American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN: 2320-0936
Volume-14, Issue-10, pp-35-44
www.ajer.org
Research Paper Open Access

Modification of the Design of The Steel Truss Structure Into A K-Truss for the Dama River Bridge in Samarinda

Tumingan[1*], Rani ZarrahPasca Ananda Zain[2], Yudi Pranoto[3]
[1,2,3]Department of Civil Engineering, Road & Bridge Engineering Study Programme, Samarinda State Polytechnic,Indonesia
**Corresponding Author*

ABSTRACT : *The Dama River Bridge in Samarinda, East Kalimantan, originally designed as a truss bridge, was modified into a K-truss bridge based on previous research, with the addition of longitudinal girders. The objective of this study was to modify the truss bridge into a K-truss steel frame bridge using SAP 2000 version 14, in accordance with SNI 1725 – 2016 regulations. The steel profiles used are WF 428 x 407 x 20 x 35 steel frames, the transverse steel girder is WF 900 x 300 x 16 x 28, the longitudinal girder is WF 450 x 200 x 9 x 14, the upper wind brace is WF 150 x 150 x 7 x 10, and the lower wind brace is an L-shaped steel 100 x 100 x 8 x 8. The SAP 2000 version 14 analysis yielded the largest axial force of – 1148375,98 kg (compression) on the WF 428 x 407 x 20 x 35 profile and the second largest axial force of – 896153,22 kg (compression) on the WF 428 x 407 x 20 x 35 profile. The results indicate that the bridge is safe for use in the K-Truss type.*

KEYWORDS: *Steel Truss Bridge, SAP 2000 Analysis, K – Truss Bridge, Structural Analysis.*

Date of Submission: 03-10-2025 Date of acceptance: 14-10-2025

I. INTRODUCTION

The city of Samarinda, capital of East Kalimantan Province, is divided by the Mahakam River, the largest river in the province with a length of approximately 920 kilometres. This river flows through various regions in Kalimantan, including Mahakam Ulu Regency, West Kutai Regency, KutaiKartanegara Regency, and the city of Samarinda. In Samarinda, the Mahakam River has several tributaries, including the Karang Mumus River. One of the bridges crossing the Karang Mumus River is the Dama River Bridge, built in 1987. The Dama River Bridge connects Jl. PangeranHidayatullah and Jl. Otto Iskandardinata. This bridge is a steel truss bridge with a span of 60 metres, a height of 5 metres, and a width of 6 metres [1], [2], [3].

Steel truss bridges are one of the most common types of bridge construction in Indonesia [4], [5]. From the development of bridges, bridge trusses come in various forms, including Pratt trusses, Howe trusses, Parker trusses, Warren trusses, and K-trusses. The Dama River Bridge is a Warren Truss steel truss bridge. The characteristics of this truss bridge are that the truss structure system does not have vertical members, so the members that work in this type of truss consist of diagonal members in the form of equilateral triangles and isosceles triangles and horizontal members as connectors between the diagonal members. The characteristics in the structural analysis of a truss bridge are that the diagonal members receive compressive forces and tensile forces [6]. In this analysis, the Dama River Bridge was modified into a K-truss bridge with changes to the main bridge frame and the addition of longitudinal girders.

Modification of the T-type steel truss bridge to K-truss is expected to be a solution in designing a structurally strong bridge with attractive aesthetics in bridge construction planning[7],[8]. The truss type frame has the advantage of being suitable for use in bridge structures with long spans. In addition, the relatively simple design of the truss structure makes this type of bridge lighter in weight and allows for even load distribution among the steel truss members. The disadvantage of the Truss-type truss bridge is that it does not perform well under concentrated loads, and the construction costs are relatively high due to the addition of trusses. In addition to being sturdy and having a low risk of buckling, the K-truss type frame bridge has the advantage of being able to reduce pressure on the vertical members or beams. The disadvantage of this type of truss bridge is that it is slightly complicated to construct. Additionally, the increased volume of steel due to the additional truss members results in this type having a relatively heavy structural weight. [9]. This study aims to determine how the strength of the structure, construction convenience [10], and heavier load compare when planning to use the

K-Truss type versus the Truss type bridge.

