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ANLYTICAL STUDY OF EFFECT OF RC OMRF AND SMRF IN MULTY STORIED BUILDINGS USING SAP 2000

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Abstract - *To resist earthquakes, Reinforced concrete special moment frames are utilized as part of seismic force-resisting structures in buildings. Columns, Beams, and beam- column joints in moment frames are balanced & detailed to resist flexural, axial, & shearing movements. The main purpose of current investigation is the study of comparative performance of SMRF and OMRF frames, designed as per IS codes, via nonlinear analysis. Software program is utilized to design & model the structures. A performance of SMRF structure & OMRF structure with no infill & fixed support conditions result states that the base shear capacity of OMRF structures is 20 to 40% additional than that of SMRF structures. The behavior of SMRF structure & OMRF structure with no infill & hinged support condition result states that OMRF structures resist 20-40% additional base shear than that be resisted by SMRF structures. The behavior of SMRF building with fixed & hinged support conditions states that an act of SMRF structures under fixed & hinged support condition is an identical. The SMRF structures with similar no. of bays and diverse no. of storeys experiment states that all the SMRF structures deliberated has exactly the similar amount of initial slope in the push over curve. The SMRF structures with similar no. of storeys & diverse no. of bays experiment gives the result that the no. of bays play huge part in the immovability of the structures measured for the current investigation.*

***Key Words*: SMRF, OMRF, Base Shear, Fixed Support, Hinged Support, Nonlinear Analysis, Infill, SAP 2000 etc.**

1. INTRODUCTION

SMRF introduced in India about 1993. IS 13920(1993) was utilized for proportioning and detailing of SMRF in India, which later was written in 2002. To resist earthquakes, Reinforced concrete special moment frames are utilized as part of seismic force-resisting structures in buildings. Columns, Beams, and beam-column joints in moment frames are balanced & detailed to resist flexural, axial, & shearing movements. Due to these forces structure sways over many displacement phases throughout strong earthquake ground shaking. Moment frames are mostly chosen as the seismic force-resisting arrangement when architectural space planning tractability is vital. Concrete moment frames are chosen for Seismic Zone III, IV or V, these are desired to be detailed as special RC moment frames. Balancing & detailing necessities for a special moment frame will allow the frame to securely go through wide inelastic deformations which are predictable in these seismic zones. It can be utilized in Seismic Zone I or II, though it will not be the best inexpensive design. It is essential to consider strength and stiffness both in the design of special moment frames. The design base shear eqn. of present building codes integrate a seismic force reduction factor R that shows the degree of inelastic response predictable for design-level ground motions, as well as the ductility capacity of the framing system. A SMRF should be predictable to retain multiple cycles of inelastic response if it experiences design level ground motion. When a structure sways during an earthquake, the spreading of damage over height depends on the spreading of lateral drift. If the structure has weak columns, drift tends to focus in one or a few stories, and may go beyond the drift capacity of the columns. On the other side, if columns deliver a stiff and strong spine over the structure height, drift will be more equivalently spread, and confined loss will be decreased. These type of failure is known as Beam Mechanism or Sway Mechanism. It is a design standard that should be firmly involved though designing SMRF. Structural Designers implements the strong-column/weak-beam standard by requiring that the addition of column strengths exceed the addition of beam strengths at each beam-column link of a special moment frame. Ductile response needs that members yield in flexure, and that shear failure be ignored. Shear failure, exclusively in columns, is comparatively brittle and can lead to quick loss of lateral strength and axial load-carrying capacity. Column shear failure is the maximum frequently mentioned reason of concrete structure failure and collapse in earthquakes. Shear failure is ignored by using of a capacity-design methodology. The common methodology is to classify flexural yielding regions, design those regions for code-required moment strengths, and then determine design shears based on equilibrium supposing the flexural yielding regions form possible moment strengths. The possible moment strength is estimated using processes that develop a higher estimation of the moment strength of the designed cross-section. Mostly hoops are provided at the ends of beams and columns, also at beam-column joints. It needs to be effective, hooks should be closed by 135° rooted in the concrete, and it avoids hooks to be opened if the cover of concrete removed. Cross-ties should involve longitudinal reinforcement around the perimeter to increase confinement efficiency. Hoops need to be closely distributed lengthwise of longitudinal axis of the member, both to restrain the concrete and confine buckling of longitudinal reinforcement. Cross-ties, which generally have 90° and 135° hooks to ease construction, must have their 90° and 135° hooks alternated along the length of the member to raise confinement efficiency. Especially if axial loads are low than shear strength reduces in members subjected to multiple inelastic deformation reversals. In these types of members it is needed that the involvement of concrete to shear resistance be ignored, that is, $V_c = 0$. So, shear reinforcement is essential to resist the whole shear force. Loss of concrete cover due to severe seismic loading can outcome as decrease development and lap-splice strength of longitudinal reinforcement. Lap splices should be provided away from maximum moment sections and must have locked hoops to restrain the splice in the event of cover spalling. Current study shows on several characteristics associated to the performance of SMRF buildings. The main purpose of current investigation is the study of comparative performance of SMRF and OMRF frames, designed as per IS codes, via nonlinear analysis. The more genuine performance of the OMRF and SMRF building needs modelling the stiffness and strength of the infill walls. The differences in the sort of the infill walls utilizing in Indian constructions are substantial. On the basis of modulus of elasticity and the strength, it may be categorized as strong or weak. SMRF buildings are generally built in earthquake prone nations like India since they offer much greater ductility. Failures perceived in previous earthquakes illustrate that the collapse of such buildings is primarily due to the development of soft-storey mechanism in the ground storey columns.

