Vibration Problem due to Railway Loading

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Abstract. Train is one of transportation mode is increasingly polular ini Indonesia nowdays, although in developed counttries this transportation has long been a very advanced mode of mass trsnportation. Problems due to railroad tracks adjacent to densely populated settlements cannot be avoided. Problems such as noise levels can interfere with the health and comfort of the environment, vibrations in the surrounding environment due to passing trains cause some damage to civilian buildings such as residents' houses and high rise buildings aswell. This field study shows the potential problem due to mass train loading (Babaranjang) in Bandar Lampung.

1. Introduction

Railways in Indonesia in the last decade have grown very rapidly. Starting from the many renovations at several existing train stations, to the construction of several new train tracks. One of them is the construction of LRT (light rapid transit) type trains in several big cities, such as Jakarta, Bandung and Palembang. In addition to this development having a positive impact, there are also negative impacts that arise such as noise and vibration. This condition will greatly affect the health of the people living around the railroad tracks. Noise is a sound or noise that is unwanted and can interfere with the health and comfort of the environment which is expressed in decibels (dB). If the noise is on the threshold greater than 85 db it can be annoying. Vibration is a motion back and forth around equilibrium. Equilibrium here means the state in which an object is at rest if there is no force acting on it. Vibrations that exceed the allowable threshold will have a vascular and neurological effect, and cause changes in blood pressure.

Vibration in buildings is influenced by several parameters such as the interaction between building and foundation, type or type of foundation and geotechnical parameters [1]. In general, a stiff foundation will produce a greater natural frequency dynamic response than a flexible foundation. The vibrations from the ground support beneath the building due to trains can make building occupants uncomfortable or disturbed. These vibrations come from rail transit systems, road traffic, construction in the field and also industrial factories [2] [3] [4]. This study of vibration problems becomes interesting to research because of the environmental impact it causes on the surrounding environment. Table 1 below is the threshold for rail vibration speed at several required building types in Indonesia.

Table 1. Threshold for the speed of rail vibration in several types of buildings

Class	Type of Buildings	Peak Velocity (mm/detik)
1	Designations and ancient buildings that have high historical value	2
2	Buildings with existing damage, visible damage to the walls	5
3	The building is in good technical condition, there are minor damages such as: cracked plaster	10
4	Strong buildings, for example: industrial buildings made of concrete or steel	10-40

2. Vibration due to Train

When a train passes near the building it causes vibrations which are transferred to the rail system and transmitted to the sleeper and then to the ballast. The waves that are emitted can be in the form of body waves and surface waves. If a body wave encounters a hard ground surface below it, it will be turned back towards the surface and will arrive at the adjacent building. While surface waves will propagate through the ground surface and arrive at the nearest building as shown in Figure 1 below. When arriving at the building, these waves will propagate vertically through the vertical elements of the building such as columns and then will be transferred to horizontal components such as beams and plates. The vibrations that occur in this building can be felt by residents of the building.