II. THEORETICAL FOUNDATION

According to Struyck and Van Der Veen [11], a bridge is a structure built over a lower obstacle. These obstacles can be ravines, valleys, railways, rivers, bodies of water, or other physical obstacles. The purpose of a bridge is to provide a passageway for people or vehicles to cross an obstacle. In addition, bridges also serve as an alternative to connecting road sections, thereby shortening distances [12].

A. Steel Truss Bridge

A truss bridge is a bridge composed of beams connected to each other by gusset plates, with rivets, bolts or welds. These truss members only bear axial compressive or tensile forces, unlike girders which bear bending moments and shear forces [13].Steel truss bridges are generally classified into several types, such as Warren truss, Howe truss, Pratt truss and K-truss. The following are the types of truss bridges:

1. Truss Bridge

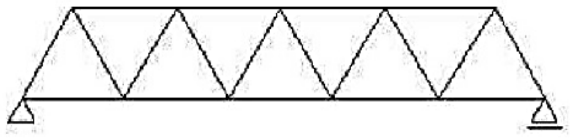

Figure 1. Warren Truss Type (Triangular Frame)

The truss bridge was first patented by two British engineers in 1848 and was quickly adopted by American bridge design. This type of bridge is still widely used to construct steel truss bridges. The main structure is trapezoidal in shape and the diagonal trusses are triangular in order to withstand axial and lateral forces. In this bridge, the forces that occur (tension and compression) are absorbed by the diagonal members that form an isosceles triangle.

2. Pratt Truss Bridge

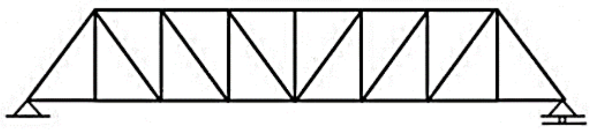

Figure 2. Pratt Type (Diagonal Down Frame)

The Pratt truss bridge was invented by Thomas and Celeb Pratt in 1844. This type of truss is a truss with vertical members and diagonal members that slope downwards towards the centre of the truss span [14].The diagonal beams only receive tension forces, while the vertical beams receive compression forces. This type of bridge has good tensile strength.

3. Howe Truss Bridge

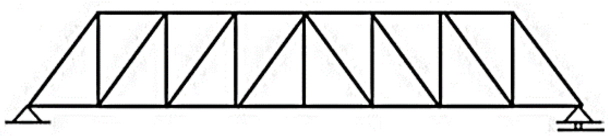

Figure 3. Howe Type (Double Truss)

The Howe truss bridge structure has two vertical and diagonal elements and is the opposite of the Pratt truss structure, in which the diagonal members slope upwards as they approach the centre of the span. This results in a different force distribution system, with the vertical members receiving tensile forces and the diagonal members receiving compressive forces.

4. K-Type Truss Bridge

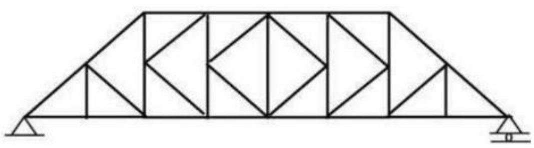

Figure 4. Type K – Truss (K-shaped Frame)

A K-truss bridge is a type of bridge whose main structure (main girder) is shaped like the letter K, where the compression members serve to distribute the load and connect the tension members (vertical) [15].

B. Loading On Bridges

The load calculation and SAP2000 version 14 analysis of the Dama River Bridge, Samarinda, East Kalimantan, refers to [16].

1. Dead Load Structure (MS)

Dead load is the load that is always present in a bridge structure due to the weight of the bridge structure itself. This load refers to the dead load of the bridge superstructure. The specific gravity (γ) and volume of the materials used will affect the dead load of the bridge structure.

2. Additional Dead Load (MA)

Additional dead load (Super Dead Load) is a load outside the bridge structure but will always be present on the bridge structure. This additional dead load includes asphalt, pavements, and railings (safety barriers).

