Choosing the Best Probabilistic Model for Estimating Seismic Demand in Steel Moment Frames

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Abstract: *Provided that fundamental components of an quake demand, capacity and limiting conditions, to be reasonably determined. The great crash due to uncertainty and the structural response to that exists.It should be said that estimation of seismic demand of structures has become a major challenge. The reason is that the seismic demand using a probabilistic framework is possible. A method commonly known by the name of probabilistic seismic demand. The main core of probabilistic seismic analysis of the fundamental components of modern design method is based on the model of probabilistic seismic demand. The main task of selecting an appropriate model is establishing a mathematical relationship between seismic demand parameters and ground motion severity index is the seismic demand ¬cause a significant increase in the accuracy of estimated. Such pre a field, selected the best model for probabilistic seismic steel moment resisting frames based on such factors as for applicability, effectiveness, efficiency and adequacy will be main in this research. The main task of selecting an appropriate model to establish a mathematical relationship between the intensity of ground motion index and parameter of seismic demand and can cause a dramatic increase in accuracy of seismic demand estimate. With such a background, choosing the best model for probabilistic seismic demand about steel moment resisting frames based on factors such as practicality, effectiveness, efficiency and efficiency is carried out. The main objective of this research in this selection, is the use of a fully methods in statistical calculations, which are very powerful tool in the simultaneous bayesian modeling of the accident, and caused the results obtained to be reliable and practical. In this paper,out of the models of probabilistic seismic demand with a single severity index, with a combined severity index, and with two single severity indexes, the best model is selected. The results show that the model's current estimates seismic demand, in terms of first-mode spectral acceleration. Frames with different levels of accuracy and precision are not identical in tall frames lose their accuracy in tall buildings. Also, due to the problems on the model being applied is a combination of indicators It seems that the best model is the model can be found with two single severity index. Based on these results, the model is a linear combination of spectral accelerations of first and second modes.*

Keywords: *Probabilistic models for seismic demand, steel moment frame, demand estimation, performance-based design*

I. Introduction

Estimating seismic demand is one of the main components of a new method for performance-based design. In this way, a reasonable estimate of the parameters of the seismic demand is generally chosen to represent a structural displacement response that is nonlinear behavior of structures. It is inevitable for comparison with the amount of the performance-based design framework [1]. But the biggest challenge in estimating seismic demands is uncertainty in the quantity and frequency of accidents. This source of uncertainty can be of two types, namely uncertainty in earthquake ground motions (such as earthquake magnitude, distance, etc.) as well as uncertainties in the nonlinear behavior of structures (such as hard, plasticity, nonlinear functions, etc.). So it is natural that the uncertainty is required to perform the estimation due to the accident, using a probabilistic framework. Probabilistic seismic demand analysis is applied to such a framework [2]. The usual method for creating such a framework is based on removing the uncertainty of seismic behavior of structures with uncertainties by using a parameter called severity index (Intensity Measure), [3]. Various studies have shown that the first-mode spectral acceleration, spectral acceleration, especially, SA1, can be an appropriate severity index [4]. Severity index is a parameter that on the one hand cans the risk level of the earthquake, and on the other hand it could be indicative of the level of seismic risk at different levels of performance, it was connected to the seismic demand parameters. So in this way, the problem of estimating seismic demand turns into two separate issues, seismology, and the other one structural. If the seismic demand parameter is the maximum relative displacement between classes and selected to be shown with DR IM , severity index mark is displayed, the seismic demand estimation problem can be solved as follows [2]:

$$P[DR > x] = \int P[DR > x \mid IM = y].\,|\,dH_{IM}(y)\,| \qquad (1)$$

In this expression, HIM (y) means annual incidence of IM parameters exceed a certain value, or in other words the curve y parameter of the differential severity index that has been used at point y. This is generally calculated by probabilistic seismic hazard analysis method that this paper does not focus on it; there are several references [4]. An important component of this relationship, the term P [DR> x | IM = y] means the probability that the seismic demand parameter exceeds a certain value of the parameter x if y is interpreted to be of equal intensity.