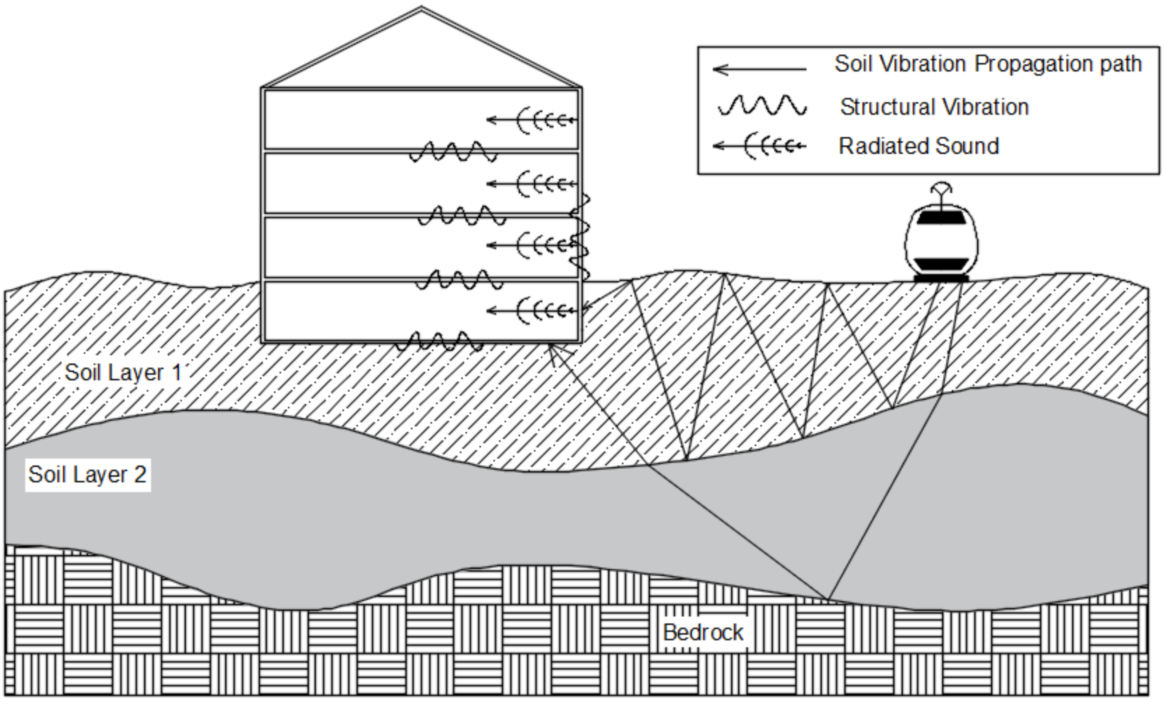
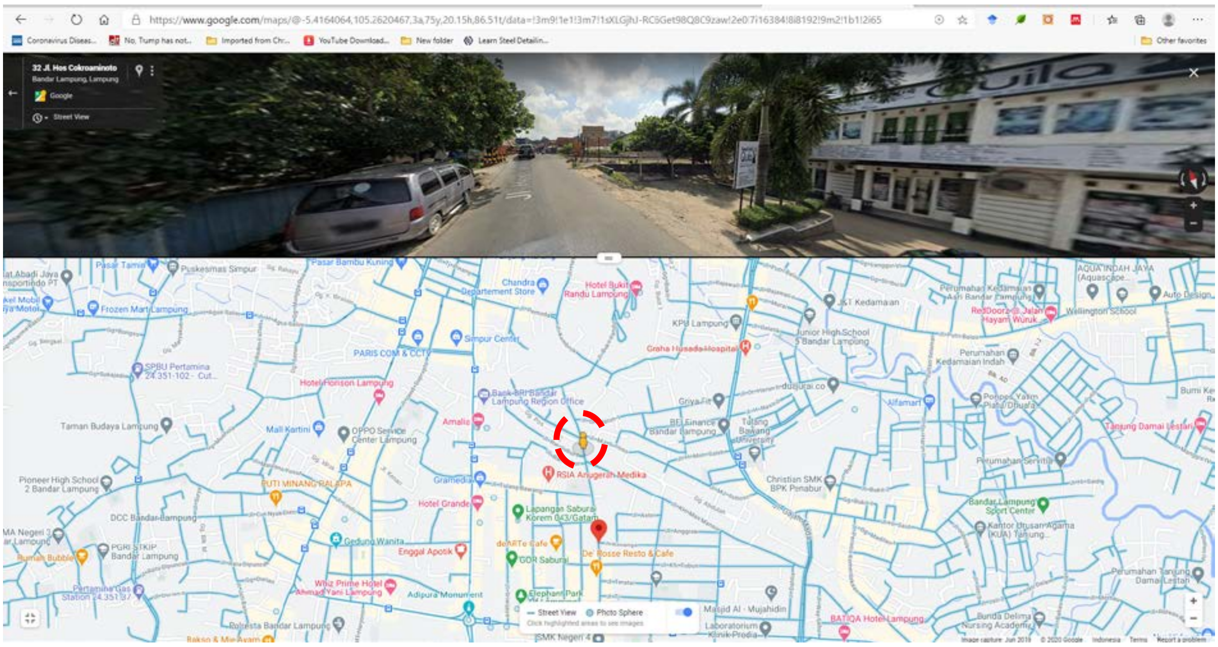


Figure 1. Vibration from train transferred to buildings

3. Case Study

This field study was conducted at Hos Cokroaminoto street, Rawa Laut, Central Tanjungkarang, Bandar Lampung as shown on the map in Figure 2. Data was collected at railway track only about 10 meter away from railway closing doors as shown in Figure 3 using accelerometer sensors. These sensors read acceleration in three direction. Direction of X was along with railway track, Y-direction was perpendicular to the railway track and vertical Z-direction to the ground below. Data was recorded using portable Labquest 2 through bluetooth channel.



