ft)
Girder	0.851

Slab Load Applied Along Girder

Tributary width used to compute slab load is measured from top CL girder
Slab load is uniform along entire girder length.

Slab unit weight with reinforcement = 0.150 kip/ft^3
Casting Regions 1

Load Type	w (kip/ft)
Total Slab Weight	0.850

Distribution of Uniform Barrier, Sidewalk, and Pedestrian Loads to Girder

Load Type	Total Weight (kip/ft)	Fraction to Girder	Girder Load (kip/ft)
Left Ext. Barrier	0.376	0.333	0.125
Right Ext. Barrier	0.376	0.000	0.000

Pier Diaphragm Loads

Pier	Location	P (kip)	Moment Arm (ft)	M (kip-ft)
1	Ahead Bearing	0.00	0.000	0.00
2	Back Bearing	0.00	0.000	0.00

User Defined Loads

Distributed Loads

Interval	Load Case	Start Location (ft)	End Location (ft)	Start Magnitude (kip/ft)	End Magnitude (kip/ft)	Description
Interval 10: Cast Deck, Apply User Defined Loads	DC	0.000	123.500	0.113	0.113	3" haunch load

Live Load Details

Live Loads used for Design

The following live loads were applied to the design (Service and Strength I) limit states:

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AASHTO LRFD 3.6.1.2: HL-93 Design Vehicular Live Load

Live Loads Used for Fatigue Limit States
The following live loads were applied to the Fatigue I limit state:
AASHTO LRFD 3.6.1.4: Fatigue Vehicular Live Load

Live Loads Used for Design Permit Limit State
No live loads were applied to the design permit (Strength II) limit state

User Defined Loads
Locations are measured from left support.
Point loads were not defined for this girder

Distributed Loads

Event	Load Case	Start Location	End Location	Start Magnitude (kip/ft)	End Magnitude (kip/ft)	Description
Event 4: Cast Deck	DC	0.00 %	100.00 %	0.113	0.113	3" haunch load

Moment loads were not defined for this girder

Prestress Force and Strand Stresses

Effective Prestress at Mid-Span

Loss Stage	Permanent Strand			
	Effective Force (kip)	Time-Dependent Effects (KSI)	Instantaneous Effects (KSI)	f_{pe} (KSI)
At Jacking	2021.36	0.000	0.000	202.500
Before Prestress Transfer	2021.36	0.000	0.000	202.500
After Prestress Transfer	1826.89	0.000	19.482	183.018
At Lifting	1826.89	0.000	19.482	183.018
At Shipping	1682.90	14.425	19.482	168.593
After Erection	1682.90	14.425	19.482	168.593
After Deck Placement	1538.91	28.850	19.482	154.168
After Superimposed Dead Loads	1538.91	28.850	19.482	154.168
Final (permanent loads only)	1538.91	28.850	19.482	154.168
Final with Live Load (Service I)	1538.91	28.850	19.482	154.168
Final with Live Load (Service III)	1538.91	28.850	19.482	154.168
Final with Live Load (Fatigue I)	1538.91	28.850	19.482	154.168

Stress Checks
Specification = TxDOT 2017

Interval 2: Prestress Release : Service I Compression

Service I
For Temporary Stresses before Losses [5.9.2.3.1]
Compression Stresses [5.9.2.3.1a]
f'_{ci} = 6.000 KSI

Compression stress limit = $-0.7f'_{ci}$ = -3.900 KSI

Concrete strength required to satisfy this requirement = 6.224 KSI

Location from Left Support (ft)	Location from End of Girder (ft)	Pre-tension		Service I		Demand		Precompressed Tensile Zone		Status (C/D)
		f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	Top	Bottom	
(STRF) -0.750	(STRF, 0.0L$_r$) 0.000	0.000	0.000	0.000	0.000	0.000	0.000	No	Yes	Pass (∞)
(PSXFR) 2.250	(PSXFR) 3.000	0.702	-2.873	-0.190	0.147	0.512	-2.727	No	Yes	Pass (1.43)
(Debond) 11.250	(Debond) 12.000	0.708	-2.901	-0.705	0.543	0.004	-2.358	No	Yes	Pass (1.65)
11.750	(0.1L$_r$) 12.500	0.738	-3.037	-0.731	0.563	0.007	-2.474	No	Yes	Pass

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Location from Left Support (ft)	Location from End of Girder (ft)	Pre-tension		Service I		Demand		Precompressed Tensile Zone		Status (C/D)
		f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	Top	Bottom	
										(1.58)
(PSXFR, Debond) 14.250	(PSXFR, Debond) 15.000	0.885	-3.722	-0.857	0.661	0.028	-3.061	No	Yes	Pass (1.27)
(PSXFR) 17.250	(PSXFR) 18.000	1.210	-4.817	-1.001	0.772	0.209	-4.045	No	Yes	**Fail** (0.96)
24.250	(0.2L$_r$) 25.000	1.216	-4.844	-1.299	1.002	-0.083	-3.842	No	Yes	Pass (1.02)
36.750	(0.3L$_r$) 37.500	1.225	-4.880	-1.705	1.315	-0.480	-3.565	No	Yes	Pass (1.09)
49.250	(0.4L$_r$) 50.000	1.231	-4.902	-1.949	1.502	-0.718	-3.399	No	Yes	Pass (1.15)
(HP) 55.575	(HP) 56.325	1.232	-4.907	-2.010	1.550	-0.778	-3.357	No	Yes	Pass (1.16)
(0.5L$_s$) 61.750	(0.5L$_r$) 62.500	1.233	-4.909	-2.030	1.565	-0.797	-3.344	No	Yes	Pass (1.17)
(HP) 67.925	(HP) 68.675	1.232	-4.907	-2.010	1.550	-0.778	-3.357	No	Yes	Pass (1.16)
74.250	(0.6L$_r$) 75.000	1.231	-4.902	-1.949	1.502	-0.718	-3.399	No	Yes	Pass (1.15)
86.750	(0.7L$_r$) 87.500	1.225	-4.880	-1.705	1.315	-0.480	-3.565	No	Yes	Pass (1.09)
99.250	(0.8L$_r$) 100.000	1.216	-4.844	-1.299	1.002	-0.083	-3.842	No	Yes	Pass (1.02)
(PSXFR) 106.250	(PSXFR) 107.000	1.210	-4.817	-1.001	0.772	0.209	-4.045	No	Yes	**Fail** (0.96)
(PSXFR, Debond) 109.250	(PSXFR, Debond) 110.000	0.885	-3.722	-0.857	0.661	0.028	-3.061	No	Yes	Pass (1.27)
111.750	(0.9L$_r$) 112.500	0.738	-3.037	-0.731	0.563	0.007	-2.474	No	Yes	Pass (1.58)
(Debond) 112.250	(Debond) 113.000	0.708	-2.901	-0.705	0.543	0.004	-2.358	No	Yes	Pass (1.65)
(PSXFR) 121.250	(PSXFR) 122.000	0.702	-2.873	-0.190	0.147	0.512	-2.727	No	Yes	Pass (1.43)
(STLF) 124.250	(STLF, 1.0L$_r$) 125.000	0.000	0.000	0.000	0.000	0.000	0.000	No	Yes	Pass (∞)

