Application of hybrid simulation on evaluating seismic performance of zonal hanging curtain wall system under vertical earthquake action

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Motivation and Overview

- ➢Utilizing hybrid simulation to investigate the vertical seismic performance of zonal hanging curtain wall (CW) system of Shanghai Tower;
- ➢Develop the performance based seismic design method for CW system;

Shanghai Tower is the tallest high-rise building in China with a height of 632 m (showed in Fig. 1). Its exterior curtain wall (CW) system adopts the flexible zonal hanging system, which is hung to the suspension beam of strengthening story vertically by sag rods as Fig. 2. In this investigation, the hanging CW system of zone 8 was chosen as analyzed object, the 3D model was simplified into 2D model, as shown in Fig. 3.

Fig.1 Shanghai center tower

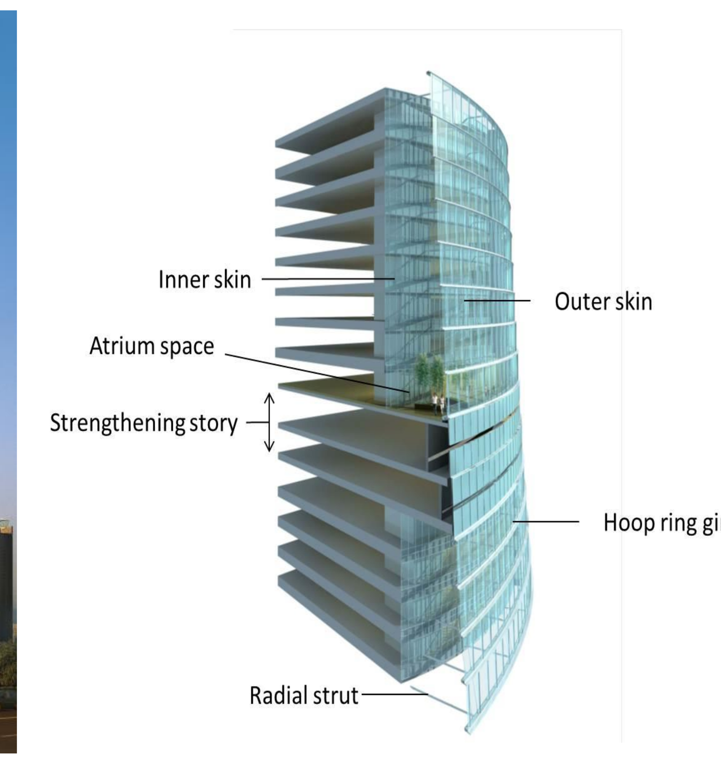

Fig.2 Typical zone section of CW system

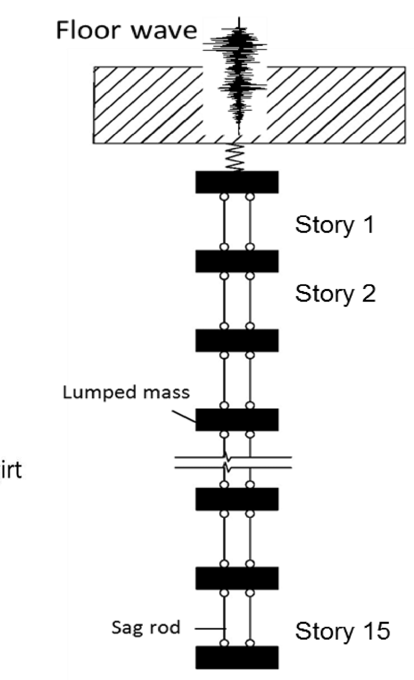

Fig.3 Simplified 2D model

Analytical study

- ➢Factors: dynamic property of main structure; stiffness ratio between suspension beam and sag rod(β), installation position and dynamic characteristics of CW system;
- ➢Analytical object: CW system of zone 8;
- ➢Determine the most serious conditions: floor wave from US1213 as input; β=0.1; test specimen for hybrid simulation is the uppermost sag rod (Fig. 4-7);

