# EFFECTS OF VIBRATION LOCATED ON THE STEEL TRUSS BRIDGES UNDER MOVING LOAD

Mohamad Ibrahim Zaed Ammar, Endah Wahyuni and Data Iranata
Department of Civil Engineering, Institute Teknologi Sepuluh Nopember Surabaya, Indonesia
mhzaed22@yahoo.com, endah@ce.its.ac.id, iranata80@gmail.com

## ABSTRACT

Structural vibration control as an advanced technology in engineering consists of implementing energy dissipation devices or control systems into structures to reduce excessive structural vibration, enhance human comfort and prevent catastrophic structural failure due to strong winds and earthquakes, among other inputs**.** When the bridge carries heavy traffic, vibrations in the bridge structural elements subjected to high levels of stress. This tension bridge subjected to fatigue. This paper studies and focus the effects of vibration of steel truss bridges and finally to suggest future directions of research and innovation. The possibilities of modal properties of global and local vibration method in determining the structural changes in the truss bridges discussed located to the results of finite element analysis

.

**Keywords**: Steel Truss Bridges, Vibration, Moving Load, Finite Element Method

## I. INTRODUCTION

Bridges have built a long time it is very active in the world. Today, modern bridges tend to use high strength materials. Bridges are very sensitive to dynamic loadings can be exposed to the impact of vibration caused by the dynamic effects such as wind, earthquake and vehicle movement as well as cyclic loading. In addition, vibration can effect safety as well as comfort of users and limit serviceability of the bridge. The main objective of present review paper are investigate the vibration analysis effect on steel truss bridge, where it will cover all the studies related to the use of the vibration testing carried on bridge structure. The next object is the studies related to understand the mechanisms behavior of the steel truss bridge when the structure to be subjected to a set of moving loads.

## II. BRIDGE MODEL

A truss bridge is a bridge composed of connected elements, which may stressed from tension or compression or sometimes both in response to dynamic loads. Truss bridges are one of the oldest types of modern bridges. Truss bridges achieve their efficiency for spanning longer distances via their lightweight due to triangulation and the primary action of their members in axial tension and compression. Modern highway truss bridges are predominantly either continuous or cantilever structures. Advantages of such a simplified structural system of steel truss bridges include the simplicity in relation to design, fabrication and the low cost of maintenance and construction. However, the wide girder spacing and simplified lateral bracing system may cause problems related to vibration serviceability due to external dynamic loads such as wind, vehicle loads. Merritt and Brockenbrough (2006) defines truss as a structure that acts like a beam but with many components or members, subjected primarily to axial stresses, and arranged in triangular patterns. The ideal design of trusses is the one where the end of each member at joint is free to rotate independent of the other members at the same joint. Otherwise, the member subjected to secondary stresses. On the other hand, if a truss subjected to loads other than joint or panel loads, then bending stresses would produce in that particular member. The rigid trusses gave satisfactory service and eliminated the possibility of frozen pins, which induce stresses not usually considered in design. Experience indicates that rigid and pin-connected trusses are nearly equal in cost, except for long span. Therefore, modern design prefers rigid joints.

## III. VIBRATION AND LOADING TEST

Huang, et al (2011) dealt with the three-dimensional vibration analysis of prestressed concrete bridges under moving vehicles. The prestressed bridges modeled by four node isoperimetric flat shell elements with the transverse shearing deformation take into account with using software ANSYS. The vehicle modeled as a single or two degree-of-freedom system. Forced vibration of bridge under moving vehicle is displacement response of the vehicle and that at the middle point of the flange for different road roughness conditions. The road roughness condition has significant effect on the responses of both the bridge and the vehicle. It also appears that the roughness of the road has an impact on the more important of the vehicle on the bridge. Effect of prestressing is force on the responses at different locations in a section of the bridge. It known that the dynamic responses at different locations in a section are different for a box girder. In this section, the effect of the prestressing force on the responses at different locations of a section of the box-girder bridge. The effect on the responses of bridge will increase significantly. The dynamic responses computed for the vehicle-bridge interaction system by systematic integration approach. The effect of prestressing force on the dynamic response of the vehicle-bridge coupled system investigated. The numerical simulations indicate that with the increase of the prestressing force, the natural frequencies of the bridge decrease, and the dynamic responses of the bridge increase. Thus, the prestressing force cannot neglect when its magnitude is relatively high.

