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RESEARCH ARTICLE OPEN ACCESS

Pushover Analysis for Multistorey RC SMRF and OMRF

Saudamini Jambhulkar*, Prof L G Kalurkar**
*(Department of Civil engineering, BAMU University, Aurangabad
** (Department of civil engineering, BAMU University, Aurangabad

ABSTRACT
Moment resisting frames are commonly used as the dominant mode of lateral resisting system in seismic regions for a long time. The poor performance of Ordinary Moment Resisting Frame (OMRF) in past earthquakes suggested special design and detailing to warrant a ductile behavior in seismic zones of high earthquake (zone III, IV & V). Thus when a large earthquake occurs, Special Moment Resisting Frame (SMRF) which is specially detailed with a response reduction factor, R = 5 is expected to have superior ductility. The response reduction factor of 5 in SMRF reduces the design base shear and in such a case these building rely greatly on their ductile performance. To ensure ductile performance, this type of frames shall be detailed in a special manner recommended by IS 1392. Special proportioning and detailing requirement results in frame capable of resisting strong earthquake shaking without significant damage. These moment resisting frame are called as "Special Moment Resisting frames". In this study, the buildings are designed both way as SMRF and OMRF, and their performance is compared. For this the buildings are modeled and pushover analysis is performed in SAP2000.
Keywords: SMRF, OMRF, Response Reduction Factor, SAP2000, Pushover analysis.

I. INTRODUCTION

According to Indian standards moment resisting frames are classified as Ordinary Moment Resisting Frames (OMRF) and Special Moment Resisting Frames (SMRF) with response reduction factors 3 and 5 respectively. Moment-resisting frames are commonly used in urban areas worldwide as the dominant mode of building construction. However, documented poor performance of ordinary moment frames in past earthquakes warned the international community that this structural system required special design and detailing in order to warrant a ductile behaviour when subjected to the action of strong earthquake. Current design provisions assigned the highest R factor to SMRF. The elastic forces are reduced by a response reduction factor to calculate the seismic design base shear. . Present study is an attempt to evaluate the response reduction factors of SMRF and OMRF frames and to check the adequacy of R factors used by IS code containing objectives as,

(i) To find Earthquake response of frames designed as SMRF and OMRF according to IS 1893 (2002) using Pushover analysis.
(ii) To determine the Performance level of SMRF and OMRF frames using Pushover analysis.

1.1 Pushover Analysis: Pushover analysis is a static, nonlinear procedure to analyse the seismic performance of a building where the computer model of the structure is laterally pushed until a specified displacement is attained or a collapse mechanism has occurred as shown in Fig.The loading is increased in increments with a specific predefined pattern such as uniform or inverted triangular pattern. The gravity load is kept as a constant during the analysis. The structure is pushed until sufficient hinges are formed such that a curve of base shear versus corresponding roof displacement can be developed and this curve known as pushover curve. A typical Pushover curve is shown in Fig.The maximum base shear the structure can resist and its corresponding lateral drift can be found out from the Pushover curve.

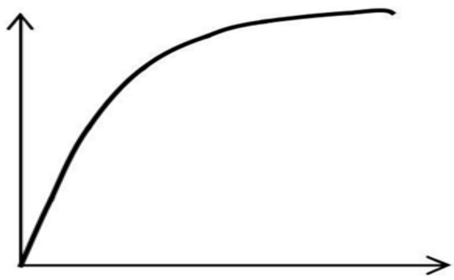


Fig.1 Lateral Load Distribution and a Typical Pushover Curve

II. DIFFERENCE BETWEEN SMRF & OMRF

2.1 SMRF
1. It is a moment-resisting frame specially detailed to provide ductile behaviour and comply with the requirements given in IS 13920.
2. R = 5
3. Low design base shear.
4. It is safe to design a structure with ductile detailing

2.2 OMRF

1. It is a moment-resisting not meeting special detailing requirement for ductile behaviour.
2 .R = 3
3. High design base shear
4. It is not safe to design a structure without ductile detailing.

