THAILAND

- STATE OF SEISMIC RISK MITIGATION IN THAILAND

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1 INTRODUCTION

Earthquake hazards have been quite remote in the minds of Thai people until recently when they have experienced several earthquakes which, although moderate in the global norm, were major events for Thailand. On April 22, 1983, an earthquake, which registered 5.9 on the Richter scale, struck near a dam site about 200 kilometers from Bangkok, the capital of Thailand. The event was accompanied by several foreshocks and aftershocks. These earthquakes were later proved to be reservoir induced. The main tremor was felt all over the western part and most of the central part of the country. Five years later, on November 6, 1988, a large earthquake, of magnitude 7.3 on the Richter scale, hit the southern part of China near the Burmese border. Although the epicenter was more than 1,000 kilometers from Bangkok, the quake was felt by people in medium- and high-rise buildings. The persistence in effects is due to the fact that underlying Bangkok is deep soft alluvial which tends to amplify the motion of incoming seismic waves. The threat from earthquake was demonstrated again in the following year on September 29 and October 1 when several moderate earthquakes (5.3-5.4 Richter) hit the northern part of Thailand along the Burmese border. In the city of Chiang Mai, about 180 kilometers from the epicenter, the intensity of ground shaking was rated as VI on the Modified Mercalli scale.

2 SEISMIC DATA

The foregoing accounts are not the only events experienced by Thai people, but these are the most recent and have the most impact on the society. Figure 1 shows the locations of epicenters, tremors of which were felt in Thailand since 1912. Table 1 lists some information on such earthquake events (Prachuabb 1990).

