Comparative analysis of plate girder designs in the Composite bridge between AASHTO LRFD bridge design specifications 2017 regulation with sni 1729: 2015

Donal Essen\textsuperscript{a}, Ryza Nur Rohman\textsuperscript{b}

\textsuperscript{a} Universitas Mercu Buana Jakarta, Indonesia, donaldessenstmt@gmail.com
\textsuperscript{b} Universitas Mercu Buana Jakarta, Indonesia,, ryza.jisung31@gmail.com

Abstract

In the world of construction there are various methods and types of materials used to support the passage of a construction work. One of them is composite girder plate. Composite girder plate is one of the many construction methods that combine two construction materials that are physically different in nature, namely concrete with steel. This type of composite girder plate construction is commonly used for bridge construction work with a fairly large span and width. In its use, of course, it must be preceded by stages of careful planning on a standard and valid basis as well. In the following research will discuss and look for similarities and differences regarding the two types of rules in the planning of composite girder plates, namely the rules of planning composite girder plates using AASHTO LRFD bridge design specifications 2017 with SNI 1729: 2015. After doing the initial stages of modeling using CSI Bridge software using the profile cross section constraints of the AASHTO provisions, the internal force obtained is Moment Force (Mu) of 3469.13 kNm and Shear Force (Vu) of 225.98 kNm. Then proceed with the analysis of calculations with the help of Microsoft Excel software namely calculating using the AASHTO LRFD bridge design specifications 2017 regulations for stability requirements of strong boundary conditions on the bending requirements. Then a Nominal Moment (\(\Omega M_n\)) value of 6420.19 kNm is obtained. Then proceed to calculate the same planning constraints, but this time using SNI 1729: 2015 regulations. Obtained Nominal Moment Value (\(\Omega M_n\)) of 6579.88 kNm.

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1. Introduction

The Unitary State of the Republic of Indonesia is an archipelago whose islands are separated by strait and wide ocean. But that is not a significant obstacle and is the main reason for the Central Government to carry out the mandate of the nation listed in Pancasila precisely in the 5th precept that reads “social justice for all the people of Indonesia”.

The government continues to strive in national development which targets that all islands in Indonesia must be connected through the infrastructure of the work of the nation's people, which are expected to facilitate the booming

\* Corresponding author.

Email: donaldessenstmt@gmail.com (Donal Essen)
economic movement and its benefits for all the people of Indonesia.

As Engineers in the world of construction we are expected to be able to actively participate in this National development effort. One type of construction that will be used in these efforts is the bridge. The bridge consists of many models and of course related to their respective functions. From a small bridge that serves to cross people located on the highway to a large bridge connecting the islands that can be passed by motorized vehicles, such as motorcycles, cars, trucks, buses and so forth.

In its planning, the bridge itself is divided into several construction components such as:
1) Abutment
2) Bearing
3) Pier
4) Pilecap
5) Bored Pile
6) Girder (Komposit / Non Komposit)
7) Deck
8) Highway
9) Pedestrian
10) Tension Of all the construction components, of course there are planning rules that are binding, standard and systematic.

Basically, the construction of a large bridge will definitely require quite long stretches and it is also likely that there will be no column / pier in the middle, so this composite bridge selection is one of the solutions in implementing bridge construction work.

In the planning stage of bridge girders, of course it is accompanied by specific reference standards in the calculation and analysis of its construction, one of which is SNI 1729: 2015 with AASHTO LRFD Bridge Design Specifications. The two construction regulations together show how the procedures in calculating and analyzing the design of composite bridges, especially girder plates. The different designs of the two reference regulations will be discussed in my study this time.

2. Methodology

In planning this Plate Girder using 2 literacy rules namely from AASHTO LRFD bridge design specifications 2017 with SNI 1729: 2015. In the process of analysis also requires a software called CSI Bridge specifically for designing a bridge. From this software we are helped to get a reference to the forces in moment Style (Mu) and Shear Force (Vu). Then we will re-use Microsoft Excel software to enter into two related literacy calculations.