Interval 2: Prestress Release : Service I Tension

Service I
For Temporary Stresses before Losses [5.9.2.3.1]
Tension Stresses [5.9.2.3.1b]

f'_{ci} = 6.000 KSI

Tension stress limit in areas other than the precompressed tensile zone = $0.2400\lambda\sqrt{f'_{ci}}$ = 0.588 KSI

Tension stress limit in areas with sufficient bonded reinforcement = $0.2400\lambda\sqrt{f'_{ci}}$ = 0.588 KSI

Concrete strength required to satisfy this requirement = 6.224 KSI

Location from Left Support (ft)	Location from End of Girder (ft)	Pre-tension		Service I		Demand		Tension Limit		Precompressed Tensile Zone		Status (C/D)
		f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	Top (KSI)	Bottom (KSI)	Top	Bottom	
(STRF) -0.750	(STRF, 0.0L$_r$) 0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.588	-	No	Yes	Pass (∞)
(PSXFR) 2.250	(PSXFR) 3.000	0.702	-2.873	-0.190	0.147	0.512	-2.727	0.588	-	No	Yes	Pass (1.15)
(Debond) 11.250	(Debond) 12.000	0.708	-2.901	-0.705	0.543	0.004	-2.358	0.588	-	No	Yes	Pass

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Location from Left Support (ft)	Location from End of Girder (ft)	Pre-tension f_t (KSI)	f_b (KSI)	Service I f_t (KSI)	f_b (KSI)	Demand f_t (KSI)	f_b (KSI)	Tension Limit Top (KSI)	Bottom (KSI)	Precompressed Tensile Zone Top	Bottom	Status (C/D)
												(10+)
11.750	(0.1L_r) 12.500	0.738	-3.037	-0.731	0.563	0.007	-2.474	0.588	-	No	Yes	Pass (10+)
(PSXFR, Debond) 14.250	(PSXFR, Debond) 15.000	0.885	-3.722	-0.857	0.661	0.028	-3.061	0.588	-	No	Yes	Pass (10+)
(PSXFR) 17.250	(PSXFR) 18.000	1.210	-4.817	-1.001	0.772	0.209	-4.045	0.588	-	No	Yes	Pass (2.82)
24.250	(0.2L_r) 25.000	1.216	-4.844	-1.299	1.002	-0.083	-3.842	0.588	-	No	Yes	Pass (-)
36.750	(0.3L_r) 37.500	1.225	-4.880	-1.705	1.315	-0.480	-3.565	0.588	-	No	Yes	Pass (-)
49.250	(0.4L_r) 50.000	1.231	-4.902	-1.949	1.502	-0.718	-3.399	0.588	-	No	Yes	Pass (-)
(HP) 55.575	(HP) 56.325	1.232	-4.907	-2.010	1.550	-0.778	-3.357	0.588	-	No	Yes	Pass (-)
(0.5L_s) 61.750	(0.5L_r) 62.500	1.233	-4.909	-2.030	1.565	-0.797	-3.344	0.588	-	No	Yes	Pass (-)
(HP) 67.925	(HP) 68.675	1.232	-4.907	-2.010	1.550	-0.778	-3.357	0.588	-	No	Yes	Pass (-)
74.250	(0.6L_r) 75.000	1.231	-4.902	-1.949	1.502	-0.718	-3.399	0.588	-	No	Yes	Pass (-)
86.750	(0.7L_r) 87.500	1.225	-4.880	-1.705	1.315	-0.480	-3.565	0.588	-	No	Yes	Pass (-)
99.250	(0.8L_r) 100.000	1.216	-4.844	-1.299	1.002	-0.083	-3.842	0.588	-	No	Yes	Pass (-)
(PSXFR) 106.250	(PSXFR) 107.000	1.210	-4.817	-1.001	0.772	0.209	-4.045	0.588	-	No	Yes	Pass (2.82)
(PSXFR, Debond) 109.250	(PSXFR, Debond) 110.000	0.885	-3.722	-0.857	0.661	0.028	-3.061	0.588	-	No	Yes	Pass (10+)
111.750	(0.9L_r) 112.500	0.738	-3.037	-0.731	0.563	0.007	-2.474	0.588	-	No	Yes	Pass (10+)
(Debond) 112.250	(Debond) 113.000	0.708	-2.901	-0.705	0.543	0.004	-2.358	0.588	-	No	Yes	Pass (10+)
(PSXFR) 121.250	(PSXFR) 122.000	0.702	-2.873	-0.190	0.147	0.512	-2.727	0.588	-	No	Yes	Pass (1.15)
(STLF) 124.250	(STLF, 1.0L_r) 125.000	0.000	0.000	0.000	0.000	0.000	0.000	0.588	-	No	Yes	Pass (∞)

Interval 10: Cast Deck, Apply User Defined Loads : Service I Compression

Service I
Stresses at Service Limit State after Losses [5.9.2.3.2]
Compression Stresses [5.9.2.3.2a]
f'_c = 7.300 KSI

Compression stress limit = -0.6f'_c = -4.380 KSI

Concrete strength required to satisfy this requirement = 5.307 KSI

Location from Left Support (ft)	Pre-tension f_t (KSI)	f_b (KSI)	Service I f_t (KSI)	f_b (KSI)	Demand f_t (KSI)	f_b (KSI)	Precompressed Tensile Zone Top	Bottom	Status (C/D)
0.000	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (8.12)
(0.0L_s) 0.000	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (8.12)

