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

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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 (ØMn) 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 (ØMn) of 6579.88 kNm.

Keywords: Composite Girder, Comparative Analysis of Design, and AASHTO LRFD bridge design specifications 2017.

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

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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) Abuttment
2) Bearing
3) Pier
4) Pilecap
5) Bored Pile
6) Girder (Komposit / Non Komposit)
7) Deck
8) Highway
9) Pedestrian
10) TensionOf 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

n steel girder = 4

2.1.1 Weight Self (MS)

a) Weight of I Steel girder
Weight of I Steel girder is calculated automatically by the program,
with γ_baja = 78.5 Kn/m^3

b) Deck Weight
P deck = 10000 Kn/m

c) Diafragma Weight
The diafragma have dimensions :
Volume of Diafragma 150x150x15 = 6060 kg x 2 sisi
(@7,5 m x 24 =180 m = 15btg) = 12120 kg
specific gravity of steel γ_baja = 78.5 Kn/m^3

2.1.2 Additional Dead Load (MA)

a) Load of Pedestrian
q_trotoar = 3000 kN/m

b) Load of Barrier
q_(Bt.barrier) = 480 kN/m
c) Load of asphalt
q_aspal = 0,35 gr/m^2
d) Load of screeding concrete
q_(bet.screed) = 10000 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

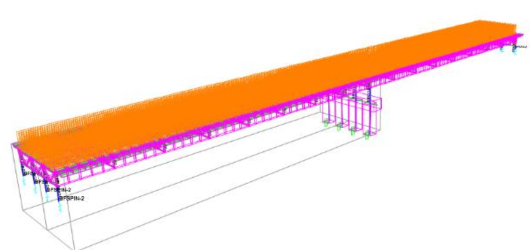
If L ⩽ 30 m : q = 9,0 kPa
If L > 30 m : q = 9,0 (0,5+ 15/L) kPa

Evenly distributed load intensity (BTR)	q	= 7,88 kPa = kN/m^2
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/mTechnical Notes.

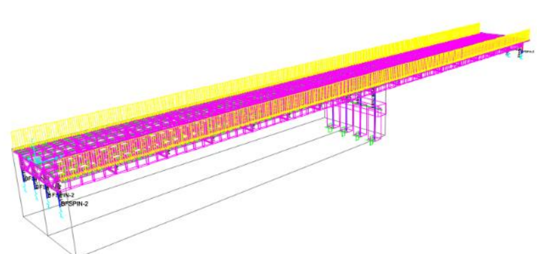
Manuscripts should be written in English. Invited contributions may exceptionally be in Portuguese. This template for preparation of manuscripts for Cienc. Tecnol. Mater. should be followed.

2.1 Load applications in modeling of composite bridge steel girders

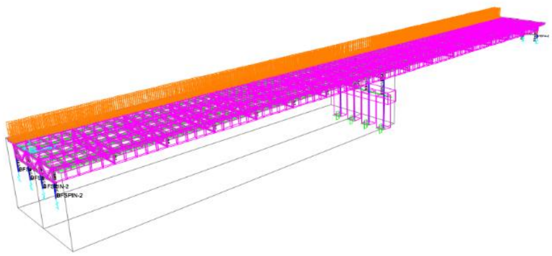
2.2.1 Asphalt load applications on bridges



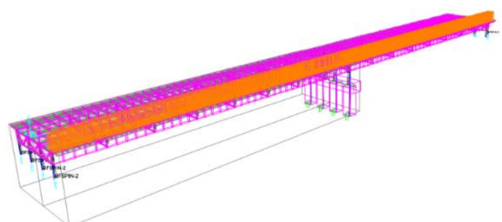
2.2.2 Application of concrete load barriers on the right and left side of the bridge



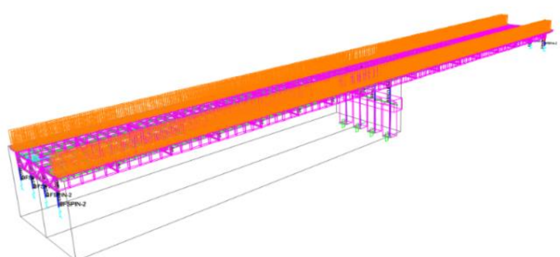
2.2.3 sidewalk load applications on the left side on the bridges