3. The Burden of Life

a. Truck Load 'T'

Based on [16] concerning Truck Loads, the load values for each wheel axle are as follows:
Front wheel axle: 2500 kg
Middle and rear wheel axles: 11250 kg

b. Load on Lane 'D'

The lane load is divided into two loads, namely: evenly distributed load (BTR) and centred line load (BGT), where each load has provisions reviewed from [16] as follows:

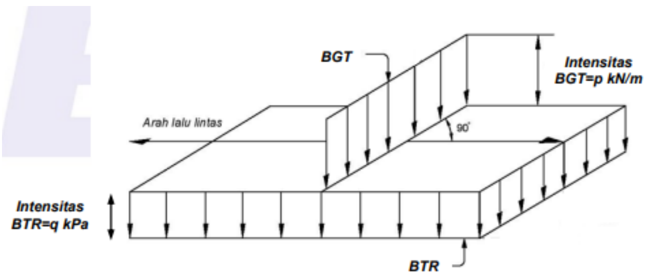

Figure 5. Evenly Distributed Load and Centred Line Load

- Evenly distributed load
  This load has provisions reviewed based on the length of the bridge as follows:
  L <30 metres then: load = 9 kPa
  L >30 metres then: load = 9 x (0.5 + 15 : bridge length) = kPa (1)
  If the bridge length is 60 metres, then: 9 × (0.5 + 15 : 60) = 6,75 kPa
- Centred line load
  4900 kg/m x (1 + dynamic load factor) (2)
  BGT = 4900 x (1 + 0.37) = 6713 kg/m

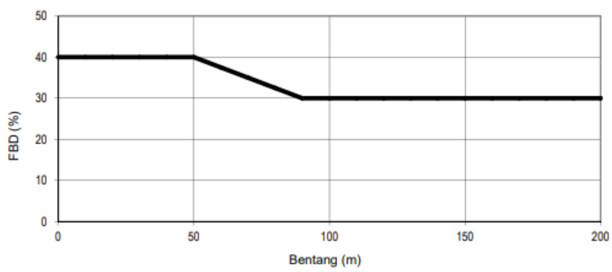

Figure 6. Dynamic Load Factors for Load T for Lane 'D' Loading

c. Pedestrian Load

The load on bridges due to pedestrian traffic has been specified in SNI 1725-2016. As stated in Article 8.9 on Loading for Pedestrians (TP), 'All pavement components wider than 600 mm must be designed to carry pedestrian loads with an intensity of 5 kPa and are considered to work simultaneously with vehicle loads on each vehicle lane.' (SNI 1725-2016:46). Therefore, the pedestrian load is 5 kPa at each lower node point.

d. Wind Load

Wind load on structures (EWs) In the absence of more precise data, the design wind pressure in MPa can be determined using the following equation:

$$P_D: P_B \left(\frac{V_{DZ}}{V_B}\right)^2 \quad (3)$$

Description:

PB: is the base wind pressure as specified in the table (MPa)

Table 1. Basic wind pressure

Upper Building Components	Compressed air (MPa)	Suction Wind (MPa)
Frames, Columns, and Arches	0,0024	0,0012
Block	0,0024	N/A
Flat Surface	0,0019	N/A

The total wind load should not be less than 4.4 kN/mm on the compression side and 2.2 kN/mm on the suction side of frame and arch structures, and not less than 4.4 kN/mm on beams or girders.

e. Brake Force (TB)

The braking force must be taken from the greatest of:

- 25% of the design axle weight of the lorry, or
- 5% of the planned truck weight plus the evenly distributed lane load BTR

The braking force must be applied to all lanes in accordance with Section 8.2 and containing traffic travelling in the same direction. This force must be assumed to act horizontally at a distance of 1800 mm above the road surface in each longitudinal direction and the most decisive one must be selected. For bridges that will be converted to one-way in the future, all planned lanes must be loaded simultaneously when calculating the braking force. The lane density factor specified in Section 8.4.3 applies to the calculation of braking force.

f. Earthquake Load (EQ)

The elastic response coefficient Csm is obtained from the bedrock acceleration map and acceleration spectra corresponding to the earthquake zone and the design earthquake recurrence period. The acceleration coefficient obtained based on the earthquake map is multiplied by an amplification factor corresponding to the soil conditions to a depth of 30 m. The calculation of the earthquake's effect on this bridge refers to [17] SNI 2833:2016 and SNI 1725:2016 [16] for earthquake loads calculated with,

$$EQ = Csm / R \times Wt \quad (4)$$

With,

EQ : earthquake load (Kg)