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Location from Left Support (ft)	Pre-tension f_t (KSI)	Pre-tension f_b (KSI)	Service I f_t (KSI)	Service I f_b (KSI)	Demand f_t (KSI)	Demand f_b (KSI)	Precompressed Tensile Zone Top	Precompressed Tensile Zone Bottom	Status (C/D)
(PSXFR) 2.250	0.533	-2.183	-0.302	0.233	0.231	-1.950	No	Yes	Pass (2.25)
(Debond) 11.250	0.555	-2.273	-1.398	1.078	-0.843	-1.195	No	Yes	Pass (3.67)
(0.1L$_s$) 12.350	0.608	-2.519	-1.520	1.172	-0.912	-1.347	No	Yes	Pass (3.25)
(PSXFR, Debond) 14.250	0.701	-2.948	-1.724	1.329	-1.023	-1.619	No	Yes	Pass (2.71)
(PSXFR) 17.250	0.962	-3.833	-2.030	1.565	-1.067	-2.268	No	Yes	Pass (1.93)
(0.2L$_s$) 24.700	0.986	-3.925	-2.703	2.084	-1.717	-1.842	No	Yes	Pass (2.38)
(0.3L$_s$) 37.050	1.015	-4.042	-3.547	2.735	-2.532	-1.307	No	Yes	Pass (1.73)
(0.4L$_s$) 49.400	1.033	-4.112	-4.054	3.125	-3.021	-0.986	No	Yes	Pass (1.45)
(HP) 55.575	1.037	-4.129	-4.181	3.223	-3.144	-0.906	No	Yes	Pass (1.39)
(0.5L$_s$) 61.750	1.038	-4.135	-4.223	3.256	-3.184	-0.880	No	Yes	Pass (1.38)
(HP) 67.925	1.037	-4.129	-4.181	3.223	-3.144	-0.906	No	Yes	Pass (1.39)
(0.6L$_s$) 74.100	1.033	-4.112	-4.054	3.125	-3.021	-0.986	No	Yes	Pass (1.45)
(0.7L$_s$) 86.450	1.015	-4.042	-3.547	2.735	-2.532	-1.307	No	Yes	Pass (1.73)
(0.8L$_s$) 98.800	0.986	-3.925	-2.703	2.084	-1.717	-1.842	No	Yes	Pass (2.38)
(PSXFR) 106.250	0.962	-3.833	-2.030	1.565	-1.067	-2.268	No	Yes	Pass (1.93)
(PSXFR, Debond) 109.250	0.701	-2.948	-1.724	1.329	-1.023	-1.619	No	Yes	Pass (2.71)
(0.9L$_s$) 111.150	0.608	-2.519	-1.520	1.172	-0.912	-1.347	No	Yes	Pass (3.25)
(Debond) 112.250	0.555	-2.273	-1.398	1.078	-0.843	-1.195	No	Yes	Pass (3.67)
(PSXFR) 121.250	0.533	-2.183	-0.302	0.233	0.231	-1.950	No	Yes	Pass (2.25)
(1.0L$_s$) 123.500	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (8.12)
123.500	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (8.12)

Interval 10: Cast Deck, Apply User Defined Loads : Service I Tension

Service I
Stresses at Service Limit State after Losses [5.9.2.3.2]
Tension Stresses [5.9.2.3.2b]

f'_c = 7.300 KSI

Tension stress limit in the precompressed tensile zone = $0.2400\lambda\sqrt{f'_c}$ = 0.648 KSI

Concrete strength required to satisfy this requirement = 5.307 KSI

Location from Left Support (ft)	Pre-tension f_t (KSI)	Pre-tension f_b (KSI)	Service I f_t (KSI)	Service I f_b (KSI)	Demand f_t (KSI)	Demand f_b (KSI)	Tension Limit Top (KSI)	Tension Limit Bottom (KSI)	Precompressed Tensile Zone Top	Precompressed Tensile Zone Bottom	Status (C/D)

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Location from Left Support (ft)	Pre-tension		Service I		Demand		Tension Limit		Precompressed Tensile Zone		Status (C/D)
	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	Top (KSI)	Bottom (KSI)	Top	Bottom	
0.000	0.132	-0.539	0.000	0.000	0.132	-0.539	-	0.648	No	Yes	Pass (-)
(0.0L$_s$) 0.000	0.132	-0.539	0.000	0.000	0.132	-0.539	-	0.648	No	Yes	Pass (-)
(PSXFR) 2.250	0.533	-2.183	-0.302	0.233	0.231	-1.950	-	0.648	No	Yes	Pass (-)
(Debond) 11.250	0.555	-2.273	-1.398	1.078	-0.843	-1.195	-	0.648	No	Yes	Pass (-)
(0.1L$_s$) 12.350	0.608	-2.519	-1.520	1.172	-0.912	-1.347	-	0.648	No	Yes	Pass (-)
(PSXFR, Debond) 14.250	0.701	-2.948	-1.724	1.329	-1.023	-1.619	-	0.648	No	Yes	Pass (-)
(PSXFR) 17.250	0.962	-3.833	-2.030	1.565	-1.067	-2.268	-	0.648	No	Yes	Pass (-)
(0.2L$_s$) 24.700	0.986	-3.925	-2.703	2.084	-1.717	-1.842	-	0.648	No	Yes	Pass (-)
(0.3L$_s$) 37.050	1.015	-4.042	-3.547	2.735	-2.532	-1.307	-	0.648	No	Yes	Pass (-)
(0.4L$_s$) 49.400	1.033	-4.112	-4.054	3.125	-3.021	-0.986	-	0.648	No	Yes	Pass (-)
(HP) 55.575	1.037	-4.129	-4.181	3.223	-3.144	-0.906	-	0.648	No	Yes	Pass (-)
(0.5L$_s$) 61.750	1.038	-4.135	-4.223	3.256	-3.184	-0.880	-	0.648	No	Yes	Pass (-)
(HP) 67.925	1.037	-4.129	-4.181	3.223	-3.144	-0.906	-	0.648	No	Yes	Pass (-)
(0.6L$_s$) 74.100	1.033	-4.112	-4.054	3.125	-3.021	-0.986	-	0.648	No	Yes	Pass (-)
(0.7L$_s$) 86.450	1.015	-4.042	-3.547	2.735	-2.532	-1.307	-	0.648	No	Yes	Pass (-)
(0.8L$_s$) 98.800	0.986	-3.925	-2.703	2.084	-1.717	-1.842	-	0.648	No	Yes	Pass (-)
(PSXFR) 106.250	0.962	-3.833	-2.030	1.565	-1.067	-2.268	-	0.648	No	Yes	Pass (-)
(PSXFR, Debond) 109.250	0.701	-2.948	-1.724	1.329	-1.023	-1.619	-	0.648	No	Yes	Pass (-)
(0.9L$_s$) 111.150	0.608	-2.519	-1.520	1.172	-0.912	-1.347	-	0.648	No	Yes	Pass (-)
(Debond) 112.250	0.555	-2.273	-1.398	1.078	-0.843	-1.195	-	0.648	No	Yes	Pass (-)
(PSXFR) 121.250	0.533	-2.183	-0.302	0.233	0.231	-1.950	-	0.648	No	Yes	Pass (-)
(1.0L$_s$) 123.500	0.132	-0.539	0.000	0.000	0.132	-0.539	-	0.648	No	Yes	Pass (-)
123.500	0.132	-0.539	0.000	0.000	0.132	-0.539	-	0.648	No	Yes	Pass (-)

