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"NONLINEAR SEISMIC ANALYSIS AND MODELLING OF MASONRY INFILL FRAME WITH OPENING"

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ABSTRACT

The present study is focused on Incremental Dynamic Analysis (IDA)method for the analysis of sample building.Incremental Dynamic Analysis (IDA) is an emerging structural analysis method that offers thorough seismic demand and limit-state capacity prediction capability by using a series of nonlinear dynamic analyses under a suite of multiply scaled ground motion records.The seismic performance of the Masonry Structure is quantified in terms of yield and collapse capacities in terms of various ground motion indices, which are derived from IDA curves. The yield capacity of the structure is defined as the level of Intensity at which the IDA curve leaves the linear path. Similarly, the collapse capacity is defined as the IM level at which the IDA curve becomes horizontal. Fragility curves defined as the probability of exceeding a damage level (yielding/collapse) at various levels of IM are then plotted for these two damage levels. The fragility curves for yielding and collapse damage levels are developed by statistically interpreting the results of the time-history analyses. Hazard-survival curves are generated by changing the horizontal axis of the fragility curves from ground motion intensities to their annual probability of exceedance using the log-log linear ground motion hazard model. The results express at a glance the probabilities of yielding and collapse against various levels of ground motion intensities.

A set of 7 selected ground motion time histories has been used to analyse Masonry Structure for performing IDA.

SAP2000 (version-14) is used for analyzing the Masonry structure. Pushover analysis, Incremental dynamic Analysis and Fragility Analysis has been applied on Masonry structure.Present work can be used as the guideline for the seismic behavior of Masonry structure.

Keyword: *Incremental Dynamic Analysis, Mansory Structure,Seismic performance*

I. INTRODUCTION

Masonry buildings of brick and stone are superior with respect to durability, fire resistance, heat resistance and formative effects. Because of the easy availability of materials for masonry construction, economic reasons and merits mentioned above this type of construction is employed in the rural, urban and hilly regions up to its optimum, since it is flexible enough to accommodate itself according to the prevailing environmental conditions.

The past earthquake survey has proved that the masonry buildings are most vulnerable to and have suffered maximum damages in the past earthquakes. Of the great number of masonry buildings subjected to strong earthquakes, many were severely damaged and collapsed. Consequently, masonry has been considered as an unsuitable material for the construction of buildings in seismic zones.

Sometimes, separation of walls and even out – of –plane collapse occurred. Also, many times, despite the favorable structural layout of those buildings in plan and good connection of walls, the quality of masonry materials was not good

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enough to spare the walls from diagonal cracking, disintegration, and ultimate collapse. In the case if contemporary masonry buildings, adequate structural layout turned out to be an extremely important issue. The buildings with structural walls in one, usually the transverse, direction only, were not able to resist earthquakes with predominant ground motion in the weak direction of the building.

Under seismic conditions, the induced seismic energy will dissipate uniformly over the entire structure. If structural elements are not distributed uniformly in the plan and elevation of the structural system, however, concentration of stresses might occur in the zones of non-uniformity, resulting in heavy damage and collapse of the structure.

Earthquake ground motion is a tri-dimensional phenomenon. It is, however, not known which will be the main direction of ground motion during an expected seismic event. Therefore, the resisting elements of each structure in a seismic zone should be designed to resist the seismic excitation in both principal directions of the building. The consequences of neglecting the necessity of having an adequate number of sufficiently resistant structural walls in both principal directions of the building are severe.

Symmetric distribution of resisting elements in the plan of the building will prevent possible torsional vibration, which often causes unexpected behaviour of the structure when subjected to strong seismic ground motion. In order to avoid torsional effects resulting from differences in ground motion in the case of long rectangular buildings. It is desirable to limit the length of a single part of the building to four times its width.

In the present scenario, because of the wide range of geometry possible with masonry frame, the accumulated understanding is still limited, thus there is a need of an attempt to be proposed to lay down certain recommendations which will be used as general guidelines for the performance study of masonry frame subjected to seismic loading.

The seismic evaluation is helpful for retrofitting of the structure and carried out through Qualitative and Analytical methods.

