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# PERFORMANCE OF MULTISTOREYED REINFORCED CONCRETE SMRF USING ETABS

Mujahid Belim[1]
[1]PG Student, Department Of Civil Engineering, B. R. Harne College Of Engineering And Technology, Mumbai, India

Dr. V A Patil[2]
[2]Project guide and Principal, B. R. Harne College of Engineering And Technology, Mumbai, India

*Abstract*:Reinforced concrete special moment frames are used as a 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. Special proportioning and detailing requirements end in a frame capable of resisting strong earthquake shaking without significant loss of stiffness or strength. These moment resisting frames are called "Special Moment Resisting Frames" due to these additional requirements which improve the seismic resistance as compared with less requirement detailed Intermediate and Ordinary Moment Resisting Frames the look criteria for SMRF building unit of measurement given in IS13920 (2002), during this study, the building unit of measurement designed each as SMRF and OMRF, and their performance is compared. For this the building unit of measurement modeled and pushover analysis is performed in ETABS. The pushover curves unit of measurement is premeditated from the analysis result and thus the behavior of building is studied for diverse support condition and infill conditions. The behavior parameters are found for each building the values obtained from pushover curves and are investigated.

*Keywords*:Moment resisting frames, SMRF, OMRF, Pushover analysis, Static Non- linear analysis, plastic hinges, ETABS, ductility factor, earthquake engineering, response reduction factor.

## I.INTRODUCTION

The design criteria for SMRF buildings are given in IS 13920 (2016). 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 ETABS. 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 Design Categories III, IV or V, they are required to be detailed as special reinforced concrete moment frames. Proportioning and detailing requirements for a special moment frame will enable the frame to safely undergo extensive inelastic deformations that are anticipated in these seismic design categories. Special moment frames may be used in Seismic Design Categories I or II, though this may not lead to the most economical design. Both strength and stiffness need to be considered in the design of special moment frames. According to IS 13920(2016), special moment frames are allowed to be designed for a force reduction factor of R= 5.

### *A. Principles of Design for Special Moment Resisting Frames*

The proportioning and particularization necessitiesfor special moment frames are meant to confirm that inelastic response is ductile. Main goals are: (1) to realize a strong-column/weak-beam design that spreads inelastic response over many stories.

### *B. Strong Column Weak Beam Concept*

When a building sways throughout an earthquake, the distribution of damage over height depends on the distribution of lateral drift. If the building was weak columns, drift tends to concentrate in one or a number of stories (Fig 1-1a), and will exceed the drift capability of the columns. On the opposite hand, if columns offer a stiff and powerful spine over the building height, drift are going to be a lot of uniformly distributed (Fig 1-1c), and localized damage are going to be reduced. The type of failure that's shown in Fig 1-1c is thought as Beam Mechanism or Sway Mechanism. To boost it's vital to acknowledge, that the columns in a given story support the load of the complete building on top of those columns, whereas the beams solely support the gravity loads of the floor of that kind a part; thus, failure of a column is of

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larger consequence than failure of a beam. Recognizing this behavior, building codes specify that columns be stronger than the beams that frame into them. This strong-column/weak-beam principle is key to achieving safe behavior of frames throughout strong earthquake ground shaking. It is a design principle that has to be strictly followed while designing Special Moment Resisting Frames.Structural Designers adopts thestrong-column/weak-beam principle by requiring that the sum of column strengths exceed the sum of beam strengths at every beam-column association on of a special moment frame.

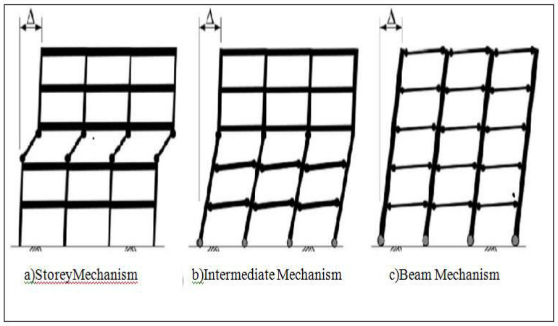


Fig1:Different Failure Mechanism

## II. OBJECTIVES

- To study the behavior of OMRF and SMRF buildings designed as per IS codes.
- To study the effect of support conditions on the performance of OMRF and SMRF.