Interval 16: Open to Traffic : Service I Compression without live load

Service I
Stresses at Service Limit State after Losses [5.9.2.3.2]
Compression Stresses [5.9.2.3.2a]

f'_c = 7.300 KSI

Compression stress limit = -0.5f'_c = -3.285 KSI

Concrete strength required to satisfy this requirement = 7.181 KSI

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Location from Left Support (ft)	Pre-tension		Service I		Demand		Precompressed Tensile Zone		Status (C/D)
	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	Top	Bottom	
0.000	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (6.09)
($0.0L_s$) 0.000	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (6.09)
(PSXFR) 2.250	0.533	-2.183	-0.306	0.243	0.228	-1.939	No	Yes	Pass (1.69)
(Debond) 11.250	0.555	-2.273	-1.414	1.127	-0.859	-1.146	No	Yes	Pass (2.87)
($0.1L_s$) 12.350	0.608	-2.519	-1.537	1.225	-0.929	-1.294	No	Yes	Pass (2.54)
(PSXFR, Debond) 14.250	0.701	-2.948	-1.743	1.389	-1.042	-1.559	No	Yes	Pass (2.11)
(PSXFR) 17.250	0.962	-3.833	-2.052	1.635	-1.090	-2.197	No	Yes	Pass (1.50)
($0.2L_s$) 24.700	0.986	-3.925	-2.733	2.178	-1.747	-1.748	No	Yes	Pass (1.88)
($0.3L_s$) 37.050	1.015	-4.042	-3.587	2.858	-2.572	-1.184	No	Yes	Pass (1.28)
($0.4L_s$) 49.400	1.033	-4.112	-4.099	3.266	-3.067	-0.845	No	Yes	Pass (1.07)
(HP) 55.575	1.037	-4.129	-4.227	3.368	-3.190	-0.761	No	Yes	Pass (1.03)
($0.5L_s$) 61.750	1.038	-4.135	-4.270	3.402	-3.232	-0.733	No	Yes	Pass (1.02)
(HP) 67.925	1.037	-4.129	-4.227	3.368	-3.190	-0.761	No	Yes	Pass (1.03)
($0.6L_s$) 74.100	1.033	-4.112	-4.099	3.266	-3.067	-0.845	No	Yes	Pass (1.07)
($0.7L_s$) 86.450	1.015	-4.042	-3.587	2.858	-2.572	-1.184	No	Yes	Pass (1.28)
($0.8L_s$) 98.800	0.986	-3.925	-2.733	2.178	-1.747	-1.748	No	Yes	Pass (1.88)
(PSXFR) 106.250	0.962	-3.833	-2.052	1.635	-1.090	-2.197	No	Yes	Pass (1.50)
(PSXFR, Debond) 109.250	0.701	-2.948	-1.743	1.389	-1.042	-1.559	No	Yes	Pass (2.11)
($0.9L_s$) 111.150	0.608	-2.519	-1.537	1.225	-0.929	-1.294	No	Yes	Pass (2.54)
(Debond) 112.250	0.555	-2.273	-1.414	1.127	-0.859	-1.146	No	Yes	Pass (2.87)
(PSXFR) 121.250	0.533	-2.183	-0.306	0.243	0.228	-1.939	No	Yes	Pass (1.69)
($1.0L_s$) 123.500	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (6.09)
123.500	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (6.09)

Interval 16: Open to Traffic : Service I Compression

Service I
Stresses at Service Limit State after Losses [5.9.2.3.2]
Compression Stresses [5.9.2.3.2a]

f'_c = 7.300 KSI

Compression stress limit = $-0.6f'_c$ = -4.380 KSI

Concrete strength required to satisfy this requirement = 7.181 KSI

Bridge: Job: 10/11/2022

Location from Left Support (ft)	Pre-tension		Service I		Demand		Precompressed Tensile Zone		Status (C/D)
	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	Top	Bottom	
0.000	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (8.12)
(0.0L$_s$) 0.000	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (8.12)
(PSXFR) 2.250	0.533	-2.183	-0.340	0.243	0.193	-1.939	No	Yes	Pass (2.26)
(Debond) 11.250	0.555	-2.273	-1.572	1.127	-1.017	-1.146	No	Yes	Pass (3.82)
(0.1L$_s$) 12.350	0.608	-2.519	-1.709	1.225	-1.101	-1.294	No	Yes	Pass (3.38)
(PSXFR, Debond) 14.250	0.701	-2.948	-1.938	1.389	-1.237	-1.559	No	Yes	Pass (2.81)
(PSXFR) 17.250	0.962	-3.833	-2.281	1.635	-1.319	-2.197	No	Yes	Pass (1.99)
(0.2L$_s$) 24.700	0.986	-3.925	-3.036	2.178	-2.050	-1.748	No	Yes	Pass (2.14)
(0.3L$_s$) 37.050	1.015	-4.042	-3.981	2.858	-2.966	-1.184	No	Yes	Pass (1.48)
(0.4L$_s$) 49.400	1.033	-4.112	-4.547	3.266	-3.514	-0.845	No	Yes	Pass (1.25)
(HP) 55.575	1.037	-4.129	-4.687	3.368	-3.650	-0.761	No	Yes	Pass (1.20)
(0.5L$_s$) 61.750	1.038	-4.135	-4.732	3.402	-3.694	-0.733	No	Yes	Pass (1.19)
(HP) 67.925	1.037	-4.129	-4.687	3.368	-3.650	-0.761	No	Yes	Pass (1.20)
(0.6L$_s$) 74.100	1.033	-4.112	-4.547	3.266	-3.514	-0.845	No	Yes	Pass (1.25)
(0.7L$_s$) 86.450	1.015	-4.042	-3.981	2.858	-2.966	-1.184	No	Yes	Pass (1.48)
(0.8L$_s$) 98.800	0.986	-3.925	-3.036	2.178	-2.050	-1.748	No	Yes	Pass (2.14)
(PSXFR) 106.250	0.962	-3.833	-2.281	1.635	-1.319	-2.197	No	Yes	Pass (1.99)
(PSXFR, Debond) 109.250	0.701	-2.948	-1.938	1.389	-1.237	-1.559	No	Yes	Pass (2.81)
(0.9L$_s$) 111.150	0.608	-2.519	-1.709	1.225	-1.101	-1.294	No	Yes	Pass (3.38)
(Debond) 112.250	0.555	-2.273	-1.572	1.127	-1.017	-1.146	No	Yes	Pass (3.82)
(PSXFR) 121.250	0.533	-2.183	-0.340	0.243	0.193	-1.939	No	Yes	Pass (2.26)
(1.0L$_s$) 123.500	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (8.12)
123.500	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (8.12)

Interval 16: Open to Traffic : Service III Tension

Service III
Stresses at Service Limit State after Losses [5.9.2.3.2]
Tension Stresses [5.9.2.3.2b]
f'_c = 7.300 KSI

Tension stress limit in the precompressed tensile zone = $0.1900\lambda\sqrt{f'_c}$ but not more than 0.600 KSI = 0.513 KSI