In essence, it is the task of linking parameters of indices and parameters of seismic demand that is responsible for the distribution and is calculated assuming a normal distribution of data and the use of a probabilistic model. The core of the estimation of seismic demand, the demand for seismic probabilistic model (Probabilistic Seismic Demand Model) or PSDM is short. PSDM is a general mathematical relation of the parameters of the different functional levels of seismic demand parameters.

The probabilistic relationship between the mean and the standard deviation is a functional level, although the standard deviations are generally considered to be constant.

In fact, this short article also demonstrates the role of a probabilistic model for estimating seismic demand. Therefore, the present study was done in order to choose the best model for probabilistic seismic demand for structural steel bending of the frame. The seismic demand parameter is the maximum relative displacement between classes, based on various studies, it is more suitable for describing the behavior of a response of steel moment frames, especially in the overall structure in collapse mode.

II. Generic frames used for modeling of steel moment frames

One of the main goals of this paper is to obtain results that can be generalized for all of steel moment frames. To this end, the general frame concept is used to model structures [5]. In this research, the nonlinear behavior of the users is applied using rotational springs (stiffness and resistance to decay) at the foot of the beams and columns Peak-Oriented Modeling and model for showing the behavior of the hysteresis loop (Hysteresis Curve) as well as to consider a cycle of decline by the model of Ibarra et al. In this paper the general frame of five classes 3, 6, 9, 12 and 15 floors are being used on the cover of the first mode period equal to one-tenth of their classes, respectively, 3/0, 6/0 9 / 0, 2/1 and 5/1 second. The next two legal costs, charges the same for all classes, high and during the opening of classes they are respectively 12 and 24 feet. The latest software version is OPENSEES. The software is extremely powerful nonlinear analysis of structures, has been helping.

III. Selecting accelerators suitable for nonlinear dynamic analysis

In this study, 80 of the theoretical value based on the standard terms of magnitude and distance Bin Strategy are selected and divided into four groups of 20 were classified as follows [6].

- A long, long distance (LMLR) Features: 6.5 <MW <7.0 30 Km <R <60 Km
- A very short distance (LMSR) Features: 6.5 <MW <7.0 30 Km <R <60 Km
- A low, long distance (SMLR) Features: 5.8 <MW <6.5 30 Km <R <60 Km
- A small, short distance (SMSR) Features: 5.8 <MW <6.5 13 Km <R <30 Km

IV. Analysis of nonlinear dynamical accelerator

Unknown parameters in a model of probabilistic seismic demand should be estimated according to the results of nonlinear dynamic analysis. Dynamic multiplier analysis is the best format for the analysis [7]. In this analysis, using a scale factor which can be larger or smaller than a parameter of theoretical intensity, gradually from a very low level to high level, which is the cause of severe nonlinear behavior of structures be to scale.

In this paper, in order to create a complete database, which can be a basis for estimating the unknown parameters of the probability models used in seismic applications, enabling dynamic analysis of structural models under the three main uses 80 theoretical introduction to the [8]. As an example of the results of the dynamic analysis enhancer for frames 3 and 15 in Figure (1) is observed. It should be noted that in order to avoid being crowded figure, only the results of the theoretical group of 20 is seen instead of 80 theoretical LMLR. This is shown in Fig.

