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HEIGHT EFFECT ON RESPONSE REDUCTION FACTOR DUE TO ECCENTRICALLY BRACED STEEL FRAMES

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Abstract: Response modification factor (RMF) is the type of seismic design parameters to recognize the nonlinear concert of building structures during solid earthquakes. As such, relying on this factor, various seismic design codes lead to decrease the structural loads. This research to calculate the response modification factors (RMF) of conventional eccentric braced frames (EBFs). Since, the response modification factor depends on the ductility and over-strength, the static nonlinear study has been accomplished on building models including type three length of link beam, with 3,5,7 and 10 stories and with different brace arrangements (open chevron invert V and open diagonal bracing), Further, the linear dynamic and incremental nonlinear dynamic study was performed on building models under Indian conditions. The results indicated that the response modification factor for open diagonal eccentric braced frame was higher than the open chevron eccentric braced one. It is also found that the length of the link beam and the height of buildings have had larger effect on the response modification factors.

***Index Terms* – response modification factor, seismic design, moment resisting frames, concentrically braced frames.**

I. INTRODUCTION

The structures should be designed in such a way that could resist adequate against severe earthquakes and should provide ease and peace of mind for those live there in case of minor tremors. In other words, a structure through its ductile behavior should dissolve not only a extensive amount of imported energy but should be in a position to control the distortions and transfer the force to foundation through enough lateral stiffness in ground motions.

This study based on seismic engineering in medium or high-rise buildings. Also, they have often been projected as cheaper and more effective substitute to the most common moment resisting frames (MRFs) or concentrically braced frames (CBFs).

These characteristics illustrated the attention of designers to EBFs hence, most of the standard IS codes placed the basis of seismic design of EBFs on resistance and ductility. It must be remembered that the final capacity of dissolute energy in every structure depends upon factors such as: structure’s seismic h parameter, characteristics of earthquake records and environmental conditions of the place where a structure is located. Considering, the response modification factor is the reflection of energy degeneracy within the boundary of plastic w.r.t the lack of overturning and huge deformations in structure. With respect to height and length of the link beam of structure, there are many the of various parameters effective on the response modification factor (RMFs) and that in this research has been studied on EBFs.

II. METHODOLOGY

2.1 Response Modification Factor (R factor)

The elasticity of a structure under an earthquake can produce base shear force and stress which are noticeably greater than the real structure response. Under such conditions, the structure can absorb quiet energy and resists when it enters the inelastic series of deformation. Overstrength is related to the fact that the maximum lateral strength of a structure usually exceeds its design strength. Hence, seismic codes reduce design loads, taking advantage of the fact is that the structures hold both overstrength and ductility.

The response modification factor is determined as follows:

$$R = R\mu . R_S \qquad \dots(1)$$

Where R_μ is denoted as reduction factor and R_s is overstrength factor.