2.1 Calculation of load on the bridge

2.1.1 Weight Self (MS)

a) Weight of Steel girder
   Weight of Steel girder is calculated automatically by the program, with $\gamma_{baja} = 78.5 \text{ Kn/m}^3$

b) Deck Weight
   $P_{deck} = 10000 \text{ Kn/m}$

c) Diafragma Weight
   The diafragma have dimensions : Volume of Diafragma $150\times150\times15$ = 6060 kg x 2 sisi
   (@$7.5 \text{ m} \times 24 = 180 \text{ m} = 15 \text{btg}$) = 12120 kg
   specific gravity of steel $\gamma_{baja} = 78.5 \text{ Kn/m}^3$

2.1.2 Additional Dead Load (MA)

a) Load of Pedestrian
   $q_{trotoar} = 3000 \text{ kN/m}$
2.1.3 Calculation of Truck loads “T” (TT)

Dynamic load factor (FBD) for BGT is taken  
FBD = 0.300

Front wheel weight  
P_rd = 25.000 kN

Rear wheel weight  
P_rb = 112.500 kN

Front wheel weight + FBD  
P_1 = 32.5 kN

Rear wheel weight + FBD  
P_2 = 146.25 kN

2.1.4 Traffic Weight Calculation

If L ≤ 30 m : q = 9.0 kPa

If L > 30 m : q = 9.0 ( 0.5+  15/L ) kPa

Evenly distributed load intensity (BTR)  
q = 7.88 kPa = kN/m²

Centralized line load intensity (BGT)  
p = 49.000 kN/m

Dynamic load factor (FBD) for BGT is taken  
FBD = 0.300

Load evenly distributed (BTR)  
q = 14.40 kN/m

Central line load (BGT) + FBD  
p = 109.76 kN/m

Technical Notes.

Manuscripts should be written in English. Invited contributions may exceptionally be in Portuguese. This template for preparation of manuscripts for Cienc. Tecnol. Mater. should be followed.

2.1 Load applications in modeling of composite bridge steel girders

2.2.1 Asphalt load applications on bridges

2.2.2 Application of concrete load barriers on the right and left side of the bridge
2.2.3 sidewalk load applications on the left side on the bridges

2.2.4 sidewalk load applications on the right side on the bridges

4.2. Pedestrian concrete load applications on the bridges

2.2 Load Combination

Based on SNI 1725 – 2016, the combination used can be seen in table 1 (in Indonesia).

2.3 Examination of Proportion Limits for Profile Cross-section Batas

The proportion of cross section must be checked to ensure the stability of the profile used meets the requirements. The determination of the cross-section proportion is regulated in Article 6.10.2

Proportion of Cross-Body Plate Without Stiffener (6.10.2.1.1-1)

\[
\frac{D_W}{t_W} = \frac{1160}{14} = 82.86 \text{ mm}
\]

Proportion of flens plate (6.10.2.2)

\[
\frac{b_f}{2t_f} \leq 12
\]
\[ \frac{b_f}{2t_f} = \frac{300}{2 \times 20} = 7,5 \]

7,5 ≤ 12 ......Ok

\[ b_f \geq \frac{D_W}{6} \]

\[ \frac{D_W}{6} = \frac{1160}{6} = 193,33 \text{ mm} = 0,193 \text{ m} \]

\[ b_f = 0,300 \text{ m} \]

0,300 m ≥ 0,193 m ......Ok

\[ t_f \geq 1.1 t_w \]

1.1t_w = 1.1 \times 0,014 m = 0,0154 m

\[ t_f = 0,020 \text{ m} \]

0,020 m ≥ 0,0154 m ......Ok

\[ 0.1 \leq \frac{I_{yc}}{I_{yt}} \leq 10 \]

\[ I_{yc} \frac{t_f \cdot b_f^2}{12} = 0.0033 \text{ m}^4 \]

\[ I_{yt} \frac{t_f \cdot b_f^2}{12} = 0.0033 \text{ m}^4 \]

0.1 ≤ \[ \frac{I_{yc}}{I_{yt}} \] ≤ 10

0.1 ≤ 1 ≤ 10
2.4 Structure Analysis

Internal force on girder

**Bending Force (Mu)** = -3469.13 kNm

![Fig.1 international force on girder](image)

2.5 Section Classification

Straight bridges with composite cross sections must be checked against:

- \( f_{ct} = f_y = 345 \text{ Mpa} \)
- \( f_{ct} \leq 485 \text{ Mpa} \)

\[ 345 \leq 485 \text{ Mpa} \ldots \ldots \ldots \text{Ok} \]

\[ 2 \cdot \frac{D_{cp}}{t_w} \leq 3.76 \sqrt{\frac{E_s}{f_c'}} \]

