

Assessment of Seismic Damage on The Exist Buildings Using Fuzzy Logic

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Abstract. Earthquake as a natural disaster could damage the lives of many people and buildings all over the world. These is micvulnerability of the buildings needs to be evaluated. Accurate evaluation of damage sustained by buildings during natural disaster events is critical to determine the buildings safety and their suitability for future occupancy. The earthquake is one of the disasters that structures face the most. There fore, there is a need to evaluate seismic damage and vulnerability of the buildings to protect them. These days fuzzy systems have been widely used in different fields of science because of its simpli city and efficiency. Fuzzy logic provides a suitable framework for reasoning, deduction, and decision making in fuzzy conditions. In this paper, studies on earthquake hazard evaluation of buildings by fuzzy logic modeling concepts in the literature have been investigated and evaluated, as a whole.

Keywords: Seismic Damage, Earthquake, Historical Buildings, Fuzzy Logic

1. Introduction

Earthquake as a natural disaster could harm the lives of numerous people all over the world. It can impose a hugeeconomical burden on societies, as well. even if earthquake may be unpredictable, proper planning could significantly reduce the damages [1]. Natural disasters such as earthquakes and high winds pose a serious threat to all structures. Recent earthquakes, such as the 1994 Northridge, USA the 1995 Kobe, Japan and the 1999 Kocaeli, Turkey earthquakes caused extensive destructive damage to structures [2]. These earthquake damages in Turkey and all the world take attention for the preserve of the buildings against to earthquake hazard. The earthquake performance evaluation and upgrading of non-standard design existing buildings are among the most significant issues [3]. Especially, Historical buildings preservation, with global respect for cultural heritage, has become a booming trend world-wide due to the emphasis on its benefits, concerning architectural, economic, social, political and spiritual values [4].Exist buildings are vulnerable to earthquakes cause major financial losses and serious disruption on utilities and services for whole community [3-5].Nearly 50 percent of large cities around the world are placed nearby seismic belts.

In developed countries, sensitive technologies used in infrastructural equipment tend to be damaged during earthquakes. However, cities in developing countries are less protected against earthquakes [6]. Global seismic hazard map, All quakes over magnitude 5 since 1973 and Worldwide Earthquakes: 2000 – 2009 are shown Figure 1,2 and 3, respectively.





Figure 1. Global seismic hazard map [7]

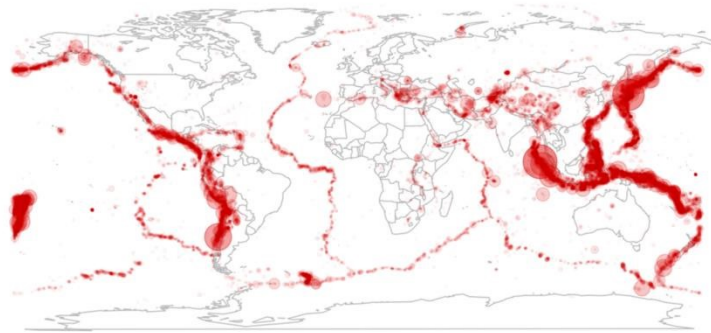


Figure 2. All quakes over magnitude 5 since 1973 [8]

