Ground Motion Prediction Equations For Far Field Earthquake Considered By Strike Slip Fault Mechanism

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Abstract. The ground motion prediction equation (GMPE) was developed using regression analysis. This estimation process needs to use a GMPE which provides peak ground acceleration (PGA) estimates incorporating a number of earthquake magnitude, distance and other seismic parameters. The database consisting of more than 35 PGA dataset from different earthquakes recorded by Seismology Station in Malaysia have been used to develop the relationship for this paper. This study aims to investigate the new relationship attenuation to gain exact peak ground acceleration at the location on site. In the Southern Asia region (Indonesia, Philippine and Malaysia) for example, there is significant hazard from earthquake along the strike slip fault.

Introduction

Attenuation is when the seismic waves move farther away from the epicenter which is they grow smaller as they are attenuated by the ground. The energy with which an earthquake affects a location depends on the running distance. The attenuation in the signal of ground motion intensity plays an important role in the assessment of possible strong ground shaking. This phenomenon is tied in to the dispersion of the seismic energy with the distance. There are two types of dissipated energy which is geometric dispersion caused by distribution of the seismic energy to greater volumes and dispersion as heat.

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A large number of attenuation relations have been developed by different investigators since the record of ground motions become more available. In general, they are categorized according to tectonic environment and site condition (i.e. rock, soft soil, or stiff soil). A seismic wave loses energy as it propagates through the earth (attenuation). This phenomenon is tied in to the dispersion of the seismic energy with the distance.

Strike Slip Earthquake

Strike-slip earthquakes commonly occur along vertical fault plane as one side of the fault slides horizontally past the other. If the far side of the fault shifts to the right it is termed a right-lateral fault and if it shifts to the left, it is left-lateral fault. With dip-slip earthquakes, the fault is usually at an angle with the earth's surface and the movement is up or down. For faults that make an angle with the earth's surface, names are given for the two sides of the fault. The top side of the fault is known as the hanging wall and the bottom side is the footwall.

On a normal-slip fault, the hanging wall moves down and the footwall up and on a reverse-slip fault, the reverse happens with the hanging wall moves up and the footwall moves down. A common feature along normal-slip faults is for the hanging wall to collapse and create a secondary fault that dips into the main fault. The area downdropped between these two faults is called a graben. If a fault has both strike-slip and dip-slip movement, it is known as an oblique-slip fault.

Methodology

Site specific seismic hazard evaluation studies require estimation of strong ground motion from probable earthquakes. The estimation of peak ground acceleration in terms of magnitude, source-to-site distance, tectonic environment and source type using attenuation relationships has been a major research topic in seismic hazard estimation studies. Such relationships are developed in the past for various regions and comprehensive reviews have been published for such relationships [1,2,3,4,5]. Most of the relationships are developed using worldwide acceleration data acquired through the strong motion arrays. The general form of regression models have been described by Campbell [2].

For the regions where strong motion data is not available for such analysis, the attenuation relationships developed for other regions are used based on the resemblance of the characteristics of the both regions. In some of the cases, where lesser data is available the empirical relations are developed by pooling some of the data from other regions also [5].

The vertical accelerations are generally smaller than horizontal accelerations for strong motion data from earthquakes recorded at shorter distances. An attenuation relationship for peak ground vertical acceleration is developed in the present study [6]. This relationship is then compared with the attenuation relationship developed on the same data set for peak ground horizontal ground acceleration and the ratios of vertical to horizontal peak ground acceleration are then compared with the actual ratios recorded by the stations.

An attenuation relationship for far field earthquakes considered by strike slip mechanism has been developed. The attenuation relationship function was developed using regression analysis by part of researchers. In this research, the new attenuation function for strike slip mechanism is followed a typical forms of attenuation relationship proposed by previous researchers [7,8].

As suggested by Fahmy [9], comparison between prediction values of PGA and the measured peak ground acceleration values recorded by seismology stations in Malaysia were carried out in this study. This is because to select the most suitable attenuation model to be used for the development of the RSA on the soil surface at the study area. The measured PGA data from seismometers were collected from Malaysia Meteorological Service [10].

Result and Data Analysis

Peak Ground Acceleration (PGA) Data.

Peak Ground Acceleration (PGA) is a measure of earthquake intensity. According to Sokolov [11], the PGA is strictly depending on earthquake magnitude, distance and local geological condition. The high peak acceleration gives more destructive effect than lower peak acceleration, with percentage of structure damages depending on the period of PGA. According to Fadzli [12], the attenuation relations relate the peak ground acceleration is important parameters in seismic hazard analysis.

PGA is very important for earthquake hazard assessments and emergency response operations. One of the earthquake hazard assessments is the determination of earthquake effect and type of ground motion at the site. Typically, this is done by means of an earthquake ground motion attenuation relationship which provides the estimation of ground motion for an earthquake of a given magnitude at a different distance through a curve fitted to the observed data. The development of an attenuation relationship is based exclusively on the recorded seismic events [13].