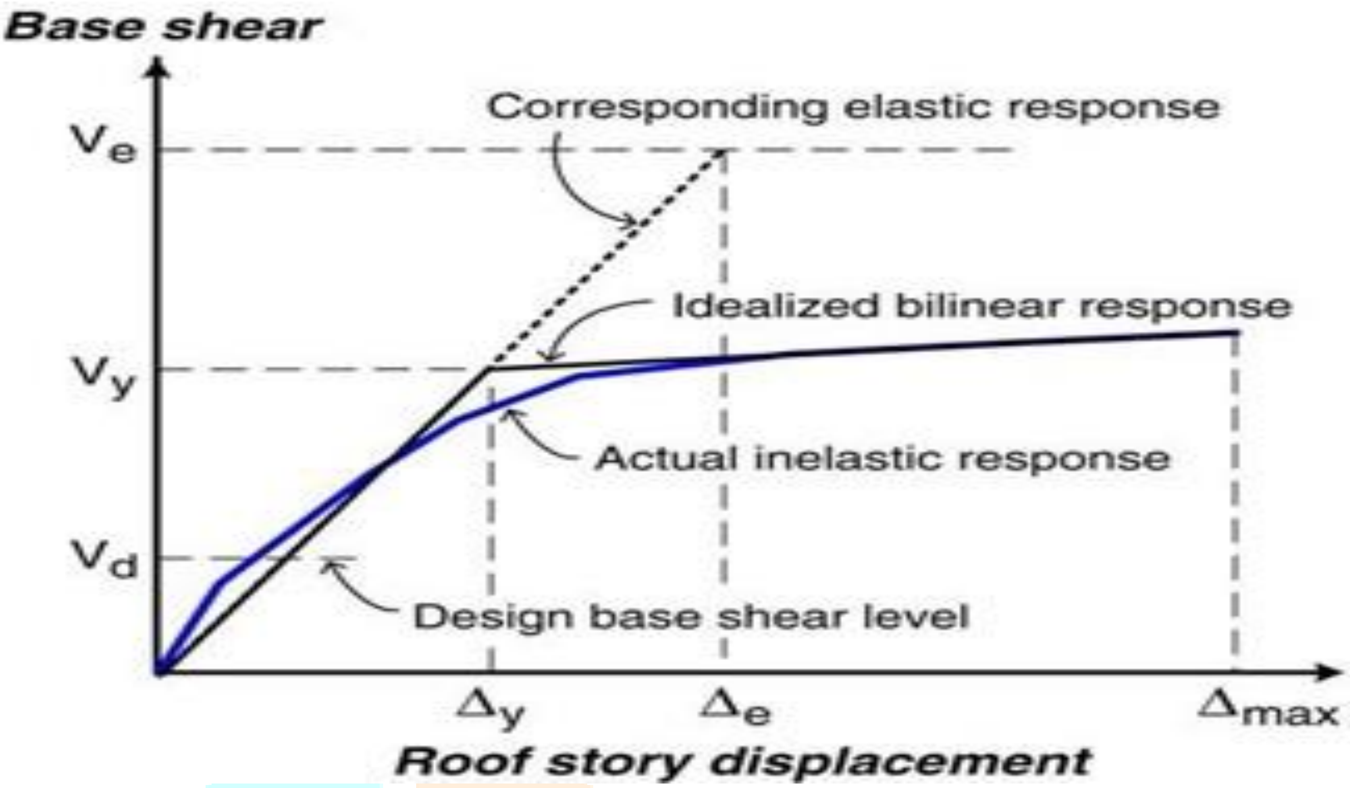

Fig. 1 Definition of Nonlinear Parameters

2.2 Reduction Factor due to Ductility (Rµ)

R_μ is a parameter that measures the global nonlinear response of a structure exposed to the hysteretic energy. Several proposals have been put forward for R_μ. To calculate R_μ in a nonlinear static analysis, we could apply the equation proposed by Fajfar (Fajfar, 2002), the reduction factor R_μ is written as follows:

$$R_\mu = (\mu - 1)\frac{T}{T_c} + 1 \qquad T < T_c \ sec \qquad \ldots(2)$$

$$R_\mu = \mu \qquad T \geq T_c \ sec \qquad \ldots(3)$$

where, T = Fundamental period,

T_c = Characteristic of ground motion = 0.5 for the soil type II that has been considered here based on the Indian Earthquake Resistance Design Code (Standard No. 2800)

μ is the structural ductility factor determined as follows:

$$\mu = \frac{\Delta_{max}}{\Delta_y} \qquad \ldots(4)$$

where Δ_{max} = maximum displacement

Δ_y = Yield displacement

2.3 Overstrength Factor (Rs)

Considering some of the intermittent quake incidents, it seems building structures could take the forces considerably larger than those designed for. The presence of significant reserved strength that was not accounted in design, explains this phenomenon (Rahgozar and Humar, 1998). As a matter of fact, the overstrength helps structures stand safety not only against sever tremors but reduces the elastic strength demand, as well. Here, this is performed using the force reduction factor (Mahmoudi, 2003). The overstrength factor (R_{sd}) is defined as follows:

$$R_{sd} = \frac{V_y}{V_d} \qquad \ldots(5)$$

Where V_y = Yield base share

V_d = Design base share

2.4 Structural Models

To calculate the response modification factors, reduction factors due to overstrength factor, and ductility, some open chevron invert V eccentric braced frames (EBFs) and open diagonal eccentric braced frames (EBFs) with 3, 5, 7 and 10 stories as well as a 6m long bay were selected. The height of every model structure was fixed to 3.0 m. Fig. 2 shows the plan and brace configuration of the model structures. For gravity, the dead and live loads respectively of 6.5 and 2 KN/m2 were used. To evaluate the seismic design base shear, parameters like as importance factor of I=1, seismic zone factor of A = 0.36, soil type II and the response modification factor $R\mu = 7$ were considered for EBFs based on the Indian Earthquake Resistance Design Code (Building and Housing Research Center, 2005).

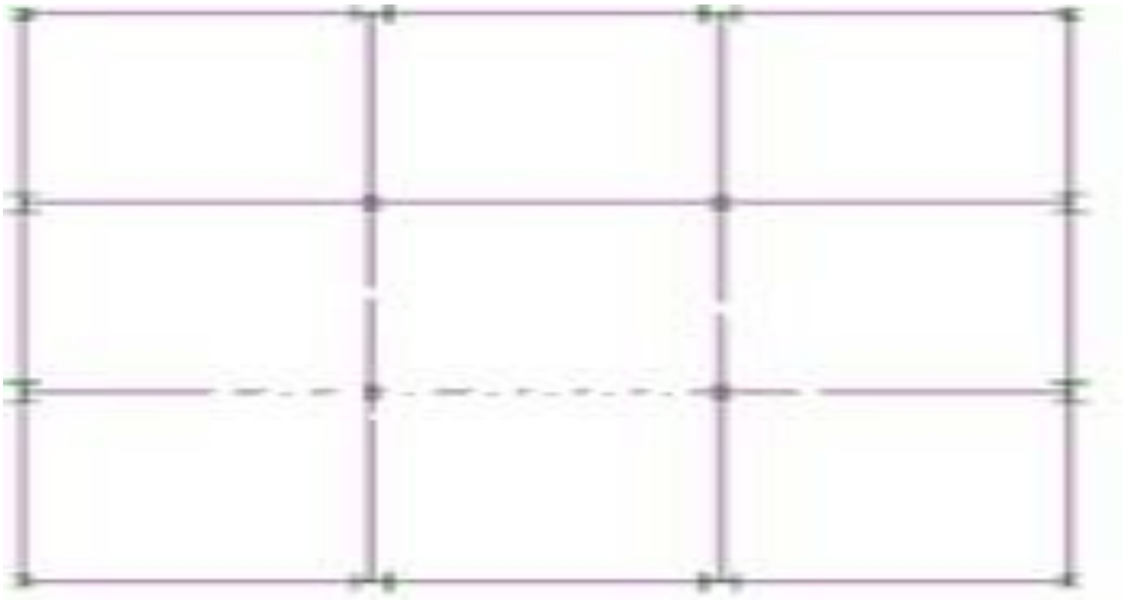

Fig. (a)