1.1 MOMENT RESISTING FRAMES

It is a frame which are formed by Beams and columns with a rigidly jointed connection. It's basically resist the flexure.

1.2 SPECIAL MOMENT-RESISTING FRAME

SMRF is designed and detailed as per IS 13920 code which delivers additional ductility requirements to the frame.

1.3 ORDINARY MOMENT-RESISTING FRAME

As per IS 456, a frame is designed is an ordinary moment resisting frame. Special ductility provisions as per IS 13920 is not considered.

1.4 OBJECTIVE OF THE STUDY

- To investigate the behavior of OMRF and SMRF buildings designed as per IS codes.
- To investigate the influence of sort of infill walls in the performance of the SMRF buildings.
- To investigate the influence of support conditions on the performance of OMRF and SMRF.

1.4 OVERVIEW OF SAP 2000

SAP2000 is a user friendly software to perform: Modeling, Analysis, Design, and Reporting. SAP2000 has a wide selection of templates for quickly starting a new model. The frame element uses a general, three-dimensional, beam-column formulation which includes the effects of biaxial bending, torsion, axial deformation, and biaxial shear deformations. SAP2000 has a built-in library of standard concrete, steel and composite section properties of both US and International Standard sections.

- Accuracy of the solution,
- Confirmation with the Indian Standard Codes,
- Resourceful nature of solving any type of problem,
- User friendly interface.

2. METHODOLOGY

The buildings are modelled in SAP2000 for nonlinear analysis. Static 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.

Material properties and Geometric parameters assumed

- Unit weight of concrete 25 kN/m^3
- Unit weight of Infill walls 18 kN/m^3
- Characteristic Strength of concrete 25 MPa
- Characteristic Strength of reinforcement 415 MPa
- Compressive strength of strong masonry (E_m) 5000 MPa
- Compressive strength of weak masonry (E_m) 350 MPa
- Modulus of elasticity of Masonry Infill walls (E_m) $750f'_m$
- Damping ratio 5%
- Modulus of elasticity of steel 2e5 MPa
- Slab thickness 150 mm
- Wall thickness 230 mm

Loads considered for designing structures

- Self-weight of beams & columns As per dimensions
- Weight of slab 11.25 KN/m

Infill Weight	11.8 KN/m
Parapet weight	2.5 KN/m
Floor Finish	2.5 KN/m^2
Live Load	3.0 KN/m^2

Seismic Design Data assumed for Special Moment Resisting Frames

Seismic Zone	V
Zone factor	0.36
Response reduction factor	5
Importance factor	1
Soil Type	Medium soil
Damping Ratio	5%
Frame Type	SMRF

Seismic Design Data assumed for Ordinary Moment Resisting Frames

Seismic Zone	V
Zone factor	0.36
Response reduction factor	3
Importance factor	1
Soil Type	Medium soil
Damping Ratio	5%
Frame Type	OMRF

