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PRELIMINARY SURVEY
ON
PRESENT STATUS AND SCOPE OF SEISMOLOGY
AND
EARTHQUAKE ENGINEERING IN THE UNION OF BURMA

May, 1971

Japanese Mission on Seismology and Earthquake Engineering
under COLOMBO Plan for Technical Co-operation
in South and South-East Asia

Overseas Technical Cooperation Agency

PRESENT STATUS AND SCOPE OF SEISMOLOGY AND EARTHQUAKE ENGINEERING IN THE UNION OF BURMA

REPORT ON PRELIMINARY SURVEY
OF
PRESENT STATUS AND SCOPE
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SEISMOLOGY AND EARTHQUAKE ENGINEERING
IN THE
UNION OF BURMA

Compiled by

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October, 1971

Preface

The Government of Japan, in responce to the request of the Government of Union of Burma, decided to carry out a preliminary study on Earthquake problems in Burma, and entrusted this task to the Overseas Technical Cooperation Agency (OTCA) which is an executing agency of the Government of Japan.

OTCA organized a study team of 4 experts headed by Prof. Shunichiro Omote, Acting Director, International institute of seismology and Earthquake Engineering and dispatched it to Burma in January, 1971.

The study team stayed there for 2 weeks and successfully completed the field study including discussion with the Authorities concerned, and collection of data with the whole hearted cooperation from the Government of Union of Burma and others.

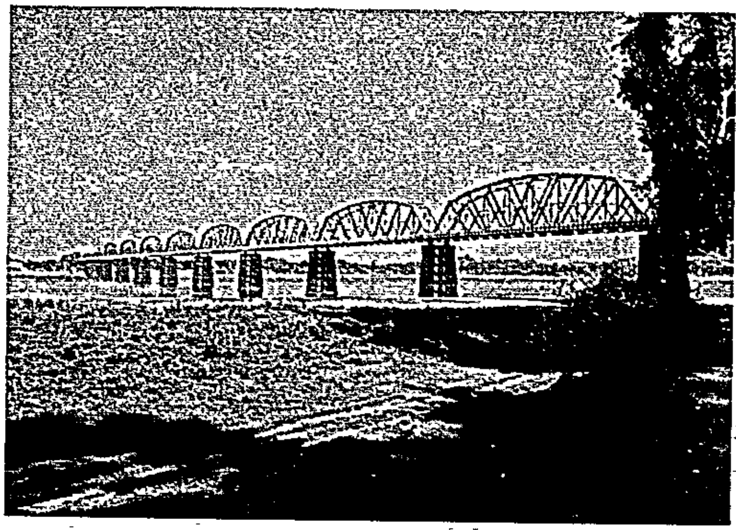
After its return to Japan, the team made further studies on data and information, and the results were hereby compiled into the present report.

Finally, on behalf of OTCA, I wish to take this opportunity to express my sincere gratitude for the Generous Cooperation and assistance extended to the team during its stay by the Government of Burma.

May, 1971.

K. Tatsuke

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency
Tokyo, Japan



Photograph 2.2.1
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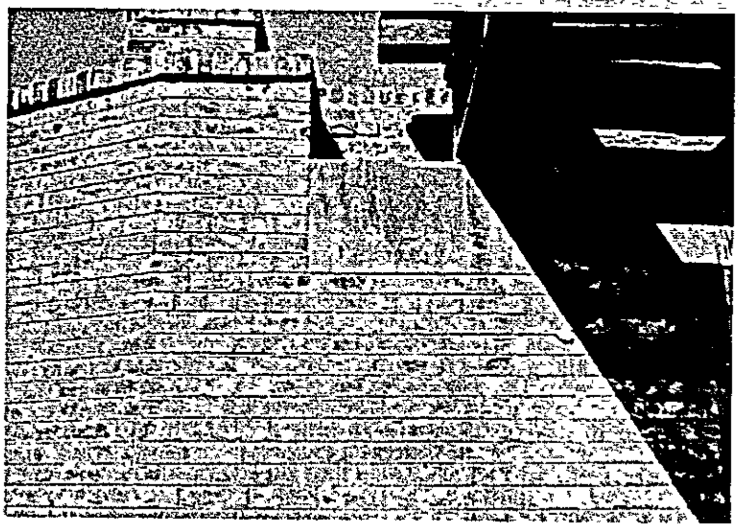

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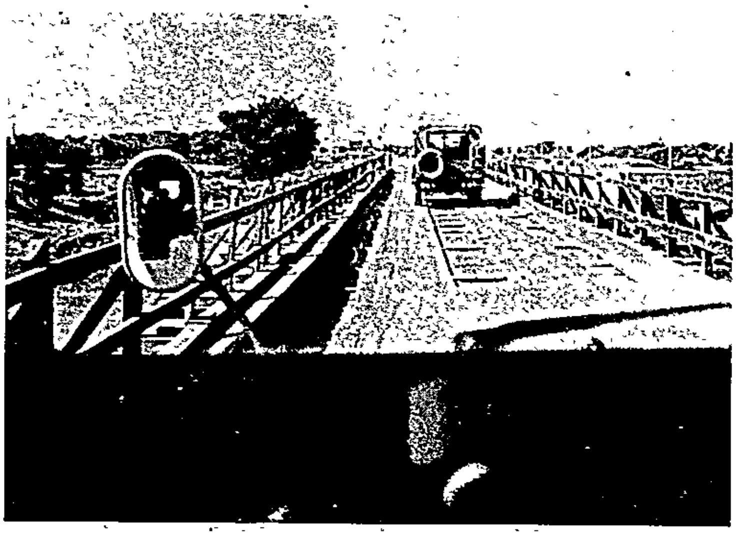

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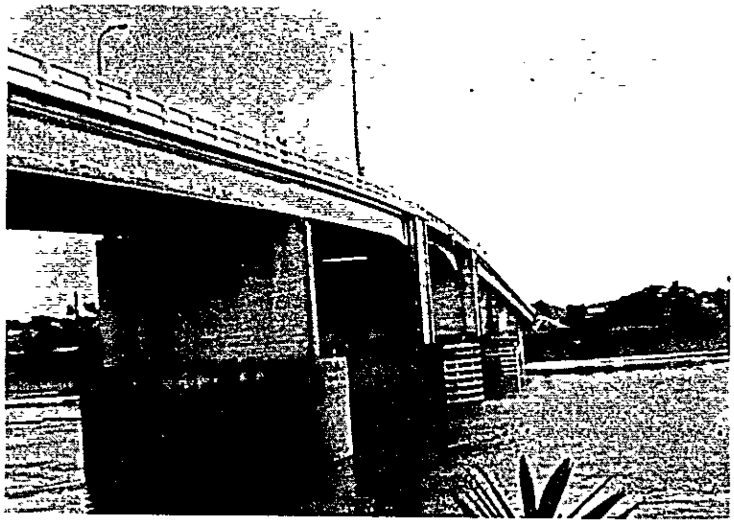

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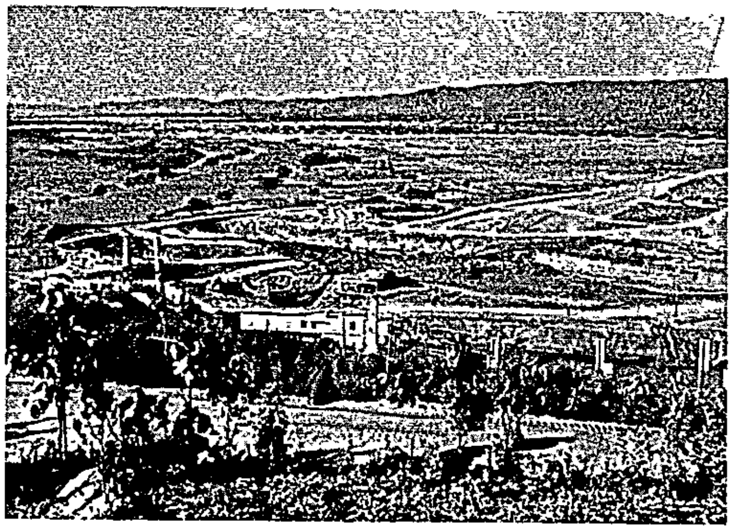

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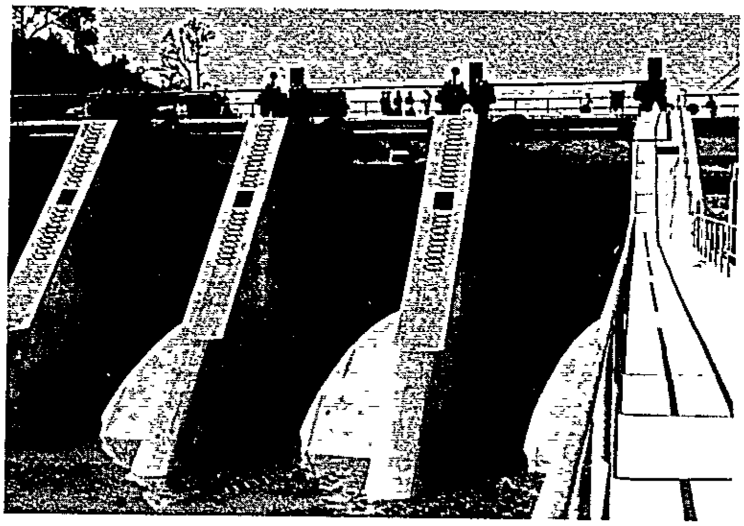

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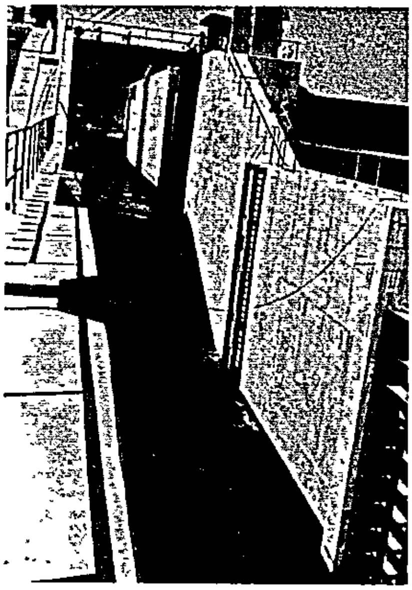

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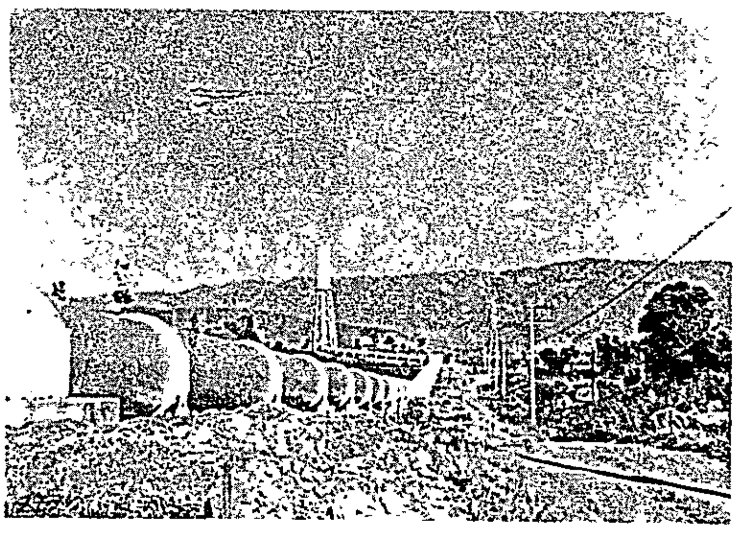

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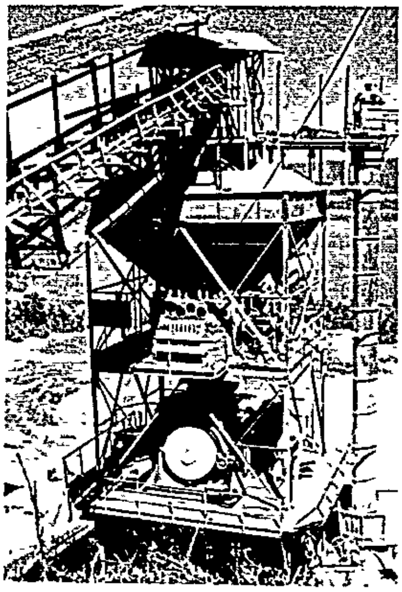