Concrete strength required to satisfy this requirement = 4.852 KSI

Bridge: Job: 10/11/2022

Location from Left Support (ft)	Pre-tension		Service III		Demand		Precompressed Tensile Zone		Status (C/D)
	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	Top	Bottom	
0.000	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (-)
(0.0L$_s$) 0.000	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (-)
(PSXFR) 2.250	0.533	-2.183	-0.306	0.329	0.228	-1.854	No	Yes	Pass (-)
(Debond) 11.250	0.555	-2.273	-1.414	1.521	-0.859	-0.752	No	Yes	Pass (-)
(0.1L$_s$) 12.350	0.608	-2.519	-1.537	1.653	-0.929	-0.866	No	Yes	Pass (-)
(PSXFR, Debond) 14.250	0.701	-2.948	-1.743	1.874	-1.042	-1.074	No	Yes	Pass (-)
(PSXFR) 17.250	0.962	-3.833	-2.052	2.205	-1.090	-1.628	No	Yes	Pass (-)
(0.2L$_s$) 24.700	0.986	-3.925	-2.733	2.932	-1.747	-0.993	No	Yes	Pass (-)
(0.3L$_s$) 37.050	1.015	-4.042	-3.587	3.838	-2.572	-0.203	No	Yes	Pass (-)
(0.4L$_s$) 49.400	1.033	-4.112	-4.099	4.380	-3.067	0.269	No	Yes	Pass (1.91)
(HP) 55.575	1.037	-4.129	-4.227	4.514	-3.190	0.384	No	Yes	Pass (1.34)
(0.5L$_s$) 61.750	1.038	-4.135	-4.270	4.554	-3.232	0.419	No	Yes	Pass (1.23)
(HP) 67.925	1.037	-4.129	-4.227	4.514	-3.190	0.384	No	Yes	Pass (1.34)
(0.6L$_s$) 74.100	1.033	-4.112	-4.099	4.380	-3.067	0.269	No	Yes	Pass (1.91)
(0.7L$_s$) 86.450	1.015	-4.042	-3.587	3.838	-2.572	-0.203	No	Yes	Pass (-)
(0.8L$_s$) 98.800	0.986	-3.925	-2.733	2.932	-1.747	-0.993	No	Yes	Pass (-)
(PSXFR) 106.250	0.962	-3.833	-2.052	2.205	-1.090	-1.628	No	Yes	Pass (-)
(PSXFR, Debond) 109.250	0.701	-2.948	-1.743	1.874	-1.042	-1.074	No	Yes	Pass (-)
(0.9L$_s$) 111.150	0.608	-2.519	-1.537	1.653	-0.929	-0.866	No	Yes	Pass (-)
(Debond) 112.250	0.555	-2.273	-1.414	1.521	-0.859	-0.752	No	Yes	Pass (-)
(PSXFR) 121.250	0.533	-2.183	-0.306	0.329	0.228	-1.854	No	Yes	Pass (-)
(1.0L$_s$) 123.500	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (-)
123.500	0.132	-0.539	0.000	0.000	0.132	-0.539	No	Yes	Pass (-)

Interval 16: Open to Traffic : Fatigue I Compression

Fatigue I
Stresses at Service Limit State after Losses [5.9.2.3.2]
Compression Stresses [5.9.2.3.2a]

f'_c = 7.300 KSI

Compression stress limit = -0.4f'_c = -2.920 KSI

Concrete strength required to satisfy this requirement = 4.548 KSI

Bridge: Job: 10/11/2022

Location from Left Support (ft)	Pre-tension		Fatigue I		Demand		Precompressed Tensile Zone		Status (C/D)
	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	f_t (KSI)	f_b (KSI)	Top	Bottom	
0.000	0.132	-0.539	0.000	0.000	0.066	-0.270	No	Yes	Pass (10+)
$(0.0L_s)$ 0.000	0.132	-0.539	0.000	0.000	0.066	-0.270	No	Yes	Pass (10+)
(PSXFR) 2.250	0.533	-2.183	-0.169	0.122	0.098	-0.970	No	Yes	Pass (3.01)
(Debond) 11.250	0.555	-2.273	-0.781	0.563	-0.504	-0.573	No	Yes	Pass (5.09)
$(0.1L_s)$ 12.350	0.608	-2.519	-0.849	0.612	-0.545	-0.647	No	Yes	Pass (4.51)
(PSXFR, Debond) 14.250	0.701	-2.948	-0.963	0.695	-0.612	-0.780	No	Yes	Pass (3.75)
(PSXFR) 17.250	0.962	-3.833	-1.133	0.818	-0.652	-1.099	No	Yes	Pass (2.66)
$(0.2L_s)$ 24.700	0.986	-3.925	-1.506	1.089	-1.013	-0.874	No	Yes	Pass (2.88)
$(0.3L_s)$ 37.050	1.015	-4.042	-1.974	1.429	-1.467	-0.592	No	Yes	Pass (1.99)
$(0.4L_s)$ 49.400	1.033	-4.112	-2.252	1.633	-1.736	-0.423	No	Yes	Pass (1.68)
(HP) 55.575	1.037	-4.129	-2.319	1.684	-1.801	-0.380	No	Yes	Pass (1.62)
$(0.5L_s)$ 61.750	1.038	-4.135	-2.338	1.701	-1.819	-0.366	No	Yes	Pass (1.61)
(HP) 67.925	1.037	-4.129	-2.319	1.684	-1.801	-0.380	No	Yes	Pass (1.62)
$(0.6L_s)$ 74.100	1.033	-4.112	-2.252	1.633	-1.736	-0.423	No	Yes	Pass (1.68)
$(0.7L_s)$ 86.450	1.015	-4.042	-1.974	1.429	-1.467	-0.592	No	Yes	Pass (1.99)
$(0.8L_s)$ 98.800	0.986	-3.925	-1.506	1.089	-1.013	-0.874	No	Yes	Pass (2.88)
(PSXFR) 106.250	0.962	-3.833	-1.133	0.818	-0.652	-1.099	No	Yes	Pass (2.66)
(PSXFR, Debond) 109.250	0.701	-2.948	-0.963	0.695	-0.612	-0.780	No	Yes	Pass (3.75)
$(0.9L_s)$ 111.150	0.608	-2.519	-0.849	0.612	-0.545	-0.647	No	Yes	Pass (4.51)
(Debond) 112.250	0.555	-2.273	-0.781	0.563	-0.504	-0.573	No	Yes	Pass (5.09)
(PSXFR) 121.250	0.533	-2.183	-0.169	0.122	0.098	-0.970	No	Yes	Pass (3.01)
$(1.0L_s)$ 123.500	0.132	-0.539	0.000	0.000	0.066	-0.270	No	Yes	Pass (10+)
123.500	0.132	-0.539	0.000	0.000	0.066	-0.270	No	Yes	Pass (10+)

Moment Capacity

Positive Moment Capacity for Strength I Limit State [5.6]

Location from Left Support (ft)	M_u (kip-ft)	ϕM_n (kip-ft)	ϕM_n Min (kip-ft)	Status	
				ϕM_n Min $\leq \phi M_n$ ($\phi M_n/\phi M_n$ Min)	$M_u \leq \phi M_n$ ($\phi M_n/M_u$)
0.00	1135.51	0.00	Pass	Pass

