Dynamic Characteristics of Long Two-story Building with Large Atria and Skylights

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1. Introduction

For low-rise buildings, standard structural design laws generally require static loading analysis only. Compared with high-rise buildings, large-scale low-rise buildings often have relatively irregular shapes and several larger atria in the building plans[1)]. As a result, their actual dynamic properties have not been understood well so far. This paper reports dynamic properties of a long two-story shopping mall building with atria and skylights. System identification result obtained by microtremor measurement reveals that the building has some specific characteristics caused by its unique design.

2. Building and Microtremor Measurement

Figure 1 shows accelerometer locations on the 2nd and 3rd floor. The roof is the 3rd floor for car parking. The structure is a typical large-scale low-rise steel building with the following unique natures: (1) two stories; (2) 540m by 120m plan; (3) large skylights at the roof and many large atria at the 2nd floor. (4) two expansion joints (Exp.J.) dividing the structure into three parts (Parts W, C and E).

49 spots in the building were selected to measure microtremor vibration. Natural frequencies and the corresponding modal shapes are identified by singular value decomposition of power spectral density matrices of microtremor responses in the frequency domain (FDD method). The damping ratios are evaluated in lower modes by Random Decrement (RD) method. The RD method is also utilized to verify the natural frequency evaluation by FDD method.

3. Identification Result

Table 1 shows major natural frequencies. Figures 2 and 3 select ten modal shapes from Table 1. In x-direction, the 1st lateral modes are at 1.47Hz and 2.09Hz. In y-direction, the 1st lateral modes are at three different frequencies: 1.25Hz, 1.46Hz and 1.84Hz. Local torsional modes around skylights and atria are found at several natural frequencies. The damping ratios in the 1st lateral modes are 1% to 2%.

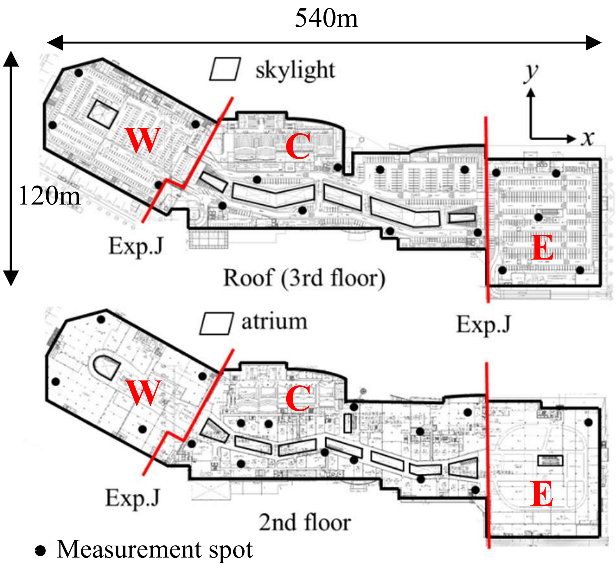

Figure 1. Roof (3rd floor) and 2nd floor plans

Table 1 Major natural frequencies and modal shapes

Dir.	Freq. (Hz)	Modal shape and part
x	1.47	1st lateral modes in C & E
	2.09	1st lateral mode in W
	2.71	Local torsional mode around skylights in C
	3.56	Local torsional mode around skylights in C
	3.96	2nd lateral modes in C & E
	5.42	Torsional mode around skylights & atria in C
	5.62	Local torsional mode around skylights in C
	8.50	Torsional mode in C
y	1.25	1st lateral mode in E
	1.46	1st lateral mode in C
	1.84	1st lateral mode in W, Torsional in C & E
	3.61	Local lateral mode around main entrance in C
	4.15	Local torsional mode around atria in C
	5.37	Local torsional mode around atria in C
	5.71	Local torsional mode around atria in C
	8.50	Torsional mode in C