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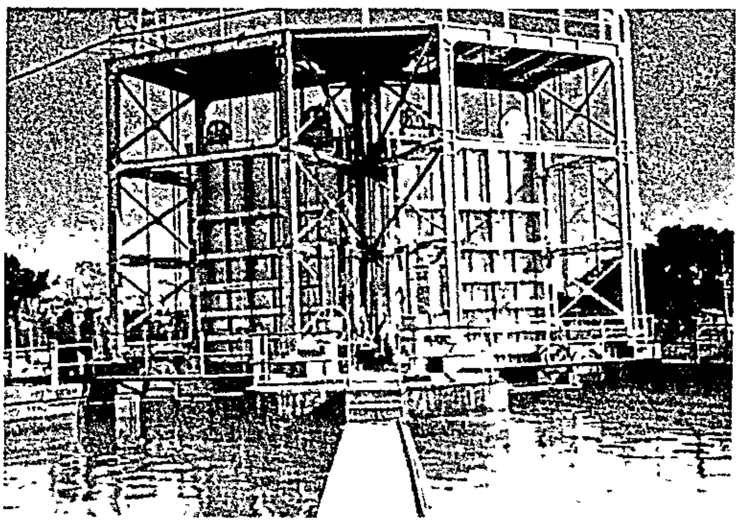

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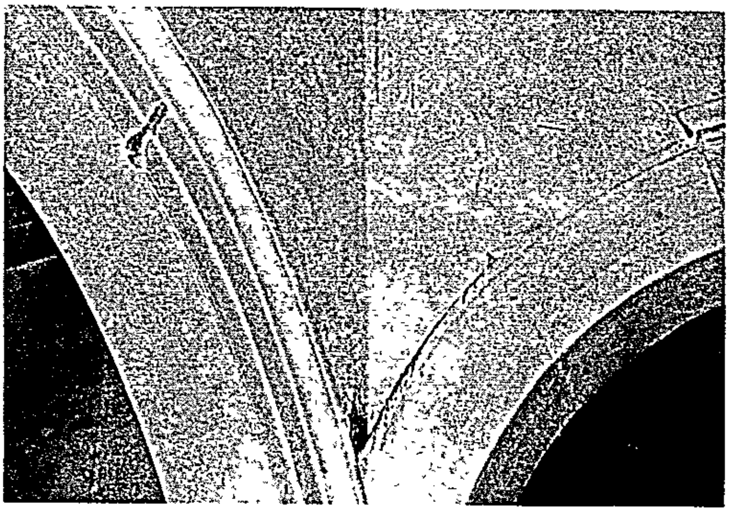
Outside View of State House



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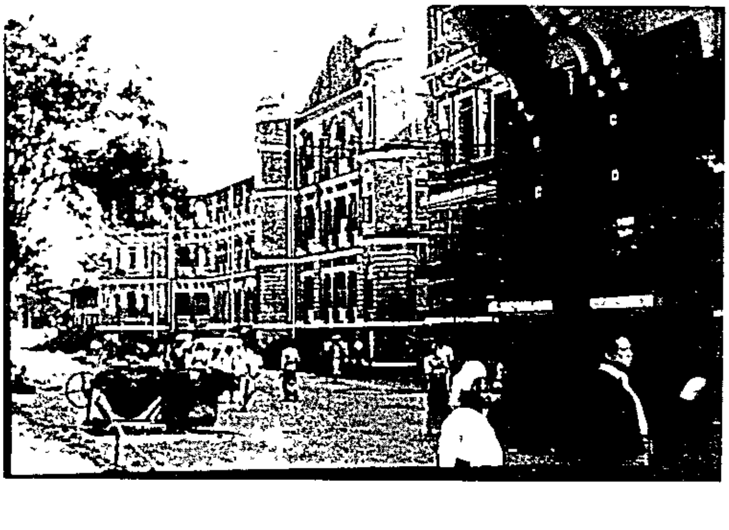
Inside View of State House



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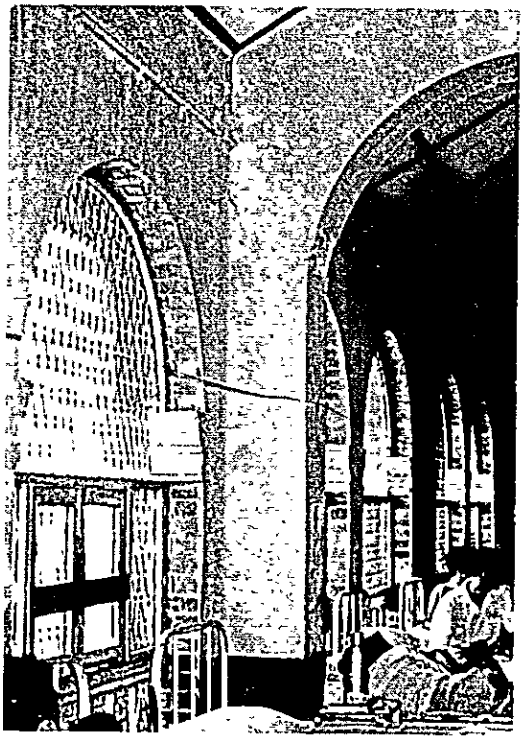

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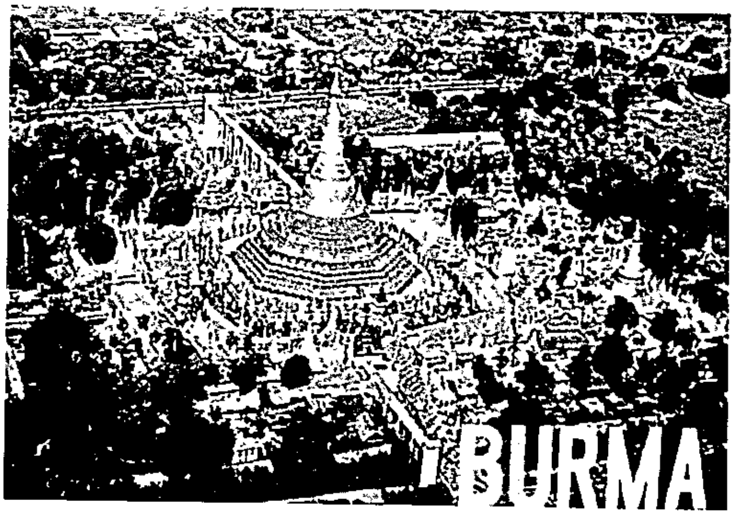

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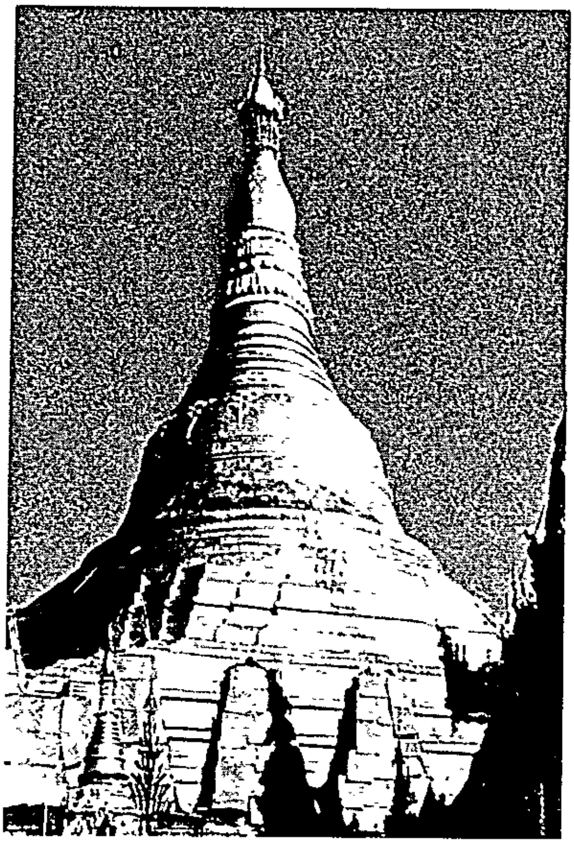

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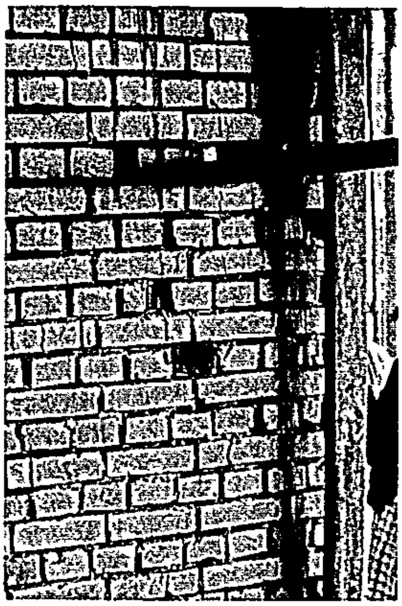

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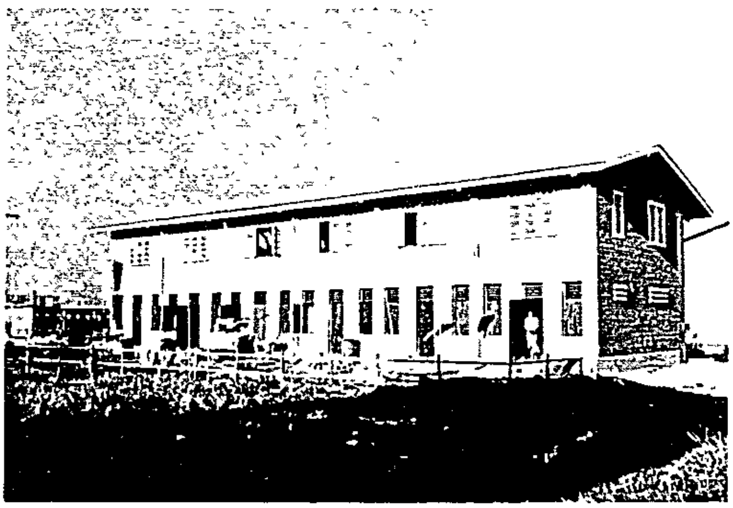

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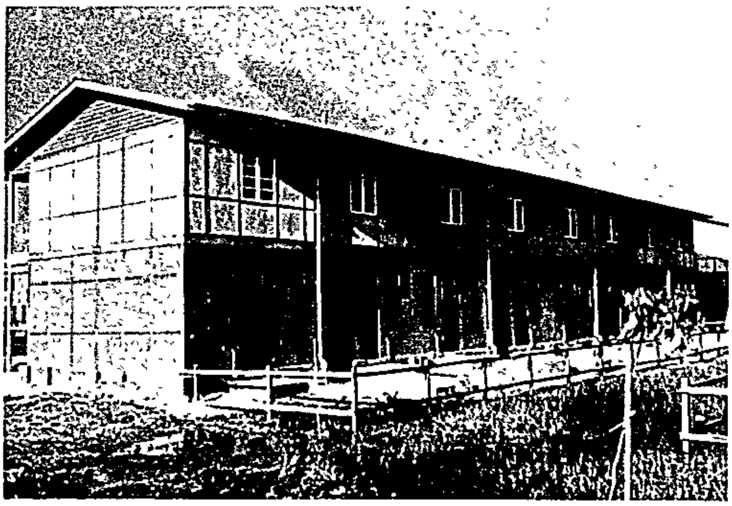

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Brick-nogging Apartment
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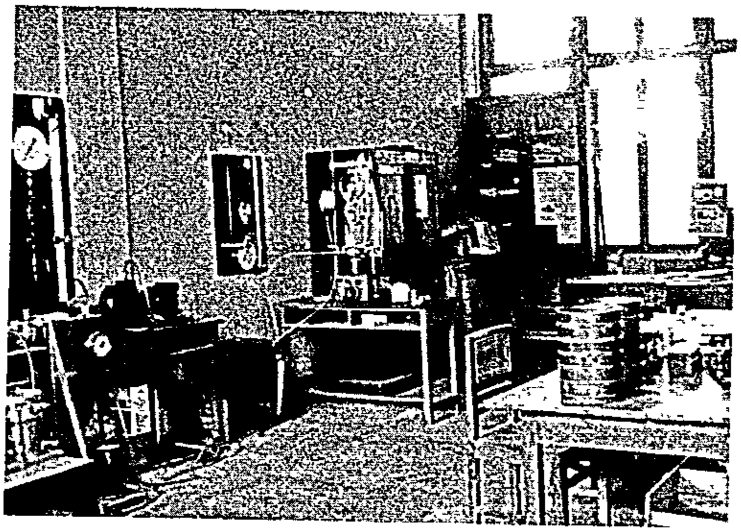

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Contents

1. Introduction

1.1 Objective of the Mission

An earthquake shook the area of Rangoon, the Capital of the Union of Burma on September 9, 1970, causing damage to the golden rod at the top part of the most respected pagoda of the Shwe Dagon as well as to several buildings including the State House of His Excellency Mr. Ne Win, the Chairman of the Revolutional Council of the Union of Burma, though it was an old historical brick building built in the period of the British reign.

