THE EFFECT OF TRUSS MODIFICATION AND OPTIMIZATION ON THE PERFORMANCE OF THE NEW BRIDGE SEPANJANG STRUCTURE

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INTRODUCTION

In general, a bridge is a construction that serves to connect two parts of the road that are cut off by obstacles such as valleys, river channels, lakes, irrigation canals, rivers, railroads, highways that cross not a plot and others. At this time many bridges have been built, ranging from long, medium, and short span bridges. But the infrastructure is not supported by an adequate bridge structure, resulting in damage to the construction of the bridge structure. (Pangestuti, et al 2015).

The Long Bridge is a steel frame bridge that connects the Sidoarjo Park and Mastrip Street segments in Surabaya. The bridge, which has a length of 90 meters, experienced cracks on the floor of the bridge and during the repair the bridge was closed for two weeks. (Kominfo East Java). This is a concern because in planning a steel frame bridge, the bridge structure must meet applicable standards, while also considering the efficiency of the structure in order to obtain an optimal structure, both in terms of the total weight of the structure and the ability to withstand loads (2).

Before designing a bridge, the selection of the truss configuration is of course the main thing that must be considered. Because each frame has different performance characteristics, both in terms of total weight in terms of efficiency and in terms of structural strength. Some of the commonly used bridge configuration models include the pratt, howe, warren, and K-truss types. Pratt, howe and warren trusses are generally used in spans above 180 ft (55 meters) to 200 ft (61 meters) (6). Meanwhile, the type of configuration used in this Long Bridge uses a warren type configuration.

This study aims to determine the performance of the Panjang Bridge with the warren type, as well as modifying the configuration and optimizing the bridge frame elements so that it is expected to produce a bridge structure that is more efficient, both in terms of weight and strength, in this case in terms of deflection. Given the importance of the role of bridges for human life, the feasibility of the bridge construction must be reviewed, in relation to the classification of the bridge according to the level of service and its ability to accept loads (10).

METHOD

A truss bridge consists of a bridge construction structure composed of frames then placed on a plane and connected by joints at each connection point (5). Basically a truss bridge is a combination of elements that form a triangle and are arranged in a stable manner.

Many researches on the behavior of steel truss bridges have been carried out, both to determine the behavior of steel truss bridges to the loads that occur, various types of configurations of steel truss bridge structures, as well as methods to improve the performance of steel truss bridges so that their service life is longer. Each bridge configuration has different characteristics in holding the load. This affects the deflection that occurs due to the load acting on the bridge.

Deformation is a change in the structure of a structural system due to the influence of external loads. The members of the frame structure that have been loaded...
are subjected to axial tensile and compressive forces, and the internal stresses are uniformly distributed across their cross sections. While the deflection is the displacement of the initial neutral point surface to a neutral position after deformation (3).

A comparison of several types of bridge configurations in terms of total structural weight and deflection is given by (3) which considers the effect of chamber application. From this research, it can be seen that the K-truss type bridge produces a smaller deflection than steel truss bridges in general such as the Warren type. However, this study also shows that the K-truss type has a larger total structural weight compared to other structures. Based on these previous studies, it is necessary to conduct research to determine the efficiency of the steel truss bridge structure when viewed in terms of the weight of the structure and the deflection that occurs. Optimization of the structural profile of the steel truss bridge proposed in this study will also reduce the total weight of the steel truss bridge structure. If efficiency can be achieved, then construction costs can be reduced.

In this study, the structure of the Long Bridge will be modeled in the SAP2000 software. The Structural Analysis Program (SAP2000) is a fairly sophisticated building structure analysis program. SAP2000 is the most recent version of the SAP structural analysis program series, both SAP80 and SAP90. The advantages of the SAP2000 program, among others, are shown by the facilities for element design, both for steel and concrete (8).

