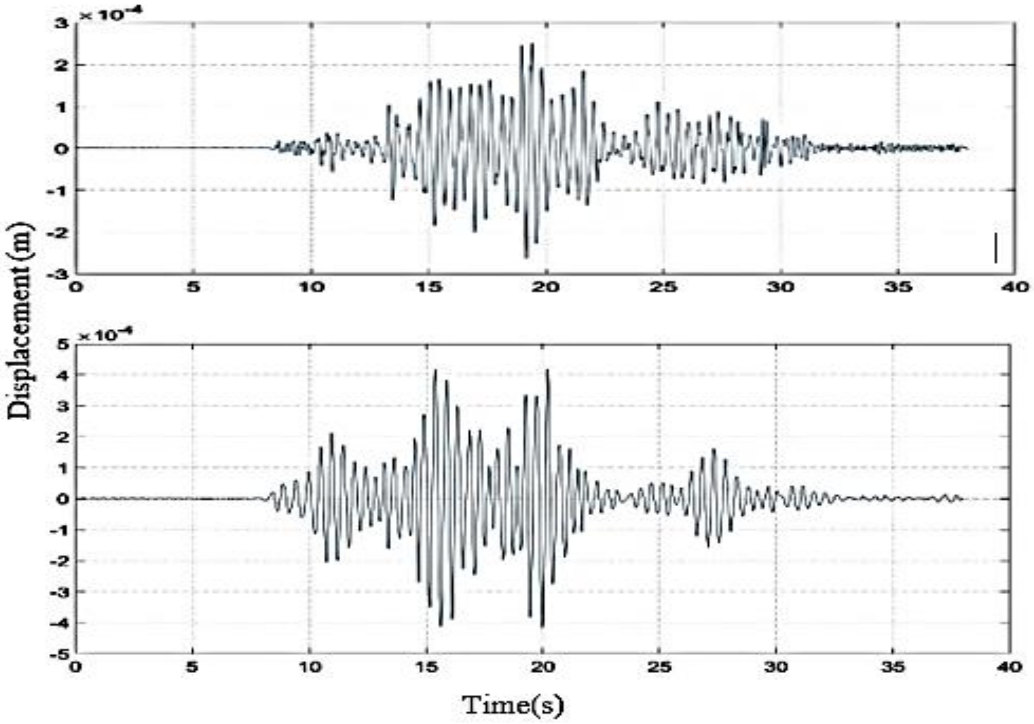

Fig. 6 Displacements response under the truckload (upper: vertical, lower: transverse)

