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ATTENUATION RELATIONSHIP FOR THE HORIZONTAL COMPONENT OF PEAK GROUND ACCELERATION (PGAH) USING GENE EXPRESSION PROGRAMMING (GEP)

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Although, earthquake had been considered as an unknown phenomena several centuries ago, today, given the scientific advances made in the field of seismic geotechnical engineering and more knowledge of internal structure of the earth, it is possible to understand the various phases of earthquake and its effects on the earth movement. However, despite the achieved progress, it is impossible to prevent earthquakes or to predict the precise time of its occurrence anywhere in the world, but it is possible to prepare for it by building earthquake resistant structures. In fact, the purpose of designing earthquake resistant structures is to construct structures that can withstand seismic loads that does not undergo a lot of damage and rescue the inhabitants. In order to achieve this goal, it is necessary to predict and estimate the severity of possible earthquakes in each area in accordance with its various features which is impossible but through risk analysis. The prerequisite of risk analysis studies is to identify the parameters of powerful earth movement for different areas.

The amount of earth movement is attributed to the magnitude, distance from the site to the source, the source mechanics, geology of the region, surface topography and dynamic properties of the material propagation (Kramer). Also, other parameters including soil nonlinear behavior, orientation, propagation failure, field effects and the impact of stress loss on earth's movement can be even more effective than some of the above mentioned independent parameters (Somerville & Graves, 2003). To predict and estimate the parameters of the powerful earth movement, due to using above effective parameters, relations named attenuation relationships are applied. Attenuation relationships indicate the decrease of parameters of powerful earth movement by distance from the earthquake center and usually, their outputs are peak horizontal and vertical accelerations (PGA), peak ground velocity, and elastic and inelastic response spectra. Of course, in most researches and studies, attenuation relationships are used to obtain the peak ground acceleration.

The first attenuation model of peak ground acceleration was provided in 1954 for earthquakes in America by Newman which first parameter involved was distance of accelerographs from earthquake's center and even the role of earthquake magnitude was not considered in this regard (Amiri et al., 2007). Subsequently, models were developed from the 1970s to mid-1980s in which beside the distance of accelerograph from earthquake's center, magnitude of earthquake was included in calculations as well. But today, attenuation models are transformed into more complex ones which have become more accurate by applying advances of computer science, using smart methods to present these relations and by considering the effect of various parameters such as magnitude, distance, soil type, and tectonic conditions, etc. Such as this models be referred to Zafarani et al. (2018) and Soghrat et al. (2012). The purpose of present study is to provide a new global attenuation relationship to estimate peak ground horizontal acceleration of the earth (PGAH) using Intelligent Genetic Algorithm. Regarding the globalized final relation, records have been used throughout the world and they have been selected completely randomly and with appropriate disperse. These records are taken from PEER site by applying filters with moment magnitude greater than 4

and hypo central distance of 15 to 150 km. Subsequently, 1318 records were found each of which was processed separately and then peak ground acceleration of each recorded earthquake at each station was taken. The important point in this section is that there are two horizontal acceleration components in two orthogonal directions per record. In this study, the root sum of squares of two orthogonal components are used in order to take into account the most critical condition.

Finally, after correcting the existing records and deleting some of them, 1239 records remained as final records and parameters of moment magnitude, hypo central distance and shear wave velocity of each record are considered as variable and root of sum squares of peak ground horizontal acceleration in two horizontal orthogonal direction was treated as objective function for Gene Expression Programming (GEP) and they were introduced, defined and processed. Gene Expression Programming (GEP) is actually a developed genetic algorithm and genetic programming that were presented by Ferreira in 1999 and its output are developed trees which are connected by sum operator and presents the final attenuation relationship as Equation 1.

$$\log(PGA) = \frac{0.586^3 - (16.64 + R)}{Exp(M)} + \frac{\frac{v}{M^2} - 7.72}{(0.47 - M) \times \mathrm{R}} + \sqrt[3]{M} + \sqrt[3]{Exp\left(\left(\frac{R}{-9.17}\right) + R^{-0.59}\right)}$$

where M is moment magnitude, R is the hypo central distance in km, v is shear wave velocity in m/s and PGA is peak ground acceleration in cm/s^2. Finally, the fitness function is calculated using the root-mean-square error (RMSE) and 765 is obtained from 1000 showing the high proportion of the final attenuation relation with measured values from the previous earthquakes. In addition, the logarithmic standard deviation of proposed model is obtained 0.187. Figure 1 shows the difference value of PGA resulting from the attenuation relation and real PGA for each record.

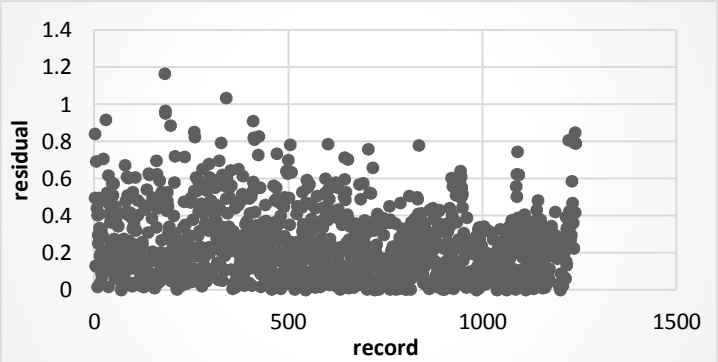

Figure 1. Residual trends of inter and intra-event error.

Also, the accuracy and correctness of these relations are confirmed by comparing the obtained attenuation relation with the results obtained from the previous studies. Generally, some strength points of this study are:

First, the widespread being of statistical population and addition of records in recent years to earthquake catalogue leads to more precise attenuation relation.

Second, using the Gene Expression Programming (GEP) helps to minimize the difference between the predicted values in this study, due to the attenuation relation and measured values from past earthquakes.

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