On reviewing the literature available it can be said that there is an inadequacy of research on seismic performance of 3D structures, while a large number of papers and research work for 2D structures is available.

Erol Kalkan*et al*(2006) reported essential and critical component of evolving performance-based design methodologies is the accurate estimation of seismic demand parameters. Nonlinear static procedures (NSPs) are now widely used in engineering practice to predict seismic demands in building structures. While seismic demands using NSPs can be computed directly from a site-specific hazard spectrum, nonlinear time-history (NTH) analyses require an ensemble of ground motions and an associated probabilistic assessment to account for aleatoric variability in earthquake recordings.

R. Cardoso *et al* contributed for the evaluation of the seismic vulnerability of old masonry buildings that are an important percentage of the building stock of cities from south of Europe. Considering Lisbon’s downtown old masonry buildings as an example, the principal structural material is not only masonry but also wood elements that may exist wrapped up in it. In order to evaluate seismic behaviour of these buildings, it is necessary to identify the presence of wood and masonry, evaluate their strength characteristics and the Contribution of both materials to global behaviour. Some tests that are usually made to identify the existence of each material and to evaluate their strength characteristics, are presented in this paper. As often it is not possible to perform those tests, some values for the principal strength parameters obtained from bibliographic research are also presented.

Babu and Venkatasubramani (2011) investigated seismic retrofit using brick inserts to upgrade the capacity of reinforce concrete frame with brick masonry infill wall and to addresses the buildings without following the details as stated in BIS 13920. The overall aim of his study was by adding a small brick insert in the partial infilled RC structures, the structure could double its strength.

Asteris (1996) presents a method of contact points for the analysis of masonry infilled frames subjected to earthquake static loads (in-plane lateral loads) . the main goal is the modeling of infilled frames and investigation of their behavior. Especially, the influence of masonry infill wall to the asesimicbehavior of the plane frames.

The literature survey in the performance and behaviour of masonry structures when subjected to seismic loads suggests that the requirement of establishing a methodology for studying response of masonry structure to earthquake loads has become essential.

Therefore, on the basis of certain objectives, some methodology needs to be proposed for learning the behaviour of masonry structures under seismic type of loads.The specific aims and objectives of the present problem are:

1) To study the existing methods and procedures given for the analysis and design of Masonry Building with opening subjected to seismic loading.
2) To use non linear seismic analysis on Masonry Building.

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3) To explore Incremental Dynamic Analysis with reference to the Masonry Building under consideration using SAP 2000.
4) To determine drift ratio of Masonry building under consideration.
5) To perform fragility Analysis on Masonry Building. To execute performance assessment of representative sample frame from fragility curves in terms of various ground motion parameters.
6) To develop hazard survival curves and determine probabilities of surviving specified damage states
.

The structural analysis program SAP2000 based on the finite element method is used for modeling and analysis.

II. METHODOLOGY

The seismic performance i.e. analysis of masonry structures is attempted in the current problem. For this, the proposed methodology is as follows:

1) An extensive survey of the literature on the response of Masonry structures to seismic loading is performed.
2) Based on the numerical and parametric study, a step-by-step procedure for the simplified seismic analysis of Masonry structure has been suggested.
3) Perform linear static and linear dynamic analysis (RSP) in SAP2000 for evaluating Base shear of masonry frame and compare with base shear from IS: 1893 which calculated manually.
4) A problem of a Masonry Building is taken and analyzed by the Pushover analysis.
5) Based on the numerical and parametric study, a step-by-step procedure for the simplified seismic analysis of masonry frame has been suggested.
6) A problem of a Masonry structure is taken and analyzed by Non-Linear Time History Analysis for 7 selected ground motions.
7) IDA Curves between PGA and Drift ratio for selected 7 Ground Motion has been plotted & with the help of these IDA curves Fragility and Hazard Survival Curves are obtained.

SAP2000 software is used to perform the Nonlinear Dynamic Analysis of Masonry Structure using displacement control strategy, where gravity load applied prior to the pushover analysis. Yielding and collapse can be determined analytically with reasonable accuracy from the IDA curves for a particular building against a particular ground motion. The yield capacity of the structure is defined as the IM point at which the IDA curve leaves the linear path. When the structure reaches its collapse capacity, practically, an increase in IM produces an infinite increase in EDP.It is clear from IDA curves that there exist variations in EDP-IM relationship with respect to different ground motions.

