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Research Article

DESIGN AND COMPARATIVE STUDY OF MULTISTOREYED SPECIAL MOMENT RESISTING FRAMES

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ABSTRACT

The moment resisting frames which have special proportioning and detailing that results in a frame capable of resisting strong earthquakes without significant loss of stiffness and strength are called Special Moment Resisting Frame (SMRF). And those frames which are stringently detailed are called Ordinary Moment Resisting Frames(OMRF). The design criteria for (SMRF) buildings is given in IS 13920 (2002). In this study two reinforced concrete buildings that is, 12 storey and 16 storey buildings are designed as SMRF and OMRF buildings. Only fixed end condition is considered for the study. Their performance is observed by performing pushover analysis for both type of buildings. The pushover analysis is performed using SAP – 2000 (19 – Version) and pushover curves are plotted for both types of buildings in X and Y directions. A pushover curve is comprising of Base Shear versus Roof Displacement.

INTRODUCTION

Our country lie in earthquake prone area and many of the destructive earthquakes occurred in the history so far resulting in high number of casualties due to collapse of buildings and dwellings. Due to wrong construction practices and ignorance for earthquake resistant design of buildings in our country, most of the existing buildings are vulnerable to future earthquakes. In the simplest case, seismic design can be viewed as a row-step process. The first, and usually most important one, is the conception of an effective structural system that needs to be configured with due regards to all important seismic performance objectives, ranging from serviceability consideration to life safety and collapse prevention. A major challenge for the performance based seismic engineering is to develop simple yet efficiently accurate methods for analyzing designed structures and evaluating existing buildings to meet the selected performance objectives Elastic analyses are insufficient because they cannot realistically predict the force and deformation distributions after the initiation of damage in the building. Inelastic analytical procedures become necessary to identify the modes of failure and the potential for progressive collapse. The need to perform some form of inelastic analysis is already incorporated in many building codes.

What is Pushover Analysis?

The pushover analysis is nothing but a static non-linear analysis under permanent vertical loads and gradually increasing lateral loads. The equivalent static lateral loads approximately represent earthquake induced forces. A plot of the total base shear versus top displacement in a structure is obtained by this analysis that would indicate any premature failure or weakness. Figure 1.1 shows the graph of base shear versus roof displacement. The analysis is carried out up to failure, thus it enables determination of collapse load and ductility capacity. On a building frame, and plastic rotation is monitored, and lateral inelastic forces versus displacement response for the complete structure is analytically computed. This type of analysis enables weakness in the structure to be identified. The decision to retrofit can be taken in such studies. The seismic design can be viewed as a two-step process. The first, and usually most important one, is the conception of an effective structural system that needs to be configured with due regard to all important seismic performance objectives, ranging from serviceability considerations. This step comprises the art of seismic engineering. The rules of thumb for the strength and stiffness targets, based on fundamental knowledge of ground motion and elastic and inelastic dynamic response characteristics, should suffice to configure and rough-size an

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effective structural system. Elaborate mathematical/physical models can only be built once a structural system has been created. Such models are needed to evaluate seismic performance of an existing system and to modify component behavior characteristics (strength, stiffness, deformation capacity) to better suit the specified performance criteria.

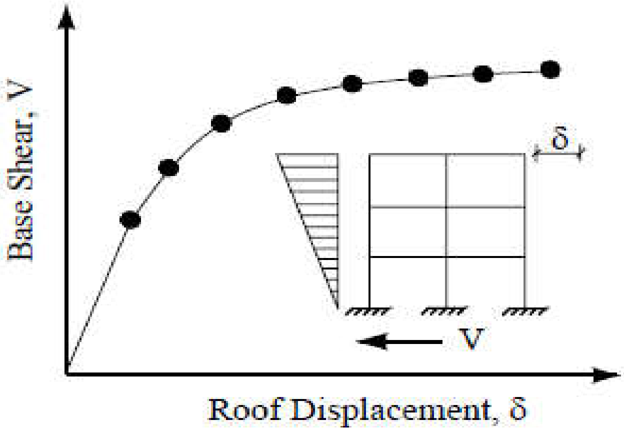

Figure 1 Typical Pushover Curve of The Building

Why Pushover Analysis is Necessary?

