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RESEARCHES ON PUSHOVER ANALYSIS METHOD OF MASONRY STRUCTURES WITH FRAME-SHEAR WALL AT THE BOTTOM

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ABSTRACT

The masonry structures with frame-shear wall at the bottom have their own characteristics of elasto-plastic performance. The pushover analysis method is introduced and the horizontal displacement-pattern and load-pattern are studied. The inverted-triangular distribution pattern, uniformity distribution pattern and combination of the two patterns are adopted in pushover analysis method of this structure.

Keywords: masonry structures with frame-shear wall at the bottom; horizontal load-pattern; horizontal displacement-pattern; pushover analysis

INTRODUCTION

Masonry structures with frame-shear wall at the bottom are widely used in the frontage buildings because of their convenience and economy. But the seismic performance of this type structure is weak due to the excess lateral stiffness difference of bottom and upside. It is shown that the seismic performance of this structure are not only determined by each anti-seismic capacity of bottom and upside, but also determined by the lateral stiffness ratio and anti-seismic capacity matching extent of bottom and upside structures (Zheng and Xue, 2004). Pushover analysis is becoming a popular tool for seismic performance evaluation of existing and having been designed structures. The basic procedures of pushover is to hold fixed vertical load, apply predetermined lateral loads patterns or displacement patterns distributed along the vertical side. As the lateral loads or displacement increases continuously, the elements will be in a plastic state. Under the intense earthquake, the structure will yield and the natural vibration period and inertia force will change, so any lateral loads patterns can not completely reflect the deformation and force of the structure. Many domestic and international scholars (Yang et al., 2000; Yin et al., 2003; Helmut Krawinkler and G.D.P.K, 1998; Wei and Feng, 2002; B.Gupta et al., 2002) have played a lot of researches on the merit and shortcoming of pushover analysis method.

The gradual increase of lateral loads or displacement along the vertical side is called level load-pattern or displacement-pattern. The level load-pattern is obtained by normalizing the top floor force equal to 1.0 and the level displacement -pattern is obtained by normalizing the top floor displacement equal to 1.0.

The study of paper (Li et al., 2005) indicates that displacement-pattern is more completely to reflect

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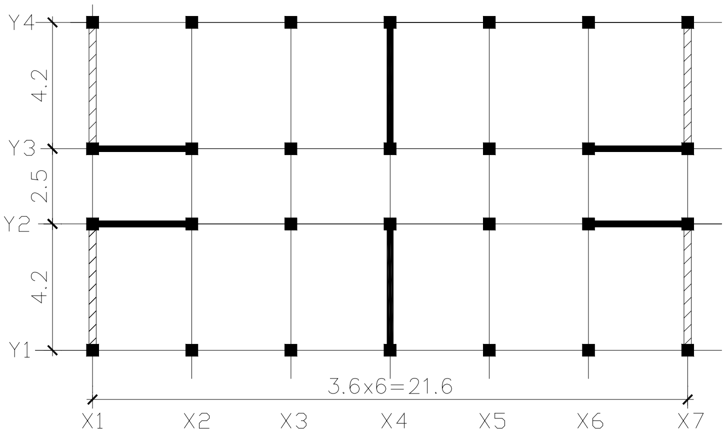
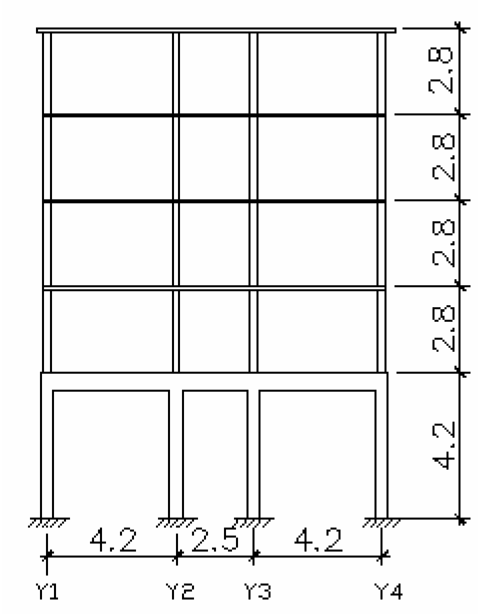
the inelastic displacement of frame structure than force-pattern ender different intensity earthquake. The lateral load-pattern has great influence on the results of pushover analysis in paper (Xiong and Qi, 2001). Nonlinear static and dynamic time history analysis are used to assess the seismic response in this paper by CANNY (Li, 2002) program. The load-pattern and displacement-pattern are studied in order to adopt more reasonable approach to analyze the seismic performance of this type structure.

