STUDY OF BEHAVIOR PARAMETERS OF THE BUILDING WITH VARIATIONS IN STORY AND NUMBER OF BAYS

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Abstract:- *The objective of this study is to investigate the seismic behavior of the structure having various structural configurations like OMRF(ordinary moment resisting frames) and SMRF(special moment resisting frames). A comparative study of all the types of frames will shed some light on the type of frame to be adopted for seismic loads in Indian scenario. Reinforced concrete special moment frames are used as part of seismic force-resisting systems in buildings that are designed to resist earthquakes. The design criteria for SMRF buildings are given in IS 13920 (2002). In this study, the buildings are designed both as SMRF and OMRF, and their performance is compared. For this, the buildings are modeled and pushover analysis is performed in SAP2000 software.*

The behavior parameters are found for each building using the values obtained from pushover curve and is investigated. Findings are then studied and a conclusion is drawn using the results.

***Key Words**: Pushover analysis, Ordinary moment resisting frames, Special moment resisting frames, Behaviour parameters, SAP2000*

1. INTRODUCTION

Reinforced concrete special moment frames are used as part of seismic force-resisting systems in buildings that are designed to resist earthquakes. Beams, columns, and beam column joints in moment frames are proportioned and detailed to resist flexural, axial, and shearing actions that result as a building sways through multiple displacement cycles during strong earthquake ground shaking. The building behaviour parameters can be calculated from the values obtained from the pushover curve and the results are tabulated. It is found that the value of ductility factors are more for SMRF buildings, reinstating the fact that SMRF buildings are more ductile.

1.1 Moment resisting frame

It is a three dimensional structural system composed of interconnected members, without structural walls, so as to function as a complete self-contained unit with or without the aid of horizontal diaphragms or floor bracing systems, in which member resist gravity and lateral forces primarily by flexural actions. As per IS 1893:2002 they can be classified as:

A. **Ordinary Moment Resisting Frame:** It is a moment resisting frame not meeting special ductile detailing requirement for ductile behavior. Response reduction factor *(R)* is taken as 3 in OMRF.

B. **Special Moment resisting Frame:** It is a moment resisting frame specially detailed to provide ductile behavior. Response reduction factor *(R)* is taken as 5 in SMRF.

Indian Codes divide the entire country into four seismic zones (II, III, IV & V) depending on the seismic risks. OMRF (Ordinary Moment Resisting Frame) is probably the most commonly adopted type of frame in lower seismic zones. However with increase in the seismic risks, it becomes insufficient and SMRF (Special Moment resisting Frame) frames need to be adopted.

1.3 When to use SMRF

Moment frames are generally selected as the seismic force-resisting system when architectural space planning flexibility is desired. When concrete moment frames are selected for buildings assigned to Seismic **zones III, IV or V,** they are required to be detailed as special reinforced concrete moment frames the standard is optional in zone ll.

According to IS 13920(2016), special moment frames are to be designed for a force reduction factor of R= 5. i.e. they are allowed to be designed for a base shear equal to one-fifth of the value obtained from an elastic response analysis. Moment frames are generally flexible lateral systems; therefore, strength requirements may be controlled by the minimum base shear conditions of the code.

1.4 Building behavior parameters

In force-based seismic design procedures, behaviour factor, R (EC8), or R_w, also referred to by other terms, including response modification factor (FEMA 1997, UBC 1997), is a force reduction factor used to reduce the linear elastic response spectra to the inelastic response spectra (Maheri and Akbari,2011). In other words, behaviour factor is the ratio of the strength required to maintain the structure elastic to the inelastic design strength of the structure. The behaviour factor R, therefore accounts for the inherent ductility and over strength of a structure and the difference in the level of stresses considered in its design. It is generally expressed in the following form taking into account the above three components,

$$R = R_\mu \times R_s \times Y \qquad ...1.4.1$$

where, R_μ is the ductility dependent component also known as the ductility reduction factor, R_s is the over strength factor and Y is termed the allowable stress factor. With reference to Figure 1, in which the actual force–displacement response curve is idealized by a bilinear elastic–perfectly plastic response curve, the behaviour factor parameters may be defined as:

$$R_\mu = \frac{Ve}{Vy} \qquad ...1.4.2$$

$$Rs = \frac{Vy}{Vs} \qquad ...1.4.3$$

$$Y = \frac{Vs}{Vw} \qquad ...1.4.4$$

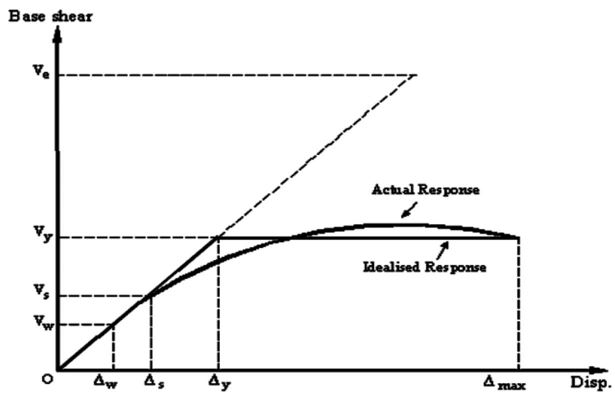
And the behaviour factor, R is redefined as:

$$R\ (R_w) = \left(\frac{Ve}{Vy}\right) \times \left(\frac{Vy}{Vs}\right) \times \left(\frac{Vs}{Vw}\right) \qquad ...1.4.5$$

where, V_e, V_y, V_s and V_w correspond to the structure's elastic response strength, the idealized yield strength, the first significant yield strength and the allowable stress design strength, respectively. For structures designed using an ultimate strength method, the allowable stress factor Y, becomes unity and the behaviour factor is reduced to:

$$R = R\mu \times Rs = \left(\frac{Ve}{Vy}\right) \times \left(\frac{Vy}{Vs}\right) = \frac{Ve}{Vs} \qquad ...1.4.6$$

Fig. 1 Pushover graph for evaluation of behaviour factor, (Maheri and Akbari, 2003)



The structure ductility μ, is defined in terms of maximum structural drift (Δ_{max}) and the displacement corresponding to the idealized yield strength (Δ_y) as:

$$\mu = \frac{\Delta max}{\Delta y} \qquad ...1.4.7$$

1.5 Objective of the work

To carry out analysis and design of the building using SAP 2000 software for height of 6, 8, 10 & 12 stories and 5, 7, 9 & 10 number of Bays, and to study the behavior parameters of the building considered and conclusions were drawn from the results.

2.LITERATURE REVIEW

Ambika-Chippa et. al. (2014) Conducted seismic analysis and design of RC moment resisting space frame with shear wall (Dual System). In moment resisting frame and dual system, two cases were selected for this study. In moment resisting frame Special Moment Resisting Frame and Ordinary Moment Resisting Frame were considered with Variations of heights. For bare frame and frame with brick infill, and in dual system, structure with shear wall and without shear wall were considered with (G+8) storey for (5x5) bay for frame with brick infill with same loading conditions. Frame has been analyzed and designed using STAAD ProV8i software.

Kiran Parmar et. al. (2013) This study deals with the comparison between three dual lateral load resisting systems in the multistory buildings. Dual system which used in the multistory building to resist lateral loads such as wind/earthquake are used in this study are 1. Moment resisting frame with shear wall (MRSW) 2. Moment resisting frame with bracing (MRBR) 3. Flat slab with shear wall (FSSW).

Rao et al. (1982) conducted theoretical and experimental research on infill frames with opening strengthened by lintel beams. It was concluded that the lintel over the opening does not have any effect on the lateral stiffness of an infill frame.

R. Hasan and D.E. Grierson (2002), conducted their study with simple computer-based push-over analysis technique for performance-based design of building frameworks subject to earthquake loading. Findings were rigidity-factor for elastic analysis of semi-rigid frames, and the stiffness properties for semi-rigid analysis are directly adopted for push-over analysis.

D. Özhendekci, D., & Özhendekci, N. (2012) It is shown in this paper that arrangement of span is a critical parameter for the perspective of the designer, so it in straight affects the economy and seismic performance of the design. But, previous study has not given sufficient interest to the valuation of its effects. So three different 10-story special moment resisting steel frames with having different span actions are designed in such a way to the provisions of Turkish seismic design codes which having similar allowable capacity design and stress design procedures which are available in AISC Manual and Seismic procedures for Steel Buildings. With the given geometric properties & design earthquake load, a constant seismic effective mass is kept for frames which was assumed to be suitable for evaluation purposes

Oğuz, Sermin (2005), Verified the effects and the accuracy of invariant lateral load patterns utilized in pushover analysis to predict the behavior imposed on the structure due to randomly Selected ground movement generating elastic deformation by studying various levels of Nonlinear response. For this purpose, pushover analyses using various invariant lateral load patterns and Modal Pushover Analysis were performed on reinforced concrete and steel moment resisting frames covering a wide range of fundamental periods. Pushover analyses carried out by using both DRAIN-2DX and SAP2000.

Asokan (2006) studied how masonry infill walls in the frames of a building changes the overall lateral stiffness and strength of the structure. He proposed a plastic hinge model for infill wall to be used in nonlinear performance based analysis of a building and concluded that the ultimate load (UL) approach along with the proposed hinge property provides a better estimate of the inelastic drift of the building.

