CHAPTER I
INTRODUCTION

1.1 Background

Thailand is considered as a low seismicity country due in large part to the absence of large, damaging earthquakes in historical times. The country has experienced only some moderate earthquakes in the northern part and a few major earthquakes from nearby countries like Myanmar and South of China. Some of these were felt in Bangkok and the neighboring communities which directed researchers to investigate more on the potential risks from earthquakes of these regions.

A growing population in Bangkok calls for a need of a more reliable seismic design of structures. Distant earthquakes pose potential hazard to Bangkok due in large part to the capability of the underlying soil to amplify earthquake ground motions. Thus, it is imperative to employ an appropriate seismic zone factor in the analysis and design of buildings and other infrastructures. This is to ensure a safe and sound environment for the whole Thai community as well as for the large number of foreigners traveling around the area.

This research is an independent assessment as well as confirmation of the probable earthquake ground motions in Bangkok. Results of this study are critical factors in the formulation of Bangkok-specific seismic design criteria. As a fundamental step in seismic hazard analysis, a comprehensive evaluation of existing attenuation models is conducted for the main purpose of determining the most suitable model for the region. The possible earthquake ground motion that may induce a significant effect to the structures in the city is estimated by integrating as much information as possible to acquire a certain level of accuracy consistent with the available data.

1.2 Problem Statements

Regions of moderate to low seismicity are currently facing an intricate condition involving the prediction of probable seismic hazard. Paucity of strong motion records in these areas hampers earthquake ground motion estimation as well as the conduct of a comprehensive regression analysis of available data. While it is fortunate to have low hazard, the associated seismic risk due to occasional but large earthquakes still exists. For this reason, the need to adopt appropriate attenuation relations arises that is able to approximately represent the geological and seismological conditions of the area under consideration.

1.3 Research Objectives

This research intends to attain the following objectives:

1. To determine the most suitable attenuation model for Thailand
2. To provide a good estimate of the level of ground motion intensity in Bangkok

1.4 Scope of Study

In particular, this research covers the scope of work outlined below:

1. Collection of ground motion records and other relevant information from local agencies and institutions such as Meteorological Department of Thailand (TMD), Electricity Generating Authority of Thailand (EGAT), Department of Mineral Resources (DMR) and Asian Institute of Technology (AIT).
2. Analysis of existing attenuation models based on data used, suitable ranges and applicability and parameters involved in the equation.
3. Generation of attenuation curves and calibration of earthquake ground motion data to these plots to observe the trend and compare the recorded PGA data with the estimated ground motions of each model.
4. Ground motions estimation by considering the maximum probable earthquake magnitude generated by an active fault at a specified distance to Bangkok.

1.5 Literature Review

Bangkok is the capital city of the Kingdom of Thailand. Thailand is situated in the East of Andaman-Sumatran earthquake belt as part of Trans-Asiatic belt. Each time that major quakes transpired in such belts, it was always felt in Bangkok (Hwan, 1985).

Figure 1.1 Oblique view of Bangkok, Thailand

The city is a classic example of a low seismicity region. Its location is more than two hundred kilometers away from the nearest active fault in the western part of the country. In accordance to the zoning criterion of the U.S. Uniform Building Code (UBC), Bangkok is categorized under seismic zone 1 which is considered as low seismic risk zone (Padermkul, 1999).

In an effort to conduct seismic hazard assessment of Bangkok, a number of researches has been carried out to provide a plausible estimate of probable ground motions. This significant stage in the analysis uses an attenuation relation which is derived through the regression analysis of strong ground motion records. However, inadequacy of high amplitude accelerograph records in Thailand inhibits the development of an attenuation model specific for the country.

In dealing with regions of low seismicity, existing attenuation models developed using strong motion database from another region in a different tectonic setting are employed in the hazard analysis. It is assumed that such attenuation equation exhibits geological as well as seismological attributes that are comparable to the region under consideration.

In the seismic risk zoning conducted by Shrestha in 1987, several attenuation models are evaluated through the comparison of the computed peak ground acceleration (PGA) values with the actual measured accelerations recorded at Srinagarind Dam and Khao Laem Dam in April 1983 and July 1985. Among the selected attenuation relations, it was concluded that Esteva and Villaverde's (1973) model yields an estimate of PGA that is more consistent with the field records compared with other selected models such as those proposed by Katayama, Oliveira, McGuire and Watabe.