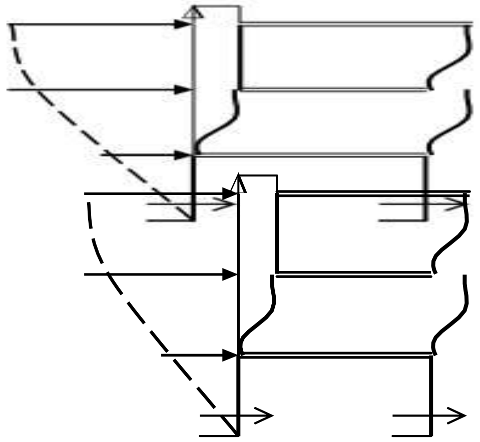


Fig. -1: Base Shear

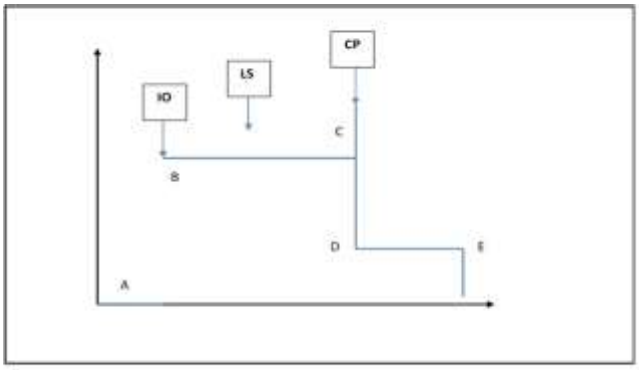


Fig. -2: Typical load – deformation relation and target performance levels

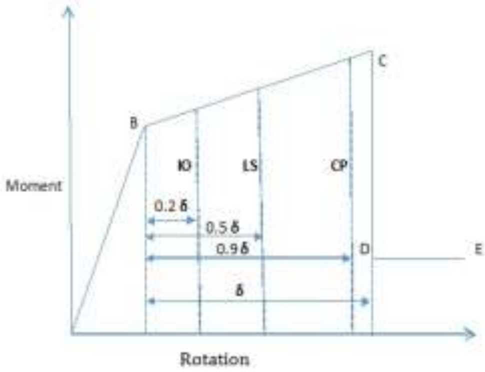


Fig. -3: showing nonlinear hinged property of strut

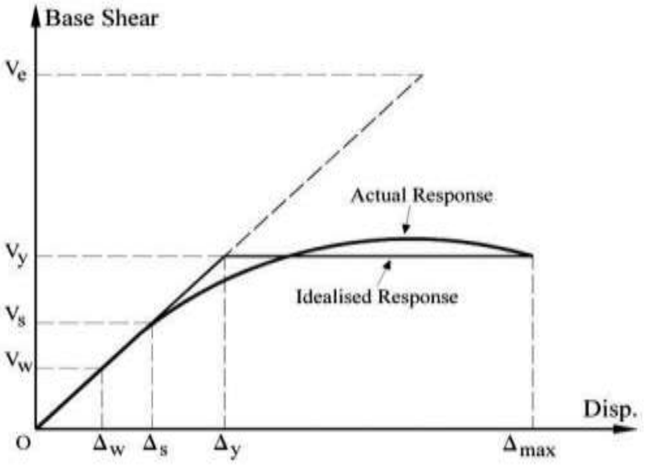


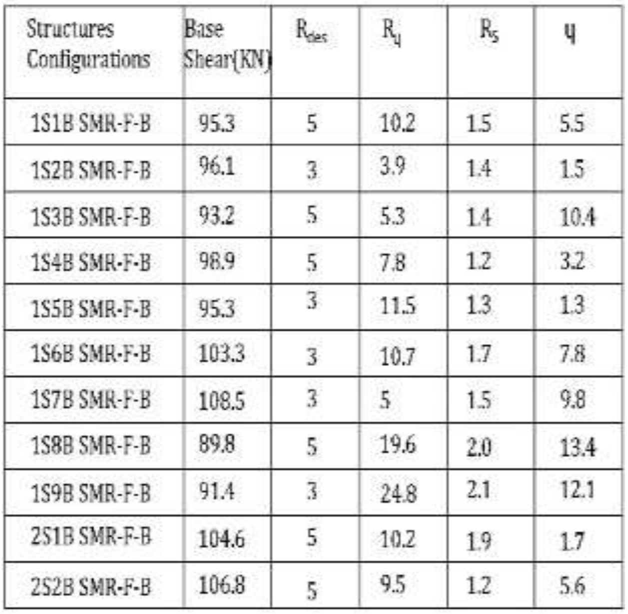
Fig. -4: Typical pushover graph for evaluation of behavior factor

3. RESULT AND DISCUSSION

BEAHAVIOUR CONTRAST OF THE STRUCTURES

A no. 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 inter-storey drift limit, column hinging mechanism, limit on drop in the overall lateral resistance and stability index limit, were considered. They concluded that the inter-storey 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 behavior parameters of the bare frame buildings considered is tabulated in Table- 1.



