SEISMIC DEVELOPMENT AND STUDY OF FRAGILITY CURVE

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Abstract - For an earthquake with spectral intensity corresponding to weak shaking, the exceedance probability for the small affect is pretty substantial along with the amounts defined by excessive damage states like average, Extensive, complete are negligible. Whereas if there's an earthquake of good intensity the structure is much more apt being crossed the destruction states of moderate and slight, From the derived fragility curves, it's found that seismic vulnerability is substantially influenced by the structural irregularity, so the PGA/PGV ratio of ground movements features a noteworthy impact on the fragility curves. The numerical outcomes certainly indicate that space RC frame structures start to be much susceptible to earthquake damage as the program irregularity increases. This agrees nicely with a lot of the prior investigation results as well as the actual damage observed in previous earthquakes. Structural irregularity is definitely the one of the main factors behind the failure or maybe collapse of components, therefore significant focus must be paid out when conducting seismic vulnerability evaluation. This particular analysis aims to derive much more correct as well as proper seismic fragility curves for space RC frame structures with various degrees of plan irregularity with the three-dimensional models of theirs and check out the impact of structural irregularity on theseismic vulnerability.

Keywords — Seismic Analysis, Fragility Curve, Reinforced Concrete Structures

I. INTRODUCTION

1.1 Fragility Curve

A fragility analysis is an effective tool for vulnerability assessment of structural systems. The fragility curve, which is developed from the behavior model of structure, capacity and a suite of ground motions, is a graphical representation of the seismic vulnerability of a structure It shows common fragility curves for different limiting values for damage Parameter. The intensity measurehere's the spectral displacement of the earthquake. As thelimiting value enhances the curve shifts towards properly and gets to be more level. From the figure it could be observed that at weak shaking the probability of exceedance with the cap state corresponding too little damage is rather high. For powerful earthquakes probability of exceedance is 100 % for the very first curve, meaning small damage is extensive, moderate, and sure damages will probably occur. But probability that total damage will occur is very low. Regions of different damage states including slight, moderate, Complete and extensive damages are marked in between each fragility curves. With the severity of damage, the parameter defining the maximum state of damage improves, & the exceedance probability decreases.

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1.2 Theoretical Background

Earthquakes cause economic losses apart from the torturous pain of loss of lives. Seismic risk assessment is the first step within the disaster prevention strategy and in reducing the associated risks of infrastructures. The comprehensive studyof seismic risk is often divided into 3 components- Hazard, Vulnerability and Exposure. Hazard is that the event capable of inflicting harm whereas

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Vulnerability represents the

degree of loss of a component ensuing from a hazard. Exposure is that the amount of parts (population, the economic activities, and therefore the constructions and structures) exposed to a hazard. It's well understood that it'snot the earthquake that kills however the failure of the buildings exposed to those earthquakes. So understanding the behavior of the buildings throughout Earthquake may bea growing space of research. Assessing the vulnerability of the structures as seismic performance are often useful for riskmitigation and emergency response coming up with.

1.2 Integrated Computational Framework

Since source codes for both software packages are open to the public, modifications that are necessary could be made to create an integrated platform of ZEUS-NL and FERUM. The incorporated computational platform, called FERUMZEUS, is started with the improvement of linking interface between the ZEUS-NL. And FERUM The linking interface makes achievable the automatic exchange of info between two distinct analysis programs during fragility analysis, and also it enables implicit calculation of efficient derivation and failure probability of fragility curves. Fig. 1.5presents the computational platform of FERUMZEUS. In this particular platform, FERUM supplies ZEUS NL with deterministic enter values for selected arbitrary variablesdepending on their distribution sorts, along with ZEUS-NL generates an analytical style with the determined enter parameters. Next, ZEUS-NL determines the structural capability (supply) from a push over evaluation and also estimates the seismic effect (demand) from an inelastic response history evaluation.

The evaluation results are sent to FERUM, and FERUM evaluates the limits state functionality numerically as supply minus need. FERUM consistently calls ZEUS-NL till the failure probability is discovered with FORM. The integrated platform is produced around MATLAB, so the procedure offragility curve derivation is automated.

