Shaking Table Test on Seismic Performance of Ceiling without Braces and Artificial Spacing to Surrounding Object

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Summary

A ceiling without artificial spacing to surrounding object ("non-clearance ceiling") is a kind of suspended ceiling, which uses walls, beams or other surrounding objects to support the seismic force of the ceiling. Some previous studies reported that larger gaps between the ceiling and the surrounding objects cause a larger collision force for the ceiling.

In this study, a shaking table test was carried out to investigate the seismic performance of the non-clearance ceiling. The main parameters of the tests are the type of the surrounding objects (beam or light gauge steel wall), axis of the ceilings, gap width and the scale of the input earthquake waves.

Keywords: suspended ceiling; plaster board; light gage steel wall; earthquake response, collision, shaking table test.

1. Introduction

A large number of suspended ceilings collapsed during strong earthquakes such as the Tohoku earthquake in 2011. Suspended ceilings are composed of light gauge steel furrings and plaster boards (see figure 1).

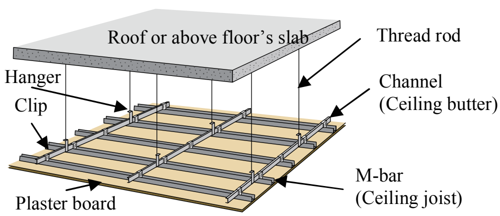


Figure 1: Typical Japanese ceiling system

The non-clearance ceiling which uses walls, beams or other surrounding objects to support seismic force of the ceiling is a kind of seismic designed ceiling on which several studies have been made. In order to avoid heavy collisions between the ceiling and surrounding objects under seismic excitation, it is very important to ensure contact between the edges of the ceiling and the surrounding objects. In this paper, the non-clearance ceilings are investigated by focusing on

i) the influence of the gap on seismic response and collision of the ceiling

ii) testing the new method to make the gaps zero.

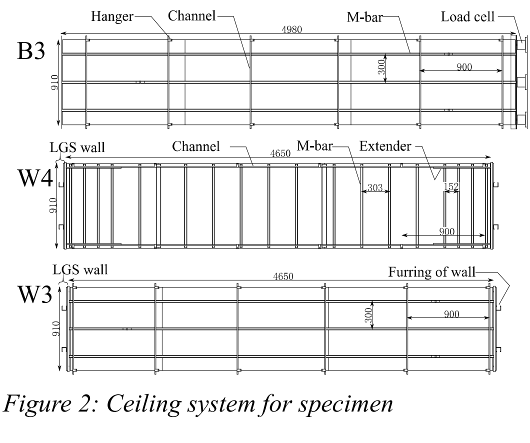
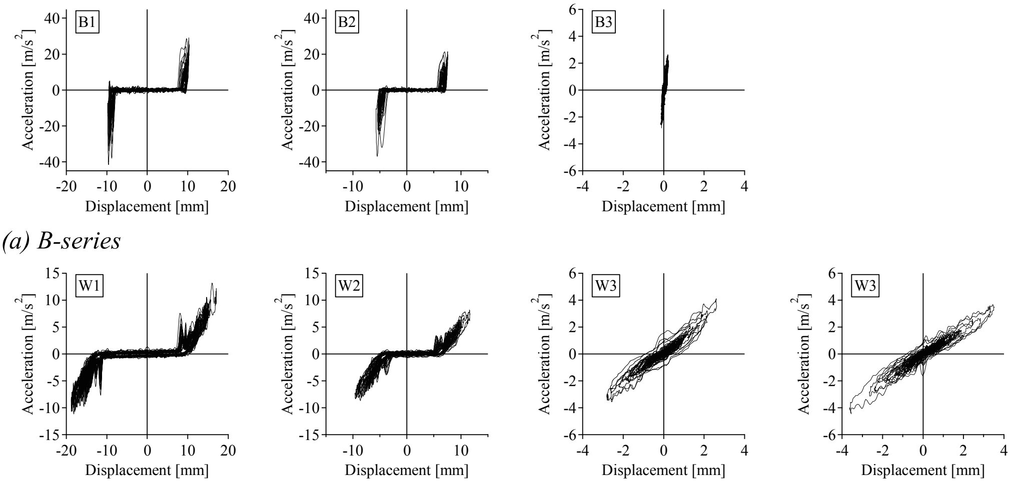


Figure 2: Ceiling system for specimen



(a) B-series

(b) W-series

Figure 3: Hysteresis curve

2. Outline of Shaking-Table-Test

Figure 2 shows the shape of some ceiling specimens. Specimens B1 and W1 had gaps of 10 mm between the edges of the ceiling and the steel beams or the LGS walls on each side. Specimens B2 and W2 had 5 mm gaps. Specimens B3, W3 and W4 had the edges of the M-bar or channel touching the steel beams or LGS walls (i.e. no gap).

3. Outline of Test Results

Figure 3 shows the relationship between the acceleration and the displacement of the centre of the ceiling under Kobe L1 input. The acceleration of B-series specimens shows a sudden increase and a peak larger than that of W-series specimens with the same gap. The peak acceleration of the specimen of larger gap is larger in both B-series and W-series.

The zero-gap ceiling like the specimen B3, W3 and W4 also has collision like the specimens that have some gaps. The axial deformation of the ceiling and the deformation of the wall make the gap on the other side of the ceiling. This temporary gap causes collisions when the displacement turned over. The acceleration of the ceiling is smaller than that of the specimen with permanent gap.

4. Conclusion

The shaking table test of non-clearance ceiling was carried out focusing on the influence of the gap between the edge of the ceiling and the surrounding beam or wall. The followings conclusions can be drawn from this experiment.

1. Non-clearance ceiling shows no damage under Level-2 earthquake input.
2. The acceleration of the ceiling had two peaks – at the moment of collision and at the moment of maximum deformation.
3. Ceilings with lesser gap show lesser response acceleration.
4. Zero-gap ceiling, M-bars or channels of which touch on the beam or LGS wall shows lesser acceleration than that of the ceiling with gaps.
5. LGS wall collapsed under level-2 input. These walls should be designed to be safe for forces from the ceiling.