Study on Damping Evaluation of Shell and Spatial Structures

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Summary

Damping ratios are evaluated through impact vibration experiments and microtremor observation of two concrete spherical shell structures and two spatial structures. In the experiments, velocity detectors are used and velocities are measured at each measurement point. Further, damping characteristics of shell and spatial structures have been analysed using 55 data of damping of shell and spatial structures.

Keywords: damping, damping ratio, damping evaluation, shell and spatial structures, velocity, impact vibration, microtremor observation

1. Introduction

Accurate estimates of the damping ratio at the design stage make understanding the dynamic behaviour of the structure possible, and with effective use of the building's inherent vibration properties, it is possible to reduce stress on structural members, reduce construction costs and make related energy savings. Also, with the greater emphasis on earthquake countermeasures since the Hanshin-Awaji earthquake, building response prediction has taken on great importance, and there is an urgent need to improve the accuracy of damping prediction.

Shell and spatial structures hold large numbers of people and are widely used as emergency refuges in the event of disasters. Therefore, there is a pressing social need for more research to improve accuracy of damping ratio and dynamic behaviour estimation. With this in mind, experimental measurement and analysis of a number of shell and spatial structures has been carried out by Shingu Laboratory and others, and a database has been constructed with the goal of improving our understanding of their damping characteristics. The results of this research have been presented in journals [1]-[3] and the book [4]. However, the data accumulated and analysed to date is still not sufficient for a full picture of the damping characteristics of shell and spatial structures.

2. Objective structures

The objective shell and spatial structures are shown in *Fig.1*.

Fig. 1 From left to right, Spherical Shell (Funabashi City), Spherical Shell (Narashino City), Conical Shape Structure (Ichikawa City), Sports Hall (Nihon University)

3. Results

Damping ratios of the four shell and spatial structures are shown in *Table 1*, and the relationship between damping ratio and span is shown in *Fig.2* and Equation (1).

Table1. Damping Ratios of Four Shell and Spatial Structures (%)

	Impact Vib.	Microtremor
Spherical Shell (Funabashi City)	3.3	1.3
Spherical Shell (Narashino City)	3.9	1.2
Conical Shape Structure (Ichikawa)	1.6	1.1
Sports Hall (Nihon University)	2.9	1.1

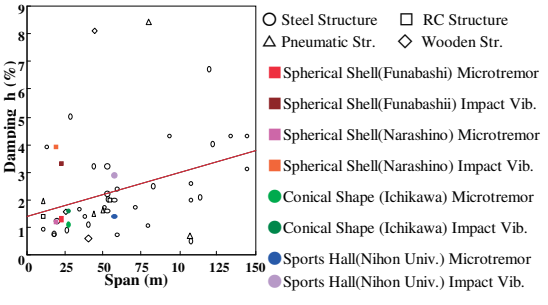

Fig.2 Relationship between Damping Ratio and Span

$h = 0.0152L + 1.45$ (1), Where, h: damping ratio (%), L:span(m), L is larger about 10m.

References

[1] Shingu K., Aoki Y., and Kubota K., A Fundamental Study on Damping of Shell and Spatial Structures -Damping Characteristics of a Tensegric Truss Arch-, *AIJ Journal of Technology and Design.*, No.17, 121-126, (in Japanese) (2003)

[2] Tatemichi I., Study on Damping Characteristics of Spatial Structures Based on Measured Data: *AIJ Journal of Technology and Design*, No.20, 87-92, (in Japanese) (2004)

[3] Yukawa M., Shingu K., and Hiratsuka K., Study on Damping Evaluation of Shell and Spatial Structures-Vibration Experiment of Hyperbolic Paraboloidal and Cylindrical Shell Roofs, *Journal of Struct. Constr. Eng.*, *AIJ*,Vol.74 No.646,2271-2280, (in Japanese) (2009)

[4] Architectural Institute of Japan (AIJ), Damping and Vibration Control of Shell and Spatial Structures, Maruzen, (in Japanese) (2008)