Where:

\( 2 \cdot \frac{D_{cp}}{t_w} = \frac{647.14}{14} = 46.22 \text{ mm} \)

\[ 3.76 \sqrt{\frac{E_s}{f_c'}} = 265.87 \]

\[ 23.11 \leq 265.87 \ldots \ldots \ldots \text{Ok} \]

3. Plate Girder Design (AASHTO LRFD Bridge Design Specifications 2017)

3.1 Bending Planning

a) Top Flens

Force that works:
M_girder = 3673.04 kN.m (From Software CSI Bridge)
M_pelat = 140.39 kN.m (From Software CSI Bridge)

I_σ = 1722087236.9 mm^4

Tension on the top flens:

\[
\text{Tension} = \frac{(1.1 \times M_{\text{girder}} + 1.3 \times M_{\text{pelat}}) \cdot \sigma_{\text{ys}}}{I_\sigma}
\]

\[
= \frac{(1.1 \times 3673.04 \, \text{kN.m} + 1.3 \times 140.39 \, \text{kN.m}) \times 1128.7 \, \text{mm}}{1722087236.9 \, \text{mm}^4}
\]

= 27,678 MPa

Lateral bending stress values are assumed fl=0

F_1 = 0

b) Check the nominal melt resistance in the top flens
   Check against the requirements 6.10.3.2.1

Tension on the top flens:

\[f_{\text{bu}} = \text{top flens} = 27,678 \, \text{MPa}
\]

Reduction factor for bending

\[\varphi_f = 0.90\]

For cross sections with similar material, Rh is taken 1,

Rh = 1

Nominally melting flens

\[\varphi_f \cdot Rh \cdot F_y = 310.5 \, \text{MPa}
\]

\[f_{bu} + F_1 \leq \varphi_f \cdot Rh \cdot F_y\]

\[27,678 + 1 \leq 310.5 \, \text{MPa} \]

\[28,678 \leq 310.5 \, \text{MPa} \]

\[\text{Ratio} = \frac{f_{bu} + F_1}{\varphi_f \cdot Rh \cdot F_y} = \frac{28,678}{310.5} = 0.092\]

c) Check the bending resistance of the top flens

d) Local buckling
   Calculate the slenderness ratio of the compressed flens

\[\lambda_f = \frac{b_f}{2f_f} = \frac{0.800}{2 \times 0.02} = 7.5\]

Calculate the limit of slenderness ratio for compact compressed flens

\[\lambda_{pf} = 0.38 \sqrt{\frac{E_f}{f_y}} = 9.149\]

If \[\lambda_f \leq \lambda_{pf}\]

7.5 \leq 9.149 local buckling from top flens is

\[F_{nc, FLB} = R_b R_h f_y\]
Calculate the limit of slenderness ratio for non-compact of web

\[ \lambda_{yw} = 5.7 \left( \frac{E_s}{f_y} \right)^{1/2} = 137.24 \]

Calculate the value of the web loading shedding factor (R_b)

Factor R_b = 1 for strength checks when constructibility and if the following conditions are met:

For a positive bending composite cross section without a longitudinal stiffener that meets the following requirements:

\[ \frac{D}{t_w} \leq 150 \]
\[ \frac{1160}{14} = 82.86 \leq 150 \ldots \text{Oke} \]

Local buckling from top flens is

F_{ne LTB} = R_b R_h f_{ye} = 345 \text{ MPa}

Lateral torque bend resistance

F_b = 5 \text{ m}

Jari-jari girasi efektif untuk tekuk torsi lateral (rt)

\[ \Gamma_t = \frac{bf}{\sqrt{12 \left( 1 + \frac{1}{3} \frac{D.tw}{bf.tf} \right)}} = \frac{0.300}{\sqrt{12 \left( 1 + \frac{1}{3} \left( \frac{1160}{0.014}, \frac{0.014}{0.300}, \frac{0.014}{0.020} \right) \right)}} = 0.083 \text{ m} \]

Long limit without bracing (L_p)

\[ L_p = 1.0 \times rt \times \frac{E_s}{\sqrt{f_y}} = 1.0 \times 0.083 \times \frac{200000}{345} = 1.998 \text{ m} \]

