Study on deformation of frame-shear structure under earthquake action

Bo Li

School of Architecture Engineering, Binzhou University , Binzhou 256600, China

alibo20070025@126.com

Abstract: Earthquake disaster is one of the most serious natural disasters at present，The study of the deformation mechanism of the high-rise frame shear wall structure under the earthquake action is beneficial to the prevention of structural damage and collapse. In this paper, a 18 story frame shear wall structure is taken as the research object. It uses the ABAQUS finite element software to establish the numerical analysis model. 4 ground motions which are consistent with the statistical significance of the large earthquake design spectrum are selected, and the dynamic time history analysis of the structure is carried out. The results show that the beam is damaged firstly at the top of the beam. The shear wall limb is first destroyed at the bottom of the structure，When the structure is designed, the reinforcement of the top beam and the bottom of the wall should be strengthened so as to improve its seismic performance.

Keywords: Frame shear wall structure； Ground motion；Interlayer displacement angle；ABAQUS

1. INTRODUCTION

Since twenty-first Century, China's construction and building structure will be the first in the world, and its structural form is varied. The most common one is reinforced concrete structure. While the frame-shear wall structure has strong stiffness and good seismic ductility. Compared with the frame structure, the frame-shear structure has a better seismic performance. Due to this kind of structure mainly produces shear-moment deformations. Besides, it has a better flexural rigidity than the frame structure, and it is the main structure of the reinforced concrete structure. And earthquake is one of the main natural disasters that human beings are facing at present. Over the past 10 years, earthquakes continue to occur throughout the world. Such as the Richter 7.0 earthquake in Haiti, Richter 8.8 earthquake in Chile, Richter 9.0 earthquake in Japan, Richter magnitude 7.8 earthquake in New Zealand and so on; In China, nearly 70,000 people were killed and 20,000 were missing in Wenchuan 8.0 earthquake on May 12, 2008; On February 24, 2011, an earthquake measuring 7.1 on the Richter scale in Yushu, Qinghai Province caused as many as 3,000 deaths and 270 missing persons. On April 20, 2013, 196 people were killed and more than 10,000 were injured in the magnitude 7.0 Lushan earthquake in Sichuan Province. After the earthquake investigation, the casualties of the earthquake were mainly due to the collapse of the house structure. Therefore, the study of deformation mechanism of high-rise frame-shear structures under earthquake action is helpful to prevent structural failure and collapse. This paper mainly uses ABAQUS finite element software to establish a frame-shear wall structure finite element model for numerical simulation. Then the deformation behavior of the first line of defense beam and the most important anti-side member shear wall under structural earthquake is analyzed.

2. COMPUTATIONAL MODEL

Referring to the model given by the third reference, a high-rise reinforced concrete frame shear wall structure is selected for analysis in this paper. The number of floors is 18 above ground, the first layer is 4.5 meters, and the remaining layers are all 3.6 meters high, with a total height of 65.7 meters. The building of choice for this article is located in a Category II venue. Structure fortification intensity is taken as 8 degrees, and the earthquake grouping is the first group. Besides, in accordance with China's "Code for the design of building structures" to carry out the corresponding seismic design, The aseismic grade of the shear wall and the frame are all first class. The constant load of all layers was $8.0kn/m^2$, the uniformly distributed live load was $2.0kn/m^2$. The longitudinal reinforcement of the frame column and the edge of the shear wall is HRB400. The frame beam, the longitudinal reinforcement of the continuous beam and the shear wall are used in the HRB335 grade. The reinforcement ratio of the vertical and lateral distribution of shear wall is 0.3%. The stirrup is HPB235. Details of the dimensions and reinforcement information of the structural components are described in Table 1. In this paper, the finite element software ABAQUS is used to analyze and calculate. The wall and the connecting beam are modeled by the shell element S4R. The wall and the dark column are simulated by B31. Frame beam, the longitudinal reinforcement in the frame column and the end column in the wall column, the longitudinal reinforcement in the dark column is simulated by the beam element B31; Concrete is used

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ABAQUS own damage plastic model，the 18-story frame shear finite element model shown in Figure 1 [3].

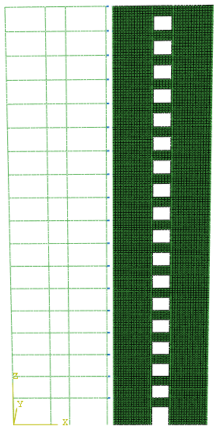

Fig.1 Finite element model of frame-shear wall structure

Table1 18-layer structure reinforcement area table

Layer number		1-3	4-9	10-18
Wall thickness(mm)		360(C40)		360(C35)
Wall dark column longitudinal reinforcement(mm^2)		2592	1440	1440
Wall end column section (mm×mm)		600×600(C40)		600×600(C35)
Wall-side columns reinforced on each side(mm^2)		1028		1028
Frame column section (mm×mm)		700×700(C40)		700×700(C35)
Frame columns are reinforced on each side(mm^2)		1400		
Frame beam section (mm×mm)		300×700(C30)		
Frame beam reinforcement(mm^2)	up	1000		
	down	1000		
Cross section of beam(mm×mm)		360×1500(C30)		
Reinforcement of continuous beam(mm^2)	up	2160		
	down	2160		

Notes: The reinforcement area of the column and the side column of the frame column is the same, ahe area of the reinforcement of the middle beam and the side beam is the same.