Note : Location data taken

Figure 2. Data location for research study

Figure 3. Accelerometer sensors was located at sleeper on left picture and another one on the ground.

Scheme of sensors application and geometry cross section of railway track and surroundings was depicted at Figure 4. There is wall seperated inhibitans houses and rail only 6 meter distance in between.

When train approaching the sensors on sleeper, acceleration in X, Y and Z direction were small which were ±0.17 m/s^2, -0.18 m/s^2 and -0.26 m/s^2 respectively. Sensor on the ground showed acceleration in X, Y and Z direction were smaller which were 0.028 m/s^2, -0.036 m/s^2 and -0.077 m/s^2 respectively. These two values, acceleration in X and Y are below 0.5% G (or 0.04905 m/s^2) which allowed for peak acceleration of residence. However in Z direction the acceleration was over the limit which gives an confortable impact for people in the residence.

Then when train pass through the sensor on sleeper the acceleration increased rapidly to -17.89 m/s^2 , 12.75 m/s^2 and 20.32 m/s^2 . The accleration on the ground increased to values of -0.28 m/s^2, 0.48 m/s^2 and 0.366 m/s^2 respectively. This values had an more effect not only to the peoples inside the building but to the building its self. Damages could be occurred to the members of strucutres for long time period.

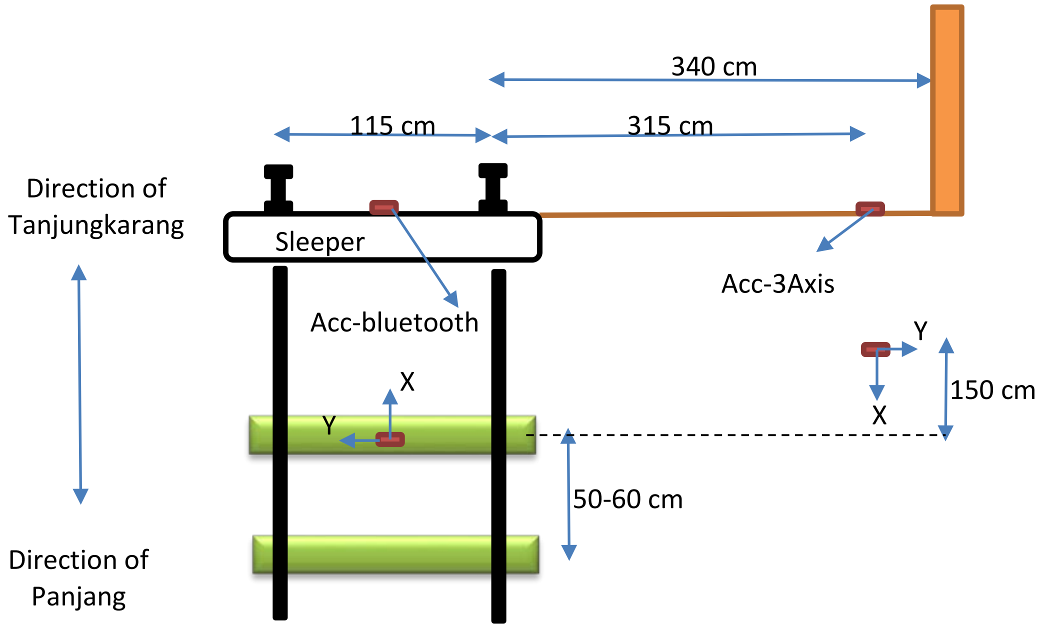


Figure 4. Sensors application on sleeper and ground

Three direction acceleration was recorded during the train pass through location of study. Train came from Tanjungkarang to Panjang with 60 carriages that brough coal. There was aproximately 120 tonnes of coal in every caarriage. Three graphs showing relationship between acceleration and time were depicted in Figure 5 to 7 respectively. Those readings obtained from sensor on sleeper. Then Figure 8 to 10 showed reading acceleration in X, Y and Z direction on ground respectively.