This particular platform is able to handle computationally expensive versions in seismic vulnerability analysis, and yesit is able to gain fragility curves really effectively with FORM. Additionally, in order to conserve computational time for the instances when expected failure likelihood is simply too low or even excessive, an algorithm is added to designate a probability zero or even one based on the estimated limit state feature worth

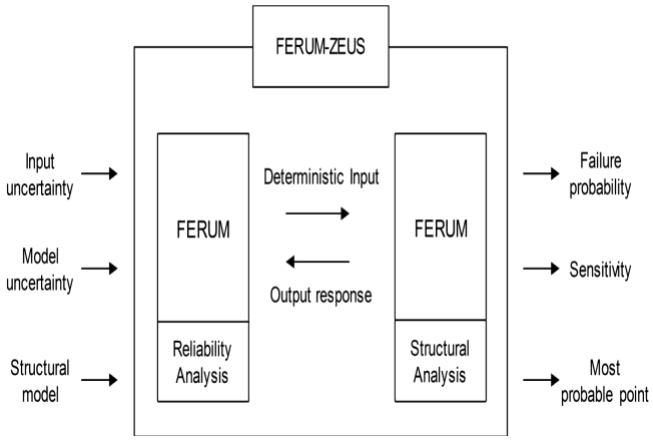

Figure 1 Typical Fragility Curve showing PGA vs. Probability of exceedance

1.4 Motivation of the Present Study

Generation of fragility curves in conventional methods involves development of large number of computational models that represent the inherent variation in the material properties of particular building type and its earthquake time history analyses to obtain an accurate and reliable estimate of the probability of exceedance of the chosen damage parameter.

II. LITERATURE REVIEW

Samoah et, al (2012) [1] analyzed the fragility overall performance of non-ductile RC frames in very low and moderate seismic zones. The structural ability of the structures was studied by inelastic pushover analysis and seismic demand is examined by inelastic time history analysis followed by analysis of fragility curves. 3 non ductile RC frames symmetrical and also routine in program and also elevation had been studied that had been developed rendering to BS 8110 (1985). The buildings taken into consideration have been 3- storey 3 bays, a 4 storey 2 bay plus a 6 storey three bay buildings to get an appreciable result. A macro element package IDARC2D (1996) was started as the inelastic dynamic and static analysis of non- ductile RC frames.

Buratti et al. (2010) [2] Response Surface (RS) models havebeen utilized by with arbitrary block effects to assess seismic fragility curves in an approximate manner with good computational efficacy. The RS models have been controlled through numerical information obtained by nonlinear incremental dynamic analyses conducted utilizing different sets of ground-motions, strength allocations in frame components, along with values of the arbitrary variables taken away for describing the ambiguities within the structural behavior. The job was mostly centered on the issueof obtaining a fair compromise between computational effort and result soundness. With reference to a 3 storey frame system, a series of numerical examinations have been presented. Different simulation tactics, defined using the principle of Design of

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Experiments (DOE), and also abridged polynomial RS models have been used. The fragility curves gotten by various methods were compared, making use of the effects from detailed Monte Carlo simulation as the reference solution.

Jeong and Elnashai et.al (2006) [3] The fragility evaluation for an irregular RC frame under bi directional earthquake burdening has premeditated by. For the contemplation of theanomalies in framework, bidirectional response and the torsion had been used as 3- Dimensional structural response attributes to stand for the destruction states of the structure irregularities is bestowed through a reference derivation. A 3 story RC plane frame was taken away that is asymmetric in plan with thickness of slab 150 mm and level of beam 500 mm to understand the damage assessments. Generation of fragility curves happened to be by computing the destruction measure by spatial damage index with statistical manipulation techniques & lognormal distributions for response variables.

Asadi and Bakhshi et.al (2012)[4] Fragility curves have been created by to be able to evaluate many probability variables such as, PGA, crucial factor (I) and normal over strength plus worldwide ductility capacity (R). These drawings were used to show when a number or a coefficientof variables were utilized to enhance the overall performancecapacity of a framework. The results showing that by rising the R, the probability of damage exceedance is dwindled; however, an increased I for hospital buildings versus office buildings, can't pledge a reduction in the risks of damage exceedance. The PGA randomness outcomes revealed that, because PGA uncertainty doesn't imply that the likelihood of damage exceedance is enhanced in general cases.

Towashiraporn et, al (2004)[5] advised an alternative strategy for implementing the structural simulation. The utilization of Response Surface Methodology in connection with the Monte Carlo simulations abridges the procedure of fragility computation. The convenience on the result surface met models gets to be more obvious for promptly deriving fragility curves for structures in a portfolio. After met models applicable for building listing inside a geographical expanseare produced, they might be utilized for evaluation of any profile of interest, situated within the very same area. The capability for quick evaluation of fragility relation for a discrete building in a target profile became a noteworthy move toward a lot more accurate seismic loss estimation.

Cornell et al. (2002) [6] investigated an established probabilistic framework for seismic assessment and design of buildings and the solicitation of its to steel moment-resisting frame structures depending on the 2000 SAC, Federal Emergency Management Agency (FEMA) steel moment frame guidelines. The framework was based upon knowing a performance objective said when the likelihood of exceedance for a specified overall performance level, which associated with demand' and capacity' of which had been discussed by the nonlinear dynamic displacements of the framework.