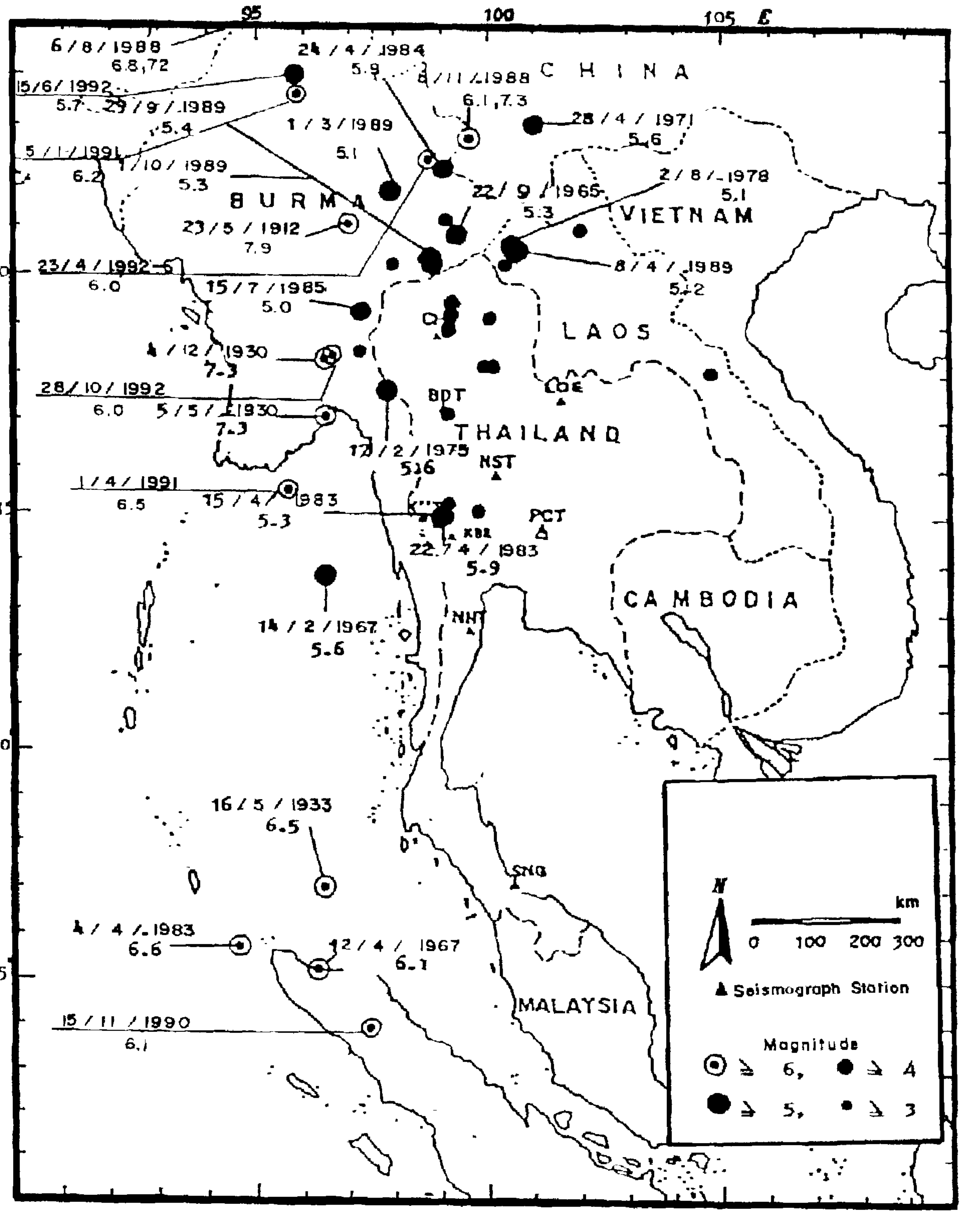

Figure 1: Location of epicenters with tremors felt in Thailand

TABLE 1: EARTHQUAKES FELT IN THAILAND* (MAGNITUDE 5.0 OR LARGER)

Day/Month/Year (Local Time)	Epicenter Lat(°N) Long(°E)	Magnitude (Richter)	Areas where tremor was felt (MM scale)
23 May 1912 (09:24)	Burma 21.0 97.0	7.9	Bangkok (IV)
5 May 1930 (20:46)	Burma 17.0 96.5	7.3	Northern and Central parts, Bangkok (V)
4 Dec. 1930 (01:52)	Burma 18.2 96.5	7.3	Northern and Central parts, Bangkok (V)
16 May 1933 (08:12)	Northern Sumatra Islands 7.0 96.5	6.5	Surat Thani, Stoon, Phangnga (V)
22 Sep. 1965 (18:25)	Burma 20.75 99.26	5.3	Chiang Mai, Chiang Rai, Lampang, Lamphun, Mae Hong Son (V)
14 Feb. 1967 (08.36)	Andaman Sea 13.7 96.5	5.6	Bangkok (IV)
12 Apr. 1967 (11:52)	Northern Sumatra Islands 5.16 96.31	6.1	Songkla, Stoon, Phuket (V)
28 Apr. 1971 (22:32)	Burma-China Border 22.98 101.02	5.6	Chiang Mai (V)
17 Feb. 1975 (10:18)	Ta Song Yang district, Tak 17.6 97.9	5.6	Northern and Central parts, (V-VI)
2 Aug. 1978 (14:46)	Thai-Laos Border 20.5 100.7	5.1	Chiang Rai (IV)
4 Apr. 1983 (16:24)	Northern Sumatra Islands 5.7 94.7	6.6	Bangkok (IV)
15 Apr. 1983 (16:24)	Si Sawat District, Kanchanaburi 14.95 99.14	5.3	Kanchanaburi and Bangkok
22 Apr. 1983 (07:38)	Si Sawat District, Kanchanaburi 14.95 99.07	5.9	Western, Northern and Central parts (V-VII)
22 Apr. 1983 (10:22)	Si Sawat District, Kanchanaburi 14.96 99.06	5.2	Kanchanaburi and Bangkok
24 Apr. 1984 (05:30)	Burma-China Border 22.1 99.1	5.9	Chiang Rai (IV)
15 July 1985 (17:39)	Burma 19.2 97.3	5.0	Chiang Mai (IV)
6 Aug. 1988 (07:36)	Burma-India Border 25.1 95.1	6.8 M_b 7.2 M_s	Bangkok (III) (in high rise buildings)
6 Nov. 1988 (20:03)	Burma-China 22.79 99.61	6.1 M_b 7.3 M_s	Chiang Rai, Chiang Mai & Bangkok (in high-rise buildings) (V-VI)
1 Mar. 1989 (10:25)	Laos 21.73 97.94	5.1 M_l	Upper northern part (V)
8 Apr 1989 (04:40)	Laos 20.58 100.48	5.2	Chiang Rai (V)
27 Aug. 1989 (22:21)	Burma-Thai Border 20.30 98.77	4.4 M_b 5.0 M_l	Upper northern part (V)
29 Sep 1989 (04:52)	Burma-Thai Border 20.29 98.77	5.4 M_b 5.5 M_l	Upper northern part (VI)
1 Oct. 1989 (01:19)	Burma-Thai Border 20.27 98.85	5.3 M_b 6.0 M_l	Upper northern part; Minor damage in non-structural brick walls in some taller buildings (VI)
9 Jan. 1990 (22:35)	Andaman sea 11.59 95.02	5.2 M_b	Ranong
15 Nov. 1990 (09:34)	Northern Sumatra 3.91 97.46	6.1 M_b	Phuket, Songkla and Bangkok (in high-rise building)
5 Jan. 1991 (21:57)	Burma 23.61 95.90	6.2 M_b	Northern part and Bangkok (in high-rise buildings)
1 April 1991 (10:53)	Burma 15.65 95.69	6.5 M_b	Bangkok (in high-rise buildings)
12 June 1991 (10.05)	Andaman sea 14.85 96.31	5.0 M_b	Bangkok (in some high-rise buildings)
23 April 1992 (21.18)	Burma 22.34 98.84	6.0 M_l	Chiang Rai, Chiang Mai & Phayao
15 June 1992 (09:48)	Burma 23.98 95.89	5.7 M_b	Bangkok (in high-rise buildings)
28 Oct. 1992 (14:02)	Burma 18.3 96.8	6.0 M_l	Chiang Rai, Chiang Mai, Mae Hong Son & Bangkok (in high-rise buildings)