## III. METHODOLOGY

*A. Problem statement:*

Table 1:
Seismic data assumed for SMRF

| SR No. | Design Parameter | Value |
|---|---|---|
| 1 | Seismic Zone | V |
| 2 | Zone factor (Z) | 0.36 |
| 3 | Response reduction factor (R) | 5 |
| 4 | Importance factor (I) | 1 |
| 5 | Soil type | Medium soil |
| 6 | Damping ratio | 5% |
| 7 | Frame Type | Special Moment Resisting Frame |

Table2:
Details of all fixed support bare frames

| Sl No | Frame Name | Frame type | No. of storeys | No. of bays | R | Frame Type | Support conditions |
|---|---|---|---|---|---|---|---|
| 1 | 8F7B-SMRF-F-B | Bare | 8 | 7 | 5 | SMRF | Fixed |
| 2 | 10F7B-SMRF-F-B | Bare | 10 | 7 | 5 | SMRF | Fixed |
| 3 | 6F2B-SMRF-F-B | Bare | 6 | 2 | 5 | SMRF | Fixed |
| 4 | 6F4B-SMRF-F-B | Bare | 6 | 4 | 5 | SMRF | Fixed |
| 5 | 6F6B-SMRF-F-B | Bare | 6 | 6 | 5 | SMRF | Fixed |
| 6 | 8F7B-OMRF-F-B | Bare | 8 | 7 | 3 | OMRF | Fixed |
| 7 | 10F7B-OMRF-F-B | Bare | 10 | 7 | 3 | OMRF | Fixed |
| 8 | 6F2B-OMRF-F-B | Bare | 6 | 2 | 3 | OMRF | Fixed |
| 9 | 6F4B-OMRF-F-B | Bare | 6 | 4 | 3 | OMRF | Fixed |
| 10 | 6F6B-OMRF-F-B | Bare | 6 | 6 | 3 | OMRF | Fixed |

Table 3:
Details of all hinged support bare frames

| Sl No | Frame Name | Frame type | No. of storeys | No. of bays | R | Frame Type | Support conditions |
|---|---|---|---|---|---|---|---|
| 1 | 8F7B-SMRF-H-B | Bare | 8 | 7 | 5 | SMRF | Hinged |
| 2 | 10F7B-SMRF-H-B | Bare | 10 | 7 | 5 | SMRF | Hinged |
| 3 | 6F2B-SMRF-H-B | Bare | 6 | 2 | 5 | SMRF | Hinged |
| 4 | 6F4B-SMRF-H-B | Bare | 6 | 4 | 5 | SMRF | Hinged |
| 5 | 6F6B-SMRF-H-B | Bare | 6 | 6 | 5 | SMRF | Hinged |
| 6 | 8F7B-OMRF-H-B | Bare | 8 | 7 | 3 | OMRF | Hinged |
| 7 | 10F7B-OMRF-H-B | Bare | 10 | 7 | 3 | OMRF | Hinged |
| 8 | 6F2B-OMRF-H-B | Bare | 6 | 2 | 3 | OMRF | Hinged |
| 9 | 6F4B-OMRF-H-B | Bare | 6 | 4 | 3 | OMRF | Hinged |
| 10 | 6F6B-OMRF-H-B | Bare | 6 | 6 | 3 | OMRF | Hinged |

Table 3:
Seismic data assumed for OMRF

| SR No. | Design Parameter | Value |
|---|---|---|
| 1 | Seismic Zone | V |
| 2 | Zone factor (Z) | 0.36 |
| 3 | Response reduction factor (R) | 3 |
| 4 | Importance factor (I) | 1 |
| 5 | Soil type | Medium soil |
| 6 | Damping ratio | 5% |
| 7 | Frame Type | Ordinary Moment Resisting Frame |

