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Intelligent Transportation System: Traffic Load Monitoring and Remote Sensing Structural Health Monitoring of Critical Bridges in Metro Manila using Multi Modal Analysis

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Abstract. Bridge load limit monitoring is a major problem in the Philippines. Since this was not implemented strictly, the structural integrity of the bridges was affected hence it resulted to frequent maintenance, retrofitting of strucutral members and collapse. The integrity of the bridge continously decreases through time once the maximum load limit was experienced by the structure. Therefore, this study aims to emphasize the importance of traffic load monitoring in conducting structural health assessment of bridges aside from earthquake and mass loads. The 7.7% increase in the flexure stress of the bridge deck indicates that truck loading has a significant effect on the bridge. In addition for this, variation on the truck volume for peak hours and non peak hours will correlate to the reading of the smart sensor attached on the bridge for structural health monitoring.

1. Introduction

One of a pre stress concrete bridge in metro manila was closed due to a visible major cracks on the bridge deck and deformation on girders. The bridge was constructed 50 years ago and included on the list of critical bridges to be retrofitted by the governent agency two years ago, but due to expected traffic the repair was delayed. Also, the bridge load limit was not strictly supervised and 6,000 trucks passes daily. Fourty more bridges in Metro Manila, considered as critical bridges are scheduled to be retrofitted. [1]

Numerous incidents of bridge failure due to overloading happens just like in Davao city, a bridge in Calinan riverside fails because of a 10 tons truck pass despite of the 5 tons bridge load limit.

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Considering those incidents, it is really importat to consider the traffic loads in assessing the structural integrity of a bridge.

This study focused on the significance of traffic load monitoring for structural health monitoring of a certain bridge in Navotas, Philippines. Through the use of accelerometer for the monitoring of the frequency of the bridge with influence of the truck loads for traffic load monitoring. Theoretical model and values of the stresses are included in this paper, but the actual reading of the sensor will not be disclosed at this moment. [4,5]

Figure 1. Cracks on Bridge Deck.

Figure 2. Actual Bridge Footage

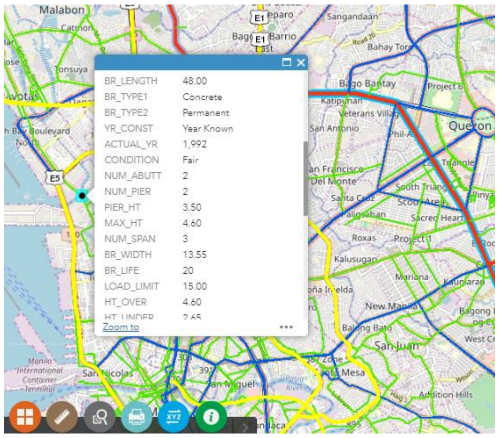

Figure 3. DPWH Bridge Inventory

The figure above shows the actual bridge footage and the properties came from the dpwh bridge inventory. The actual load limit of the bridge is 15 Tons, and the main vehicles passing are cargotrucks because it is near the port area.

According to the Map given by the Philippine Vulcanology and Seismology, the bridge is located in the part of Metro Manila which has high susceptibility of liquefaction but this paper does not include the analysis of the foundation and scouring. The bridge was located near the port area and the foundations of the piers are submerged in a river. This will open to a series of studies which will include multi hazards analysis affecting this bridge. [2]

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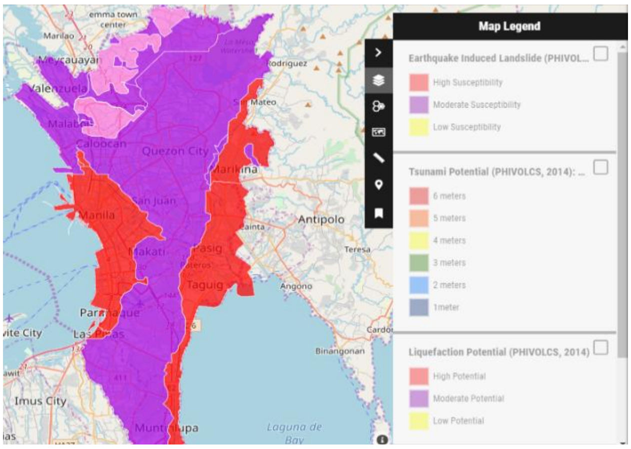


Figure 4. Liquefaction Susceptability Map by PhiVOLCS.