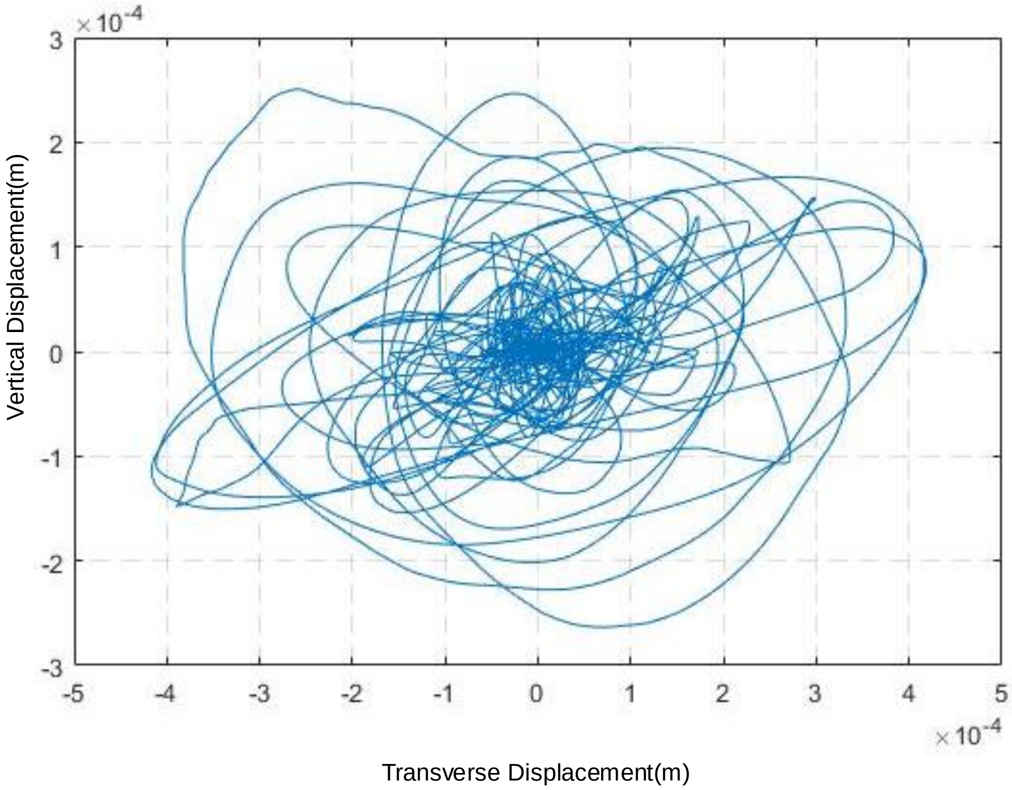

Fig.7 Lissajous pattern of vertical direction versus transversal horizontal direction

Fig. 5 shows the acceleration and Fig. 6 its derived displacement response in vertical and transversal horizontal direction under truckload.
The dynamic response shows significant behavior in transverse direction higher the vertical direction. One of the primary reason for the behavior is considered to be weak or detached connections between members.
Additionally, Fig. 7 shows an intricate pattern of structural vibration with different frequency and phase of vibration and indicated that imbalance or degradations of the structure show non-linearity of structure vibration between the vertical and transverse direction.

## 3. STRUCTURAL ANALYSIS

### 3.1 Modeling and analysis consideration

In general, satisfactory modeling of a structure should follow some documents with reliable information on details on geometries of the structure.

However, no information on structural detail on the Bailey bridge is available in the organization in Laos.

Hence, the bridges were modeled, based on the assembling manual, which was found in another country earlier, and actual geometries measured at the site. Table 4 shows the geometry of the bridge members.

Table 4 Bridge member shape and dimension

| *Descriptions* | *Shape type* | *Dimensions (mm)* | | | | |
|---|---|---|---|---|---|---|
| | | H | B | tw | tf | Dia. |
| *Panel Top Chord* | Cannel | 100 | 51 | 5 | 5 | - |
| *Panel Vertical chord* | Cannel | 78 | 37 | 5 | 5 | - |
| *Panel Diagonal chord* | Cannel | 77 | 35 | 5 | 5 | - |
| *Panel reinforcement* | Cannel | 100 | 51 | 5 | 5 | - |
| *Stringer/Floor Beam* | I Section | 150 | 70 | 5 | 5 | - |
| *Transom/Cross beam* | I Section | 260 | 112 | 11 | 11 | - |
| *Sway Brace* | Round | - | - | - | - | 30 |
| *Deck-803(Wooden)* | Plate | 55 | - | - | - | - |
| *Vertical-bracing* | Cannel | 77 | 58 | 5 | 5 | - |
| *Horizontal bracing frame* | Angle | 50 | 50 | 5 | 5 | - |
| *Diagonal horizontal frame* | Plate | 5 | 40 | - | - | - |

The structure was modeled and analyzed with the bridge structural analysis software MIDAS Civil 2016 of student license version. The software is designed for mainly finite element analysis. Structure analysis used material of high strength low alloy steel, which has properties of the modulus of elasticity 195000 MPa and the yielding strength 338-344 MPa (King, Wu, & Duan, 2013).

For most structure members including transoms or crossbeam and desk support systems, except the bridge deck was assumed as appropriated wood material which has an elastic modulus of 15,810 MPa and 750 kg/m$^3$ of the density.

The bridge dimension is 3.9 meters wide, 36.48 meters of total length and 1.54 meters high.

Truss members were modeled by beam element type, which the member connections were considered to be rigid, reinforcement and bracing system also modeled as the rigid-link to the main members. All material assumed as same properties all structure members.

## 4. RESULTS AND DISCUSSIONS

### 4.1 Deflection

The structural analysis considered on linearity elasticity, Fig. 8 shows loading and model and stress observation points. Table 3 shows a measured and analysis values comparison.

Due to abnormal found from the measurement of transducers; thus, only the deflection measured by the total station is compared to the deflection from the analysis.

From the Table 3, when the loading at span 1 the analysis results smaller than the measured and show deferent of 6.05, 4.73, and 1.79 millimeters on point 1, 2 and 3 respectively while the experimental and analysis show acceptable range when the loading truck is at span 2 by 2 millimeters in average for each point.

However, the existing structure shows higher deflection when the loading truck was at span1; it is assumed to be caused by unknown potential degradations. Since the original bridge structure was collapsed and recovered in 2015 using existing parts, that may remain defected such as local and global buckled of the members.

