# 2020-JTSP-BangunVibration_Analysis_on_The_Bridge

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# Vibration Analysis on the Bridge Structures Caused by Train Load

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**Abstract**: The Muktiharjo Kaligawe railway bridge or BH 9 located in KM 3+450 is a truss bridge that has a special function, that is as a railway network where the BH 9 is a bridge with the steel frame type. Tests and analysis were conducted on two points of the bridge structures, those are in one third span of the bridge's structure and another in the middle span of the bridge's structure. The acceleration of vibration when the sensor accelerometer placed in one third part of the bridge's structure influenced Y the most. While the acceleration of vibration when the sensor accelerometer was placed in the middle part of the bridge's structure influenced Z the most. The maximum acceleration in the one third part of the bridge structure where the Argo Anggrek train with the speed of 47 mph has the maximum acceleration towards X of 1.346270 m/s2, the maximum acceleration towards Y is 1.639314 m/s2, and the maximum acceleration towards Z is 1.315038 m/s2. Meanwhile, the maximum acceleration where the accelerometer placed in the middle part of the bridge, Argo Anggrek train with the speed of 49 mph has the maximum acceleration toward X of 1.053043 m/s2, the maximum acceleration towards Y is 0.631594 m/s2, and the maximum acceleration towards Z is 1.191879 m/s2. The maximum acceleration when the accelerometer placed in the middle part of the bridge, Maharani train with the speed of 45 mph has the maximum acceleration towards X of 1.231041 m/s2, the maximum acceleration towards Y is 1.425204 m/s2, and the maximum acceleration towards Z is 1.319857 m/s2. Meanwhile the maximum acceleration when the accelerometer placed in the middle part of the bridge where Maharani train pass with the speed of 46 mph has the maximum acceleration towards X of 0.509838 m/s2, the maximum acceleration towards Y is 0.639036 m/s2, and the maximum acceleration towards Z is 1.073661 m/s2.

**Keywords**: Bridge, Vibration, Acceleration, Accelerometer.

## INTRODUCTION

The economic development in one country mainly depends on the infrastructure availability, including the availability of bridge. The railway bridge is a crucial infrastructure for the railway network [1]. Railroad is a crucial infrastructure for the freight transportation which its eligibility should be treated and monitored well [2]. Vibration is the process of the change in the soil structure, which makes the soil moving. [3]. *Sensor accelerometer* is a proper device to measure acceleration, this thing is not always the same as the coordinate acceleration (the speed changes of devices in space), but the speed that related to the heavy burden experienced by the test mass located inside the frame of *sensor accelerometer*. [3].

The purpose of this research is to find out the differences of maximum acceleration when the accelerometer sensor was placed in one third part and middle part of the bridge when the bridge received any loader from trains.

## METHODOLOGY

This research was conducted at the Muktiharjo Kaligawe railway Semarang KM 3 + 450. The *sensor accelerometer* was placed in one third part of the bridge and the middle part of the bridge.


**FIGURE 1**. Location of research

In this research, *accelerometer sensor* and *seismic monitoring* were used to detect the measure of vibration caused by passing by trains. This could later reveal the acceleration of vibration then the data were analyzed to find out the vibration frequency and vibration style [5]. The frequency of the vibration is the quantity of vibrate produced in a second [5]. The frequency can be calculated with equation of:

$$f = \frac{1}{T} \quad \text{or} \quad f = \frac{N}{T} \qquad \text{(a)}$$

With:

f = the frequency of vibration (Hz);
T= the vibration period (s);
T =the time that the vibration require(s); N =the quantity of vibration (n).