Impressed with this earthquake and weighed with several other earthquakes of the slighter intensity which were also felt in the same area successively, the Government of the Union of Burma extended a request to the Government of Japan for sending a Mission composed of well qualified experts on seismology and earthquake engineering so that the scientific and technical level of Burma in the field of seismology and earthquake engineering could be improved quite urgently.

The first request of the Burmese Government was to send experts from Japan who can extend survices for longer period, say, one-two years, by which such materialized fruits as the drafting of earthquake resistant design code for building and civil engineering structures, the presentation of guide line for building constructions, the construction of seismic zoning map of Burma, etc., could be born urgently.

Carefull and friendly examination on the request raised by the Government of Burma was made by the Japanese authorities concerned which made it clear that, currently, we have too small informations on the present status on seismology and earthquake engineering in Burma to send a full scale team of experts in the above field, so it has come out to send firstly a Preliminary Survey Mission of short term duration for carrying out thorough investigation on the present status of Burma in these fields together with the deep insight into the right request of the local experts on these subjects opening the way by which the long term cooperation of Japan could be extended to Burma most effectively.

Upon the hearty acceptance of the Government of Burma on the above view of Japanese authorities it was agreed upon between the two parties to send firstly a Preliminary Survey Mission composed by four experts in the short period of two weeks.

The main objectives of the present Mission were (1) to investigate the present status of the seismological observation works in Burma and to find the way for improving the station networks and seismology studies, (2) to investigate the present status on the design and construction works on houses, buildings and civil engineering structures then to give partinent advices for establishing code and regulations for earthquake resistant design, (3) to find the way by which the level of the field engineering in these field could be improved urgently, (4) to give suggestions for the training of young researchers and technical people in the advanced countries, (5) to enforce the curricula in the universities and institutions in the field of seismology and earthquake engineering.

The items above mentioned are representing the immediate objectives of the present Mission which was send to Burma in a capacity of a technical cooperation Mission of the Overseas Technical Corporation Agency of Japan. However, fruits of the technical cooperation to Burma in the field of seismology and earthquake engineering can not be born if the continued cooperation should not be extended to Burma following the present Mission. Upon such considerations in preparing the present report, the Mission undertook to give descriptions covering somewhat rather wider scope including the general situation of Burma, in the hope to be of good use in providing helpfull informations for the future experts of the Technical Cooperation Mission on seismology and earthquake engineering to be sent to Burma after this Mission for extending long term services.

1.2 Members of the Mission

The composition of the Japanese Mission to Burma on Seismology and Earthquake Engineering under Colombo Plan for Technical Cooperation in South and South-East Asia was as follows:

Chief Prof. Syun'ichiro OMOTE,	International Institute of Seismology and Earthquake Engineering, Building Research Institute	General
Member Dr. Eiichi KURIBAYASHI,	Public Works Research Institute, Ministry of Construction	Civil Engineering structures
Member Dr. Masaji ICHIKAWA,	Meteorological Research Institute, Japan Meteorological Agency	Seismology
Member Dr. Tsuneo OKADA,	Institute of Industrial Science, University of Tokyo	Building construction engineering

1.3 Itinerary of the Mission

13th (Wed.)	19.30	Leave Tokyo (PA 001)
14th (Thurs.)	15.00	Arrive Rangoon (UBA 222)
	16.30	Visit to Embassy of Japan
15th (Fri.)	9.30	Call on Col. Htin Kyaw, secretary and Lt. Col. Soe Tin, Additional secretary, Ministry of Public Works and Housing
	10.30	Rearrangement of proposed itinerary of the mission
	12.00	Call on U Chein Hai, Deputy secretary, Ministry of National Planning
	12.30	Luncheon invited by Col. Htin Kaw and Lt. Col. Soe Tin
	14.30	Visit to U Tun Yin, Director General of Burma Meteorological Department
		Discussion on seismicity and observation networks in Burma and inspection of Kaba-aye Seismological Observatory

16th (Sat.)	9.30	Visit to U Ko Ko, Director of Construction Corporation Discussion with engineers and scientists of Ministries concerned and university staffs on seismology and earthquake engineering
	14.00	Visit to construction sites of U Wisara Housing Project and Chomery 34th st. apartment house, Thaketa bridge and construction site of Thuwuna Satellite town
17th (Sun.)	8.00	Visit to Shwe Dagon Pagoda and Rangoon zoo
18th (Mon.)	6.30	Leave Rangoon (UBA)
	9.00	Arrive Mandalay
	11.00	Visit to Mandalay Seismological Station
	12.00	Visit to U Hla Shwe, Rector of Mandalay Art and Science University Discussion with Prof. U Thet Paw, Dr. Win Shwe and their colleagues on geology in Burma partially in the Mandalay district
	15.30	Visit to Daw Tin Hla, Librarian of National Library and Museum in Mandalay
	16.00	Visit to Mandalay Palace and several monasteries to obtain the information on earthquake damage
19th (Tues.)	8.00	Leave Mandalay
	9.00	Arrive Sagaing District through Ava bridge Visit to U Si, Command Engineer or Construction Corporation in Sagaing
	11.00	Visit to Sagaing hill to make a survey of the Sagaing fault Visit to several pagodas to obtain information on damage due to the 1956 Sagaing Earthquake
	14.00	Leave Sagaing
	15.00	Arrive Mandalay
	16.00	Visit to the ruin of Mingun Pagoda which would be the largest one and was damaged by the 1838 Earthquake
20th (Wed.)	8.00	Visit to Maha Muni Pagoda
	9.00	Leave Mandalay
	12.00	Arrive Meiktila and meet U Tun Aung Pru, Command Engineer in Meiktila
	14.00	Visit to Mondaing Dam and Kyetmauktaung Dam
	19.00	Arrive Pagan
21th (Thurs.)	7.00	Visit to several pagodas in Pagan suffered earthquake damage by the 1956 Sagaing Earthquake
	16.00	Leave Pagan (UBA)
	18.30	Arrive Rangoon

22th (Fri.)	9.30	Visit to U Yoe Moe, Rector of Rangoon Institute of Technology
		Discussion with Prof. Dr. Aung Gyi and his colleagues on the earthquake damage due to Rangoon earthquake
	10.30	Visit to Prof. Ba Than Haq and his colleagues of Rangoon Art and Science University
		Discussion on the geological feature of southern part of Burma
	12.00	Courtery call on Prof. Dr. Nyi Nyi, Deputy Minister of Education
	13.00	Visit to damaged buildings in the down town of Rangoon
	17.00	Visit to U Kyaw Sein, Chief Engineer of Shwe Dagon Pagoda to obtain the information on the structure of pagoda and the eathquake damage
		Inquiring survey of the damage due to the 1970 Rangoon Earthquake conducted by Ichikawa and U Sein Shwe Oo almost full day
23th (Sat.)	10.00	Visit to Shwe Maw Daw Pagoda in Pegu which had been suffered from earthquake damage in 1917, 1930 etc.
	13.00	Visit to Shwe Tha Lyaung Temple (Reclining Budha)
24th (Sun.)	12.00	Luncheon invited by U Kyaw Tun
25th (Mon.)	10.00	Leave Rangoon (UBA)
	11.00	Arrive Loikaw
	12.00	Visit to U Tun Aung Gyaw, Executive engineer of Electricity Supply Board, Lawpita
	15.00	Visit to Lawpita Hydro-Electric Power Station and its Intake
26th (Tues.)	11.30	Visit to U Ohn, Chief Project Officer of Mobye Dam Construction
		Visit to construction site of Mobye Dam which is almost completed
	14.00	Meeting on a tentative conclusion for the survey of the Mission
27th (Wed.)	10.00	Visit to Ngwe Daung Dam
	14.30	Leave Loikaw (UBA)
	15.30	Arrive Rangoon.
28th (Thurs.)	7.30	Visit to State House to investigate earthquake damage
	10.00	Seminar on seismology and earthquake engineering, sponsered by the Ministry of Public Works and Housing, attended by experts from ministries and universities
	18.00	Embassy of Japan invited personnel of Burmese Government to dinner on behalf of the Mission

29th (Fri.)	9.30	Discussion meeting for the final conclusion between the Ministry of Public Works and Housing and the Mission
	10.00	Courtesy call on Col. Maung Lwin, Deputy Minister of National Planning and donation of the literatures on seismology and earthquake engineering
	12.00	Luncheon invited by Col. Maung Lwin
	18.00	Invite the Burmese personnel to dinner
30th (Sat.)	9.20	Leave Rangoon (PA 002)
	21.25	Arrive Tokyo

2. Survey of the Mission in the Union of Burma.

2-1 Earthquakes of the Union of Burma

1) General Seismicity of Burma

a) Seismic activity of Burma in related to the global seismicity

Beginning from the famous research by Richter-Gutenberg in 1949, a lot of papers have been appeared studying on the seismicity of the earth. By means of these papers it is well known presently that about 95% of earthquakes are taking place on the two majour seismic belts of the world, one is the Circum-Pasific belt, the other is the Alps-Himalaya belt. Burma is situated at almost the eastern extremity of the Alps-Himalaya belt, where it is meeting with the Pasific belt forming a Burmese-Sunda Arc. Among these two majour belts, the much larger seismic activity is definitely seen in the Circum-Pasific Belt, so it comes out that the seismic activity in Burma is fairly low compared to that of, for example, Japan or Philippines.

b) Burma Arc seismic belt

It is Gutenberg and Richter who studied first the seismic activity in the Burmese Arc to relate with the general activity of the Alps-Himalaya seismic belt (Fig. 2.1.1). The seismic belt, starting in the Sunda Archipelago then going north through the Andaman Islands Chain reaches the territory of Burma where the course of the seismic belt is shifted slightly to the east then again continue to run almost straight north nearly along the longitude of 96° E forming an arch warping to the west but only faintly. Earthquakes taking place in this belt are those that have very shallow focus.

As it runs further north the belt becomes more dispersive, showing the appearance of intermediate earthquakes near 24° N, 93° E, where the two structural arcs, the Himalaya mountain arc to the west and the Sumatra-Burmese arc to the south, are intersecting, forming a sharp angle. Such a pattern of foci distribution of the Burmese intermediate earthquakes are showing quite a similar one with those of the Hindu Kush but concentration of foci is more dispersed in the case of Burmese earthquakes.

c) Seismicity of Burma studied by recent materials

Two important papers should be referred to here in which recent seismic activity in Burma was studied fairly in detail.

First one is the paper compiled by U Sein Shwe U of the Meteorological Department of the Government of Burma in 1960, entitled "Technical Notes on Seismology".

U Sein Shew U prepared this paper when he was staying in Shillong, India, in his capacity of the Government research fellow to India, availing himself the advantage of referring a great many worthy materials on Burmese earthquakes stored in the Shillong Seismological Observatory especially those earthquakes that took place in the period when Burma was in the rule of British Empire. High appreciation is given for his paper as it contains elaborate description on the many historic earthquakes that had attacked Burma.

In Fig. 2.1.2. an epicenter map of Burma compiled by U Sein Shwe U is reproduced.

The Second paper is the one compiled by Prof. G. P. Gorshkov in 1959 entitled "Problems of Seismotectonics and Seismicity-Zoning of the Territory of the Union of Burma", and translated from Russian to English by A. V. Vinogradsky. Gorshkov prepared this paper when he was staying in Burma as a UNESCO expert on seismology and seismotectonics in the period from July 1958 to April 1959, compiling a lot of materials referred to by himself in Burma and India as well as some from USSR.

His paper contains beginning from precise descriptions on the old earthquakes in Burma, the review of important papers and literatures, then process to the stratigraphy and geological structures together with the problems of neotectonics. The most detailed description of his study is given in this chapter. Remaining part of his study is composed by regional investigation of seismic phenomena and seismicity zoning followed by catalogue and table of Burma earthquakes. Bibliography and four sheets of maps illustrating epicenter distributions, isoseismals, recent geological structures and seismicity-zoning of Burma are also of great value.