Csm : elastic earthquake coefficient

R : response modification factor

Wt : weight of the bridge superstructure

PUPR LINE Application

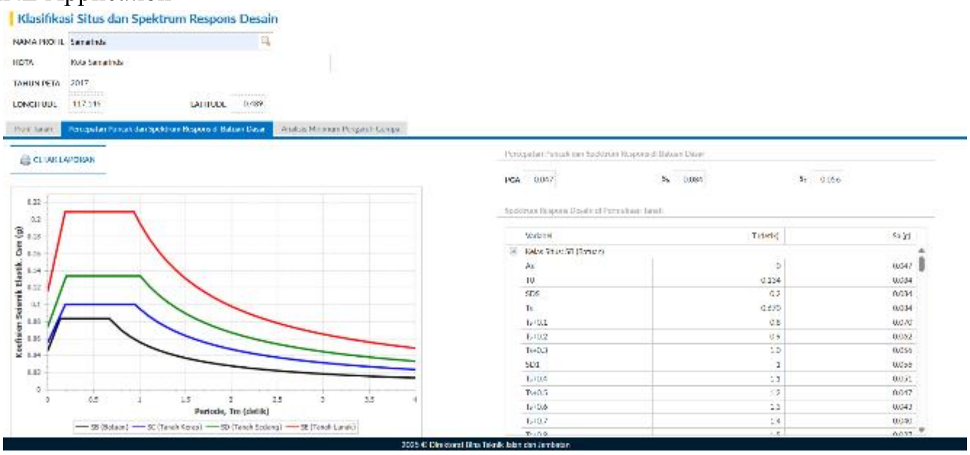

Figure 7.PUPR LINE Application

C. RSNI T – 03 – 2005 [18]

This standard regulates the design of steel structures for bridges in Indonesia with a maximum length of 100 metres, covering minimum requirements for design, fabrication, installation and modification [19]. This standard serves as a reference for bridge designers and is an improvement on the concept of 'Technical Bridge Design Regulations Part 7 – Steel Structure Design [20], which was compiled in 1992 by the Directorate General of Highways, Ministry of Public Works.

III. RESEARCH METHODOLOGY

1. Research Location and Time

The location is the area or place used for conducting research. This research was conducted on the Dama River Bridge, which connects Jl. PangeranHidayatullah and Jl. Otto Iskandardinata, located in Samarinda, East Kalimantan. This bridge has a span of 60 metres, a width of 6 metres, and a height of 6 metres. The researcher chose this location because he had previously conducted research or completed an assignment given by his lecturer on the analysis and structure of the Dama River Bridge. Therefore, the researcher wanted to find information about steel truss bridges in case a steel K-truss bridge was to be built. The author of this study has developed a research plan, specifically regarding the duration of the study. In this study, the author plans to complete the research within 8 months, from January 2025 to August 2025.

2. Data Collection Techniques

a. Observation

The observation method, which involves conducting direct observations at the planned research location to ascertain the actual conditions in the field, thereby obtaining an overview that can be used as a consideration in the planning of K-truss steel frame bridges.

b. Measurement Data for the Dama River Bridge

The following data was obtained on the existing conditions:

1. Bridge length : 60 metres
2. Bridge width : 6 metres
3. Bridge height : 5 metres
4. Asphalt thickness : 5 cm
5. Asphalt width : 6 metres
6. Pavement width : 60 cm
7. Sidewalk height : 45 cm
8. Frame type : Truss type
9. Steel profile

a. WF steel 300 X 300 X 10 X 15
Height : 300 mm
Wing width : 300 mm
Wing thickness : 15 mm

b. Double U Channel Steel 500 X 380 X 13 X 16.5
Height : 500 mm
Wing width : 380 mm
Wing thickness : 16.5 mm
Distance between steel : 300 mm

c. WF 150 X 150 X 7 X 10 steel
Height : 150 mm
Wing width : 150 mm
Wing thickness : 10 mm

d. WF 900 X 300 X16 X 28 steel
Height : 900 mm
Wing width : 300 mm
Wing thickness : 28 mm

e. Angle steel 100 x 100 x 8 x 8
Height : 100 mm
Width : 100 mm
Thickness : 8 mm

c. Documentation

The purpose of documentation is to collect supporting data in the form of written records and images needed in research on the design of K-Truss steel bridges.

d. Secondary Data

Secondary data is data that has been collected, processed, and published by other parties, not by researchers. This data is obtained indirectly through intermediary media.