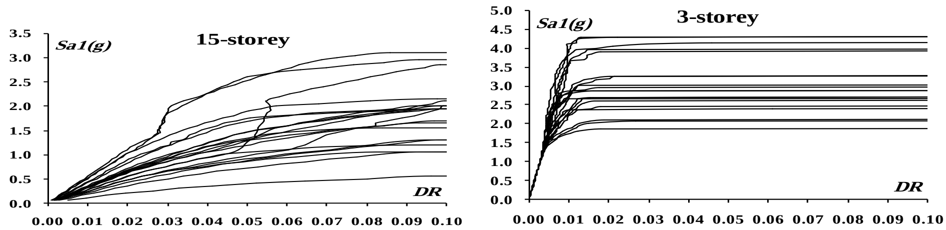

Figure 1 - Results of the dynamic analysis of accelerator in frames 3 and 15 floors LMLR

V. Evaluating the precision of probabilistic models of seismic demand

The main objective of this study was to select the best model probabilistic seismic demand for steel moment frames. To do this, different models for each of these frames is defined in terms of adequacy, efficiency and applicability. The SD model which in fact is accurate in estimating seismic demands can be a very good criterion for judging its main objective is to estimate the standard deviation using Bayesian statistics. The adequacy of the model can be attributed to the constant SD and SD to the low efficiency of the model is defined. Models defined in this study, three groups according to their severity index used in the model with a single severity index, a model with a combination of indicators and models are divided into two single severity index.

VI. Model with a single intensity index

The easiest way to build a probabilistic model of seismic demand is using a four-parameter peak ground acceleration (PGA) and spectral acceleration at the first mode, second and third order vibration with SA1, SA2 and SA3, as an indicator of severity. In this way, the four models of probabilistic seismic demand can be derived as follows:

Model No01: $\ln(\mathrm{DR}) = a.\ln(PGA) + w + \sigma.\varepsilon$

Model No02: $\ln(\mathrm{DR}) = a.\ln(SA1) + w + \sigma.\varepsilon$

Model No03: $\ln(\mathrm{DR}) = a.\ln(SA2) + w + \sigma.\varepsilon$

Model No04: $\ln(\mathrm{DR}) = a.\ln(SA3) + w + \sigma.\varepsilon$

However, in order to select the best model, it is necessary to use Bayesian statistics; the standard deviation of the four models, the model covers a number of different classes of σ to be estimated. Figure (2), standard deviation estimates for the four models No01 to No04 frame model is shown separately.

What is clear from Figure (2) concluded that the standard deviation of models is largely dependent on the number of classes. In other words, the accuracy of these models and the number of classes are different and it's not a good sign because it indicates this model is inadequate. Although the seismic demand model based on first-mode spectral acceleration estimates in short time frames 3 and 6 class, the best model, and the accuracy is quite good and efficient model is considered
But with increasing numbers of classes of frames, standard deviations, and also increases the accuracy of the model loses its effectiveness, so that the frames 9, 12 and 15 floors, the model is considered inefficient.

Notable is that the frame 15 floors, this model is the weakest model, based on the seismic demand model No03 second mode spectral acceleration estimates, accurate models, but the three-story model frame, the model is the weakest . Perhaps the only adequate model among the four models, Model No01 maximum ground acceleration based on the seismic demand estimates. But the problem is that the standard deviation is high because the model is inefficient.

Applying the case of the four models, so there is no need to talk, because all they do in terms of feasibility analysis and probabilistic seismic hazard calculations simply because they are in the best position possible, and fully functional.