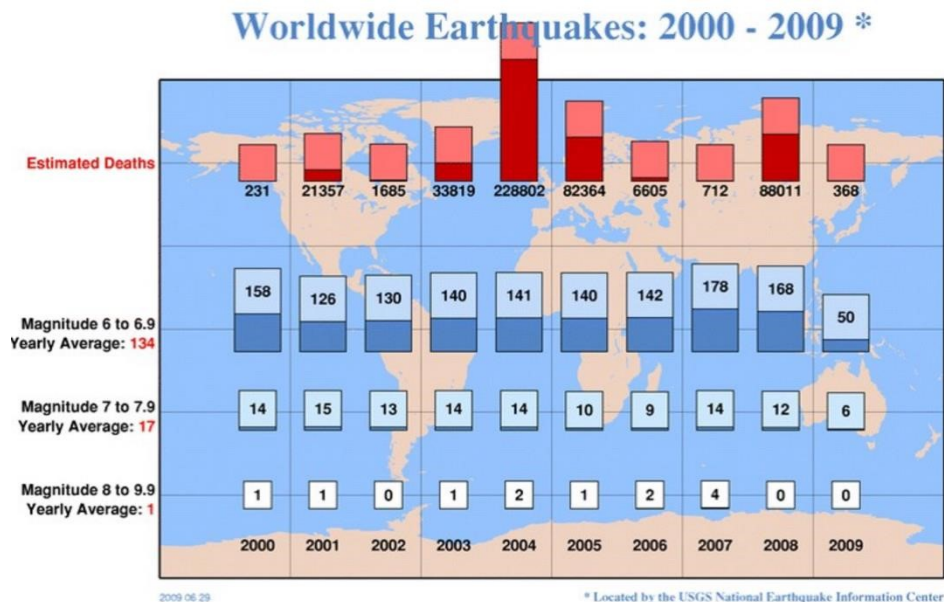


Figure 3. Worldwide Earthquakes: 2000 – 2009 [9]

Approximately 95 percent of all victims of natural disasters around the world are estimated to be from developing countries, and such individuals are twenty times greater in number than the victims of similar catastrophes in the developed World. Figure 4 shows People killed per disaster[6].

Magnitude	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
8.0–9.9	2	4	0	1	1	1	2	2	1	1	0
7.0–7.9	9	14	12	16	21	19	15	17	11	18	17
6.0–6.9	142	178	168	144	151	204	129	125	140	124	126
5.0–5.9	1,712	2,074	1,768	1,896	1,963	2,271	1,412	1,402	1,475	1,413	1,507
4.0–4.9	12,838	12,080	12,292	6,805	10,164	13,303	10,990	9,795	13,494	13,239	12,771
Total	14,703	14,350	14,240	8,862	12,300	15,798	12,548	11,341	15,121	14,795	14,421

Figure 4. Number of earthquakes worldwide for 2006-2016 [10]

Accurate evaluation of damage sustained by buildings during natural disaster events is critical to determine the buildings' safety and their suitability for future occupancy. Time is of the essence in conducting the evaluations as the damaged buildings cannot resume serving their regular purpose until they are deemed safe. The speed with which evaluations are conducted determines the duration for which the potentially damaged buildings remain unusable. The elapsed time directly translates into significant economic losses and to circumstances in which humans are exposed to precarious working and living conditions [11].

Therefore, it is really important to evaluate buildings damage as soon as possible. Nowadays it is possible to be evaluated damage on buildings with computer technologies by using different methods such as fuzzy logic methods.

2. Fuzzy Logic

The fuzzy set was introduced by LotfiZadeh in 1965 since that time Fuzzy logic has come a long way. after first presented to technical society the subject has been the focus of much independent research. Fuzzy set deals with uncertain phenomena often presented in the real-life application. thefuzzy set theory allows the object to have any degrees of membership between zero and 1 but the classical mathematics requires objects to have zero or 1 [12-13-14].

There is our limited understanding of the behavior of the vulnerable elements of the exist buildings under earthquake loads. Due to over the past decade a lot of effort has been devoted to the problem of how to evaluate earthquake damage on buildings by different techniques given the large uncertainties in the pattern of earthquake occurrence. Because of diverse uncertainties and randomness involved both in capacity and seismic demand, evaluation of potential earthquake damage should be carried out based on statistical and probabilistic techniques [15]. In a seismic risk assessment, the subjective judgment of the assessor is always influencing the evaluation and decision making process. For example, the assessor could have totally different opinions about the potential seismic vulnerability of a building if compared to opinions of another assessor, due to the differences in their knowledge and experience. the knowledge given by the assessor is in linguistic terms which aresuch as very high or very low irregularity. Therefore, the available information for this qualitative reasoning, the complexity and the lack of evaluation itself, create ambiguity in the assessment process that can be best handled with fuzzy logic. Fuzzy logic provides a mathematical way to represent fuzziness and imprecision and provides translated for linguistic and quantitative reasoning qualitative features [16].