Kodikara, et Al. (2011) studied traffic induced vibration analysis of existing steel bridge. The bridge (no. 75/4) located in padeniya-anuradhapura. a three span continuous steel truss bridge seated on elastomeric bearings tested and analyzed. The deck slab made of a reinforced concrete of 22.5cm thick, and assumed to act compositely with main girders. Assuming that C deck uncracked, the full concrete section of RC deck considered in finite element modeling. The elastomeric bearing idealized as a spring element. Modeling carried out using commercial FE software package SAP2000 with using two types of vehicles Model defined in BS5400 namely HA and HB vehicles. Since the bridge is not design for HB vehicle, used 20 tonnes HA vehicle as the critical vehicle model for the dynamic analysis. Fundamental Natural frequency of the bridge (without vibration control measures) in vertical direction in unloaded condition is 1.79Hz (for the time period of 0.56s). Code states that for superstructures with fundamental natural frequency less than 5Hz it should satisfy the maximum vertical acceleration in any part of the structure to 0.5√fom/s2 (0.8794 m/s2). Dynamic analysis of the existing bridge suggests that even for the lowest speed (20 km/h) actual vertical acceleration is higher than the allowable limit. Fundamental Natural (80 km/h) frequency of the bridge (with vibration control measures) in vertical direction in unloaded condition is 1.6Hz. Since the maximum acceleration in pedestrian walkway after installation of vibration control measures (0.23 m /s2), for the maximum speed (80 km/h) within the allowed limit of acceleration vibration serviceability of the bridge modified with elastomeric bearings deemed to be satisfied. It observed from this study that the response of the steel truss bridge with elastomeric bearings speed reduced significantly compared to the existing bridge. Another interesting fact is that acceleration response increases with vehicle speed and the mass of the vehicle. Of the notes is sufficient to point out that the installation of effective elastic bearings in the enhancing of the performance service of bridge vibration.

Matsumoto and Yamaguchi (2010) presented investigation of the feasibility of vibration-based health monitoring in steel truss bridges. The bridge used in this investigation is a bridge over a river for road traffic. The bridge consisted of five separated spans, each of which is a Warren truss with a span length of 70.77 m and a width of 6.0 m as shown in figure (1).

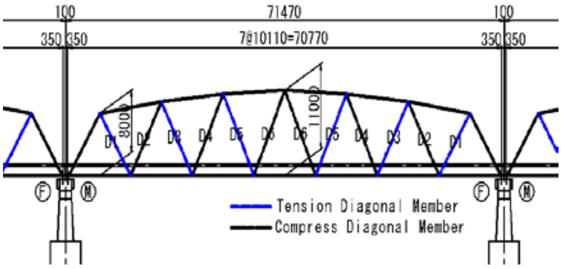


Fig.1. Steel truss bridge investigated (Matsumoto and Yamaguchi 2010)

Vibration of the bridge induced by a dump truck with a total mass of about 200 KN running at different speeds between 20 and 40 km/h while the bridge was closed to other traffic. At the quarter point from the bottom, two accelerometers attached to the web to measure in-plane motion of the diagonal member and another accelerometer attached to the flange to measure out-of-plane motion. A particular interested in this measurement to understand more about the dynamic coupling between the diagonal members and the whole structure.

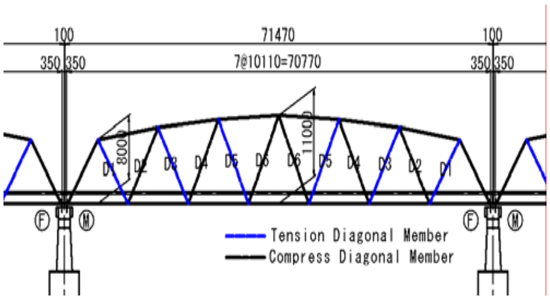


Fig.2. Positions of accelerometers in Measurement

The natural frequencies change in local modes observe at frequencies above 100 Hz were different between healthy and corroded diagonal members, while there are minor differences in the frequency range below 100 Hz. The natural frequencies of the diagonal member with pitting corrosions appeared to be lower than, those of the diagonal member without corrosions. Similar trend found with the comparison between this diagonal member with pitting corrosions and other healthy diagonal members with nominally the same dimensions. Damping change in coupled mode in the local vibration mode dominated by the motion of the diagonal member damaged and repaired, the modal frequency increased from 7.1 Hz to 9.8 Hz, approximately, and the modal damping ratio decreased from 0.0055 to 0.0039 after the reinforcement. In the global vibration modes involving the motion of the whole structure, there appeared to be changes in the modal damping ratio with minor changes in the modal frequency. It noted that there more variability in the identification of the modal damping ratio from the measurement records in the lowest order vibration modes, such as the mode at about 2.6 Hz. the relation between the changes in modal damping ratio found in the vibration mode at 7.26 Hz and the dynamic coupling between the diagonal and lower chord members. The decrease in the modal damping ratio of the global mode at 7.26 Hz may be associated with the loss of coupling between the diagonal and lower chord members that caused by the change in the mechanical property of the diagonal member. The results show a possibility of the identification of local damages in steel truss bridges, such as damages in diagonal members, from changes in the modal properties of the structure obtained from vibration measurements. A possible solution may be applying impact testing only on diagonal members that identified as critical members in redundancy analysis.

