Comparison of Wind Load on Standard Steel Truss Bridge Based on Indonesian Bridge Loading Codes

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Abstract. The truss bridge is a type of bridge that is widely used in Indonesia because of its practicality and can be constructed in short period of time. The relatively light weight of the truss bridge structure also facilitates the transportation of superstructure materials to bridge locations located in remote areas. The dimensions of the large truss bridge and the relatively light weight cause the figure bridge to be vulnerable to wind loads. Meanwhile, the bridge loading regulations including wind load is continuing to change. Previous design code BMS 1992 and SNI T 02 2005 has been superseded with SNI 1725 2016. One of the main changes to the loading regulations is related to the magnitude and how wind loads are calculated and applied to the bridge structure. This study will compare the magnitude of the wind load in the previous loading regulations in Indonesia with the latest regulations and also with wind loading according to AASHTO on steel truss bridges. A 60-class standard steel truss bridge from the Ministry of Public Works which is used for Case Study. The results showed that there was a significant increase in wind loading by applying SNI 1725 2016 loading regulations

Keywords: Bridges, Wind Load, Design Code, Truss

1. Introduction

The highway bridge is a structure used to cross people and goods over obstacles. According to the Government Regulation of the Republic of Indonesia Number 34 of 2006 on Roads, Bridge defines as a road that is located above the water level and / or above the ground level. Bridges have an important meaning in national development in supporting economic activities such as agriculture, plantations, fisheries, livestock, industry, tourism, mining, and the development of social activities.

As a public infrastructure, bridge design shall follow the rules set forth in the bridge design regulations. Bridge regulations in Indonesia, as well as in other countries, have continued to develop. The first bridge loading code in Indonesia was release in 1987 by Ministry of Public Work, and in 1992. In 2005, new regulation on Bridge Loading was release, known as SK SNI T-02-2005, and the latest Bridge Loading regulation is SNI 1725-2016. One of the important changes in SNI 1725-2016 compared to the previous regulations is the wind loading.
The wind load will greatly affect the bridge with a large cross-sectional area and type of bridge that receives a large wind load is a truss bridge. Therefore, it is important to understand the magnitude of wind load comparing with previous design standard in Indonesia.

2. Objectives

The objectives of the research are to Compare the magnitude of wind speed, the wind pressure, and the wind load on standard steel truss bridges based on SNI T-02-2005, SNI 1725-2016, AASHTO 2014, and AASHTO 2017

3. Methodology

The methodology of this research is as follow
a. A literature study was conducted to compare wind loading based on the Indonesian Loading Regulations for Bridge SNI T-02-2005, SNI 1725-2016 AASHTO 2014, and AASHTO 2017.
b. The research was conducted on a standard steel truss bridge class A 60 from the Ministry of Public Works, which is located at Padang City with the distance less than 5 km from the coast
c. The wind speed, wind pressure, and wind load are calculated based on SNI T-02-2005, SNI 1725-2016, AASHTO 2014, and AASHTO 2017

4. Case Study

The case study considered in this research is Standard Class A 60 Steel Frame Bridges as shown in Figure 1, Figure 2 and Figure 3 and located in the city of Padang. The distance of the bridge from the coast is less than 5 km, and the elevation of the bridge is 25 meter above the ground.

![Figure 1 Floor plan of class A 60 standard steel truss bridge](image1)

![Figure 2 Side view of the Class A 60 standard steel truss bridge](image2)
5. Result and Analysis

5.1 Wind Speed

The wind speed at RSNI T02 2005 is determined by the wind location of the bridge and the boundary conditions, where for service limit state the wind speed is 30 m/s for locations < 5 km from the coast and 25 m/s for other bridge location. For ultimate limit state, the wind speed is 35 m/s for locations <5 km from the coast and 30 for other locations. Furthermore, Wind speed based on SNI T02 2005 is constant with elevation. For this study, a wind speed of 35 m/s, is use, this is based on the ultimate limit where the bridge is located less than 5 km from the coast.