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*B. Results:*

Comparison of SMRF and OMRF: BARE FRAME, FIXED SUPPORT:

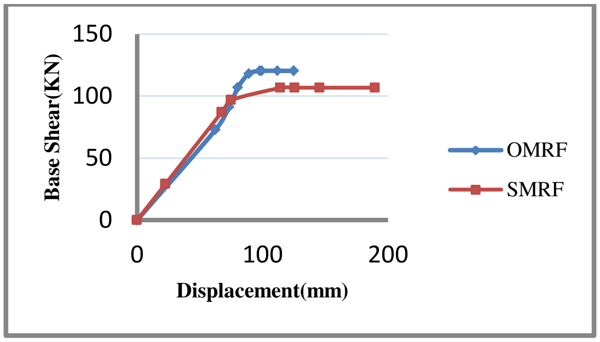


Fig. 2 Pushover curves of 6F2B OMRF and 6F2B SMRF with fixed support condition and no infill.

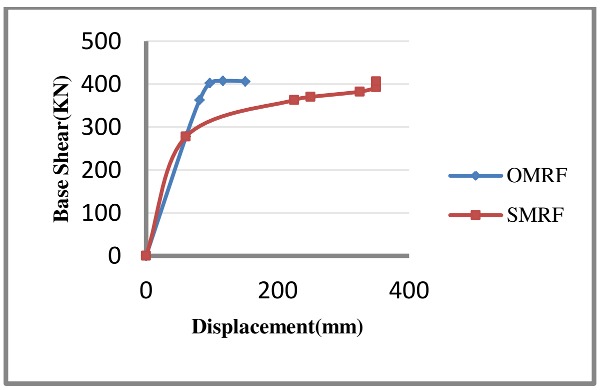


Fig. 3 Pushover curves of 8F7B OMRF and 8F7B SMRF with fixed support condition and no infill.

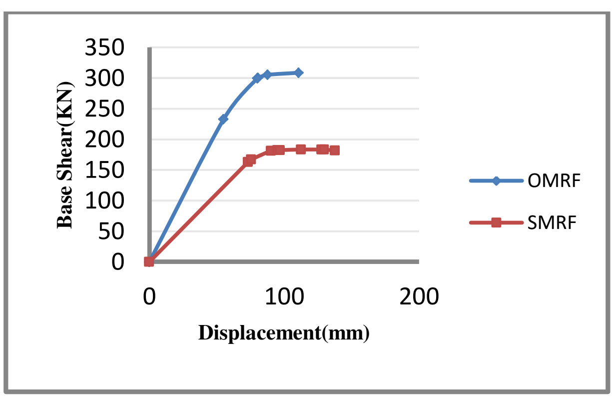


Fig. 4 Pushover curves of 6F4B OMRF and 6F4B SMRF with fixed support condition and no infill.

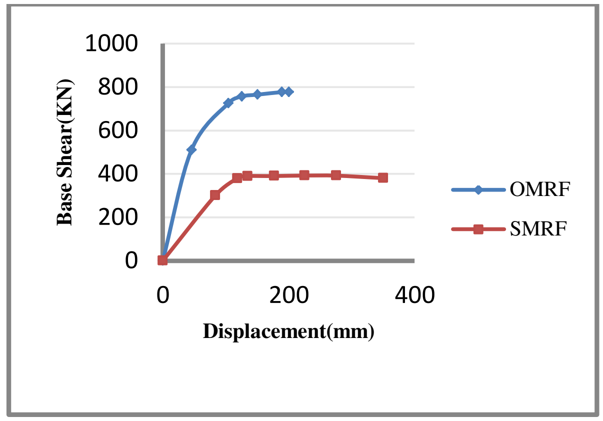


Fig. 5 Pushover curves of 10F7B OMRF and 10F7B SMRF with fixed support condition and no infill.

