INFLUENCE OF OPENING IN THE BRICK INFILLED WALL ON THE STIFFNESS OF RCC FRAME

NIKHIL BANDWAL [1], RAHUL JICHKAR [2], NITESH THIKARE [3]

[1] Asst. Prof., Dept of CE, Dutta meghe Institute Of Engineerng, Technology and Research, Wardha, Maharashtra, India,

[2] Asst. Prof., Dept of CE, Dr. Babasaheb Ambedkar College Of Engineering & Research, Nagpur , Maharashtra, India,

[3] Asst. Prof., Dept of CE, Priyadarshini Bhagwati College Of Engineering, Nagpur , Maharashtra, India,

ABSTRACT

Due to the presence of infill the frame structure modify its behavior under the action of lateral load; the frame action gets changes into the truss action. It is observed that, separation between the frame and the masonry infill at unloaded diagonal is inevitable even at low levels of load. The frame infill separation criteria have been studied with finite element analysis of infill wall. For better understanding the behavior of infilled frame under lateral loading the equivalent static analysis has been done.The opening in the infill has great influence on the stiffening properties of the infill. The influence of opening in the infill has been presented in this project and the respective stiffness comparison for infill with and without opening has been executed with certain interface criteria. Also the effect of changing the orientation of opening on the stiffness of infill has been studied. Taking the infill separation criteria the normalized width of strut have been found out. Previously the influence of opening i.e. opening on percentage basis has been studied and later the effect of real size opening i.e. opening for real size doors and windows have been presented.

INTRODUCTION

Masonry is an oldest construction material in use around the world for reason that includes accessibility, functionality, and cost. The primary function of masonry is either to protect inside of the structure from the environment (rain, snow, wind etc) or to divide inside spaces. Normally these are considered as architectural elements. Engineers often ignored their presence. Because of complexity of the problem, their interaction with the bounding frame is often neglected in the analysis of building structures. When masonry infill is considered to interact with their surrounding frames, the lateral load capacity of the structure largely increase. Neglecting the frame infill interaction may lead to an important inaccuracy in predicting the response of the structure. This occurs especially when the building is subjected to lateral loading.In multistory buildings, the ordinarily occurring vertical loads, dead or live, do not pose much of a problem, but the lateral loads due to wind or earthquake tremors are a matter of great concern and need special consideration in the design of buildings. These lateral forces can produce the critical stress in a structure, set up undesirable vibrations, and, in addition, cause lateral sway of the structure which can reach a stage of discomfort to the occupants. In many countries situated in seismic regions, reinforced concrete frames are infill fully or partially by brick masonry panels with or without openings. Although the infill panels significantly enhance both the stiffness and strength of the frame, their contribution is often not taken into account because of the lack of knowledge of the composite behavior of the frame and the infill.Infill wall can be modeled in several forms such as, equivalent diagonal strut and finite element method etc. The second type is well described in this thesis. The properties of the infill material i.e. Brick are taken from FEMA 356 and other relevant documents.For new buildings, infill wall is modeled and designed to provide high rigidity. Also older buildings are rehabilitated with infill that is compatible with the original frame work. Studies found that infill fails in two main ways; Shear failure and Corner crushing. In some cases diagonal cracks are also found predominant.

ISSN: 2278 – 7798

1.2 Objective of the Project:

The structural behavior depends on the various components such as structural members and non-structural components. Generally the strength of the non-structural member such as wall is not considered. From the performance of structures in past earthquakes and various studies carried out it is found that the non structural components also plays vital role in the performance of structures under seismic loads.The main objective of the project is to study the effect of masonry infill walls on the stiffness of structure. The effect of presence of infill wall and openings in the infill walls is studied in this project work.

Specific Objectives of research

i. Study of the various modeling techniques for the infill wall.
ii. Study the effect of infill wall on the stiffness of structure.
iii. Check the effect of opening position and size of opening on structure.
iv. Identify the suitable position of opening position in the wall.

MODELING TECHNIQUES

There are various modeling techniques and analysis methods of infill wall. Generally there are two criteria's by which the infill wall can be model i.e., separation and no separation criteria. In this chapter we use separation criteria to model the infill wall. The various analysis methods are listed below.

