(IDA) needs to be performed [6].

Hence, the response hazard curve is combined with the displacement-based capacity resulting in probability of failure which represents the annual rate of exceeding a limit state according to Equation 2:

$$P_f = \int P\left[C \le D\right] \left| dH_D\left(d\right) \right| \quad (2)$$

Where HD represents the annual rate of exceeding displacement-based demand (D) from given damage index (d) by combining results of PSHA and IDA.

Different methods are utilized to solve the above integral which in turn results in different probabilities of failure. This is literally known as epistemic uncertainty in the literature. This research was performed to study the effects of such uncertainty on reliability assessment of structures.

3- Results and Discussion

In order to study the effects of different available methods in reliability assessment outcome, a case study was performed using two RC moment resisting frames of 5- and 8-storey. The frames were designed according to Iranian national codes. Incremental dynamic analysis (IDA) was performed on both structures using IDARC program. The study was conducted on serviceability, immediate occupancy (I.O.), life safety (L.S.) and collapse prevention (C.P.) limit states and the parameters studied were: record selection methods of traditional and conditional mean spectra (CMS), probability distribution assumptions with and without consideration of collapse, seismic demand model using power law and multiple stripe analysis (MSA) and consideration of parameter epistemic uncertainty. The results of reliability index β for 8-storey frame for serviceability limit state are presented in Table 1.

A thorough investigation of the results shows that in general the epistemic uncertainty i.e. variation in reliability index as a result of different methods varies by parameter and limit state. However, it can be noticed that the variations regarding the record selection and parameter (epistemic) uncertainty are noticeable and must be considered in the analysis. For example, record selection method in Table 1 affects the reliability index by %14.35 which is noticeable.

4- Conclusions

Due to heavy computation cost of reliability assessment in large-scale structures, simplified solutions and assumptions are utilized by researchers. Existence of multiple methods for reliability assessment introduces epistemic uncertainty to reliability results. Therefore, a thorough study of such effects is important.

A parametric study using a case study of two RC frame structures were performed on common methods available for reliability assessment of structures i.e. record selection, probabilistic distribution assumption, parameter uncertainty and seismic demand models. The results show that the record selection method and inclusion of parameter epistemic uncertainty introduce noticeable variations in reliability index and must be considered in reliability assessment of structures.

Table 1. Reliability assessment of 8-storey frame for serviceability limit state

Parameter	Method	β	Variation %
Record selection	Traditional	2.142	14.35
	CMS	2.501	
Probability distribution	Collapse considered	2.501	0.68
	No Collapse considered	2.518	
Seismic demand	Power law	2.518	1.96
	MSA	2.568	
Parameter uncertainty	Epistemic + Aleatory	2.519	3
	Aleatory	2.597	

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Parametric Assessment of Uncertainties in Reliability Index of Reinforced Concrete MRF Structures Using Incremental Dynamic Analysis

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ABSTRACT: Recently, increasing attention has been paid to reliability based design methods due to its ability to consider different uncertainties associated with demand and capacity. Recent studies show that presence of unaccounted uncertainty may inflict unacceptable bias to computation of reliability index. Exact computations of global reliability index for multi-member structures are only possible through simulation methods. Therefore, researchers have proposed numerous methods using simplified assumption for reliability index calculation. Each method is different in the simplicity and accuracy it offers. For this purpose, in assessment of the effect of different uncertainty different methods of record selection for IDA analysis, probabilistic distribution of demand data and demand-capacity relation assumptions were used in this study to compute reliability index for "Operational", "Immediate Occupancy", "Life Safety" and "Collapse Prevention" limit states. The results showed that considering epistemic uncertainty in record selection and probabilistic distribution dramatically affects the reliability index and thus should be considered in future analyses.

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1- Introduction

In order to assess seismic performance of structures under probable earthquakes during its life time, several methods exist of which statistical approaches have received considerable attention recently. The reliability theory, a branch of total probability theory, has the ability to consider uncertainties regarding loading and structural parameters such as material properties, geometrical dimensions and non-linear analysis. So much that it plays an important and undeniable role in analysis, design and safety assessment of structures and has become the core of current codes and regulations. With probabilistic nature of reliability theory, the risk level associated with a code's design can be estimated [1]. Since accurate calculation of reliability in large-scale structures requires excessive computations, researchers have used different methods and simplifications to calculate structural reliability [2-4]. The multiplicity of available methods and assumptions means that the calculated reliability index is usually associated with uncertainties of epistemic types which cannot be reduced by increasing data. Therefore, it is necessary to analyze the effect of such uncertainties in reliability assessment.

This research was conducted to study the effects of different parameters on reliability assessment such as record selection methods, probability distribution assumption, power law and multiple-strip analysis (MSA) methods for estimation of seismic demand and inclusion of parameter epistemic uncertainty. A parametric study was performed using two RC moment resisting frames and the results showed that the uncertainty due to record selection and probability distribution are significant and should be considered in reliability calculations.

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2- Reliability Analysis

Failure or collapse is generally due to higher loads or smaller capacities of structural members expected by design codes. In probabilistic performance assessment, the performance is expressed as annual rate of exceeding a given limit state [5] Accordingly, a probabilistic procedure to determine probability of a limit state can be utilized for structural reliability. The annual rate of exceeding a structural limit state or briefly probability of failure depends on the three parameters of earthquake intensity, displacement-based seismic demand and seismic capacity. This can be expressed by Equation 1 as:

$$P_f = P\left[D > C\right] \quad (1)$$

Where D and C are displacement-based seismic demand and seismic capacity respectively. In general, in order to calculate the probability of failure, the problem is divided into two sections using total probability theory. Each section is solved separately and the results are combined to form the failure probability. For this purposed, probabilistic seismic hazard analysis (PSHA) and incremental dynamic analysis