

# Study of Bridge Upper Structure Design with Composite Box Girder for Coal Mining Trailer Loads (Case Study: Belayan River - Kutai Kartanegara)

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## Abstract

In the process of mobilizing coal on mine hauling road, which have to cross rivers, a bridge that is capable of carrying the traffic load from the mining truck is required. This study aims to plan a bridge structure with a composite box girder for coal mine trailer loads. In this study, the authors conducted a loading analysis based on SNI 1725 (2016) and planning the cross-sectional proportions based on the applicable provisions in (AASHTO, 2017). This research was carried out in several stages, starting from design of section proportions, flexure design, shear design, stiffener and shear connector. The results of this study show that the composite box girder can be applied at the research location and also the proportion of the cross-section that is able to withstand traffic loads working on the bridge structure with a nominal moment resistance value of 78856.13 kN.m which is greater than the ultimate moment due to loading that occurs with a value of 66912.64 kN.m.

## Keywords

Bridge Design, Bridge Upper Structure, Composite Box Girder

## 1. Introduction

Kalimantan is known as the island of a thousand rivers, in Kalimantan there are also many coal mines. In the process of mobilizing coal on mine hauling roads that intersect with river flows, it is necessary to have a bridge capable of carrying the traffic load from the mining truck. This study aims to plan the structure of the bridge with a composite box girder for coal mine trailer loads.

## 2. Methodology

The methods applied in the writing of this thesis uses literary study method and quantitative method, the study of literature is finding a theoretical basis that is relevant to the case study and quantitative stages of the research process using data in the form of numbers as an analysis tool.

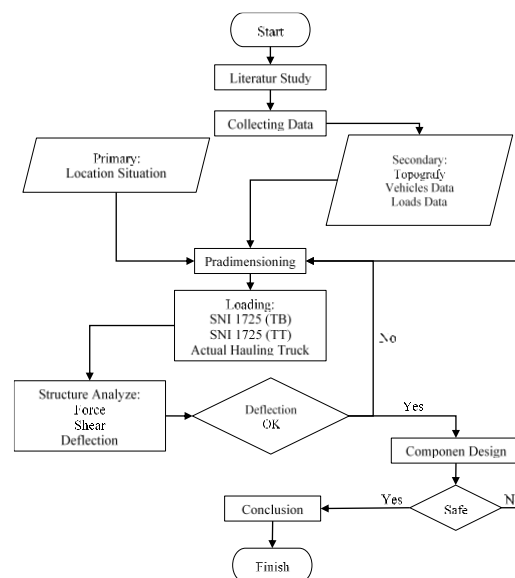


Figure 1. Flowchart of Research  
Source: Data in Research, 2020

## 2.1. Vehicles Data

In this case study, the mining transport vehicles used can be seen in Figure 2.

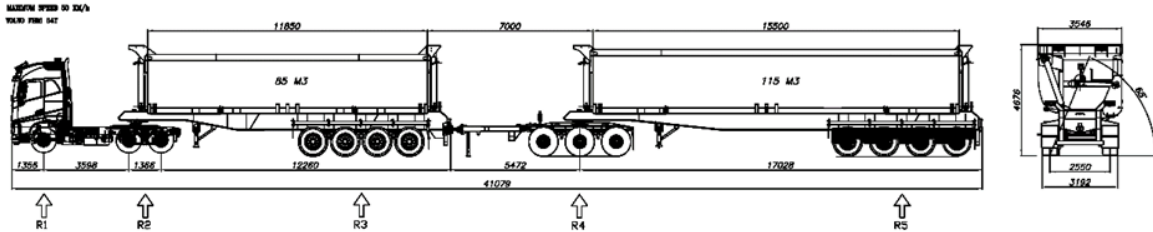


Figure 2. Hauling Truck  
Source: Data in Research, 2020

## 2.2. Loads Data

In this case study, loads data from mining transport vehicles used can be seen in table 1.

