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Application of AHP Method and Site Specifications in Seismic zonation and building vulnerability assessment (Case Study: Kermanshah City)

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Abstract

Different methods for seismic zonation and building vulnerability assessment are produced in different parts of the world. In these studies, seismic zonation is generally based on the geotechnical profile of the soil and the shear wave velocity. In 2013, Karmania hazard model (KHM) was presented to Iran, in which seismic zonation and vulnerability assessment of buildings and individuals in the worst earthquake scenarios are based on the basic parameters of the site, such as soil texture, groundwater level, microteremore data, and alluvial depth. In this study analytic hierarchy process (AHP (is applied in KHM model for seismic zonation and building vulnerability assessment of Kermanshah city. The results show that the vulnerability level for 80% of residential buildings would be low to moderate, but 2% of buildings would suffer from complete destruction (D1), 7% with very high destruction (D2) and 11% with high destruction (D3). Finally, the model is verified with the help of the data and observations from the Sarpol Zahab earthquake, which shows that the model is in good agreement with the actual earthquake data.

Key words*: Seismic zonation, earthquake intensity, building vulnerability*

Extended Abstract:

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1. Introduction

Natural disasters are often a sudden and severe event, causing mortal and financial losses and affecting the lives of the communities involved. Overview of the historical data shows that Iran has always faced many environmental crises and is among the most vulnerable parts of the world in terms of environmental hazard. The earthquake is the most important natural disaster in Iran. The experiences of past earthquakes and the damage caused by them have shown that for earthquake safety, two essential factors have to be considered. The first factor is the safety of structures against earthquake-induced movements, and the second factor, which is less considered, is the safety of the site. Considering the severity of the damages caused by the earthquake, one of the main activities to reduce the risks of earthquakes and increase the general safety, is to conduct earthquake hazard zonation studies in various urban areas. Regarding this issue, today, most seismic countries in the world, seismic hazard zonation studies is considered as an important step in the comprehensive risk management program (Global Bank Project, 2009).

Today, the use of new methods for seismic risk assessment, rapid estimation of casualties and earthquake damage are among the most important issues in the field of earthquake hazard management. In Iran, KHM model (Karmania Hazard Model), provided by Hassanzadeh et al, this model is an appropriate tool for rapid assessment of earthquake damage, and estimates the damages to buildings, the mortality of individuals and the basic resources needed. In this model, vulnerability assessment is provided by subsurface data, vulnerability curves of buildings and population data (Hassanzadeh et al., 2013).

The most important goal of the research is seismic zonation and seismic vulnerability analysis of Kermanshah city buildings based on KHM method. In this study, for the worst earthquake scenario, maximum earthquake intensity is calculated based on the attenuation relationships, geotechnical, geophysical and geological data. Then, using information about buildings and vulnerability curves, the seismic vulnerability of buildings in Kermanshah city is estimated.

2. Methodology

In this study the KHM method is applied that is created for buildings vulnerability assessment and human losses in Iran (Hassanzadeh et al., 2013). The first steps in this study were identifying the effective parameters of seismic zonation of Kermanshah city and providing a comprehensive and reliable database of these parameters in the GIS. The input parameters of the model are soil type, thickness of alluvium, ground water table, and predominant period of the site. In the next step, the AHP method was used to analyze the data and produce an amplitude map (seismic zonation map).

In this study, the AHP method was used at two levels. First, a 4 × 4 matrix is created, in which the parameters are compared on the basis of experts opinion (Table 1). At the second level, the elements of each parameter are assigned ranging from 1 to 9 based on pairwise judgment.

Table 1. Weights of the basic parameters of the model by AHP method

	Soil type(S)	Alluvial thickness(A)	Groundwater table (W)	Predominant Period(P)	Weight
Soil type (S)	1	1	2	3	0.36
Alluvial thickness(A)	1	1	2	2	0.33
Groundwater table(W)	0.5	0.5	1	1	0.16
Predominant Period (P)	0.33	0.5	1	1	0.15

To generate the seismic zonation map (amplification map), the weights of the AHP method was assigned to the layers, then the layers are combined (Equation 1).

$$M_i = \sum S_i A_i W_i P_i \quad (1)$$

Where M_i is the seismic zonation map in area i; S_i is the soil type in area i; W_i is the ground water table in area i; P_i is the predominant period in zone i and A_i is the alluvial thickness in area i. Finally, for producing the ground shaking map, the seismic zonation map and the raw intensity map were combined (Equation 2).

$$GSM = \sum M_i I_i \quad (2)$$

Where GSM is the ground shaking map; M_i is the seismic zonation map in area i, and I_i is the raw intensity map in area i. In order to produce the raw intensity map, attenuation relationships of Iranian earthquake were used (Ambraseys and Melville 1982; Chandra, et al., 1979).

In this study, for investigating the vulnerability of Kermanshah buildings, the city buildings were divided into 9 groups with the help of census data of 2017 information. This categorization is consistent with the vulnerability curves of buildings in Iran (Japan International Cooperation Agency (JICA2000)). Finally, by use of the city buildings data and the final shaking intensity map, the vulnerability of Kermanshah city buildings was estimated.

3. Discussion and conclusion

In this study, seismic zonation and building vulnerability assessment for the worst earthquake scenario in Kermanshah city are produced, which applied site specifications and AHP method. Bore hole data, geophysical data, documents, geological maps and satellite imaginary were used to define the characteristic of the site, and building data were also collected with field observations and library studies. Essential parameters based on the KHM model are: soil type, thickness of alluvium, ground water table, and predominant period. Data are scattered and can't directly be used. Therefore, it is converted in to the shapefiles and interpolation tools are applied in GIS. Ground shaking map shows that for the worst earthquake scenario, the seismic intensity would be from 7 to 8 in MMI scale. Maximum shaking was along the margin of the Ghare Sou River and decreases by

moving away from the river. The city buildings were divided in to 9 groups based on the 2017 census, JICA vulnerability curves, and field surveys. Destruction levels of Kermanshah buildings were from light destruction (D5) to total destruction (D1). About 80% of city buildings would experience destruction from light to moderate level. But for remaining buildings that include 20% of total buildings, considerable damage would happen. 2% are exposed to totally destruction (D1), 7% and 11% would experience very high destruction (D2) and high destruction (D3) respectively. Model validation was performed by Sarpol Zahab earthquake data (On November 12th, 2017) and field observation. Results show that there is a good agreement between model and actual data.

References:

Ambraseys, N. N., Melville, C. P., 1982. A History of Persian Earthquakes Cambridge Univ. Press, New York.

Chandra, U., McWhorter, J. G., Nowroozi, A. A., 1979. Attenuation of intensities in Iran .Bulletin of the Seismological Society of America, 69(1): 237-250.

Global Bank Project Number 4697-IRN., 2009. The Evaluation of Risks and Seismic Risks in Provinces Ghazvin, Zanjan, Hamedan, and Kermanshah, The Final Report of the First Part: Seismic Microzonation of Kermanshah.

Hassanzadeh, R., Nedović-Budić, Z., Razavi, A. A., Norouzzadeh, M., Hodhodkian, H., 2013. Interactive approach for GIS-based earthquake scenario development and resource estimation (Karmania hazard model), Computers & geosciences, 51: 324-338.

Japan International Cooperation Agency (JICA) and Center for Earthquake and Environmental Studies of Tehran (CEST), 2000. The Study on Seismic Micro- zoning of the Greater Tehran Area in the Islamic Republic of Iran, Tehran, Iran. 1: pp. 379.