IV. RESULTS AND DISCUSSION

Bridge Structure Data and Bridge Class
Modified Bridge Data (K-Truss)

1. Bridge length : 60 m
2. Bridge width : 6 m
3. Bridge height : 5 m
4. Asphalt thickness : 0.05 m
5. Asphalt width : 6 m
6. Pavement width : 0.6 m
7. Pavement height : 0.2 m
8. Frame type : K-Truss type
9. Steel profile :

Steel frame
WF steel 428 x 407 x 20 x 35
Height : 0.428 m
Width : 0.407 m
Wing thickness : 0.035 m

Cross girder
WF steel 900 x 300 x 16 x 28
Height : 0.900 m
Width : 0.300 m
Flange thickness: 0.028 m

Longitudinal girder
WF steel 450 x 200 x 9 x 14
Height : 0.450 m
Width : 0.200 m
Wing thickness : 0.014 m

Upper wind bracing
a. WF steel 150 x 150 x 7 x 10
Height : 0.150 m
Width : 0.150 m
Wing thickness : 0.010 m

Lower wind bracing
b. Angle steel 100 x 100 x 8 x 8
Height : 0.100 m
Width : 0.100 m
Wing thickness : 0.008 m

Bridge Class
The bridge class used in this study is class B, which refers to bridges located on district roads. The traffic load designed for class B bridges is lighter than that for class A bridges. Designed as a permanent bridge with a total width of 7 m (6 m carriageway and 0.5 m pavement width (right and left)), it uses BM-100 traffic load (100% in accordance with the loading in the Loading Specifications for Bridges & Highways No. 12/1970 [20].

A. SAP 2000 Veris 14 Analysis Results

The results of the load analysis conducted using SAP 2000 version 14 software are as follows:

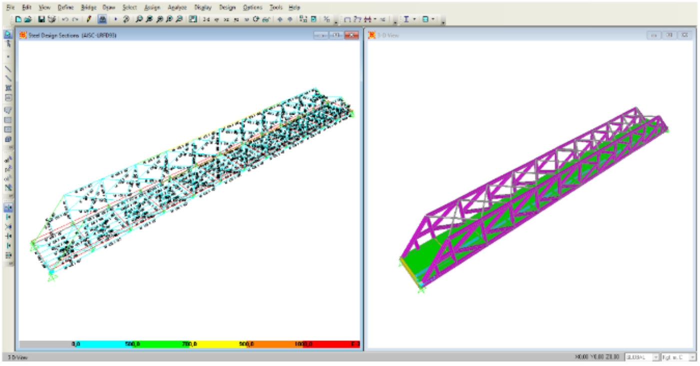

Figure 8. Run Sap 2000 v. 14

1. Main Frame

Table 2. Main Frame Structure Analysis Results

Main Frame Recap		
Combination	Description	P (Kg)
Strong 1	Press	-1148375,98
Strong 2	Press	-993220,48
Strong 3	Press	-442213,54
Strong 4	Press	-450176,23
Strong 5	Press	-447901,18
Mild 1	Press	-778080,30
Mild 2	Press	-896153,22
Mild 3	Press	-702208,84
Mild 4	Press	-391898,24
Ekstrem 1	Press	-565917,62
Ekstrem 2	Press	-643495,37

2. Crossbeam

Table 3. Results of Cross Beam Analysis

Main Frame Recap		
Combination	Description	P (Kg)
Strong 1	Pull	97079,99
Mild 1	Pull	55954,82

3. Extended Beam

Table 4. Results of Longitudinal Beam Analysis

Main Frame Recap		
Combination	Description	P (Kg)
Strong 1	Pull	4076,22
Mild 1	Pull	2685,54

4. Wind Bond

Table 5. Wind Bond Analysis Results

Main Frame Recap		
Combination	Description	P (Kg)
Strong 1	Press	-2275,97
Mild 1	Press	-1777,95

B. Strength Test Results

1. Main Frame

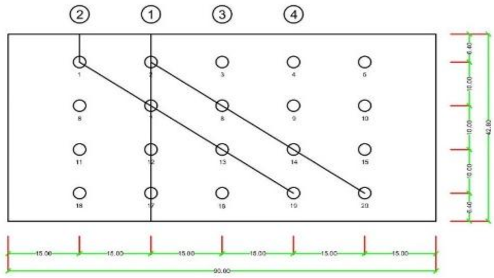

Figure 9. Main Frame Steel Plate

Calculating Tension Bars
Check strength

$$Nu \leq ØnNn$$
$$1148375{,}98 \leq 0{,}85 \text{ x } Nn$$
$$1148375{,}98 \leq 0.85 \text{ x } 3525725$$
$$1148375{,}98 \leq 2996866{,}57 \text{ kg}$$