It is reproduced here a seismicity map of Gorshkov in Fig. 2.1.3., in which Gorshkov points out firstly that there is observed a great difference in the seismicity of the north Burma and south Burma, which is clearly separated by the parallel of 22° N.

As to the number of earthquakes, 77% are taking place in the north Burma where occupying the area of only 30% of whole Burma. It means that the south Burma, though it is covering the larger part of Burma, say about 70% of all land, earthquakes taking place in this area amount to only 23% of all earthquakes that take place in the territory of Burma.

Speaking with the larger earthquakes, of which magnitude is equal to 5.3 or more, 83% of them are taking place in the area north to the 22° N parallel.

Though it comes out from the above statistics that only 17% of rather larger earthquakes occur in the south Burma, the Mission must emphasize that it should not derive the mistaken conclusion that earthquake desaster which might be caused by the attack of larger earthquakes would be much smaller in the south Burma, where Rangoon and many other big cities are existing, compared to that of north Burma.

Secondary, Gorshkov points out that the Arakan mountain region in the south Burma, seeing from the view point of seismotectonic, is showing geologically a simple folding structure having no big geological faults in it, therefore, quite an active seismicity will not be expected in this area. However, Gorshkov himself is giving a carefull remarks calling upon the attention that the above discussion should not be interpreted with misunderstanding that destructive earthquakes will not take place in the south Burma.

It must also be remarked that both of the reports referred to above are giving much attentions on the reliability of the location of epicenter in their discussions, expressing that with respect to their epicenter maps, in some cases, it might come out that it is necessary for shifting the location of epicenter even for about 1 degree of geographic coordinates.

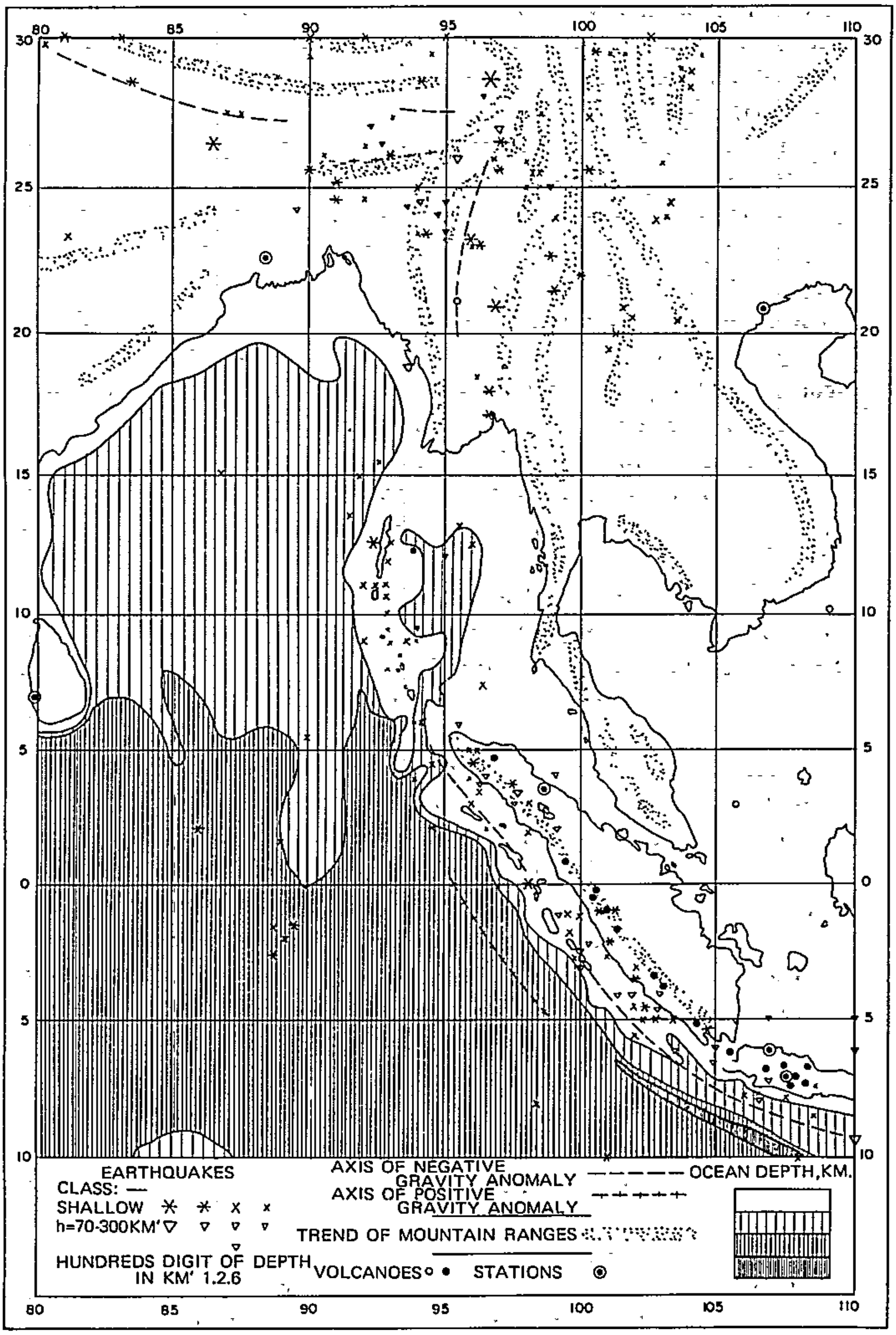


Fig. 2.1.1. Epicentre distribution in Burma (After U Sein Shew)

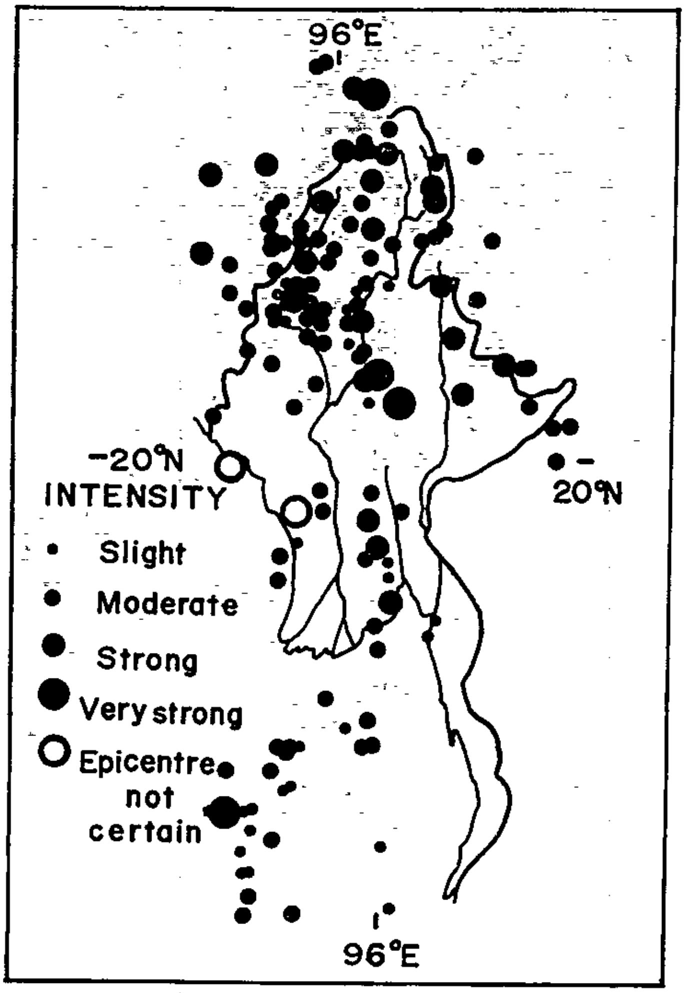


Fig. 2.1.2 Epicentre distribution
in Burma
(After U Sein Shwe U)

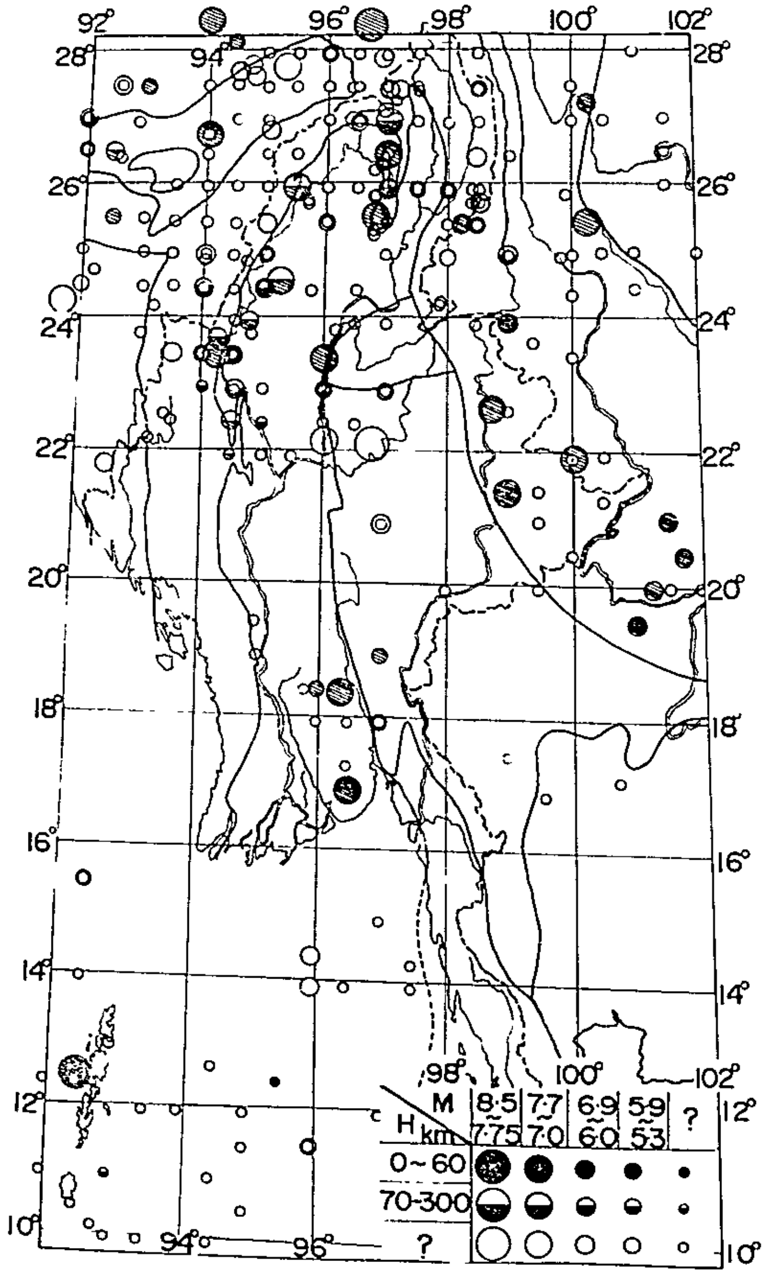


Fig. 2.1.3 Seismicity map of Burma
(After Gorshkov)

Therefore it is strongly hoped that much effort should be extended in future for relocating all these old earthquakes with improved accuracy making use of all available materials. For the purpose of finding out new reliable data it is expected that deciphering of the ancient manuscripts in the monastery of pagodas might provide invaluable materials.

If it could be succeeded in locating epicenters of old earthquake in the accuracy of ±1/4 degree or so, together with the discussions in the following Sections the seismotectonic study of Burma will be improved outstandingly.

d) Seismicity studied upon the data furnished by the US Coast and Geodetic Survey (USCGS)

By virtue of the devotional services extended by the USCGS for the World Wide Standard Seismograph Networks a great success was attained for improving the accuracy in locating epicenters of earthquakes covering the whole earth. Territory of Burma is also enjoying the favour of improved accuracy. Recently the ESSA of USCGS has compiled epicenter maps covering the period 1961–67.

Maps in Figs. 2.1.4 A and B are extracted from the ESSA maps to show the area in and around Burma, in which A represents epicenters of rather shallow earthquakes of which focal depth is smaller than 100 km, and B is for the earthquakes of deeply seated having the focal depth in the range from 100 to 700 km.

