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Performance Evaluation of RC Framed Asymmetric Edifices Using N2 Method

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ABSTRACT: Due to change in technology and occupant needs, most of the edifices in recent times are asymmetric in nature. The behaviour of the asymmetric edifices is complicated when it is subjected to earthquake compared to symmetric edifices. Hence, for safety purpose, there is a need to study the complex behaviour of asymmetric edifices by conducting performance evaluation. In the present study the performance evaluation of four RC edifices is carried out using N2 method. An exertion is made to obtain the demand and capacity spectrum of these edifices. It was found that, just by changing ordination of column there is a huge variation in lateral load carrying capacity of the edifices and the performance of the edifices can be assessed by pushover scrutiny by studying the performance point, which is the intersection of demand and capacity spectrum.

KEYWORDS: N2 method, Pushover scrutiny, Pushover curve, Performance point, Demand spectrum, Capacity spectrum.

I. INTRODUCTION

In order to check how the existing and new edifices will behave when they are subjected to earthquake the engineers need to conduct the performance evaluation of edifices. The performance evaluation of edifices is carried out using linear and nonlinear procedures. Many of the researchers worked on performance evaluation of edifices and it has been realized that nonlinear pushover scrutiny is considered as a renowned performance evaluation technique. The performance of the edifices can be assessed by pushover scrutiny by studying the performance point, which is the intersection of demand spectrum and capacity spectrum [1]. In pushover scrutiny the demand spectrum obtained by earlier earthquake data, will be in single degree of freedom [SDOF] system and the capacity spectrum [2, 3] obtained by conducting the pushover scrutiny is of multi degree of freedom [MDOF] system. One of the main drawbacks of nonlinear pushover scrutiny is, the demand spectra is in SDOF system and the capacity spectrum is in MDOF system. In order to overcome this drawback Peter Fajfar and his team developed a new method for performance evaluation of the edifices which is known as N2 method [4, 5]. In this method both the capacity and the demand spectrums will be in SDOF system. In N2 method it is necessary to have a force displacement relationship of MDOF system which can be obtained by conducting pushover scrutiny with respect to centre of mass [6]. This MDOF system force displacement relationship is converted to force displacement relationship of SDOF systems [4, 5]. By using SDOF system, force displacement relationship, the capacity spectrum of SDOF system will be obtained. In case of symmetric edifices the displacements of all the joints and the centre of mass will be approximately same and there will be no torsional effect. But in case of asymmetric edifices the displacements of the different joints and at the centre of mass are different. Hence the behaviour of asymmetric edifices is complex as compared to symmetric edifices subjecting to earthquake [7] and they show torsional behaviour. In the present study an exertion is made to study the complex behaviour of

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asymmetric edifices which are subjected to lateral loads using N2 method. N2 method overcomes all the drawbacks of pushover scrutiny. The complex behaviour of asymmetric edifices is examined by studying the capacity curve and performance point.

II. RELATED WORK

BeenaKumari [2] has studied the reaction and load bearing capacity of RC frame using nonlinear finite element scrutiny under pushover loading. For the purpose of scrutiny she created model of 4 stories RC frame using software ATENA, which uses finite element analysis. She also compared scrutiny results with experimental results and the pushover curves achieved from finite element scrutiny agree in linear and nonlinear range with the experimental results. SharathIrappaKammar and Tejas D Doshi[3] studied the effect of irregularities on edifices which are subjected to earthquake forces using nonlinear static pushover scrutiny. To study the performance of edifices they considered plan irregular edifices with re-entrant corners with shear walls. They followed the procedure of pushover scrutiny as per ATC 40 & studied the irregularities as per IS 1893 – 2000. They conducted the nonlinear static pushover scrutiny using software SAP 2000. They used FEMA 356 to study the hinge properties. They came to know that as the load carrying capacity of edifices with shear wall increases, the base shear also increases and there is a reduction in displacements of the edifices with SW when compared to edifices without SW. They also saw that edifices with re-entrant corners are more liable to suffer from earthquake damages which are caused due to effect of torsion. Peter fajfar [4] conducted a research work to study the performance edifices under earthquake forces. He formulated N2 method in acceleration-displacement pattern. He used inelastic spectra instead of using elastic spectra. He also discussed the derivation of N2 method in his work. He also compared N2 method with the methods which are given in FEMA 273 & ATC 40 and later discussed differences and likeness between them.