Structures Configurations	Base Shear(KN)	R_{des}	R_μ	R_s	μ
1S1B SMR-F-B	95.3	5	10.2	1.5	5.5
1S2B SMR-F-B	96.1	3	3.9	1.4	1.5
1S3B SMR-F-B	93.2	5	5.3	1.4	10.4
1S4B SMR-F-B	98.9	5	7.8	1.2	3.2
1S5B SMR-F-B	95.3	3	11.5	1.3	1.3
1S6B SMR-F-B	103.3	3	10.7	1.7	7.8
1S7B SMR-F-B	108.5	3	5	1.5	9.8
1S8B SMR-F-B	89.8	5	19.6	2.0	13.4
1S9B SMR-F-B	91.4	3	24.8	2.1	12.1
2S1B SMR-F-B	104.6	5	10.2	1.9	1.7
2S2B SMR-F-B	106.8	5	9.5	1.2	5.6

Table -1: Behavior constraints of Structures adopted

STOREY-WISE CONTRAST OF SMRF STRUCTURES

The structures with the similar no. of bays are deliberated in this relative investigation. The structures measured are 1S1B SMRF-, 1S2B SMRF & 1S3B SMRF, each comprising 7 bays. The pushover curves are plotted. It is observed that 1S2B SMRF AND 1S2B SMRF reflect excellent ductility when compared to 1S3B SMRF. The graphs show that the 10 storey and 8 storey buildings can withstand a higher magnitude of base shear compared to the 4 storey building. But it can be seen that the slope of the curve for all buildings is almost same. Even though the magnitude of base shear that these buildings withstand is less compared to that, which can be withstood by Ordinary Moment Resisting frames, this comparison again shows that fact that Special Moment Resisting Frame buildings possess excellent ductility when compared to Ordinary Moment Resisting Frame buildings.

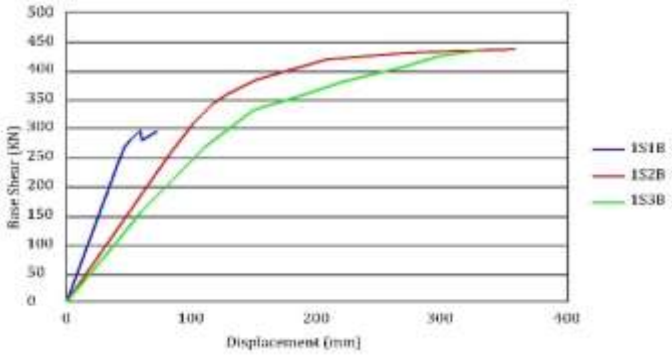


Fig. -1: Displaying the storey wise comparison of SMRF buildings with fixed support conditions and no infill.

BAY-WISE CONTRAST OF THE SMRF STRUCTURES

The buildings with the same number of storeys are considered in this comparative study. The buildings considered are 1S2B SMRF, 1S4B SMRF AND 1S6B SMRF, all having 6 storeys. The pushover analysis is performed and Base shear vs Displacement graphs are plotted and it is observed that 1S4B SMRF AND 1S6B SMRF reflect excellent ductility when compared to 1S2B SMRF. It is observed that 1S6B SMRF can withstand a base shear of 370 KN, 1S4B SMRF can withstand a base shear of 250 KN and 1S2B SMRF can withstand a base shear of 120 KN. This shows that 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 increase by 3 times it can be proposed that the number of bays play a major role in the stability of a building.

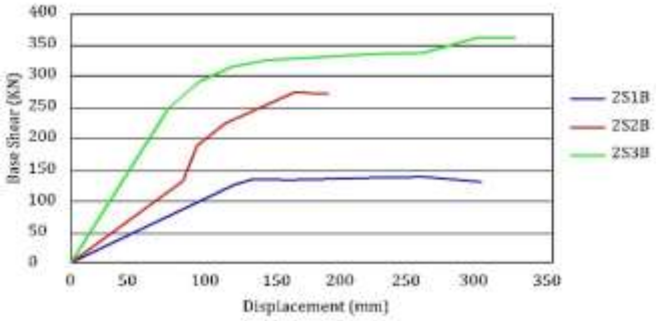


Fig. -2: Displaying the bay wise comparison of SMRF buildings with fixed support conditions and no infill

