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Review On Fragility Analysis of High-Rise Building structure

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Abstract: In general the most suitable choise in improvement of reinforcement concrete frame against lateral loding is used steel bracing system. The use of steel bracing was potential advantage over other scheme like higher strength and stiffness, economical, occupies less space, add much less weight to existing structure. Both empirical and analytical fragility curves was considered. the use of steel bracing systems for strengthening seismically inadequate reinforced concrete frames was a viable solution for enhancing earthquake resistance. almost all the software like ETABS, SAP2000 linear or Nonlinear static analysis presented by high-rise building structure. main parameter consider fragility curves, the P-Δ effect, base shear, lateral displacement, axial force, story drift, etc. it was found that all bracing system the lateral displacement of frame very effectively. The fragility curves were developed in trems of PGA for these limit states; namely: slight, moderate, major and collapse with lognormal distribution assumption. The aim of this study is to development of analytical fragility curves for high-rise building structure.

Keywords: Fragility analysis, steel bracing, Reinforced concrete frame, Fragility curve, Lateral Displacement, Storey Drift, Performance levels

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1. Introduction

Damage estimation is one the main prerequisites for all 'earthquake risk reduction programs' in any earthquake prone country. However, there are very few data with regard to the relation between level of damage in various buildings and the earthquake characteristics. Most of the developed fragility curves are based on the actual data gained from the damaged buildings in past earthquakes, which do not necessarily include all types of the existing buildings in various countries. Up to now, many researchers have tried to develop the fragility curves for the existing buildings by using the real data or various types of analyses, including Push Over.

During the last decades, seismic vulnerability and effectiveness of seismic strengthening techniques for different types of structures (e.g., bridges, buildings etc.) are usually investigated via seismic probabilistic analysis through development of fragility curves. As a short definition, seismic fragility gives the probability that a structure or structural component will reach or exceed a specific level of damage during earthquakes of certain intensity. Therefore, fragility curves may be used to make probabilistic estimates of different damages during ground motion.

1.1 Type of bracing

There are two types of bracing systems

1. Concentric Bracing System

The steel braces are usually placed in vertically aligned spans. This system allows to obtaining a great increase of stiffness with a minimal added weight. Concentric bracings increase the lateral stiffness of the frame thus increases the natural frequency and also. usually decreases the lateral storey drift. However, increase in the stiffness may attract a larger inertia force due to earthquake. Further, while the bracings decrease the bending moments and shear forces in columns and they increase the axial compression in the columns to which they are connected.

2. Eccentric Bracing

Reduce the lateral stiffness of the system and improve the energy dissipation capacity. The lateral stiffness of the system depends upon the flexural stiffness property of the beams and columns, thus reducing the lateral stiffness of the frame. The vertical component of the bracing forces due to earthquake causes lateral concentrated load on the beams at the point of connection of the eccentric bracings.

2. LITERATURE REVIEW

a) Bracing System

Akbri, Aboutalebi and Maheri[1] discussed on Seismic fragility Assessment of Steel X-braced analysis SAP2000. He research 4-storey,8-story,12-story steel braced RC frames are considered to cover typical low-rise , medium-rise, high-rise framed building.

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The result of fragility curves of braced frames had also been compared with unbraced moment-frames. When designed for a specific base shear, steel-braced RC dual systems (braced frames and moment resisting framed) have better performances (i.e., lower damage probability) and larger capacities than their equivalent unbraced RC frames. On the other hand, stronger brace + weaker frame reduces the damage probability of the whole dual system. The frame height, chevron bracing respond better in extensive and complete damage states in comparison with X-bracing And Chevron-braced RC frames. He presented seismic fragility vulnerability assessment for steel x-brace and chevron-braced RC frame via development of analytical fragility curves. he study several parameters including the height of the frame , the p-Δ effect ,the fraction of base shear for which the bracing system had been designed and type of bracing system had been investigated. He presented nonlinear time history.

Bhojkar and Bagade[2] studied seismic evaluation of high-rise structure by using steel bracing system. He presented seismic analysis of reinforced concrete (RC) building with different types of bracing. He presented G+9 using STAAD-PRO. The X-type of steel bracing significantly contributes to the structural stiffness and reduces the maximum interstory drift of the frames. The bracing system improves not only the lateral stiffness and strength capacity but also the displacement capacity of the structure. He presented using steel bracing the total weight on the existing building will not change significantly. The lateral displacement of the building is reduced up to 65% by using X type of bracing system. The axial force is maximum for X bracing system is up to 22%.