Meanwhile, acceleration is the parameter that conclude the change of acceleration from the starting until a certain speed [5]. Wave acceleration can be calculated by the equation of:

$$\boldsymbol{a = -\omega^2 A \sin(\omega t - kx)} \qquad \text{(b)}$$

With:

**ω** =Radians speed = 2πf or 2π/T;
t =The time required (s);
A =amplitude (m);
k =the number of waves;
x =point of distance (m)

The methods that being used in this research is quantitative method which later analyze the result from the ground using Geopsy and excel. This research consisted of some steps, those are:

1. Literature study, it was performed to study about the related literature to this research. The literature study of this research consisted of books, journals, articles and other scientific works that investigated the topic of this research for the sake of the goals of this research.
2. Preparation step, preparing the equipment needed to conduct this research, starting from asking for research permission to DAOP 4 Semarang and coordinating with Semarang bridge's resort for accompaniment during the research.
3. Execution step, in this step, accelerometer sensor 2g, electric wire, connector, battery, speed gun, and laptop were used. Accelerometer sensors were used to record the vibration produced by the railroad when the train passed by, speed guns were used to measure the speed of the train when it passed by.

During the research, accelerometer placed in one third part of the bridge and in the middle part of the bridge. Accelerometer sensor was regulated with X facing the east using compass. The vibration data were obtained while the train were passing the railroad until the vibration turned to normal. Then all of the data placed at the memory card that already being prepared. Image 1 shows the *set-up instrument* in measuring the vibration at the bridge's structure, where the accelerometer placed on the bridge's structure then the data records from *accelerometer* quickly connected to the laptop that already has DsAcc installed. *Speed gun* used to measure the train's speed. The speed of the train that being reviewed is when the train passing the bridge's part where the sensor placed. *Speed gun* placed facing the train and the button pressed when the train passing the railroad.

**FIGURE 2** Sensor accelerometer placed at the bridge's structure with X facing the east.


**FIGURE 3** Speed gun (measuring the speed of the train)

## RESULT AND DISCUSSION

The research was conducted to find out the differences of maximum acceleration between one third part of the bridge and the middle part of the bridge using *accelerometer*. The measurements of the bridge's structure as the cause of train's load performed by taking two types of train, Argo Anggrek and Maharani. Based on the result of the research, the graphics data in one third part of the bridge's structure and the middle part of the bridge's structure were obtained.

## The acceleration graphics in one third part of the bridge

Accelerometer placed on the bridge's structure influenced the vibration that occurred during the passing by train. To find out the result of the vibration, sensors were placed in one third part of the bridge's structure. The results of vibration in one third part of the bridge's structure are shown on fig. 1 and fig.2.

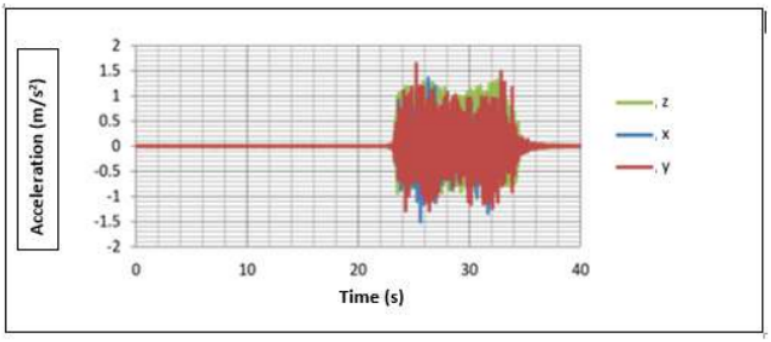


**FIGURE 1.** The acceleration of vibration on the bridge's structure when Argo Anggrek passed by

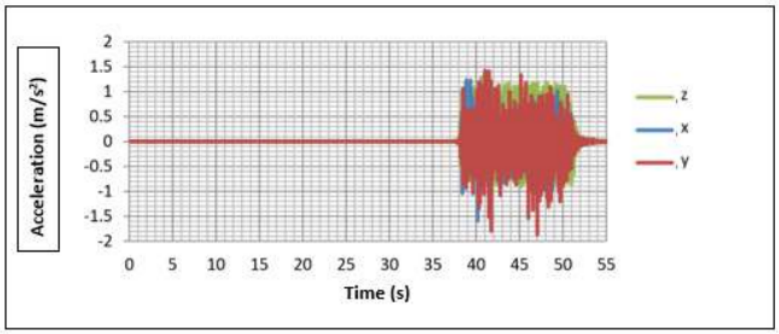


**FIGURE 2.** The acceleration of vibration on the bridge's structure when Maharani passed by

## The acceleration graphics in middle part of the bridge

Accelerometer placed on the bridge's structure influenced the vibration that occurred during the passing by train. To find out the result of the vibration, sensors were placed in middle part of the bridge's structure. The results of vibration in middle part of the bridge's structure are shown on fig.3 and fig.4.