2.1 Description of Masonry Building Frame

Two Storey 2D Masonry building frame is used with width 3.6m, storey height 3m, wall thickness 0.2m. In the above frame two columns are used of 200x200mm and beam of 200x100mm. Two frames are considered for comparative study out of which first frame is without opening and second frame is with opening of size 1x2m.

2.2Parameter of Masonry Building Used

Table 1: Parameter of Masonry Building

Span in X direction	3.6 m
Wall Thickness	0.2 m
Live load	3kN/m^2
Grade of Concrete	M-20
Type of Steel	HYSD bars
Column Height	6.0 m
Column Size	0.2m X 0.2m
Column Longitudinal reinforcement	1 % reinforcement

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Column transverse reinforcement	10d @ 150 centre to centre
Column Support condition	Fixed
Beam Size	0.20 m x 0.10m
Opening Size	1mx2m

2.3 Modeling Approach

The modeling approach includes the development of model, discretization of model, finite element modeling using SAP2000, selection of analysis procedures and hinge properties.

2.4 Analysis Procedure

From the different analysis procedures -

1. Linear - Static Procedure (NSP) (Pushover Analysis),
2. Nonlinear - Dynamic Procedure (NDP) (Time-history Analysis)
3. Incremental Dynamic Analysis (IDA)
4. Fragility Analysis

III. RESULTS AND DISCUSSION

3.1 Comparison of Base Shear and Displacement from Different Analysis without Opening

Table 2 : caption

Analysis Case Results	LSP (Equivalent Static Load)	LDP (RSP)	IS: 1893
Base Shear	170kN	175kN	145kN
Displacement	5.48mm	5.68mm	7mm

