INVESE ANALYSIS FOR HEALTH MONITORING OF A HISTORICAL MASONRY BUILDING

C. BUACHART[1], C. HANSAPINYO[2], A. PIMANMAS[3], M. MIYAMOTO[4], and T. SUWAN[5]

[1] *Asst. Prof., Department of Civil Engineering, Chiang Mai University, Thailand*
[2] *Assoc. Prof., Department of Civil Engineering, Chiang Mai University, Thailand*
[3] *Prof., Department of Civil Engineering, Kasetsart University, Thailand*
[4] *Assoc. Prof., Faculty of Engineering, Kagawa University, Japan*
[5] *Assoc. Prof., Department of Civil Engineering, Chiang Mai University, Thailand*
Correspond to Assoc. Prof. C. HANSAPINYO (chayanon@eng.cmu.ac.th)

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1. INTRODUCTION

Among the various types of buildings, historic ones have been built for a long time, and the construction methods and materials that were used at the time were substandard. Hence, they are susceptible to vibration and deteriorated environmental impacts. Earthquakes have the power to cause massive destruction to historical buildings. As an earthquake cannot be avoided, many efforts have been made to establish an effective preparedness plan [1-4]. To achieve the task, information about the dynamic properties of the structures, e.g., the damping ratio and fundamental period of vibration, is indispensable.

In this work, two vibrational sensors were installed on the pagoda at the top and base levels to monitor the real-time vibration responses when an earthquake or a sensitive vibration occurred. The inverse analysis method was used to backward identify the dynamic properties of a masonry pagoda from the measured vibration responses. The target structure named Umong stupa, located in Chiang Mai, Thailand, was assumed to be a single-degree-of-freedom mass-spring-damper system, as shown in Fig. 1. With the measured four seismic waves as the input excitation and initially assumed dynamic properties, the numerical solution of the equation of motion using Duhamel's time integration for the top acceleration was determined. Then, the Gauss-Newton algorithm was applied to obtain the dynamic parameters, which iteratively minimized the sum-of-squares error (*SSE*) between the calculated and real-time measured accelerations, as shown in Eq.(1)

$$SSE^{(k+1)} = \sum_{i=0}^{n}\left[\ddot{u}\left(b_1^{(k+1)}, b_2^{(k+1)}, t_i\right) - \ddot{u}_m(t_i)\right]^2 \quad (1)$$

Where $\ddot{u}\left(b_1^{(k+1)}, b_2^{(k+1)}, t_i\right)$ and $\ddot{u}_m(t_i)$ are respectively the k+1 iterative acceleration with dynamic parameters $b_1^{(k+1)}$ and $b_2^{(k+1)}$ and the measured relative acceleration at the time t_i.

2. RESULTS AND CONCLUSIONS

The values of the converged value of dynamic parameters, natural frequency (*f*), and the damping ratio (ζ) are shown in Table 1.

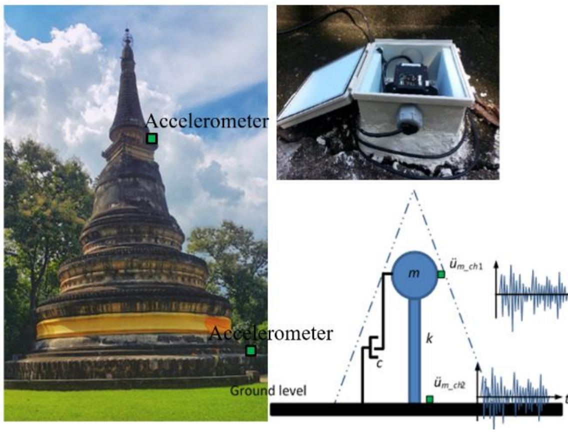

Figure 1. Umong stupa, accelerometers, and single-degree-of-freedom mass-spring-damper model.

Table 1. The computed dynamic properties using the proposed algorithm

Seismic wave	NS direction		EW direction	
	ζ	*f* (Hz)	ζ	*f* (Hz)
Wave 1	0.0298	3.57	0.0147	3.62
Wave 2	0.0277	3.62	0.0241	3.68
Wave 3	0.0154	3.52	0.0128	3.57
Wave 4	0.0194	3.48	0.0184	3.59
Average	0.0231	3.55	0.0175	3.62

In summary, with the proposed analytical algorithm and the attached sensors, real-time monitoring can be successfully done. The change in physical properties due to damages or deterioration altering the vibrational behavior can be continuosly detected.

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