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Moment Resisting Frame with Rubber Base Isolation for Development of Earthquake Resisting Structures

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ABSTRACT: *Structural analysis for a base isolated four storied moment resisting frame with elastomeric seismic isolation bearing has been studied using SAP2000 software. Dynamic analysis was performed for the moment resisting frame with base isolation and the results were compared with the results obtained for moment resisting frame without base isolation. The isolating elastomer is a rubber and its total stiffness is calculated to be 3169 kN/m. The spectral displacement for the first mode suffered by the isolated building was calculated using the response spectrum curve, and found to be 0.121 m/sec^2. The thickness of required rubber material is calculated to be 0.121 m, assuming 100% maximum shear strain. The analysis showed that the displacement in the frame has decreased when the base isolator is added. This means that the force transferred to the building is reduced due to the presence of base isolator. The frame with base isolator produced a shear of 71.79kN – a significant shear reduction of around 88%. Thus, using rubber elastomer for base isolation, it is possible to avoid large plastic deformation of moment resisting frame and reduce shear resulting from large scale earthquake.*

Keywords: *Seismic Analysis, Seismic Base Shear, Base Isolation.*

I. INTRODUCTION

Our intuition tells us “strengthen to resist damage”. But it is an illusion because when the foundation is rigidly fixed to the superstructure, the earthquake force will be directly transferred to the superstructure without any change in frequency resulting in heavy damage. In a base isolated structure the seismic protection is achieved by shifting its natural period away from the range of the frequencies for which the maximum amplification effect of ground motion is expected. In this way the input seismic energy introduction in to the structure is significantly reduced and consequently it is possible to avoid large plastic deformation and related damage phenomena due to non-linear response. In the base isolation strategy, at the same time it is possible to obtain a considerable reduction of large displacements attained at the base level as a consequence of the energy dissipation due to damping and hysteretic properties of isolation device. In simple words the basic concept in this approach is to uncouple a structure from the ground by interposing a flexible element/bearing between the structure and foundation. Many buildings have been constructed on some type of rubber bearings, and such structures have shown superior performance in earthquakes.

The system that has been adopted most widely in recent years is typified by the use of elastomeric bearings, the elastomer is made of either natural rubber or neoprene. In this approach, the building or structure is decoupled from the horizontal components of the earthquake ground motion by interposing a layer with low horizontal stiffness between the structure and the foundation. This layer gives the structure a fundamental frequency that is much lower than its fixed-base frequency and also much lower than the predominant frequencies of the ground motion. The first dynamic mode of the isolated structure involves deformation only in the isolation system, the structure above being to all intents and purposes rigid. The isolation system does not absorb the earthquake energy, but rather deflects it through the dynamics of the system.

II. DESIGN

The inclusion of base isolation means that a building is cushioned against the shocks of earthquakes. Instead of designing the building to resist high earthquake forces, the isolation system is designed to allow the building to stay more or less still while the ground moves underneath it in strong earthquakes. As a result the building need only be designed for much smaller forces. A seismic base isolator is a flexible support of a building, which should fulfill the following requirement:

- The material is stiff under low service loads like wind and small tremors.
- Period of vibration of the system is increased sufficiently so as to reduce the seismic force response.
- It should have the ability to with stand the large displacement and pulse-type base motions from near-fault earthquakes.
- It should have a parallel damping mechanism such that the relative deflection between the building and the ground is reduced.

To start with we have to calculate the load coming on the column. In this paper we have design the base isolation for the four storied moment resisting frame, when it is located in zone V. The frame taken for study was moment resisting frame with shear wall. Moment frames consist of beams and columns in which bending of these members provides the resistance to lateral forces. Moment-resisting frames are detailed to ensure ductile behavior of the beam-to-column joints and are normally used in zones of higher seismicity. It has 4 bay at a spacing of 5m in the X direction and 3 bay in the direction of Z at a spacing of 6m, 4.5m, 4.5, respectively. It has ground plus three stories. The height of the ground floor is 4.5m and the heights of the rest of the three floors are 3.2m each as shown in Figure 1.