* Compiled by Sumalee Prachuab, Geophysical Sub-Division, Meteorological Department

3 STRATEGIES IMPLEMENTED TO MITIGATE SEISMIC RISK

Since the 1983 earthquake, public concern for the safety of buildings. has increased because structures in Thailand normally have not been designed for seismic effects, although these (the higher buildings) are generally designed for wind loading in accordance with the existing building code of Thailand. The 1983 earthquake saw the following developments as a consequence:

(1) Drafting of the first seismic code: The most effective means of seismic risk mitigation is to build structures strong and ductile enough to absorb induced motion. A subcommittee under the national committee responsible for building regulations of Thailand was thus set up to draft the first seismic resistant building design code for Thailand. Due to lack of data, essentially the UBC 1982 edition was followed in drafting the seismic code for Thailand.

(2) Establishment of the National Earthquake Committee of Thailand: The Committee was formed in September 1985 with the endorsement of the cabinet. The main tasks of the Committee are:

- To coordinate with domestic and/or international associations, organizations or authorities dealing with earthquake activities for exchange of knowledge, opinion and data,
- To promote study and research on earthquake related subjects,
- To disseminate knowledge on seismic risk mitigation to the public,
- To propose measures and strategies for seismic risk mitigation.

The Committee is composed of representatives from government departments as well as private institutes, which may be directly or indirectly involved in seismic risk mitigation. The Meteorological Department of Thailand acts as its Secretariat.

(3) Cooperation of the Earthquake Engineering and Vibration Research Laboratory at Chulalongkorn University (CU-EVR) and the Department of Public Works, the Interior Ministry: Established in 1986, CU-EVR is aimed at conducting research related to seismic hazard and seismic resistant design of buildings in Thailand as well as vibration problems due to other sources such as wind and traffic. In 1991, CU-EVR, in a joint effort with the Department of Public Works, set up a comprehensive seismic monitoring system for two buildings in Bangkok. The program will be extended to large cities in more seismic prone regions in the northern and western parts of Thailand.

(4) Collaboration of the Department of Mineral Resources (DMR) and the Electricity Generating Authority of Thailand (EGAT): The cooperation, which began in 1989, involves personnel from DMR and EGAT to embark on a program of study on geology, earthquake, and mineral resources of the Nam Yuam River Basin project in the Mae Sariang District, Mae Hong Son Province.