According to SNI 1726 2016, the wind speed at elevation of 10 m shall be determined based on wind speed charts at bridge location for various return periods. Since there is no data available it is assumed that $V_{10}$ and $V_B$ = 90 - 126 km/h.

The ultimate wind speed in accordance with AASTHO 2017 is determined by the 3 second gust wind speed. For this study, it is assumed that the 3 second gust is the wind speed of 126 km/hour multiplied by the multiplier factor of 1.29 or 162.5 km/hour.

5.2 Wind Pressure

The wind pressure according to RSNI T02 2005 is calculated using Equation 1:

$$T_{ew} = 0.0006 C_w V_w^2 A_b$$

Where $V_w$ is the design wind speed, 35 m/s, $C_w$ is the drag coefficient, 1,2 for truss bridges, $A_b$ is the area of the coefficient of the side of the bridge, for this comparison study is 1 m2. Since the wind speed based on SNI T02 2005 is constant with elevation, the wind pressure also will be constant with elevation. The negative wind pressure a coefficient is 0.5 of the positive wind pressure.

Based on SNI 1725 2016 and AASTHO 2014 the wind pressure is as determined using Equation 2

$$P_D = P_B \left(\frac{P_{DZ}}{V_B}\right)^2$$

Where $V_{DZ}$ is the design wind speed at the design elevation, $Z$, $V_B$ is the design wind speed an elevation of 10 m, $P_B$ is the base wind pressure (MPa), 0.0024 for positive wind pressure and 0.0012 for negative wind pressure.

Based on AASTHO 2017 the wind pressure is determine using Equation 3.

$$P_Z = 2.56 \times 10^{-6} V^2 K_Z G C_D$$

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Figure 3 Top bracing plan of class A 60 standard steel truss bridge
Where $V$ is the 3 second gust wind speed of, $K_Z$ is the exposure pressure and the elevation coefficient and is taken as 1. $G$ is the gust effect factor taken equal to 1. $C_D$ is the drag coefficient, taken equal to 1.3.

Comparison of wind pressure from elevation 10 m to 40 m is presented in Figure 4 for positive wind pressure and Figure 5 for negative wind pressure.

![Comparison of Positive Wind Pressure](image1)

**Figure 4** Comparison of Positive Wind Pressure

![Comparison of Negative Wind Pressure](image2)

**Figure 5** Comparison of Negative Wind Pressure

Based on Figure 4 and Figure 5, it can be seen that the wind pressure based on SNI 1725 2016 higher than SNI T02 2005 and up to elevation 25 m, SNI 1725 2016 gives lower value than AASHTO 2017.

5.3 Wind Force

According to SNI T02 2005, the wind force is considered to work evenly on the outermost plane of the frame with the assumption that the effective area is 30% of the projected area.
SNI 1725 2016, AASHTO 2014, and AASHTO 2017 the wind load is calculated as the line load on each structural element by multiplying the wind pressure by the width exposed to the wind load. For truss bridges, the wind load for each element is calculated separately and used to calculate the force on each of the elements.

The comparison of the total wind load on standard steel truss bridge class A 60 at various bridge elevation is presented in Table 1, Table 2, and Figure 5. The Comparison of wind load relative to RSNI T02 2005 is presented in Table 3 and Figure 6.

