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Modal Parameter Identification of a CANDU Reactor Building Using Ambient Vibration Measurements

Sanghyun Choi [a*], Daehyork Kim[a], Sooyong Park [b], Keunhoo Jung [b]
Chang-Hun Hyun [c], Moon-Soo Kim[c], Sang-Yun Kim[c]
[a]*Korea National Railroad College, Dept. of Railroad Facility Engineering, Uiwang, Kyunggi-do 437-763, Korea*
[b]*Korea Maritime University, Div. of Architecture & Ocean Space, Dongsam-dong, Pusan 606-791, Korea*
[c]*Korea Institute of Nuclear Safety, Structural Systems & Site Evaluation Dept., Yuseong-gu, Daejeon 305-600, Korea*
[*]*Corresponding author: schoi@krc.ac.kr*

1. Introduction

As the importance of nuclear energy increases, the concerns on the integrity of structures in existing nuclear power plant (NPP) are rising. Like other major structures, the integrity of NPP structures is monitored periodically through inspection programs. However, evaluation of overall structural integrity require considerable time and cost. One of the more effective methods that have gained attention for identifying the structural condition of the whole structure is the dynamic response monitoring method, which utilizes measured dynamic responses from a structural system to assess the physical properties of the structure [1]. Park et al. [2] has successfully extracted modal parameters of the reactor containment building of Ulchin NPP unit 5 using ambient vibration measurement.

In this paper, the modal parameters of the CANDU reactor building in Wolsung NPP, extracted using the ambient vibration measurements, are presented. The ambient vibration of the reactor building is measured using accelerometers mounted on the building. The parameters, i.e. resonant frequencies and corresponding mode shapes, are identified using the peak picking method.

2. Experimental Setup

The reactor building of Wolsung unit 2 was selected for the purpose of this study. The vibration due to rotatory machines inside the building was measured using the accelerometers mounted on the outer surface of the building at 8 locations of the same level (Fig. 1), 19.5 m above the ground level. The fixed reference data were measured at the location between Sensor 1 and 2. The measurement duration was about 60 min. Instrumentation used to conduct the ambient vibration test consisted of 5 Kistler K-Beam accelerometers (Fig. 2), a data logger (Tokyo Sokki), and a portable computer (Fig. 3). Instrumentation and test settings used for the ambient vibration tests are summarized in Table 1.

3. Modal Identification

Measured acceleration responses and corresponding power spectral density (PSD) are depicted in Fig. 4 for Sensor 2. The autopower spectrum (AS) was obtained using the PSD function of the MATLAB. The final PSD was calculated via averaging PSDs for every 1,024 data. To reduce leakage error, the Hanning window and data overlapping of 512 data were applied. The cross spectrum (CS) between the reference measurements and the other measurements were obtained using the CSD function of the MATLAB. From the frequency response functions, obtained using the AS of the reference location and the CSs, modal parameters were extracted. Identified resonance frequencies and corresponding mode shapes are presented in Fig. 6.

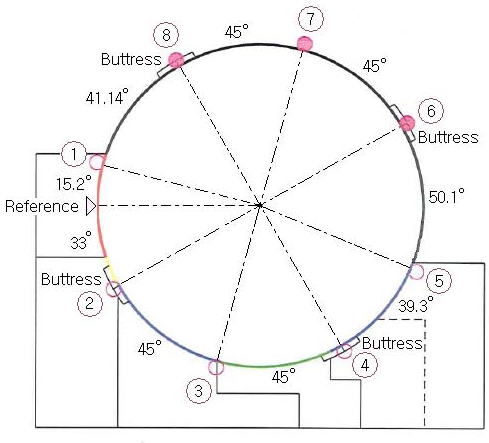
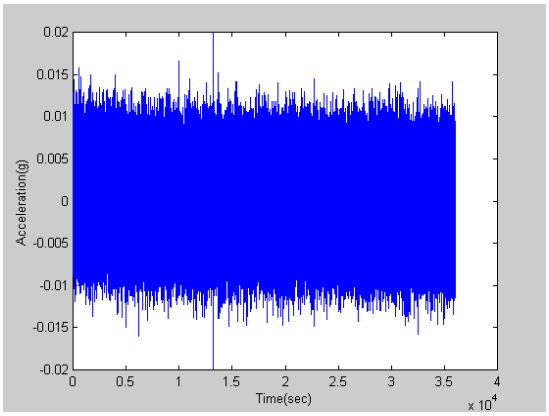


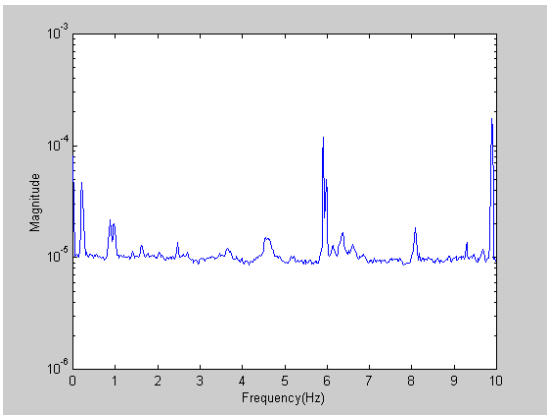
Fig. 1. Sensor locations.

Fig. 2. Accelerometers

Fig. 3. The digital dynamic strain meter and the amplifier.



(a) Acceleration response

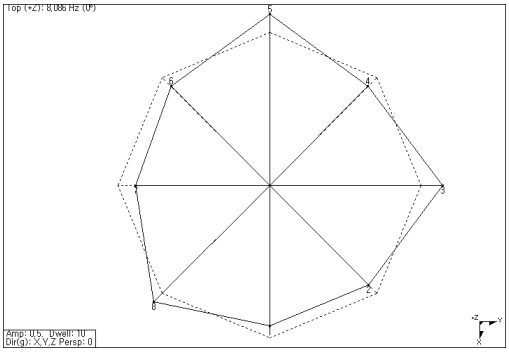


(b) PSD

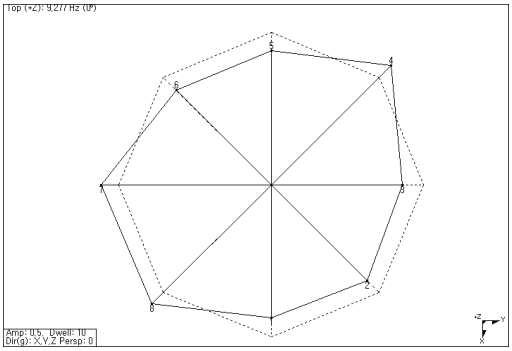
Fig. 4. Acceleration response and corresponding PSD at Sensor 2

Table 1: Test Parameters

Parameter	Setting	Notes/Units
Sample Freq.	20	Hz
Sample Length	720,000	per Channel
Spectral Resolution	0.0195	Hz



(a) Mode 1 (8.086Hz)



(b) Mode 2 (9.277Hz)

Fig. 5. Identified resonant frequencies and modeshapes.

4. Conclusions

Ambient vibration of a CANDU reactor building was measured and modal parameters, i.e., resonant frequencies and corresponding mode shapes, were extracted. The modal parameters were identified using the peak picking method. Further research will be conducted to identify the correspondence between the obtained experimental modes and the analytical modes using the finite element model for the building.

REFERENCES

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