3. METHODOLOGY

The buildings are modeled in SAP2000 and nonlinear pushover analysis is carried out on all structures under consideration. Their response is monitored and pushover curves are plotted, comprising of Roof Displacement values vs Base Shear. Total of 12 frames are selected varying number of stores and number of bays with regard to response reduction factors and confinement detailing. The storey height is 3.5m and bay width is 3m, which is same for all of the frames. Each frame is designed as OMRF and SMRF considering response reduction factors to be 3 & 5 respectively. As per IS code suggestions a response reduction factor of 3 for OMRF and 5 for SMRF are chosen. The table 3.1 below shows Material properties and Geometric parameters assumed in this study

Sl No.	Properties	Values
1	Unit weight of concrete	$25KN/m^3$
2	Unit weight of Infill walls	$18kN/m^3$
3	Characteristic Strength of concrete	25 MPa
4	Yielding Strength of steel	415 MPa
5	Compressive strength of strong masonry (E_m)	5000MPa
6	Compressive strength of weak masonry (E_m)	350MPa
7	Modulus of elasticity of Masonry Infill walls (E_m)	$750f'_m$
8	Damping ratio	5%
9	Modulus of elasticity of steel	2e5 MPa
10	Slab thickness	150 mm
11	Wall thickness	230 mm

Following table 3.2 shows Seismic Design Data assumed for Ordinary Moment Resisting Frames and Special Moment Resisting Frames

Sl No.	Design Parameter	Value
1	Frame Type	OMRF
2	Seismic Zone	V
3	Zone factor (Z)	0.36
4	Response reduction factor (R)	3&5 respectively
5	Importance factor (I)	1
6	Soil type	Medium Soil
7	Damping ratio	5%

Following table 3.3 shows loads considered for designing of considered buildings

Sl No.	Type of Load	Value
1	Self Weight of Beam and Column	As per dimensios
2	Weight of slab	11.25 KN/m
3	Infill weight	11.8 KN/m
4	Parapet weight	2.5 KN/m
5	Floor finish	$2.5 KN/m^2$
6	Live load	$3.0 KN/m^2$

4. RESULTS

A number of performance parameters may govern the capacity of a structure. In order to carry out an inelastic pushover analysis, one or a number of these parameters should be considered for determination of the displacement limit state (Δ_{max}). In a comparative study conducted by Mwafy and Elnashai (2002) on different classes of buildings, a number of global collapse criteria, including interstorey drift limit, column hinging mechanism, limit on drop in the overall lateral resistance and stability index limit, were considered. They concluded that the interstorey drift is the collapse parameter that controls the response of buildings designed to modern seismic codes. The R factor parameters for each system were extracted from the respective pushover response curve. The ductility dependent component, Rμ, is calculated using Equations 1.4.1 to 1.4.6 and ductility factor, μ, is determined from Equation 1.4.7.

The behaviour parameters of the bare frame buildings considered is tabulated in Table 4.1 and 4.2 given below.

TABLE 4.1

Building Configuration	BASE SHEAR (KN)	R_{des}	R_{μ}	R_s	μ
BF-SMRF-10St5B	98.6	5	12.6	1.4	5.7
BF-SMRF-10St7B	129.6	5	13.6	1.3	11.8
BF-SMRF-10St10B	156.9	5	17.9	1.4	29.3
BF-SMRF-6St9B	110.5	5	7.8	1.7	2
BF-SMRF-8St9B	135.4	5	26.7	2.2	8.6
BF-SMRF-12St9B	146.5	5	9.6	1.4	2.75

TABLE 4.2

Building Configuration	BASE SHEAR (KN)	R_{des}	R_{μ}	R_s	μ
BF-OMRF-10St5B	162.3	3	3.5	1.3	1.8
BF-OMRF-10St7B	211.2	3	4.8	1.3	8.7
BF-OMRF-10St10B	256.3	3	4.5	1.2	1.6
BF-OMRF-6St9B	235.4	3	3.1	1.2	1.1
BF-OMRF-8St9B	226.8	3	17.9	1.3	4.6
BF-OMRF-12St9B	216.5	3	4.2	1.1	1.6

5. CONCLUSIONS

The building behavior parameters such as the ductility reduction factor R_{μ}, the over strength factor R_S, and the ductility factor μ, are calculated from the pushover curve of each building. The behavior parameters give an idea about the performance of the building and from the values of $R\mu$ and μ obtained, it can be concluded that SMRF buildings possess higher ductility than OMRF buildings. The over strength factor R_s, is also having a value greater than 1 in all cases depicting the fact that the buildings designed for current study can withstand more loads than what they are designed for.

The SMRF buildings with same number of bays and different number of storeys are compared. The pushover curve is plotted and it is found that the ductility and the magnitude of base shear that can be resisted, increases with increase in the number of storeys. It is observed that all the SMRF buildings considered has almost the same value of initial slope in the push over curve.

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7. BIOGRAPHIES

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