

# Torsional response of ceilings during earthquake

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## 1. Introduction

The ceiling standards under the Building Standards Act requires the arrangement of diagonal members in good balance to reduce the torsional response of the ceiling during earthquakes. Yet, the standards do not necessarily clarify the satisfactory levels and conditions of the balance, such as cases when the arrangement becomes unbalanced because of the relationship with facilities and devices like the case shown in Figure 1.

This study examines the torsional response of the ceiling during earthquake to clarify the condition of a well-balanced arrangement.

## 2. Outline of examinations conducted in FY 2018

First, diagram-based earthquake response evaluations and display methods were examined because torsional response is affected by multiple parameters and tends to become complicated. The diagram made it easier to estimate torsional response and interpret the results.

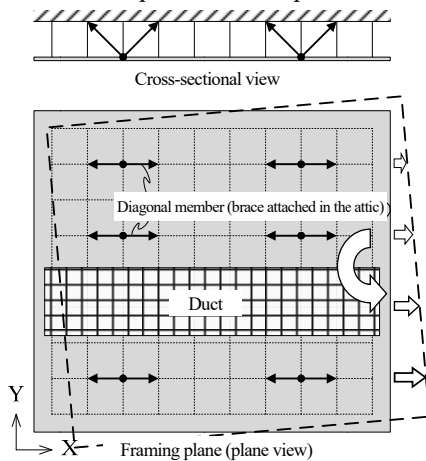


Figure 1 Torsional response of ceiling during earthquake (Top: Sectional view, Bottom: Framing plan)

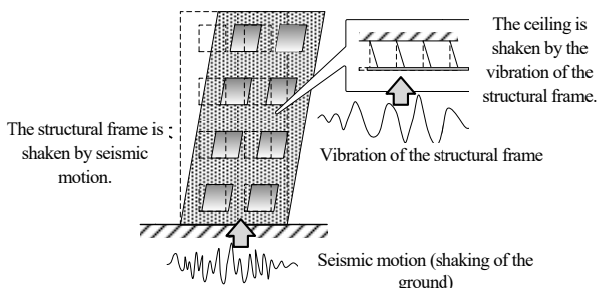
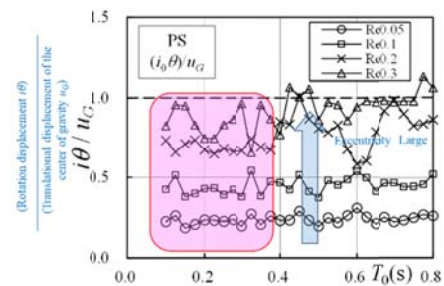


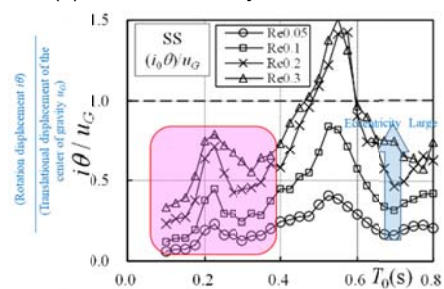
Figure 2 How the ceiling is shaken

Since the ceiling is attached to the structural frame, it is not shaken by seismic motion during an earthquake; rather, it is shaken by the vibration of the structural frame (Figure 2). To check these differences in the ways of being shaken, examinations were conducted while comparing vibrations caused by seismic motion and the vibrations caused by structural frames. As a result, the study found that the ratio between the torsional (rotational) displacement to the translational displacement of the center of gravity was smaller in the latter under a certain condition (Figure 3). This means that the torsional response hardly occurs in the ceiling.

Conditions of a well-balanced arrangement are going to be continuously clarified in the next fiscal year by repeating examinations.



(a) When shaken by seismic motion



(b) When shaken by the vibration of structural frame

Figure 3 Ratio of torsion (rotation) displacement

[symbol]  $i$ : rotation radius,  $\theta$ : rotation angle,  $u_G$ : translational displacement of the center of gravity,  $T_0$ : natural period without eccentricity, Re: eccentricity ratio

For more information:

1) Tadashi Ishihara: An observation concerning the torsional response during earthquake in secondary system: The 15th Japan Earthquake Engineering Symposium. December 2018