III. PROBLEM STATEMENT

The models have been prepared by varying the following parameters
1. No. of storeys,
2 .type of support,
3. type of frame – bare/with infill and
4. design of frame – OMRF/SMRF

3.1 Seismic Data:

As per IS 1893-2002 part-Seismic Zone: V
Zone factor (Z): 0.36
Response reduction factor (R): 5 for SMRF
: 3 for OMRF
Importance factor (I): 1
Soil Type: Medium
Damping: 5%
Frame type: SMRF and OMRF

3.2 Material Property*:*

Concrete:
Compressive strength of concrete: 25 N/mm^2
Poisson's ratio: 0.2
Density: 25 kN/m^3
Modulus of Elasticity: 5000 √fck
: 25000 N/mm^2
Steel: HYSD reinforcement of grade Fe 415 confirming to IS: 1786 is used throughout.

IV. MODELLING

Computer modeling of the building is performed using the finite element softwareSAP-2000 (nonlinear version). R.C Buildings of different storey are modeled as beam-column building composed of columns, beams. The columns are assumed to be fixed/Hinged at their base. A detailed two-dimensional model is employed for Pushover analysis. The 2D models of buildings are created using SAP-2000. This software is able to represent material nonlinearity of frame elements to model yielding and post yielding behavior through plastic hinges. Default hinges properties are based on Federal Emergency Management Agency (FEMA-273) criteria.

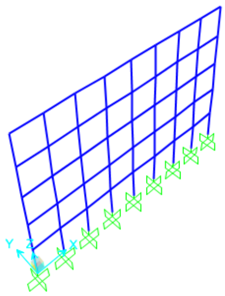
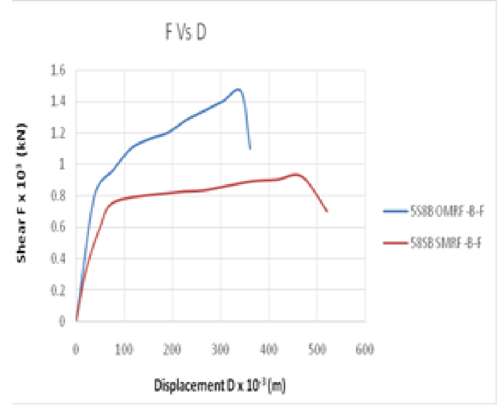


FIG.2 PICTURE OF 5S8B OMRF (5 STOREY 8 BAY OMRF)

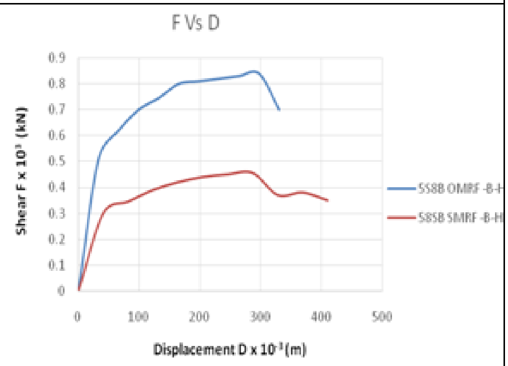
V. RESULTS

CASE 1 :- 5S8B BARE FRAME - FIXED SUPPORT



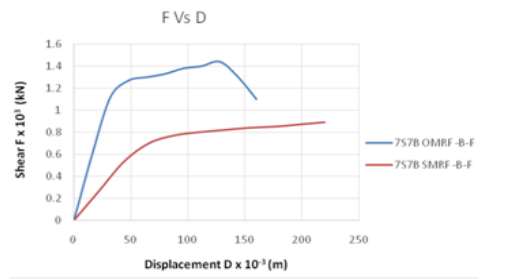
The figure shows the pushover curved of 5S8B bare frames designed as both SMRF and OMRF with fixed support conditions. 5S8B frame designed as OMRF exhibit a higher capacity of base shear and lower displacement than that of 5S8B SMRF framed.