3. THE CHOICE OF GROUND MOTION

The uncertainty of the calculated results is greatly influenced by the ground motion. According to the provisions of the code for seismic design of buildings in China, The selected ground motion should be in accordance with the site category of the building structure. What's more，the shear wave speed should also be consistent. Accordingly, based on the II class site category and its shear wave velocity is within the range of 250~500m/s2, this paper selects 4 ground motions from the American Pacific seismic data center (PEER) to meet the statistical significance of the response spectrum of the standard frequency design. The parameters of the ground motion are shown in Table 2. The ground motion recording acceleration time history curve is shown in Figure 2. And according to the aseismic design standard (GB50011-2010), the time history analysis of different seismic fortification level is carried out with the maximum value of seismic acceleration time. As shown in formula (1).

$$\dot{a}(t) = a(t) \bullet \dot{A}_{\max} / A_{\max} \quad (1)$$

where: $\dot{a}(t)$, $\dot{A}_{\max}$ represente the adjusted acceleration curves and peaks, respectively；for rare earthquakes , $\dot{A}_{\max}$ is equal to 400cm/s^2 ; $a(t)$, $A_{\max}$ are the acceleration curve and peak of the original record, respectively.

Table 2 Ground motion records and ground motion parameters

Number	Seismological record name	Recording station	PGA(g)	PGV(cm/s)	PGD(cm)
N1	Chi-Chi , Taiwan 1999/09/20	TCU033	0.293	47.9	65.28
N2	Northridge 1994/01/17	90009 N. Hollywood - Coldwater Can	0.271	22.2	11.7
N3	Superstitn Hills(A) 1987/11/24	5210 Wildlife Liquef. Array	0.134	13.4	5.2
N4	Cape Mendocino 1992/04/25	89324 Rio Dell Overpass - FF	0.385	43.9	22.03

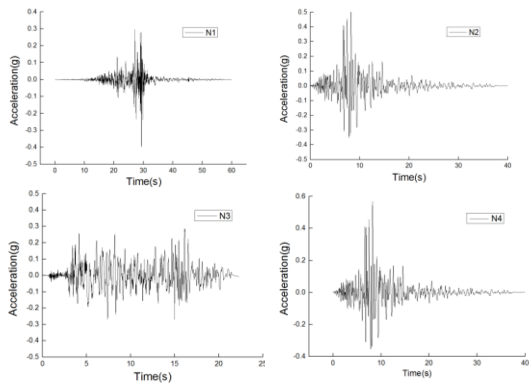

Fig.2 Acceleration curve of ground motion recording

4. RESULTS OF TIME HISTORY ANALYSIS

The 4 ground motions selected above are modulated. The dynamic time history analysis of the structure is carried out when the PGA reaches a large earthquake level (400gal). The calculated the end rotation angle of a continuous beam and the interlayer displacement of the wall are shown in Figure 3 and figure 4.

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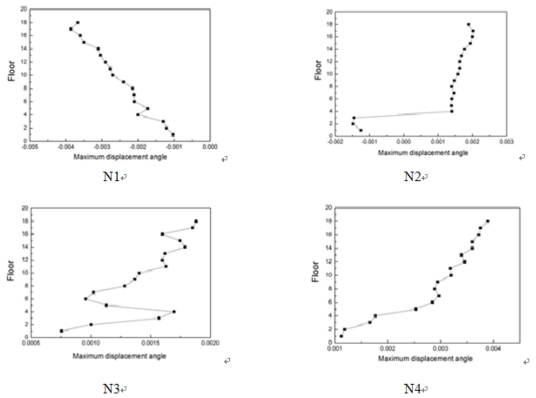

Fig.3 Angle of rotation at the end of a continuous beam

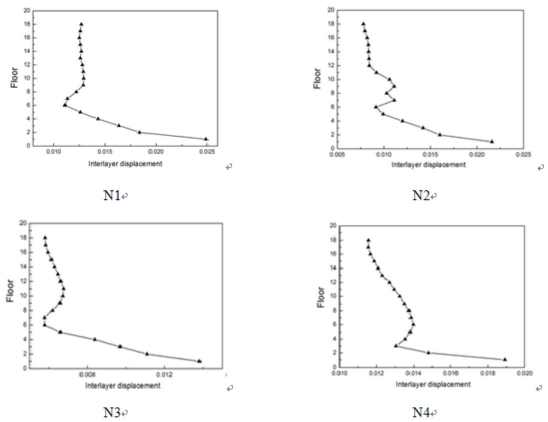

Fig. 4 interlayer displacement of shear wall

5. CONCLUSIONS AND SUGGESTIONS

Through the dynamic time history analysis of a reinforced concrete frame shear wall structure with 18 layers, it is known that for the high-rise frame-shear wall structure, under the earthquake action, the first line of defense for building earthquake resistance - continuous beam， the rotation angle of the beam at the top of the structure is the largest. Therefore, during the earthquake, the top beam at the top was the first to destroy. The interlayer displacement at the bottom of the shear wall limb (especially at the height of the bottom 1/10 structure) is obviously greater than that in the upper part of the wall. ; In large earthquakes, the structural damage occurred first at the bottom of the shear wall. Accordingly, in the structural design, the reinforcement of the upper beam of the frame shear wall structure should be strengthened. ， and it is necessary to improve its seismic performance. For shear walls, the reinforcement of the bottom of the wall should be strengthened so as to improve its seismic performance.

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