The structural simulation case, representing a cross-sectional defect state by halved the cross-section and the displacements response of the analysis model approaching testing value.

Column 1 of Table 3, observation point 1 shows some high deference. Others of checkpoints show the fair comparison between testing and analysis of the initial state.

The above indication, we confirmed and validated the structure model. Point 1 is assumed for insufficient connection or degradations at that point.

### 4.2 Stress Analysis

The Fig. 9 and 10 show stress response under various static load case of loading as well as unloading condition. The load was based on actual loading test truck (100%) as Fig.1 and only considered span 1 loading due to the loading test was mainly measured at span 1. The loading position was at 1/4 of span 1 as Fig. 4. The 0% represented the unloading condition, which only stress under self-weight was calculated. Load case was individual wheel increasing loading of the testing truck by 125% to 1,000% to get the trend line of loading versus maximal stress to classify the stress capacity of the structure.

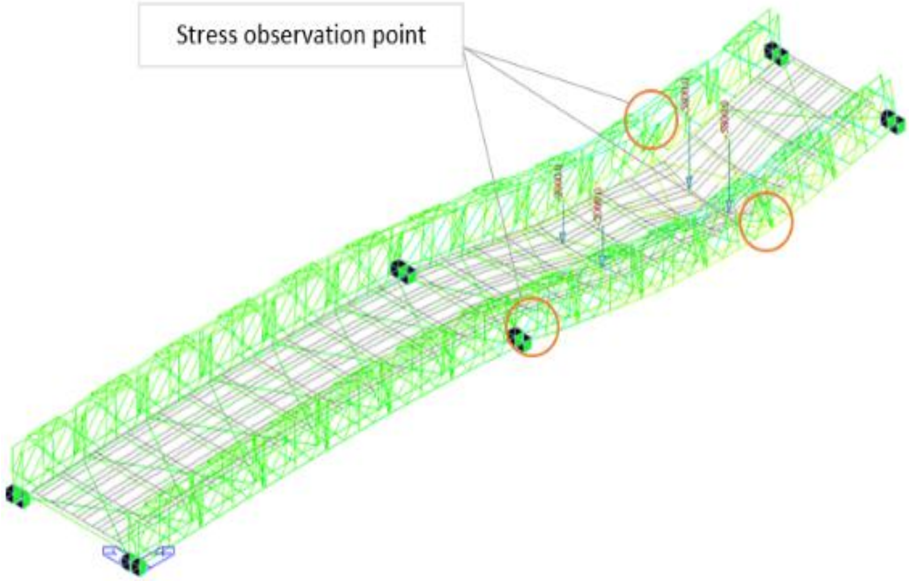

Fig. 8 Stress observation points

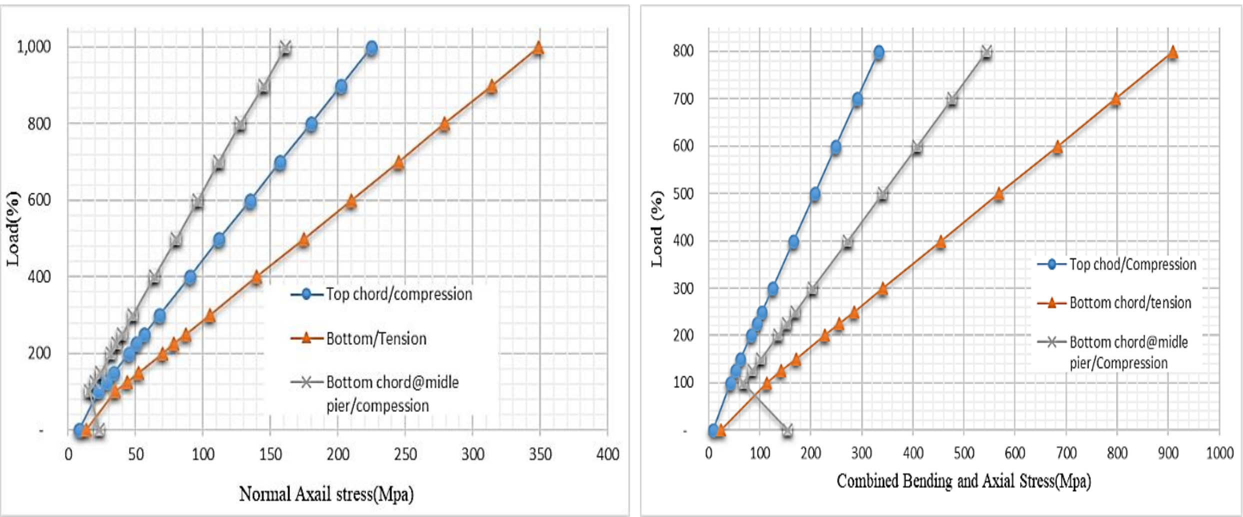

Fig. 9 Normal Stress and Combined under the various truckload of rigid state model

