

APPROPRIATE ATTENUATION MODEL FOR CHIANG MAI, THAILAND FROM FIELD MEASUREMENT TO MODEL EQUATION

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ABSTRACT: Earthquake occurs frequently in Thailand especially in upper northern part in past 5 years ago. Thailand has also many fault, especially upper northern. The upper northern part may risk by earthquake. The earthquakes damage of buildings or people and these damages will depend on peak ground acceleration (PGA). Peak ground acceleration (PGA) is an important factor for analysis and design of building or related structure on top. This study was analyzed earthquake attenuation model of group Next Generation Attenuation Models (NGA) and Stable Continental Region. First group, the model was listed as Abrahamson and Silva (2008) and Idriss (2008). For the second group, the model was listed as Toro et al. (1997), Hwang and Huo (1997) and Dahle et al. (1995). Each model analysis was done by using the earthquake intensity that had happened according to the earthquake that detected from field measurement of 6.3 Richter scale on May 5th 2014. The epicenter was in Mae Lao district, Chiang Rai province in northern of Thailand. The result of this research was summarized by mean of peak ground acceleration (PGA) between the attenuation models and the field data measurement by checking the accuracy of each model. It can be concluded that the attenuation model of Abrahamson and Silva (2008) give more accurate acceleration data compare to other models.

Keywords: Earthquake, Peak ground acceleration (PGA), Attenuation models

1. INTRODUCTION

The upper northern of the country, most of Thailand are characterized by mountains, is one of the causes of the earthquake fault and earthquake statistics in countries, Thailand often occur on the North. The earthquake occurred, causing structural damage to buildings. The PGA (Peak Ground Acceleration) is a value that is important to the severity of the earthquake will be used to analyze the attenuation, more distance from the center of the earthquake, the PGA, it's even less. This paper is study for the appropriate attenuation models for Chiang Mai, Thailand area.

This paper presents a study of equations for the appropriate of attenuation to Chiang Mai. The earthquake in Mae Lao, Chiang Rai on May 5th 2014 was selected as a reference of earthquake magnitude recorded by field measurement data. The accelerometers were installed at Mae Ngud Somboonchon Dam in Chiang Mai. Previously the related study on attenuation model was mainly depends on distance of the source and ground condition. Chintanapakdee et al. (2008) [1] was studied the attenuation models which divided into several groups depend on the ground condition.

2. MATERIALS AND METHODS

2.1 Details and equipment

2.1.1 Details of the earthquake

On May 5th 2014 at 6:08 pm many recording instrument were detected the earthquake occurred located on Saikaow sub district, Phan district, Chiang Rai, latitude 19.685 °E longitude 99.687 °N. The magnitude earthquake was 6.3 Richter and occurred at 7 km depth from the ground. Subsequently, the earthquake data has analyzed by various kind of additional information. Finally the accurate and updated data which changes of original location to new location at latitude 19.748 °E longitude 99.692 °N. This new location located on Dong Mada sub district, Mae Lao district, Chiang Rai. (Fig. 1)

2.1.2 Accelerometer

In this study the accelerometer was used by mean of monitoring field data which frequency was expressed in the form of acceleration waves and peak ground acceleration (PGA). Accelerometer equipment Model version 130-SMA was selected as shown in Fig. 2. The location of field installment of those three points around center of the dam and mounting position was also shown in Fig. 3.

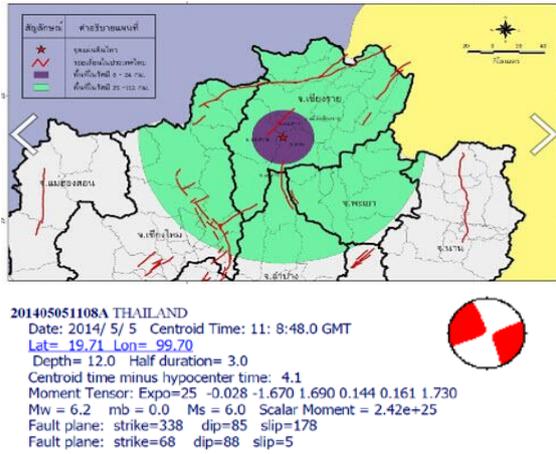


Fig.1 The epicenter on May 5th 2014, Dong Mada, Mae Lao, Chiang Rai and detailed by from Global CMT Catalog [2]

- Y axis = 0.314 m/s² = 0.032 g = 3.2 %g
- Z axis = 0.380 m/s² = 0.038 g = 3.8 %g

2.2 Theory

2.2.1 Attenuation model

The attenuation equation from various researchers were studied and analyzed. The first group is Next Generation Attenuation Models (NGA), NGA is to improve and gather information of the earthquake from the original equations. NGA composed of Abrahamson and Silva (2008)[3] and Idriss (2008)[4]. The second group is Stable Continental Region, Stable Continental Region is divided into groups by the type of earthquake is a stable movement. It is listed of Toro et al. (1997) [5], Hwang and Huo (1997) [6] and Dahle et al. (1995) [7].