Analysis methods:

Available analysis methods for the strength and stiffness of infill frames can be generally classified into the following:

i. Method based on the concept of elementary strength of materials treating the wall to act compositely with the frame.
ii. Method based on concept of equivalent strut.
iii. Method based on finite element analysis
iv. Method based on result of experimental investigations.
v. Method based on Plasticity and collapse design approach

Method based on finite element method:

Infill frame can be modeled by finite element method also. Finite element method is a very powerful technique and any type of modeling can be done in this method. The validity and acceptability of analysis and design of any engineering problem depends on its numerical modeling. In this project the finite element analysis of infill frames is discussed in details.

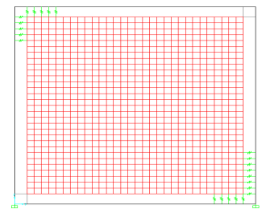


Figure 1: Separation not allowed

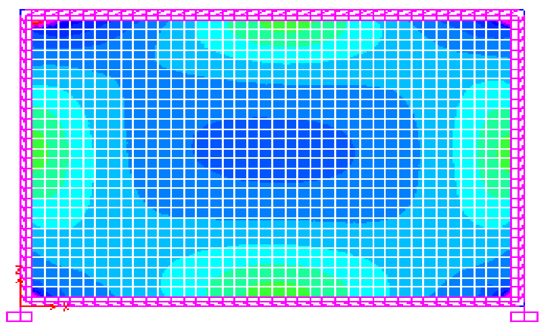
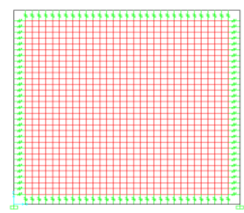


Figure 2: Separation allowed



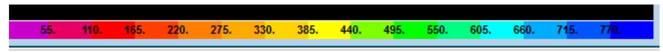
Frame infill separation and no separation criteria:
Generally there are two criteria's by which the infill wall can be model i.e., separation and no separation criteria. In modeling of infill wall the spring element is used which represent the mortar to act as a connecting link between frame and infill wall. If the force is acting in one direction at the top corner, a single diagonal strut is formed and if the forces are acting from two directions, then the muti-diagonal strut is formed. Various researchers are given various formulas to calculate the width of this strut. For modeling the infill wall separation criteria is used which is described below.

a. Separation between frame and infill is not allowed

The Figure (3.1(a)) represents the brick masonry infilled wall when the separation of frame and infill is not allowed. The first diagram shows the FEM model of brick masonry when the interface element (springs) is used to represent mortar for the contact between masonry and frame. Restraints are also shown in the above diagram and the frame is considered as fix at base. The second diagram (fig.3.1(c)) shows the contour of stress in the plane of masonry. When the separation between frame and infill is not allowed the stress formation in the brick masonry is in haphazard manner.

b. Separation between frame and infill is allowed

The Figure (3.1(b)) represents the brick masonry infilled wall when the separation of frame and infill is allowed. The first diagram (3.1(b)) shows the FEM model of brick masonry when the interface element (springs) is used to represent mortar for the contact between masonry and frame upto some length. In the Figure the contour formed shows a clear picture of formation of strut along the diagonal direction of the masonry.



Analysis of 2D (G+2) Frame

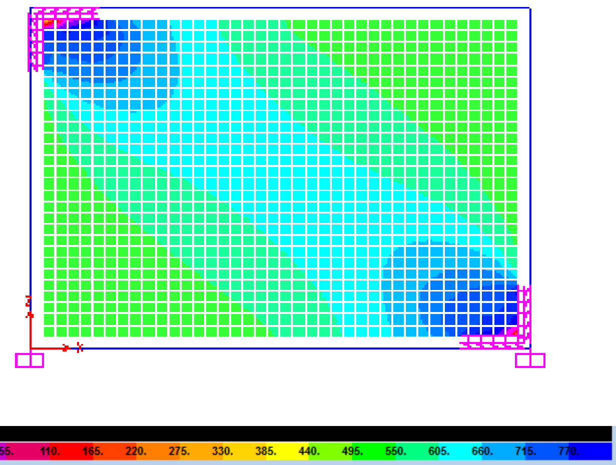


Figure 4: Stresses in separation criteria

In the analysis of 2D (G+2) frame four different models viz.,fully infill frame, fully infill frame with opening of door and window at the left corner of the frame, at centre of the frame and at the right corner of the frame are considered as shown in fig 4.12b, 4.12c, 4.12d and 4.12e respectively. To determine the effect, one lateral force of 500 KN is applied at the left hand top corner of the frame and computed the respective displacements at various nodes. The results for shear force and bending moment are also tabulated.