Strength requirement met
Calculating Tensile Rod
Check strength

$$Nu \leq Nn$$
$$1148375{,}98 \leq 1343584{,}94 \text{ kgf}$$

Strength requirement met

2. Crossbeam

Nominal Moment (Mn)

$$ØMn> Mu$$
$$382{,}827{,}88 > 97{,}079{,}99 \text{ Kgf-m}$$

Since ϕMn> Mu (382827,88 > 97079,99 Kgf-m), the WF 900 x 300 x 16 x 28 profile is capable of withstanding the moment that occurs, so the profile can be used for bridge cross beams.

3. Extended Beam

Ultimate Moment Analysis (Mu)

$$ØMn> Mu$$
$$144619 > 27142 \text{ Kgf-m}$$

Since ØMn> Mu, it can be concluded that the WF 450 x 200 x 9 x 14 steel profile is capable of bearing the moments that occur, making it safe for use.

4. Wind Bond

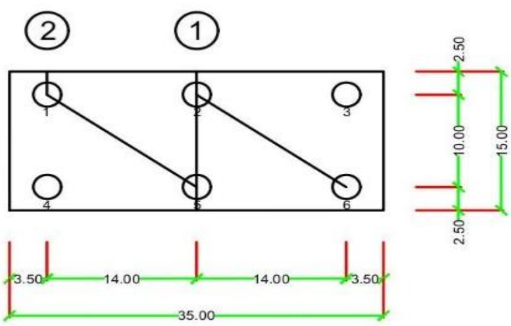

Figure 10. Run Sap 2000 v. 14

Calculating Tension Bars

Check strength

$$Nu \leq ØnNn$$

$$2275{,}97 \leq 0.85 \text{ x } Nn$$

$$2275{,}97 \leq 0.85 \text{ x } 391964$$

$$2275{,}97 \leq 333169{,}81 \text{ Kg}$$

Strength requirement met

Calculating Tension Rods

Strength check

$$Nu \leq Nn$$

$$2275{,}97 \leq 147523{,}43 \text{ Kgf}$$

Strength requirement met

V. CONCLUSION

Conclusion

From the results of the research and discussion presented, the conclusions drawn from this study are:

1. The analysis results obtained the following steel profile dimensions:

   Bridge Data K - Truss

   a. Main frame WF 428 x 407 x 20 x 35

   b. Cross girder WF 900 x 300 x 16 x 28

   c. Longitudinal girders WF 450 x 200 x 9 x 14

   d. Upper wind braces WF 150 x 150 x 7 x 10

   e. Lower wind braces 100 x 100 x 8 x 8
2. Based on the results of the SAP 2000 version 14 calculations performed on the K-truss bridge, the results obtained for the main frame member forces due to the largest combination strength 1 borne by the member were -1,148,375,98 kg (compression) on frame S34 and the bar force due to the largest Layan 2 combination borne by the bar of -896153,22 kg (compression) on frame S34 using the WF 428 x 407 x 20 x 35 profile.
3. From the main frame calculations, the width of the k-truss used on the bridge is 900 mm, the height is 428 mm, and the thickness is 30 mm, with a total of 20 bolts using a bolt diameter of 26 mm on the main frame. The wind brace has a width of 350 mm, a height of 150 mm, and a thickness of 3.5 mm, with a total of 6 bolts using a bolt diameter of 26 mm.

Recommendation

Based on the conclusions obtained, there are matters that need to be followed up, namely by conducting a comprehensive analysis of the upper and lower building structures so that more valid results can be obtained.

REFERENCES

[1]. Istiyanto, Hendra, (2024). Evaluation of the Impact of Steel Corrosion on the Structural Capacity of the Dama River Bridge, Curve S: Journal of Civil Engineering Science and Application, Vol. 12, No. 03, December 2024, 108-114, DOI:https://doi.org/10.31293/teknikd.v12i3.8444 .