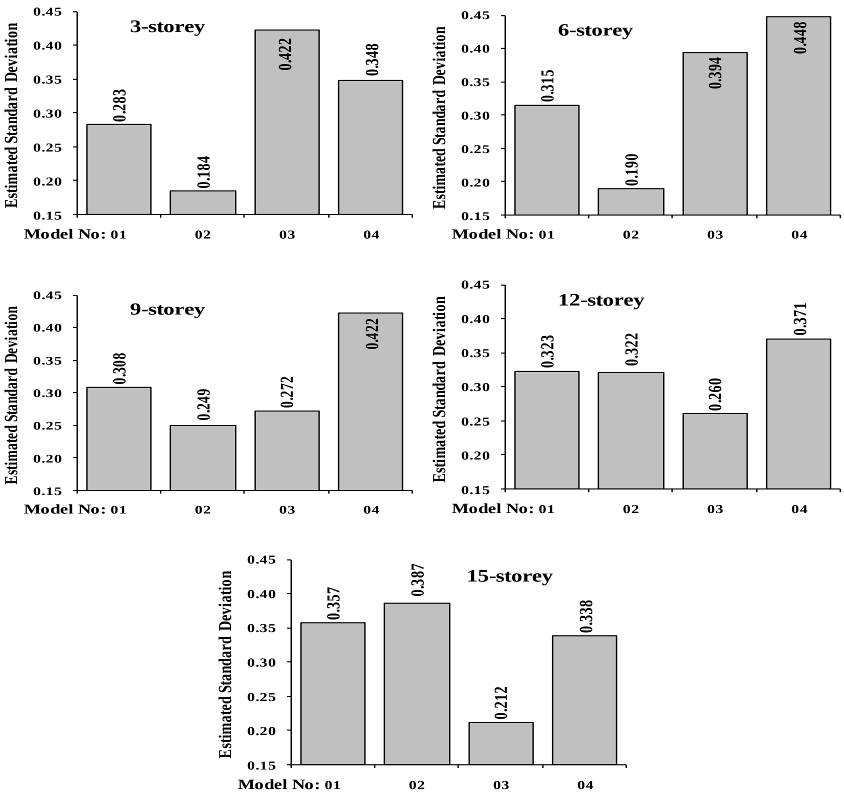

Figure 2 - Standard deviation of the estimated probabilistic models with a single severity index

In general, and as a result it should be stated that although the four models built in this area, they are simple and functional, but should be viewed with suspicion in their performance and efficiency.
In other words, none of the models can be a single severity index as the best model for all frames with different classes recommended. It seems that the use of such models in estimating seismic demand to prevent a selective effect on the model results for different structures of the different models used.

VII. Model with a combination of indicators

This section will attempt to use a combination of parameters, optimum probabilistic model is constructed. In order to use the four parameters PGA, SA1, SA2 and SA3, thirteen combined severity index is defined as IM used to be made of 13 different models as follows.

Model No05: $\ln(\mathrm{DR}) = a.\ln(\frac{SA1 + PGA}{2}) + w + \sigma.\varepsilon$

Model No06: $\ln(\mathrm{DR}) = a.\ln(\frac{SA1 + SA2}{2}) + w + \sigma.\varepsilon$

Model No07: $\ln(\mathrm{DR}) = a.\ln(\frac{SA1 + SA3}{2}) + w + \sigma.\varepsilon$

Model No08: $\ln(\mathrm{DR}) = a.\ln(\sqrt{SA1.PGA}) + w + \sigma.\varepsilon$

Model No09: $\ln(\mathrm{DR}) = a.\ln(\sqrt{SA1.SA2}) + w + \sigma.\varepsilon$

Model No10: $\ln(\mathrm{DR}) = a.\ln(\sqrt{SA1.SA3}) + w + \sigma.\varepsilon$

Model No11: $\ln(\mathrm{DR}) = a.\ln(\sqrt{SA1^2 + PGA^2}) + w + \sigma.\varepsilon$

Model No12: $\ln(\mathrm{DR}) = a.\ln(\sqrt{SA1^2 + SA2^2}) + w + \sigma.\varepsilon$

Model No13: $\ln(\mathrm{DR}) = a.\ln(\sqrt{SA1^2 + SA3^2}) + w + \sigma.\varepsilon$

No05 to No13 SD models are estimated using Bayesian statistics, in the form (3) has shown, it can be about the performance and efficiency of these models has commented.