Preliminary data required for analysis

Type of structure	one bay two storey frame (SMRF)
Seismic zone	II (table 2, IS 1893 (part 1): 2002)
Infill wall	230 mm thick including plaster
Size of beam	230mm x 350mm
Size of column	350mm x 350mm
Specific weights	for RCC 25 kN/m^3
Size of door	(1 x 2.1) m
Size of window	(0.7 x 1.2) m

For the purpose of analysis taking M20 grade of concrete

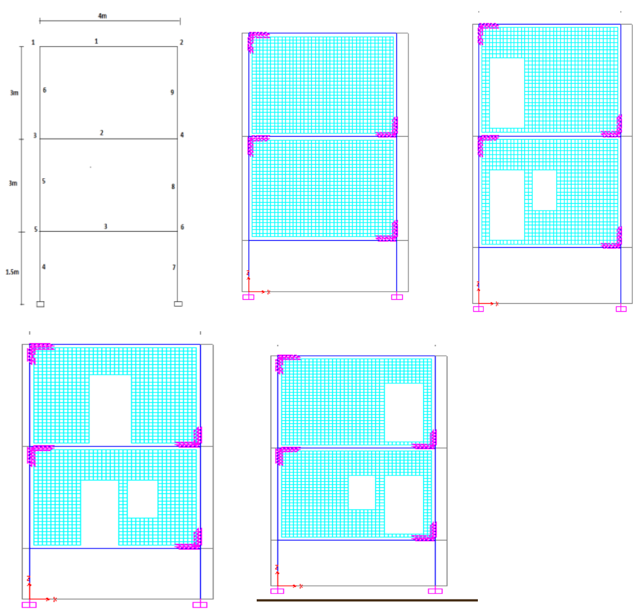
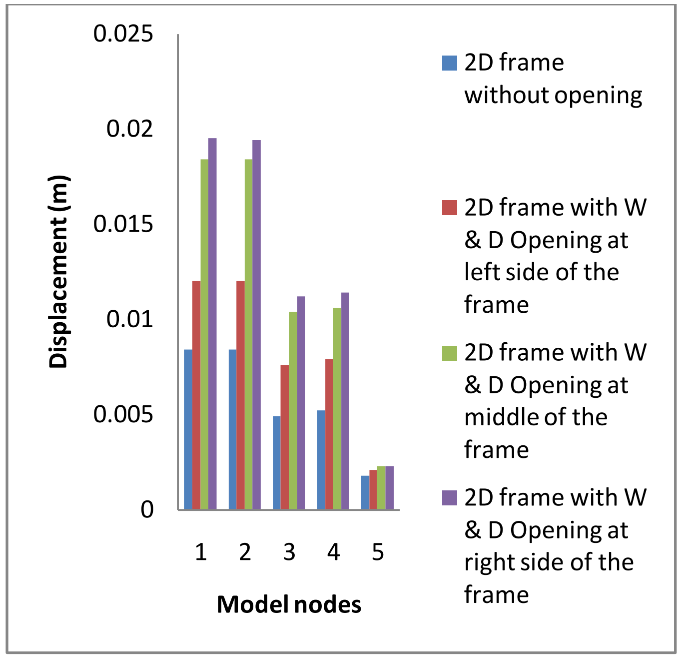


Figure 5: 2D frame with door and window opening at different position.

model nodes	2D frame without opening (m)	2D frame with W & D Opening at		
		left side of the frame (m)	middle of the frame (m)	right side of the frame (m)
1	0.0084	0.012	0.0184	0.0195
2	0.0084	0.012	0.0184	0.0194
3	0.0049	0.0076	0.0104	0.0112
4	0.0052	0.0079	0.0106	0.0114
5	0.0018	0.0021	0.0023	0.0023
6	0.002	0.0022	0.0024	0.0002

