SEISMIC ANALYSIS OF HYBRID MULTI-STORY LIGHT WOOD FRAMES IN CHINA

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ABSTRACT: The new edition of Chinese code for design of timber structures (GB50005), expected to be released in 2015, will permit light wood frame buildings (LWF) up to seven stories with (up to 3-storey wood frame structure on top of concrete, masonry or steel structures). This paper studied the seismic design of this type of hybrid structure. The seismic analysis of 12 various cases was conducted. Structural behaviour was investigated via the finite element software SAP2000. It was observed that the stiffness ratio of steel frame podium to the wood frames in most cases is less than 4, in which the base shear method can be used. In addition, suggestions to the design of steel and wood hybrid structures were proposed.

KEYWORDS: Seismic analysis, Hybrid wood structure, Multi-story light wood frames

1 INTRODUCTION

The new edition of Chinese code for design of timber structures (GB50005), expected to be released in 2015, will permit light wood frame buildings (LWF) up to seven stories with a maximum 4-story steel podium structure.

In this paper, hybrid model of upper wood frames and lower steel frames was studied since steel frames are quite popular and widely used in the real construction. Steel frames usually are more flexible than concrete. By using SAP2000, numerical model was developed to predict the seismic responses in this study. Hybrid structure of upper wood frames and lower steel frames with 12 various combinations were analyzed.

2 ANALYSIS METHOD

In SAP2000, all the wood-framed shear walls were simulated by a simplified equivalent model of lateral resistant element with three rigid beams and a pair of spring elements.

Base shear analysis method, response spectrum analysis method and linear dynamic time-history analysis method were conducted to investigate the structural behaviour.

2.1 DESCRIPTION OF HYBRID BUILDING STRUCTURES

The index building plan layout is 9.6m wide by 13.2m long with upper wood frames and lower steel frames. Two types of shearwalls are designed as SW1 and SW2 with openings. Various combinations of steel podiums and upper wood frames were designed. They are: 1+1, 1+2, 1+3, 2+1, 2+2, 2+3, 3+1, 3+2, 3+3, 4+1, 4+2 and 4+3.

2.2 FINITE ELEMENT MODELLING (FEM)

All materials are assumed to behave within the elastic range. 12 FEM were developed in SAP2000 with the methods above (See Figure 1).

Figure 1: FEM of 12 combinations

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2.3 SEISMIC ANALYSIS

In this study, the building rotation was not considered in the analysis. The proposed hybrid structures were analyzed with base shear method, response spectrum analysis and dynamic time-history analysis, respectively. The analysis results were compared to show the difference between different methods and to verify the simplified methods applicability.

3 ANALYSIS RESULTS

The stiffness ratios and the mass ratios of steel frames to wood frames and period ratios of the entire structure to the upper wood frame structure were investigated.

The displacement at the top of the entire structure, the displacement at the top of steel frames, the maximum inter-story drift and the shear force at the bottom of the wood frames were also analyzed.

4 DESIGN SUGGESTION

For hybrid structures with one-story steel frame podium, the response spectrum method is recommended. For all the rest hybrid structure types, base shear method is acceptable to evaluate the shear force as initial engineering design.

When the lower steel frames are going up to 4 stories, cross bracing systems between the steel frames are recommended to be used to improve the structural stiffness at a certain degree.

Steel and wood frame hybrid structures basically perform well on the displacement.

For the same number of stories of wood frame structures, when they are combined with a steel frame podium, the shear force on the bottom of the wood frame structures are increasing with the increase of the lower steel frame stories.

The assumption of rigid diaphragm is acceptable. Study suggests that there is no obvious difference in base shear with rigid and flexible diaphragm assumptions.

5 CONCLUSION

12 different hybrid combinations were investigated in this paper via SAP2000, which indicated that hybrid structure of steel and wood frames basically could be designed by simplified methods of base shear and response spectrum. This will make the engineering work more efficient and easy to deal with the seismic analysis. In addition, when the lower steel frame podium goes up to 4 stories, cross bracing system is recommended to improve the rigidity.

REFERENCES