To summarize the improbability and randomness within the structural demand provided the soil movement amount as well as the structural capacity probabilistic model distributions have been being used. A customary probabilistic tool, the entire probability theorem was accustomed convolve the probability distributions for need, capacity, then earth motion intensity hazard. An analytical expression was shipped because of the likelihood of exceeding the overall performance level as the main product of the improvement of framework. Consideration of anxiety in the probabilistic modeling of need & capacity allowed for the meaning of trust statements because of the likelihood performance objective being achieved. This strategy is calledas Cornell's technique in this particular study

Rabitz and Alis et.al (2001) [7] illustrated the use of Random sample High Dimensional Model Representation (RS HDMR) by captivating two examples, Sensitivity analysis as well as an inverse issue within dynamical methods. RS-HDMR was proven to get computationally very much effective to compute awareness catalogues with high accuracy, and as a result this technique could be used toconstruct a data generating dynamical system.

Li et al. (2001) [8] An illustration of High Dimensional Model Representation was performed by in fiscal instruments whose great derives from the worth of various other merchandises. Additionally they recommended the application of this technique in industrial plant or financial system effectiveness under conditions of constrained online resources, along with various other related mathematical issues.

Rajib et al. (2009) [9] proposed a brand new computational instrument for forecasting failure probability of structural/mechanical methods subject to arbitrary loads, geometry, and material properties. The technique involved high dimensional model representation (HDMR) which facilitates lower dimensional approximation of the initial substantial dimensional implicit restrict state/performance feature, reaction area generation of HDMR constituent capabilities and Monte Carlo simulation. Outcomes of nine numerical examples that involved mathematical features and structural mechanics issues demonstrated that the proposed strategy offers correct & computationally effective estimates of the likelihood of failure.

III. METHODOLOGY

Five various kinds of analytical models have been explored; one was for a typical framework, and four had been for irregular structures. The regular framework

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design had coincident centers of mass and stiffness, while the irregular versions had different eccentricity from the non-coincident centers. Eccentricity is described as the distance between center of center and stiffness of mass, along with dimensionless eccentricity is identified as the ratio of the eccentricity to the floor dimension. Irregular models have eccentricities that differ from 2.5 to 10 % of the floor dimension in the transverse path. In the irregular versions, stiffness is dispersed symmetrically, but mass features a nonsymmetrical division under the assumption that reside lots are asymmetrically distributed across the slabs. To generate different amounts of structural irregularity, various values of live a lot are applied to each one half of the slabs. Table one summarizes the eccentricities, basic periods, along with reference names of the five analytical versions. Fig. 3.2 shows first three mode shapes of the standard model and 10 % irregular mode. The second and first modes match to the translational effect in the longitudinal and transverse path, and the final method corresponds to the torsional effect.

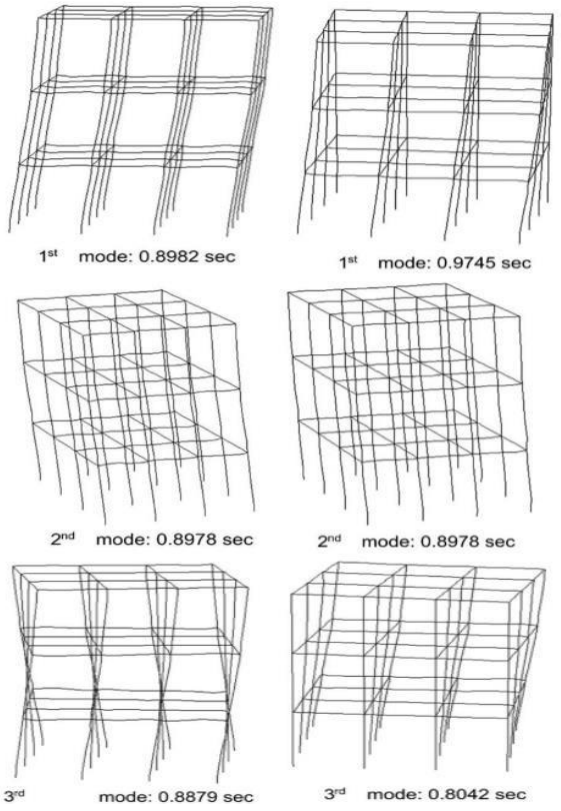


Fig. 3.2 First three mode shapes of selected analytical models: (a) regular model (ME000); and (b) 10% irregular model (ME100)

IV. RESULT AND DISCUSSION

4.1 Effect of Structural Irregularity on Seismic Vulnerability

The result of structural irregularity on seismic vulnerability is examined by comparing fragility curves and the statistical parameters of theirs. Table 4.7 summarizes lognormal parameters for seismic fragility curves of space RC frame structures. The proportions of the ME100 (10 % abnormal model) mean to ME000 (regular model) mean had been 91.9, 85.8, along with 54.2 % for serviceability, damage control, then collapse prevention limit states, respectively. Fig. 4.6 shows the way the lognormal mean values are influenced by the eccentricity and also depicts fitted curves with second degree polynomials. It is clearly shown the space RC frame structures with good irregularity are a lot more vulnerable than the regular structure. Fig. 4.7 compares fragility curves for various structural models with all the given three limit states. The fragility curve adjustments toward the left as the level of irregularity improves; quite simply, the chance of failure improves with the expansion of structural irregularity. As observed in the figure, approach irregularity has a terrific effect on the structural overall performance during earthquakes or perhaps seismic vulnerability. This agrees perfectly with the reality that plan-irregular structures are extremely vulnerable to earthquake injury, as confirmed by structural damages as well as losses to such structures during past earthquakes.