Lisantono (1994) used isoseismal maps to derive attenuation relations by applying the least-square technique. Two cases of attenuation models are formulated with and without the effect of site amplification factors. These derived equations are also compared with the similar set of existing attenuation models chosen by Shrestha (1987). To evaluate these attenuation models, the data obtained from Srinagarind and Khao Laem Dam were chosen as field records. Only seven acceleration data were available and these were used to evaluate the attenuation equations. It was observed that Esteva and Villaverde's (1973) model provides estimates that are more consistent with Lisantono's derived equations although the former predicted higher ground motions in the near field and lower ground motions in the far field.

Padermkul (1999) cited that Warnitchai and Sangarayakul (1998) adopted the models from the Eastern North America (ENA) in their seismic hazard investigation for Bangkok and Chiangmai. The appropriateness of the models is assessed by comparing the peak rock outcrop acceleration (PRA) computed using the attenuation relations with the PGA collected from historical earthquake records. As a result, predicted PRA values showed consistency with the recorded data.

To improve the reliability in assessing the appropriate attenuation model for Thailand, new attenuation models developed for Western North America (WNA), Europe (EU) and Central and Eastern North America (CENA) are evaluated by Warnitachai *et al.* in 2000. These models characterize the attenuation properties of shallow crustal earthquakes in stable continental regions and active tectonic regions. Empirical equations proposed by Abrahamson and Silva (1997), Campbell and Bozorgnia (1994), Sadigh et al. (1993) and Boore et al. (1997) comprise the WNA models. Attenuation relations formulated based on strong-motion data from Europe and Italy are also represented which include empirical relationships from Ambraseys and Bommer (1992) and Sabetta and Pugliese (1987). Attenuation equations for low seismicity regions like CENA are those developed by Toro and McGuire (1987), Atkinson and Boore (1995) and Hwang and Huo (1997), which used simulated ground motions in place of recorded data. In addition to these selected ground motion relations, Esteva's model was also incorporated in the analysis.

As part of result of this research, Figure 1.2 depicts the comparison of PRA attenuation curves for earthquakes of moment magnitudes (M_w) 7.2 and 8.0. WNA and EU models are applicable for short distances up to 100 km. Within this distance limit, it can be observed from the comparison that the PRA curves produced are similar. On the other hand, models formulated for stable continental regions like CENA generate curves with higher PRA values within a distance range of 10 to 200 km. It was also noted that Esteva's model is quite comparable with the CENA models.

Attenuation relationships based on estimates of PRA values from past earthquakes with epicenters located in Myanmar are represented by the thick curves. Based on these results, it was concluded that CENA and Esteva models best describe the regional attenuation properties such as the low attenuation rates of Bangkok.

The computer program Shake91 was employed in the process to evaluate the response of the underlying soil deposits in Bangkok to bedrock motions. To be able to conduct this site wave propagation analysis, a generalized soil profile developed by Ashford *et al.* in 2000 and requisite dynamic soil properties like shear wave velocity, mass density and correlation of strain dependent shear modulus and damping are collected. Shown in Figure 1.3 is the generalized Bangkok soil and shear wave velocity profiles utilized in this study. Since the surficial geologic setting at Bangkok appears qualitatively similar to the setting of Mexico City, it was mentioned that

Bangkok is susceptible to the same type of soil amplification of ground motions which caused much of the destruction during the September 19, 1985 Michoacan earthquake.

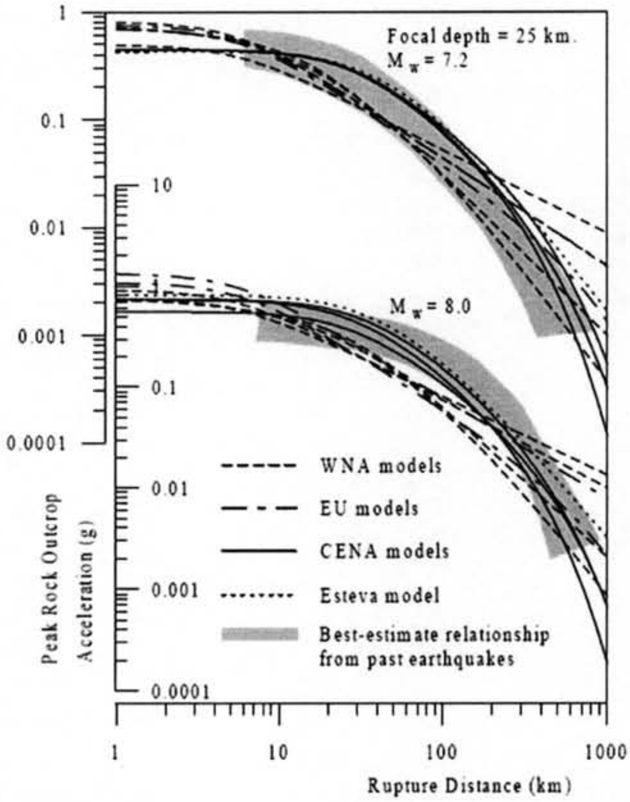

Figure 1.2 Comparison of attenuation relationships (Warnitchai *et al.*, 2000)