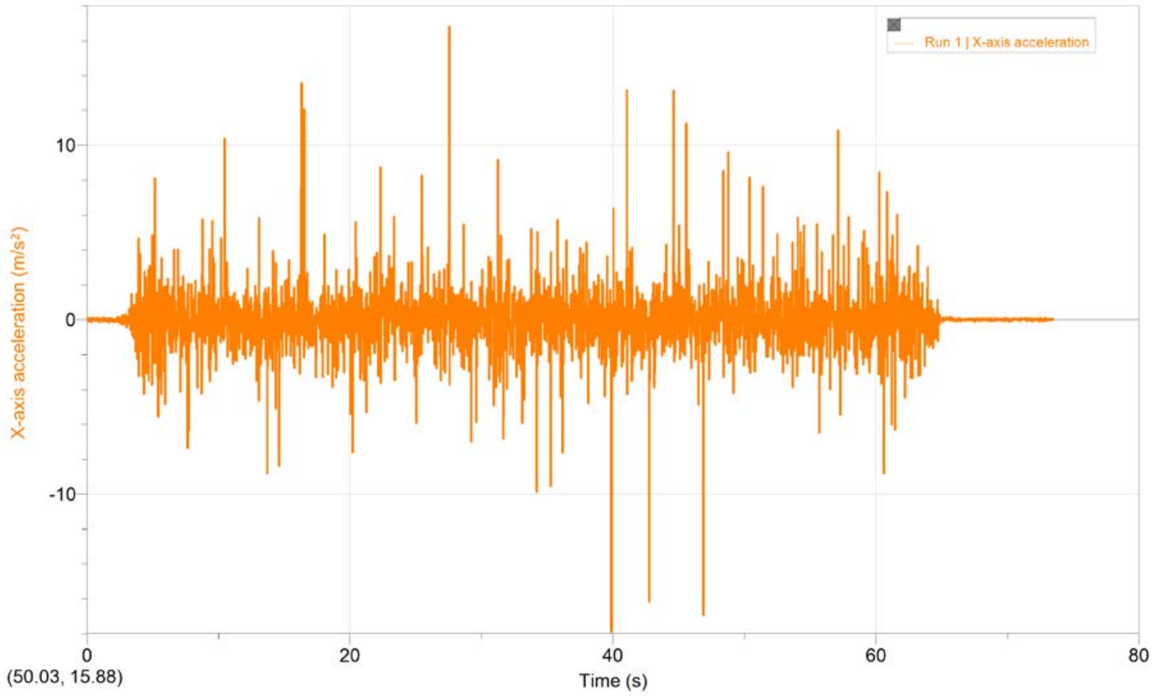


Figure 5. Acceleration in X-direction on sleeper due to train laoding of 60 carriages contained coal

