International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 15
May 2018

"Appraisal and Strengthen of Masonry Structure under Seismic Loading"

Piyush Mahajan & Arpit Chawda

ABSTRACT

In last decades, through further development of computer technology in civil engineering, so many different seismic analyses became possible and accuracy of the analysis is increased. Therefore there are lots of methodologies for seismic assessment in use. Many of the existing structure, which do not fulfill the current seismic requirements, may suffer extensive damage or even collapse if shaken by a severe ground motion. The aim of appraisal is to assess the seismic capacity of earthquake vulnerable structure or earthquake damaged structure for future use. The evaluation may also prove helpful for degree of intervention required in seismically deficient structures. The aim of seismic evaluation is to assess the possible seismic response of buildings, which may be seismically deficient or earthquake damage for its possible future use. The seismic evaluation is helpful for retrofitting of the structure. Incremental Dynamic Analysis 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. Incremental Dynamic Analysis procedure is adopted here for the analysis of sample structure. A suite of seven selected ground motion time histories used to analyze Masonry Structure for performing Incremental Dynamic Analysis. 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 Incremental Dynamic Analysis curves. The yield capacity of the structure is defined as the level of Intensity at which the Incremental Dynamic Analysis curve leaves the linear path. 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.*

Design software 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.

INTRODUCTION

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 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.

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OBJECTIVE OF THE STUDY

- To analysis and design of Masonry Building subjected to seismic loading.
- To use non linear seismic analysis on Masonry Building.
- To explore Incremental Dynamic Analysis with reference to the Masonry Building under consideration using design software.
- To determine drift ratio of Masonry building under consideration.
- 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.
- To develop hazard survival curves and determine probabilities of surviving specified damage states.

METHODOLoGY

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

- An extensive survey of the literature on the response of Masonry structures to seismic loading is performed.
- Based on the numerical and parametric study, a step by step procedure for the simplified seismic analysis of Masonry structure has been suggested.
- 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.
- A problem of a Masonry Building is taken and analyzed by the Pushover analysis.
- Based on the numerical and parametric study, a step by step procedure for the simplified seismic analysis of masonry frame has been suggested.
- A problem of a Masonry structure is taken and analyzed by Non-Linear Time History

  Analysis for seven selected ground motions.
- Incremental Dynamic Analysis 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.

RESULT AND DISCUSSION

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Design software (SAP2000) 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.