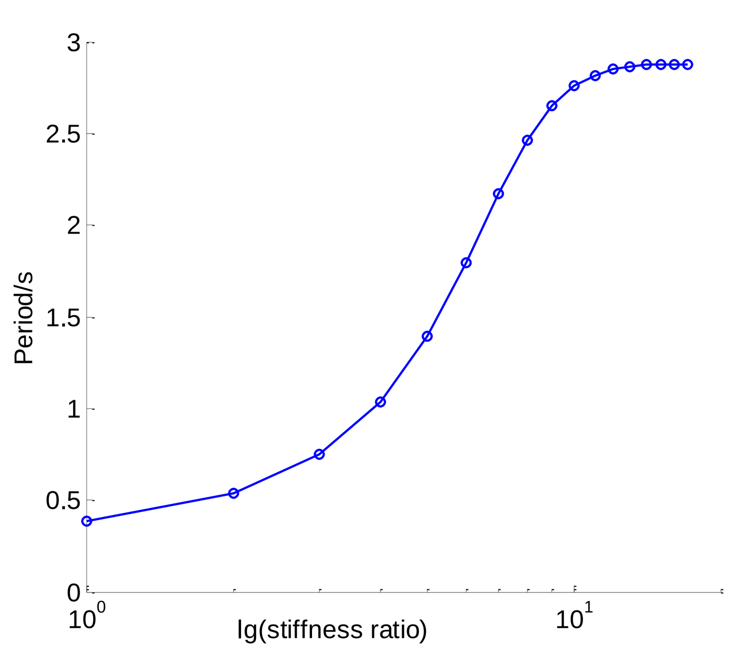

Fig.4 Period of CW system under different stiffness ratio

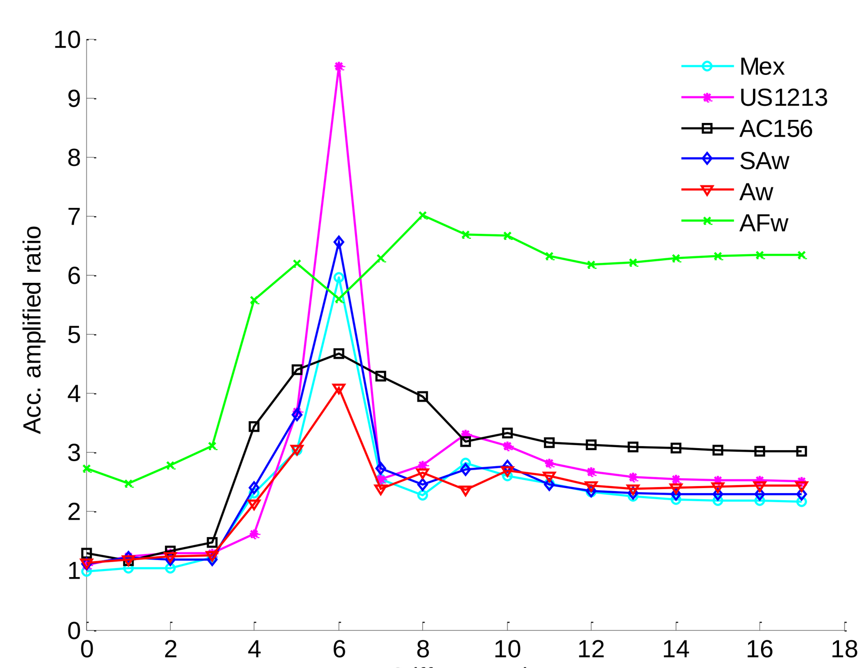

Fig.5 Envelope AAI of each stiffness ratio under different input

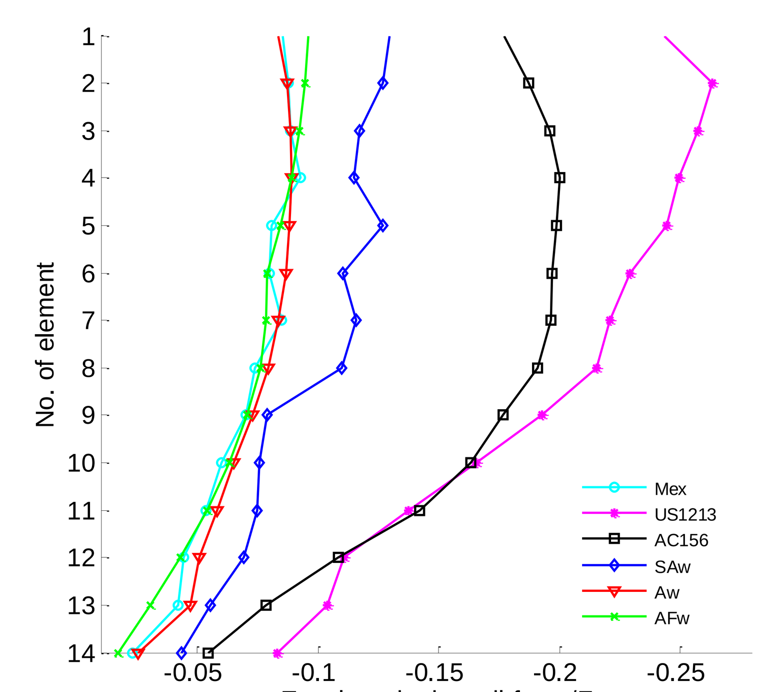

Fig.6 Envolope min. axil force/Fy under diff. input

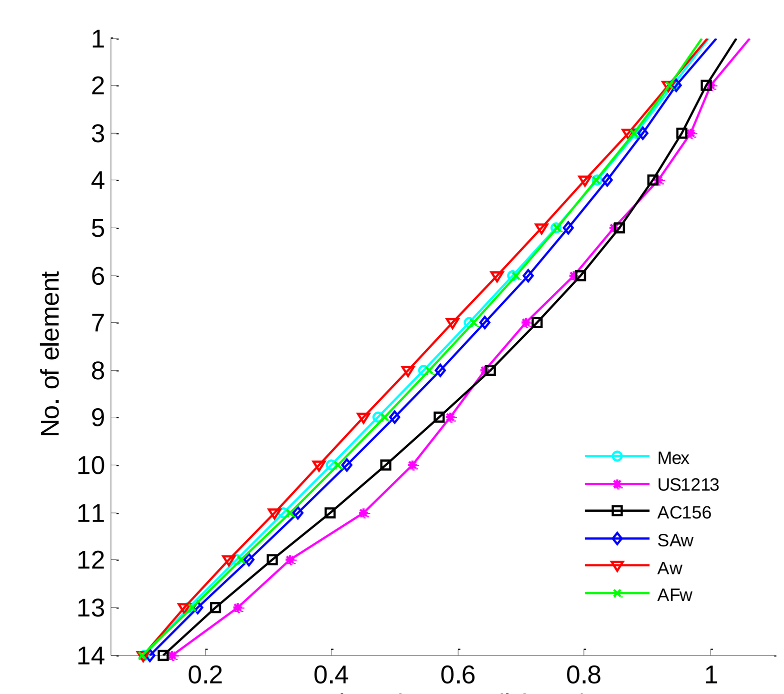

Fig.7 Envelope max. axil force/Fy under diff. input

Hybrid Simulation Test

- ➢ Testing system: OpenSees and OpenFresco system in University of California, Berkeley (as Fig. 8).
- ➢Test specimen: 1/13 scaled steel rod with the same slenderness;
- ➢Test input: floor wave from US1213 with basic and rare intensity 7;
- ➢Test result: specimen buckled during the test and broke in rare intensity 7 (as Fig. 9);