BAY-WISE CONTRAST OF THE SMRF STRUCTURES

In this study, the performance of SMRF buildings with strong and weak infill is compared. For strong infill condition the value of modulus of elasticity of brick is taken as 5000 MPa whereas for weak infill it is taken as 350 MPa. The static pushover curve of 1S4B SMRF building with strong and weak infill shows the case of 1S4B SMRF buildings and it is observed that the building with strong infill can withstand a base shear of 1650 KN while the building with weak infill can resist a base shear of 700 KN. Similar behavior is observed for 1S2B SMRF and 1S7B SMRF buildings. It can concluded that the SMRF buildings with stronger infill have base shear capacity of about 1.5 to 2.5 times more than that of SMRF buildings with weak infill. Moreover, the pushover curves for buildings modelled with weak infill are performing in a linear manner compared to those buildings which are modelled with strong infill. This suggests that SMRF buildings with strong infill perform better than those with weak infill.

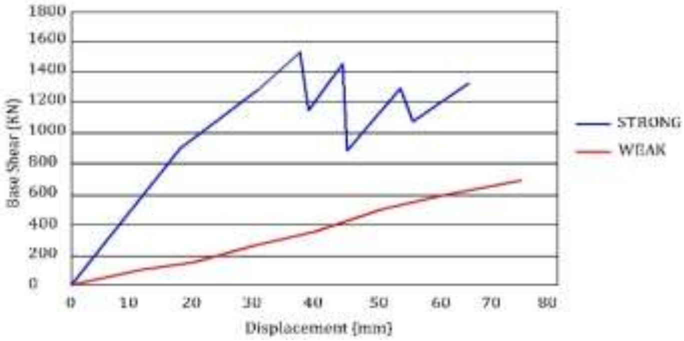


Fig. -3: Displaying the comparison of 1S4B SMRF buildings with strong and weak infill and fixed support conditions.

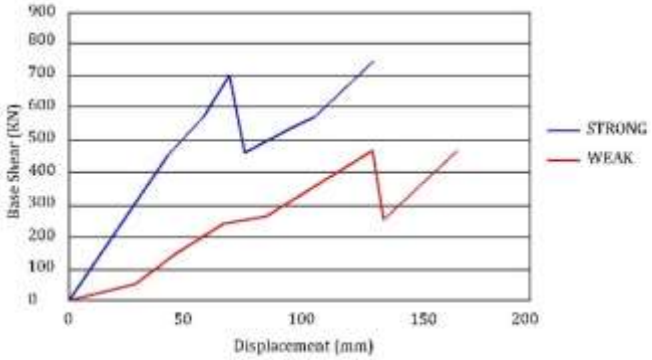


Fig. -4: Displaying the comparison of 1S2B SMRF buildings with strong and weak infill and fixed support conditions.

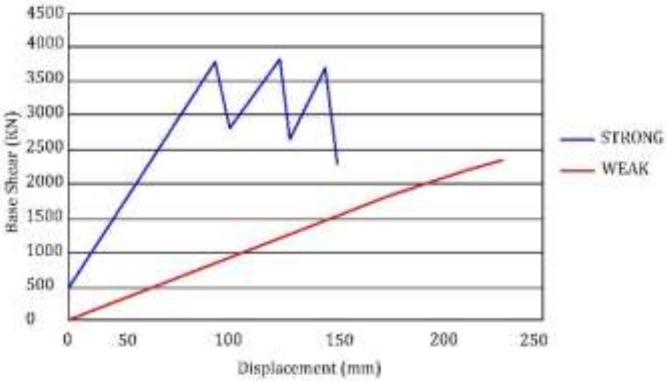


Fig. -4: Displaying the comparison of 1S7B SMRF buildings with strong and weak infill and fixed support conditions.

SUMMARY

- Static nonlinear pushover analysis is carried out on all buildings under consideration. Their response is monitored and pushover curves are plotted, comprising of Base Shear vs Roof Displacement values.

- The pushover curves of SMRF buildings and OMRF buildings are compared, for both fixed and hinged support conditions. It is found that the base shear capacity of OMRF is about 20- 40% more than that of a SMRF building. But the displacement capacity of SMRF is about 75-200% more than that OMRF. This concludes that SMRF buildings are more ductile than OMRF.

- The SMRF buildings with fixed and hinged support conditions are also compared and it is found that the performance is almost the same.

- The building behavior parameters are also 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.

- A comparative study on the basis of number of storeys is done for SMRF buildings and it is found that the ductility and the magnitude of base shear that can be resisted, increases slightly with increase in the number of storeys. The slope of the pushover curve for all buildings is almost the same.