Fig.2 Accelerometer equipment Model version 130-SMA

Considering the epicenter measured that the distance has approximately 110 km from Mae Lao district to Mae Ngud Somboonchon Dam shown in Figure 4. From field accelerometer data in the dam, it's have been recorded during that strong earthquake by showing the maximum acceleration as following data,

- X axis = 0.187 m/s² = 0.019 g = 1.9 %g

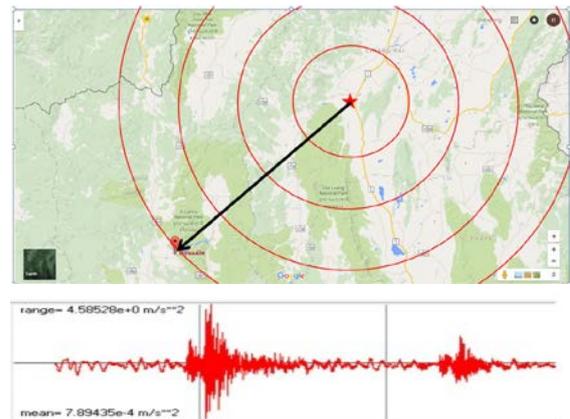


Fig.4 The distance between epicenter to Mae Ngud Somboonchon Dam and maximum acceleration data

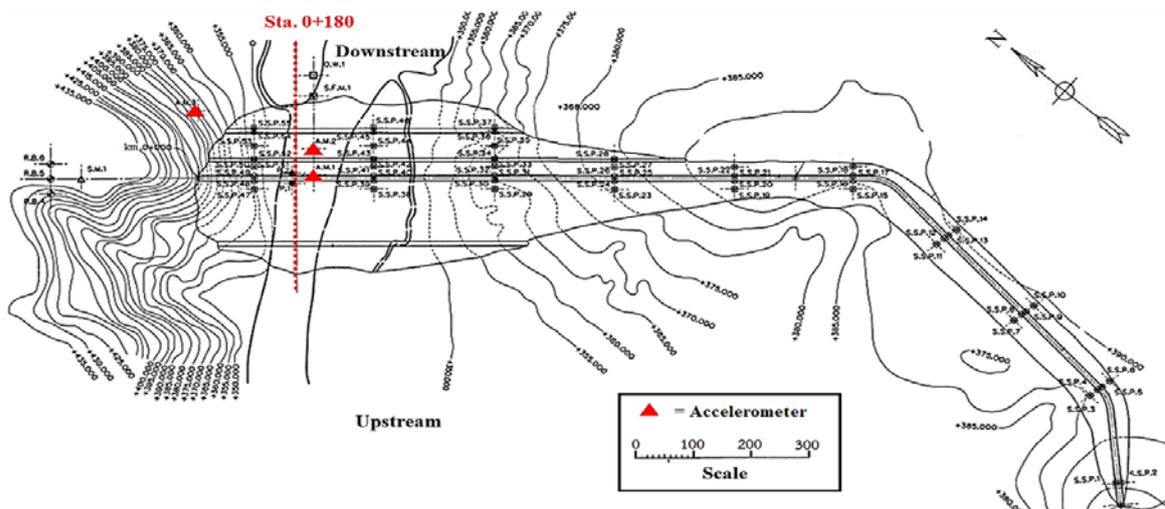


Fig.3 Accelerometer and the mounting position

The detail for calculation this earthquake are moment magnitude = 6.3, depth of epicenter = 7 km, distance between epicenter to the Mea Ngud Somboonchon Dam = 110 km.

Group 1: Next Generation Attenuation Models (NGA)

•Abrahamson and Silva (2008) [3]

Developed from the model Abrahamson and Silva (1997) used data format of NGA has a more complex model equations for maximum acceleration and neutral surface as shown in Eq. (1)

$$\ln(PGA) = f_{base} + f_{fault} + AS + f_{site} + f_{TOR} + f_{dist} \quad (1)$$

Function 1 Base Model (f_{base}) and is given by:

$$a_1 + a_4(M - c_1) + a_8(8.5 - M)^2 + [a_2 + a_3(M - c_1)] \ln(\sqrt{R_{rup}^2 + c_4^2}) \quad (2)$$