DISCUSSION

A. Planning Data
- Bridge Length = 90 m
- Number of segments = 15 segments
- Bridge Height = 5 m
- Road Width = 9.2 m
- Pavement Width = 1 m
- Sidewalk height = 13 cm
- Concrete Thickness = 35 cm
- Asphalt thickness = 5 cm
- Bolt Diameter = 20 mm

Bridge Frame Profile:
- Main Frame = WF 350.350.13.13
- Portal Trunk = WF 250.175.11.16
- Wind Bond = L 100.100.8
- Diagonal Bar = WF 350.300.14.22

B. Bridge Load
Loading on bridges has been regulated in SNI T-02-2016 concerning Loading Standards for Bridges, and Circular Letter of the Minister of Public Works No. 02/SE/M/2010 concerning Guidelines for Planning and Implementation of Bridge Construction, some of the existing loads will be selected to be included and then analyzed using the SAP 2000 auxiliary program.

The bridge that is built must be able to withstand the external loads that work. Broadly speaking, the loading on the bridge is divided into four, namely fixed loads, traffic loads and environmental actions as well as special loads.

1. Fixed Load
a) Dead load due to self-weight of the bridge structure based on the weight of the material.
b) Additional dead load due to self-weight of non-structural elements whose value is calculated based on the weight of the material used.
c) Force due to shrinkage and creep of concrete. This expense is not included.
d) Ground pressure. This load is not included because the analysis only discusses the superstructure of the bridge.

d) Light vehicle load. This load is not taken into account.

2. Traffic Load
a) Line load “D”.
b) Truck load “T”.
c) Brake force. This load is not taken into account.
d) Pedestrian load. This load is not taken into account.
e) Light vehicle load. This load is not taken into account.

3. Environmental Action
a) Wind load. This expense is not included.
b) Earthquake load. This expense is not included.
c) Force due to temperature. This expense is not included.

4. Special Load
a) Prestressing force. This load is not included because the bridge structure does not use prestressed concrete.
b) Impact force. This load is not included because the bridge is considered to be free from any impact.

a. Dead Load

Dead load is the weight of the part and other structural elements it bears. Included in this is the weight of the bridge material and parts which are structural elements, plus non-structural elements which are considered fixed (4). Dead load is obtained from the value of the volume weight of the structure multiplied by its dimensions.

In the modeling of the bridge in this study, the dead load included is the uniform load, namely the concrete and asphalt slab, then the concentrated load which is the longitudinal girder. However, on the bridge as long as there is no longitudinal girder installation, it will not be included in the modeling in SAP2000.

All loads are uniformly or concentratedly borne by the transverse girders before being transferred to the bridge abutments.

Even Load: Concrete and Asphalt Slab
Concrete Slab = $t_s \times \gamma_{\text{beton}} \times b \times \gamma_{\text{MS}}^U$
= 0.35 × 24 × 5 × 1.3
= 54.6 kN/m

Asphalt Slab = $t_s \times \gamma_{\text{asphalt}} \times b$
= 0.05 × 22 × 5
= 5.5 kN/m

Live Load

Live load is the load of the vehicle wheels working on the bridge. There are 2 live loads included in the research model, namely the vehicle lane load "D" and the truck load "T".

Vehicle Lane Load “D”:

Line load “D” consists of evenly distributed load (BTR) and total line load (BGT). The evenly distributed load (BTR) has a value of q kPa, where the value of q depends on the span of the bridge (9). Here is the value of q based on the L bridge:
L 30 m: q = 9 kPa
L 30 m: q = 9.0 (0.5 + 15/L) kPa
Source: RSNI T-02-2005 Table 11.

Line load: One BGT with an intensity of p kN/m must be placed perpendicular to the direction of traffic on the bridge. The value of p is 49.0 kN/m. In general, the "D" load will determine in the calculation which has a span ranging from medium to long.

Figure 2 Vehicle lane load D
(Source: 9)

Truck Load “T”

Truck load “T” is one heavy vehicle with 3 axles placed at several positions in the design traffic lane. Each axle consists of two loading contact areas which are intended to simulate the influence of heavy vehicle wheels. One “T” truck is applied to each one lane of design traffic (9).