3.2 IDA Curve For 7 Time Histories With Opening

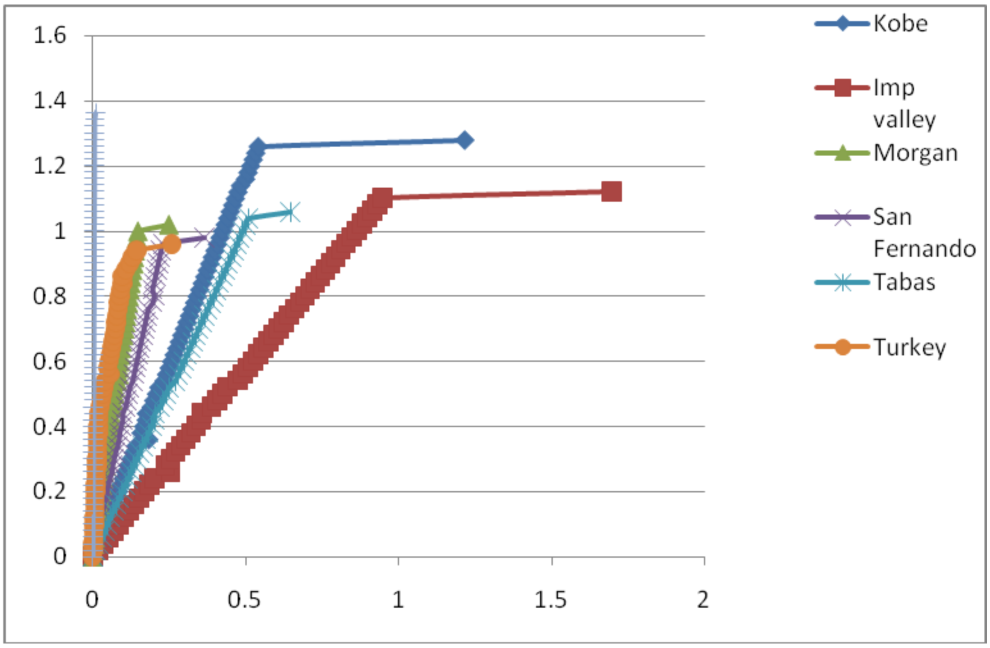

Fig 1: IDA curve for 7 Time history with opening

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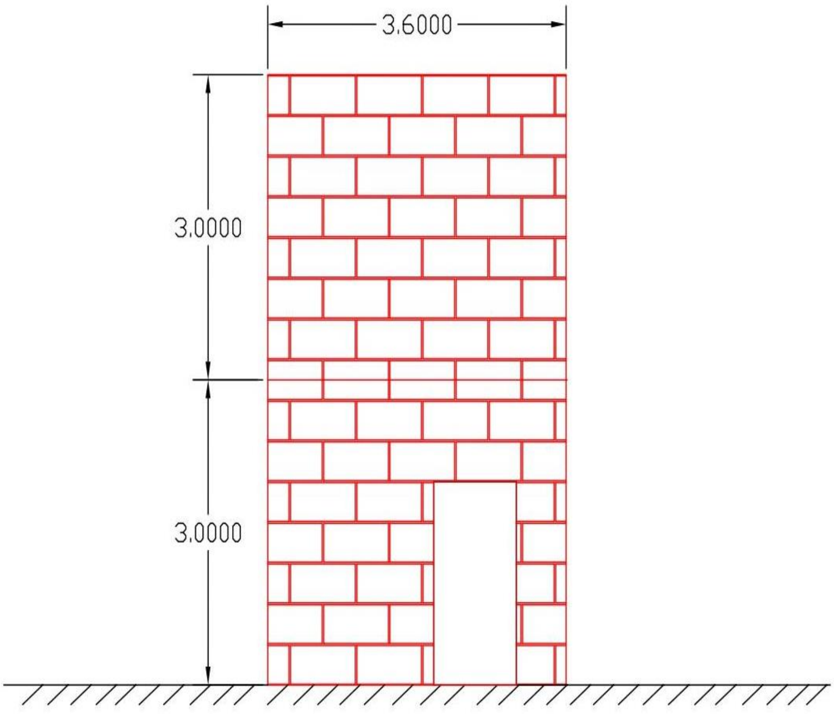

3.3Fragility Curve of Masonry Building for with opening From (SAP-2000)

Table 1: Yield Values of SDOF Model (A) w.r.t PGA for generation of Fragility Curves

Yield Values				
Eqk	**PGA**	**ISD (DRIFT)**	**LN(PGA)**	**LN(DRIFT)**
Imp Valley	1.42	0.2536	-1.347073648	-1.371997056
Morgan	0.96	0.043	-1.272965676	-3.146555163
San Fernando	1.62	0.098	-0.867500568	-2.3227878
Tabas	0.66	0.203	-0.820980552	-1.5945493
Turkey	1.08	0.054	-0.510825624	-2.918771232
Victoria	1.2	0.0023	-0.733969175	-6.074846156
Kobey	.96	0.183	-1.021651248	-1.698269126
MED			-0.867500568	-2.3227878
STDV			0.297012779	1.620741297
BCD			0.328962902	1.626899613

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Table 2:Collapse values of Masonry frame w.r.t PGA for generation of Fragility Curves With opening

Collapse Values				
Eqk	**PGA**	**ISD (DRIFT)**	**LN(PGA)**	**LN(DRIFT)**
Imp Valley	1.42	0.0428	0.350656872	-3.151217176
Morgan	0.96	0.246	-0.040821995	-1.402423743
San Fernando	1.62	0.1666	0.482426149	-1.792159549
Tabas	0.66	0.8761	-0.415515444	-0.132275039
Turkey	1.08	0.0365	0.076961041	-3.310443018
Victoria	1.2	0.5884	0.182321557	-0.53034829
Kobey	.96	0.246	-0.040821995	-1.402423743
MED			0.076961041	-1.402423743
STDV			0.294458622	1.204604976
BCD			0.32665866	1.212878043