Fuzzy theory can be applied to establish indicators for earthquake danger or hazard levels. Fuzzy theory is extremely important in building structural analysis. It can indicate that damage conditions or overlaps of different destruction conditions ranging from light structural damage to total collapse. Corresponding earthquake fragility curves can be used to assess the structural risk and damage scale for buildings resulting from an earthquake. Combining fuzzy theory with dynamic risk safety analysis can facilitate safety planning for reconstruction areas following earthquakes [17].

3. Assesment of Seismic Damage and Fuzzy Logic

For the background presented in this section,assessment of seismic damage problems related to buildings type can be addressed through a Fuzzy logic analysis.

Table 1 summarizes the main scientific works available in the literature considering the application of Fuzzy Logic in the assessment of seismic damage problems, putting in evidence the field of application, the objective of the evaluation, the Fuzzy logic technique used and the scientific journal in which the work was published.

Table 1. Some Main works available in the literature concerning Fuzzy Logic applications in assessment of seismic damage on buildings

Authors	Year	Fields of application	Objectives of the evaluation	Journals
Sen and Ekinci [18]	2016	Assessment of Earthquake vulnerability	To evaluate the Earthquake Vulnerability Analysis in Structure Scale with Fuzzy Logic Method in GIS	International Journal of Environment and Geoinformatics
Sen [3]	2010	Earthquake hazard evaluation	To make rapid visual earthquake hazard evaluation of existing buildings by using fuzzy logic	Expert Systems with Applications
Fischer et al. [19]	2002	Structural damage estimation	To advised the use of fuzzy logic in structural damage estimation	Engineering Structures
Demartinos and Dritsos [20]	2006	Pre-earthquake assessment	To discussed the performance of a fuzzy logic based rapid visual screening procedure	Earthquake Spectra
He et al. [21]	2013	Earthquake Damage Assessment	To Assessment Earthquake Damage on RC Structures by Fuzzy logic	Mathematical Problems in Engineering
Alesheikh [1]			To Evaluate earthquake vulnerability with fuzzy logic and GIS	
Elenas et al. [22]	2013	Earthquake Damage Assessment	To classification of seismic damages in buildings	Computational Methods in Structural Dynamics and Earthquake Engineering Phd Thesis
Komsari [16]	2011	Seismic risk evaluation	To evaluate seismic risk of wood frame construction with fuzzy based techniques	
Pakdamarand Guler [23]	2008	Performance evaluation	To evaluate performance of There in forced concrete structures with fuzzy logic approach	The 14 th world conference on Earthquake Engineering
Shao et al [24]	2014	Earthquake Damage Assessment	To estimate earthquake damage on buildings using with fuzzy logic application	Journal of Central South University

4. Conclusions

The assessment of seismic damage identification of buildings in pre-earthquake and post- earthquake period presents a very significant task, which must be accomplished in rapid, simple, economic and efficient manner. This paper presents an assessment of seismic damage on the buildings based on Fuzzy techniques.

The search results show that fuzzy logic theory can be use to predict and assessment building damage rates and that estimated results are parallel to real disaster figures. Prediction of disaster damage using building damage rates can provide a reference for immediate disaster response during earthquakes and for regular disaster prevention and rescue planning [24].

As shown in a case study in the United States, the uncertainty of earthquake danger or hazard analysis can be handled with a decay curve obtained using fuzzy theory and regression analysis. the results of this research show that using an appropriate membership function can decrease uncertainty regarding building damage triggered by earthquakes and can be applied to various natural disasters [17].

In any engineering analysis, due to uncertainties which is in structural components and materials, approximation cannot be avoided. Consequently, the fuzzy logic model gives simplicity, speed and flexibility at the deciding buildings' damage assessment.

There is a need to more analyze on exist buildings by conducting experiments and observations. Future work in the area could focus on multiple research directions. The study will be enhanced with real models and fuzzy logic theory will be applied on models.

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