QUANTITATIVE EVALUATION FOR INFLUENCE OF ECCENTRICITY TO DESIGN ASYMMETRIC HOUSING STRUCTURE WITH FLEXIBLE RIGIDITY AT FLOORS

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ABSTRACT: Seismic behaviours of wooden frame structures built up by the Japanese traditional constructing way were considered. In this paper, seismic vibrations according to eccentricity of the structures are focused on. Target structure is adopted as the single story of wooden frame specimen which was examines through shaking-table tests at "E-defense" in Hyogo, Japan in 2011. Numerical case studies are carried out on the parameter modified models in this study. Seismic response evaluations are observed at the point of horizontal torsion motion of floor and shearing gaps between load resistant lines under un-satisfying rigid-floor condition. As a result, it is assured that "eccentricity ratio" could be adequately used adequately the index to estimate influence of unbalanced seismic vibration even if the floor stiffness is not regarded as being rigid.

KEYWORDS: Eccentricity, Asymmetry of structure, Flexible floor stiffness, Wooden housing

1 INTRODUCTION

A number of practical housing structures have eccentricity due to unbalancing in stiffness or weight localization, to a greater or less extent. Those are originated by imbalance of wall location in housing plan or second floor part in housing elevation. Eccentricity of structures causes torsion vibration when earthquake motion is acting on. In general structural design procedures, extent of eccentricity are estimated by considering the "index for eccentricity ratio" of designing buildings. Where, eccentricity ratio is the index defined under the assumption that the floor's stiffness can be regarded to be rigid enough. However, floor stiffness of most of wooden structures is hard to consider as being rigid and such a condition is really different from the designing cases for Steel or RC constructions.

In this paper, asymmetric models of wooden structures are investigated to consider effects of eccentricity of the model on seismic responses. Through those studies, floor stiffness of the structural model is considered for range from soft to rigid. Namely, "eccentricity ratio" of the structural model is re-examined to use an index for seismic response of unbalanced structure expanded to un-satisfying rigid-floor condition.

2 MODELING AND VALIDATION ITEMS

Target structural model is adopted as practically being examined on the shaking table. Testing specimen is full-scale wooden frame which has single-story and 2 x 3 spans. At first, parametric surveys are carried out for finding out adequate values of structural parameters of numerical model to reproduce seismic responses of examining wooden frame specimen.

Figure 1: Plan view of evaluative specimen

Figures 1 shows a pattern of wall arrangements of the testing frames used in the shaking table examination. The size of every diaphragm is designed as square of 3,640 x 3,640 [mm]. As seen in this figure, column supports are arranged at every corner of diaphragms, the longer-length direction (L) of 3 spans to stretch has 4 built-up column rows (L1, L5, L9 and L13). Foundations of this frame structure are not anchored to its basement, so that those bottoms of columns are made to slip under large seismic excitation.

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2.1 ANALYTICAL MODEL

As seen in Figure 2, analytical model are adopted multi-degree of freedom system and every mass is allowed two-dimensional horizontal motions. Each floor’s mass are concentrated at each lattice point (which column is located) intersecting on load resistant lines, and volume of each mass is distributed by its responsible floor area. Each floor’s mass are supported by column at the lattice point, and two-directional shear springs are located at those column positions.

Figure 2: Analytical model

2.2 CONSIDERING ISSUES

In this study, two kinds of cases of unbalanced model, eccentricity of weight and eccentricity of stiffness (or strength) are estimated (as shown in Figure 3). Extent of eccentricity is indexed by eccentricity ratio in both cases.

Figure 3: Conceptual diagram of case studies

2.3 COMPARISON OF ECCENTRICITY OF MASS AND STIFFNESS

Seismic response analyses are carried out for two kinds of eccentricity model. Figures 4 shows those two cases, (a) is corresponding to unbalanced strength and (b) is to unbalanced mass. As seen in those figure, shearing gaps between load resistant lines are likely to occur at the border part of changing mass. The maximum responses are almost same in the both cases if the eccentricity ratio ($R_{ey}$) is the same value.

Figure 4: Inter-story displacement (1F-2F)

2.4 INFLUENCE OF FLOOR’S STIFFNESS

Influence of the floor stiffness is also evaluated. Figures 5 shows those two cases, (a) is corresponding to unbalanced strength and (b) is to unbalanced mass. As seen in those figure, if a certain extent of value of stiffness at the floor could be gained, the maximum response is not much changed by changing the value of floor stiffness. And also, it is observed to be almost same in the both cases of the eccentricity source.

Figure 5: Inter-story displacement (1F-2F)

3 CONCLUSIONS

Asymmetric models of wooden structures are investigated in this paper to consider effects of eccentricity through numerical seismic response analyses.

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