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Development of the novel analysis platform for evaluation of structural robustness of CPT Boom

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1. Introduction

As shown in Fig.1, Concrete Pump Truck (CPT) is special kind of construct equipment which transport the concrete to desired location and the major parts of this equipment is consist of pump, concrete pipe, boom and so on. In the construction field, recently, high-rise construction trend is dramatically increased and therefore the enlargement of the CPT structure is inevitable and the bigger and longer boom structure has been developed. Obviously, huge structure can suffer from their weight itself. Moreover, this structure can be affected by various dynamic loadings such as slurry pumping, tilting, gust and so on.

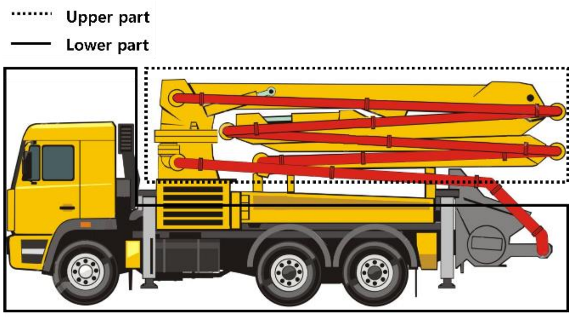


Fig.1 General specification of CPT

In order to solve this structural problems of CPT, several studies have been conducted. Jiang [1] analyzed the structural behavior of CPT boom using multibody dynamics and Finite Element Analysis (FEA). Wu et al. [2] performed the engineering failure analysis to determine the fatigue life of CPT boom for the welding zone. Han and Kwon [3] suggested the optimized shape of a gusset plate to increase the torsional stiffness of CPT boom. However, it is hard to develop the engineering platform to simulate the actual stress state of the CPT boom and this kinds of researches cannot be easily found out.

In this study, therefore, newly developed analysis platform is introduced and this platform is corrected by actual stress state for the representative case. Consequently, this new platform can be used to evaluate the structural robustness including fatigue life for the CPT boom successfully.

2. New analysis platform for CPT boom structure

In fact, the accurate engineering platform is very important to evaluate the stress state and design life of the boom structure. However, the evaluation from the experimental analysis for every loading cases are very expensive and inefficient because there are various loading situations for the CPT boom structure as mentioned earlier. On the other hand, the analysis results from FEA is often inappropriate in accurate perspective especially a complicated structure like CPT boom. Therefore, new analysis platform is required based on the FEA and the discrepancy from the limitation of numerical technique must be corrected by actual experimental results.

The major discrepancy of stress state between FEA and real case is from structural damping. It is very difficult to define the damping coefficient from numerical technique thus this value is usually determined by experimental technique because this value is generally determined by many factors such as contact conditions, surface, temperature, size and so on. Therefore the appropriate damping coefficient must be defined by correlation with experimental result.

3. Experimental configuration and FEA correction for damping behavior

In order to develop the correlation between FEA and experimental results, the general strain gage is used. The target model is 70m length with five CPT booms. The strain gage is attached on the upper and bottom plate of the 1st boom. In order to avoid any uncertainty, the location of strain gage is not attached near the gusset plate, which is the kind of torsional stiffener. The attached strain gage is shown in Fig.2.

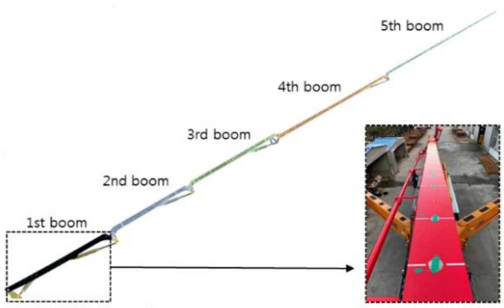


Fig.2 Strain gauge attachment

In this study, the only 1st boom is considered as flexible body and the others is assumed as rigid body for computational efficient. In fact, this assumption can cause the discrepancy of structural stiffness between real and FE model but this is scarcely affect the assessment of the structural robustness of a CPT boom especially fatigue life because the logarithmic decrement is used to find the damping coefficient in this study. In this numerical technique, the stress cycle and magnitude are almost similar for both cases [4].

After obtaining the data from strain gage, first of all, the real stress profile must be manipulated by considering the stress generated by the monotonic loading caused by the position of CPT boom and therefore the real stress profile must be shifted from the measured stress profile. Fig. 3 shows the real and the measured stress profile for moving from 30° to 70° from the ground.

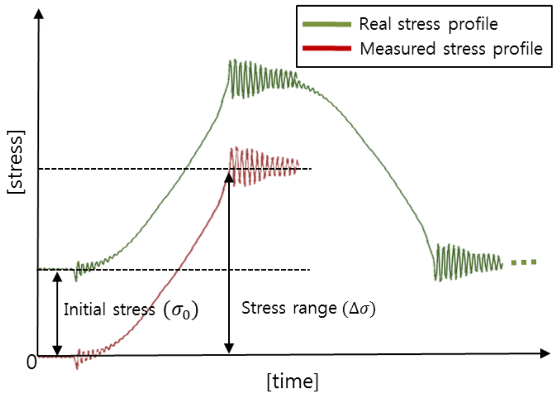


Fig.3 Typical stress profile

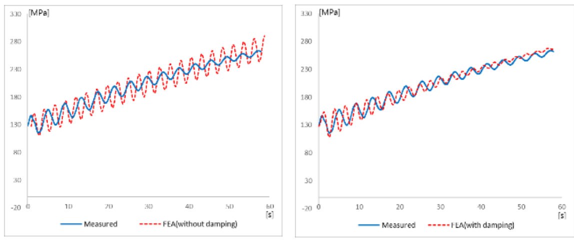
As most important part, the damping coefficient must be defined appropriately. In this study, therefore, the logarithmic decrement is firstly derived from measured data and the damping coefficient which is used in the FE model, is finally defined and described in Eq. (1)

$$\zeta = \frac{1}{\sqrt{1+\left(\frac{2\pi}{\delta}\right)^2}} \qquad \text{Eq. (1)}$$

Where, ζ : damping coefficient

δ : logarithmic decrement

Fig. 4 (a) shows the measured data and data generated by FEA without damping. This FEA data does not reflect any energy dissipation. With correction for damping effect, however, it is noted that both measured and FEA data are well matched as shown in Fig.4 (b).



(a) without damping (b) with damping

Fig.4 Comparison between measure and FEA data

4. Conclusion

A new analysis platform is developed to enhance the structural robustness for CPT boom structure. This platform is based on FEA and the limitation of numerical technique is successfully corrected by experimental data. The major limitation of FE simulation is the discrepancy by damping effect and this can be overcome by defining the proper damping coefficient introducing the logarithmic decrement. It is concluded that the newly developed analysis platform can be used to evaluate the structural robustness for the boom-like structure including fatigue life without any further expensive test.

Acknowledgment

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