III. RC EDIFICES CONSIDERED FOR SCRUTINY

A reinforced concrete framed edifices with the height 16 m (G+3) and with dimension of plan as 5 m X 5 m located in seismic zone 4 is selected for scrutiny purpose. The grade of concrete & steel used for construction of the edifice is M20 and Fe415 respectively. The edifices are located on hard soil and the thickness of slab corresponds to 130 mm. Since the edifices are located in seismic zone 4, as per IS 1893 (part 1): 2002 the zone factor is 0.24, importance factor is 1 and response reduction factor is 3. For scrutiny purpose, we selected 4 different edifices. The above specification is same for all 4 edifices. Fig. 1 shows the floor and roof plan of edifice 1.

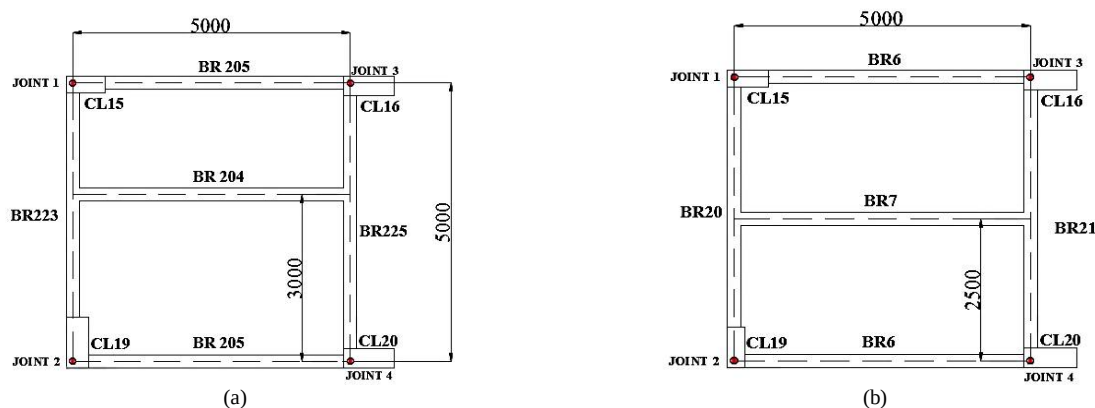


Fig. 1. Plans of edifice 1 (a) Floor plan (b) Roof plan

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Fig. 2 shows the floor and roof plan of edifices 2. The mass of the edifices 1 and 2 remains same and the only change is the orientation of the columns.

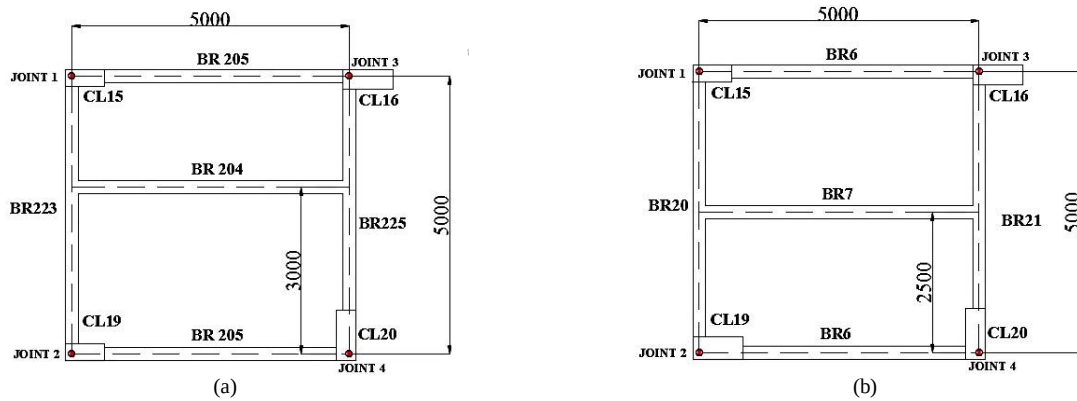


Fig. 2. Plans of edifice 2 (a) Floor plan (b) Roof plan

Fig. 3 shows the floor and roof plan of edifices 3. The mass of the edifices 1, 2 and 3 remains same and the only change is the orientation of the columns.