Comparison of Base Shear and Displacement from different analysis

WITHOPENING

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

IDA Curve for 7 Time Histories With opening

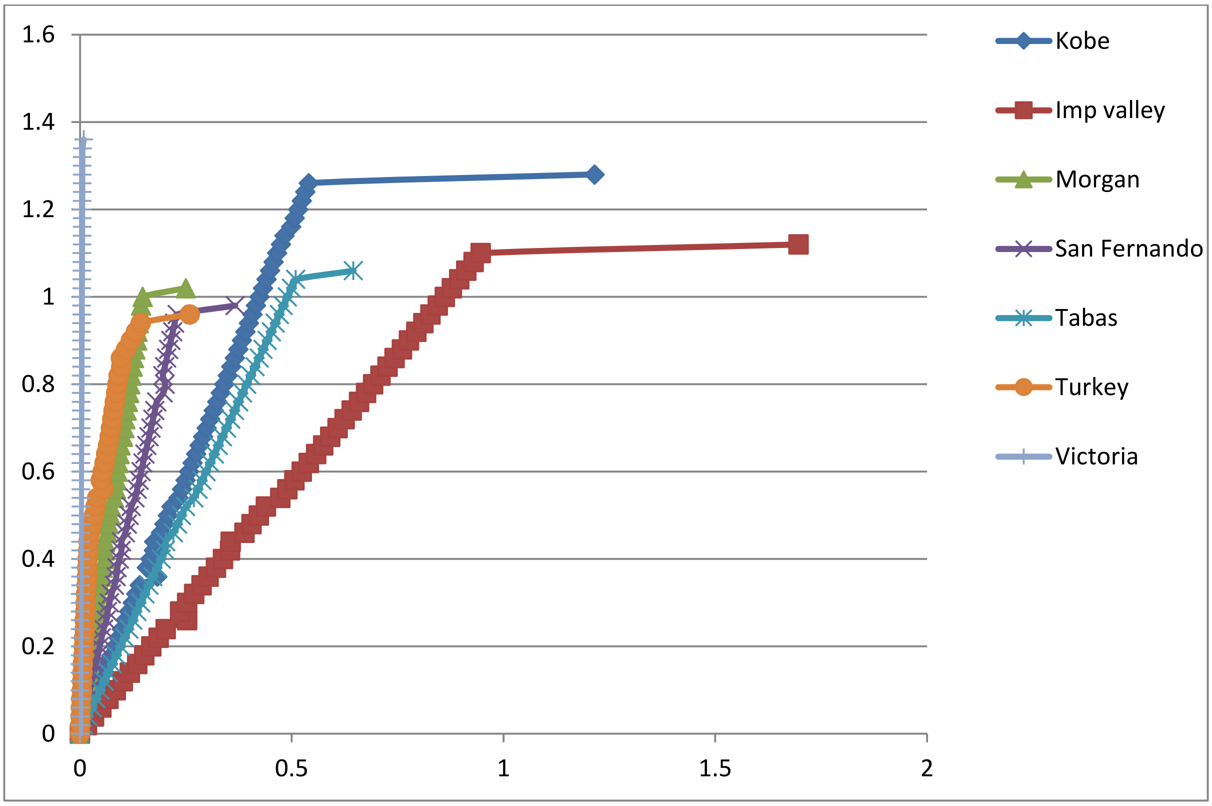

Fig 1: IDA curve for 7 Time history with opening

Yield values of Masonry frame w.r.t PGA for generation of Fragility Curves With opening:-

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

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

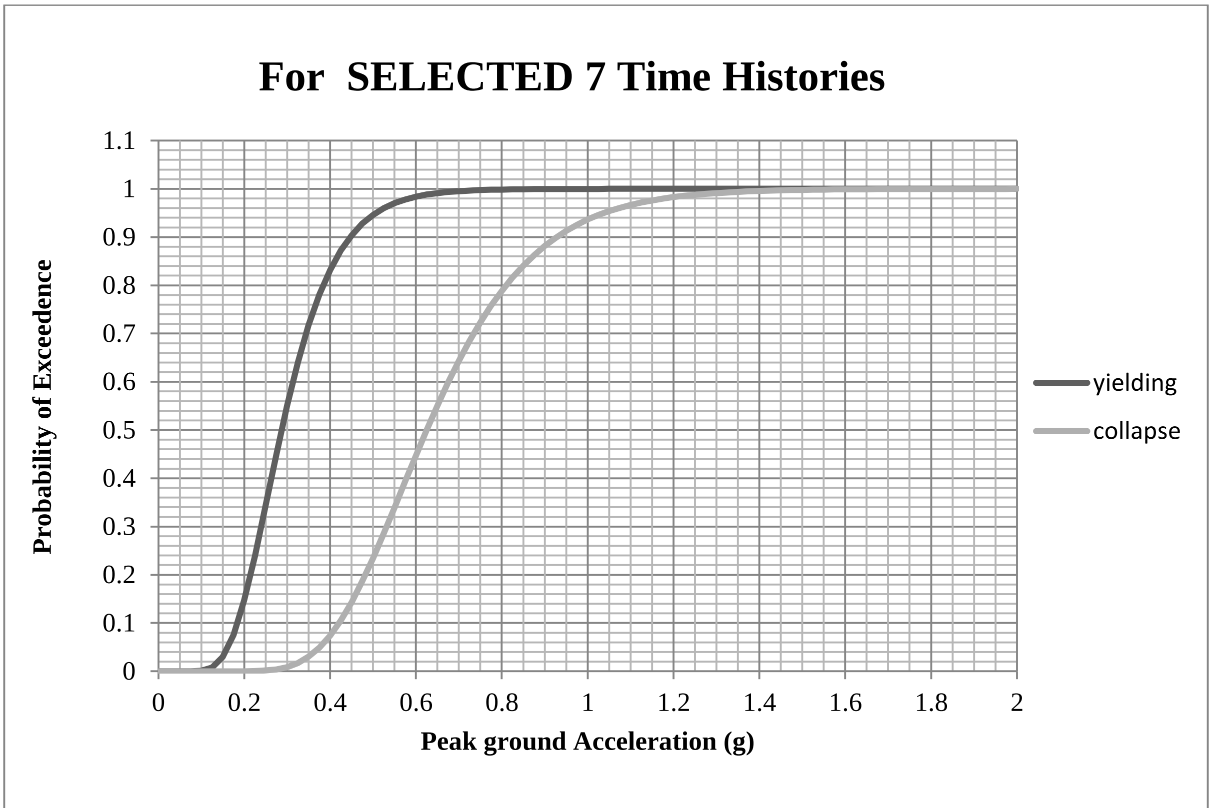

Fig 2: Fragility Curve for Selected Ground Motion

Performance Assessment of Masonry frame with opening for fragility curves:-

Selected Ground Motion:

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

Probability of Surviving at different Damage States:

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.

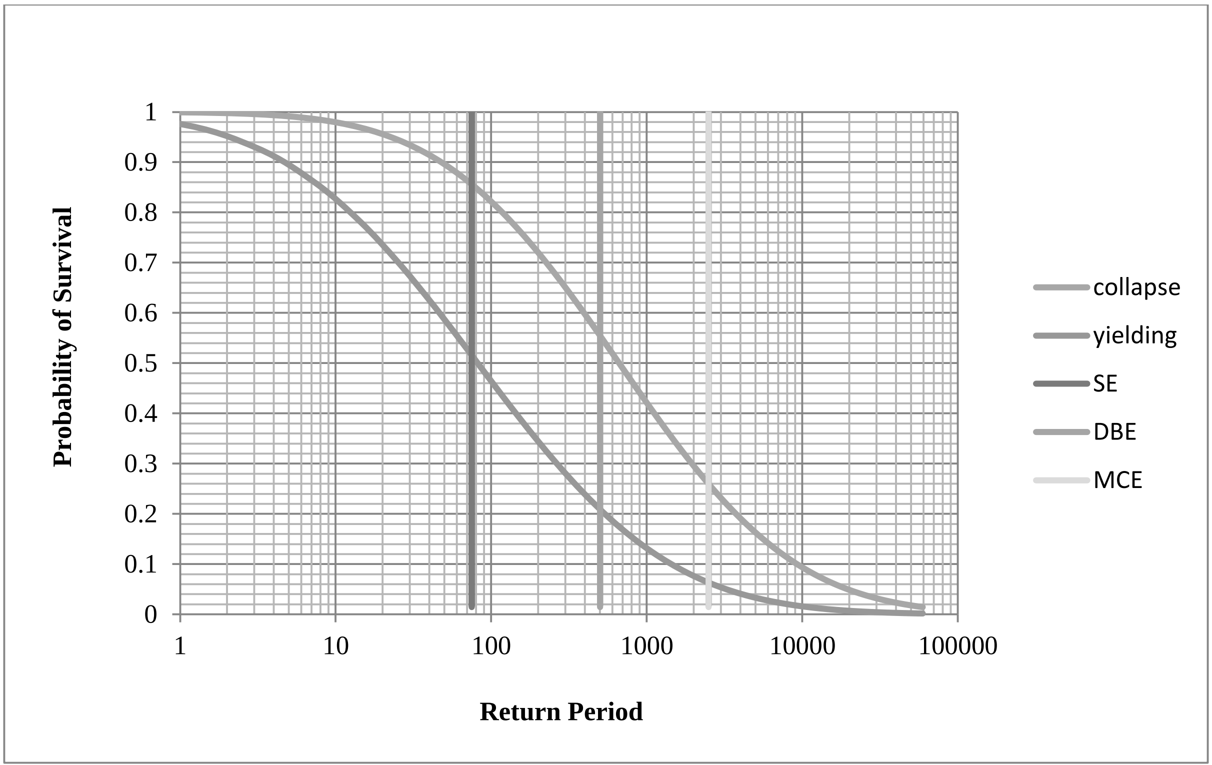

Fig 3: Hazard Survival Curve

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. From the results obtained it can be concluded that .72g (2MCE) is most vulnerable earthquake for masonry infill frames which gives almost more than 90% damage.

3. Therefore looking at recent earthquake scenario it is very much essential to have seismic evaluation of existing masonry frames based on IDA.

4. Incremental dynamic analysis results by IDARC are more conservative as compare to

   SAP 2000.

5. Nonlinear seismic analysis methods must be incorporated in Indian seismic codes for performance based earthquake design of structures.

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