International Research Journal of Multidisciplinary Science & Technology
www.irjmrs.com ISSN : 2455-930X

FRAGILITY OF SHEAR WALL STRUCTURE

Vigneshwari S[1], Muthulakshmi S[2]

[1]Department of Civil Engineering, SRM University, Ramapuram, Chennai, India
[2]Asst. Professor (O.G), Department of Civil Engineering, SRM University, Ramapuram, Chennai, India

---***---

Abstract - *Earthquakes are considered to be one of the unpredictable and devastating natural hazards. Seismic risk assessment of building can reduce the devastating effects of earthquakes. There are many methods available for seismic risk assessment. One such method is fragility curve using nonlinear analysis of structures. Fragility curves are used to describe the probability of damage being exceeded by particular damage state. HAZUS technical manual is used for the development of fragility curves. For the analysis, the shear wall buildings are modeled in SAP2000 v14. Nonlinear static analysis procedure as per ATC40 guidelines is used for the analysis of shear wall structure. The fragility curves are plotted considering spectral displacement as a ground motion.*

KEYWORDS: Fragility curves, Sap2000, HAZUS, Nonlinear static analysis.

1. INTRODUCTION:

Earthquake causes multiple hazards to potentially inflicting large economic, property and population loss. Seismic vulnerability assessment is used for quantification of risk involved due to expected earthquake in a region. The vulnerability is usually represented in terms of either Fragility curves or damage probability matrices (DPM). The Seismic vulnerability is commonly expressed through probabilistic fragility functions. Fragility curves express continuous relationships between a ground motion intensity measure (IM) and the probability that specified structure will reach or exceed predefined damage states. The fragility curves can be derived from both time history and pushover analysis. Nonlinear time history analysis is complex and requires much time for completion. Therefore nonlinear static analysis is used for deriving the fragility curves as perHAZUS manual. Here the effect of fragility curves for various placement of shear wall for RC structure. Four building models were considered in this paper for the development of fragility curves. Each model has different placement of shear wall. The pushover analysis is performed as per ATC40 guidelines. The pushover curve obtained is converted into building capacity curve. HAZUSestablish the fragility curves for various damage states such as slight, moderate, extensive and complete. Spectral displacement is used as a ground motion parameter. Displacement is used as a ground motion parameter. SAP2000 v14 is used for the modeling of building and pushover analysis. Results are used for development of fragility curves.

2. LITERATURE REVIEW:

The researchers have recognized that the need of vulnerability assessment for seismic evaluation of buildings they have found that the fragility curve is one of the key factors for seismic vulnerability assessment. The literature has been referred from various research paper is illustrated Zenping WEN, et al. (2000) presented a paper on prediction of the probability of earthquake damage to existing buildings in china. Nonlinear static method is used for vulnerability analysis of high rise RC structure. This paper has presented a simplified procedure for evaluation for the probability of earthquake damage to existing building in china. It recommends estimating seismic losses based on ground motion parameter in china.

Murat and Zekeriya (2006) studied the fragility analysis of mid-rise RC buildings they had performed dynamic analysis on 3, 5, 7 storey buildings using 12 artificial earthquake records. They used PGA and spectral displacements as ground motion. Also they used inter-storey drift and spectral displacement values as a damage parameter.

Raipure (2015) presented a study on development of fragility curves for open ground storey buildings she had used probabilistic seismic demand model (PSDM) as per power law for the generation of fragility curves. The OGS framed structure was considered and the building is located in seismic zone-v. Twenty computational models were developed in the program ETABS for nonlinear dynamic analysis for each case.

Vasudev yathambady, et al. (2016) presented a study on seismic vulnerability assessment of RC building using pushover analysis and fragility curve. They performed non linear static analysis for same structure with different zones, Soil types and number of floors. The author concluded that The taller structures under severe zones constructed in loose Soil are most vulnerable to seismic excitation.

3. MODELLING:

The plan considered in the present study is of commercial building. The building plan is having complex geometry and is modeled in SAP2000.The building models are considered with bare frame and infill wall. Shear wall are introduced in to the building. The building is located in high seismic zone and medium soil site. The height of each storey is 3m. The grade of the steel is Fe415. Live load is taken as 4 kN/m^2. Density of the concrete is taken as 25 KN/m^2.