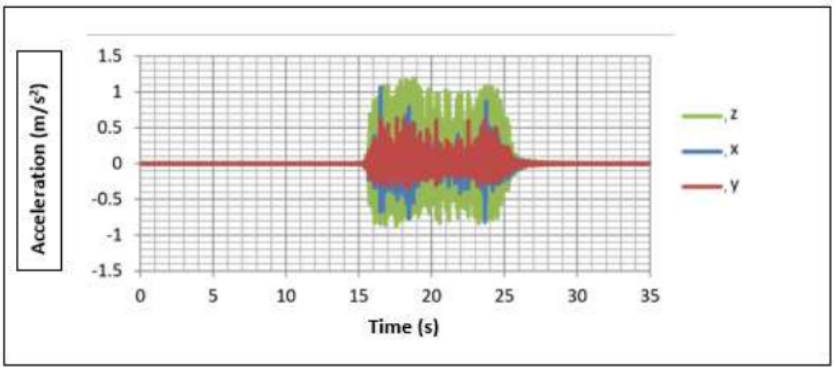


**FIGURE 3.** The acceleration of vibration on the bridge's structure when Argo Anggrek passed by

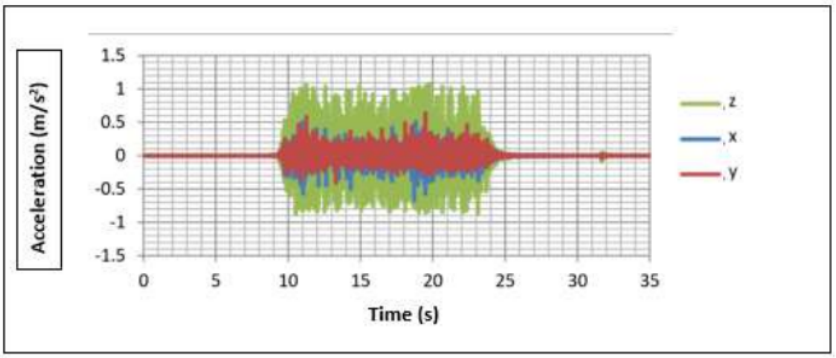


**FIGURE 4.** The acceleration of vibration on the bridge's structure when Maharani passed by

The result of speed measured and maximum acceleration on both trains can be seen on the table 1 below:

**TABLE 1.** The result of measuring the speed of train and the vibration acceleration from various position of accelerometer in one third part of the bridge's structure.

| Train | Vibration Acceleration | | | The speed of train in (mph) |
|---|---|---|---|---|
| | to X ($m/s^2$) | to Y ($m/s^2$) | to Z ($m/s^2$) | |
| **Argo Anggrek** | 1.346270 | 1.639314 | 1.315038 | 47 |
| **Maharani** | 1.231041 | 1.425204 | 1.319857 | 45 |

**TABLE 2.** The result of measuring the speed of train and the vibration acceleration from various position of accelerometer in middle part of the bridge's structure.

| Train | Vibration Acceleration | | | The speed of train in (mph) |
|---|---|---|---|---|
| | to X ($m/s^2$) | to Y ($m/s^2$) | to Z ($m/s^2$) | |
| **Argo Anggrek** | 1.053043 | 0.631594 | 1.191879 | 49 |
| **Maharani** | 0.509838 | 0.639036 | 1.073661 | 46 |