CASE STUDY AND ANALYSIS METHODS

A case study has been carried out to analyze the force and deformation characteristics of this type structures. The structure plane and section is shown as in Fig.1. Earthquake fortification intensity is 70(0.15g), Ⅱground. The thickness of reinforced concrete shear wall at first story is 200mm, frame column dimension 450×450mm, X-direction beam dimension 300×550mm, Y-direction beam dimension 300×600mm, concrete property C30. The thickness of brick masonry stories is 240mm, brick property MU10, mortar property M7.5. The seismic response of such building are presented under the El Centro(NS), Kobe（NS）、Taft（NS）excitations by dynamic time history analyses. The earthquake intensity include minor level, moderate level and major level of earthquake ground motions (corresponding Earthquake acceleration 0.055m/s2、0.15 m/s2、0.31 m/s^2).



(a) Plane of first story



(b) Section

Figure 1. Structure configuration.

The inverted-triangular distribution pattern, uniformity distribution pattern and combination of the two patterns are adopted in pushover analysis method of this structure. And the results are compared with the outcome of time history analyses. The combination scale of inverted-triangular and uniformity distribution pattern is 1:1. The three distribution patterns are shown as in Fig.2.

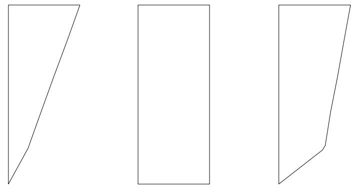


Figure 2. Three distribution patterns.

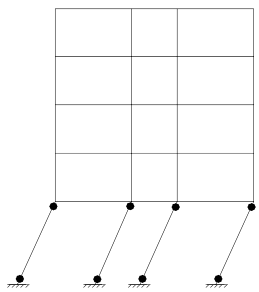
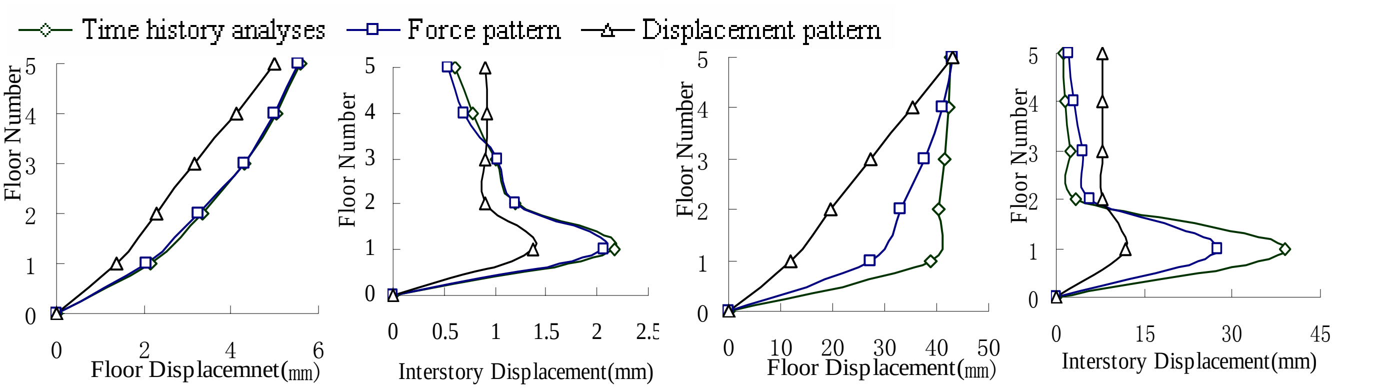


Figure 3. Column yielding mechanism.