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-sectionBatas

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)

$$\frac{b_f}{2t_f} \leq 12$$

$\frac{b_f}{2t_f} = \frac{300}{2 \times 20} = 7{,}5$

$7{,}5 \leq 12$ ....Ok

$b_f \geq \frac{D_W}{6}$

$\frac{D_W}{6} = \frac{1160}{6} = 193{,}33$ mm = 0,193 m

b_f = 0.300 m

0.300 m $\geq$ 0.193 m ....Ok

$t_f \geq 1.1\ t_w$

$1.1 t_w$ = 1.1 x 0,014 m = 0,0154 m

t_f = 0,020 m

0.020 m $\geq$ 0,0154 m ....Ok

$0.1 \leq \frac{I_{yc}}{I_{yt}} \leq 10$

$I_{yc}\ \frac{t_f \cdot b_f^3}{12} = 0.0033\ m^4$

$I_{yt}\ \frac{t_f \cdot b_f^3}{12} = 0.0033\ m^4$

$0.1 \leq \frac{I_{yc}}{I_{yt}} \leq 10$

$0.1 \leq 1 \leq 10$

Tabel 1 – Kombinasi beban dan faktor beban

Keadaan Batas	MS MA TA PR PL SH	TT TD TB TR TP	EU	EW_s	EW_L	BF	EU_n	TG	ES	Gunakan salah satu		
										EQ	TC	TV
Kuat I	γ_p	1,8	1,00	-	-	1,00	0,50/1,20	γ_{TG}	γ_{ES}	-	-	-
Kuat II	γ_p	1,4	1,00	-	-	1,00	0,50/1,20	γ_{TG}	γ_{ES}	-	-	-
Kuat III	γ_p	-	1,00	1,40	-	1,00	0,50/1,20	γ_{TG}	γ_{ES}	-	-	-
Kuat IV	γ_p	-	1,00	-	-	1,00	0,50/1,20	-	-	-	-	-
Kuat V	γ_p	-	1,00	0,40	1,00	1,00	0,50/1,20	γ_{TG}	γ_{ES}	-	-	-
Ekstrem I	γ_p	γ_{EQ}	1,00	-	-	1,00	-	-	-	1,00	-	-
Ekstrem II	γ_p	0,50	1,00	-	-	1,00	-	-	-	-	1,00	1,00
Daya layan I	1,00	1,00	1,00	0,30	1,00	1,00	1,00/1,20	γ_{TG}	γ_{ES}	-	-	-
Daya layan II	1,00	1,30	1,00	-	-	1,00	1,00/1,20	-	-	-	-	-
Daya layan III	1,00	0,80	1,00	-	-	1,00	1,00/1,20	γ_{TG}	γ_{ES}	-	-	-
Daya layan IV	1,00	-	1,00	0,70	-	1,00	1,00/1,20	-	1,00	-	-	-
Fatik (TD dan TR)	-	0,75	-	-	-	-	-	-	-	-	-	-

Catatan : - γ_p dapat berupa $\gamma_{MS}, \gamma_{MA}, \gamma_{TA}, \gamma_{PR}, \gamma_{PL}, \gamma_{SH}$ tergantung beban yang ditinjau

- γ_{EQ} adalah faktor beban hidup kondisi gempa

2.4 Structure Analysis

Internal force on girder

Bending Force (Mu) = -3469,13 kNm

Fig.1 internasional force on ginder

2.5 Section Classification

Straight bridges with composite cross sections must be checked against:

$f_{yf} = f_y$ = 345 Mpa

$f_{yf} \leq$ 485 Mpa

345 ≤ 485 Mpa...................Ok

$$2 . \frac{D_{cp}}{t_w} \leq 3.76 \sqrt{\frac{E_s}{fc'}}$$

Where :

$$2 . \frac{D_{cp}}{t_w} = \frac{647{,}14}{14} = 46{,}22 \text{ mm}$$

$$3.76 \sqrt{\frac{E_s}{fc'}} = 265{,}87$$

23,11 ≤ 265,87................Ok

3. Plate Girder Design (AASHTO LRFD *Bridge Design Spesification* 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_s = 17220187236,9 mm^4

Tension on the top flens:

Top flens $= \frac{(1.1\ \text{M girder} + 1.3\ \text{M pelat}).\text{ys top}}{I_s}$

$= \frac{(1{,}1\ .3673{,}04\ \text{kN.m} + 1{,}3\ .\ 140{,}39\ \text{kN.m}).1128{,}7\ \text{mm}}{17220187236{,}9\ mm^4}$

= 27,678 MPa

Lateral bending stress values are assumed fl=0

F1 = 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_{bu} = top flens = 27,678 MPa

Reduction factor for bending

$Ø_f$ = 0,90

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

Rh = 1

Nominally melting flens

$Ø_f\ .Rh\ .Fy$ = 310,5 Mpa

$f_{bu} + F1 \leq Ø_f\ .Rh\ .Fy$

27,678 + 1 ≤ 310,5 Mpa

28,678 ≤ 310,5 Mpa

Ratio $\frac{f_{bu+f1}}{Ø_f\ .Rh\ .Fy} = \frac{28{,}678}{310{,}5} = 0{,}092$

c) Check the bending resistance of the top flens

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

$\lambda_f = \frac{b_f}{2tf} = \frac{0{,}300}{2.\ 0{,}02} = 7{,}5$

Calculate the limit of slenderness ratio for compact compressed flens

$\lambda_{pf} = 0.38\sqrt{\frac{E_s}{f_y}} = 9{,}149$

If $\lambda_f \leq \lambda_{pf}$

7,5 ≤ 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

$$\lambda_{rw} = 5.7\sqrt{\frac{E_s}{fy}} = 137{,}24$$

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 stiffner that meets the following requirements:

$$\frac{D}{t_w} \leq 150$$

$$\frac{1160}{14} = 82{,}86 \leq 150 \text{ ....Oke}$$

local buckling from top flens is

$$F_{nc\ FLB} = R_b R_h f_{yc} = 345 \text{ MPa}$$

Lateral torque bend resistance

Lb = 5 m

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

$$r_t = \frac{bf}{\sqrt{12\left(1+\frac{1}{3}\cdot\frac{D.tw}{bf.tf}\right)}} = \frac{0{,}300}{\sqrt{12\left(1+\frac{1}{3}\cdot\left(\frac{1{,}160 .\ 0{,}014}{0{,}300 .\ 0{,}020}\right)\right)}} = 0{,}083 \text{ m}$$

Long limit without bracing (Lp)

$$Lp = 1{,}0 \cdot rt \cdot \sqrt{\frac{E_s}{fy}} = 1{,}0 \cdot 0{,}083 \cdot \sqrt{\frac{200000}{345}} = 1{,}998 \text{ m}$$

Long limit without bracing (Lr)

$$Lr = \pi\ rt \cdot \sqrt{\frac{E_s}{fy}} = 3{,}14 \cdot 0{,}083 \cdot \sqrt{\frac{200000}{345}} = 6{,}275 \text{ m}$$

If Lp < Lb < Lr then :

Cb = 1

Fyr = 0,7 . Fy = 0,7 . 345 = 241.5 Mpa

$$F_{nc\ LTB} = Cb\left(1-\left(1-\left(\frac{Fyr}{Rh . Fyc}\right)\left(\frac{Lb-Lp}{Lr-Lp}\right)\right) R_b R_h f_{yc} \leq R_b R_h f_{yc}\right.$$

$$= 1\left(1-\left(1-\left(\frac{241{,}5}{1 .\ 345}\right)\left(\frac{5-1{,}998}{6{,}275-1{,}998}\right)\right) x345 \leq 345\right.$$