In Fig. 9, the normal-tension stress response of the bottom chord at the 1/4 of span 1 shows almost 1000% or 10 times to reach the yield stress of 338 Mpa. The compression of the top chord at the same position higher than the bottom chord at the middle pier while considering the combination of bending stress and normal stress, it is only 3 time of testing truck weight to reach the yield stress, bottom chord at the middle pier turn higher compression than the top chord. Besides, the case of unloading, bottom chord at the pier higher then loading cases in compression up to 150% for normal stress and 200% combined stress.

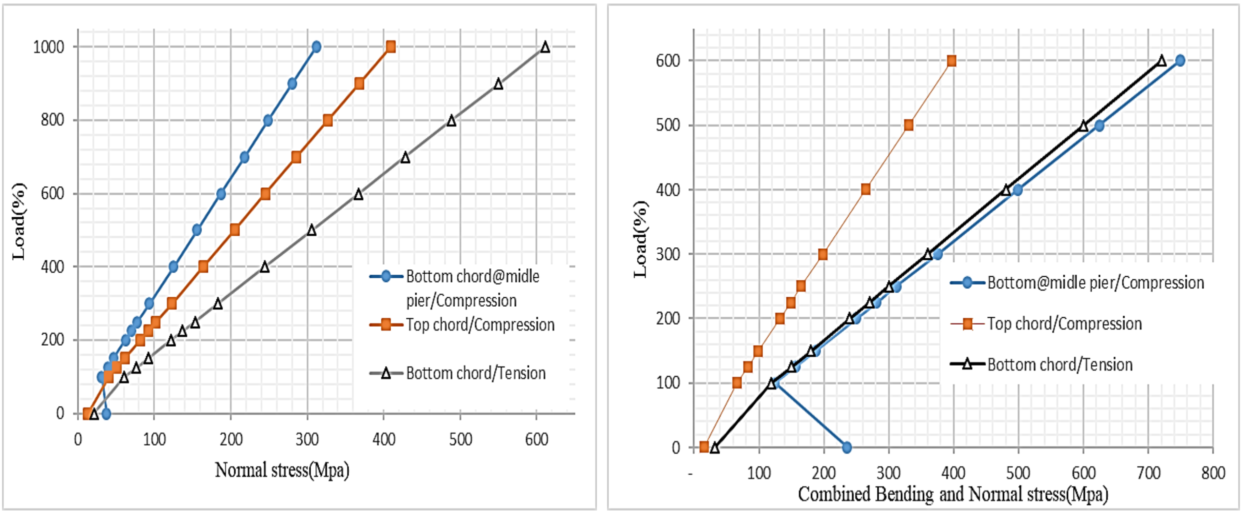

Fig. 10 Normal Stress and Combined Stress under the various truckload of defected state model

Fig. 10 for the case of defected structure model, the normal stress shows the tension stress at 1/4 of span 1 of the bottom chord reach the yield stress at 500% of loading, 50% reduced from the rigid state following linearity of elasticity.

While considering combined stress, it was reached the yield stress only at 250% of loading. Compression stress at the pier bottom chord shows higher for all top and bottom chord at the point 1/4 of span 1, deferent from the rigid state model.

## 4. CONCLUSION

In this study, experimental and structural analysis of the static and dynamic behavior of the existing and functioning Bailey bridge was studied and discussed.

Testing data was obtained and compared with the structural analysis and the summary and findings in this study as following.

1) Lissajous pattern plotted of displacement response of transverse and vertical direction show complex of vibration pattern which the structural degradations were considered in this case.
2) Degradation of the existing structure may cause the deference value between experimental and analysis.
3) The stress analysis result shows that the tension stress-resistant of rigid state model up to 10 times of the testing load. The bottom chord at the pierhead should be considered for buckling resistance due to higher compression when the structure determined of defection state, loading and combined bending and normal stress as research assumptions.

Furthermore, significant displacement in the transverse direction occurs beyond expectations under the dynamic loading.

Comparison of behavior between the experiments and the analysis suggests that insufficient connection between members causes the behavior found in the experiment.

## ACKNOWLEDGMENT

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