Function 2 Fault and Aftershock Model ($f_{fault+AS}$) and is given by:

$$a_{12}F_{RV} + a_{13}F_{NM} + a_{15}F_{AS} \quad (3)$$

Function 3 Site Response Model (f_{site}) and is given by:

$$(a_{10} + bn) \ln\left(\frac{V_{s30}}{V_{LIN}}\right) \quad (4)$$

Function 4 Depth-to-Top of Rupture Model (f_{TOR}) and is given by:

$$a_{16}F_{RV} + a_{17}(1 - F_{RV})\left(\frac{Z_{TOR} - 2}{8}\right) \quad (5)$$

Function 5 Large Distance Model (f_{dist}) and is given by:

$$a_{18}(R_{rup} - 100)(6.5 - M) \quad (6)$$

Where: M = Moment magnitude, Rrup = Rupture distance (km), FRV = Flag for reverse faulting earthquakes (1 for reverse and reverse/oblique earthquakes defined by rake angles between 30 and 150 degrees, 0 otherwise), FNM = Flag for normal faulting earthquakes (1 for normal

earthquakes defined by rake angles between -60 and -120 degrees, 0 otherwise), FAS = Flag for aftershocks (1 for aftershocks, 0 for main shocks, foreshocks, and swarms)

Table 1 Coefficient for maximum acceleration (PGA) Abrahamson and Silva (2008) [3]

c ₁	c ₄	a ₃	a ₄	n
6.75	4.5	0.265	-0.231	1.18
V _{LIN}	b	a ₁	a ₂	a ₈
865.1	-1.186	0.725	-0.968	0
a ₁₀	a ₁₂	V _{S30}	a ₁₃	a ₁₅
0.9485	-0.12	1100	-0.05	-0.405
a ₁₆	a ₁₇	a ₁₈		
0.65	0.6	-0.0067		

•Idriss (2008) [4]

This model estimated ground vibration by using the information in the database of the earthquake of NGA depends on data set soil types "Rock". This model is the simplest equations as shown in Eq. (7)

$$\ln[PSA(T)] = \alpha_1(T) + \alpha_2(T)M - [\beta_1(T) + \beta_2(T)M] \ln(R_{rup} + 10) + \gamma(T)R_{rup} + \varphi(T)F \quad (7)$$

Where: PSA (T) = pseudo-spectral acceleration, (PSA) for spectral periods of 0.01 sec, M = Moment magnitude, Rrup = Rupture distance (km), F = Refers to source mechanism designator with F = 0 for "strike slip/normal" events and F = 1 for "reverse" events;

Table 2 Coefficient for maximum acceleration (PGA) Idriss (2008) [4]

$\alpha_1(T)$	$\alpha_2(T)$	$\beta_1(T)$	$\beta_2(T)$	$\gamma(T)$
5.6362	-0.4104	2.9832	-0.2339	0.00047
$\varphi(T)$				
0.12				

Group 2 Stable Continental Region

•Toro et al. (1997) [5]

This model can be used for every move and format of hard rock (very hard to unweathered crystalline rock). Eq. (8) shown this model proposed parameter.

$$\ln(PGA) = c_1 + c_2(M - 6) + c_3(M - 6)^2 - c_4 \ln(R) - (c_4 - c_5) \max\left[\ln\left(\frac{8}{100}\right), 0\right] - c_6R \quad (8)$$

Where: $R = \sqrt{R_{jb}^2 + c_7^2}$

Table 3 Coefficient for maximum acceleration (PGA) Toro et al. (1997) [5]

c_1	c_2	c_3	c_4	C_5
2.20	0.81	0.00	1.27	1.16
C_6	C_7			
0.00210	9.30			

•Hwang and Huo (1997) [6]
The attenuation model of Hwang and Huo (1997) [6] was shown as following in Eq. (9)

$$\ln(Y_{BR}) = c_1 + c_2M + c_3 \ln[(\sqrt{R^2 + H^2}) + R_0(M)] + c_4\sqrt{R^2 + H^2} \quad (9)$$

Where: $R_0(M) = 0.06(e^{0.7M})$

Table 4 Coefficient for maximum acceleration (PGA) Hwang and Huo (1997) [6]

c_1	c_2	c_3	c_4
-2.904	0.926	-1.271	-0.00302

•Dahle et al. (1995) [7]
Dahle et al. (1995) [7] attenuation model was shown with less parameter in Eq. (10)

$$\ln(A) = c_1 + c_2M_w + c_3 \ln R + c_4R + c_5S \quad (10)$$

Where: $R = \sqrt{R_{rup}^2 + r_h^2}$

Table 5 Coefficient for maximum acceleration (PGA) Dahle et al. (1995) [7]

c_1	c_2	c_3	c_4	C_5
-1.579	0.554	-0.560	-0.0032	0.326
r_h				
6				

2.3 Method

From the field measurement data of earthquake at Chiang Rai with magnitude of 6.3 Richter scale and depth 7 km and distance from earthquake source about 110 km. The accelerometer has detected and monitored the value of PGA equal to 0.0190. The comparison between accelerometer data and each attenuation models was calculated based on PGA value. The PGA determination of attenuation models and field

accelerometer data was analyzed by mean of data measurements and their related parameters then the appropriate attenuation model was concluded for suitable PGA interpret of the upper northern of Thailand area.