Figure 3 truck load T
(Source: 9)

Curb Load

The curb/sidewalk that is on the edge of the vehicle floor must be calculated to withstand a lateral load in the transverse direction of the bridge of 500 kg/m acting on the top of the curb in question or at a height of 25 cm above the surface of the vehicle floor if the curb in question is higher than 25 cm. Because the curb height on the Sepanjang Bridge is only 13 cm, the curb load is not included in the model.
C. Modification

The bridge has several types of trusses, including the pratt type, howe truss, warren truss, and K-truss (2). The most widely applied truss bridge forms are Warren truss, Pratt truss, Howe truss and K-truss (1). The shape of each type of frame has its own advantages and disadvantages, so the shape of the frame used is adjusted to the type of bridge and the type of service.

Modifications made in this study are the configuration of the frame and optimization of the steel profile used. With a more effective frame configuration, it is possible to reduce the profile used.

The bridge frame, which was originally a Basic Warren type, will be changed to Optimized K-Truss, as shown in the following figure:

![Basic Warren and K-Truss Frame](Source: 2, et al., 2016)

The K-Truss frame was chosen because the K-Truss frame has a smaller deflection and higher efficiency than the Basic Warren frame (2).

RESULTS

A. Bridge Modeling

After obtaining primary data about the bridge, both the size and profile used, first the modeling of the bridge construction is carried out on AutoCAD software to find out the description of the bridge structure.

![Bridge Structure Modeling in Autocad](Figure 5 Bridge Structure Modeling in Autocad)

![Slice of Bridge Structure Modeling in Autocad](Figure 6 Slice of Bridge Structure Modeling in Autocad)

B. Modeling On SAP2000

To analyze the bridge structure, first describe the bridge model in the SAP200 analysis software both on the original structure and the modification plan. The analysis was carried out on one bridge segment because of the similarity in both the size of the profile and the shape of the frame.

![Modeling on SAP2000 Original Structure](Figure 7 Modeling on SAP2000 Original Structure)

![Modeling in SAP 2000 Modified Structure](Figure 8 Modeling in SAP 2000 Modified Structure)

C. Define planning data in SAP2000 Bridge structure without modification

Before modeling the structure, first define the size of the frame profile, and also the quality of the material to be used and what loads are acting on the structure. The following is the definition of the profile and planning components.

![Bridge structure material data](Figure 9 Bridge structure material data)

![Bridge Structure Profile Size Data](Figure 10 Bridge Structure Profile Size Data)
Figure 11 Working load data Bridge structure

D. Define planning data in SAP2000 Bridge structure with modification
The quality of the material used on the modified bridge is the same as the quality used on the structure without modification, only the profile on the modified bridge is designed to have a smaller size than the actual size to test whether the structure can be more economical or not.

Figure 12 Bridge Structure Profile Size Data

Deformation in Structural Structures without Modification
After analysis by the SAP2000 program, the visualization of the deformation that occurs in the bridge structure can be seen in the following figure:

Figure 13 Working load data Bridge structure

Figure 14 Structural deformation

Structure Performance Level without modification
The strength level of the structure against the working force can be seen from the color on the rod that appears in the SAP200 program, the picture below shows the green color meaning the structure is able to withstand loads that work well.

Figure 15 Structure Performance Level

Structural Deformation with Modification
The deformation seen in the output of SAP2000 shows that the deformation of the modified structure (K-truss) is smaller than that of the unmodified structure.

Figure 16 Structural Deformation

Structure Performance Level without modification
In the diagonal frame, the ends of the K-truss type frame have an orange color, meaning that the structure is prone to failure even though it is still able to withstand the working load.

Figure 17 Structure Performance Level 2

CONCLUSIONS & SUGGESTIONS
From the results of the analysis above, it can be concluded that:

1. The bridge frame based on a profile that is in accordance with the existing conditions of the bridge is still capable and is categorized as safe to withstand the working load.

2. Modification and optimization of the bridge truss can show that the truss can be more economical by reducing the bridge profile, and the visualization of the deformation of the K-truss truss is smaller than the truss without modification. The results also show that after the frame configuration and optimization of the steel profile used is changed, the bridge can still withstand the load carried.
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