Long limit without bracing (L_r)

\[ L_r = \pi \times rt \times \frac{E_s}{\sqrt{f_y}} = 3.14 \times 0.083 \times \frac{200000}{345} = 6.275 \text{ m} \]

If L_p < L_b < L_r then:

C_b = 1

F_y = 0.7 \times f_y = 0.7 \times 345 = 241.5 \text{ Mpa}

F_{ne LTB} = C_b \left( 1 - (\frac{F_y}{R_h f_{ye}}) \left( \frac{L_b - L_p}{L_r - L_p} \right) R_b R_h f_{ye} \right) \leq R_b R_h f_{ye}

= 1 \left( 1 - (\frac{241.5}{1.345}) \left( \frac{5 - 1.998}{6.275 - 1.998} \right) \right) x 345 \leq 345

= 169.51 \leq 345 \ldots \text{Oke}

Use the smallest Fnc value of the 2 conditions, so that:

F_{bu} = 27.678 \text{ Mpa}
Fbu + \( \frac{1}{3} f_1 \) = 28,011 MPa
\[ \theta_t \cdot F_{nc} = 0.90 \times 169.51 \text{ Mpa} = 152.56 \]
Fbu + \( \frac{1}{3} f_1 \) ≤ \( \theta_t \cdot F_{nc} \)
28,011 MPa ≤ 152.56 Mpa.................Ok
\[
\text{Ratio} = \left( \frac{F_{bu} + f_1}{\theta_t \cdot F_{nc}} \right) = \left( \frac{28.011}{152.56} \right) = 0.184
\]

e) Bottom Flens
\[
ys\text{._bot} = 1128.7 \text{ mm}
\]
\[
\text{bot flens} = \left( \frac{1.1 \text{ M girder} + 1.3 \text{ M plate }}{I_e} \right) \cdot ys\text{._bot}
\]
\[
= \frac{(1.1 \times 3673.04 \text{ kN.m} + 1.3 \times 140.39 \text{ kN.m}) \times 1128.7 \text{ mm}}{17220187236.9 \text{ mm}^4}
\]
= 27,678 MPa
Fbu = bot flens = 27,678 MPa
The tension flens plate must meet the following equation:
Fbu + f1 ≤ \( \theta_t \cdot R_h \cdot F_Y \)
\[ \theta_t \cdot R_h \cdot F_Y = 0.90 \times 1.345 = 310.5 \text{ MPa} \]
Fbu ≤ \( \theta_t \cdot R_h \cdot F_Y \)
27,678 MPa ≤ 310.5 Mpa.................Ok
\[
\text{Ratio} \left( \frac{f_{bu}}{\theta_t \cdot R_h \cdot F_Y} \right) = \frac{27.678}{310.5} = 0.089
\]

f) Web plate
To ensure that bending does not occur on the web during the construction process the requirements in equation 6.10.3.2.1-3 must be met,
Fbu ≤ \( \theta_F \cdot c_{rw} \)
Bend the bending coefficient
\[
K = \left( \frac{D_c}{D} \right)^2 = \left( \frac{1200}{1200} \right)^2 = 9
\]
Prisoners bend in the web
\[
F_{crw} = \frac{0.95 \cdot E_s \cdot k}{(D \times tcw)^2} = \frac{0.95 \times 2000 \times 0.5}{(1200 \times 1.4)^2} = 232.75
\]
However, the Fcr value cannot be greater than:
Fyc = Fy = 345 MPa
Fyw = Fy = 345 MPa
\[ R_{h} \cdot F_{yc} = 345 \text{ MPa} \]
\[ \frac{f_{yw}}{0.7} = 492.857 \text{ Mpa} \]

Then the bend resistance below is:

\[ \sigma_f \cdot F_{crw} = 0.90 \times 232.75 = 209.48 \]

Check bending resistance in the web

\[ F_{bu} \leq \sigma_f \cdot F_{crw} \]
\[ 27,678 \text{ MPa} \leq 209.48 \text{ MPa} \]

\[ \text{Ratio} \quad \frac{F_{bu}}{\sigma_f \cdot F_{crw}} = \frac{27,678}{209,48} = 0.13 \]

3.2 Determination of plastic neutral axis

Width of compression flens \( b_{cf} = b_f = 300 \text{ mm} \)