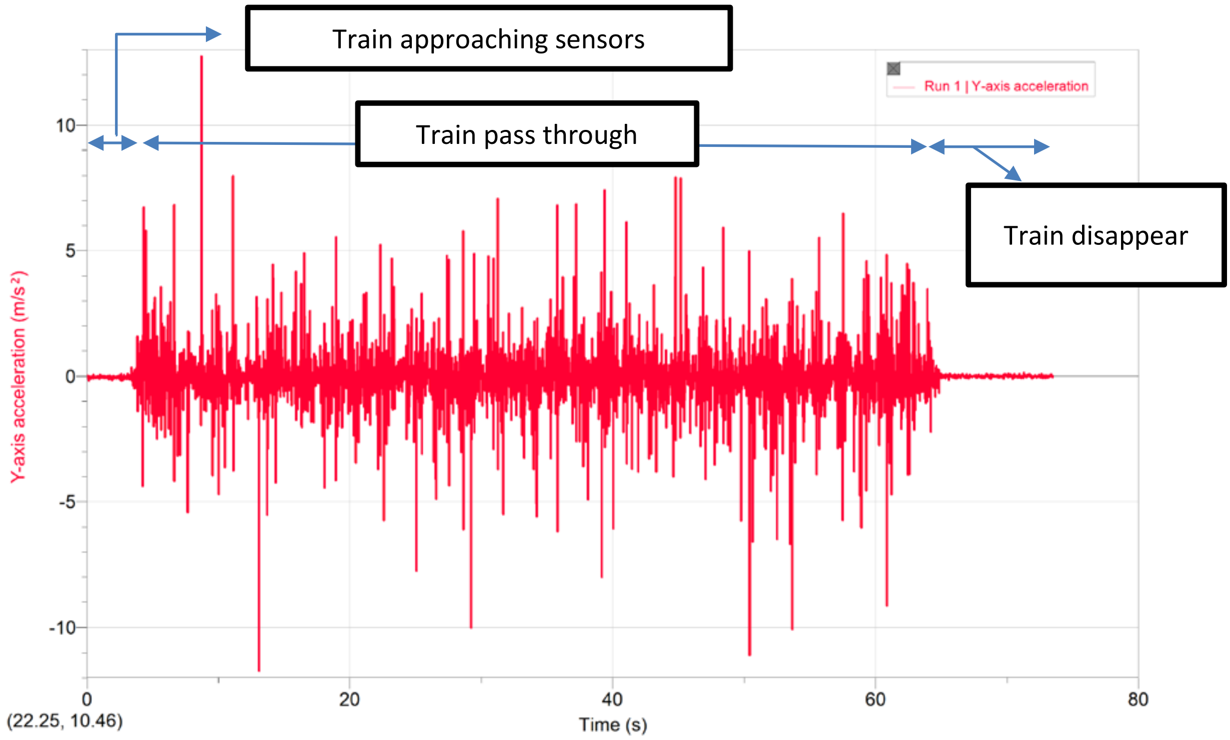


Figure 6. Acceleration in Y-direction on sleeper due to train laoding of 60 carriages contained coal

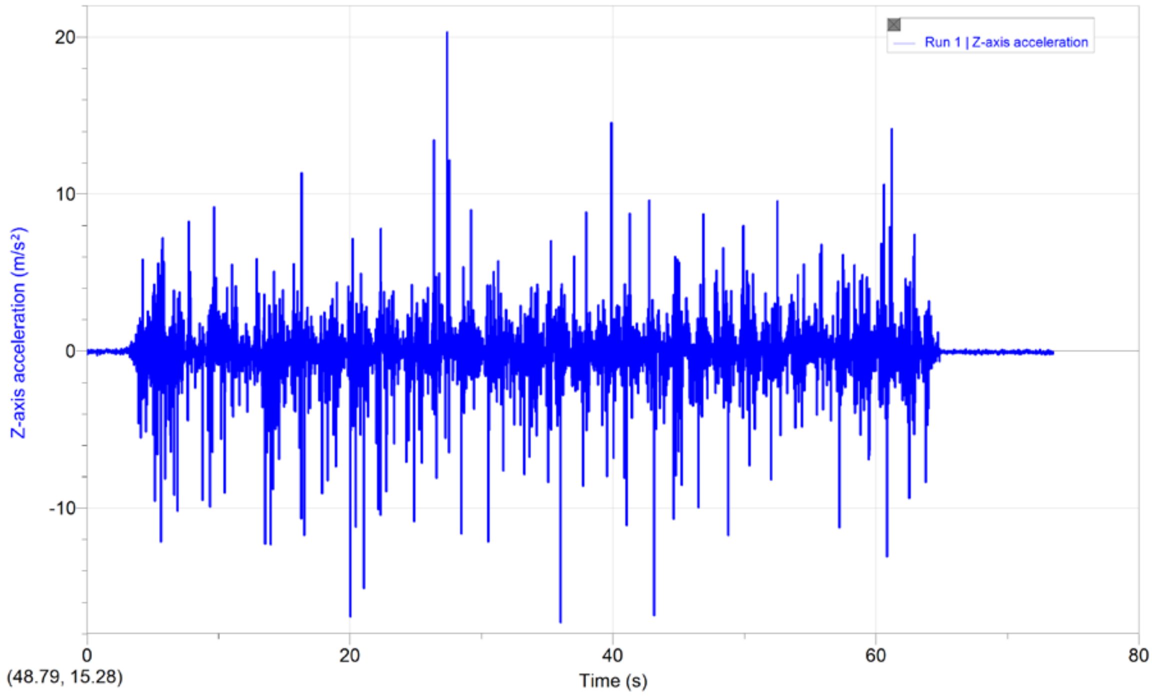


Figure 7. Acceleration in Z-direction on sleeper due to train laoding of 60 carriages contained coal