**Tabel 1** Comparison of wind loads on standard A class 60 m steel truss bridges at various bridge elevations

| Elevation (m) | SNI T02 2005 | SNI 1725 2016 |
|---------------|--------------|--------------|
|               | Positive Wind (kN) | Negative Wind (kN) | Load Factor | Total (kN) | Positive Wind (kN) | Negative Wind (kN) | Load Factor | Total (kN) |
| 10            | 193,83       | 96,92        | 1.20        | 348,90     | 440,57       | 148,83        | 1.40        | 825,16     |
| 15            | 193,83       | 96,92        | 1.20        | 348,90     | 609,39       | 205,86        | 1.40        | 1141,35    |
| 20            | 193,83       | 96,92        | 1.20        | 348,90     | 745,74       | 251,92        | 1.40        | 1396,73    |
| 25            | 193,83       | 96,92        | 1.20        | 348,90     | 860,98       | 290,85        | 1.40        | 1612,56    |
| 30            | 193,83       | 96,92        | 1.20        | 348,90     | 961,27       | 324,73        | 1.40        | 1800,40    |
| 35            | 193,83       | 96,92        | 1.20        | 348,90     | 1050,38      | 354,83        | 1.40        | 1967,30    |
| 40            | 193,83       | 96,92        | 1.20        | 348,90     | 1130,77      | 381,99        | 1.40        | 2117,85    |

| Elevation (m) | AASHTO 2014 | AASHTO 2017 |
|---------------|-------------|-------------|
|               | Positive Wind (kN) | Negative Wind (kN) | Load Factor | Total (kN) | Positive Wind (kN) | Negative Wind (kN) | Load Factor | Total (kN) |
| 10            | 270,17      | 91,27       | 1.40        | 506,02     | 701,63       | 237,02        | 1.00        | 938,65     |
| 15            | 373,70      | 126,24      | 1.40        | 699,92     | 776,11       | 262,18        | 1.00        | 1038,29    |
| 20            | 457,32      | 154,49      | 1.40        | 856,53     | 828,95       | 280,18        | 1.00        | 1108,98    |
| 25            | 527,98      | 178,36      | 1.40        | 988,88     | 896,94       | 293,88        | 1.00        | 1163,81    |
| 30            | 589,49      | 199,14      | 1.40        | 1104,08    | 903,43       | 305,19        | 1.00        | 1208,62    |
| 35            | 644,14      | 217,60      | 1.40        | 1206,42    | 931,74       | 314,75        | 1.00        | 1246,50    |
| 40            | 693,42      | 234,25      | 1.40        | 1298,75    | 965,27       | 323,04        | 1.00        | 1279,31    |
Table 2 Comparison of total wind loads on standard A class 60 m steel truss bridges at various bridge elevations

| Elevation (m) | Total Wind Load (kN) |
|--------------|----------------------|
|              | SNI T02 2005 | AASHTO 2014 | SNI 1725 2016 | AASHTO 2017 |
| 10           | 348.90       | 506.02      | 825.16        | 938.65       |
| 15           | 348.90       | 699.92      | 1141.35       | 1038.29      |
| 20           | 348.90       | 856.53      | 1396.73       | 1108.98      |
| 25           | 348.90       | 988.88      | 1612.56       | 1163.81      |
| 30           | 348.90       | 1104.08     | 1800.40       | 1208.62      |
| 35           | 348.90       | 1206.42     | 1967.30       | 1246.50      |
| 40           | 348.90       | 1298.75     | 2117.85       | 1279.31      |

Figure 6 Comparison of total wind loads on standard A class 60 m steel truss bridges at various bridge elevations

Based on Table 1, Table 2, Figure 5, Table 3, and Figure 6. It can be seen that the total wind load based on AASHTO 2014 ranges from 145% to 372% compared to the 2005 SNI T02 2005. The total wind load based on SNI 1725 2016 ranges from 237% to 607% compared to the 2005 SNI T02 2005, and the total wind load based on AASHTO 2017 ranges from 269% up to 367% compared to the 2005 SNI T02 2005.
6. Conclusion and Recommendation

Based on the results of the analysis of the research conducted it can be concluded that:

a. The wind speed at elevation 10 m based on SNI T02-2005 and SNI 1725-2016 is relatively the same, however based on SNI 1725-2016 the wind speed will vary with elevation

b. The wind pressure based on SNI T02-2005 constant with elevation and the value is significantly smaller than SNI 1725-2016

c. There is an increase in wind load of 362% in SNI 1725 2016 compared to SNI T02 2005 for the standard A 60 truss bridge.

d. It is suggested to do the review of standard truss bridge due to wind action by applying the new wind load

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