$$= 169{,}51 \leq 345 \text{ ....Oke}$$

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

Fbu = 27,678 Mpa

Fbu + $\frac{1}{3}$. f1 = 28,011 MPa

$\emptyset_f$. Fnc = 0,90 x 169,51 Mpa = 152,56

Fbu + $\frac{1}{3}$. f1 ≤ $\emptyset_f$. Fnc

28,011 MPa ≤ 152,56 Mpa..................Ok

Ratio = $(\frac{f_{bu}+f_1}{\emptyset_f \,.\, Fnc}) = (\frac{28{,}011}{152{,}56}) = 0{,}184$

e) Bottom Flens

ys_bot = 1128,7 mm

bot flens = $\frac{(1.1 \text{ M girder} + 1.3 \text{ M pelat}).\text{ys\_bot}}{I_s}$

$= \frac{(1{,}1 \,.\, 3673{,}04 \text{ kN.m} + 1{,}3 \,.\, 140{,}39 \text{ kN.m}).1128{,}7 \text{ mm}}{17220187236{,}9 \, mm^4}$

= 27,678 MPa

Fbu = bot flens = 27,678 MPa

The tension flens plate must meet the following equation:

Fbu + f1 ≤ $\emptyset_f \,.Rh \,.Fy$

$\emptyset_f \,.Rh \,.Fy$ = 0,90 . 1 . 345 = 310,5 MPa

Fbu ≤ $\emptyset_f \,.Rh \,.Fy$

27,678 MPa ≤ 310,5Mpa................Ok

Ratio $\frac{f_{bu}}{\emptyset_f \,.Rh \,.Fy} = \frac{27{,}678}{310{,}5} = 0{,}089$

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 ≤ ØFcrw

Bend the bending coefficient

$K = \frac{9}{(\frac{Dc}{D})^2} = \frac{9}{(\frac{1200}{1200})^2} = 9$

Prisoners bend in the web

$Fcrw = \frac{0.95 \,.Es \,.k}{(\frac{D}{tw})^2} = \frac{0.95 \,.200000 \,.9}{(\frac{1200}{14})^2} = 232{,}75$

However, the Fcr value cannot be greater than:

Fyc = Fy = 345 MPa

Fyw = Fy = 345 MPa

$Rh\,.\,Fy$c = 345 MPa

$\frac{f_{yw}}{0.7}$ = 492,857 Mpa

then the bend resistance below is :

$\emptyset_f$ Fcrw = 0,90 x 232,75 = 209,48

Check bending resistance in the web

Fbu ≤ $\emptyset_f$ Fcrw

27,678 MPa ≤ 209,48 MPa

Ratio $\frac{f_{bu}}{\emptyset_f\,.F_{crw}} = \frac{27{,}678}{209{,}48}$ = 0,13

3.2 Determination of plastic neutral axis

Width of compression flens	$b_{cf} = b_f$	= 300 mm
Thickness of compression flens	$t_{cf} = t_f$	= 20 mm
Width of tension flens	$b_{tf} = b_f$	= 300 mm
Thickness of tension flens	$t_{tf} = t_f$	= 20 mm
Web Height	D_w	= 1160 mm
Web thickness	t_w	= 14 mm
Compression force of deck plate	P_s = 0,85 . Fc' . b_{ef} . h_s	= 21250 kN
Axial force on the reinforcement of the deck plate	P_{rt}	= 2010,6 kN
Axial force on the reinforcement under the deck plate	P_{rb}	= 2010,6 kN
Axial force on the top flens	$P_c = b_{cf}\,.\,t_{cf}\,.\,f_y$	= 2070 kN
Axial force on the web	$P_w = D_w\,.\,t_w\,.\,f_y$	= 5602,8 kN
Axial force on the bottom flens	$P_t = b_{tf}\,.\,t_{tf}\,.\,f_y$	= 2070 kN