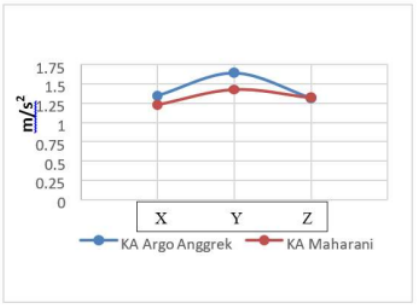


**Figure 5.** Maximum acceleration in one third part

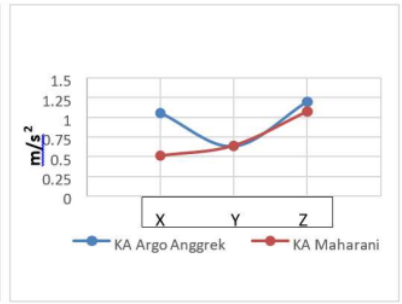


**Figure 6.** Maximum acceleration in middle part

## CONCLUSION

From the data analysis and research conducted, we can conclude:

A. The acceleration of vibration when accelerometer sensor was placed in one third part of the bridge mostly happened towards Y. In addition, the acceleration of vibration when the accelerometer sensor was placed in the middle part of the bridge mostly happened towards Z.

B. The maximum acceleration when accelerometer was placed in one third part of the bridge when Argo Anggrek passed by with the speed of 47 mph had the maximum acceleration towards X of 1.346270 $m/s^2$, the maximum acceleration towards Y is 1.639314 $m/s^2$, and the maximum acceleration towards Z is 1.315038 $m/s^2$. In addition, the maximum acceleration when the accelerometer was placed in the middle part of the bridge when Argo Anggrek passed by with the speed of 49 mph has the maximum acceleration towards X of 1.053043 $m/s^2$, the maximum acceleration towards Y is 0.631594 $m/s^2$, and the maximum acceleration towards Z is 1.191879 $m/s^2$.

C. The maximum acceleration when accelerometer was placed in the middle part of the bridge when Maharani passed by with the speed of 45 mph has the maximum acceleration towards X of 1.231041 $m/s^2$, the maximum acceleration towards Y is 1.425204 $m/s^2$, and the maximum acceleration towards Z is 1.319857 $m/s^2$. In addition, the maximum acceleration when accelerometer was placed in the middle part of the bridge when Maharani passed by with the speed of 46 mph has the maximum acceleration towards X of 0.509838 $m/s^2$, the maximum acceleration towards Y is 0.639036 $m/s^2$, and the maximum acceleration toward Z is 1.073661 $m/s^2$.

## REFERENCES

[1] A. Nugroho, "Evaluasi Kondisi Jembatan Kereta Api Bentang Tunggal" in Media Teknik Sipil UGM, juli 2007.

[2] A. Setiono and D. Hanto, "Penggunaan akselerometer pada ponsel *android untuk merekam getaran kabin kereta api*," in 10th *Annual Meeting on Testing and Quality,* 2015.

[3] A. A. Putra and M. Irawaty, "*Penerapan Sensor Accelerometer Untuk Membandingkan Gempa Data BMKG dan Google Earthquake pada Perangkat Smartphone Android".* Yogyakarta, November 2003.

[4] R. Kusumawardani, U. Nugroho, Lahari, W. Yuniarti and A.S.Hilmi. "Analysis of ESAL factor on flexible pavement at weleri ring road, Indonesia" in *Proceedings of the American Institute of Physic (AIP)* 1818, Paper No.020037, 2017.

[5] M.A.Zelin. "Analisis Getaran Akibat Beban Dinamis Kereta Api Terhadap Struktur Rel", 2017

[6] R. Kusumawardani, K. B. Suryolelono, B. Suhendro and A. Rifa'i, "The dynamic response of unsaturated clean sand at a very low frequency". International Journal of Technology, 7(1), 123-131, 2016.

[7] R. Kusumawardani, U. Nugroho, Lahari, W. Yuniarti, A. S. Hilmi, M. H. Fansuri, M.H and T. Mindastiwi, "Investigation of subgrade particles acceleration due to dynamic loading", Aceh International Journal of Science and Technology, 6(3), 97-10, 2017.

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