III. ELASTOMERIC RUBBER BEARING

III. I Calculation of horizontal stiffness of the rubber:
The total horizontal stiffness of the rubber isolators is computed using single degree of freedom system equation,
Horizontal stiffness (K) was calculated using the below equation

$$K = 4 * \Pi * f\wedge 2 * \left[\frac{W}{g}\right]$$

From the above equation the total horizontal stiffness is calculated as 3169.01 kN/m

III. II Calculation of the thickness of the rubber:
The spectral displacement for the first mode suffered by the isolated building is calculated using the response spectrum curve for the given horizontal frequency and for the appropriate damping value and using the following expression.
Spectral displacement: S_d =Spectral displacement, S_a

$$S_d = \frac{Sa}{(2 * \Pi * f_n)\wedge 2}$$

S_a =displacement from response spectrum curve,
f_n =horizontal frequency.
The Spectral displacement was found to be 0.121 m / sec^2. The thickness of the rubber material of the isolator is evaluated using the allowable maximum shear strain permitted for the isolator. The allowable maximum shear strain for the isolator is taken as 100%.

Thickness of rubber = Sd / γ , Where, γ =Allowable maximum shear strain. Thickness of rubber was calculated to be 0.121 m. Once the thickness and shear modulus of the rubber are know, the area of the rubber

$$\mathrm{Ki} = \frac{G * A}{t_r}$$

material to produce the given amount of horizontal stiffness is calculated using the following expression.
Where Ki = Horizontal stiffness, G =Shear modulus of the rubber, A =Area of the rubber, tr =Thickness of the rubber. From the above formula the area is calculated to be 0.0247 m^2.

From the area calculated above the diameter (180 mm) of the rubber is calculated. Thickness of individual layer of rubber are calculated as below,

S = D / 4*t , t = 5mm.

Total number of layers = total thickness / individual layer thickness = 25 numbers

The shim thickness is generally taken to be not less than 2.54mm and not greater than 3.16mm. Therefore, thickness of the shim =3mm.The end plates are usually between 19.1mm and 38.1 mm. Therefore, thickness of end plate =25mm.

IV. DISCUSSION

Dynamic analysis is performed for the moment resisting frame selected with the base isolation. The response of the structure when base isolation is added to the structure is compared with the response of the structure without base isolation. The analysis of the structure with base isolation is performed with the use of SAP2000 package. The results are compared as follows.

- **Comparing the displacements:**

The fig 3 and 4 clearly shows that there is a change in the displacement of the frame. The displacement in the frame has decreased when the base isolator is added. This decrease in the displacement show that the force transferred to the building is reduced due to the presence of base isolator. When this happens then there will be a reduction in the requirement of reinforcement in beams and columns. In this way the input seismic energy introduced in to the structure is significantly reduced and consequently it is possible to avoid large plastic deformation and will reduce the reinforcement requirement and prove to be economical and safe.

- **Comparing the base shear:**

Base shear can be put in simple words as the horizontal component of the seismic shaking. The horizontal components of shaking are the most damaging to buildings because structures are already designed to withstand the vertical force of gravity. From the analysis performed for the frame with base isolator and without base isolator in SAP2000 the base shear results are taken. The frame with fixed base has a base shear of 618kN. The frame with base isolation has a base shear of 71.79kN. There is a decrease of 88.38% in the base shear when the structure with base isolator is compared with the structure without base isolator.