In one-dimensional site response analysis, several accelerograms with peak acceleration values ranging from 0.005 to 0.09 g were considered. These records were measured from rock sites for earthquake magnitude ranging from 7 to 8 which occurred within site-to-source distances of 80 to 350 km. These acceleration records represent the rock outcrop motions in Bangkok. To arrive at input rock outcrop motions values, records were scaled to different peak acceleration starting from 0.002 up to 0.075g. As an end result, amplification factor, which is defined as the ratio of PGA to PRA, is estimated. It was concluded that the surficial deposits of Bangkok soil may be capable of amplifying the earthquake ground motions about three to four times for strong input motions. Structures with natural periods between 0.5 to 1.5 seconds would most likely be affected if the maximum capable ground motion occurs in the region.

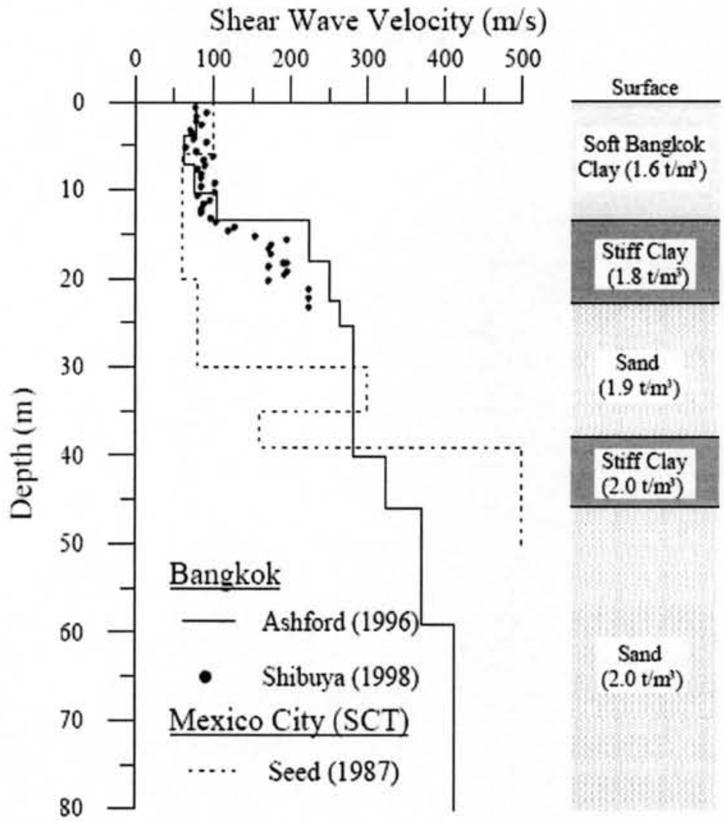

Figure 1.3 Generalized soil and shear wave velocity profiles (Ashford *et al.*, 2000)

Lukkunaprasit (2006) presented a brief account of earthquake-related events in Thailand. It was mentioned that buildings in Bangkok has to be designed for an appropriate seismic resistance in order to address the possible seismic hazard. Using the attenuation model proposed by Boore *et al.* (1997), a PGA on rock of about 2% g was estimated based on a magnitude 7.0 earthquake at the active fault nearest to Bangkok which is approximated to be 200 km away. Consequently, the amplification of ground motion due to the soft soil underneath the city is estimated to be 4 times the PGA on rock which results in a PGA on soil of 8% g.

As response to these imminent hazards, researchers have recognized the need to improve the design and construction of structures. In connection to this, the search for the most appropriate attenuation model for the region continues as the local ground motion records become more available. The present study particularly embarks upon the comprehensive assessment of these existing attenuation relationships to determine the most suitable model for Thailand. Once known, this could in turn lead to a better estimate of the probable ground motions that could pave the way in upgrading the existing design code.