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Location from Left Support (ft)	M_u (kip-ft)	ϕM_n (kip-ft)	ϕM_n Min (kip-ft)	Status	
				ϕM_n Min $\leq \phi M_n$ ($\phi M_n / \phi M_n$ Min)	$M_u \leq \phi M_n$ ($\phi M_n / M_u$)
(0.0L$_s$) 0.000				(∞)	(∞)
(0.1L$_s$) 12.350	3186.48	7958.93	4238.01	Pass (1.88)	Pass (2.50)
(0.2L$_s$) 24.700	5643.47	11282.59	7505.81	Pass (1.50)	Pass (2.00)
(0.3L$_s$) 37.050	7370.97	11867.27	7376.35	Pass (1.61)	Pass (1.61)
(0.4L$_s$) 49.400	8401.06	11870.48	7281.07	Pass (1.63)	Pass (1.41)
(0.5L$_s$) 61.750	8717.70	11871.55	7249.31	Pass (1.64)	Pass (1.36)
(0.6L$_s$) 74.100	8401.06	11870.48	7281.07	Pass (1.63)	Pass (1.41)
(0.7L$_s$) 86.450	7370.97	11867.27	7376.35	Pass (1.61)	Pass (1.61)
(0.8L$_s$) 98.800	5643.47	11282.59	7505.81	Pass (1.50)	Pass (2.00)
(0.9L$_s$) 111.150	3186.48	7958.93	4238.01	Pass (1.88)	Pass (2.50)
(1.0L$_s$) 123.500	0.00	1135.51	0.00	Pass (∞)	Pass (∞)

Shear

Ultimate Shears for Strength I Limit State [5.8]

Location from Left Support (ft)	Stirrups Required	Stirrups Provided	$|V_u|$ (kip)	ϕV_n (kip)	Status ($\phi V_n / V_u$)
(CS) 5.196	Yes	Yes	309.21	511.34	Pass (1.65)
(1.5H) 7.292	Yes	Yes	300.00	502.79	Pass (1.68)
(Debond) 11.250	Yes	Yes	282.69	486.38	Pass (1.72)
(0.1L$_s$) 12.350	Yes	Yes	277.90	483.81	Pass (1.74)
(SZB) 12.461	Yes	Yes	277.42	398.52	Pass (1.44)
(PSXFR, Debond) 14.250	Yes	Yes	269.65	397.64	Pass (1.47)
(SZB) 22.461	Yes	Yes	234.29	332.64	Pass (1.42)
(0.2L$_s$) 24.700	Yes	Yes	224.74	330.21	Pass (1.47)
(0.3L$_s$) 37.050	Yes	Yes	172.70	317.23	Pass (1.84)
(SZB) 37.461	Yes	Yes	170.98	258.36	Pass (1.51)
(0.4L$_s$) 49.400	Yes	Yes	121.79	219.01	Pass (1.80)
(HP) 55.575	Yes	Yes	96.75	210.95	Pass (2.18)
(0.5L$_s$) 61.750	Yes	Yes	72.00	213.44	Pass (2.96)
(HP) 67.925	Yes	Yes	96.75	210.95	Pass

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Location from Left Support (ft)	Stirrups Required	Stirrups Provided	$\|V_u\|$ (kip)	ϕV_n (kip)	Status $(\phi V_n/V_u)$
					(2.18)
(0.6L$_s$) 74.100	Yes	Yes	121.79	219.01	Pass (1.80)
(SZB) 86.039	Yes	Yes	170.98	258.36	Pass (1.51)
(0.7L$_s$) 86.450	Yes	Yes	172.70	317.23	Pass (1.84)
(0.8L$_s$) 98.800	Yes	Yes	224.74	330.21	Pass (1.47)
(SZB) 101.039	Yes	Yes	234.29	332.64	Pass (1.42)
(PSXFR, Debond) 109.250	Yes	Yes	269.65	397.64	Pass (1.47)
(SZB) 111.039	Yes	Yes	277.42	398.52	Pass (1.44)
(0.9L$_s$) 111.150	Yes	Yes	277.90	483.81	Pass (1.74)
(Debond) 112.250	Yes	Yes	282.69	486.38	Pass (1.72)
(1.5H) 116.208	Yes	Yes	300.00	502.79	Pass (1.68)
(CS) 118.304	Yes	Yes	309.21	511.34	Pass (1.65)

[LRFD 5.8.3.2] The reaction introduces compression into the end of the girder. Load between the CSS and the support is transferred directly to the support by compressive arching action without causing additional stresses in the stirrups. Hence, A$_v$/S in this region must be equal or greater than A$_v$/S at the critical section.

Horizontal Interface Shears/Length for Strength I Limit State [5.7.4]

Location from Left Support (ft)	5.7.4.5			5.7.4.2			5.7.4.1		
	s (in)	s$_{max}$ (in)	Status	a$_{vf}$ (in^2/ft)	a$_{vf\,min}$ (in^2/ft)	Status	$\|v_{ui}\|$ (kip/ft)	ϕv_{ni} (kip/ft)	Status $(\phi v_{ni}/\|v_{ui}\|)$
0.000	3.000	48.000	Pass	1.600	N/A	N/A	66.003	185.066	Pass (2.80)
(0.0L$_s$) 0.000	3.000	48.000	Pass	1.600	N/A	N/A	66.003	185.066	Pass (2.80)
(FoS) 0.542	3.000	48.000	Pass	1.600	N/A	N/A	66.003	185.066	Pass (2.80)
(Bar Develop.) 1.471	3.000	48.000	Pass	1.600	N/A	N/A	66.003	185.066	Pass (2.80)
(Bar Cutoff) 2.375	3.000	48.000	Pass	1.600	N/A	N/A	66.003	185.066	Pass (2.80)
(SZB) 2.461	6.000	48.000	Pass	0.800	N/A	N/A	66.003	144.266	Pass (2.19)
(H) 5.042	6.000	48.000	Pass	0.800	N/A	N/A	66.003	144.266	Pass (2.19)
(CS) 5.196	6.000	48.000	Pass	0.800	N/A	N/A	66.003	144.266	Pass (2.19)
(1.5H) 7.292	6.000	48.000	Pass	0.800	N/A	N/A	64.037	144.266	Pass (2.25)
(Debond) 11.250	6.000	48.000	Pass	0.800	N/A	N/A	60.342	144.266	Pass (2.39)
(0.1L$_s$) 12.350	6.000	48.000	Pass	0.800	N/A	N/A	59.320	144.266	Pass (2.43)
(SZB) 12.461	8.000	48.000	Pass	0.600	N/A	N/A	59.216	134.066	Pass