Mishra, Sharma and Garg [3] discussed on analysis of RC building frames for seismic forces using different types of bracing systems. Bracing systems is very efficient and unyielding lateral load resisting system. G+ 10 story building frame is analysed for different bracing system under seismic loading. STADD-Pro software is used for analysis purpose. The results of various bracing systems (X Bracing, V Bracing, K Bracing, Inverted V Bracing, and Inverted K Bracing) are compared with bare frame model analysis to evaluate the effectiveness of a particular type of bracing system in order to control the lateral displacement and member forces in the frame. The concept of using steel bracing is advantageous to resist the seismic forces. The bracing system effectively reduces the lateral displacement (up to 80%) of the structure compared to Bare frame. Steel bracings the amount of forces in members significantly reduces. Bracing system proves as a effective member to control the story drift (up to 56%) in structures as compare to Bare compared to without steel bracing which indicates that stiffness of building is increases.

Sarokolal , Faghihmaleki & Gholampour[4] discussed on fragility curve assessment of collapse and yielding limit state for steel buildings with X-brace. He presented three samples of Steel Moment Frame with X-Bracing of three, eight and twelve stories were selected. Incremental dynamic analysis (IDA) was performed for the samples using seismostruct.v6 software. Fragility curves were extended based on Peak Ground Acceleration (PGA) for the area destroyed by collapse and yielding, this was done While Log was assumed to be distributed normally. The yielding occurs in lower efficiency and its line's slope is also high which represents the fast occurrence of yielding in the structure, while the collapse efficiency is greater and it has a milder slop. Comparing the fragility curves of 3 buildings during the collapse, it was determined that when the height of the buildings increases, the collapse of the buildings increases as well. The taller structures exceed the allowed level and also an increase in destruction probability. Comparing the fragility curves of 3 buildings during the yielding state, it was determined that shorter structures will yield more rapidly and that was why their capacity is lower than that of taller structures. Frames using bracing member as a resistive member margin of safety against collapse increased.

Chavan & Jadhav [5] discussed seismic response of RC building with different arrangement of steel bracing system. He presented seismic analysis of reinforced concrete (RC) building with different types of bracing (diagonal l ,V type, invert V type, X type) is studied. A seven-story (G+6) building is situated at seismic zone III. The building models are analyze by equivalent static analysis as per IS 1893:2002 using STAAD-PRO V8i software. The lateral displacement of the building is reduced by 50% to 56% by the use of X type steel bracing system and X bracing type reduced maximum displacement. The steel braced building of base shear increase Non-Linear time history Analysis.

Majd, Hosseini and Moein Amini[6] discussed on development fragility curves for steel building with X-bracing by nonlinear time history analyses. He presented regular in both plan and elevation to avoid the torsion effects, include a set of 2 by 4-bay and another set of 4 by 6-bay plan having 3, 5 or 7 stories. Two damage indices, including the "Inter-story drifts" and the "Axial plastic deformation of bracing elements" were used. He presented nonlinear dynamic analyses RAM PERFORM software fragility curves of steel moment frames of various numbers of stories up to ten just based on the inter-story drifts. The two damage indices of 'Inter-story drift' (ISD and 'Axial plastic deformation' (APD) of bracing elements" the second index is more reliable for developing the fragility curves for steel.

b) Case study of eccentric steel bracing system

Ozel and Guneyisi[7] presented a case study Effects of eccentric steel bracing systems on seismic fragility curves of mid-rise R/C buildings. A six storey mid-rise R/C building was selected. T1he strengthening of the original structure, D, K, and V type eccentric bracing systems were utilized and each of these bracing systems was applied with four different spatial distributions in the structure. Nonlinear time history analysis was used to analyze the structures subjected to this set of earthquake accelerations generated in terms of peak ground accelerations (PGA), whilst monitoring four performance limit states. The fragility curves were developed in terms of PGA for these limit states; namely: slight, moderate, major, and collapse with lognormal distribution assumption. The seismic reliability achieved through the use of D, K, and V type eccentric braces was evaluated by comparing the median values of the fragility curves of the existing building before and after retrofits. He presented nonlinear time history analysis SAP2000. Fragility curves after retrofitting with steel braces improvement (less fragile) compared to those before retrofit by as much as 1.8 times (V1 braced frame) based on median PGA values. The fragility analysis, distributions of the eccentric steel braces slightly affect the seismic reliability of the braced frames. Reduction curves were proposed to develop fragility curves after retrofit on the basis of available fragility curves of the existing structures.