With respect to these maps we especially notice that epicenters of shallower earthquakes in Fig. 2.1.4 A are disposed in the west half of the plain of the Central Low-land and along the west boundary that borders the Central Low-land to Arakan-Naga mountain range. Such a disposition of epicenters differs somewhat in its pattern from that which was presented by Gorshkov in Fig. 2.1.2, in the point that the epicenter disposition in the latter map was showing a seismic belt located somewhat eastly along the small hill ridge passing Pegu, Toungoo and Mandaley, while the new map is showing a belt along the geosyncline lying with the Irawadi basen, then going up to the north where joining the seismically active region in the north Burma. Rangoon City is found in the belt of new seismicity map of USCGS which calling upon the carefull attention for protecting the city from the future attack of destructive earthquakes.

The epicenter maps of USCGS here referred to in Figs. 2.1.4 A, B are showing epicenter locations with definitely improved accuracy, while fatal defect of this map lies in that it can cover only a very short duration of time, say, about ten years or so.

In discussing a global seismicity, USCGS map provides excellent data for depicting a large scale seismicity in general throughout the whole earth, while for the purpose of discussing local seismicity of some limited area it should be well kept in mind that the map is showing epicenters only in a very limited period.

Though no epicenter is seen along the line from Pegu, Toungoo to Mandaley in this map, it should not be taken that around Pegu no earthquake will take place in future too.

e) Seismicity of Burma in related to the global plate tectonics

New interpretation was proposed by T. Santo for the seismic activity around

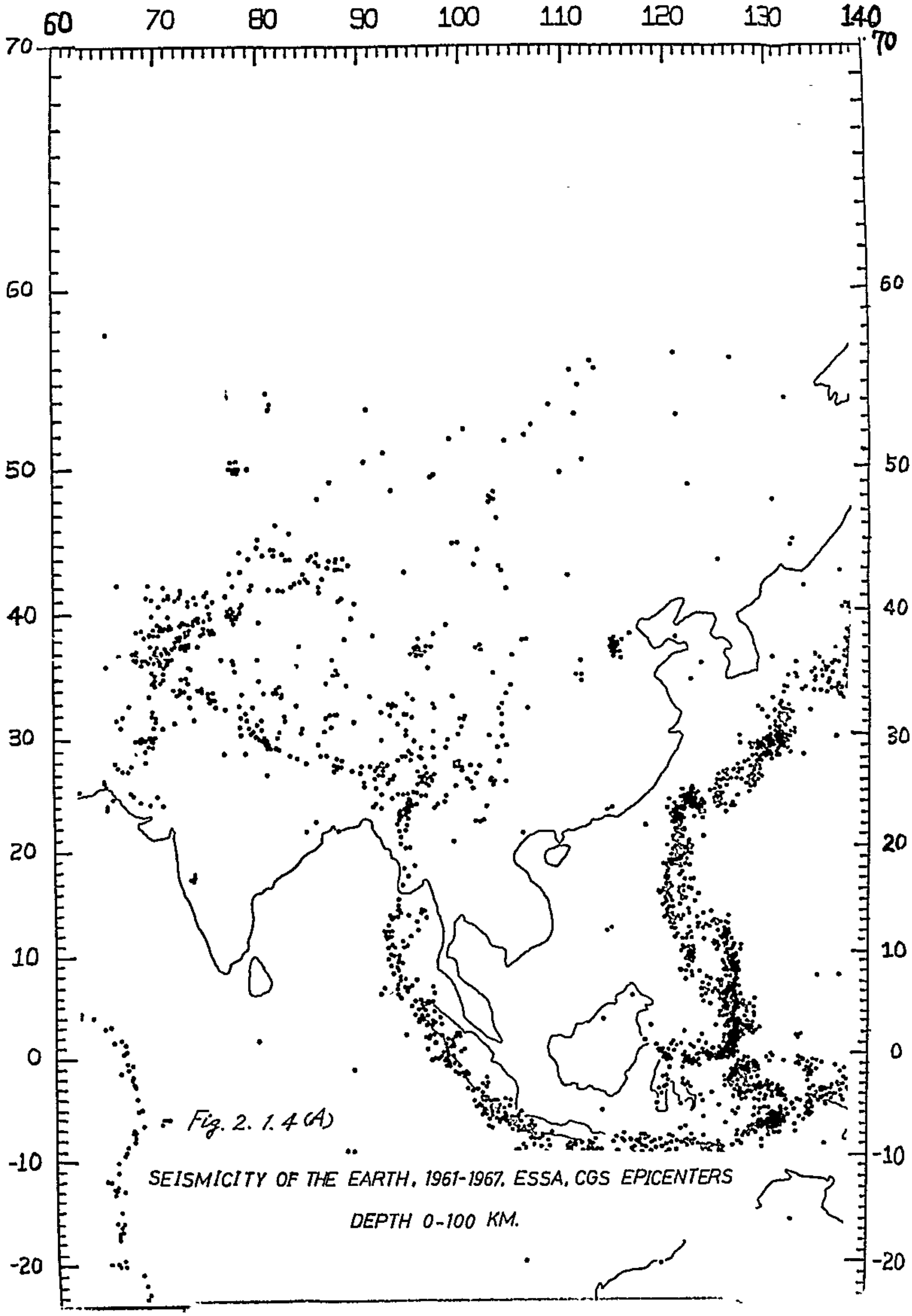


Fig. 2. 1. 4 (A)

SEISMICITY OF THE EARTH, 1961-1967, ESSA, CGS EPICENTERS

DEPTH 0-100 KM.

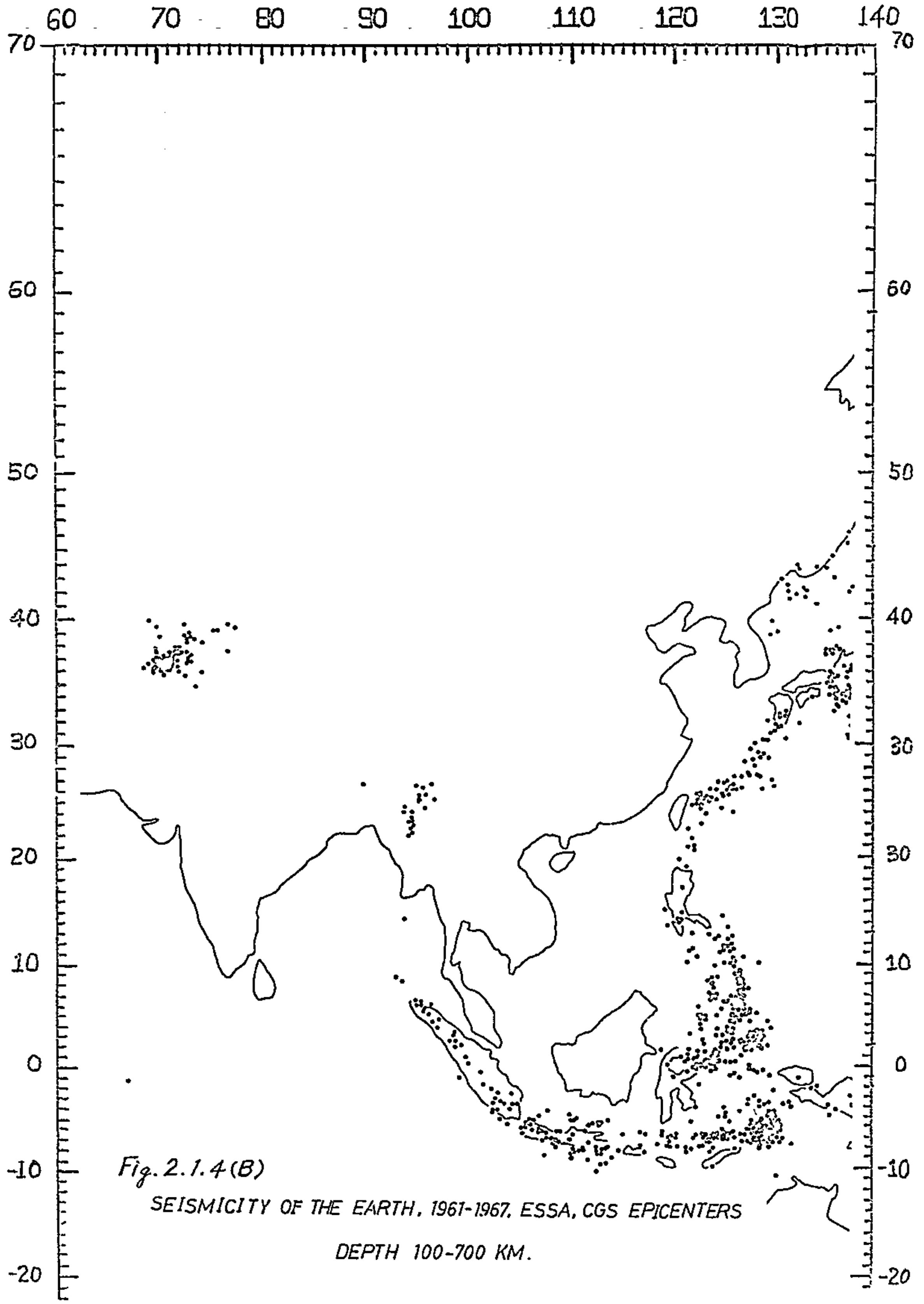


Fig. 2.1.4(B)

SEISMICITY OF THE EARTH, 1961-1967, ESSA, CGS EPICENTERS

DEPTH 100-700 KM.

the area of Burma from the standpoint of new global plate tectonics theory basing upon the data on earthquake foci provided by USCGS.

It can clearly be seen that foci distribution of Burmese earthquakes is represented a characteristic pattern, when they are projected on a vertical plane along a rib of a fun of which pivot is placed on the location of 100° E, 22° N, as will be shown in Figs. 2.1.5 A and B.

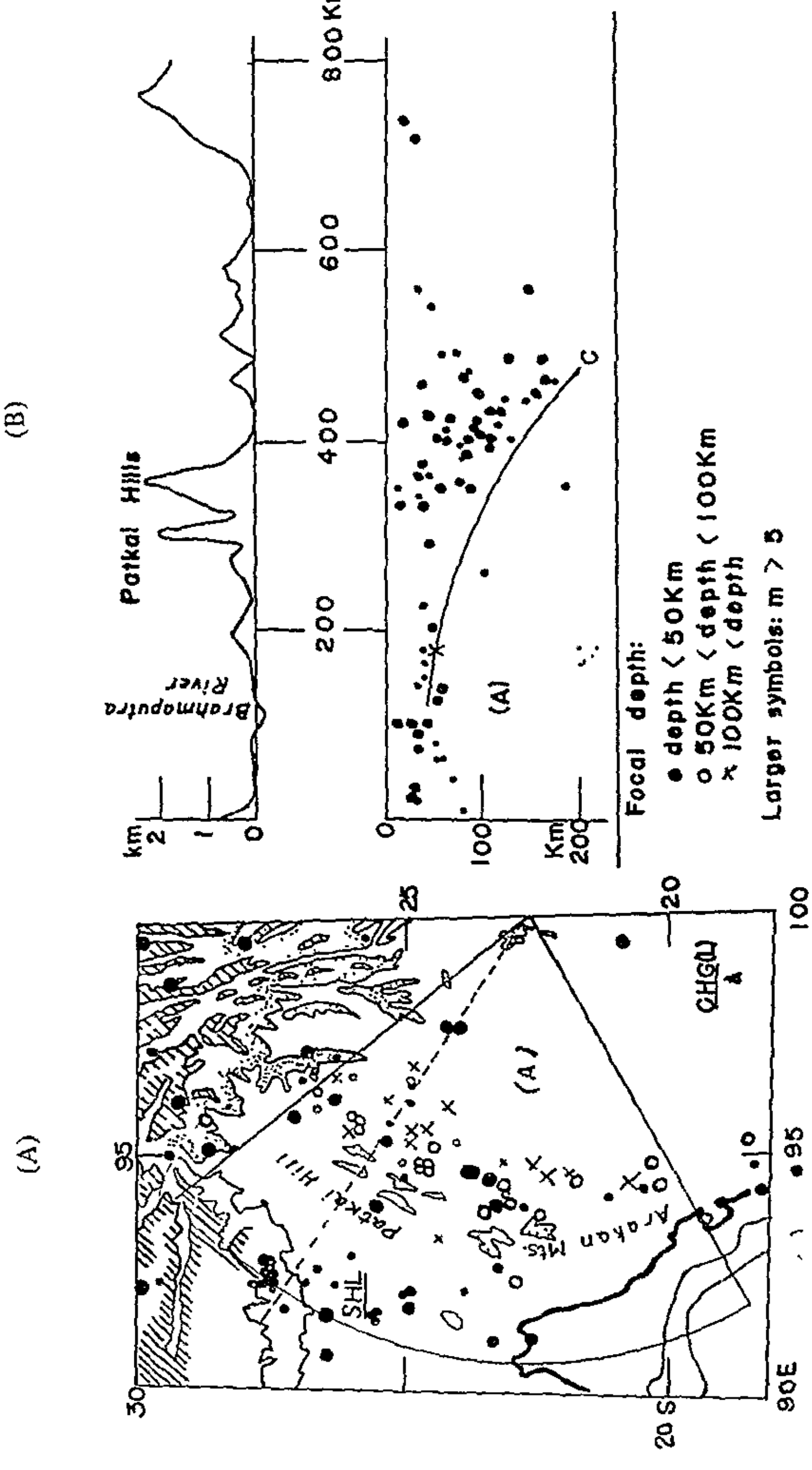


Fig. 2.1.5 A : Epicentre distribution in Burma
B : Vertical section of seismic foci distribution (After T. Santo)

Earthquakes in the Assam plain are showing very shallow focal depth originating in the crust then mantle earthquakes become frequent underneath the Arakan-Patkai mountain ranges. As it comes into the inland there are observed deeper earthquakes upto the depth of about 200 km. Such a pattern of vertical distribution of seismic foci in Burma as explained above, together with the bow-shaped trend of Arakan-Patkai mountains warping to the west indicates a characteristic nature of the island arc-trench system to be explained as the continuation from the Java-Sumatra islands arc.