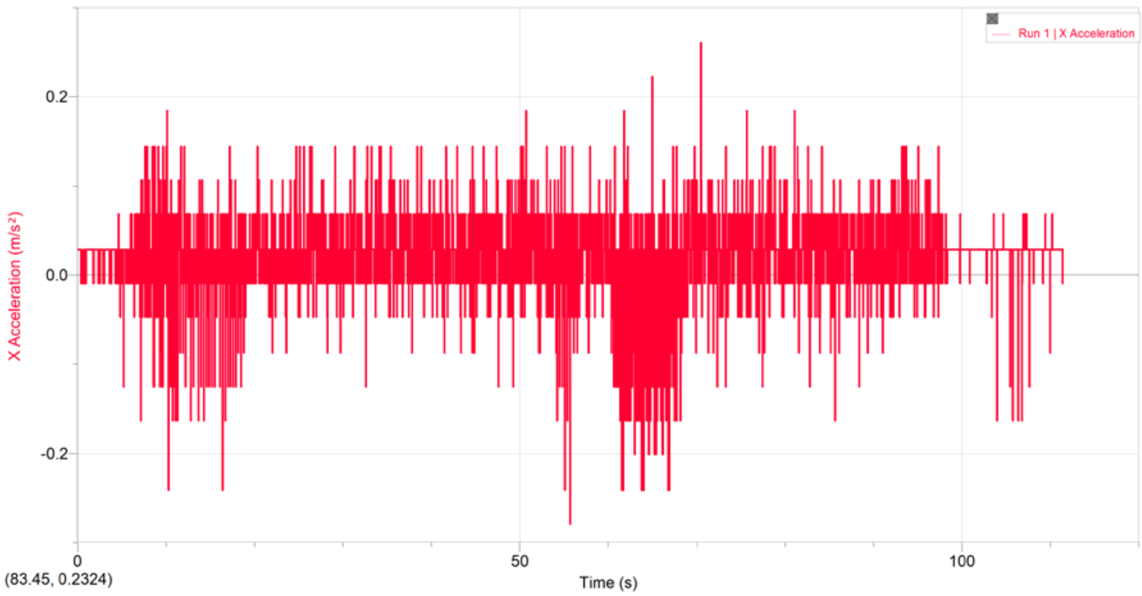


Figure 8. Acceleration in X-direction on ground due to train laoding of 60 carriages contained coal

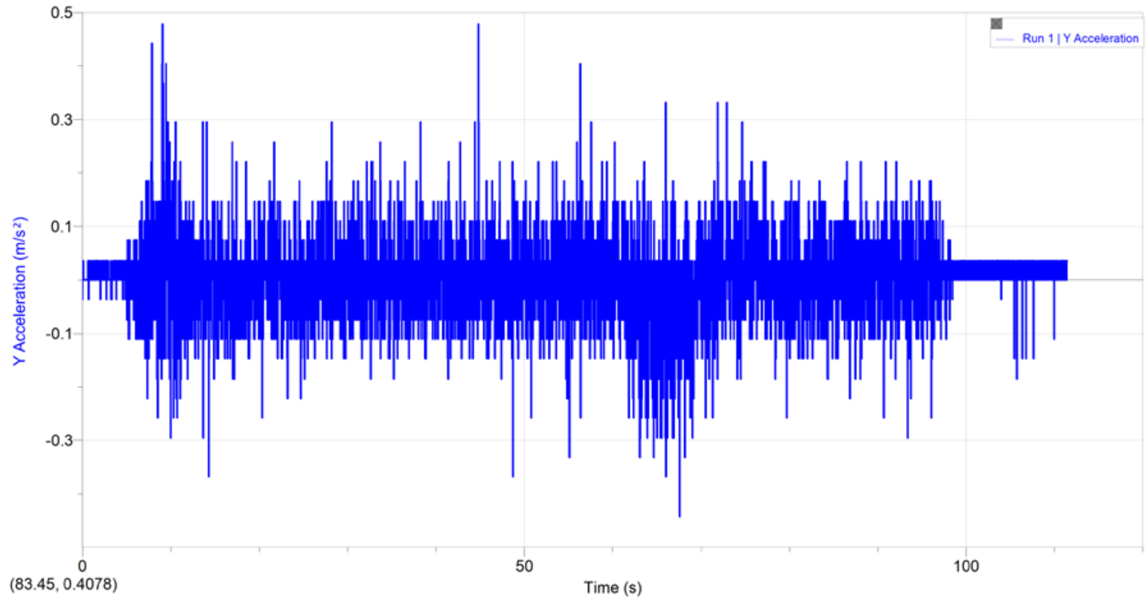


Figure 9. Acceleration in Y-direction on ground due to train laoding of 60 carriages contained coal