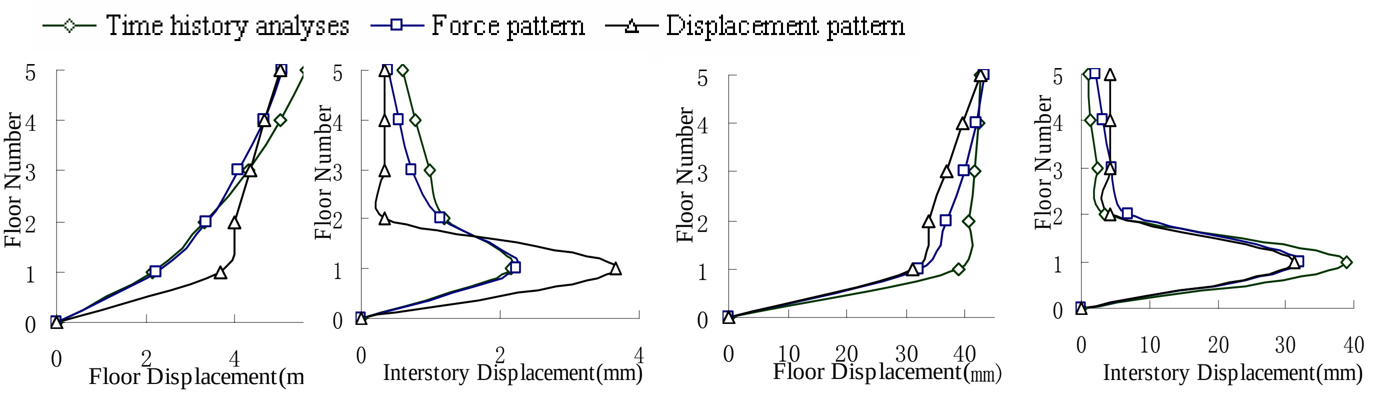
ANALYSIS RESULTS

The comparison of force-pattern based pushover and displacement-pattern based pushover have shown as in Figs.4, 5, and 6. The case analysis reveals that the results of force-pattern based pushover is very near to the response of time history under moderate level earthquake, and the results of major level earthquake is also same to moderate level earthquake. The force-pattern based pushover results are more close to the time history than displacement-pattern based pushover results, but the displacement of first story is smaller.



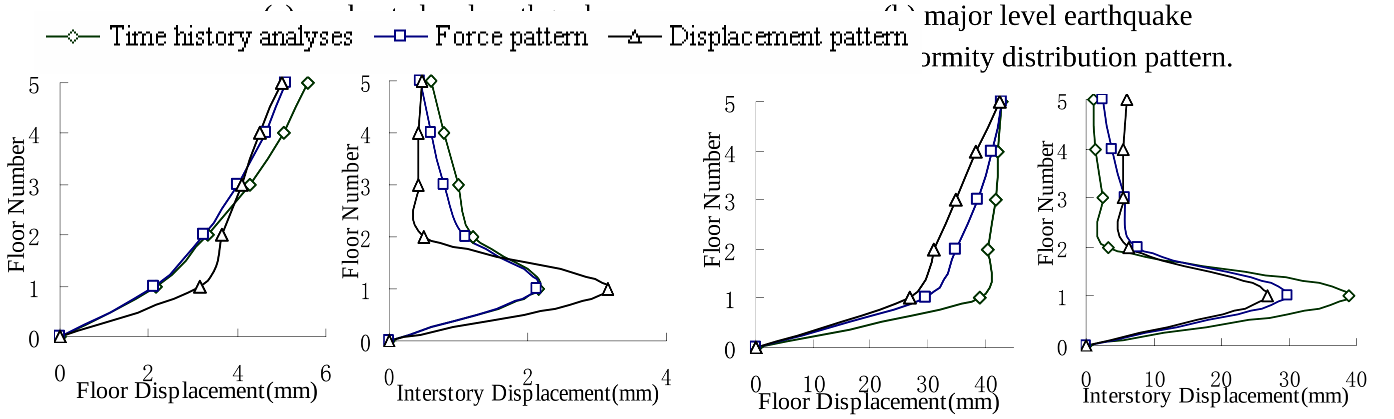
(a) moderate level earthquake (b) major level earthquake