Thickness of compression flens \( t_{cf} = t_f = 20 \text{ mm} \)

Width of tension flens \( b_{tf} = b_f = 300 \text{ mm} \)

Thickness of tension flens \( t_{tf} = t_f = 20 \text{ mm} \)

Web Height \( D_w = 1160 \text{ mm} \)

Web thickness \( t_w = 14 \text{ mm} \)

Compression force of deck plate \( P_z = 0.85 \cdot F_{c'} \cdot b_{ef} \cdot h_z = 21250 \text{ kN} \)

Axial force on the reinforcement of the deck plate \( P_{rt} = 2010.6 \text{ kN} \)

Axial force on the reinforcement under the deck plate \( P_{rb} = 2010.6 \text{ kN} \)

Axial force on the top flens \( P_0 = b_{cf} \cdot t_{cf} \cdot f_y = 2070 \text{ kN} \)

Axial force on the web \( P_w = D_w \cdot t_w \cdot f_y = 5602.8 \text{ kN} \)

Axial force on the bottom flens \( P_2 = b_{2f} \cdot t_{2f} \cdot f_y = 2070 \text{ kN} \)

Case I \( (P_c + P_w \geq P_z + P_{rb} + P_0) \)
\[ P_c + P_w = 7672.8 \text{ kN} \quad \leq \quad P_t + P_{rb} + P_0 = 25330 \text{ kN} \]

Case II \( (P_c + P_w + P_t \geq P_z + P_{rb}) \)
\[ P_c + P_w + P_2 = 9472.8 \text{ kN} \quad \leq \quad P_z + P_{rb} = 23260 \text{ kN} \]

Because case II meets the requirements, the PNA is in the top flens, so:

\[ Y = \left( \frac{t_{cf}}{2} \right) \cdot \left( \frac{P_w - P_c - P_{rt} - P_{rb}}{P_r} + 1 \right) \]
3.3 Check ductility

\[ D_p \leq 0.42D_t \]

Distance from the upper side of the concrete deck to the neutral axis of the composite cross section at a plastic moment (\( D_p \))

\[ D_p = h_s + t_{cf} + y \]
\[ = 250 \text{ mm} + 20 \text{ mm} + 7,64 \]
\[ = 307.64 \]

Total height of composite cross section (\( D_t \))

\[ D_t = D + h_s \]
\[ = 1200 \text{ mm} + 250 \text{ mm} \]
\[ = 1450 \text{ mm} \]

\[ 0.42D_t = 609 \]
\[ D_p \leq 0.42D_t \]
\[ 307.64 \leq 609 \]

3.4 Check the steel compact section

\[ D_p \leq 0.1D_t \]
\[ 0.1D_t = 145 \]
\[ 307.64 \geq 145 \]

3.5 Calculation of Plastic Moment

\[ d_z = t_{cf} + D_w + \frac{t_{tf}}{2} - y \]
\[ = 20 + 1160 + \frac{20}{2} - 7,64 \]
\[ = 1182.36 \]

\[ d_s = \frac{h_s}{2} + t_{cf} + y \]
\[ = \frac{250}{2} + 20 + 7,64 \]
\[ = 152.64 \]

\[ d_w = \frac{D_w}{2} + t_{tf} \cdot y \]
So the plastic moment can be calculated with:

\[ M_p = \frac{P_e}{2\tau_{ef}} \cdot (Y^2 + (t_{ef} - Y^2)) + P_a \cdot d_a + P_r1 \cdot d_r1 + P_r2 \cdot d_r2 + P_c \cdot d_c \]

\[ M_p = 6145.8 \text{ kN.m} \]

Calculate the nominal moment value:

\[ M_n = M_p \cdot (1.07 - 0.7 \cdot \frac{D_p}{D_r}) \]

\[ M_n = 6145.8 \text{ kN.m} \cdot (1.07 - 0.7 \cdot \frac{307.64}{1450}) \]

\[ M_n = 5663.26 \text{ kN} \]

\[ M_u = 3469.13 \text{ kNm} \quad \text{(From Software CSI Bridge)} \]

\[ \Phi_f = 1.0 \]

\[ \Phi_f \cdot M_n = 1.0 \cdot 5663.26 \text{ kN} \]

\[ = 5663.26 \text{ kN} \]