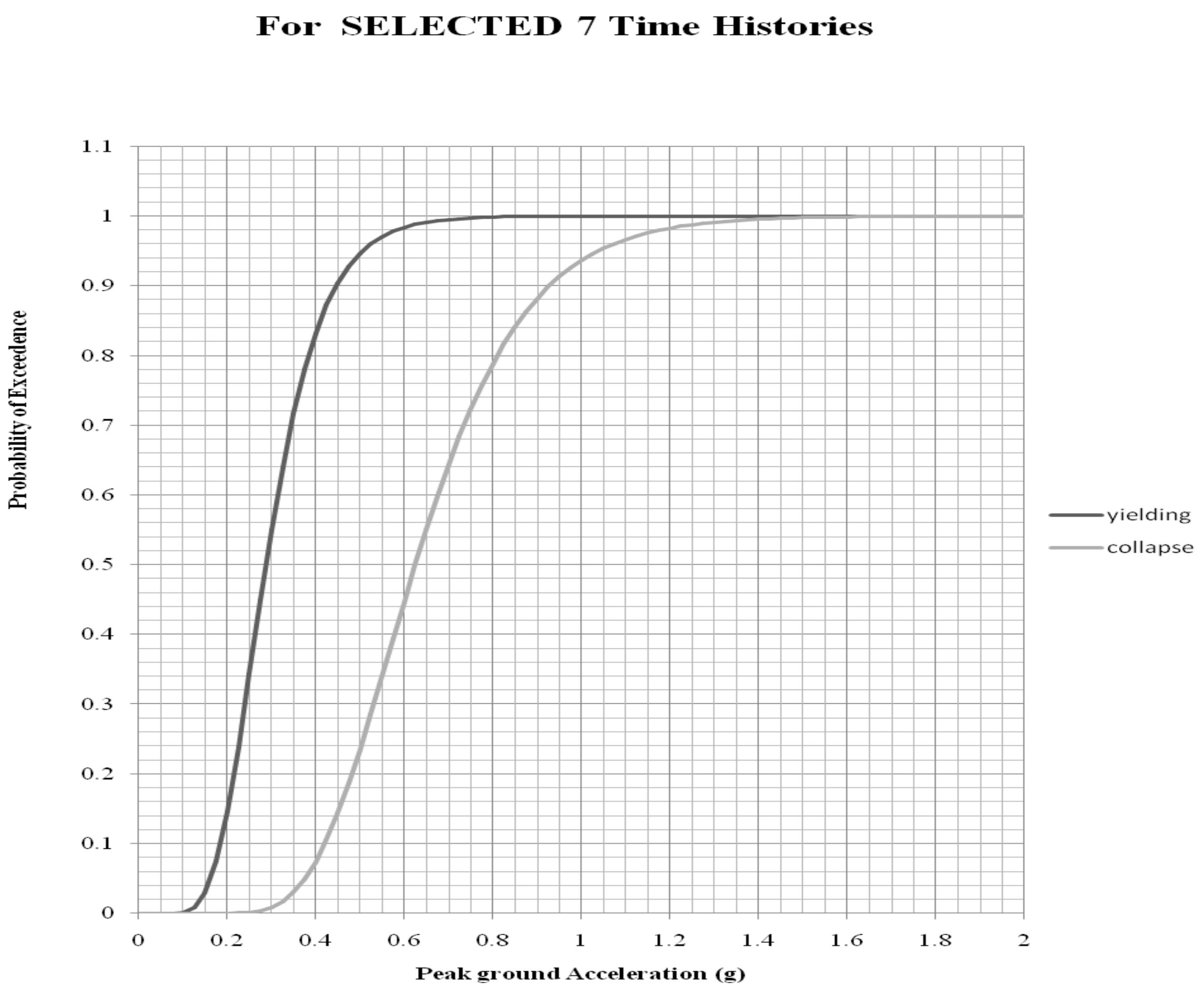

Fig 2: Fragility Curve for Selected Ground Motion

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3.4 Performance Assessment of Masonry frame with opening for fragility curves:-
Selected Ground Motion:

Table 3: Performance Assessment of Masonry frame without opening

Ground Motion Idicies	Damage State	Capacity with 5% Probability of exceeding damage state
PGA	Yield	0.33 g
	Collapse	0.9 g

3.5 Probability of Surviving at different Damage States:

Table 4: Probability of surviving at different Damage States

Return Period	Probability of Survival	
	Yield	Collapse
50	.62953	.909
100	.56551	.88293
475	.22230	.84509
1000	.11854	.60271
2500	.08129	.40629

The fourth row means that if a ground motion of return period of 475 years i.e DBE with annual frequency of 0.002 occurs, the probability of surviving against yielding is 22% and probability of surviving against collapse is 60% for RC Shell Structure.