CASE 2 :- 5S8B BARE FRAME – HINGED SUPPORT



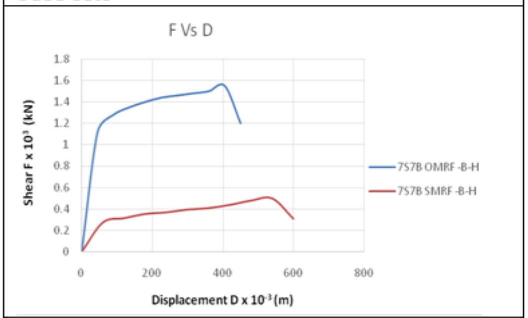
The figure shows the pushover curved of 5S8B bare frames designed as both SMRF and OMRF with hinged support conditions. Initially, in both the frames, base shear increases linearly with the roof displacement but 5S8B OMRF yields very much later than SMRF. The 5S8B frame designed as OMRF exhibit a higher capacity of base shear than that of 5S8B SMRF frame. But, the displacement of SMRF is more than OMRF.

CASE 3 :- 7S8B BARE FRAME - FIXED SUPPORT



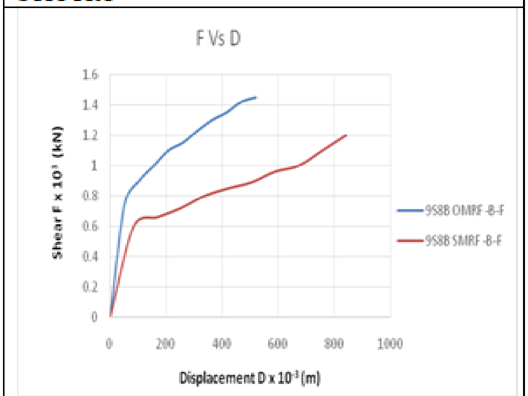
The figure shows the pushover curved of 7S8B bare frames designed as both SMRF and OMRF with fixed support conditions. Initially, in both the frames, base shear increases linearly with the roof displacement but 7S8B OMRF yields very much later than SMRF. The 7S8B frame designed as OMRF exhibit a higher capacity of base shear than that of 7S8B SMRF frame.

CASE 4 :- 7S8B BARE FRAME – HINGED SUPPORT



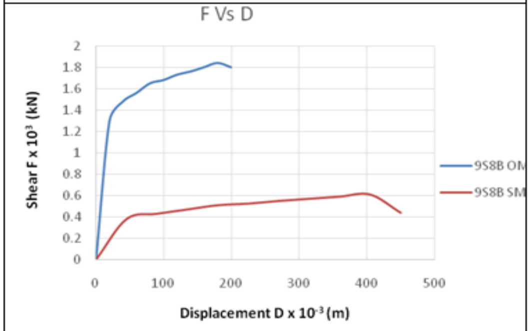
The figure shows the pushover curved of 7S8B bare frames designed as both SMRF and OMRF with hinged support conditions. The Base shear capacity of 7S8B OMRF is thrice that of 7S8B SMRF. But, the displacement of SMRF is more than OMRF.

CASE 5 :- 9S8B BARE FRAME - FIXED SUPPORT



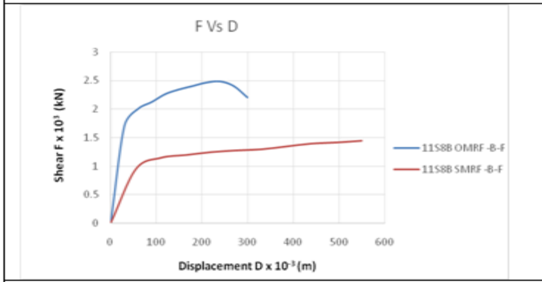
The figure shows the pushover curved of 9S8B bare frames designed as both SMRF and OMRF with fixed support conditions. The performance of these curves is similar to that of earlier frames with slight variation that, in this case, SMRF has a bit larger base shear capacity as compared to earlier cases.