Table 1. Loading Data

Description	R1	R2	R3	R4	R5	Total
Volvo FH16	6.013	4.997				11.010
SDT 85m3	693	6.291	20.516			27.500
Payload (coal 85m3)	2.328	21.140	48,782			72.250
Dolly				8.000		8.000
SDT 115m3				10.621	22.509	33.310
Payload (coal 115m3)				38.269	59.481	97.750
Gross Combination Weight	9.034	32.428	69.298	56.890	81.990	249.640

Source: Data in Research, 2020

## 2.3. Material Properties

In this case study, the materials used can be seen in table 2.

Table 2. Material Property

Material	Grade
Concrete	K-400
Rebar <math>\phi 10\text{mm}</math>	BJTP 24
Rebar > <math&gt;d13\text{mm}&lt; math&gt;<="" td=""> <td>BJTD 40</td> </math&gt;d13\text{mm}&lt;>	BJTD 40
Steel	JIS G1306 SM 490 YB

Source: Data in Research, 2020

## 3. Result and Discussion

### 3.1. Section Proportion

In this case study, preliminary section property was created as shown in Figure 3.

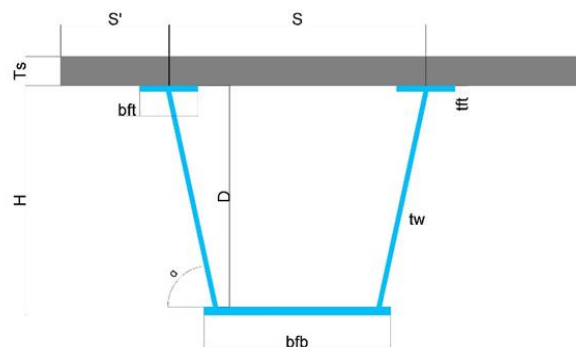


Figure 3. Preliminary Section Property  
Source: Data in Research, 2020

where,

$H = 2200\text{mm}$	$D = 2150\text{mm}$	$S = 2800\text{mm}$	$\alpha = 71^\circ$
$t_{ft} = 25\text{mm}$	$t_w = 20\text{mm}$	$t_{fb} = 25\text{mm}$	$T_s = 250\text{mm}$
$b_{ft} = 400\text{mm}$	$b_{fb} = 1500\text{mm}$		

a. Web Proportion

Inspection of webs proportion is planned to be proportional to resist a bending, webs shall be proportioned such that:

$D/t_w \leq 150$  eq. 6.10.2.1.1-1 Webs without longitudinal stiffener

$D/t_w \leq 300$  eq. 6.10.2.1.2-1 Webs with longitudinal stiffener

However, webs than have larger  $D/t_w$  values than specified by equation are relatively inefficient, are likely to be more susceptible to distortion-induced fatigue.

$2150/20=107,5 \leq 150$  OK! Webs without longitudinal stiffener

b. Flanges Proportion

Inspection of flanges proportion, flanges shall be proportioned such that:

$b_f / [2t_f] \leq 12$  eq. 6.10.2.2.1-1  $\square$  is partial upper limit to ensure the flanges will not distort excessively when welded to the web.

$b_f \geq D/6$  eq. 6.10.2.2.1-2  $\square$  limits this ratio to maximum value of 6

$t_f \geq 1,1 t_{weq}$  eq. 6.10.2.2.1-2  $\square$  ensures than some resistant will be provided by the flanges against web shear buckling.

$400/(2 \cdot 25)=8 \leq 12$   $\square$  OK!

$400 \geq 2150/6=358,3$   $\square$  OK!

$25 \geq 1,1 \cdot 20=22$   $\square$  OK!

c. Modeling

Modeling of cross-sectional proportions that have been carried out can be seen in figure 4.

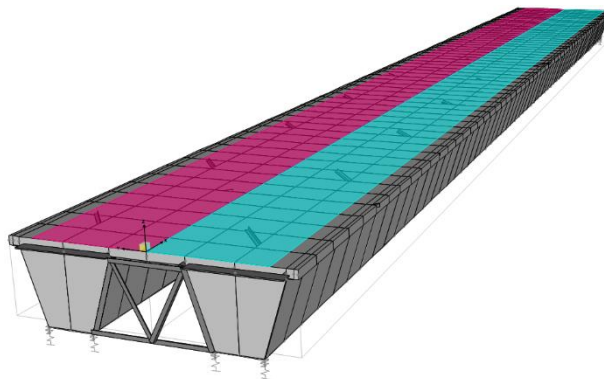


Figure 4. 3D Modeling U Composite  
Source: Data in Research, 2020

d. Loading

Loading is carried out based on the applicable provisions of SNI 1725: 2016 with loads that can be seen in table 3.