The evidence that the earthquakes in Burma show a typical pattern of the islands arc-trench system, in spite of the fact that Burma is located in the continent, is providing very important and interesting materials for promoting a theory of the continued movement of India landmass pressing the Asian landmass mainly to the north and partly to the east as expected from the global plate tectonics hypothesis.

However, in order to promote the argument of this theory, there are many subjects to wait for the future reserches, such as, there are observed no earthquake having deeper focal depth greater than 300 or more kilometers, or no evidence is found for tracing the deep trench that might have had been existed in front of the arc-shaped mountain lands of old Arakan-Patkai of Burma before the Indian landmass approached to the continent, and so on.

2) Historically Noticeable Earthquakes in Burma

i) Introduction

In the preceeding chapter we have looked through the general seismicity of Burma. In this chapter we shall pay our special attention to the historic larger earthquakes in Burma. Total number of earthquakes which provided materials in the discussion of general seismicity amounted to about 400, but among these 400, 20 of them are considered to be major earthquakes that caused damage somewhere in Burma. Talking with the earthquake energy discharged, contribution from smaller earthquakes is so small as to amount less than a few per cent while almost all earthquake energies are those from major earthquakes, so it will be important to pay more attention to each of these major earthquakes.

In order to prepare the descriptions of each of these noticeable earthquakes we mainly referred to the following materials;

1. Geology of Burma, Chapter IV Earthquakes, by Chhibber, 1934
2. Problems of Seismotectonics and Seismicity-Zoning of Burma, by Gorshkov, 1959
3. Technical Notes on Seismology by U Sein Shwe U, 1960
4. Burma and Earthquakes by Dr. Maung Thein, 1970

The most detailed descriptions are given in the Chhibbers' book and some part of them are quoted to the paper of U Sein Shwe U. In our report some parts of these descriptions were quoted, for which kind permission our hearty gratitude are due.

The last named report namely the report of Maung Thein which was written originally in Burmese language, was made available for us through the English translation by Mr. Aung Shew. Assistant Engineer, Irrigation Department, Ministry of

Forest and Agriculture, for which kind cooperation the Mission expresses its highest appreciation.

ii) Description of individual earthquake

Arakan Earthquake of 2 April, 1762.

The earliest earthquake on record which affected Burma, took place at 5:0 p.m. on 2 April, 1762. It was very violent and destructive and was felt all over Bengal, Arakan etc., chiefly and more severely in the northern part of the east coast of the Bay of Bengal. Water rose in tanks and river at Dacca rose to a height of 6 feet causing disasters. There were openings in earth and fountains of water, sand and mud. There was a gradual sinking of earth and about 60 square miles of land submerged in some places. Elevation of Arakan coast and beaches occurred. Houses fell, cavity opened up with a length of 200 cubits in some place and two volcanoes were reported to have opened up on Seeta Kunda hills From this record the intensity in Modified Mercalli Scale seems to be about X to XI.

Ava Earthquake of 23 March, 1839.

"A very serious and destructive earthquake within Burmese limits occurred on 23 March, 1839, at about 4:0 a.m The shock was felt throughout the whole Burman Empire from Bhamo to Rangoon. This earthquake was felt at Moulmein, and for a distance of a thousand miles from north to south. In the morning not a pagoda was to be seen standing intact. This earthquake caused such terrible destruction, so much so that the Pagoda of Mingon, doubtless one of the largest masses of solid brickwork in the world, was utterly shattered. The banks of the river between Amarapoora and Ava were rent in many places, from which large quantities of water and sand of a blackish appearance had been ejected. There never was a correct list of the number of people killed; but there must have been from three to four hundred Ava must have been about the center. From this record the intensity in Modified Mercalli Scale seems to be XI".

Kyaukpyu Earthquake of 1843 and 1848.

Next earthquake on record occurred at Kyaukpyu at 11:0 p.m. on 6 February, 1843. It caused magnificent eruptions from the mud volcanoes and slight tremors at Ramri, lasting till 1 o'clock in the morning. Another earthquake in the same year, on 30 October, at 7:45 a.m. was more violent, but lasted only two minutes. It was felt only slightly at Ramri, but more severely at Civil Magazine, as well as other buildings.

Amarapoora Earthquake of 1855.

Two slight earthquakes were felt at Amarapoora on 18 September and 5 October, 1955.

Thayetmyo Earthquake of 24 August, 1858.

In the reports of Chhibber and U Sien Shwe U this earthquake is described under the heading of "Earthquake of 1858" in the former report and "Earthquake in British Burma of 24th August, 1858 (Epicenter near Thayetmyo)" in the latter. In our present report for the purpose of keeping the harmony with the heading of other earthquakes the above heading was given to this earthquake.

There was a destructive earthquake on 24th August, 1858. The shock was most severe near Thayetmyo and Prome, though it extended as far as Rangoon and Moulmein, wherever, however, very little damage was caused. At Thayetmyo the houses rocked considerably and most of the pagodas were badly damaged, the tops falling to the south-west, while several were entirely reduced to ruins.

Course of river was ıeversed and river bed rose out of water. Rushing sound as of a large flight or birds preceded the shocks. Tremulous vibratory movement was experienced. At Kyaukpyu and Allanmyo, violent vibration was felt. The Principal Assistant at Ramri reported the entire disappearance of False Island, situated south-east of the island of Cheduba,(18° 38′ N and 93° 55′ E), no trace of it being seen after 24 August.

The epicenter must have been under the ranges of hills lying between Irrawaddy and Bay of Bengal in about the parallel of Prome and Thayetmyo, from this record the intensity at Thayetmyo seems to be between X and XI in modified Mercalli Scale of 1931.

Moulmein Earthquake of 6 January 1868.

A slight earthquake was felt at Moulmein on 6 January 1868.

Mandalay Earthquake of 16 February 1871.

Earthquake was felt at day break on 16 February 1871 in Mandalay in two successive and gentle shocks. It did no damage.

In 1874 a severe earthquake occurred in the Southern Shan States, and its effects there were widespread.

Bay of Bengal Earthquake of 31 December, 1881.

On the morning of 31 December 1881, an earthquake which is believed to have originated in the Bay of Bengal, west of the Andaman Islands, was felt over an area of 2,000,000 square miles. Besides affecting a large portion of the Indian Peninsular and Bengal, it was also felt on the Burma Coast, including some of the islands in the Mergui Archipelago, and caused much damage in the Andaman and Nicobar Islands. The surface of the ocean was greatly disturbed, and waves were formed which continued to roll against the coastlines for several hours after the cessation of the earth waves, which lasted only for a few seconds. The first tidal wave was recorded at Port Blair at 8:10 a.m., followed by others in succession at about 15 minutes interval, with a height of about three feet from crest to hollow. They continued till 9:00 p.m. The velocity of the waves, as computed by Major Roges, varied from 2 to 6.9 miles per minute. At Rangoon, Moulmein and various points in the Mergui Archipelago the earthquake was distinctly perceptible, though much less violent; but no trace of sea-wave was met with any of the tidal stations in this quarter, the belt of islands and shoals which extends from Cape Negrais to the island of Sumatra, practically dividing the Bay of Bengal into two portions, must have formed a barrier to the sea-waves, for, though great and numerous at Port Blair, they died down in the deep sea beyond and in no case reached the eastern coastline. The sea-wave perceived was positive, the crest preceding the trough and raising the sea-level.

Rangoon Earthquake of 23 July 1884.

An earthquake of moderate intensity occured at Rangoon on 23 July 1884. Two shocks were felt, doors were rattled, etc., but no damage was done. It was also felt at Thayetmyo.

Maymyo Earthquake of 23 May, 1912.

In the reports of Chhibber and U Sien Shwe U, this earthquake is described under the heading of "Burma Earthquake", while Maug Thein is giving the heading of Maymyo Earthquake together with the explanation which follows; "a very severe earthquake that is considered the strongest earthquake in Burma had occurred at 9:0 a.m. on 23 May, 1912 at Maymyo. It is called Maymyo Earthquake, although its epicenter was situated near Taunggyi. Gutenberg and Richter gave the location of the epicenter of this earthquake at 21°N, 97°E, distant only 20 km or so to the north-east from Taunggyi, assigning the magnitude of 8.0.", "The earthquake of 23 May 1912 was preceded by two lesser shocks, the first occurring on 16 May at about 3:0 a.m., and its intensity on the Rossi-Forel scale did not exceed V. The second violent earthquake of 21 May, has shaken the whole of the greater part of the Northern and Southern Shan States and the districts as far as Toungoo and Pegu, as well as northern Siam. The minimum area over which it was felt approximated to 125,000 square miles. In the central parts of the area an intensity of at least VII on R–F scale was attained.

The great earthquake of 23 May was felt all over Burma from Mergui district in the south to the northern frontiers, covering an area of approximately 375,000 square miles and disturbed recording instruments throughout the world. Reports from Maymyo stated nearly every brick building in the town suffered.

There were, in addition, huge land slides. At Mandalay a number of brick building were badly cracked, some of them losing their upper portions altogether. At Mogok nearly every brick building in the twon was cracked and about 60 pagodas collapsed.

Dr. Coggin Brown has shown that the movement along the great Kayukkyan fault gave rise to the Maymyo Earthquake, basing on the reason that the maximum intensity of IX was experienced in the neighbourhood of the Kyaukkyan Fault, east of Maymyo, that the major axis of the elongated oval enclosed by the innermost isoseismal line coincides nearly with the Kyaukkyan Fault, and that the railway was bent close to that point where it crosses the Kyaukkyan fracture, but was quite undamaged where it traverses other fault of the plateau.

Pegu Earthquake of 5 July, 1917.

An earthquake of some intensity was felt in parts of Lower Burma on 5 July, 1917. Unfortunately the data available are very meagre. The only damage reported occurred to the famous Shwemawdaw Pagoda at Pegu; its umbrella or hti with all the jewels was shaken down and destroyed several smaller pagodas at its base.

The Rangoon Earthquakes of September and December 1927.

Three smart earthquake shocks were experienced in Rangoon on 10 September, 1927, at 12.5 p.m., 12.47 p.m. and 4.25 p.m. (Rangoon time), but none of them did any appreciable damage. In the early morning of 17 December, at 2.25 a.m., a much severer shock occurred, which caused wide-spread alarm and a certain amount of damage. It attained an intensity of VII on the Rossi-Forel scale in Rangoon and did a certain amount of damage to buildings in this city. It was felt over an area of 5,000 square miles, comprising the districts of Hanthawaddy, Insein and Tharrawaddy, and also the Maubin and Yandon townships of the Maubin district and the Dedaye township of the Pyapon district.

Dr. Coggin Brown has published a detailed account of this earthquake and the interested reader is referred to the Records of the Geological Survey of India.

North-East Frontier (Htawgaw) Earthquakes of 19, January, 1929.