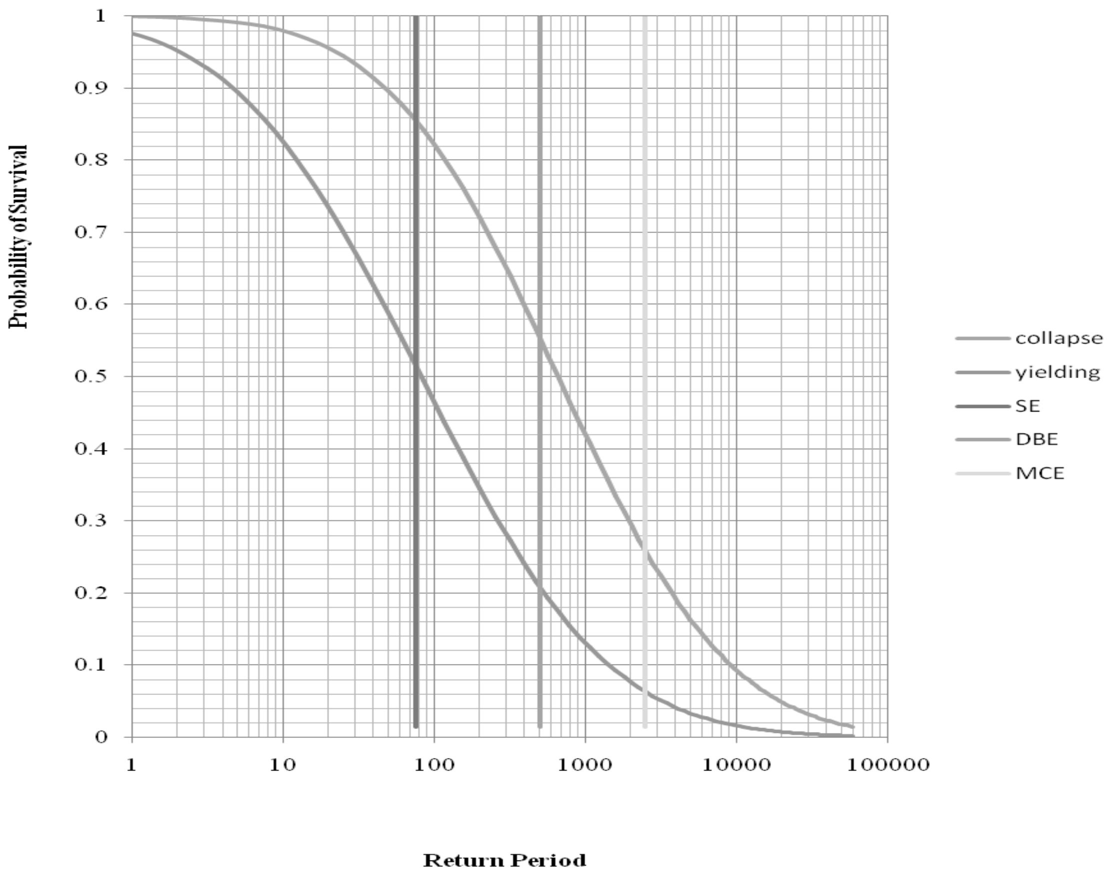

Fig 3: Hazard Survival Curve

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IV. CONCLUSION

From the basis of Fragility Analysis of Masonry Building conclusions are –

1) Masonry infill frame with opening gives lesser value of PGA (g) as compare to without opening.
2) 72g (2MCE) is most vulnerable earthquake for masonry infill frames which gives almost more than 90% damage.
3) Seismic evaluation of existing masonry frames based on IDA is necessary looking at recent earthquake scenario.
4) The effect of infill masonry material should be incorporated in Indian seismic code in terms of improved seismic design coefficient as it is significant when compare with bare frame.
5) Infill masonry material improves significantly lateral resistance capacity of the building as compare to bare frame.
6) Nonlinear seismic analysis methods must be incorporated in Indian seismic codes for realistic performance-based earthquake design of structures.