Case I **($P_c + P_w \geq P_t + P_{rb} + P_s$)**

$P_c + P_w$ = 7672,8 kN ≤ $P_t + P_{rb} + P_s$ = 25330 kN

Case II **($P_c + P_w + P_t \geq P_s + P_{rb}$)**

$P_c + P_w + P_t$ = 9472,8 kN ≤ $P_s + P_{rb}$ = 23260 kN

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

$$Y = \left(\frac{t_{cf}}{2}\right).\left(\frac{P_w - P_c - P_{rt} - P_{rb}}{P_t} + 1\right)$$

$Y = \left(\frac{20}{2}\right) . \left(\frac{5602{,}8-2070-2010{,}6-2010{,}6}{2070} + 1\right)$

$Y = 7{,}64$

3.3 *Check ductility*

Dp ≤ 0,42Dt

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

Dp $= h_s + t_{cf} + Y$

= 250 mm + 20 mm + 7,64

= 307,64

Total height of composite cross section (Dt)

Dt $= D + h_s$

= 1200 mm + 250 mm

= 1450 mm

0,42Dt = 609

Dp ≤ 0,42Dt

307,64 ≤ 609

3.4 *Check the steel compact section*

Dp ≤ 0,1Dt

0,1Dt = 145

307,64 ≥ 145

3.5 *Calculation of Plastic Moment*

$d_t = t_{cf} + D_w + \frac{t_{tf}}{2} - Y$

$= 20 + 1160 + \frac{20}{2} - 7{,}64$

= 1182,36

$d_s = \frac{h_s}{2} + t_{cf} + Y$

$= \frac{250}{2} + 20 + 7{,}64$

= 152,64

$d_w = \frac{D_w}{2} + t_{tf} - Y$

$= \frac{1160}{2} + 20 - 7{,}64$

= 592,36

d_{rt} = 0 mm

d_{rb} = 0 mm

So the plastic moment can be calculated with :

Mp $= \frac{P_c}{2.t_{cf}} . (Y^2 + (t_{cf} - Y^2)) + P_s. d_s. + P_{rb}. d_{rb} + P_w. d_w + P_c. d_c$

Mp = 6145,8 kN.m

Calculate the nominal moment value :

Mn = Mp . (1,07 – 0,7 . $\frac{D_p}{D_t}$)

Mn = 6145,8 kN.m. (1,07 – 0,7 . $\frac{307{,}64}{1450}$)

= 5663,26 kN

Mu = 3469,13 kNm (From ***Software CSI Bridge***)

Φf = 1.0

Φf . Mn = 1,0 . 5663,26 kN

= 5663,26 kN

3.6 Check the cross section capacity

Mu ≤ Φf . Mn

3469,13 kNm ≤ 5663,26 kN...............Oke

Ratio $= \frac{Mu}{\Phi f . Mn}$

$= \frac{3469{,}13 \text{ kNm}}{5663{,}26 \text{ kN}}$

= 0,61 m

3.7 Plate GirderDesign (SNI 1729:2015)

3.7.1 Hand Calculation

3.7.1.1 Materials

Es = 200000 Mpa

Fy = 345 Mpa

Wsteel = 78.5 Kn/m^3

Ec = 4700 $\sqrt{f_y}$ = 87298,63

Fc' = 40 Mpa

Wconc = 25 kN/m^3

3.7.1.2 Section

IWF *built-up* 1200x300x14x20mm

d = 1200 mm

b_f = 300 mm
t_f = 20 mm
t_w = 14 mm
A_{steel} = 282,4 cm^2 (From ***Software Etabs 2016***)
S_{steel} = 9997,7 cm^3 (From ***Software Etabs 2016***)
Z_{steel} = 11789,6 cm^3 (From ***Software Etabs 2016***)
I_{steel} = 599864,5 cm^4 (From ***Software Etabs 2016***)

3.7.1.3 Deck

t_c = 250 mm
h_r = 50 mm
s_r = 300 mm
w_r = 20 mm

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 kNm (diperoleh dari ***Software CSI Bridge***)