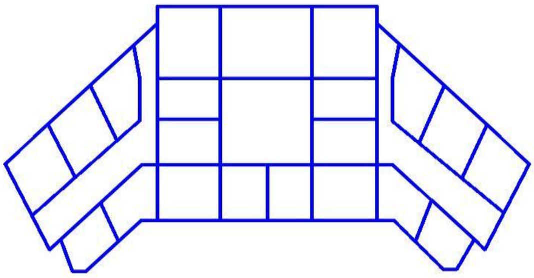

Figure 1.plan of the building model

Automatic hinges were assigned to beams and columns by using auto hinge property in SAP2000. The following parameters are considered in the analysis and design of the building model:

Table1: Description of building model

MEMBERS	GRADE	DIMENSION
Beam	M25	300x500mm
Column(up to10thfloor)	M30	800x800mm
Column(above 10thfloor)	M30	600x600mm
Slab	M25	125mm
Wall	M30	250mm

Development of pushover curves

Pushover analysis is a static nonlinear method in which the structure is subjected to increasing lateral load distributed throughout the height until collapse take place. Pushover loads are assigned as per IS1893-2002(part-1). Pushover load are applied in terms of parabolic load pattern. Displacement based pushover analysis is performed in SAP2000 v14 as per the guidelines of FEMA 356 and ATC40. The parabolic lateral load pattern at 'i' is calculated as following.

$$Q_i = V_B (W_i\, h_i^2) / \sum_{j=1}^{n} W_i\, h_j^2$$

The lateral loads are applied in longer direction of the building as point loads. After the analysis, capacity curve (pushover curve) in the form of Base shear vs. Roof displacement will be obtained from the display menu. The capacity curve thus obtained is converted into ADRS format. Performance point is obtained as intersection of capacity spectra and elastic demand spectra. The performance point of spectral displacement is used for fragility curve derivation. The example of ADRS curve for without infill structure is shown below.

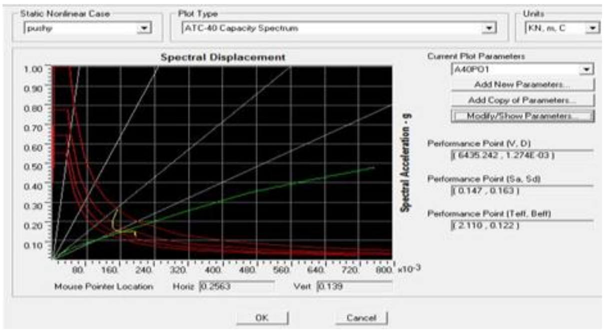

Figure 2:ATC40 capacity spectrum curve

Development of fragility curves

There has been numerous works in the literature for the evaluation of the fragility curves of the structures, however there is no specific approach available. For the development of fragility curves, guidelines given by HAZUS technical manual have been used. HAZUS methodology was developed for FEMA by National Institute of Building Science (NIBS) to reduce seismic hazard in United States. The procedure for deriving fragility curves are provided by HAZUS technical manual.

The conditional probability of being in or exceeding a particular damage state, ds, given the spectral displacement Sd and is defined by Eq. (2)

$$P[ds \mid S_d] = \Phi\left[\frac{1}{\beta ds}\ln\left(\frac{S_d}{S_{d,ds}}\right)\right] \qquad (2)$$

Where,

Sd is the spectral displacement defining the threshold of a particular damage state,

Sd,ds is median value of spectral displacement at which the building reaches the threshold of damage states, can be calculated by various damage state models,

βds is standard deviation of natural logarithm of spectral displacement for damage states, ds and is the standard normal cumulative distribution function.

Many researchers have proposed damage states, out of which a model proposed by Giovinazzi and Lagomarsino has been used in the current study.

Table2: damage state thresholds defines with the agreement of capacity spectrum

Damage states	Spectral displacements (sd,ds)
Slight	0.7Sdy
Moderate	1.5Sdy
Extensive	0.5(Sdy + Sdu)
Complete	Sdu

Where,

Sdy is the yield spectral displacement

Sdu is the ultimate spectral displacement

The βds value can be directly taken from the tables given in HAZUS technical manual by choosing appropriate values of degradation or kappa factors and βC and βD values for different types of buildings.

4.RESULTS AND DISCUSSION

In this paper five building models were considered for the development of fragility curves. Fragility curves are generated for four damage states as per HAZUS. Such as slight, moderate, extensive, complete which represents damage to the structural and non-structural elements in the structure.

CASE STUDY 1:

A G+15 storey RC framed structure without infill is considered. The structure is modeled in SAP2000 v14. Pushover analysis is performed for this case. The probability of damage for the structure is carried out. This value is kept as base for comparing the fragility curve obtained by other case studies. The building is designed as per IS 13920. The design details for beam and column are shown below:

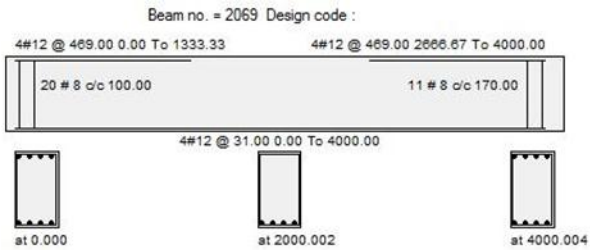

Figure 3. Reinforcement details for beam

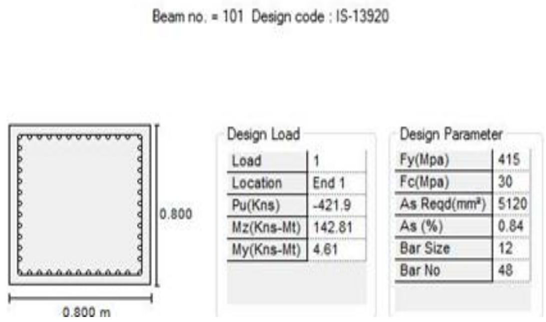

Figure 4. Reinforcement details for column

The fragility curve obtained can be used to find the probability of damage for specified spectral displacement. The table 3 shows the probability of exceedance of particular damage state for the spectral displacement value of 0.25 m.