Most of the existing buildings can become seismically deficient since seismic design code requirements are constantly upgraded and advancement in engineering knowledge. Further, Indian buildings built over past two decades are seismically deficient because of lack of awareness regarding seismic behavior of structures. The widespread damage especially to RC buildings during earthquakes exposed the construction practices being adopted around the world, and generated a great demand for seismic evaluation and retrofitting of existing building stocks (Helmut Krawinkler).

What are Special Moment Resisting Frames?

The moment resisting frames those are specially detailed to provide ductile behavior and comply with the requirements given in IS 4326 or IS 13920 or SP6 are called Special Moment Resisting Frames. 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. Special proportioning and detailing requirements result in a frame capable of resisting strong earthquake shaking without significant loss of stiffness or strength. These moment-resisting frames are called "Special Moment Frames" because of these additional requirements, which improve the seismic resistance in comparison with less stringently detailed Intermediate and Ordinary Moment Frames (NEHRP).

Principles for Design of Special Moment Resisting Frames

A special moment resisting frame should be expected to sustain multiple cycles of inelastic response if it experiences design-level ground motion. The three main principles that are important while designing a special moment resisting frames are as follows (NEHRP).

1. To achieve a strong-column / weak-beam design that spreads inelastic response over several stories.
2. To avoid shear failure.
3. To provide details that enable ductile flexural response in yielding regions.

Problem Description

The buildings to be designed and analysed are twelve storey and sixteen storey regular shape buildings. The two buildings are designed as SMRF and OMRF buildings and then the pushover analysis is performed on both the buildings.

Design data and material properties assumed for both the buildings are as follows.

Table 1 Material properties assumed for SMRF and OMRF buildings

Sr. NO.	Design Parameters	Values	
		SMRF	OMRF
1	Characteristic strength of concrete	25 N/mm²	25 N/mm²
2	Characteristic strength of steel	415 N/mm²	415 N/mm²
3	Unit weight of concrete	25 KN/m³	25 KN/m³
4	Unit weight of brick	20 KN/m³	20 KN/m³
5	Slab thickness	150 mm	150 mm
6	External wall thickness	230 mm	230 mm
7	Internal wall thickness	150 mm	150 mm

Table 2 Design data (seismic) assumed for SMRF and OMRF buildings

Sr. NO.	Design Parameters	Values	
		SMRF	OMRF
1	Response reduction factor (R)	5	3
2	Seismic zone	V	V
3	Zone factor (Z)	0.36	0.36
4	Soil type	Medium	Medium
5	Importance factor (I)	1	1

Table 3 Load intensities assumed for design calculations

Sr.No	Load Type	Values2
1	Live load	3 KN/m²
2	Dead load (Self weight of element)	As per size of member
3	Floor finish	1 KN/ m²
4	Parapet wall load	4.6 KN/m
5	Wall load	11.6 KN/m
6	Roof live load	3.5KN/ m²

RESULT AND DISCUSSION

The comparative study of SMRF and OMRF buildings has been done by performing pushover analysis on both buildings and observing their pushover graphs.

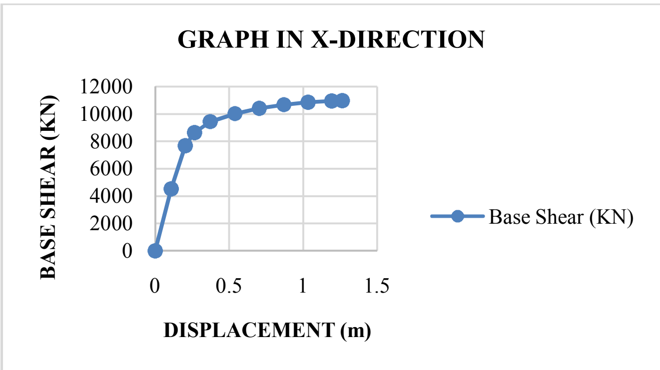

Figure 1 Pushover Curve for 12 Storey SMRF Building (X-Direction)

Following are the pushover graphs obtained after performing pushover analysis.