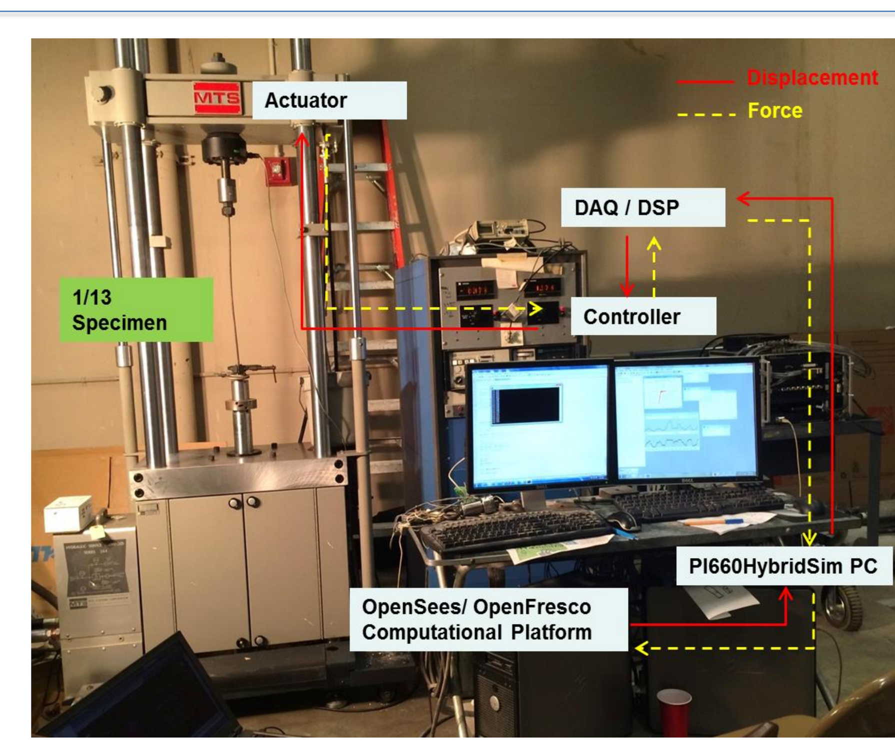

Fig.8 Hybrid simulation system utilized in the test

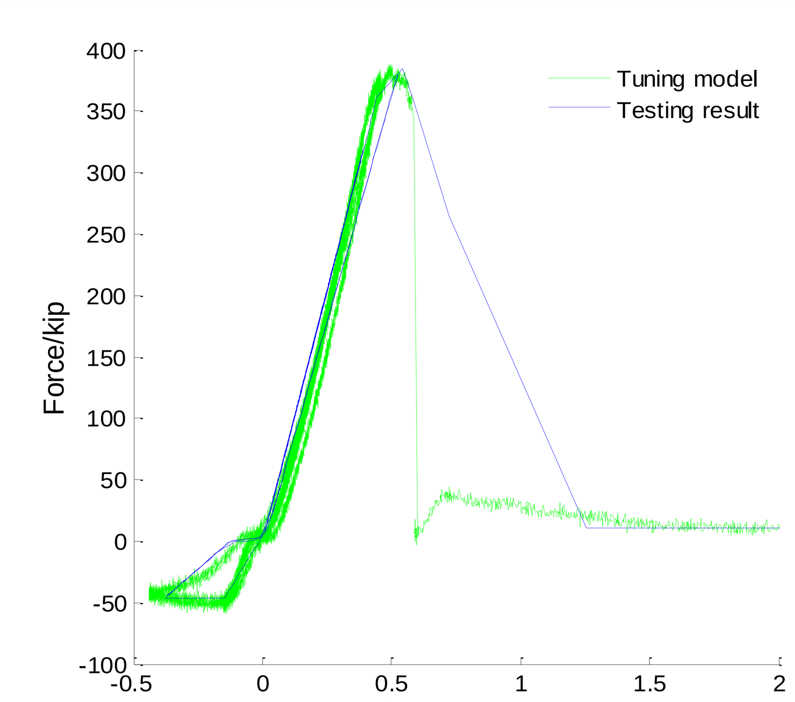

Fig.9 Force-deformation relation ship of test specimen

Future work

- ➢Perform parameter study with tuning model;
- ➢Conduct hybrid simulation of 3D model in Tongji University (as Fig.10);
- ➢Develop the performance based seismic design method for CW system;

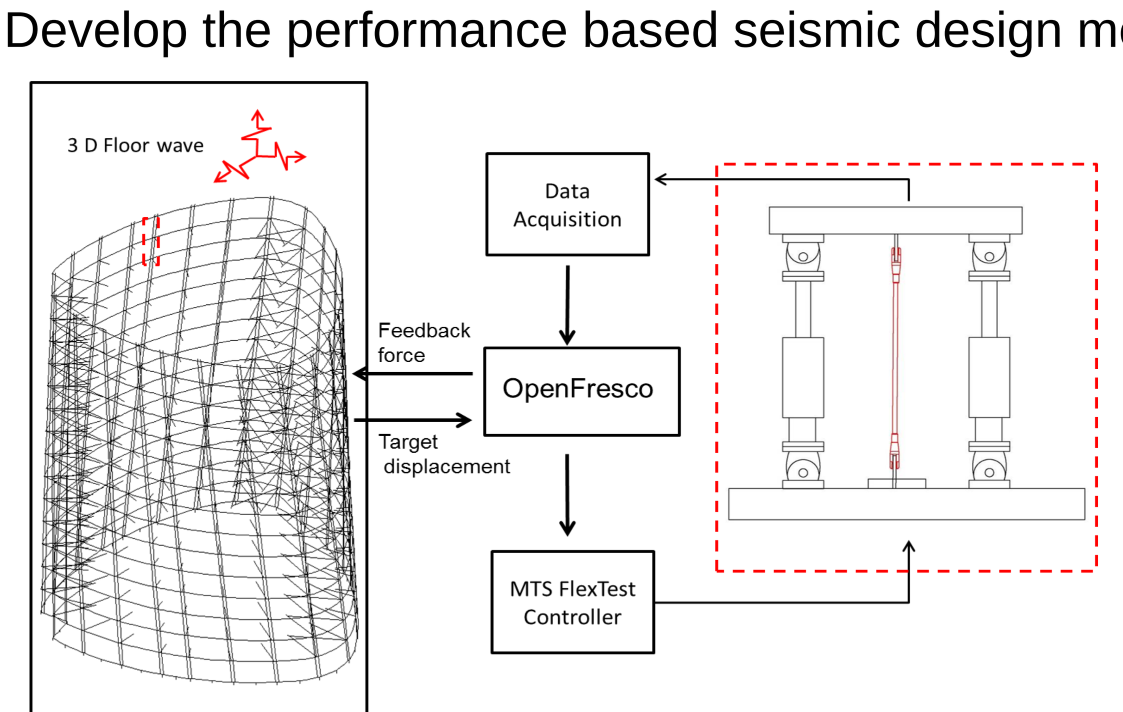

Fig.10 Schematic Hybrid simulation system for 3D model test in Tongji University

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