Table 3. Loading

Linier Static	Moving Load
Self Weigth (MS)	Lane Load (TD)
Additional Dead Load of Barrier (MA)	Truck Load (TT)
Additional Dead Load of Walkway (MA)	Braking Load (TB)
Additional Dead Load of Finishing Surface (MA)	Hauling Truck Load (TA)
Additional dead load of rainwater puddles (MA)	Pedestrian Load (TP)

Source: Data in Research, 2020

For the load combinations applied in each limit state can be seen in table 4.

Table 4. Load Combination

Kombinasi	MS	MA	TD	TT	TB	TP	TAk
Kuat 1a	1,3	2	1,8			1,8	
Kuat 1b	1,3	2		1,8		1,8	
Kuat 1c	1,3	2			1,8	1,8	
Kuat 1d	1,3	2				1,8	1,8
Kuat 2a	1,3	2	1,4			1,4	
Kuat 2b	1,3	2		1,4		1,4	
Kuat 2c	1,3	2			1,4	1,4	
Kuat 2d	1,3	2				1,4	1,4
Layan 1a	1	1	1			1	
Layan 1b	1	1		1		1	
Layan 1c	1	1			1	1	
Layan 1d	1	1				1	1
Layan 2a	1	1	1,3			1,3	
Layan 2b	1	1		1,3		1,3	
Layan 2c	1	1			1,3	1,3	
Layan 2d	1	1				1,3	1,3

Source: Data in Research, 2020

### 3.2. Research results

The results of research were obtained from the analysis process and literature study. The analysis process is carried out in the CSi Bridge software. The analysis process is carried out after all loads and load cases are in accordance with the loads acting on the bridge structure. Load case is used as a function used for loading analysis in a boundary state. So that the decisive moment is obtained at 66912.64 kN.m with a shear force of 4526.04 kN.

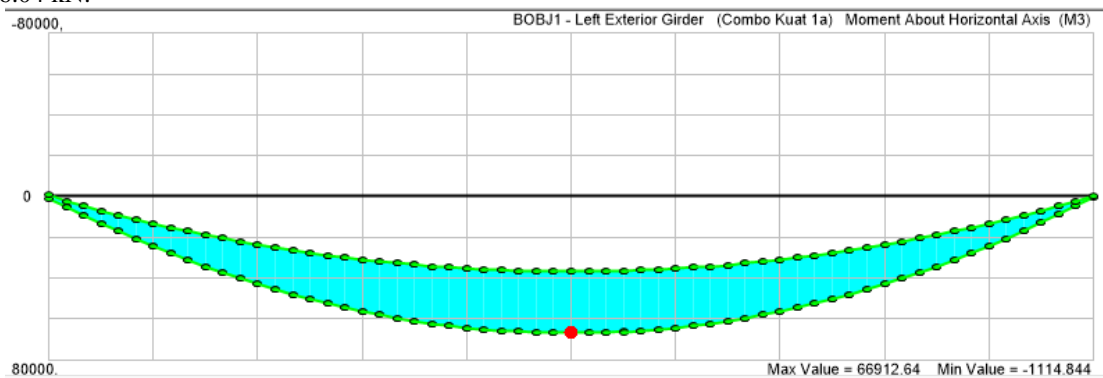


Figure 5. Ultimate Momen  
Source: Data in Research, 2020



Figure 6. Ultimate Shear Force  
Source: Data in Research, 2020

### 3.3. Flexure Design

The compact section on a straight bridge must satisfy the following requirements:

The yield strength of the flanges should not be more than 70 ksi  $f_y \leq 485$  Mpa

Webs proportion shall satisfy of eq. 6.10.2.1.1-1  $D/t_w \leq 150$ ,

The cross section shall satisfy of eq. 6.10.6.2.2-1  $(2D_{cp})/t_w \leq 3,76 \sqrt{E/f_y}$

For straight bridges that do not meet the above requirements and curved bridges even though they meet the requirements, they must be considered non-compact cross-sections.