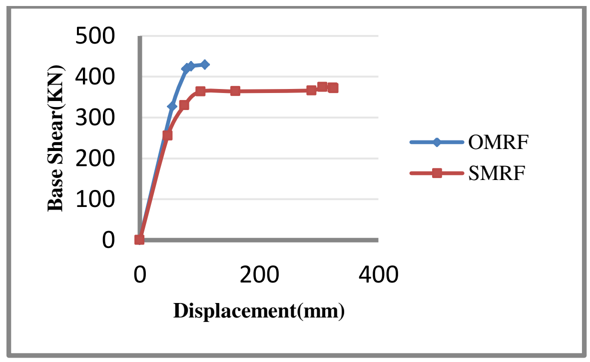


Fig. 6 Pushover curves of 6F6B OMRF and 6F6B SMRF with fixed support condition and no infill.

Comparison of SMRF and OMRF: BARE FRAME, HINGED SUPPORT

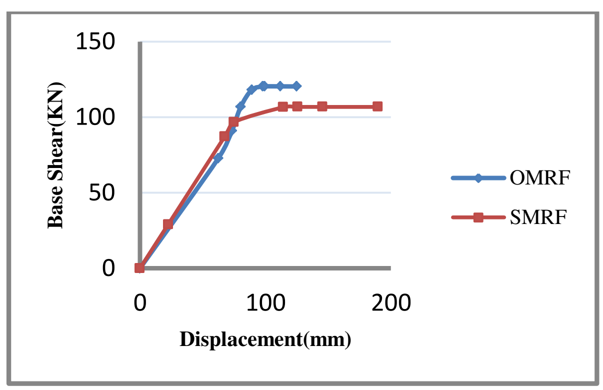


Fig. 7 Pushover curves of 6F2B OMRF and 6F2B SMRF with hinged support condition and no infill.

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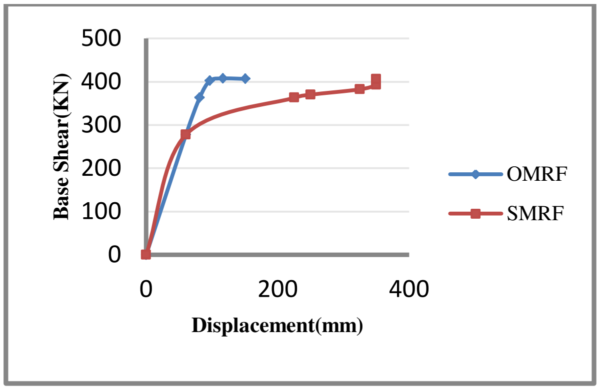


Fig. 8 Pushover curves of 8F7B OMRF and 8F7B SMRF with hinged support condition and no infill.

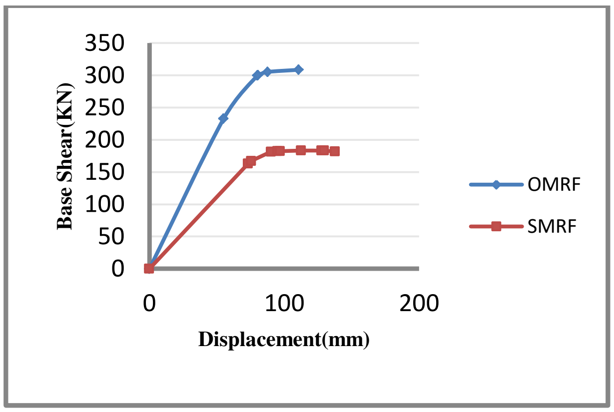


Fig. 9 Pushover curves of 6F4B OMRF and 6F4B SMRF with hinged support condition and no infill.