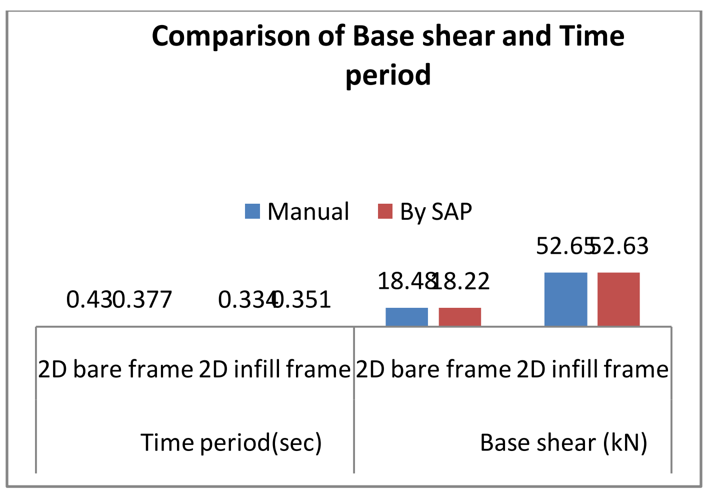


5.2.4 Static analysis of 2D frame structure

Static analysis of 2D frame is carried out to check the effect of presence of infill on the base shear and time period.

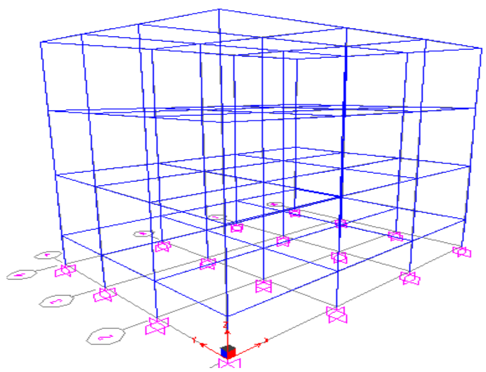
Table 5.4 – Comparison of Base shear and Time period

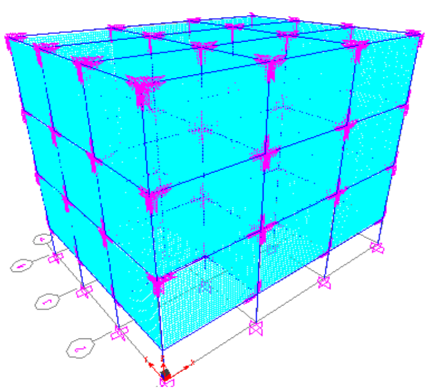
Methods	**Time period(sec)**		**Base shear (kN)**	
	2D bare frame	**2D infill frame**	**2D bare frame**	**2D infill frame**
Manual	0.43	0.334	18.48	52.65
By SAP	0.377	0.351	18.22	52.63

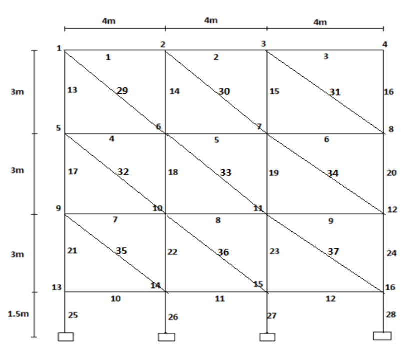


- Analysis of 3D frame with infill in x and y direction

The seismic analysis is carried out with infill in x and y direction by using equivalent static method.







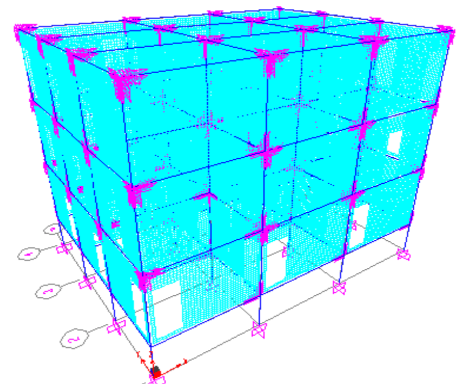


Table Displacements at nodes of 3D frame with infill in x and y direction

Floor Level	3D frame without opening			3D frame with opening
	Bare frame (m)	Frame with Infill as FE(m)	Frame with Equivalent diagonal strut (m)	(m)
Roof	0.0037	0.0011	0.0004	0.0025
Second Storey	0.0029	0.0009	0.0003	0.0019
First storey	0.0016	0.00055	0.0002	0.0011
Plinth level	0.0002	0.00018	0.0002	0.00017