Table3. Probability of damage state for case study1

Damage state	Probability of damage
slight	1.00
moderate	0.65
extensive	0.40
complete	0.20

CASE STUDY 2:

A G+15 storey RC structure with shear wall placed at its core is considered. Grades of concrete and steel are taken as M25, M30 and Fe415 respectively. Figure 5 shows the placement of shear wall for case study2.

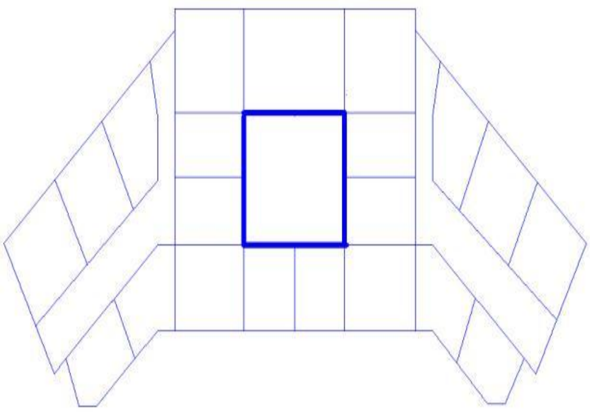

Figure 6. Plan of the case study2

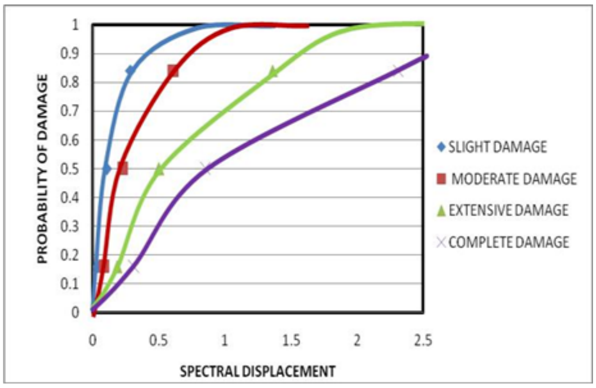

Figure 7. Fragility curve for case study2

The table 4 shows the probability of exceedance of particular damage state for the spectral displacement value of 0.25 m.

Table 4. Probability of damage state for case study2

Damage state	Probability of damage
slight	0.85
moderate	0.60
extensive	0.30
complete	0.15

5 .CONCLUSION

In this study, HAZUS methodology for the generation of fragility curves for G+15 storey structure with different orientation of shear walls are studied. From the study it is concluded that this methodology can be adopted to predict the damage level of the building corresponding to particular value of spectral displacement. Considering the fact that this analysis is based on HAZUS technical manual, the following conclusions can be stated:

- The increase in stiffness and strength is significant in shear wall buildings when compared to without infill structures.
- For specified spectral displacement, the structure without infill has more probability of damage when compared with shear wall structures.
- Shear walls can be effectively added to reduce the probability of damage.

REFERENCES:

[1]. FEMA, HAZUS technical manual MH MR1, Earthquake loss estimation methodology, Department of homeland security, Washington, USA, 2003.

[2]. ATC40, Seismic evaluation and retrofit of concrete building-volume I, Report no.ssc 96-01, Redwood city, Applied technology council,1996.

[3]. FEMA 356, Pre standard and commentary for seismic rehabilitation of buildings, Federal emergency management agency, April 2011.

[4]. Sergio lagomarsino et al., macroseismic and mechanical models for the vulnerability and damage assesment of current buildings, september 2006.

[5]. Y.U.Vazurkar,D.J.chaudhari,"Development of fragility curves for RC buildings",IJER, vol.5, pp. 591-594, Febraury 2016.

[6]. M.Rota,A.Penna and G.Magenes," A procedure for deriving analytical fragility curves for masonry buildings," Beijing, China, October 2008 [14th world conference on earthquake engineering]

[7]. Suraj V.Borele, Dr. Debarati Datta," Damage assement of structural system using fragility curves," vol 2, June 2015, pp 72-76.

[8]. K.Vasudev Yathambady, B.Shivakumara swamy,"Seismic vulnerability assesment of RC structure using pushover analysis and fragility curve," IJESC, vol. 6, May 2016.

[9]. Vesile Hatun Akansel, Ahmet Yakut,"Fragility of shear wall buildings with torsional irregularity," 2012,[15th world conference on earthquake engineering]