3.7.2.2 Moment capacity

$\Phi_b M_n = \frac{\Phi_b \cdot Z_s \cdot F_y}{12}$

$= \frac{0{,}90 \cdot 11789600000 \cdot 345}{12}$

= 3,05 x 10^{15}

3.7.2.3 Pre-composite deflection

$\Delta_{nc} = \frac{5W_D \cdot L^4}{384\,EI}$ = 73,07 mm (diperoleh dari ***Software CSI Bridge***)

Camber= 0,8 . Δ_{nc}

= 0,8 . 73,07 mm

= 58,46 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 kNm (diperoleh dari ***Software CSI Bridge***)

3.7.3.2 Full composite action available flexural strength

Effective width of slab :

b_{eff} = 2,5 m = 2500 mm

Resistance of steel in tension :

C = P_y = $A_s \cdot F_y$
= 28240 mm^2 . 345 Mpa
= 9742800 N

Resistance of slab in compression :

A_c = $b_{eff} \cdot t_c$
= 2500 mm . 250 mm

= 625.000 mm^2

C = 0,85 . f'c . A_c

= 0,85 . 40 . 625.000 mm^2

= 21250000 N

Depth of compression block within slab :

$$\alpha = \frac{C}{0{,}85 \cdot b_{eff} \cdot f'c} = \frac{9742800\ \text{N}}{0{,}85 \cdot 2500\ \text{mm} \cdot 40}$$

= 114,62

Moment resistance of composite beam for full composite action :

$$d_1 = (t_c + h_r) - \frac{\alpha}{2} = (250\ \text{mm} + 50\ \text{mm}) - \frac{114{,}62\ \text{mm}}{2}$$

= 242,69 mm

$$\Phi M_n = \Phi\,(P_y \cdot d_1 + P_y \cdot \frac{d}{2})$$

$$= 0{,}9\ (\ (9742800\ \text{N} \cdot 242{,}69\ \text{mm}) + (9742800\ \text{N} \cdot \frac{1200\ mm}{2})$$

= 0,9 (2364480132 N.mm + 5845680000 N.mm)

= 0,9 . 8210160132 $N.mm$

= 7389144119 $N.mm$ = 7389,14 kNm

3.7.3.3 Partial composite action available flexural strength

Based on the force provided by the shear studs – see below :

C = 0,532 . P_y

= 0,532 . 9742800 N

= 5183169,6 N

Depth of compression block within concrete slab :

$$\alpha = \frac{C}{0{,}85 \cdot b_{eff} \cdot f'c} = \frac{5183169{,}6\ \text{N}}{0{,}85 \cdot 2500\ mm \cdot 40}$$

= 60,98 mm

$$d_1 = (t_c + h_r) - \frac{\alpha}{2} = (250\ \text{mm} + 50\ \text{mm}) - \frac{60{,}98\ \text{mm}}{2}$$

= 269,51 mm

Compressive force in steel section :

$$\frac{P_y - C}{2} = \frac{9742800\ \text{N} - 5183169{,}6\ \text{N}}{2} = \frac{9742800\ \text{N} - 5183169{,}6\ \text{N}}{2}$$

= 2279815,2 N

Steel section flange ultimate compressive force :

C_{flange} = $b_f \cdot t_f \cdot F_y$

= 300 mm . 20mm . 345 Mpa

= 2070000 N

Distance from the centroid of the compressive force in the steel section to the top of the steel section :

$$d_2 = t_f \cdot \frac{(P_y - C)/2}{2 \cdot C_{flange}}$$

$= 20mm . \frac{(9742800\ N - 5183169{,}6\ N)/\ 2}{2\ .\ 2070000\ N/mm}$

= 20mm . 0,55 mm

= 11 mm

Moment resistance of composite beam for partial composite section :

ΦM_n = Φ (C . (d_1+ d_2) + P_y . ((d_3- d_2)

= 0,90 (5183169,6 N . (269,51 mm + 11 mm) + 9742800 N . ($\frac{1200}{2}$ mm – 11mm)

= 6473196094 N

= 6473,20 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	Check		
		Momen (*Mu* < *ØMn*)		
		Mu (kNm)	***ØMn (kNm)***	**Status**
1	AASHTO LRFD Bridge Design Spesifications 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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