The National Earthquake Committee, through the main contribution of Committee Chairman Dr. S. Chandrangsu and Sr. Lt. S. Yensuang (then Director of Studies and Research Division, Meteorological Department), drafted six work plans which can be regarded as the seismic risk mitigation master plan for the Kingdom. Six subcommittees were formed to implement the work plans, which are:

- Establishment of seismic zoning map and seismic risk map,
- Study on site amplification and dynamic response of structures,
- Study on attenuation of ground acceleration,
- Public relations and organization of seminars on earthquake related subjects,
- Development of measures for seismic risk mitigation,
- Study on active faults.

It can be observed that the National Earthquake Committee placed emphasis on investigation and research work, realizing that data and research findings related to seismology and earthquake engineering of the country, which are scarce, are essential for a meaningful formulation of an appropriate seismic risk mitigation master plan.

4 SEISMIC ZONING MAP

Chandrangsu (1986), in his capacity as chairman of the national seismic code drafting subcommittee, proposed a seismic zoning map (Figure 2) for use in connection with the first seismic code of Thailand. The country is divided into three zones, viz. zone 0 corresponding to zero seismicity; zone 1 corresponding to intensity V-VI Modified Mercalli (MM) scale; and zone 2 to VI-VII MM scale. This map was subsequently modified to fit the provincial boundaries in Thailand (Figure 3). It is interesting to note that a different intensity map (Figure 4) proposed by Nutalaya (1985) shows slightly higher intensity in certain regions than the one by Chandrangsu. As noted previously, Subcommittee 1 of the National Earthquake Committee is responsible for establishing a better seismic zoning map for Thailand.

5 ACTIVE FAULTS

The destructive Andaman-Sumatra Fault to the west of the country and the Sagaing Fault in east-central Burma basin to the northwest of Thailand are a few hundred kilometers from the nearest cities of the Kingdom. Nutalaya et al. (1985) described twelve seismic source zones in Thailand, Indochina and part of Burma and China. Nine major fault systems (Figure 5) have been identified in Thailand (Nutalaya 1990). However, their potential hazard is still a subject for investigation. Efforts have been ongoing toward this aspect (Poobrasert, 1992). During the period 1986-1989 the Department of Mineral Resources undertook the IGCP Project of Regional Crustal Stability and Geological Hazards to assess regional crustal stability and seismic activities and the development of monitoring, protection and precautionary measures against geological hazards. Recent preliminary study by means of thermoluminescent dating technique indicates that the few major fault zones (Thoen Fault, Mae Sariang-Mae Hong Son Fault and Moei-Uthai Thani Fault) in the northern and western parts of Thailand could be classified as potentially active ones, with faulting activities being dated back as far as 160,000 to 3,000,000 years (Minutes of

Meeting, Subcommittee 6, National Earthquake Committee of Thailand, 1992).