2. Methodology

The bridge consist of three lanes and three span concrete deck, two pier and one column each, and the abutments are integral at the support. The bridge model was done using STAAD bentley structural software. The supports are roller at the supports while pin at the piers. The load cases considered are dead load, lane load, and truck load. Single and Double HS 20-44 are considered and enveloped by 1 meter increment. [3]

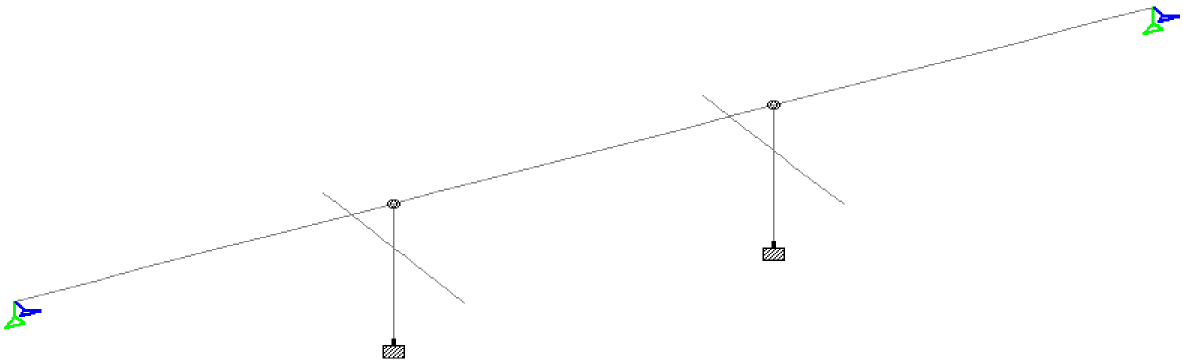
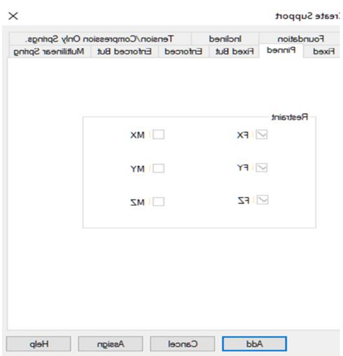
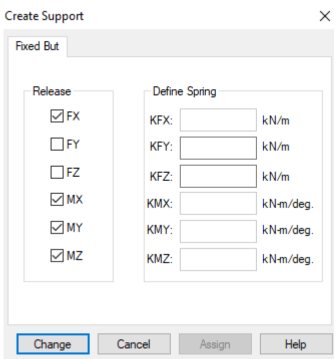


Figure 5. Bridge Model.





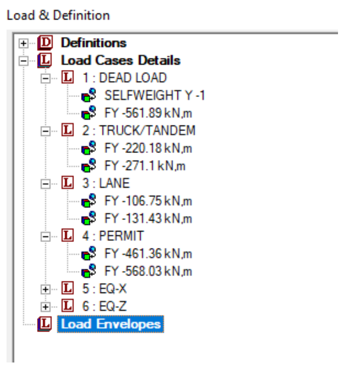


Figure 6. Supports at the Piers **Figure 7.** Support at the Abutment **Figure 8.** Loads and Definitions