According to Chhibber it seems there were observed fairly noteworthy activity of earthquake swarm in the North-East Frontier of Burma that borders the Yunnam District of China, of which activity seemed started a few years before 1929 showing the frequency at least two or three and sometimes more per year. The severest one took place on 19 January, 1929, by which all the stone masonry buildings in Htawgaw were so badly damaged that they were considered no longer fit for human habitation. The earthquake was felt in the Districts of Bhamo and Katha and as far east as Teng Yue in Yunnan. Intensity at Htawgaw was estimated at IX on the R–F scale. On 16 December 1929 at 2:30 a.m., another severe shock occurred at Htawgaw with an intensity IX on R–F scale. As a consequence of this earthquake cracks developed in various places and land slide and rock falls occurred on the Htawgaw-Khamltham.

The Swa Earthquake of 8 August, 1929.

On the 8 of August, 1929, a very severe, but local shock occurred, which seems to have its epicenter a few miles west of Swa (19.13°N, 96.14°E) in the Toungoo District. Here a metregauge railway belonging to Messrs. Steel Bros. & Co. was severely damaged. In places the track was twisted and bent, fishplates and bolts snapped, bridges and culverts collapsed, the sides of cuttings fell in, loaded trucks were turned upside down and coolie huts shaken to pieces. This earthquake was reported from Yamethin, Pyinmana, Yenangyang and Tharrawaddy.

The Pegu Earthquake of 5 May, 1930.

The Pegu earthquake which took place at about 8:18 p.m. on 5 May, 1930, caused the practical destruction of the town of Pegu with a loss of at least 500 lives; it also caused many deaths and great damage to property in Rangoon. It was sensible to human beings as far as the Kyaukpyu and Mergui districts up and down the coasts respectively, as far north as Mongmit in the Northern Shan States, across the greater part of the Southern Shan States and the Kingdom of Siam. The outer curve marking these approximate limits passes into the Bay of Bengal, the Andaman Sea and the Gulf of Siam. The shock was registered by recording instruments at seismological stations in every part of the world.

The region of maximum intensity lies within isoseismal IX on the Rossi-Forel scale. At Pegu itself a considerable portion of the town was ruined, and fire, which broke out at once, added to the horror of the situation. Large cracks appeared in the ground and exuded sand and water. Big pieces of the river bank slid into the stream.

Pado Earthquake of 16 September 1930.

For some time after the Pegu earthquake of 6 May 1930, the main center of seismic activity in this part of Burma moved into the neighbourhood of Pado

(18°02'N – 96°36'E) 48 miles north of Pegu, and close to the steep extreme flank of Pegu Yoma. Here 13 separate earthquakes of slight intensity were recorded in six months from July to December 1930. A smarter shock on 16 September 1930 cracked walls, so that its intensity corresponds to V of Modified Mercalli Scale of 1931.

Pyu Earthquake of 4 December 1930.

A severe earthquake occurred about 1:20 a.m. on 4 December, 1930, and wrecked most of the masonry buildings in the town of Pyu, killing some 30 persons. C. Brown concluded that the epicenter of this earthquake lies a few miles to the west of Pyu. It was felt within an area of 22,000 square miles. The intensity within the epicentral tract was X on R–F scale.

Shwebo Earthquake of 4 December 1930.

On the 4 December 1930 (same date as Pyu Earthquake) an earthquake occurred in Upper Burma near Shwebo, and it had no apparent connection with a series of aftershocks belonging to Pyu Earthquake themselves. In Shwebo it was strong enough to cause house timber to creak, so that its intensity will correspond approximately with IV of Modified Mecalli Scale.

Kamaing Earthquake 28 January, 1931.

A very violent earthquake occurred on 28 January, 1931, at 2:31 a.m. The epicentral tract of this earthquake was very hilly, of which maximum elevation was 4982 feet above sea-level. The hilly slopes were scarred in numerous places by big cracks, not infrequently about 2 feet wide and with a drop of about 3 to 4 feet on one side. Big fissures, sometimes several hundred feet long, developed in the epicentral tract and its neigbourhood. These fissures in alluvial tracts were accompanied by spoutings of sand and water.

Even in Kamaing, which is just outside the epicentral tract, all the glassware and crockery of the Inspection Bungalow were broken, three big almirans were overturned, and mirrors and notice boards were thrown to the floor. No masonry buildings exist in the epicentral area, but all those in Kamaing, the Court House, the Subdivisional Officer's bungalow and P.W.D. Inspection Bungalow were severely damaged. Two small pagodas in the local Ponggyi Kyaung (monastry) were destroyed. Even a small bamboo house in Kamaing collapsed. From the nature of the damage done Chhibber convinced the earthquake had an intensity of at least IX on R–F scale.

Amherst Earthquakes of August and September 1931.

A strong earthquake was felt on 6 August, 1931, having a direction of north to south and followed by daily weaker shocks till the 14 of August 1931.

Another strong shock, having a direction of southwest to northeast occurred on the 20 September 1931.

Pyinmana Earthquake of 10 August, 1931.

A strong earthquake occurred at Pyinmana which was also strongly felt at Kalaw on 10 August, 1931. It was felt with lesser intensity at Yamethin, Pyawbwe, Toungoo, Meiktila, Mandalay, Maymyo, Ywataung, Paungdawthi, Myitkyo and Yitkangale.

Kyaukse Earthquake of 19 August 1931.

Another smart shock occurred at Kyaukse and felt at Mandalay, Ywataung and Kalaw on 19 August 1931.

Great Assam Earthquake of 15 August 1950.

A very great earthquake occurred on the 15 August, 1950 at northeast Assam (29°N – 97°E) near the extreme northern border of Burma. It has a magnitude of about 8.5 and a total release of about 4×10^{26} ergs of energy. It has affected northern Burma where the intensity VI of Rossi-Forel Scale reached Myitkyina, and had brought great disaster at Assam.

The earthquake was of tectonic origin and shallow focus and of depths of order 15 kilometers. The energy of the earthquake must therefore have been produced as a result of a number of rocks or a single solid rock occurring a large volume below this depth subjected to gradually increasing strain, reaching the yield point and finally cracking. The strain energy was thus converted into energy of internal motion leading to the production of elastic waves which spread throughout the earth. Shearing stress on a block ten kilometers thick and nearly 20,000 square kilometers in area could be produced by pressure (of nature of an overthrust) due to a slow movement of the Himalayan arc from northeast to southwest and of the protruding Indian Peninsular Rock (of the nature of an underthrust) southwest to northeast, thus producing a shearing couple on the block in anti clockwise direction. When the strain is released by the bursting of the rook, it is to be expected that a rotation in clockwise direction would be observed. It is interesting to record that the rotation of ground at Digboi (Upper Assam) was clockwise.

Maninur-Burma Border Earthquake of 22 March 1954.

A strong earthquake having magnitude 7 to 7¼ and energy of order 8×10^{22} ergs occurred on the Burma side of Manipur–Burma Border (24°38′N – 95° 15′E) on 22 March 1954. It has a depth of about 18 kilometers and duration of about 3 minutes. The area in India, East Pakistan and Burma over which the shock was strongly felt with minor damage caused at few places was about 119,000 square miles and the total area over which the shock was felt was 909,000 square miles. The radius of perceptibility (that is an average distance from the epicenter in which the shock was felt) was 540 miles.

The earthquake did not cause major damage even near the epicenter. The maximum intensity is VI on Midified Mercalli Scale. The shock was felt more widely on India side than Burma. Fall of intensity on Burma side is rather remarkably rapid. This may be due partly to the alluvial nature of the soil in East Pakistan and India and partly due to the mechanism of faulting at the focus.

The Sagaing Earthquake of 16 July, 1956.

On 16 July, 1959, at 3:0 p.m. a severe earthquake shock the Sagaing and Mandalay districts. This earthquake is called the Sagaing Earthquake having the magnitude of 7 by Richter scale. There were caused the death of more than 40 lives and large destructions.

The Ava bridge that spans on the Irrawaddy River was shifted at its footing. Many buildings and several pagodas on the Sagaing mountain were destroyed.

The Maximum intensity at its epicentral area is estimated at VIII–IX on the Modified Mercalli Scale.

The Earthquake of 27 February, 1964.

An earthquake occurred on 27 February, 1964 with epicenter at 21.7°N, 94.4°E having magnitude of 6.4 and depth of 102km. The earthquake was felt noticeably within a radius of about 300km, but no damage was reported.

iii) Summary and remarks

a) Statistics of larger earthquake

In Table 1, there is reproduced a statistics taken from the report of Maung Thein which is representing only those larger earthquakes that took place after 1904.

Table 1

Large earthquake in and around Burma since 1904

	Magnitude range	Number of earthquakes	
		In Burma	In and around Burma
1st class violence	8 ½	0	1
violent	7 ¾ to 8 ½	2	3
very destructive	7 to 7.7	13	22
destructive	6 to 6.9	15	50

It is observed from this table that the biggest class of earthquake has taken place not in the territory of Burma but in Assam area, India, and larger activity of very destructive and destructive earthquakes is seen outside of Burma of which epicentral areas are mainly limited in Assam and adjacent area of India and is Yunnan district in China.

b) Geographical distribution of larger earthquakes

Many maps that is showing the geographical distribution of these larger earthquakes are presented in the papers we referred to in Section 2–1. Among these many maps we shall reproduce here in Fig. 2.1.6 a map prepared by Chhibber in his book because this is the only map which is showing clearly the approximate location of epicenters of the very old earthquakes in Burma.

It may be easily noticed that there is fairly a large difference in the way of disposition of epicenters between this map and the maps we have already referred to in the preceeding sections. In the Chhibber's map it is indicated a general line of weakness along which several important earthquakes are seen lined from south to north along a line almost well coinciding with the geological large fault that borders the Shan Plateau to the Central Lowland.

This is a very important point suggesting the need for the future study, but here again there stands in front of us a problem of the reliability on the epicenter location for promoting future research.

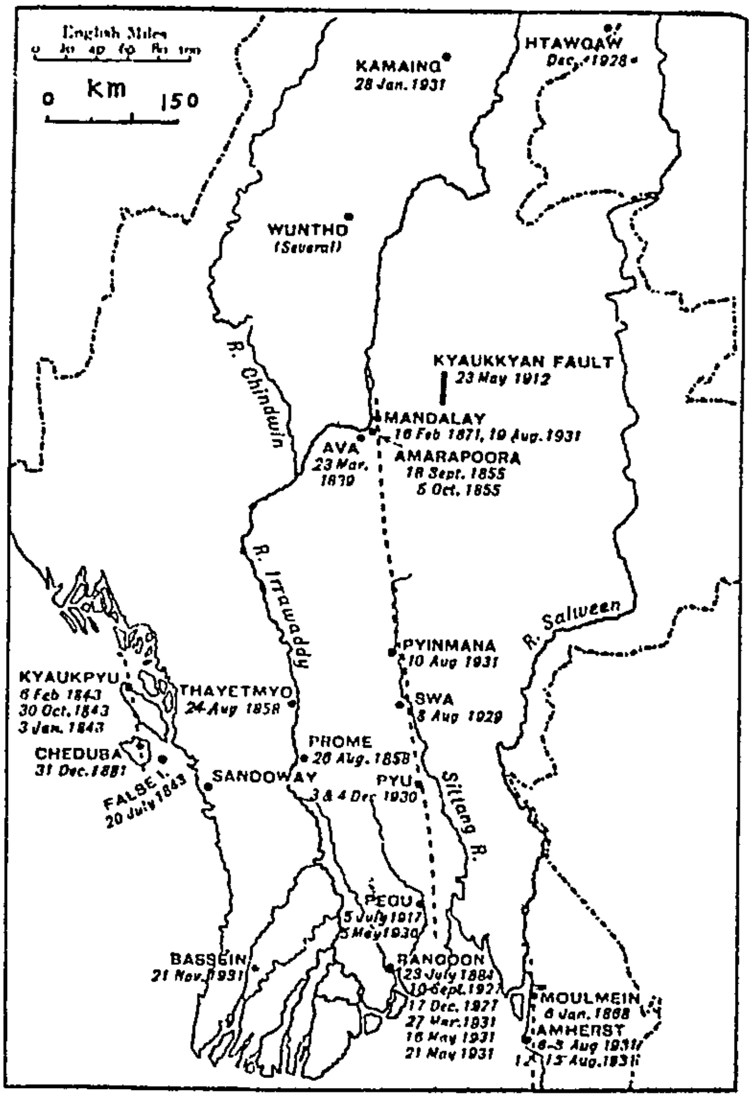
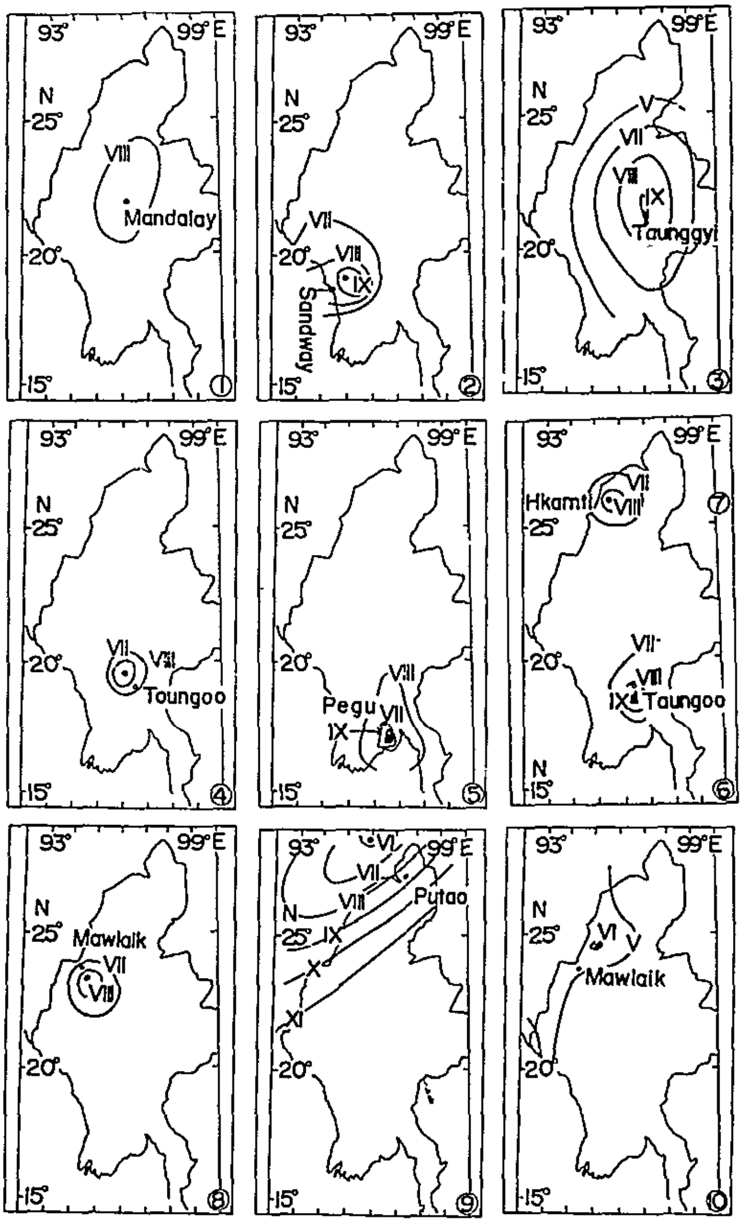