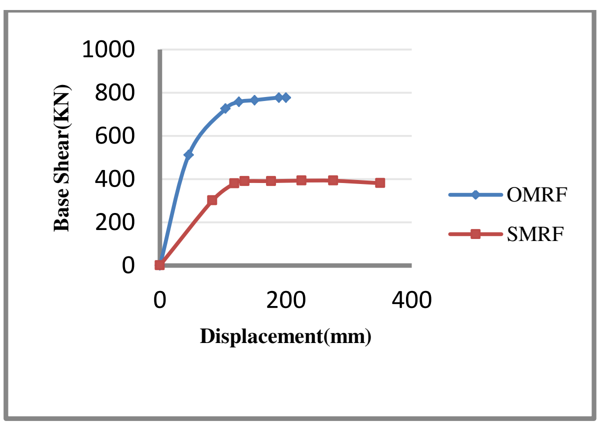


Fig. 10Pushover curves of 10F7B OMRF and 10F7B SMRF with hinged support condition and no infill.

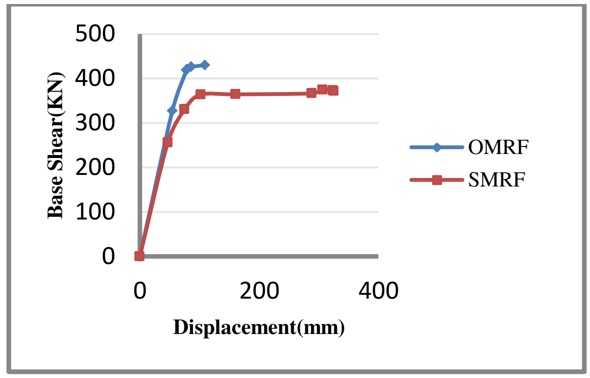


Fig. 11 Pushover curves of 6F6B OMRF and 6F6B SMRF with hinged support condition and no infill.

COMPARISON OF SPECIAL MOMENT RESISTING FRAMES WITH FIXED AND HINGED SUPPORTS.

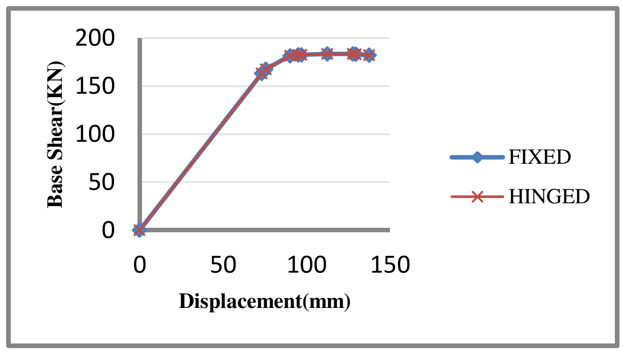


Fig. 12 Pushover curves of 6F4B SMRF with both fixed and hinged support condition and no infill.

## IV. CONCLUSIONS

- The behavior of SMRF buildings and OMRF buildings with bare frame and fixed support conditions are compared. It is found that the buildings designed as SMRF performs much better as compared to the OMRF building. The ductility of SMRF buildings is almost 50% to 240% more than the OMRF buildings in all cases, the reason being the heavy confinement of concrete due to splicing and usage of a greater number of stirrups as ductile reinforcement. It is also found that the base shear capacity of OMRF buildings is 11 to 70% more than that of SMRF buildings.
- The behavior of SMRF buildings and OMRF

buildings with bare frame and hinged support conditions are compared. It is found that the buildings designed as SMRF performs much better as compared to the OMRF buildings. The ductility of SMRF building is about 50 to 240% more than that of OMRF buildings. But OMRF buildings resist 11 to 70% base shear than that of resisted by SMRF buildings.

- The behavior of SMRF buildings with fixed and hinged support conditions is compared. It is found that performance of SMRF buildings under fixed and hinged support condition is the same. It is concluded that the support condition doesn't have a major role in the current study.
- 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 have almost the same value of initial slope in the pushover curve.
- The SMRF buildings with same number of stories and different number of bays are compared. The pushover curve is plotted and it is found that the magnitude of base shear that can be resisted increases with increase in the number of bays. As the number of bays increases from 2 to 4, the base shear capacity will increase by 2 times. And when it increases from 2 bays to 6 bays, the magnitude of the base shear the building can withstand, increases by 3 times. It can be proposed that the number of bays play a major role in the stability of the buildings considered for the present study.

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