CASE 6 :- 9S8B BARE FRAME – HINGED SUPPORT



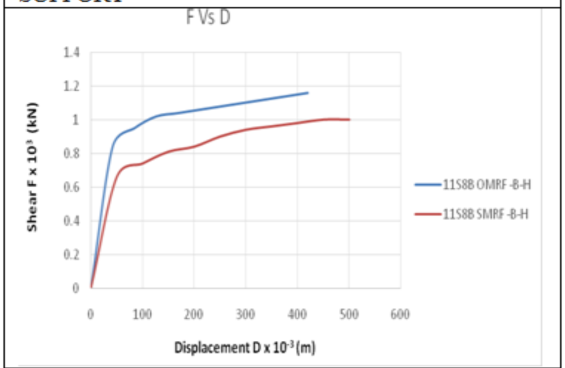
The figure shows the pushover curved of 9S8B bare frames designed as both SMRF and OMRF with hinged support conditions. The Base shear capacity of 9S8B OMRF is four times that of 9S8B SMRF. But, the displacement of SMRF is more than OMRF.

CASE 7 :- 11S8B BARE FRAME - FIXED SUPPORT



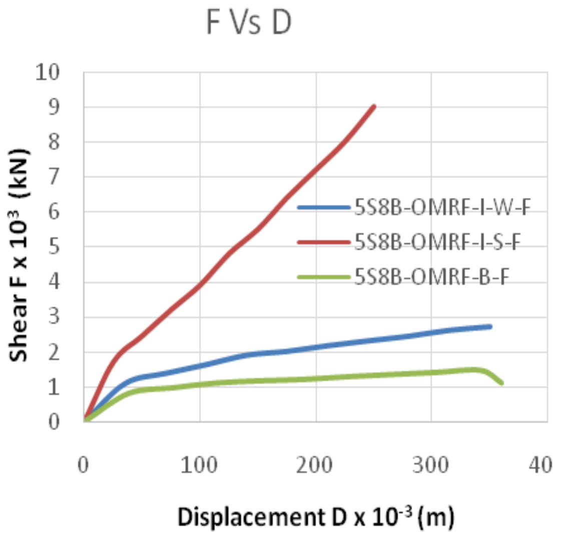
The figure shows the pushover curved of 11S8B bare frames designed as both SMRF and OMRF with fixed support conditions. Initially, in both the frames, base shear increases linearly with the roof displacement but 11S8B OMRF yields very much later than SMRF. The 11S8B frame designed as OMRF exhibit a higher capacity of base shear than that of 11S8B SMRF frame.

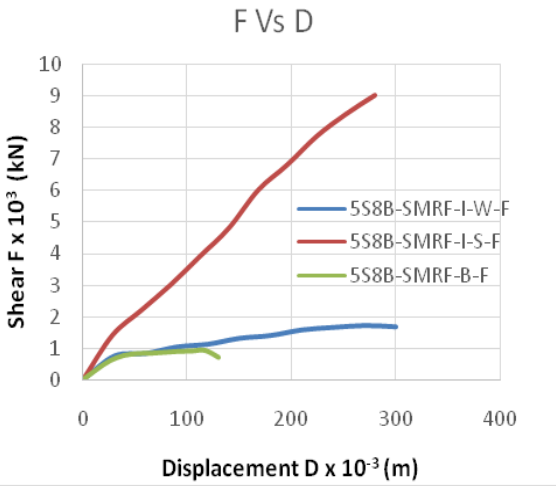
CASE 8 :- 11S8B BARE FRAME – HINGED SUPPORT



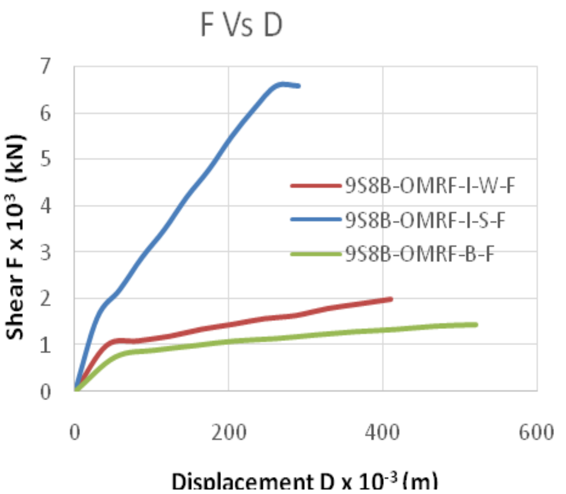
The figure shows the pushover curved of 11S8B bare frames designed as both SMRF and OMRF with hinged support conditions. The Base shear capacity of 11S8B OMRF is higher that of 11S8B SMRF by very small amount. But, the displacement of SMRF is little more than OMRF.