At the strength limit state, the compact section shall satisfy requirement:

$$M_u + 1/3 f_l S_{xt} \leq \phi_f M_n \quad \text{Eq. 6.10.7.1.1-1}$$

$$M_u \leq [\phi_f M]_n = 66\,912,64 \text{ kN.m} \leq 0,9 \times 87\,617,93 = 78\,856,13 \text{ kN.m} \quad \text{OK!}$$

This equation is an interaction equation that adds the effect of lateral buckling to the tensile wing, which is represented by the lateral bending stress elastic calculated wings, combined with ultimate bending moment.

Nominal Flexural Resistance eq. 6.10.7.1.2 can be determined if:

$$D_p \leq 0,1 D_t \text{ then}$$

$$M_n = M_p \quad \text{Eq. 6.10.7.1.2-1}$$

otherwise, then

$$M_n = M_p (1,07 - 0,7 D_p/D_t) \quad \text{Eq. 6.10.7.1.2-2}$$

$$M_n = 112\,602,9 (1,07 - 0,7 \cdot 1021,6/2450)$$

$$M_n = 87\,617,93 \text{ kN.m}$$

For the value of the positive plastic moment, the composite cross section can be divided into 7 cases depending on the amount of PNA,

$$M_p = P_w/2D [ [Y^-]^2 + (D - Y^-)^2 ] + [ P_s d_{s+} + P_{rt} d_{rt+} + P_{rb} d_{rb+} + P_c d_{c+} + P_t d_t ]$$

$$M_p = 112\,602,9 \text{ kN.m}$$

Where,

$$Y^- = (D/2) [ (P_t - P_c - P_s - P_{rt} - P_{rb}) / P_c + 1 ] = 746,6 \text{ mm}$$

### 3.4. Shear Design

At the strength limit state, the straight or curves webs shall satisfy:

$$V_u \leq \phi_v V_n \quad \text{Eq. 6.10.9.1-1}$$

$$V_u \leq \phi_v V_n \quad 4526,91 \text{ kN} \leq 8192,79 \text{ kN} \quad \text{OK!}$$

The nominal shear resistance of the body plate without stiffening shall be taken as the shear resistance or bending resistance as follows:

$$V_n = V_{cr} = C V_p \quad \text{Eq. 6.10.9.2-1}$$

where,

$$V_p = 0,58 \cdot [f_y]_w \cdot [Dt]_w \quad \text{Eq. 6.10.9.2-2}$$

$$V_p = 0,58 \cdot 365 \cdot 2150 \cdot 20 = 9103,1 \text{ kN}$$

for the ratio value (C) can be determined by the specifications below:

if  $D/t_w \leq 1,12 \sqrt{E_k / [f_y]_w}$  then,

$$C = 1,0 \quad \text{Eq. 6.10.9.3.2-4}$$

if  $1,12 \sqrt{E_k / [f_y]_w} < D/t_w \leq 1,40 \sqrt{E_k / [f_y]_w}$  then,

$$C = (1,12) / (D/t_w) \sqrt{E_k / [f_y]_w} \quad \text{Eq. 6.10.9.3.2-5}$$

if  $D/t_w \leq 1,40 \sqrt{E_k / [f_y]_w}$  then,

$$C = (1.57) / \left[ \left( \frac{D}{t_w} \right)^2 \left( \frac{E_k}{f_y} \right) \right] \quad \text{Eq. 6.10.9.3.2-6}$$

with coefficient value:

$$k = 5 + (5) / \left[ \left( \frac{d_0}{D} \right)^2 \right] \quad \text{Eq. 6.10.3.2-7}$$

#### 4. Conclusion

Based on the economic span of the study location, can use a 60m span composite girder with the working load is a linear static load and a moving load. The proportion of the cross-section obtained to carry the load with the nominal resistance moment value of 78856.14 kN.m which is still greater than the ultimate moment that occurs due to loading of 66912.64 kN.m

#### References

- AASHTO. (2017). *AASHTO LRFD Bridge Design Specification* (8th ed.). Washington, D.C.: AASHTO.  
SNI 1725. (2016). *Pembebanan untuk jembatan*. Jakarta: SNI.