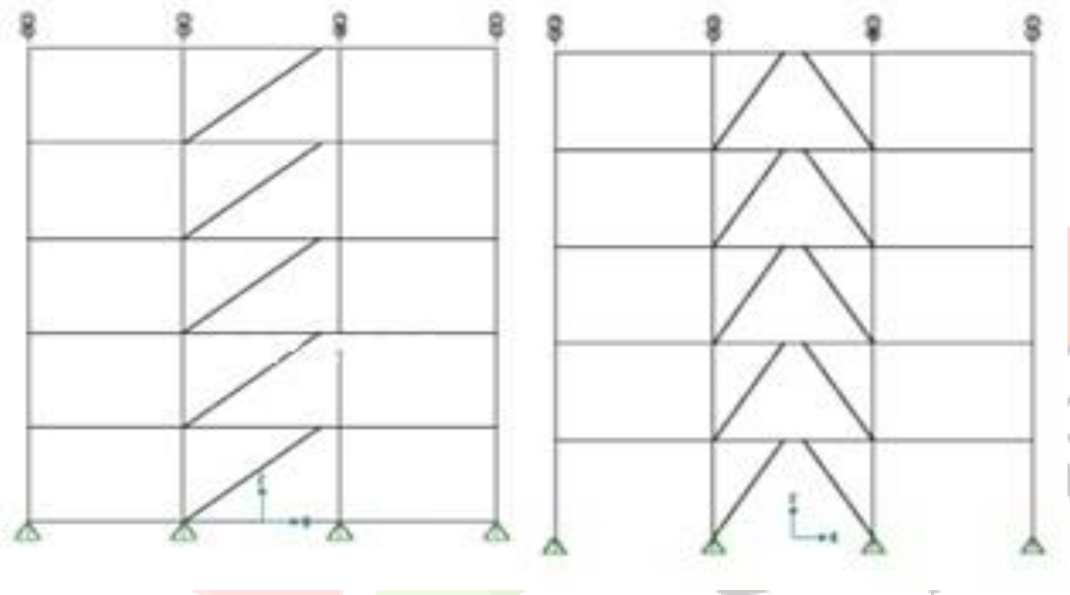

Fig. (b)

Following assumptions were made for modeling of members in a nonlinear range of deformation:

1. All The braces were connected to all columns by pins.
2. For the dynamic analysis, storey masses were placed in the storey levels considering rigid diaphragms action.
3. Idealized elastic-plastic behavior with strain hardening of 2% was considered for members with inelastic behavior.
4. The $P\text{-}\Delta$ effect was considered for geometric nonlinearities.

III. RESULTS

The results of this study can be summarized as follows:

1. It was observed that factors such as reduction due to response modification of EBFs decrease and ductility.
2. Increase in the height of buildings. However, the reduction factors due to ductility are different for eccentric braced frames and open diagonal eccentric braced frames. Also, these factors decrease with an increase in the length of link beam but there is no obvious variation on the reduction factors due to ductility.
3. It was observed that the overstrength factors of EBFs decrease with an increase in the height of buildings. The overstrength factors also increase with an increase in the length of link beam.
4. The response modification factors for eccentric braced frames with type three length of link beam (e=L/8, e=L/4, e=L/2) are evaluated as 6.93, 6.32 and 4.14mm and for open diagonal eccentric braced frames as 8.49, 7.64 and 4.83mm, respectively.
5. The identical results are also obtained for eccentric braced frames with length of link beam (e=L/8) that was analyzed using nonlinear static and nonlinear dynamic methods

Table 1 Ductility, over strength and response modification factors of the model

Number of stories	$V_d (ton)$	$V_{y(ave)} (ton)$	$V_{e(ave)} (ton)$	R_s	R_{sm}	R_{sd}	R_μ	R
3	16.07	130.23	40.12	2.72	1.145	2.36	3.25	8.68
5	27.64	164.53	56.46	2.38	1.165	1.87	3.12	7.16
7	39.05	214.20	69.62	2.16	1.165	1.79	3.09	6.44
10	48.84	229.97	75.57	1.80	1.165	1.57	3.15	5.59

IV. CONCLUSION

This paper has tried to calculate the factors such as reduction due to ductility, over strength, and the response modification factor of some conventional EBFs considering the level of life safety structural concerts. In this, the static nonlinear analysis was executed on building models of length of link beam (e=L/8, e=L/4, e=L/2 where e is length of link beam, and L is length bracing bay), with 3, 5, 7 and 10 stories and different brace arrangements. The attempt was to evaluate the response modification factors of eccentric braced frames (EBFs).

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