A SEISMIC ZONING MAP FOR THAILAND AND NEIGHBOURING REGIONS

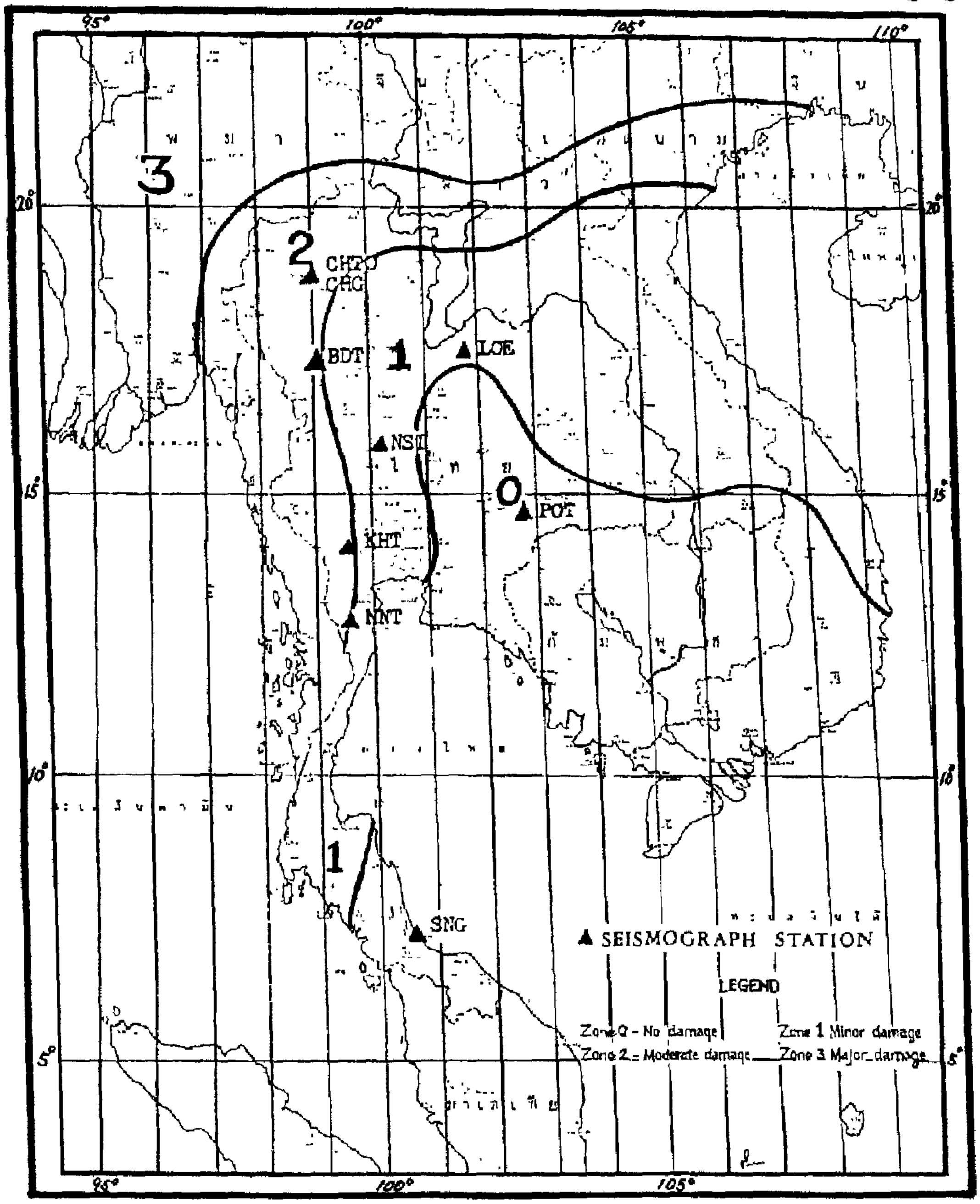

Figure 2: Proposed seismic zoning map (Chandrangsu, 1986)

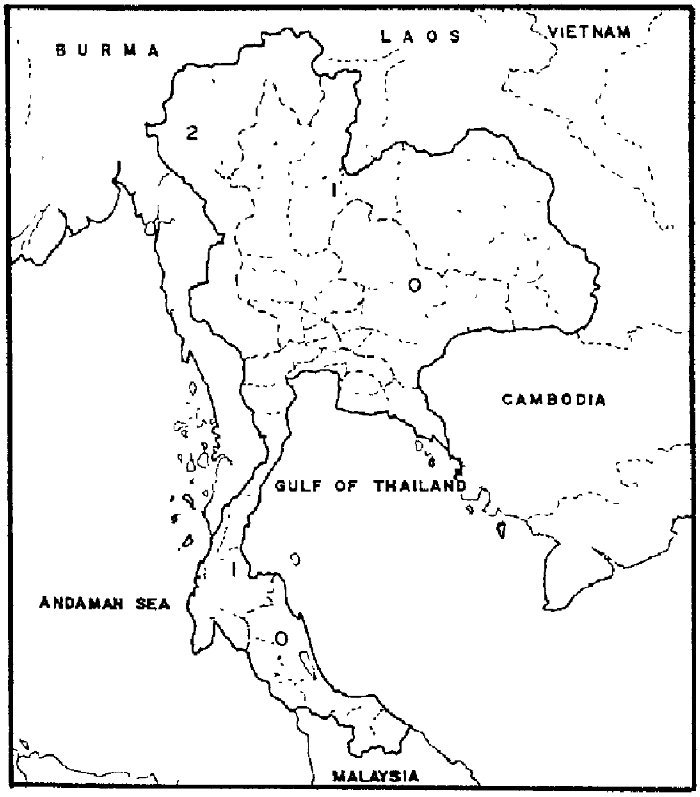

Figure 3: Adopted seismic zoning map (Yensuang, 1990)