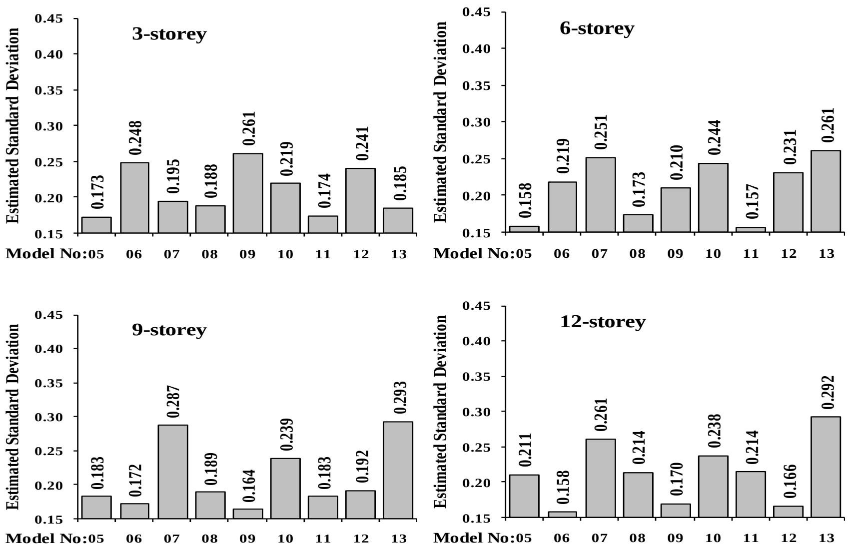

Figure 3 - Standard deviation of the estimated probabilistic models with a combination of indicators

The significant point is that the results can be seen in general SD model built in the previous section, this model is less. These models can also be argued that the standard deviation is relatively independent of the number of classes. Although this may partly reflects the efficiency of models, but it still seems to be one of the models to be recommended as an ideal model. In fact, as is known, none of these models to estimate demand at various heights is not appropriate for all legal fees.

In other words, the optimal models in short time frames within frames Rank high with good models are different. The main problem with this model is being applied. The particular combination of parameters used in the model causes they use a lot of problems associated with the performance-based design framework, because the common practice for determining seismic hazard curves using probabilistic seismic hazard analysis exists. Also, you can see that in this model, a very poor indicator of the high degree of accuracy is being exhausted. An obvious example of such a story, three-story frame model No06 spectral acceleration mode in which the first mode spectral acceleration has reduced accuracy.

In an overall assessment, using a combination of indicators can increase the efficiency and adequacy of the model is a probabilistic seismic demand and maybe even good enough to be a model. But before using such a model, two points should be considered in the first place to define the composition of the index parameter is used to ensure the efficiency and adequacy of the model for all frames. Second, the severity index is defined for a relationship, lowering the production of specific probabilistic seismic hazard analysis to be used in the application and satisfies these criteria extremely well crafted.

VIII. Model with two single intensity index

In this section we build a probabilistic model for seismic intensity using a single index is used. With the four parameters, PGA, SA1, SA2 and SA3, six models can be defined as follows:

Model No14: $\ln(\mathrm{DR}) = a.\ln(SA1) + b.\ln(PGA) + w + \sigma.\varepsilon$

Model No15: $\ln(\mathrm{DR}) = a.\ln(SA1) + b.\ln(SA2) + w + \sigma.\varepsilon$

Model No16: $\ln(\mathrm{DR}) = a.\ln(SA1) + b.\ln(SA3) + w + \sigma.\varepsilon$

Model No17: $\ln(\mathrm{DR}) = a.\ln(PGA) + b.\ln(SA2) + w + \sigma.\varepsilon$

Model No18: $\ln(\mathrm{DR}) = a.\ln(PGA) + b.\ln(SA3) + w + \sigma.\varepsilon$

Model No19: $\ln(\mathrm{DR}) = a.\ln(SA2) + b.\ln(SA3) + w + \sigma.\varepsilon$

The estimated standard deviation of the model using Bayesian statistics in the form of (4) is on display. This means the Model No15, which is a linear combination of the first and second mode spectral acceleration and standard deviations of the different frameworks, both in terms of efficiency and adequacy of the condition is quite good. The big advantage of this model is able to accurately estimate both its severity index is the seismic demand.