REFERENCES

[1] A. Saneinejad and B. Hobbs, Inelastic design of infilled frames. American Society of Civil Engineers, 121(4), (1995), 634-649.

[2] M. M. Maniyar, R. K. Khare, R. P. Dhakal, Probabilistic seismic performance evaluation of non-seismic RC frame buildings, Structural Engineering and Mechanics, 33(6), (2009) 22p.

[3] IS:456, (2000) Indian standard code of practice for plain and reinforced concrete for general building construction, Indian Standards Institution, New Delhi.

[4] ACI 318-08, American concrete institute standard building code requirements for structural concrete and commentary, reported by ACI committee 318.

[5] IS:13920, (1993) Indian standard code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces", Indian Standards Institution, New Delhi.

[6] A.Melani, R.K.Khare, R.P.Dhakal and S.R.Uma, Seismic evaluation of low rise rc frame structures designed as per IS 1893 (Part1): 2002 for zone-V. ICSSD-2012 (accepted 2011).

[7] IS:1893, (2002) Indian standard criteria for earthquake resistant design of structures, Part 1- General provisions and buildings, Indian Standards Institution, New Delhi.

[8] A. M. Reinhorn, S. K. Kunnath., and Valles-Mattox R., (2004), IDARC 2D Version 6.0: user's manual. Departament of Civil Engineering, State University of New York at Buffalo.

[9] A. M. Reinhorn, and A. Madan, R. E. Valles, Y. Reichman, J. B. Mander, Modelling of masonry infill panels for modeling of frame structures, (1995) Tech. Rep. NCEER-95-018, National Center. For Earthquake Engrg. Res., State University of New York at Buffalo, N.Y.

[10] G.V. Mulgund and A.B. Kulkarni, Seismic assessment of RC frame buildings with brick masonry infills, International Journal of Advanced Engineering Sciences and Technologies, 2(2), (2011), 140-147.

[11] M. Ghalehnovi and H. Shahraki , Masonry infilling effect on seismic vulnerability and performance level of high ductility RC frames". AIP Conference 1020 (2008), 1721-1737.

[12] A. Kadid∗ and A. Boumrkik (2008) "Pushover analysis of reinforced concrete frame structures" Asian journal of civil engineering (building and housing) Vol. 9, no. 1 pages 75-83.

[13] Paulay, T., and Priestley, M. J. N. (1992). "Seismic Design of Masonry and Reinforced Concrete Buildings." John Wiley & Sons, USA.

[14] TomazevicMiha(1999) "Earthquake – Resistant Design Of Masonry Buildings." Imperial College Press, London.

[15] Agarwal Pankaj ,Shrikhande Manish (2006) "Earthquake Resistant Design Of Structures." Prentice Hall of India pvt. Ltd., New Delhi.

[16] J. K. Bothara, J. B. Mander, R. P. Dhakal, R. K. Khare, M. M. Maniyar, Seismic performance and financial risk of masonary house, ISET Journal of Earthquake Technology 44(3-4), (2007), 421-444.

ISSN : 2455-9679
Impact Factor : 4.256

[17] Anil K. Chopra and Rakesh K. Goel (2001) "A modal pushover analysis procedure for estimating seismic demands for buildings" Earthquake Engineering and Structural Dynamics.

[18] Erol Kalkan and Sashi K. Kunnath (2004) "Method of modal combinations for pushover analysis of buildings" 13th World Conference on Earthquake Engineering.

[19] Goutam Mondal and Sudhir k Jain (2006) "Lateral stiffness of unreinforced brick infilled RC frames with central openings" Proceedings of the 8th U.S. National conference on Earthquake Engineering San Francisco, California, USA.

[20] Ashraf Habibullah, S.E., and Stephen Pyle, S.E.(1998) "Practical Three Dimensional Nonlinear Static Pushover Analysis" Structure Magazine, Winter.