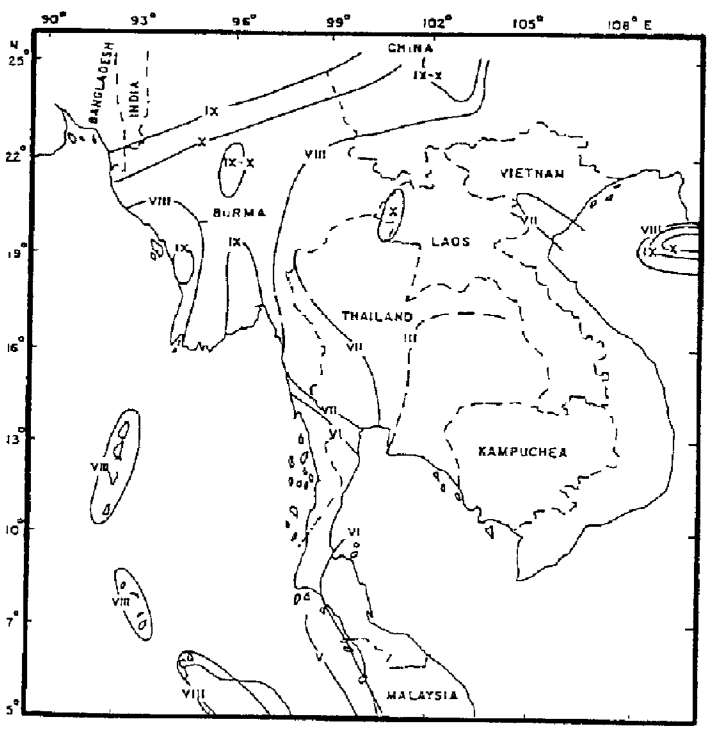

Figure 4: Intensity map in Thailand and neighboring countries (Nutalaya, et al., 1985)