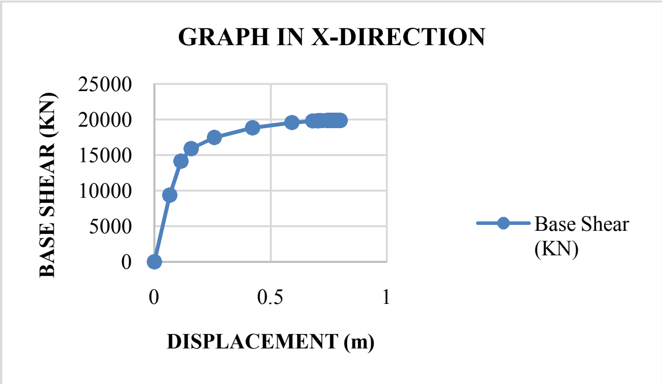

Figure 2 Pushover Curve for12 Storey OMRF Building (X-Direction)

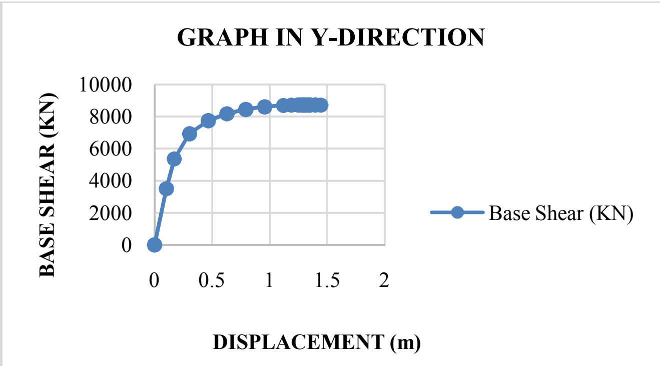

Figure 3 Pushover Curve for 12 Storey SMRF Building (Y-Direction)

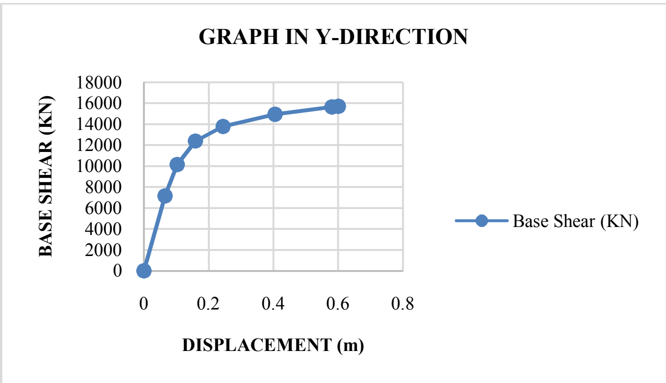

Figure 4 Pushover Curve for 12 Storey OMRF Building (Y-Direction)

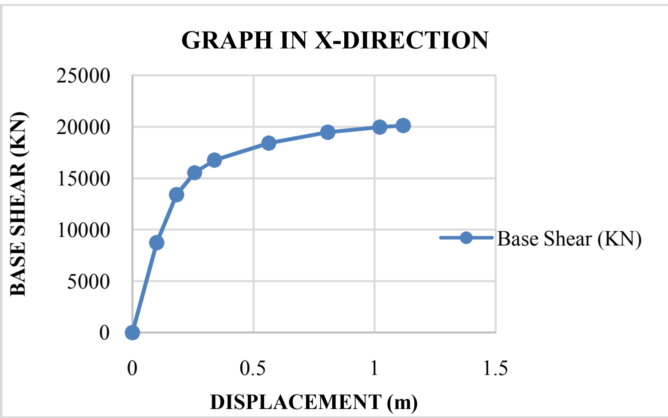

Figure 5 Pushover Curve for 16 Storey SMRF Building (X-Direction)