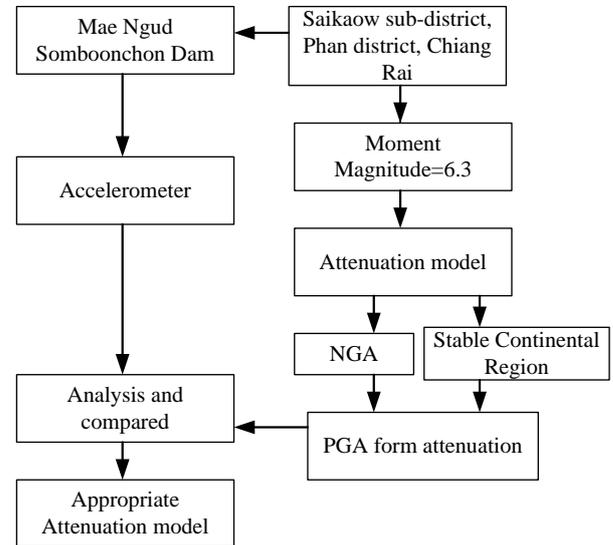


Fig.5 Methodology Flowchart

3. RESULTS AND DISCUSSIONS

The analysis of each attenuation model base on field accelerometer measuring data was performed. The area parameters of ZTOR which is the depth of 7 km, Rrup is more or less than 110 km from the epicenter to Mae Ngud Somboonchon Dam. The fault and strike slip types were selected base on each attenuation model. The value of maximum acceleration at surface (PGA) of attenuation models are summarized bellows,

- Abrahamson and Silva (2008) [3] PGA = 0.01779g
- Idriss (2008) [4] PGA = 0.01616 g
- Toro et al. (1997) [5] PGA = 0.02070 g
- Hwang and Huo (1997) [6] PGA = 0.03221 g
- Dahle et al. (1995) [7] PGA = 0.03481 g

Table 6 The PGA from attenuation models compared to field measurement data

Group	Attenuation Models	PGA(g)	%Error
NGA	Abrahamson	0.01779	6.38
	Idriss	0.01616	14.93
Stable	Toro	0.02070	8.94
Tectonic Region	Hwang	0.03221	69.50
	Dahle	0.03481	83.21

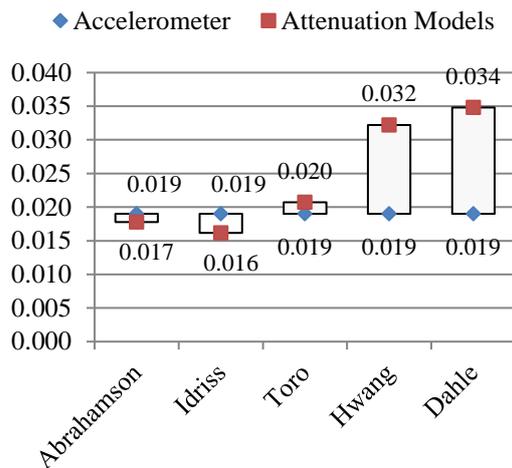


Fig.6 Calculated PGA of attenuation models compared to field measurement data

The results of this study, we conclude that the equation is the northern most is Abrahamson and Silva (2008) because of the factors used to calculate the rates for the other parameters, including the greater. The error of the equation of productivity has less however conclusion may not be as clear much may increase the comparison PGA into more like to collect data from gauging stations earthquake close to the basis or add equations into more will reduce error.

4. CONCLUSIONS

The results of this study shown that the most appropriated attenuation model base of field measurement data for upper northern part of Thailand area is Abrahamson and Silva (2008) [3]. This attenuation model is suitable because of the factors used to calculate and the rational of parameters was combined in various viewed. The percentage error of each model can be reduced if we have more field measurement data and also the earthquake source is closer distance. When the results of this attenuation model were compared to the reading of accelerometer, it was found that the Abrahamson and Silva (2008) [3] model was very close to the reading device in the X axis of 0.0191 g. The percentage error of 6.38% can be reduced by mean of energy consumption. The Abrahamson and Silva (2008) [3] model is most appropriate since this model is on NGA group which

developed all equation by adding various factors and consider.

5. ACKNOWLEDGEMENTS

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