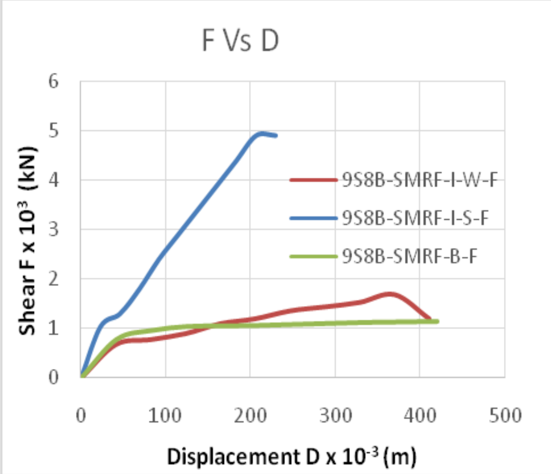
VI. COMPARISION of BARE FRAMES WITH WEAK and STRONG INFILL FRAMES



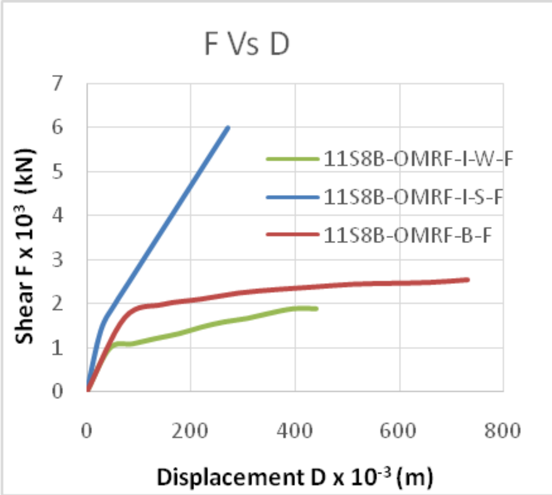


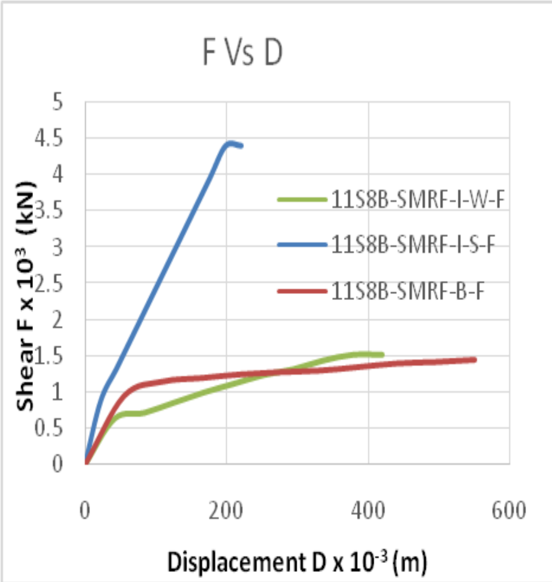
Pushover curves of Bare and infill frames with 5S8B OMRF & SMRF Configuration





Pushover curves of Bare and infill frames with 9S8B OMRF & SMRF Configuration





Pushover curves of Bare and infill frames with 11S8B OMRF & SMRF Configuration

VII. CONCLUSION

1. In both the support conditions in case of bare frames i.e. fixed and hinged support, the performance which is measured in terms of base shear capacity (curve) is much better for OMRF as compared to SMRF.
2. Displacement of SMRF is higher indicating higher flexibility of SMRF.
3. Presence of strong infill makes the frame much more stronger than weak infill and bare frames.

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