3.6 Check the cross section capacity

\[ M_u \leq \Phi_f \cdot M_n \]

\[ 3469.13 \text{ kNm} \leq 5663.26 \text{ kN} \quad \text{...............Oke} \]

\[ \text{Ratio} \quad = \frac{M_u}{\Phi_f \cdot M_n} \]

\[ = \frac{3469.13 \text{ kNm}}{5663.26 \text{ kN}} \]

\[ = 0.61 \text{ m} \]

3.7 Plate Girder Design (SNI 1729:2015)

3.7.1 Hand Calculation

3.7.1.1 Materials

| Property | Value |
|----------|-------|
| \( E_s \) | 200000 Mpa |
| \( F_y \) | 345 Mpa |
| \( W_{steel} \) | 78.5 Kn/m² |
| \( E_c \) | \( \sqrt{F_{y}} \) = 87298.63 |
| \( F_{c'} \) | 40 Mpa |
| \( W_{conc} \) | 25 kN/m³ |

3.7.1.2 Section

| Section | Width | Height | Thickness |
|---------|-------|--------|-----------|
| IWF built-up | 1200x300x14x20mm | |
| \( d \) | 1200 mm |
\[
\begin{align*}
    b_f &= 300 \text{ mm} \\
    t_f &= 20 \text{ mm} \\
    t_w &= 14 \text{ mm} \\
    A_{\text{steel}} &= 282.4 \text{ cm}^2 \quad (\text{From Software Etabs 2016}) \\
    S_{\text{steel}} &= 9997.7 \text{ cm}^3 \quad (\text{From Software Etabs 2016}) \\
    Z_{\text{steel}} &= 11789.6 \text{ cm}^3 \quad (\text{From Software Etabs 2016}) \\
    I_{\text{steel}} &= 59864.5 \text{ cm}^4 \quad (\text{From Software Etabs 2016}) \\
\end{align*}
\]

3.7.1.3 Deck
\[
\begin{align*}
    t_c &= 250 \text{ mm} \\
    h_r &= 50 \text{ mm} \\
    s_r &= 300 \text{ mm} \\
    w_r &= 20 \text{ mm} \\
\end{align*}
\]

3.7.2 Design for pre-composite condition
3.7.2.1 Construction required flexural strength
\[
M_u = \frac{W_u \cdot L^2}{8} = 3469.13 \text{ kNm (diperoleh dari Software CSI Bridge)}
\]

3.7.2.2 Moment capacity
\[
\Phi_b M_n = \frac{\Phi_b \cdot Z_2 \cdot F_y}{0.9 \cdot 11789600000 \cdot 345} = 3.05 \times 10^{12}
\]

3.7.2.3 Pre-composite deflection
\[
\Delta_{nc} = \frac{5W_D \cdot L^4}{384 EI} = 73.07 \text{ mm (diperoleh dari Software CSI Bridge)}
\]

Camber = 0.8 \cdot \Delta_{nc} \\
= 0.8 \cdot 73.07 \text{ mm} \\
= 58.46 \text{ mm}

3.7.3 Design for composite flexural strength
3.7.3.1 Required flexural strength
\[
M_u = \frac{W_u \cdot L^2}{8} = 3469.13 \text{ kNm (diperoleh dari Software CSI Bridge)}
\]

3.7.3.2 Full composite action available flexural strength

Effective width of slab:
\[
b_{eff} = 2.5 \text{ m} = 2500 \text{ mm}
\]
Resistance of steel in tension:
\[
C = P_{\gamma} = A_z \cdot F_y = 28240 \text{ mm}^2 \cdot 345 \text{ MPa} = 9742800 \text{ N}
\]
Resistance of slab in compression:
\[
A_c = b_{eff} \cdot t_c = 2500 \text{ mm} \cdot 250 \text{ mm}
\]
\[ C = 0.85 \cdot f'c \cdot A_c \]
\[ = 0.85 \cdot 40 \cdot 625.000 \text{ mm}^2 \]
\[ = 2125000 \text{ N} \]

Depth of compression block within slab:
\[ \alpha = \frac{c}{0.85 \cdot b_{eff} \cdot f'c} \]
\[ = \frac{250 \text{ mm} \cdot 40}{0.85 \cdot 2500 \text{ mm} \cdot 40} \]
\[ = 114.62 \]