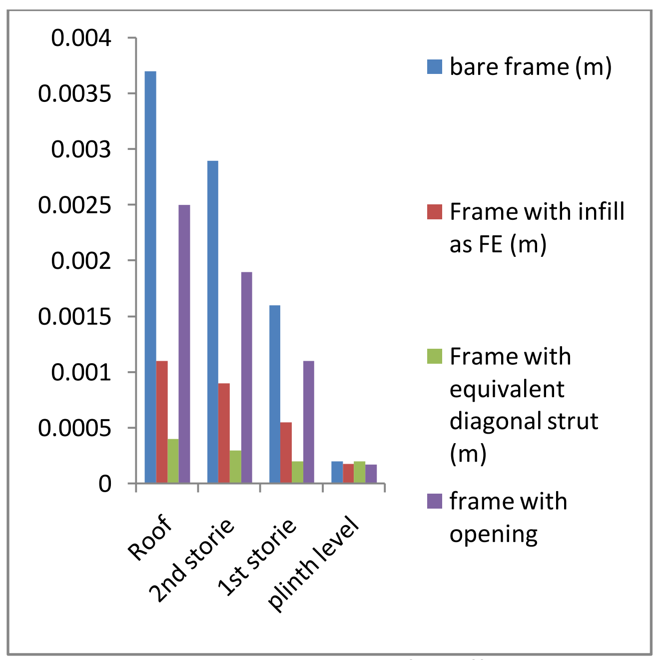


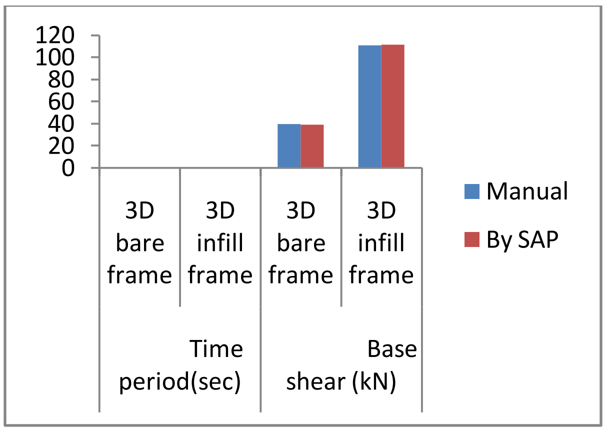
Fig.Displacements at various nodes for different 3D frame models

Static analysis of 3D frame structure

Static analysis of 3D frame is carried out to check the effect of presence of infill on the base shear and time period.

Table 5.4 – Comparison of Base shear and Time period

Methods	Time period(sec)		Base shear (kN)	
	3D bare frame	3D infill frame	3D bare frame	3D infill frame
Manual	0.43	0.483	39.87	110.82
By SAP	0.627	0.68	39.32	111.27



Conclusions

From the analysis of various models considering different parameters, following conclusions are made.

1The presence of infill wall increases the stiffness of the structure and reduces the lateral displacements. It also increases the energy dissipation capacity of the overall structure.

2. From the analysis of 2D frame, it is found that the lateral displacement of a frame with complete infill reduces by 97.16% as compared to bare frame at the roof level. Similarly the displacement at each floor reduced.

3. From the static analysis of 2D and 3D frames, it is observed that the infill has a great effect on the stiffness of the frame as compared to the bare frame. And it is concluded that the infill reduces the time period of the structure.

4. From cl. No. 4.6, it is concluded that the bare frame has the maximum deflection as compared to the fully infill frame, infill frame with ground soft storey and infill frame middle soft storey. And hence the presence of infill has a great effect firstly on lateral deflection and thereby on the stiffness of the frame.

5. The stiffness of structure reduces with increase in the percentage of opening and the position of the opening has a great influence on the stiffness of the structure. From the above study carried out in this dissertation work it is found that the stiffness of structure is minimum when the opening lies in the diagonal line.

6. The method of modeling is affecting the results and it is found that, the modeling of infilled wall as a equivalent diagonal strut provides more stiffness as compared to infilled wall modeled by finite element method.

7. The presence of opening in the infill had great influence on the stiffness of the structure and it is also observe that the change in the position of opening for the same size changes the stiffness of frame.

8. From the present study it can be conclude that the suitable position of opening is away from the diagonal zone having thickness equals to the width of diagonal strut.