- A comparative study and number of bays is also carried out for the SMRF buildings 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 increase by 3 times it can be proposed that the number of bays play a major role in the stability of a building.

- The pushover curves of SMRF buildings with strong infill and weak infill is also compared and it is concluded that the SMRF buildings with stronger infill have base shear capacity of about 1.5 to 2.5 times more than that of SMRF buildings with weak infill.

4. CONCLUSIONS

- The SMRF structures with stronger & weaker infill are carried in comparison & this is instituted that the structures with stronger infill can bear up a complex amount of base shear when related to those with weaker infill. This may be established that the SMRF structures with stronger infill consume base shear capacity of around 1.5 to 2.5 times additional than that of SMRF structures with weaker infill. Even though, an exact inference cannot be made for ductility, this may be advised that weaker infill are not favored due to their linear behavior in the pushover curve.

- The SMRF structures with identical no. of bays and diverse no. of storeys are carried in comparison. The pushover curve is schemed & this is instituted that the amount & the ductility of base shear that can be repelled, rises with rise in the no. of storeys. This is instituted that all the SMRF structures deliberated has exactly the similar amount of initial slope in the push over curve.

- The behavior of SMRF building with fixed & hinged support conditions are carried in comparison. This is instituted that an act of SMRF structures under fixed & hinged support condition is an identical. So it is decided that hinged & fixed condition do not play big part in investigation.

- A performance of SMRF structure & OMRF structure with no infill & fixed support conditions are carried in comparison. This is instituted that the structures designed as SMRF execute ample superior related to the OMRF structure. Ductility of SMRF structures is nearly 75% to 200% additional than the OMRF structures in all circumstances, the object being the heavy limitation of concrete due to splicing & utilization of additional no. of rings as ductile reinforcement. This is also instituted that the base shear capacity of OMRF structures is 20 to 40% additional than that of SMRF structures.

- The SMRF structures with stronger & weaker infill are carried in comparison & this is instituted that the structures with stronger infill can bear up a complex amount of base shear when related to those with weaker infill. This may be established that the SMRF structures with stronger infill consume base shear capacity of around 1.5 to 2.5 times additional than that of SMRF structures with weaker infill. Even though, an exact inference cannot be made for ductility, this may be advised that weaker infill are not favored due to their linear behavior in the pushover curve.

REFERENCES

[1] ACI 318, (2005) “Building code requirement for reinforced concrete and commentary”, ACI 318-05/ACI 318R-05, American Concrete Institute.

[2] Achyutha, H., R. Jagadish and S. S. Rahman (1982),” Effect of contact between infill and frame on the behaviour of infilled multi-storey frames”, Proceedings of the 6th International Brick Masonry Conference. Rome.

[3] Asokan, A., (2006) Modelling of Masonry Infill Walls for Nonlinear Static Analysis of Buildings under Seismic Loads. M. S. Thesis, Indian Institute of Technology Madras, Chennai.

[4] A. Shuraim, A. Charif, (2007) Performance of pushover procedure in evaluating the seismic adequacy of reinforced concrete frames. King Saud University

[5] ATC 40, (1996), “Seismic Evaluation and Retrofit of Concrete Buildings”, Applied Technology Council, USA.

[6] Akbas, B., Kara, F.I., and Tugsal, U.M. (2003), “Comparison of Pushover Analysis and Nonlinear Dynamic Time History Analysis on Low-, Medium-, and High-Rise Steel Frames”, Project No. 02-A-02-01-03, Scientific Research Project Fund, Gebze Institute of Technology

[7] B.Akbas. et al., (2003), carried out a pushover analysis on steel frames to calculate the seismic demands at distinct presentation levels, which needs the reviewing of inelastic behaviour of the structure.

[8] 40. Rutenberg, A., (1992),”Nonlinear Response of Asymmetric Building Structures and Seismic Codes: A State of the Art Review”, European Earthquake Engineering,6(2), 3-19.

[9] 46. X.-K. Zou, C.-M. Chan.(2005),”Optimal seismic performance-based design of reinforced concrete buildings using nonlinear pushover analysis”, Department of Civil Engineering, Hong Kong University of Science and Technology, Kowloon, Hong Kong, China

[10] 4. A. Shuraim, A. Charif, (2007) Performance of pushover procedure in evaluating the seismic adequacy of reinforced concrete frames. King Saud University

[11] Nair, Rahul V (2013) Performance Assessment of Multi-storeyed RC Special Moment Resisting Frames