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Output-Only Modal Identification of a Containment Building from Ambient Vibration Measurements

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1. Introduction

Ensuring and maintaining the structural integrity of the containment building (CB) in nuclear power plants is essential in preserving the nuclear reactor and other safety related systems from man-made as well as natural disasters, and protecting plant workers and publics from hazardous radioactive materials. To date, the structural integrity of the CB has been evaluated periodically via visual inspections, chemical tests, nondestructive strength tests, etc. However, these methods can only provide the local information on the structural condition and require considerable time and cost to estimate overall structural integrity [1].

In this paper, the possibility of monitoring the structural integrity of a CB utilizing ambient vibration measurement (AVM) is explored. The ambient vibration testing has gained attention which can avoid the interruption of normal operation of civil structures [2, 3]. To fulfill the objective, the ambient vibration of the CB of the Ulchin 5th unit was measured, and the modal parameters, resonant frequencies and corresponding modeshapes, were extracted.

2. Experimental Setup

The ambient vibration of the CB of the Ulchin 5th unit was measured to explore the feasibility of identifying modal parameters from AVM. The accelerometers were mounted on the outer surface of the CB (Fig. 1) at 9 locations of the same level (Fig. 2). The fixed reference data were measured at the location between Sensor 1 and 9 (3m above the other sensors). The measurement duration was about 170 min. Instrumentation used to conduct the AVM test consisted of 6 strain-gage-type accelerometers, a digital dynamic strain meter, an amplifier, and a portable computer (Fig. 2). Data acquisition software was the Visual Log DRA-7630. Instrumentation and test settings used for the AVM 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 1. The autopower spectrum (AS) was obtained using the PSD function of the MATLAB. The final PSD was calculated via averaging PSDs for every 2,048 data. To reduce leakage error, the Hanning window and data overlapping of 1,024 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 modeshapes are presented in Fig. 6.

Fig. 1. Accelerometers mounted on the CB surface.

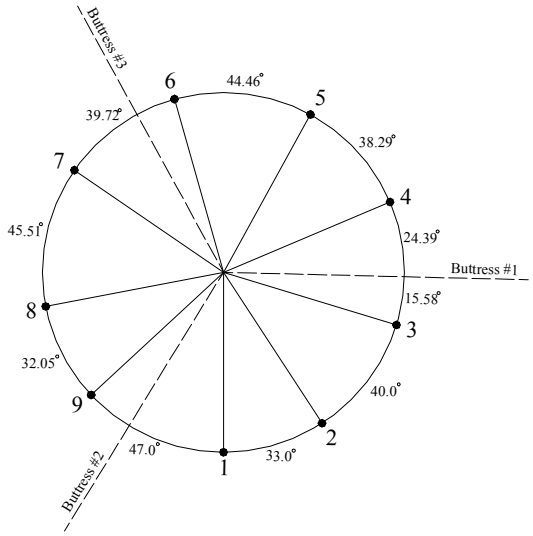
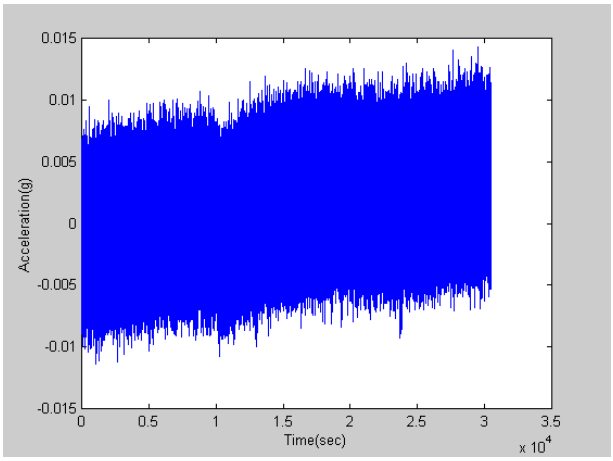
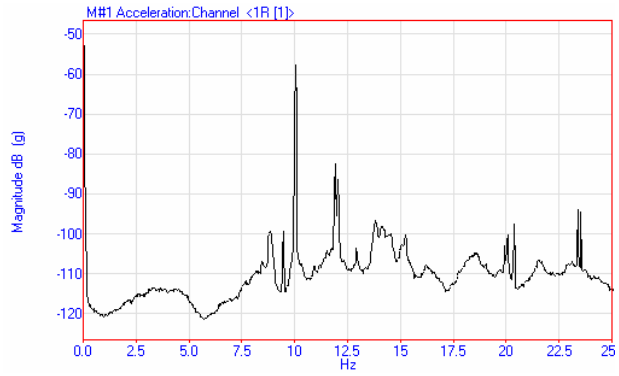


Fig. 2. Sensor locations.

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



(a) Acceleration response

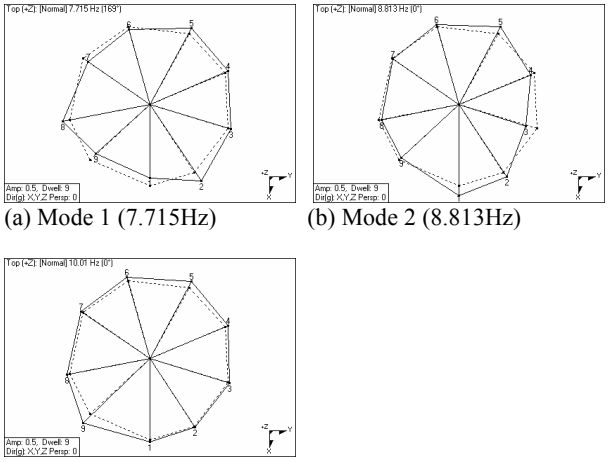


(b) PSD

Fig. 4. Acceleration response and corresponding PSD at Sensor 1

Table 1: Test Parameters

Parameter	Setting	Notes/Units
Sample Freq.	50	Hz
Sample Length	507,904	per Channel
Spectral Resolution	0.0244	Hz



(a) Mode 1 (7.715Hz) (b) Mode 2 (8.813Hz)

(c) Mode 3 (10.01Hz)

Fig. 5. Identified resonant frequencies and modeshapes.

4. Conclusions

Ambient vibration of a CB was measured to explore the feasibility of identifying modal parameters from AVM. Using the measured acceleration data, 3 resonant frequencies and corresponding modeshapes were identified. Further research will be conducted to identify the correspondence of the obtained experimental modes to the analytical modes.

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