Moment resistance of composite beam for full composite action:
\[ d_1 = (t_c + h_{c'}) \cdot \frac{\alpha}{2} \]
\[ = (250 \text{ mm} + 50 \text{ mm}) \cdot \frac{114.62 \text{ mm}}{2} \]
\[ = 242.69 \text{ mm} \]
\[ \Phi M_n = \Phi (P_y \cdot d_1 + P_y \cdot \frac{d}{2}) \]
\[ = 0.9 \cdot (9742800 \text{ N} \cdot 244,69 \text{ mm}) + (9742800 \text{ N} \cdot \frac{1200 \text{ mm}}{2}) \]
\[ = 0.9 \cdot (2364480132 \text{ N.mm} + 5845680000 \text{ N.mm}) \]
\[ = 0.9 \cdot 8210160132 \text{ N.mm} \]
\[ = 738914119.9 \text{ N.mm} \]

3.7.3.3 Partial composite action available flexural strength

Based on the force provided by the shear studs – see below:
\[ C = 0.532 \cdot P_y \]
\[ = 0.532 \cdot 9742800 \text{ N} \]
\[ = 5183169.6 \text{ N} \]

Depth of compression block within concrete slab:
\[ \alpha = \frac{c}{0.85 \cdot b_{eff} \cdot f'c} \]
\[ = \frac{250 \text{ mm} \cdot 40}{0.85 \cdot 2500 \text{ mm} \cdot 40} \]
\[ = 60.98 \text{ mm} \]
\[ d_1 = (t_c + h_{c'}) \cdot \frac{\alpha}{2} \]
\[ = (250 \text{ mm} + 50 \text{ mm}) \cdot \frac{60.98 \text{ mm}}{2} \]
\[ = 269.51 \text{ mm} \]

Compressive force in steel section:
\[ P_y - C = \frac{9742800 \text{ N} - 5183169.6 \text{ N}}{2} \]
\[ = 2279815.2 \text{ N} \]

Steel section flange ultimate compressive force:
\[ C_{flange} = b_f \cdot t_f \cdot F_y \]
\[ = 300 \text{ mm} \cdot 20 \text{ mm} \cdot 345 \text{ Mpa} \]
\[ = 2070000 \text{ N} \]

Distance from the centroid of the compressive force in the steel section to the top of the steel section:
\[ d_2 = t_f \cdot \frac{(P_y - C)/2}{C_{flange}} \]
Moment resistance of composite beam for partial composite section:
\[
\Phi M_n = \Phi (C \cdot (d_1 + d_2) + P_y \cdot (d_2 - d_1))
\]
\[
= 0.90 \left(5183169.6 \text{ N} \cdot (269.51 \text{ mm} + 11 \text{ mm}) + 9742800 \text{ N} \cdot \frac{1200}{2} \text{ mm} - 11 \text{ mm}\right)
\]
\[
= 6473196094 \text{ N}
\]
\[
= 6473.20 \text{ kN.m}
\]

4. Conclusions & Suggestions

Following are the results of a comparative analysis of Plate Girder designs using AASHTO LRFD Bridge Design Specifications 2017 with SNI 1729: 2015.

4.1.1 Comparison table of strong limits on bending requirements:

| No | Design Procedure | Momen \( (Mu < \Phi Mn) \) | Check | Status |
|----|------------------|--------------------------|-------|--------|
| 1  | AASHTO LRFD Bridge Design Specifications 2017 | 3469.13 | 5663.26 | OK |
| 2  | SNI 1729:2015 | 3469.13 | 6473.20 | OK |

In conclusion, these two calculation rules are equally safe and have not too much difference in nominal moment values, even SNI 1729: 2015 has a larger Mn nominal. It can be concluded that counting with the AASHTO LRFD Bridge Design Specifications 2017 rules is more wasteful than using SNI 1729: 2015 rules. Because in calculations using one reference measure the proportion of cross section and has a different moment capacity.

Suggestions, based on the results that have been studied can be given suggestions, including:

In the planning process of plate girders on composite bridges, especially on the requirements of strong stability in flexural conditions it is better to use the rules of SNI 1729: 2015 because it is a little more economical in classifying its appearance, because with the same proportional cross-sectional size, different moment capacity is obtained.

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