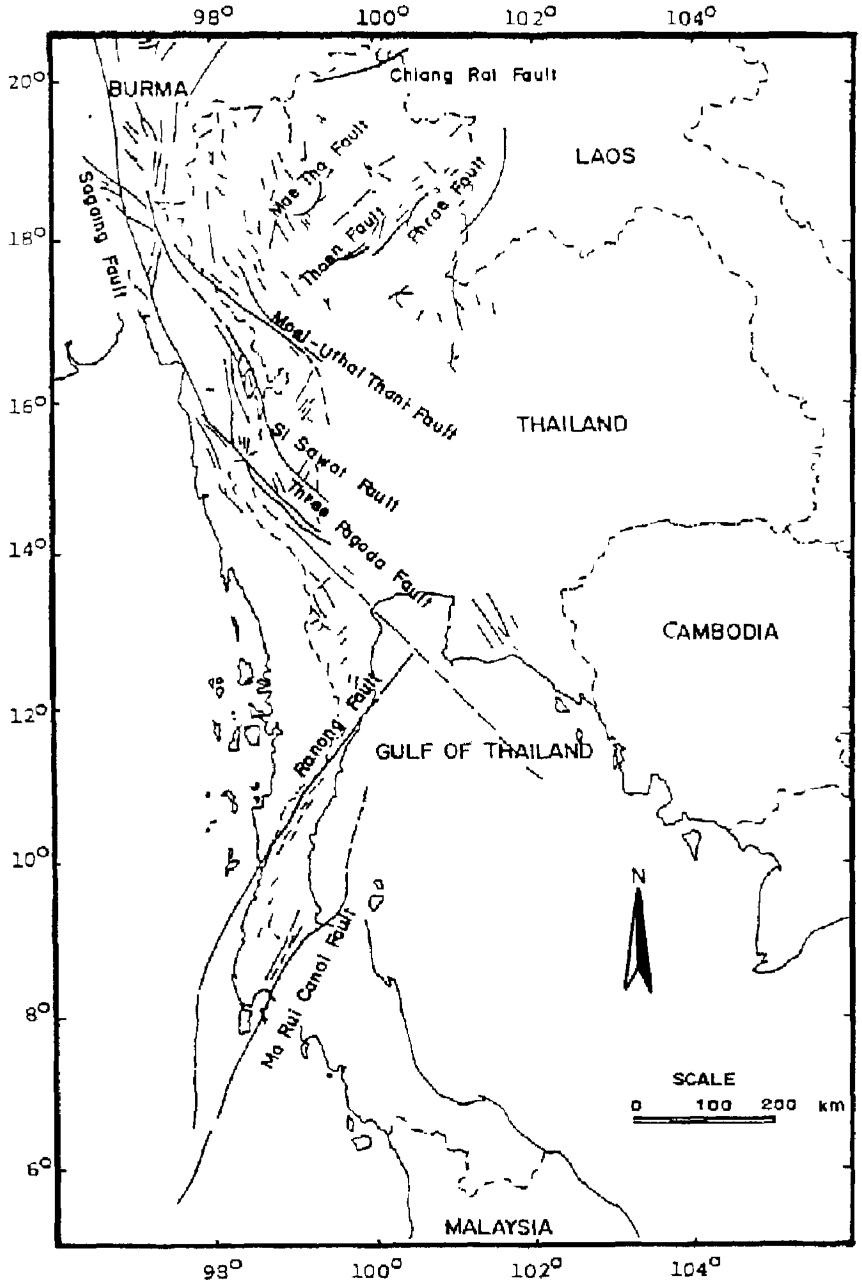

Figure 5: Major active fault zones in Thailand (Nutalaya, et al., 1985)

6 SEISMIC MONITORING FACILITIES

6.1 Seismograph stations

In 1963, the Meteorological Department of Thailand set up the first seismograph station in Chiang Mai in the northern part of Thailand, with the support and assistance of the United States Government. At present, the Meteorological Department operates 14 seismographs (2 IRIS, 4WWSSN, 8 SPS-1) in 9 seismograph stations nationwide.

6.2 Strong motion accelerographs

Under work plan 3, 10 analog type strong motion accelerographs (Kinemetrics SMA-1's) were installed along the northern and western parts of Thailand. Another 5 SMA-1's were scattered around Bangkok Metropolis. These are intended to monitor the seismic waves traveling from the more seismically active regions to Bangkok, with an aim to study the attenuation of the waves through the distance.

The Electricity Generating Authority of Thailand which owns hydroelectric power plants in Thailand also installed a dozen or so SMA-1's at major dam sites (viz. Bhumibol, Srinagarind, Khao Laem and Rachaprabha dams). In addition, EGAT possesses several portable strong motion accelerographs.

6.3 Monitoring of Buildings

Since 1982, the Earthquake Engineering and Vibration Research Laboratory of Chulalongkorn University, in collaboration with the Department of Public Works, has been monitoring two buildings in Bangkok for seismic response. The task is part of work plan 2 of the National Earthquake Committee of Thailand. One building, 6 stories high, is located in the campus. The other one, Baiyoke Tower, which is 149 m high, is situated some 5 kilometers away in a downtown area. Two triaxial and 12 uniaxial low frequency Kinemetrics accelerometers and one 100-m deep down-hole accelerograph were installed. Signals from accelerographs, recorded in digital form in five recorders, can be retrieved via a laptop computer. In addition, data from the Baiyoke Tower can be transmitted off-line, via telephone lines, to CU-EVR for data processing and analyses. Data obtained would be analyzed to assess the equivalent seismic forces for use in designing buildings with economy and safety. The ultimate goal is to obtain improved seismic design code values to be promulgated in the building regulations.

7 SEISMIC CODE

The first draft code was unofficially unveiled around 1985. It was also presented in a workshop organized by the National Earthquake Committee of Thailand and the Southeast Asia Association of Seismology and Earthquake Engineering (Chandrangsu 1986). This first draft code received criticism and faced considerable resistance from some engineers and developers involved in the construction industry who feared that code implementation might produce significant extra building costs. This merely arises from the misconception that earthquake resistant design would terribly escalate the cost of construction, which is not true for low seismicity regions. Academicians also questioned the appropriateness of the numerical values of some parameters in the draft code, because of the paucity of data and relevant research work concerning the seismicity of the country.