[2]. PulungPriyoPamungkas, Tumingan, Arif Wahyudianto (2024), Characteristics of Grade 8.8 M22 High-Quality Bolts for Steel Bridge Frame Connections. CurveS: Journal of Civil Engineering Science and Application, Vol. 12, No. 03, December 2024. 115-121. DOI: https://doi.org/10.31293/teknikd.v12i3.8445 .

[3]. Pamungkas, P. P., Tumingan, T., &Wahyudianto, A. (2025). The Effect of Repeated Tightening of Grade 8.8 M22 Bolts on Bridge Structural Strength. Teknika, 20(1). https://doi.org/10.26623/teknika.v20i1.10722 .

[4]. Marwa Sukma, Azizah, (2022). Comparative Analysis of Frame Height Variations in Warren Truss Bridges. Proceedings of the 6th National Seminar on Research & Community Service 2022. Field of Civil & Water Engineering, Transportation & Disaster Mitigation. https://jurnal.poliupg.ac.id/index.php/snp2m/article/view/3962.

[5]. Yatnikasari, Santi, (2021). Alternative Planning for Steel Frame Bridges Using the Lrfd Method on the Gelatik Bridge in Samarinda City. DOI: http://dx.doi.org/10.31869/rtj.v4i2.2518,

[6]. Veen, V. D. (1995). Bridges. Jakarta: PT Pradnya Paramita.

[7]. Harmianto, Rifandi, (2021). Redesigning the Steel Profile of the Merah Patikraja Bridge in Banyumas Regency Using a Type 'K' Truss Steel Frame. ISSN: 2722-9203, JOS-MRK Volume 2, Number 2, June 2021, Pages 47-52, Journal Homepage : http://jos-mrk.polinema.ac.id/ .

[8]. Sumaidi, (2019). Modification of the New Sembayat Bridge Using the Warren Truss Steel Frame System. p-ISSN: 2087-7498 ; e-ISSN: 2686-5026, Journal Homepage: http:kern@upnjatim.ac.id.

[9]. FardanyIbady, Azka, (2018). Analysis of the Capacity of K-Type Truss Bridge Structures with Non-Uniform Steel Quality in Withstanding Two-Way and Three-Way Earthquake Loads. Vol. 1 No. 2.https://sipil.studentjournal.ub.ac.id/index.php/jmts/article/view/679 .

[10]. Amalia, S., K., Tumingan, Nugroho, B., (2021). Capacity Improvement of Steel Frame Bridges Based on Existing Conditions. SNITT- Balikpapan State Polytechnic 2021 ISBN: 978-602-51450-3-2. DOI: https://doi.org/10.26623/g6dpef06 .

[11]. Struyk, H.J. & Van Der Veen, K.H.C.W, (1984). Bridge Construction. Translated by Soemargono. Jakarta: PT. Pradnya Paramita.

[12]. Purwatmoko, H., Tumingan, T., &Suryono, J. (2025). Evaluation of the Upper Structure of the Sambaliung Bridge in East Kalimantan Province. Teknika, 20(1). https://doi.org/10.26623/g6dpef06 .

[13]. Nasution, Thamrin, (2012). Steel Structures II. Department of Civil Engineering, FTSP. ITM.

[14]. Kassimali. (1993). Structural Analysis. Cengage Learning, USA.

[15]. Supriyadi, Dr. Ir. Bambang and Agus SetyoMuntohar, (2007). 'Bridge'. CaturtunggalYogyakarta. Meta Ofset.

[16]. SNI 1725 – 2016. Loading for Bridges, Jakarta: National Standardisation Agency.

[17]. SNI 2833 – 2016. Bridge Design Against Earthquake Loads, Jakarta: National Standardisation Agency.

[18]. RSNI T – 03 – 2005. Steel Structure Design for Bridges.Jakarta: National Standardisation Agency.

[19]. Elysa Putri, Adella, (2018). Comparative Analysis of Bukaka and SNI Steel Frame Structures Using Tekla Modelling on the Betapus Bridge in Samarinda. SNITT- Balikpapan State Polytechnic 2018 ISBN: 978-602-51450-1-8. https://jurnal.poltekba.ac.id/index.php/prosiding/article/view/597 .

[20]. Bridge Management System 1992, Directorate General of Highways, Ministry of Public Works and Public Housing.