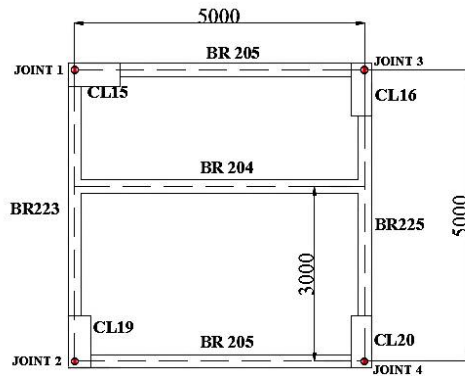


Fig. 3. Floor and roof plan of edifice 3

Fig. 4 shows the floor and roof plan of edifices 4. The mass of the edifices 1, 2, 3 and 4 remains same and the only change is the orientation of the columns.

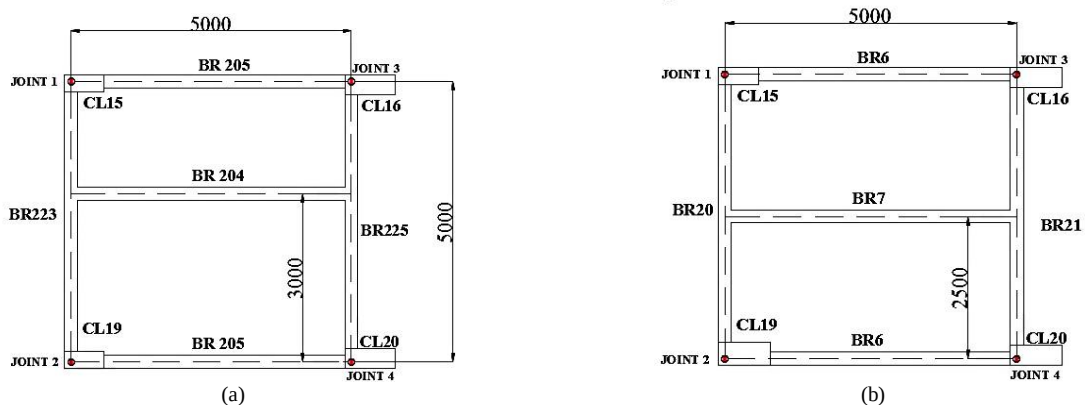


Fig. 4. Plans of edifice 4 (a) Floor plan (b) Roof plan

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In order to perform N2 method, two important things required are demand and capacity spectrum. The demand spectrum is taken from IS 1893 (part 1): 2002, which will be in SDOF system. The capacity spectrum is obtained from capacity curve of pushover scrutiny. To perform pushover scrutiny, the modelling of edifices is done using a software tool called ETABS version 16.0.3. This pushover scrutiny is done with respect to the centre of mass of edifices.

IV. EXPERIMENTAL RESULTS

By conducting a pushover scrutiny of the edifices we will get capacity curve, which is the plot between forces and displacements. The nonlinear behaviour of the building is understood with the help of pushover curve. Fig. 5 shows the capacity curves of edifices 1, 2, 3 and 4. In figure 8, the points 1, 2, 3 and 4 represent the yield points of the edifices 1, 2, 4 and 3 respectively. Up to yield point, no elements of the edifices yield. In edifice 1 we can see that till point 2 as the displacement increases force is also increasing. But beyond point 2 as the displacement increases force is decreasing. That is till point 2, no elements of edifice 1 yields completely. But beyond point 2 some of the elements of edifice 1 yield completely. In edifices 2, 3 and 4 as displacement is increasing force is also increasing. This means no elements of edifice 2, 3 and 4 yields completely.

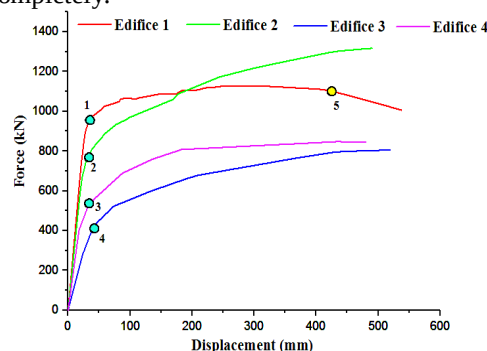


Fig. 5. Pushover curve of edifice 1, 2, 3 and 4

Fig. 6 shows the performance point of edifice 1. Usually the edifices are designed for a spectral acceleration (S_a) of 0.24 g in zone IV. This means that during earthquakes the edifices are subjected to a maximum acceleration of 0.24 g. But edifices may subject to more acceleration during earthquakes. In the present study the edifice 1 is designed for spectral acceleration of 0.24 g. But after scrutiny by seeing figure 6 edifice 1 can withstand much more spectral acceleration of 0.95g than it is designed. This means no elements of edifice 1 fails till acceleration of 0.95 g.