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Location from Left Support (ft)	5.7.4.5			5.7.4.2			5.7.4.1		
	s (in)	s_{max} (in)	Status	a_{vf} (in²/ft)	$a_{vf\ min}$ (in²/ft)	Status	$|v_{ui}|$ (kip/ft)	ϕv_{ni} (kip/ft)	Status ($\phi v_{ni}/|v_{ui}|$)
(PSXFR, Debond) 14.250	8.000	48.000	Pass	0.600	N/A	N/A	57.558	134.066	Pass (2.33)
(SZB) 22.461	12.000	48.000	Pass	0.400	N/A	N/A	50.011	131.153	Pass (2.62)
(0.2L$_s$) 24.700	12.000	48.000	Pass	0.400	N/A	N/A	47.971	131.153	Pass (2.73)
(0.3L$_s$) 37.050	12.000	48.000	Pass	0.400	N/A	N/A	36.863	131.153	Pass (3.56)
(SZB) 37.461	18.000	48.000	Pass	0.267	N/A	N/A	36.498	123.953	Pass (3.40)
(0.4L$_s$) 49.400	18.000	48.000	Pass	0.267	N/A	N/A	25.996	123.953	Pass (4.77)
(HP) 55.575	18.000	48.000	Pass	0.267	N/A	N/A	20.652	123.953	Pass (6.00)
(0.5L$_s$) 61.750	18.000	48.000	Pass	0.267	N/A	N/A	15.369	123.953	Pass (8.07)
(HP) 67.925	18.000	48.000	Pass	0.267	N/A	N/A	20.652	123.953	Pass (6.00)
(0.6L$_s$) 74.100	18.000	48.000	Pass	0.267	N/A	N/A	25.996	123.953	Pass (4.77)
(SZB) 86.039	18.000	48.000	Pass	0.267	N/A	N/A	36.498	123.953	Pass (3.40)
(0.7L$_s$) 86.450	12.000	48.000	Pass	0.400	N/A	N/A	36.863	131.153	Pass (3.56)
(0.8L$_s$) 98.800	12.000	48.000	Pass	0.400	N/A	N/A	47.971	131.153	Pass (2.73)
(SZB) 101.039	12.000	48.000	Pass	0.400	N/A	N/A	50.011	131.153	Pass (2.62)
(PSXFR, Debond) 109.250	8.000	48.000	Pass	0.600	N/A	N/A	57.558	134.066	Pass (2.33)
(SZB) 111.039	8.000	48.000	Pass	0.600	N/A	N/A	59.216	134.066	Pass (2.26)
(0.9L$_s$) 111.150	6.000	48.000	Pass	0.800	N/A	N/A	59.320	144.266	Pass (2.43)
(Debond) 112.250	6.000	48.000	Pass	0.800	N/A	N/A	60.342	144.266	Pass (2.39)
(1.5H) 116.208	6.000	48.000	Pass	0.800	N/A	N/A	64.037	144.266	Pass (2.25)
(CS) 118.304	6.000	48.000	Pass	0.800	N/A	N/A	66.003	144.266	Pass (2.19)
(H) 118.458	6.000	48.000	Pass	0.800	N/A	N/A	66.003	144.266	Pass (2.19)
(SZB) 121.039	6.000	48.000	Pass	0.800	N/A	N/A	66.003	144.266	Pass (2.19)
(Bar Cutoff) 121.125	3.000	48.000	Pass	1.600	N/A	N/A	66.003	185.066	Pass (2.80)
(Bar Develop.) 122.029	3.000	48.000	Pass	1.600	N/A	N/A	66.003	185.066	Pass (2.80)
(FoS) 122.958	3.000	48.000	Pass	1.600	N/A	N/A	66.003	185.066	Pass (2.80)
(1.0L$_s$) 123.500	3.000	48.000	Pass	1.600	N/A	N/A	66.003	185.066	Pass (2.80)
123.500	3.000	48.000	Pass	1.600	N/A	N/A	66.003	185.066	Pass (2.80)

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Longitudinal Reinforcement for Shear Check - Strength I [5.7.3.5]

$$A_s f_y + A_{ps} f_{ps} \geq \left| \frac{M_u}{d_v \varphi_f} + 0.5 \frac{N_u}{\varphi_a} + \left(\left| \frac{V_u}{\varphi_v} - V_p \right| - 0.5 V_s \right) \cot \theta \right| \qquad 5.7.3.5\text{-}1$$

$$A_s f_y + A_{ps} f_{ps} \geq \left(\frac{V_u}{\varphi_v} - V_p - 0.5 V_s \right) \cot \theta \qquad 5.7.3.5\text{-}2$$

Location from Left Support (ft)	Capacity (kip)	Demand (kip)	Equation	Status (C/D)
(FoS) 0.542	442.23	337.37	5.7.3.5-2	Pass (1.31)
(Bar Develop.) 1.471	730.78	337.37	5.7.3.5-2	Pass (2.17)
(Bar Cutoff) 2.375	963.08	337.37	5.7.3.5-2	Pass (2.85)
(SZB) 2.461	969.02	337.37	5.7.3.5-2	Pass (2.87)
(H) 5.042	1146.47	337.37	5.7.3.5-2	Pass (3.40)
(CS) 5.196	1157.11	644.46	5.7.3.5-1	Pass (1.80)
(1.5H) 7.292	1301.20	749.78	5.7.3.5-1	Pass (1.74)
(Debond) 11.250	1573.41	940.70	5.7.3.5-1	Pass (1.67)
(0.1L$_s$) 12.350	1740.51	995.44	5.7.3.5-1	Pass (1.75)
(SZB) 12.461	1750.63	1024.34	5.7.3.5-1	Pass (1.71)
(PSXFR, Debond) 14.250	1912.61	1102.24	5.7.3.5-1	Pass (1.74)
(SZB) 22.461	2439.15	1461.38	5.7.3.5-1	Pass (1.67)
(0.2L$_s$) 24.700	2507.67	1530.64	5.7.3.5-1	Pass (1.64)
(0.3L$_s$) 37.050	2643.98	1815.93	5.7.3.5-1	Pass (1.46)
(SZB) 37.461	2644.01	1878.46	5.7.3.5-1	Pass (1.41)
(0.4L$_s$) 49.400	2644.74	1998.15	5.7.3.5-1	Pass (1.32)
(HP) 55.575	2644.93	2017.91	5.7.3.5-1	Pass (1.31)
(0.5L$_s$) 61.750	2644.99	2010.03	5.7.3.5-1	Pass (1.32)
(HP) 67.925	2644.93	2017.91	5.7.3.5-1	Pass (1.31)
(0.6L$_s$) 74.100	2644.74	1998.15	5.7.3.5-1	Pass (1.32)
(SZB) 86.039	2644.01	1878.46	5.7.3.5-1	Pass (1.41)
(0.7L$_s$) 86.450	2643.98	1815.93	5.7.3.5-1	Pass (1.46)
(0.8L$_s$) 98.800	2507.67	1530.64	5.7.3.5-1	Pass (1.64)
(SZB) 101.039	2439.15	1461.38	5.7.3.5-1	Pass (1.67)
(PSXFR, Debond) 109.250	1912.61	1102.24	5.7.3.5-1	Pass