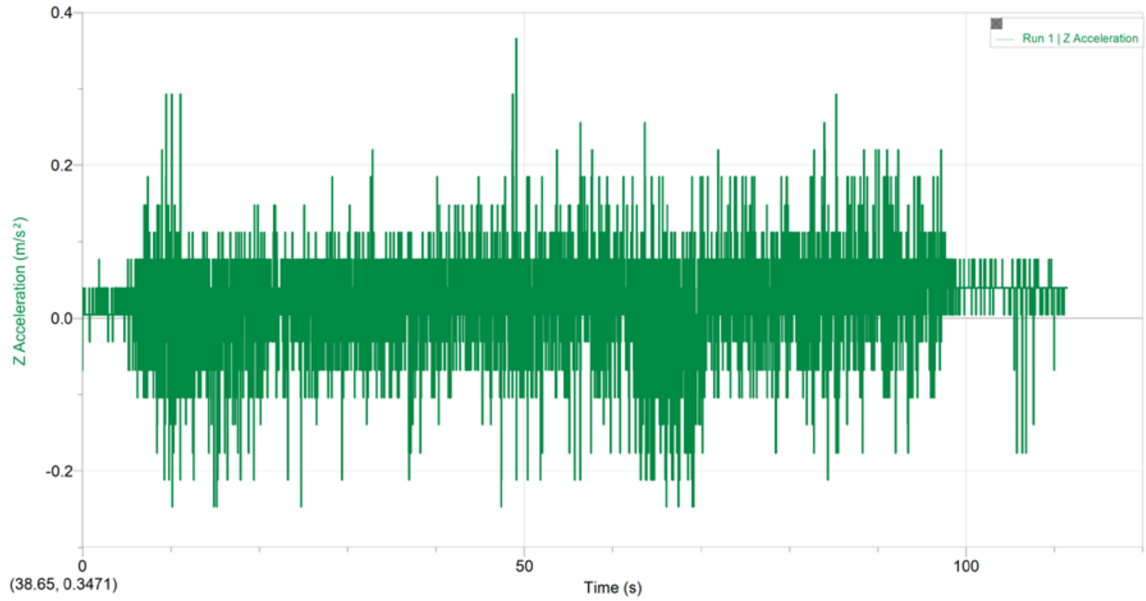


Figure 10. Acceleration in X-direction on ground due to train laoding of 60 carriages contained coal

4. Conclusions

It can be concluded as follows:

1) Potential problem due to railway loading that carry tonnes of coal and pass through densely populated settlements will effect confortable people in the residence and buildings elements as well.

2) Potential damage of structure element of buildings/ houses due to train loading are able to identify using vibration sensors.

3) Propagation of vibration decreseased from railway track as distance increased. By keeping a distance from railroad tracks, it will reduce the problems that arise due to vibration.

References

[1] T. N. T. Chik, M. F. Zakaria, M. A. Remali, and N. A. Yusoff, "*Vibration Response of Multi Storey Building Using Finite Element Modelling*," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 136, no. 1, 2016.
[2] Y. Hirao, S. Kunimatsu, and T. Hamamoto, "*Wireless Measurement System for Ground-borne Vibration and Vibration Amplifications in Buildings*," vol. 27, no. December, pp. 231–239, 2012.
[3] P. Fiala, G. Degrande, and F. Augusztinovicz, "*Numerical modelling of ground-borne noise and vibration in buildings due to surface rail traffic*," *J. Sound Vib.*, vol. 301, pp. 718–738, 2007.
[4] A. Trochidis, "*Propagation of ground-borbe vibrations from surface sources*," *J. Accoustic. Soc. Am.*, vol. 86, no. 4, pp. 1446–1452, 2014.
[5] Y. Zhang, N. Zhang, Y. Cao, and Y. Yu, "*A prediction model and its validation of railway-induced building vibrations*," *Adv. Mech. Eng.*, vol. 8, no. 10, pp. 1–10, 2016.
[6] L. Auersch, "*Force and ground vibration reduction of railway tracks with elastic elements*," *J. Vib. Control*, 2013.