Table 1: Summary of 35 selected analysis data

No	Coordinate Of Events	Date	Time	Station Involved	PGA (Z)	PGA (N)	PGA (E)	Hypocentral Distance (km)
001	1.8 N, 98.8 E	14/06/2011	0:08:00	KUM	0.000061	0.000056	0.000092	707.2
002	1.8 N, 98.8 E	14/06/2011	0:08:00	IPM	0.000112	0.000109	0.000197	707.2
003	1.8 N, 98.8 E	14/06/2011	0:08:00	FRM	0.000226	0.000680	0.000800	707.2
004	1.8 N, 98.8 E	14/06/2011	0:08:00	KGM	0.000062	0.000001	0.000216	707.2
005	1.8 N, 98.8 E	14/06/2011	0:08:00	KOM	0.000039	0.000090	0.000100	707.2
006	1.8 N, 98.8 E	14/06/2011	0:08:00	PYSM_B0	0.000438	0.000430	0.000380	707.2
007	1.8 N, 98.8 E	14/06/2011	0:08:00	PYSM_B9	0.000801	0.002281	0.002056	707.2
008	1.8 N, 98.8 E	14/06/2011	0:08:00	BKSM	0.000941	0.001760	0.001725	707.2
009	1.7 N, 98.4 E	14/06/2011	3:01:28	BRSM	0.000331	0.000630	0.000688	749.6
010	1.7 N, 98.4 E	14/06/2011	3:01:28	IPM	0.000085	0.000085	0.000068	749.6
011	1.7 N, 98.4 E	14/06/2011	3:01:28	PJSM	0.000381	0.000707	0.000783	749.6
012	3.36 N, 101.84 E	30/11/2007	2:13:00	KOM	0.000009	0.000018	0.000018	342
013	3.36 N, 101.84 E	30/11/2007	2:13:00	IPM	0.000039	0.000031	0.000026	342
014	3.36 N, 101.84 E	30/11/2007	2:13:00	KTM	0.000016	0.000019	0.000022	342
015	3.36 N, 101.84 E	12/4/2007	10:12:00	KTM	0.000022	0.000036	0.000039	341.2
016	3.36 N, 101.84 E	12/4/2007	10:12:00	KOM	0.000024	0.000038	0.000038	341.2
017	3.36 N, 101.84 E	12/4/2007	10:12:00	IPM	0.000073	0.000078	0.000464	341.2
018	6.3 N, 117.7 E	23/05/2005	19:58:00	BTM	0.000062	0.000079	0.000090	1528
019	6.3 N, 117.7 E	23/05/2005	19:58:00	KDM	0.000158	0.000185	0.000158	1528
020	6.3 N, 117.7 E	23/05/2005	19:58:00	KKM	0.000224	0.000001	0.000739	1528
021	3.5 N, 113.9 E	5/1/2004	23:29:00	BTM	0.000774	0.001476	0.001715	1132
022	3.5 N, 113.9 E	5/1/2004	23:29:00	KDM	0.000008	0.000001	0.000009	1132
023	3.5 N, 113.9 E	5/1/2004	23:29:00	KKM	0.000046	0.000124	0.000148	1132
024	3.5 N, 113.9 E	5/1/2004	23:29:00	SDM	0.000001	0.000008	0.000011	1004
025	1.7 S, 98.6 E	16/08/2009	7:38:18	BRSM	0.000215	0.000473	0.000386	1004
026	1.7 S, 98.6 E	16/08/2009	7:38:18	BTM	0.000157	0.000176	0.000152	1004
027	3.2 N, 95.9 E	26/12/2004	0:58:53	KSM	0.000182	0.000163	0.000140	926.9
028	3.2 N, 95.9 E	26/12/2004	0:58:53	KKM	0.000086	0.000066	0.000105	926.9
029	3.2 N, 95.9 E	26/12/2004	0:58:53	KGM	0.000374	0.000475	0.000370	926.9
030	4.64 N, 118.04 E	28/05/2012	16:44:00	TSM	0.000409	0.000746	0.000626	1569
031	4.64 N, 118.04 E	28/05/2012	16:44:00	LDM	0.000591	0.000560	0.000813	1569
032	4.64 N, 118.04 E	28/05/2012	16:44:00	KKM	0.000027	0.000072	0.000077	1569
033	4.56 N, 118.34 E	6/4/2012	6:36:00	KKM	0.000010	0.000022	0.000030	1603
034	4.56 N, 118.34 E	6/4/2012	6:36:00	TSM	0.000132	0.000213	0.000207	1603
035	4.56 N, 118.34 E	6/4/2012	6:36:00	LDM	0.000080	0.000114	0.000167	1603

35 data were selected for analysis of PGA. This is because waveforms with background noises have been excluded and only records, which are applicable to support a distance range recommended by selected attenuation relationships and also strike slip fault only have been accounted for. Furthermore, insignificant waveforms, which exist within the available dataset, have been removed by applying resolution values for PGA. The data shows in Table 1 used for the study has been made available by the Malaysian Meteorological Department (MMD) located in Petaling Jaya which has deployed a few of stations in Malaysia Region.

Ground Motion Prediction Equation

This study aims to investigate the new relationship of ground motion prediction equation for strike slip earthquake to gain exact peak ground acceleration at the location on site. In the Southern Asia region (Indonesia, Philippine and Malaysia) for example, there is significant hazard from earthquake along the strike slip fault.

From the obtained result, the new attenuation function is :

$$\ln Y = -116.14 - 4.18M_w + 101.34{M_w}^{0.17} - 0.99\ln\left(R + 17.77e^{-1}\left(-20.09M_w\right)\right) - 0.08H \qquad (1)$$

Where ;
Y = Mean of ground motion (PGA) in gals
M_w = Magnitude of the earthquake (moment magnitude)
R = Distance from the source to the site being considered (hypocentral distance)
H = Focal depth of site characteristics function in km

Conclusion

Based on the GMPE, community can utilize that equation on prediction of earthquake intensity occur at different location in all over the world especially for Southern Asia Region area. Meanwhile, consideration of possible equation can be selected from other researchers as comparison in term of value and result of final peak ground acceleration.

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