FUTURE SCOPE

1. This study basically deals analysis of infill frame with only linear analysis any type of non linearity is not considered, this work can be extended by considering material non linearity

2. The separation between the frame and infill was main focus in this study and all the analysis has been carried out in this regard, so the use of multistrut model can be carried out in further analysis of infill frame and the comparison between the single and multistrut model can be given.

3. In SAP2000 the infill wall is modeled as a homogeneous material so, there is no modeling done for mortar around the brick, one can use different software for modeling the mortar which can give the true behavior of the structure.

REFERENCES

1. Albanesis,S., et. al.(2004), "The influence of infill walls in R.C. frame seismic response." High performance structures and materials II.,ISBN-717-5

2. Ali H.,(2009), "Half scale three storeyinfilled R.C. buildings a comparison of experimental and numerical models." Dessertation on InstitutoUnivertario di studisuperioriuniversitadeglistudi di pavia.,(2009),pp1-47

3. Asteris,P.G.(2003), "Lateral stiffness of brick masonry infilled plane frames," Journal of Structural Engineering, ASCE, 129 vol.8, pp1071-1079

4. Dorji,J., and Thambiratnam,D.P.(2009), "Modeling and analysis of infilled frame under seismic load." Journal of Construction and Building Technology, OPEN, 3 (2009), pp119-126.

5. Fiore, A., Netti, A., and Monaco, P.(2011), "The influence of masonry infill on the seismic behavior of RC frame buildings." Journal of Engineering Structures, 44(2012), pp133-145

6. Keyvani,J., and Farzadi,M.(2011),"Impact of brick infill walls on the seismic behavior of reinforced concrete frames using finite element method." Journal of Civil Engineering (Build. and Hous.). vol.12, 6(2012), pp 789-802.

7. Memari, A. M. (2003),"Recent developments in seismic isolation systems for masonry infill and Brick veneer walls." Architectural Engineering, ASCE, pp 1-5.

8. Mulgund,G.V., and Dr. Kulkarni A.B.(2011), "Seismic assessment of R.C. Frame buildings with brick masonry infills."International Journal of Advanced Engineering Sciences and Technologies, vol. 2, 2(2011),pp 140-147

9. Murty, C.V.R., and Jain, S.K.(1996), " Beneficial influence of masonry infill walls on seismic performance of RC frame buildings."WCEE2000,pp 1-6.

10. Mondal, G., and Jain S. K.,(2008), "Lateral Stiffness of masonry infilled RC Frames with central opening." Earthquake Specra, vol., 24(3), (2008), pp 701-723.

11 Patel,S.R., and Patel, B.S.(2011), "Effect of brick infill panel in design of high rise building." National conference on recent trends in Engineering and technology at B.V.M. collage Gujrat. (2011),pp 1-4

12 Rashid,M.H., and Khatun,S.(2011), "Effect of Infill walls on structural frames." International Conference on Mechanical, Production and Automobile Engineering, (ICMPAE).

13 Nwofor, T. C., and Chinwah J.G.(2012), "Finite Element Modeling of Shear Strength of Infilled Frames With Openings." International Journal of Engineering and Technology, vol.2-6, ISSN 2049-3444(2012)

14 Rathi, R. P., and Dr. Pajgade, P. S.(2012), "Study of masonry infilled R. C. frame with and without opening." International Journal of scientific and Engineering Research, vol3-6, ISSN 2229-5518(2012), pp1-7

15 Samolia,D.M.(2012), "Analytical Modeling of Masonry Infills,"Journal of Civil and Architectural, vol. 55(2),(2012), pp 127-136

16 Surendran,S., and Kaushik,H.B.(2012), "Masonry infill RC frames with opening Review of In plane Lateral load Behavior and Approaches." Journal of Construction and Building Technology, OPEN, 6(Supp 1-M9),(2012),pp126-154.

17 Sigmund,V., and Panava,D.(2013), "Assessment of masonry infilled reinforced concrete frames with openings." Technical gazette 20-3, pp 459-466

18 Uva, G., et. al, (2012), "On the role of equivalent strut models in the seismic assessment of infilledframes." Engineering structures 42(2012), pp 83-94

19 IS 1893(Part1):2002, "Criteria for Earthquake Resistant Design of Structures", 5th Revision, Bureau of Indian Standard, New Delhi.