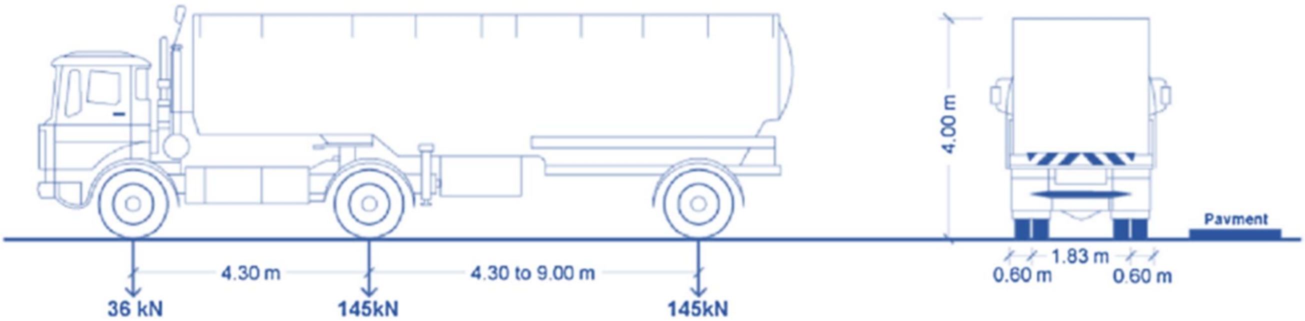


Figure 9. AASHTO HS 20-44 Truck Loading

3. Results and Discussion

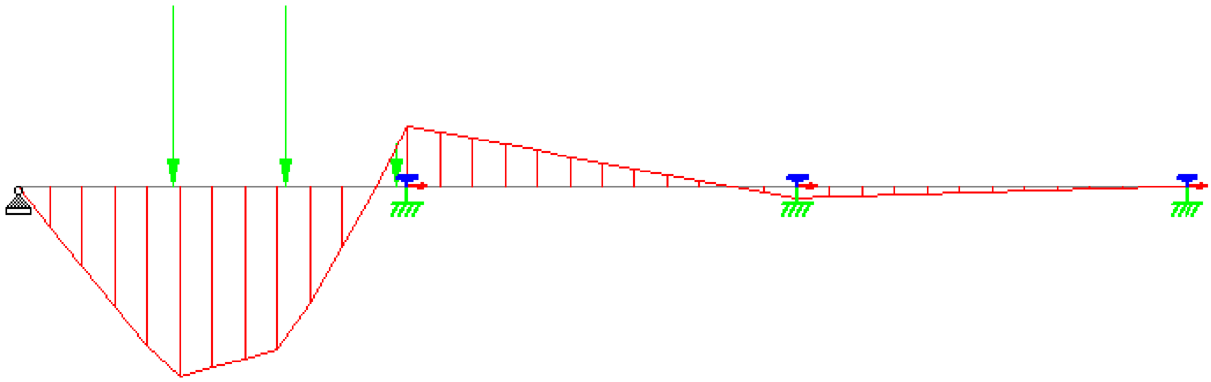


Figure 10. Forces and Stresses with Truck Loadings

The maximum bending moment, 705 KN-m occurs at the first span wherein the truck's front axle is located 0.3 meter near the first pier. While the maximum bending moment without considering the truck loading is 653 KN-m. There's an increase of 7.7% in the moment experienced by the bridge.

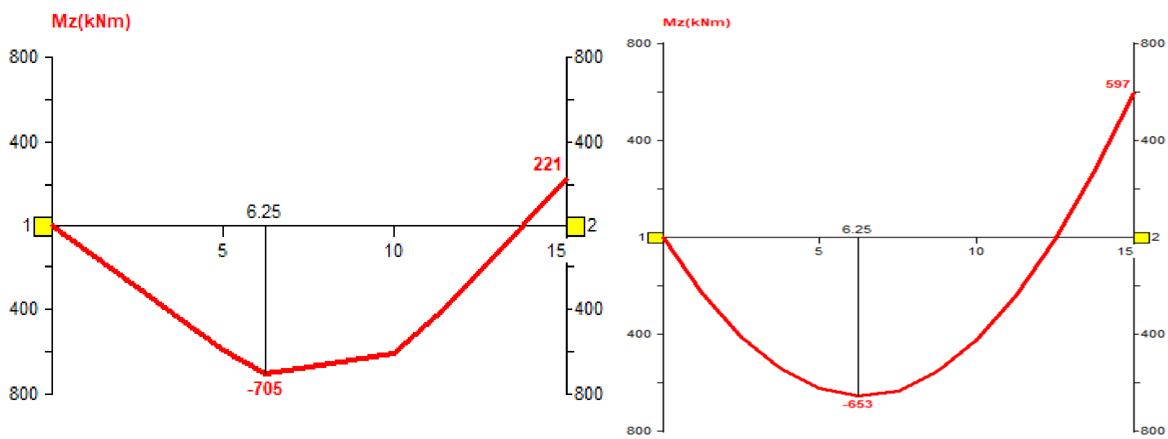


Figure 11. Moment Diagram with Truck Load **Figure 12.** Bending Moment Diagram with Dead Load

4. Conclusion

The increase by 7.7% in the maximum bending moment significantly evaluates the importance of considering the truck loading in analyzing the structural health monitoring of a bridge. Aside from earthquake loadings, live load overloading affects the integrity of the bridge in the the long run. The load limit must be strictly followed to avoid bridge failures and unexpected repairs. CCTV will be installed on the approach of the bridge and traffic calculation will be done. The installation and readings of the accelerograph will be the continuation of this study. The different data analysis in peak hours and non peak hours will also be considered.

Acknowledgements
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