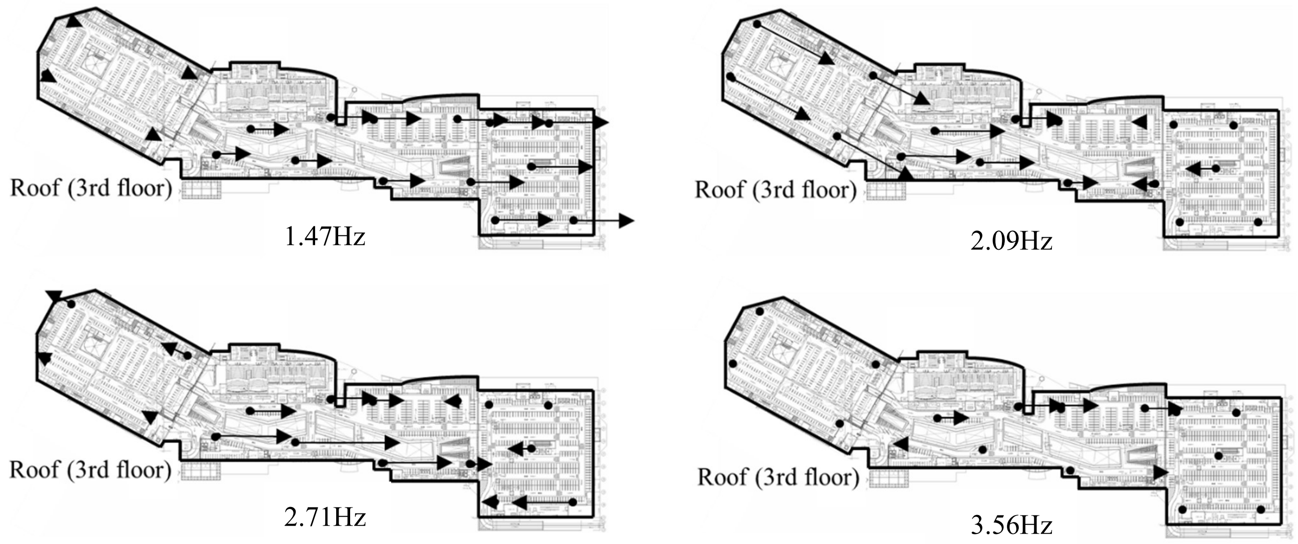

Figure 2 Selected modal shapes in *x*-direction

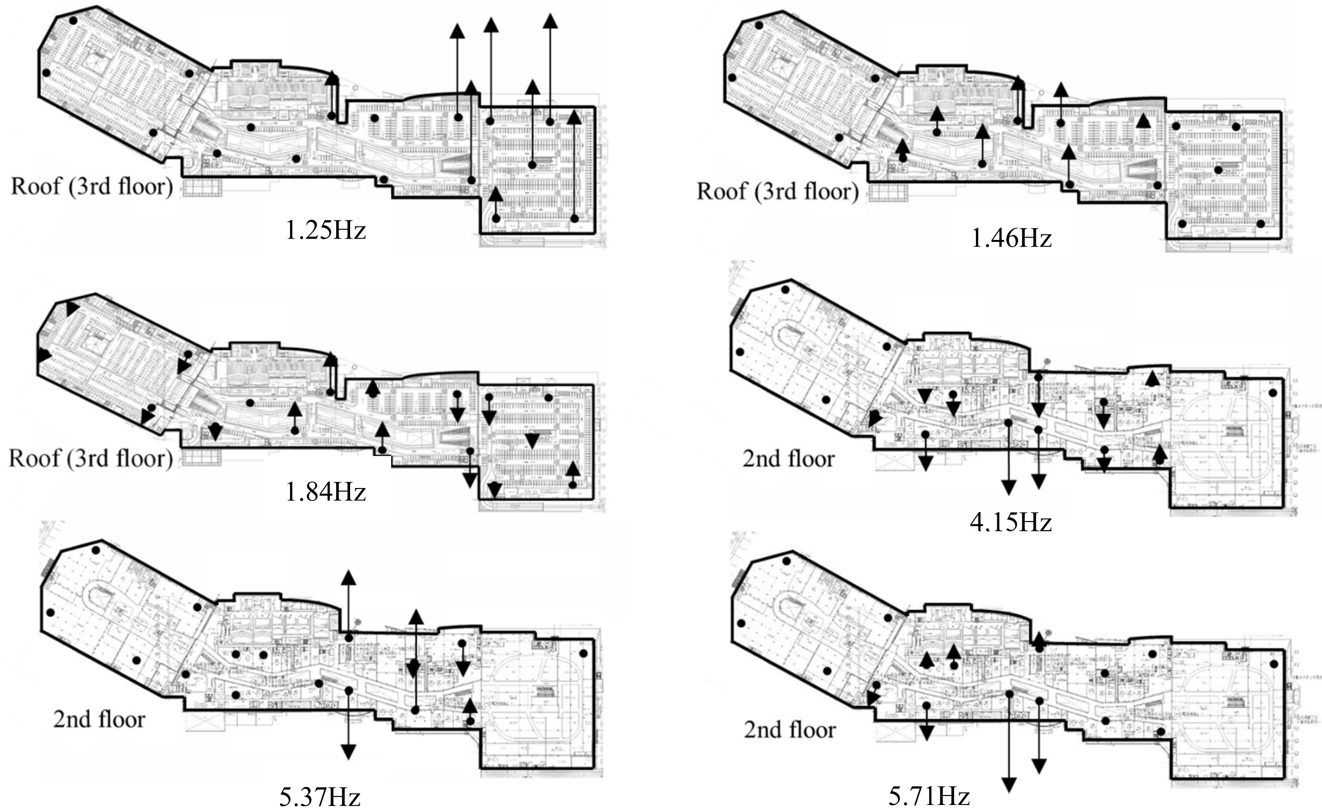

Figure 3 Selected modal shapes in *y*-direction

4. Conclusion

This paper reports modal properties of a two-story building with 540m by 120m plan, atria at the 2nd floor and skylights at the roof. The effects of Exp.J, atria and skylights are found in several vibration modes, which is different from dynamic properties of high-rise buildings with rigid floors.

Acknowledgements

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Reference

1) Toki M, Kurata M. and Ikeda Y.: Modal properties among large-scale low-rise commercial buildings, *Summaries of Technical Papers of Annual Meeting, AIJ*. B-2: 697-698, 2019 (in Japanese)