Based on evidence derived from the earthquake events of the past few decades, and on recent studies (Bergado et al., 1986; Lukkunaprasit, 1989; Lukkunaprasit, 1990), a new seismic resistant design code has been drafted with more realistic seismic zone coefficients. The new code realizes socioeconomic factors, as well as the relatively low seismicity of most of the country together with the fact that virtually no structural damage was caused by past earthquakes to modern buildings. The seismic design code subcommittee decided to make the code simple and easy to use since most engineers are not familiar with the seismic resistant design of buildings. The draft code has gone through lengthy official procedures. It is very likely that the seismic code will be put into law in the near future.

8 PUBLIC AWARENESS AND PUBLIC RELATIONS

As in many countries with low seismicity, public awareness is widely stimulated every time some tremor is felt, and then it dies down as quiescence restores. Nevertheless, allocation of budget by the government for the activities of the National Earthquake Committee has been continued for several years since 1989, thanks to the cooperation of the Budget Bureau and the good planning of the National Earthquake Committee to set up the seismic risk mitigation package for the country.

Public awareness and public relations have been exercised in various ways:

a) The mass media, through newspapers, radio and television broadcasting, have been effective in spreading news, facts and opinions on relevant matters.

b) Seminars, workshops, round-table talks and exhibitions have been organized from time to time to disseminate facts and knowledge on earthquake related subjects to the public. Involved in these activities are educational institutes, government departments and state enterprises as well as private sectors. The National Earthquake Committee of Thailand, jointly with Southeast Asia Association of Seismology and Earthquake Engineering, held the first workshop of its kind in Thailand in 1986 on Earthquake Engineering and Hazard Mitigation. The particular keen contribution of the Meteorological Department is worth mentioning. It has sent its officials to be guest speakers at more than 40 events nationwide.

c) Publication of booklets, leaflets and the like to educate the public in easy-to-read language. Again, the Meteorological Department has been the main contributor. Some of the titles published (in Thai) are:

  - Interesting facts about earthquakes
  - Summary on nature of earthquake in Thailand
  - Earthquake data for design and constructions of buildings, etc.

In addition, an interesting poster on preparedness and seismic risk mitigation was also printed for wide circulation to the public.

9 SEISMIC RISK MITIGATION WORK PLAN

In October 1990, the Interior Minister, in his capacity as chairman of the national committee for disaster mitigation, promulgated the seismic risk mitigation work plan for the country. The work plan, in essence, is an extension of the existing mitigation plan already under the responsibility of the National Public Disaster Prevention Directorate. Existing structure of the public disaster mitigation strategic plan is adopted, with the Regional Public Disaster Prevention Directorates overseeing the regional command and the Provincial Public Disaster Prevention Directorates in charge of mitigation actions in the provincial level. Under the control of each Provincial Public Disaster Prevention Directorate are units for hazard warning, rescue, relief, social welfare and peacekeeping. Lines of communication in the provincial, regional and national levels are also set up.

10 URGENT NEED

For a low seismicity region like Thailand, the first question that naturally arises is how big the most credible earthquake could be created by the potentially active faults in Thailand. Hazard assessment based on past earthquake records and probability theories cannot give the ultimate answers. Geological and seismological studies definitely are the key to solve the problem. Thailand is in urgent need of expertise and technology transfer for such investigations.

11 HELP FROM WSSI

Research work on seismology and earthquake engineering in Thailand is still in its infancy. Guidance and advice from a few experts from WSSI would be most helpful. Technology transfer is requested in the following areas:

- Investigation on active faults and their potential hazard
- Methodology for the establishment of seismic risk map
- Analyses of time history earthquake records from seismic monitoring systems to estimate seismic forces induced in buildings.

The problems cited are common to many countries, and input from WSSI can be offered to them in a single workshop, for instance, so that a unified approach is employed by each country. This would facilitate exchange and interpretation of information among countries.

12 CONTRIBUTION TOWARD SAFE AND ECONOMICAL DESIGN AND CONSTRUCTION OF BUILDINGS

Through concerted efforts of WSSI and Thailand (and possibly other countries with similar seismicity), data and research findings would be valuable for the advancement of earthquake engineering in low to moderate seismicity regions, with the ultimate goal of setting up appropriate building codes and construction practice for achieving safe and economical buildings for people.

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