c) Fragility analysis

Kircil and Polat[8] discussed on fragility analysis of mid-rise R/C frame buildings. He presented 3, 5 and 7 story buildings were designed mid-rise building. Based on capacities, fragility curves were developed in terms of elastic pseudo spectral acceleration, peak ground acceleration (PGA) and elastic spectral displacement for yielding and collapse damage levels with lognormal distribution. He presented existing building constructed in terms of *S*a, PGA and *S*d under the effect of twelve artificial ground motions with respect to different numbers of stories. The maximum allowable inter-story drift ratio and spectral displacement values that satisfy the immediate occupancy and collapse prevention performance level requirements are estimated with respect to the number of stories of the buildings using constructed fragility curves and statistical methods.

Erberik and Elnashai[9] discussed fragility analysis of flat-slab structure. He presented derivation of such fragility curves using medium-rise flat-slab buildings with masonry infill walls. Inelastic response-history analysis was used to analyze the random sample of structures subjected to the suite of records scaled in terms of displacement spectral ordinates, whilst monitoring four performance limit states. He presented fragility curves developed from this study were compared with the fragility curves derived for moment-resisting RC frames. He presented analysis of three, five and seven story had indicated rather insignificant differences in the inelastic dynamic analysis results. Comparison between the flat-slab and moment-resisting building. The earthquake losses for flat-slab structure are in the same range as for moment-resisting frames.

Shinozuka, Honorary, Feng, Lee & Naganuma[10] discussed Statistical Analysis of fragility curves. He presented Both empirical and analytical fragility curves are considered. The empirical fragility curves are developed utilizing bridge damage data obtained from the 1995 Hyogo-ken Nanbu (Kobe) earthquake. He presented methods of testing the goodness of fit of the fragility curves and estimating the confidence intervals of the two parameters (median and log-standard deviation) of the distribution. Statistical procedures were presented to test the goodness-of-fit hypothesis for these fragility curves and to estimate the confidence intervals of the two parameters of the lognormal distribution.

Bilgin[11] discussed Fragility-based assessment of public buildings in Turkey. He presented focuses on seismic fragility assessment of reinforced concrete public buildings with representative template designs. Lateral stiffness, strength and displacement capacities of the selected template designs are determined by nonlinear static analyses in two principal directions. The vulnerability of existing RC public buildings with template designs in Turkish building stock is investigated. All cases, damage probability statistics for each damage states increases with increasing seismic demand. The number of stories has a remarkable effect on the probability of exceeding moderate and severe damage limit states. Moreover, proximity between LS and CP level damage probabilities are noteworthy for 4- and 5-storey buildings.

Lallemant, Kiremidjian and Burton[12] presented Statistical procedures for developing earthquake damage fragility curves. He presented synthesis of the most commonly used methods for fitting fragility curves and highlights some of their significant limitations. Novel methods are described for parametric fragility curve development (generalized linear models and cumulative link models) and non-parametric curves (generalized additive model and Gaussian kernel smoothing). He presented various methods for developing earthquake damage to ground motion intensity relationships. It discusses the commonly used MM and least-squared approaches to fitting lognormal CDF fragility curves, pointing to some of the fundamental flaws with such methods. When developing empirical fragility curves from observed damage data, it is unusual to have actual ground motion recordings at all sites of interest.

Marco Vona[13] discussed Fragility Curves of Existing RC Buildings Based on Specific Structural Performance Levels. He presented procedure to develop analytical fragility curves for Moment Resisting Frame Reinforced Concrete buildings is presented. The seismic capacity of the selected models representing the existing RC buildings has been evaluated through non-linear dynamic simulations. Seismic response has been analyzed, considering various peak and integral intensity measures and various response parameters, such as ductility demands and Inter-storey Drift Ratio (IDR). He presented FCs are defined considering seismic risk mitigation policy needs at different territorial scales. The investigated buildings can be considered low engineered buildings, pre seismic code or old seismic code. Several other studies was based on numerical analyses. These studies were been often carried out on the basis of push-over analysis. This method is generally less accurate than Non Linear Dynamic Analyses (NDLAs) considered in the present work. On the basis of NDLAs, the specific limits have been defined for each building type analyzed. Specific relationships between damage level and damage status have been defined for each considered types.