Figure 4. Comparison of three analyses methods with inverted-triangular distribution pattern.



major level earthquake

ɔrmity distribution pattern.



(a) moderate level earthquake (b) major level earthquake

Figure 6. Comparison of three analyses methods with combination of inverted-triangular and uniformity distribution pattern.

The three distribution force-patterns pushover response and comparison to time history results are shown as in Fig.7. The analyses results indicate that inverted-triangular distribution pattern is close to time history results. The reason is that the first story is become a yielding mechanism(As in Fig.3), but the stiffness of upper stories decrease little. The floor force of upper stories is close, so the uniformity distribution pattern is more close to the force and deformation characteristics.

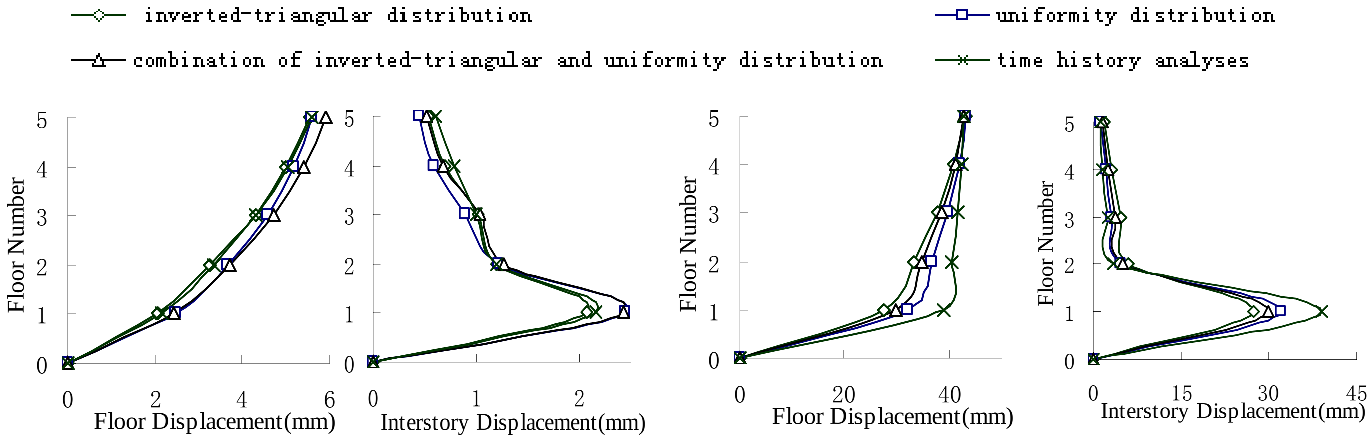


Figure 7. Comparison of three force-pattern pushover analysis to time history analysis.

CONCLUSIONS

(1) The first story lateral stiffness of masonry structures with frame-shear wall at the bottom is relatively little and the interstory displacement is great. On the contrary, the responses of upper stories are smaller. The force-pattern based pushover analysis of this type structure is better than displacement-pattern based pushover and is easier to reflect the structure force state.

(2) In different force-pattern based pushover analysis, the displacement responses of inverted-triangular distribution pattern are closer to time history analysis under moderate level earthquake, as the earthquake intensity increases, the plastic performance of first story is serious and the floor force of upper stories are becoming uniform distribution.

(3) The results of uniformity distribution pattern pushover analysis is relatively larger. The uniformity distribution force-pattern is suggested to be adopted of this type structure pushover analysis.

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