The problem is that the standard deviation and accuracy, it is always constant and satisfactory. SD model, compared with the models introduced in the previous section is very good and it can be concluded that the accuracy is unparalleled in the estimation of seismic demand. It should be noted that the application of these models requires further evaluation. The practical problem is the same as the previous section, the possible lack of probabilistic seismic hazard analysis criteria in their intensity, but the use of these models, the models that are in an index, the calculation is more difficult and require more time to volume for their calculations.

But the problem is not caused by the use of the framework design and performance estimation of seismic demand, is impossible.

However, considering all aspects can be probabilistic model No15 as a model for optimal seismic steel moment frames for seismic demand estimation presented with a number of different classes [9].

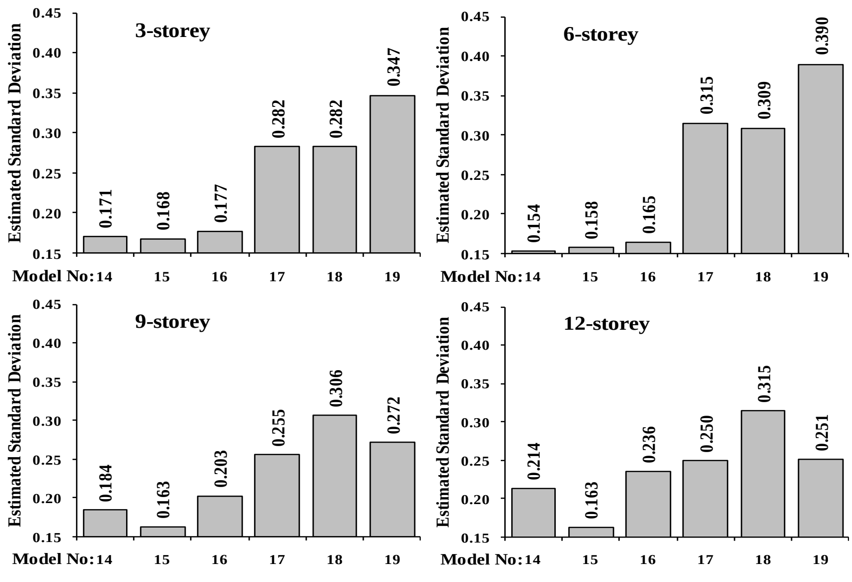

Figure 4 - SD estimated probabilistic models with two single severity index

IX. Conclusions

In this paper, the best model of probabilistic seismic demand for steel moment frames using Bayesian statistics is selected. Given the importance of estimating seismic demand, such a model can have an important role in the performance based design.

All results obtained in this study are summarized in the table below and can be based on their conclusion that the current model, the estimation of the seismic demand model with first-mode spectral acceleration, high efficiency is not required and the total finest model with a linear combination of the first and second mode spectral acceleration is introduced.

Table 1 - Summary of results from the various models of probabilistic seismic demand Probabilistic seismic demand model with a single parameter Severity Index

Some frames in model performance is acceptable, but in others a very low efficiency. Adequacy of the model is generally acceptable, except perhaps the models that have low efficiency.
Application model, the probabilistic analysis of seismic hazard in terms of practicality and ease of calculation, it is in the best position possible.
General recommendation to use this model as the model is unique in design framework based on function is not recommended. If such models are to be used to estimate the demand for each frame is used to define a model of its own.
Probabilistic seismic demand models with a combination of indicator parameters if you select the right combination of model performance indicators can be acceptable. Adequacy of the model is acceptable.
Applicability of the model of computation is not difficult, but impossible to use it, usually within a seismic hazard analysis.
Overall recommendation - a good combination of indicators, selection, and use within the context of the problem of probabilistic seismic demand is high, given that the performance is satisfactory enough can be a good model. Probabilistic seismic demand models of the two parameters of a single Model performance are acceptable. Adequacy of the model is acceptable.
Application model, the probabilistic seismic hazard analysis may be no problem, but the volume is very high and many components calculations for estimating seismic demand needs.
General recommendation if the volume of computation and time consuming if they use this model to be adopted model is very suitable and acceptable.

Resources

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