The Dynamic Measurement of the Full Scale Containment Structure

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ABSTRACT

The containment of Qin Shan Neclear Power Station in China is a prestressed concrete. The containment is composited of a cylindrical shell and a shallow spherical shell. The environmental random vibration is employed in the dynamic measurement of the full scale containment Structure. V401CR servo accelerometer is used for measuring acceleration. First, second and torsion frequencies, damping ratios, mode shapes are obtained and listed in Table 1.

Dynamic finite element method is applied to analyze vibration of the containment and results of analysis is listed in Table 1. Experimental data and results of analysis are close.

1 INTRODUCTION

The purpose of the dynamic measurement of the full scale containment is to determine the safety of the containment structure. The dynamic characteristic data are as basic parameters for investigating the change of safety of the system in future, to supply the computational model for resistant earthquake design and examine accuracy of the computational model.

There are usually three methods to excite vibration of containment for the dynamic measurement of the full scale structure, such as, the strong vibrator, a small explosion from a distance to containment, the random environmental vibration to excite vibration of containment. The random environmental vibration method is employed in this paper.

2 THE METHOD OF TESTS

The high sensitive accelerometer is used for measuring small response of acceleration of containment under action of wind, traffic, machine etc. in the random environmental vibration method. The vibration of structure is a random vibration. Frequencies, damping ratios, mode shapes can be identified in a linear system under small vibration and small damping. These assumptions can be satisfied usually in engineering.

The random environmental vibration is due to action of wind, that is action of forces. Structure may be also acted by ground motion, that is action of ground acceleration. Responses of acceleration of a structure are excited under application in combination with forces and ground motions. If actions of forces and ground motions are non-correlation in random processes, Reponses of actions of forces and ground motions are also non-correlation. Actually, Input function are not only several but also difficult to measure or unknown, therefore output functions, responses of structure can be only utilized in data process.

2.1 Natural frequencies

the high and precipitous peak will appear at the location of the natural frequncy of structure in auto-correlation or cross-correlation spectrum of measured signals. Therefore, we can identify the natural frequency from these spectra. Except this condition, it is also nesessary that the coherence function of two measured signals should be approached to 1 and the phase is by 0 ° or 180 ° . According to above conditions we can determine natural frequencies from auto-correlation or cross-correlation spectrum.

2.2 Mode shapes

After determination of natural frequencies, we can continue to identify mode shapes from ratios of amplitudes between two points of measurement in cross-correlation spectrum or transfer function.

2.3 Damping ratios

Characteristics of natural frequencies, amplitudes and damping are contained in auto-correlation and cross-correlation spectrum. The damping ratio is calculated by half-power method, during frequencies can be separated and the damping is small.

3 THE INSTRUMNETAL SYSTEM

The high sensitive accelerometers and amplifiers are demanded because the vibration of structure is very small. The servo-accelerometer V401CR, that is measurement range ± 1.0g, sensitivity 5v / g, resolution 5×10^{-6}g, frequency range DC-400Hz, Amplifier GCF-6, Type recorder R-280C, Data processors HP3562A and 7T08S are used for these tests.

4 THE TEST OF THE CONTAINMENT

The containment of Qin Shan Nuclear Power station is a prestressed concrete structure, that is constructed on rock base. The containment is composited of a cylindrical shell in which the internal diameter is 36 m and thickness is 1m, and shallow spherical shell. Except the foundation, the containment and reactor structure are separated.

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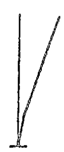
Dynamic Characteristic of Containment Table 1

	First Degree			Second Degree			Torsion		
	Frequency (HZ)	damping Ratio (%)	Mode shape	Frequency (HZ)	Damping Ratio (%)	Mode Shape	Frequency (HZ)	Damping Ratio (%)	Mode shape
Full scale Test	3.81	1.79		8.20	1.69		8.58	1.86	
Finitoe Element Method	3.78	–		12.19	–		8.22	–	

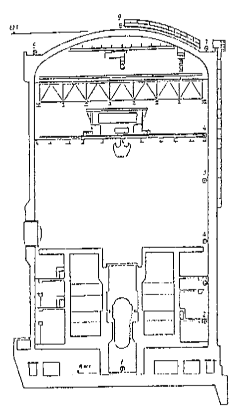


Fig.1 Outline of the containment

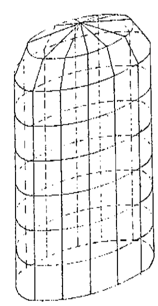


Fig.2 FEM model of the containment

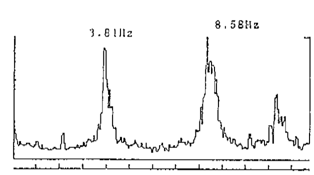


Fig.3 Auto–correlation spectrum of No.7 point

Points of measurement are set up nine points along the wall of containment. No.1 point is at center of the bottom, No.2,3,4,5,6 points of are at internal wall (Fig.1). No.7 point is at the top of the wall. No.9 point is at the center of top of the shallow spherical shell. These points of measurement will be applied to measure the translational motions. In order to measure the torsional vibration, No.8 point is set up at another terminal of diameter on the top of the wall, the location is at 180 ° for No.7. All points of measurement are shown in Fig.1. The dynamic characteristic paramertes, frequencies, damping ratios, mode shapes are listed in Table 1.

5 ANALYSIS OF DYNAMIC FINITE ELEMENT METHOD

The shell element of eight nodes is applied to analyze the vibration of containment. There are 96 elements and 296 nodes in this problem. 17 frequencies and mode shapes are obtained. Radial, tangential and torsional displacements and sectional deformations etc. are included in solutions. In order to identify axial bending and sectional torsion of the containment. It is chosen in solutions that the sectional deformation is not appeared and is still a circle, only translation as a rigid section, This mode shape is responsed to axial bending vibration. During the section is still a circle, not translation, only rotation around the vertical axis, This mode shape is responsed to torsional vibration. Results are listed in Table 1.

6 CONCLUSION

The method of random environmental vibration to excite structure is available for the dynamic measurement of the full scale containment structures.

(1)First and second degree frequencies and mode shapes of axial bending vibration and first degree frequency and mode shape of torsional vibration are identified. Higher frequencies and mode shapes are not identified because the stiffness of the containment is too big.

(2)Frequencies and mode shapes of measurement of full scale containment and analysis of finite element method are approximation.

(3)Damping ratios of different degree are close.

(4)The torsional frequency of measuring from full scale containment and analysis of finite element method is close. But the torsional mode shape is different. This different may be casued to consider the same thickness wall in analysis of finite element method, actually the wall of the containment is alterative thickness and opened a big hole.

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