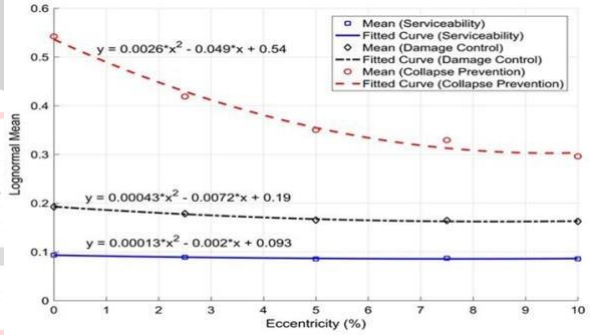
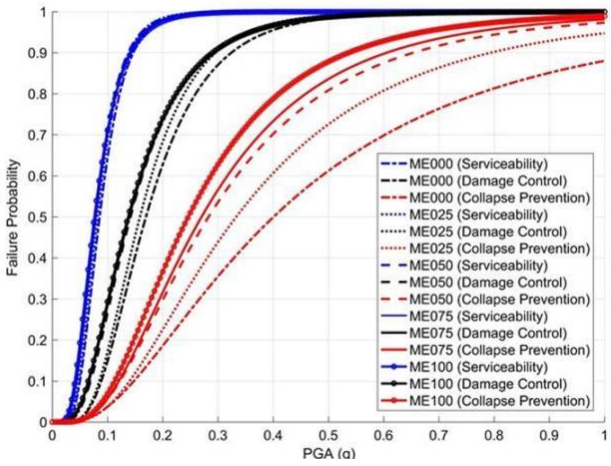


Fig. 4.1 Selected ground motion records: (a)low PGA/PGV; (b) medium PGA/PGV; (c) high PGA/PGV; and (d) average response spectrum



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V. CONCLUSION

This particular analysis aims to derive much more correct as well as proper seismic fragility curves for space RC

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frame structures with various degrees of plan irregularity with the three-dimensional models of theirs and check out the impact of structural irregularity on the seismic vulnerability of theirs. Rather than simplified designs, three dimensional analytical models are adopted to have into account realnonlinear coupled lateral torsional replies. To deal with the considerable computational problem regarding the usage of three dimensional models, this particular study establishes a computational framework which in degrades structural and also reliability evaluation. FERUM as well as ZEUS-NL are selected as the dependability as well as structural analysis programs, along with a linking interface is so long as allows automated interchange of the required information between 2 analysis equipment. Form is utilized to calculate the failure probabilities. With the entire adopted framework, seismic vulnerability of different space RC frame components, with as well as with no approach irregularity, is examined. Five distinct versions of RC frame system are analyzed, with different program problems from 0 to 10 % with a 2.5 % increment. A total of 15 ground motions are utilized, & they're classified in three groups depending on the ratio of PGA to PGV. Uncertainties in structural capability as well as earth quake demand are both considered. Three limit states are identified, damage control, serviceability, then collapse prevention. The corresponding values of interstory drift ratio for every cap state are obtained from a number of adaptive pushover analyses. Under the incorporated framework, seismic fragility curves of garden RC fame structures with various amounts of approach irregularity are successcompletely derived with the three-dimensional models of theirs on a regular private pc. This agrees nicely with a lot of the prior investigation results as well as the actual damage observed in previous earthquakes. Structural irregularity is definitely the one of the main factors behind the failure or maybe collapse of components, therefore significant focus must be paid out when conducting seismic vulnerabilityevaluation.

The primary contributions of this particular research are as follows:

(1) It establishes an integrated computational framework foreffective fragility analysis,

(2) It derives much more symbolic fragility curves with the usage of three dimensional analytical versions,

(3) It offers purposeful types of seismic fragility curves for space RC frame structures with different program irregularity, and

(4) It investigates the impact of approach irregularity on seismic vulnerability with far more reasonable fragility curves.

FUTURE SCOPE

The proposed method is anticipated to be extremely helpful when more precise seismic vulnerability for intricate buildings is needed. This particular analysis provides seismic fragility curves for typical low rise space RC frame structures with different program irregularity, though the normal application program might be restricted because seismic performance might be different with regards to the structural setup as well as the harm declare definition.

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