Phyoe and Htat (2014) presented vibration analysis of steel truss bridge under various moving loads by using STAAD Pro Software. The bridge is warren truss, through type. The bridge length is 240f with two lanes for highway and one lane for railway. case study Warren truss with vertical members with Two Number of Span and Truss Height 30ft from bottom chord to top chord, Truss Angle 56.31° Highway Width - 24ft (12ft each) Railway Width - 3.28ft (1m) Sidewalk Width - 6ft (3ft each). Elevation view and 3D view of the bridge model shown in Figure (3) and Figure (4). For vehicle live load, two types of loading (train and truck loadings) are considered.

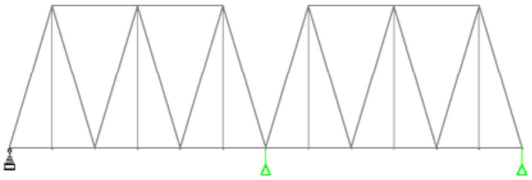
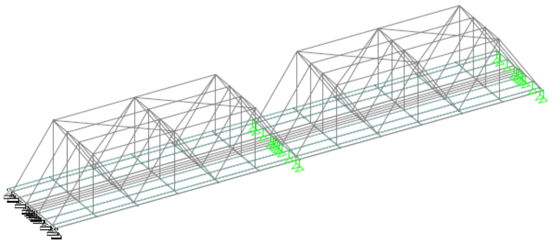


Fig.3. Elevation view of proposed bridge (Phyoe and Htat 2014)



.

Fig.4. 3D view of proposed bridge (Phyoe and Htat 2014)

In the vibration analysis, moving loads considered as harmonic loadings. The exciting period or forcing period applied the bridge model is 2.1824sec. For the vibration analysis, the influence of vehicle speed. Firstly, 45mph, 60mph and 75mph vehicle speeds considered to find the significant effect. Finally, the influence of damping ratio on the bridge model investigated. In this case, damping ratio are assumed 1%, 2%, 3%, 4% and 5%.

The effect of vibration on the steel truss bridge under moving loads. In this, the impact of vehicle speed and damping ratio investigated vibration along the bridge. First, there is a significant difference in the bridge and accelerate the speed and displacement in light of the changes of vehicle speed. In addition, it noted that the speed of the vehicle is the most important factor in the bridge vibration. The second factor is to investigate the effect of damping ratio. In this case, the difference signed although it is small in magnitude.

## IV. CONCLUSION

This paper reviewed the bridge vibration issues underlined innovation and research in the future. The future direction proposed by the current review of the study, based on the gap or shortfall in existing studies linked with bridges conventional vibration test for detecting the effects of vibration scouring the work on the bridge. In addition, an investigation into the effect of vibration promotes integrated bridges to roam also in the apparent since the behavior of the bridge is an integral a static and different from the conventional part of the bridge. The effects of different types of sediment also are a possibility of establishing a new area of research to study the effect of vibration on the bridge.

## REFERENCES

**[1]** Huang, M, Liu, L. K, Law, S. S. and Lu, Z. R, (2011). "Vibration analysis of prestressed concrete bridge subjected to moving vehicles" Interaction and Multiscale Mechanics, Vol. 4, No. 4 pp 273-289.

[2] Kodikara, K. A. T. L. Morawaka, U. D. Gunathilake, I. A. P. M. P. Lewanagamage, C. S. (2011). "Traffic Induced Vibration Analysis Of Existing Steel Bridge In Padeniya-Anuradhapura Road" 17th Eru Research Symposium, Faculty Of Engineering, University Of Moratuwa, Sri Lanka.

[3] Matsumoto, Y. Yamaguchi, H. (2010). "A field investigation of vibration based structural health monitoring in a steel truss bridge" Joint Conference on Advances in Bridge Engineering, II, Dhaka, Bangladesh, 8-10 August.

[4] Merritt, F.S, Brokenbrough, R. L. (2006) "Structural Steel Designer's" Handbook. The McGraw-Hill Companies, Inc.

[5] Phyoe, T. Htat, K. L. (2014) "Vibration Effect on Steel Truss Bridge under Moving Loads" International Journal of Science, Engineering and Technology Research (IJSETR) Vol. 3, No. 11 Pp 1-5.