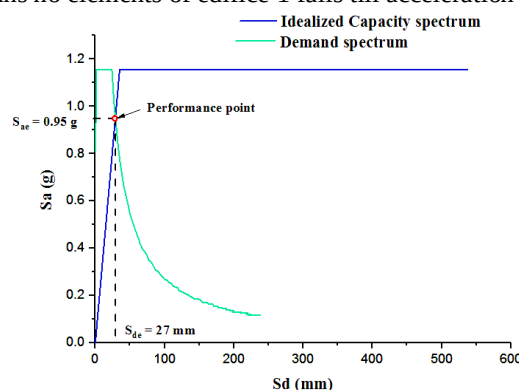


Fig. 6. Performance point of edifice 1

Fig. 7 shows the performance point of edifice 2. In the present study the edifice 2 is designed for spectral acceleration of 0.24 g. But after scrutiny by seeing figure 7 edifice 2 can withstand much more spectral acceleration of 1.09 g than it is designed. This means no elements of edifice 2 fails till acceleration of 1.09 g.

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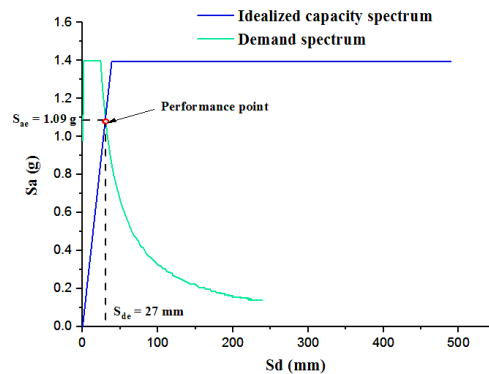


Fig. 7. Performance point of edifice 2

Fig. 8 shows the performance point of edifice 3. In the present study the edifice 3 is designed for spectral acceleration of 0.24 g. But after scrutiny by seeing figure 8 edifice 3 can withstand much more spectral acceleration of 0.54 g than it is designed. This means no elements of edifice 3 fails till acceleration of 0.54 g.

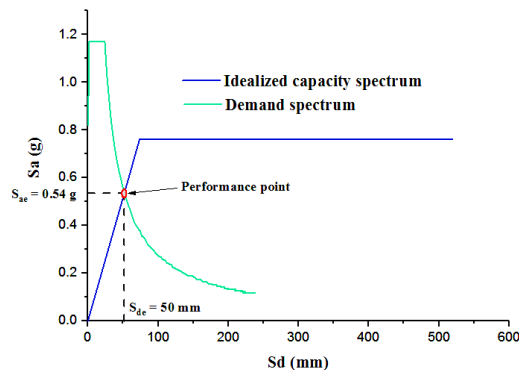


Fig. 8. Performance point of edifice 3

Fig. 9 shows the performance point of edifice 4. In the present study the edifice 4 is designed for spectral acceleration of 0.24 g. But after scrutiny by seeing figure 9 edifice 4 can withstand much more spectral acceleration of 0.8 g than it is designed. This means no elements of edifice 4 fails till acceleration of 0.8 g.

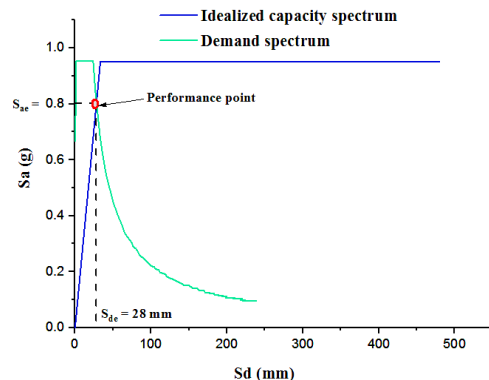


Fig. 9. Performance point of edifice 4

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V. CONCLUSION

From the scrutiny, it was found that just by changing the orientation of the columns there is huge variation in performance of the edifices. The lateral load carrying capacity of the edifices is very much dependent on the distribution of column stiffness.

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