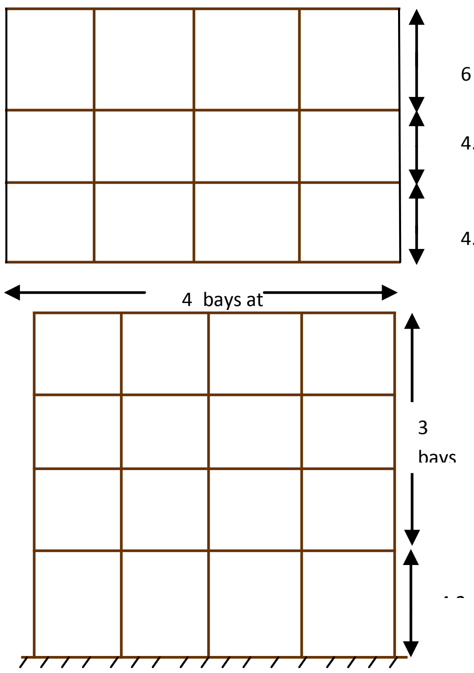

Fig .1 Plan and elevation of frame selected

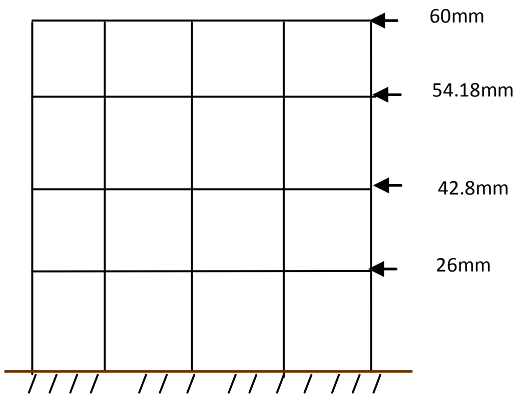

Fig. 2 Displacement of the frame without base isolation

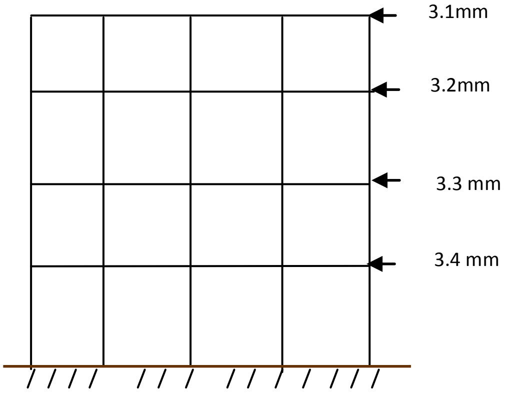

Fig. 3 Displacement of the frame with base isolation

V. CONCLUSION

Engineers realized the importance of keeping the superstructure stable while the foundation is being shaken by an earthquake. So there arises a need to design a system that puts this concept into practice. Along with many other engineers doing independent work in other countries, have produced a wealth of information about base isolators and have become common knowledge to structural engineers. By introducing base isolators the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure is considerably reduced. This concept has created a breakthrough in structural design and as years go by will prove to be a life-saving innovation of historic proportions.

REFERENCES

[1] Ahmed Ghobarah , Performance-based design in earthquake engineering: state of development, *Engineering structures, 23(8)*, 2001, 878-884.

[2] David J. Dowrick, *Earthquake Resistant Design For Engineers And Architects*, (John Wiley Heyden Publication)

[3] Elghazouli A.Y., Castro J.M. and Izzuddin B.A., Seismic performance of composite moment-resisting frames, *Engineering Structures*, 30(7), 2008, 1802-1819.

[4] James M. Kelly ,"Earthquake Resistant Design With Rubber", Springer - verlag London Limited.

[5] Javeed A., Munshi and Satyendra K. Ghosh, Analyses of seismic performance of a code designed reinforced concrete building, *Engineering Structures*, 20(7), 1998, 608-616.

[6] Mario Paz "*International Handbook Of Earthquake Engineering Codes, Programs And Examples*".

[7] Sadjadi R., Kianoush M.R. and Talebi S., Seismic performance of reinforced concrete moment resisting frames, *Engineering Structures*, 29(9), 2007, 2365-2380.

[8] Sean Wilkinson, Gordon Hurdman and Adrian Crowther, A moment resisting connection for earthquake resistant structures, *Journal of Constructional Steel Research*, 62(3), 2006, 295-302.

[9] Smith K. G., Innovation in earthquake resistant concrete structure design philosophies; a century of progress since Hennebique's patent, *Engineering Structures*, 23(1), 2001, 72-81.

[10] Wai-Fah Chen, Charles Scawthorn "*Earthquake Engineering Handbook*".

[11] IS 1893 (part 1) : 2002 "*Criteria For Earthquake Resistant Design Of Structures*".

[12] IS 4326:1993 "*Earthquake Resistant Design And Construction Of Buildings-Code Of Practice*"