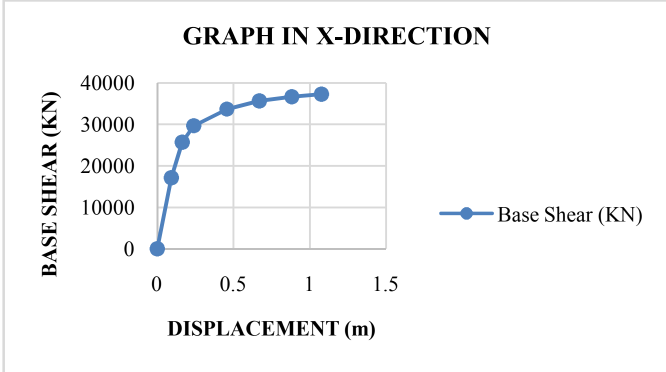

Figure 6 Pushover Curve for 16 Storey OMRF Building (X-Direction)

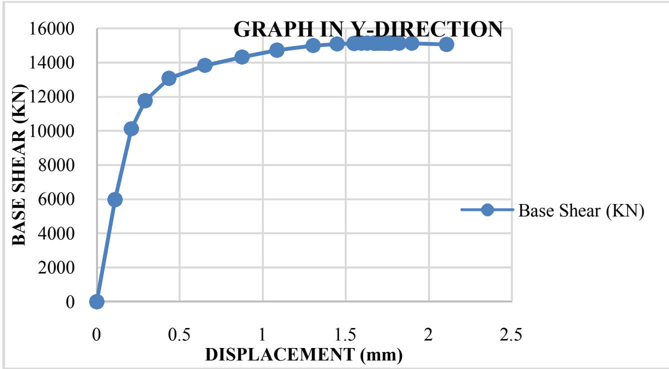

Figure 7 Pushover Curve for 16 Storey SMRF Building (Y-Direction)

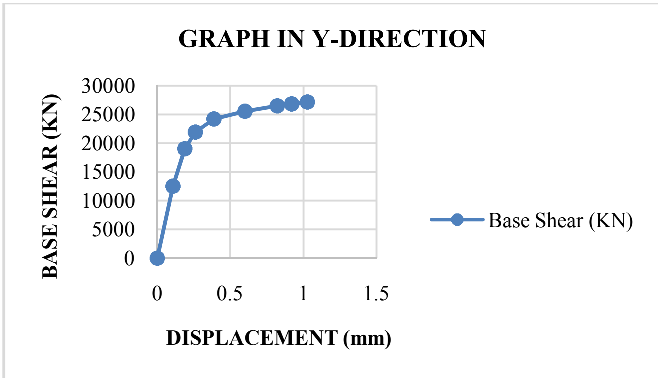

Figure 8 Pushover Curve for 16 Storey OMRF Building (Y-Direction)

From all the pushover graphs following observations have made

Table 4 Base Shear comparision of SMRF and OMRF buildings

Building Configuration	Base shear (KN)	
	SMRF Building	OMRF Building
12 Storey (X-Direction)	10975	19853
12 Storey (Y-Direction)	8718	15725
16 Storey (X-Direction)	20119	37289
16 Storey (Y-Direction)	15048	27126

Table 5 Displacement comparision of SMRF and OMRF buildings

Building Configuration	Displacement (mm)	
	SMRF Building	OMRF Building
12 Storey (X-Direction)	1264	799
12 Storey (Y-Direction)	1445	600
16 Storey (X-Direction)	1117	1076
16 Storey (Y-Direction)	2108	1026

CONCLUSION

The comparative study of SMRF and OMRF buildings has been done by performing pushover analysis for 12 storey and 16 storey RC buildings and their response is monitored. From the pushover graphs and Table no. 4 and Table no.5 the comparative observations are,

1. It is observed that the base shear capacity of OMRF buildings is 80% to 85% more than that of SMRF buildings.
2. And the ductility of SMRF buildings is 55% to 140% more than that of OMRF buildings.
3. This is due to the use of more number of stirrups as ductile reinforcement and heavy confinement of concrete due to splicing.
4. It is observed that SMRF buildings perform much better compared to OMRF buildings.
5. The ductility and magnitude of base shear that can be resisted increases with increase in number of storeys.

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