Yue li, M.ASCE & Van De Lindt[14] discussed Collapse Fragility of Steel Structures Subjected to Earthquake Mainshock-Aftershock Sequences. He presented investigates the collapse probability of mainshock-damaged steel buildings in aftershocks, as an essential

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part of developing a framework to integrate aftershock seismic hazard into performance-based engineering (PBE). He presented NEEShub data. Three approaches to generate collapse fragility for the steel building that sustain a certain state of damage from a mainshock are used to investigate the effect of damage states from mainshocks on the structural collapse capacity. It was found that structural collapse capacity may reduce significantly when the building is subjected to a high intensity mainshock. The structural collapse capacity may reduce significantly when the building is subjected to a high intensity mainshock and the structure is likely to collapse even if a small aftershock follows the mainshock. Different mainshocks were significant effect on the structural collapse fragility, when subtaintial damage occurred from the mainshock.

d) Nonlinear static (Pushover analysis)

Amini, Majd & hosseini[15] discussed on A Study on the Effect of Bracing Arrangement in the Seismic Behavior Buildings with Various Concentric Bracings by Nonlinear Static and Dynamic Analyses He presented regular multi-story steel buildings were considered with three kinds of X, V and chevron bracing, in two placements of 'two adjacent bays' and 'two non-adjacent bays' along the building height, and their seismic behaviors were investigated. The buildings were designed based on the code, and then they were evaluated by both pushover and nonlinear time history analyses, and their performances were compared with the standard Performance levels (PLs).the bracing arrangement affect the seismic behavior of steel Concentrically Braced Frame (CBF) buildings, in this study a set of steel buildings with 3, 5, and 7 stories. The buildings were evaluated by both pushover and nonlinear time history analyses, by using RAM PERFORM-3D software. In all cases the chevron bracing leads to higher stiffness compared to the other two types, while the other two types show almost the same stiffness. The amount of ultimate resistance for chevron bracing is around 50% higher than the X bracing. This means that using the same value for response modification factor of all types of concentric bracing does not seem appropriate, and the design codes needs some revision in this regard.

Rota, penna and magenes[16]] discussed A methodology for deriving analytical fragility curves for masonry buildings based on stochastic nonlinear analyses. He presented methodology is based on nonlinear stochastic analyses of building prototypes. nonlinear static (pushover) analyses are used to define the probability distributions of each damage state whilst nonlinear dynamic analyses allow to determine the probability density function of the displacement demand corresponding to different levels of ground motion. Convolution of the complementary cumulative distribution of demand and the probability density function of each damage state allows to derive fragility curves. He presented three-storey masonry building. Structural typologies with good connections between orthogonal walls and between walls and floors and with rigid diaphragms. Whose behaviour is dominated by a global response governed by in-plane mechanisms. He presented building with inappropriate connections and lack of any specific device preventing local collapse (e.g. tie rods, tie beam, etc), consideration of the such local failure modes needs to be incorporated in the assessment procedure.

3. CONCLUSION

From the literature study based on fragility analysis of RC structure following conclusions are made:

[1] The designed for base shear, steel-braced RC dual systems better performance and larger capacities in the unbraced RC frames otherwise stronger brace and weaker frame both of reduces the damage in dual system.[1]

[2] The fragility curves to select frame with and without P-Δ effect in the increase in damage probability and increase more taller frame[1].

[3] The steel braced building of base shear increase compared to without steel bracing indicates that stiffness of building was increases. [5]

[4] Stiffness of the building was increases.[2]

[5] Overall result of analytically was supplement to procedures on empirical formulation generally was calibrated on observed behaviour and damage data surveyed after earthquake.[13]

[6] The building yielding and collapse state more rapidly when column was taller regarding p-Δ effect in the effect of the number of stories height.[4]

[7] The building comparing fragility curves in the yielding state, when it is shorter structure yield more rapidly and then capacity was lower than taller structure.[4]

[8] The intensity measure for masonary building and the validation of the capacity spectrum method, current frequently used for the development of fragility function require an extensive use incremental non-linear analysis(IDA) can be carry out.

[9] The seismic fragility function development by hybrid method can be carry out.

[10] The structural collapse capacity reduce when the building was subject to a high intensity mainshock and the structure was collapse if a small aftershock follows the mainshock.[14]

[11] soil-Structure interaction, aging effect and cumulative damage and multiple hazards can be carry out.

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