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Location from Left Support (ft)	Capacity (kip)	Demand (kip)	Equation	Status (C/D)
				(1.74)
(SZB) 111.039	1750.63	1024.34	5.7.3.5-1	Pass (1.71)
(0.9L_s) 111.150	1740.51	995.44	5.7.3.5-1	Pass (1.75)
(Debond) 112.250	1573.41	940.70	5.7.3.5-1	Pass (1.67)
(1.5H) 116.208	1301.20	749.78	5.7.3.5-1	Pass (1.74)
(CS) 118.304	1157.11	644.46	5.7.3.5-1	Pass (1.80)
(H) 118.458	1146.47	337.37	5.7.3.5-2	Pass (3.40)
(SZB) 121.039	969.02	337.37	5.7.3.5-2	Pass (2.87)
(Bar Cutoff) 121.125	963.08	337.37	5.7.3.5-2	Pass (2.85)
(Bar Develop.) 122.029	730.78	337.37	5.7.3.5-2	Pass (2.17)
(FoS) 122.958	442.23	337.37	5.7.3.5-2	Pass (1.31)

Stirrup Detailing Check: Strength I [5.7.2.5, 5.7.2.6, 5.10.3.1.2]

Location from Left Support (ft)	Bar Size	S (in)	S_{max} (in)	S_{min} (in)	A_v/S (in²/ft)	A_v/S_{min} (in²/ft)*	Status
0.000	#4	3.000	24.000	2.495	1.600	0.000	Pass
(0.0L_s) 0.000	#4	3.000	24.000	2.495	1.600	0.120	Pass
(FoS) 0.542	#4	3.000	12.000	2.495	1.600	0.120	Pass
(Bar Develop.) 1.471	#4	3.000	12.000	2.495	1.600	0.120	Pass
(Bar Cutoff) 2.375	#4	3.000	12.000	2.495	1.600	0.120	Pass
(SZB) 2.461	#4	6.000	12.000	2.495	0.800	0.120	Pass
(H) 5.042	#4	6.000	12.000	2.495	0.800	0.120	Pass
(CS) 5.196	#4	6.000	12.000	2.495	0.800	0.120	Pass
(1.5H) 7.292	#4	6.000	24.000	2.495	0.800	0.120	Pass
(Debond) 11.250	#4	6.000	24.000	2.495	0.800	0.120	Pass
(0.1L_s) 12.350	#4	6.000	24.000	2.495	0.800	0.120	Pass
(SZB) 12.461	#4	8.000	24.000	2.495	0.600	0.120	Pass
(PSXFR, Debond) 14.250	#4	8.000	24.000	2.495	0.600	0.120	Pass
(SZB) 22.461	#4	12.000	24.000	2.495	0.400	0.120	Pass
(0.2L_s) 24.700	#4	12.000	24.000	2.495	0.400	0.120	Pass
(0.3L_s) 37.050	#4	12.000	24.000	2.495	0.400	0.120	Pass
(SZB) 37.461	#4	18.000	24.000	2.495	0.267	0.120	Pass
(0.4L_s) 49.400	#4	18.000	24.000	2.495	0.267	0.120	Pass
(HP) 55.575	#4	18.000	24.000	2.495	0.267	0.120	Pass
(0.5L_s) 61.750	#4	18.000	24.000	2.495	0.267	0.120	Pass
(HP) 67.925	#4	18.000	24.000	2.495	0.267	0.120	Pass
(0.6L_s) 74.100	#4	18.000	24.000	2.495	0.267	0.120	Pass
(SZB) 86.039	#4	18.000	24.000	2.495	0.267	0.120	Pass
(0.7L_s) 86.450	#4	12.000	24.000	2.495	0.400	0.120	Pass
	#4	12.000	24.000	2.495	0.400	0.120	Pass

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Location from Left Support (ft)	Bar Size	S (in)	S_{max} (in)	S_{min} (in)	A_v/S (in²/ft)	A_v/S_{min} (in²/ft)*	Status
(0.8L$_s$) 98.800							
(SZB) 101.039	#4	12.000	24.000	2.495	0.400	0.120	Pass
(PSXFR, Debond) 109.250	#4	8.000	24.000	2.495	0.600	0.120	Pass
(SZB) 111.039	#4	8.000	24.000	2.495	0.600	0.120	Pass
(0.9L$_s$) 111.150	#4	6.000	24.000	2.495	0.800	0.120	Pass
(Debond) 112.250	#4	6.000	24.000	2.495	0.800	0.120	Pass
(1.5H) 116.208	#4	6.000	24.000	2.495	0.800	0.120	Pass
(CS) 118.304	#4	6.000	12.000	2.495	0.800	0.120	Pass
(H) 118.458	#4	6.000	12.000	2.495	0.800	0.120	Pass
(SZB) 121.039	#4	6.000	12.000	2.495	0.800	0.120	Pass
(Bar Cutoff) 121.125	#4	3.000	12.000	2.495	1.600	0.120	Pass
(Bar Develop.) 122.029	#4	3.000	12.000	2.495	1.600	0.120	Pass
(FoS) 122.958	#4	3.000	12.000	2.495	1.600	0.120	Pass
(1.0L$_s$) 123.500	#4	3.000	24.000	2.495	1.600	0.120	Pass
123.500	#4	3.000	24.000	2.495	1.600	0.000	Pass

* - Transverse reinforcement required if $V_u > 0.5\phi(V_c + V_p)$ [Eqn 5.7.2.3-1]

Debonded Strands [5.9.4.3.3]
39.13 % (18 of 46) strands are debonded. The number of debonded strands should not exceed 50.00 %.

Row	Number Strands	Number Debonded Strands	% Debonded	% Debonded Limit	Outer-most Strand Bonded*	Status
1	14	6	42.86 %	50.00 %	Yes	Pass
2	14	6	42.86 %	50.00 %	Yes	Pass
3	14	6	42.86 %	50.00 %	Yes	Pass
4	4	0	0.00 %	50.00 %	Yes	Pass

* Exterior strands in each horizontal row shall be bonded.

Debonding shall not be terminated for more than 10 strands in any given section. When a total of ten or fewer strands are debonded, debonding shall not be terminated for more than 10 strands in any given section, but not more than 50.00 % of all strands may be debonded.

Number of strands terminating debonding at each section

Debond Termination Section	Location from End of Girder (ft)	Number Strands Terminating Debonding	Strand Debond Termination Limit	Status
1	12.000	8	10	Pass
2	15.000	10	10	Pass
3	110.000	10	10	Pass
4	113.000	8	10	Pass

Longitudinal spacing of debonding termination locations shall be at least 6e+01d$_b$ apart but not less than 3.000 ft.

The least distance between debond termination sections is 3.000 ft and the minimum distance is 3.000 ft
Pass

Development lengths from the end of the debonded zone are determined using LRFD Eq. 5.9.4.3.2-1 with κ = 2.0.

The longest debond length from the end of the member is 15.000 ft and the permissible length limit is 15.000 ft which is controlled by minimum length.
Pass

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The following requirements are not evaluated:
Debonded strands shall be symmetrically distributed about the vertical centerline of the cross section of the member.
Debonding shall be terminated symmetrically at the same longitudinal location.
Alternate bonded and debonded strands both horizontally and vertically

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