Fig. 2.1.6 Map showing epicentres of important earthquakes and general lines of weakness (After Chibber)

c) Iso-seismal maps of larger earthquakes

An accurate iso-seismal map is greatly valuable for promoting the detailed study on the old earthquakes, for the propose of determining the more accurate location of epicenters, reasonable estimation of magnitude and if possible the depth of focus, etc.

The report of U Sien Shwe U contains a map showing the iso-seismals of 10 larger earthquakes in Burma in which, however, it is shown all the iso-seismals of 10 different earthquakes in one map. In Fig. 2.1.7 of the present Report we re-arranged the iso-seismals of each of these earthquakes to be presented in one respective separate map so that we can have better information on the characteristic nature of intensity distribution of each of these large destructive earthquakes.



1.	23 March	1839		6.	4 December	1930
2.	24 August	1859		7.	14 August	1932
3.	23 May	1912		8.	16 August	1938
4.	8 August	1929		9.	15 August	1950
5.	5 May	1930		10.	21 March	1954

Fig. 2.1.7 Intensity distribution for larger historic earthquakes

In the report of Chhibber, seismic intensity is given by the Rossi-Forel scale and showing great many large intensity grade such as x or more in many cases while in the report of U Sien Shwe U, the intensity of rather recent earthquakes is given by Modified Mercalli Scale. For the purpose of obtaining more harmonized expression for the intensity of old and recent earthquakes, it should be required to carry out re-evaluations and re-adjustment on the intensities described in these reports.

d) Remarks

One of the most noticeable event in the description of larger earthquakes in Section 2-1-2-ii) is that in the period of 3 years or so starting 1929 to 1931 there seems several towns, which are arranged along a line, suffered earthquake damage successively starting Pegu to the south passing through Pyu, Swa, Pyinmana, Kaukse up to Mandalay and Shwebo to the north.

Chhibber and U Sien Shwe U are more included to show closer relation between the geological structure and the liner arrangement of the epicenters of these earthquakes, while it seems that Gorshkov is proposing other interpretation saying that, "Brown and Leicester, based upon the firmly established idea in existing special literature on the subjects, put forward the view that the earthquake foci of the earthquakes; Swa (1929), Pegu (1930), Pado (1930), Pyu (1930), Shwebo (1930), Daiku (1931), Pyinmana (1931) and Kyaubse (1931) of the southern Burma are connected with the scarp of the Shan Plateau. However, the relation of these epicenters of the fault line cannot be considered as final. The coordinates of epicenters received by seismometric methods for the following five earthquakes, prove that there is no lineation in the position of epicenters:

8 Aug.	1929,	Swa	21.0° N	97.0° E	
5 May	1930,	Pegu	17.0° N	96.5° E	(M = 7.3)
3 Dec.	1930,	Pyu	18.28° N	96.27° E	(M = 7.3)
4 Dec.	1930,	Shwebo	25.0° N	97.0° E	
10 Aug.	1931,	Pyinmana	18.0° N	97.0° E	

Two of these (Swa and Shwebo) are connected with the Shan Plateau structures; two (Pyu and Pegu) with the Pegu Yoma and only one (Pyinmana) is situated near the Shan Fault. No epicenter have been established for the Pado, Daiku and Kyanbse earthquakes".

e) Need for the future study

It is strongly recommended that in the future it should be studied for determining the magnitude of these large and old earthquakes so that more advanced discussions on the earthquake energy release in Burma covering the much longer period of time could be carried out.

For this purpose, firstly, more carefull and more elaborate examinations should be extended to the detailed descriptions in the Chhibber's book by which it could be expected to dig out a lot of valuable data for example to draw out more accurate isoseismals, which might lead for obtaining more reliable epicenter and magnitude, etc.

Secondly much more effort should be discharged for ranging over several other important literatures in which great many important data are expected to be described on some of the larger and old earthquakes of Burma. Among such literatures, papers that were written by Dr. T. Oldham, the founder and the Director of the Geological Survey of India (GSI) and have appeared in the early publications of GSI are having outstanding importance and value.

Thirdley it might strongly be encouraged that another important material on the description of old large earthquakes in Burma might be supplied from the deciphering of the old literatures, which might be found in some of the old pagodas, monasteries and temples. In order to obtain such a new findings great effort and successful good fortune should be anticipated by the local people, not only by the seismologist but also by other experts in the field of Burmese literature, history, archaeology and so on.

3) The 1970 Rangoon Earthquake

Rangoon, the capital of the Union of Republic of Burma, was shaken by a violent earthquake at 10:30, September 9th, 1970 (local time). The earthquake was accompanied by moderate damage to structures such as the official residence of Chairman of the Revolutionary Council (State House), the famous Shwe Dagon Pagoda, schools and a hospital, and many dwelling houses in the city.

The epicenter and magnitude of the shock have not been given by seismological organizations in the world because of the lack of seismometrical data.

Fore- and aftershocks as well as the above-mentioned parameters of the main shock were elucidated from the investigation on the phenomena, recently conducted by the Japanese Mission, who visited Burma in January 1971, and Burmese experts

In this section will be mentioned the results obtained by the investigations.

a) Hypocenter and magnitude of the main shock

The Kaba-Aye Seismological Observatory in Rangoon is furnished by the two horizontal Sprengnether seismographs and one Willmore Seismograph, but the instrument in operation is only the Willmore. Unfortunately, maintenance of both seismometer and pendulum clock which sends time marks to seismographs was not always satisfactory, and this made it difficult to read arrival times of various phases of seismic waves.

Therefore, hypocenters and other seismic parameters for the main shock and fore- and aftershocks were not determined by the conventional method for determining the parameters.

S – P times for only 4 of 27 aftershocks, recorded by the Willmore seismograph at the Kaba-Aye Observatory, were measured. The data, however, were very helpful in locating epicenters of the earthquakes.

The S – P times of the earthquakes are nearly 3 seconds, and these suggest that the events occurred in the area whose distance from the observatory is nearly 20 km.

In view of the above-mentioned fact and the distribution of seismic intensities of the main shock, which will be mentioned later, the epicenter of the main shock lies below the earth's surface in the southwestern part of Rangoon city (location of the epicenter may be 16 3/4°N and 96 1/6°E.).

Table 2.1.1. Seismic Intensity at Various Sites in and near Rangoon for the 1970 Rangoon Earthquake.
I : Seismic Intensity in Modified Mercalli Scale.

Location	I	Remarks
Heldan Station	VI	
Kemmendine	VI	
Kemmendine Station	VI	
Kemmendine State High School	VII	
Construction Corp. Motor Work Shop	V	
General Hospital	VII	
Lamadaw State High School	VII	Earth sound
New Secretariat Building	VII	
Public Work Corp. Maintenance Section	VII	Earth sound
Technical High School	V	
Mingaladon Station	II	
Okkalapa (North)	II	
Okkalapa (South)	V	
Inya Lake Hotel	IV	
Pazundaung	VI	Earth sound
Thaketa	V	Earth sound
Thuwunne	IV	
Mayangan	II	
Tenth Mile	III	Earth sound
Danyingon	II	
Insein	VI	Earth sound
Thamaing	VI	Earth sound
No. 9 Bus Terminal	II	
Yankin	V	
Ywama	III	Earth sound
Pyinmabin	II	
Htaukkyan	I	
Hlegn	I	

Judging from the maximum seismic intensity (VII in Modified Mercalli Scale) and the maximum distance of perceptibility (about 40 km), the magnitude of the main shock will be between 5 and 5 ½.

Earth sounds due to the main shock and occurrence of many aftershocks for estimated magnitude of the main shock may suggest that the focal depth of the main and after-shocks is as deep as several kilometers from the earth's surface.

b) Distribution of seismic intensities

Though it was after 5 months since the occurrence of the 1970 Rangoon Earthquake, when the Mission visited the site, it was found that the aspect of vibrations which they experienced on the occasion of the earthquake has been well retained in memory of the local people in and around Rangoon, because of the reason that no violent earthquake has taken place for a long time in Rangoon and its vicinity.

From this reason, many reliable informations concerning the seismic intensity were offered from the local people when a mission member made interview at more than 20 locations in and around Rangoon.

The distribution of seismic intensities evaluated on the basis of the informations obtained indicates that the strongest intensity is VII in the Modified Mercalli Scale at the downtown area near the Rangoon River, where moderate damage was done to some buildings (Fig. 2.1.8).

The pattern of isoseismals is elliptic rather than concentric. The major axis of the elliptic isoseismals lies in the NNW–SSE direction, and is nearly parallel to the stream of the river. It seems that the phenomenon is closely related to the geological structure of the area.

The maximum distance of perceptivity estimated from the intensity distribution is approximately 40 km.

c) Foreshock

The seismograph at the Kaba-Aye observatory detected foreshock activity. To be concrete, 9 foreshocks (seismic intensity of the largest earthquake of 9 events is VI), occurred for 2 hours from 05:40 on August 20, 1970 (local time) and one felt foreshock took place at 06:00 p.m. on August 21.

S – P times of the events are 2.2 – 2.4 seconds, which are slightly shorter than those of aftershocks. This suggests that the origins of foreshocks lie in an area being slightly close to the Kaba-Aye observatory in comparison with the area in which the main and after-shocks occurred.

It is notable that the earthquake occurring in December 1927 in Rangoon, which caused a certain damage, was also accompanied by some foreshocks.

d) Aftershock

The seismograph at the Kaba-Aye observatory recorded 27 aftershocks immediately after the occurrence of the main shock till September 14, and most of them were felt shocks. The records of aftershocks are too feeble to analyze, as mentioned before, and S – P times for only 4 events were measured. The S – P times are nearly 3 seconds.

The number of aftershocks decreases rapidly. More concretely, 10 aftershocks occurred for the first half a day after the occurrence of the main shock, 6 events in the

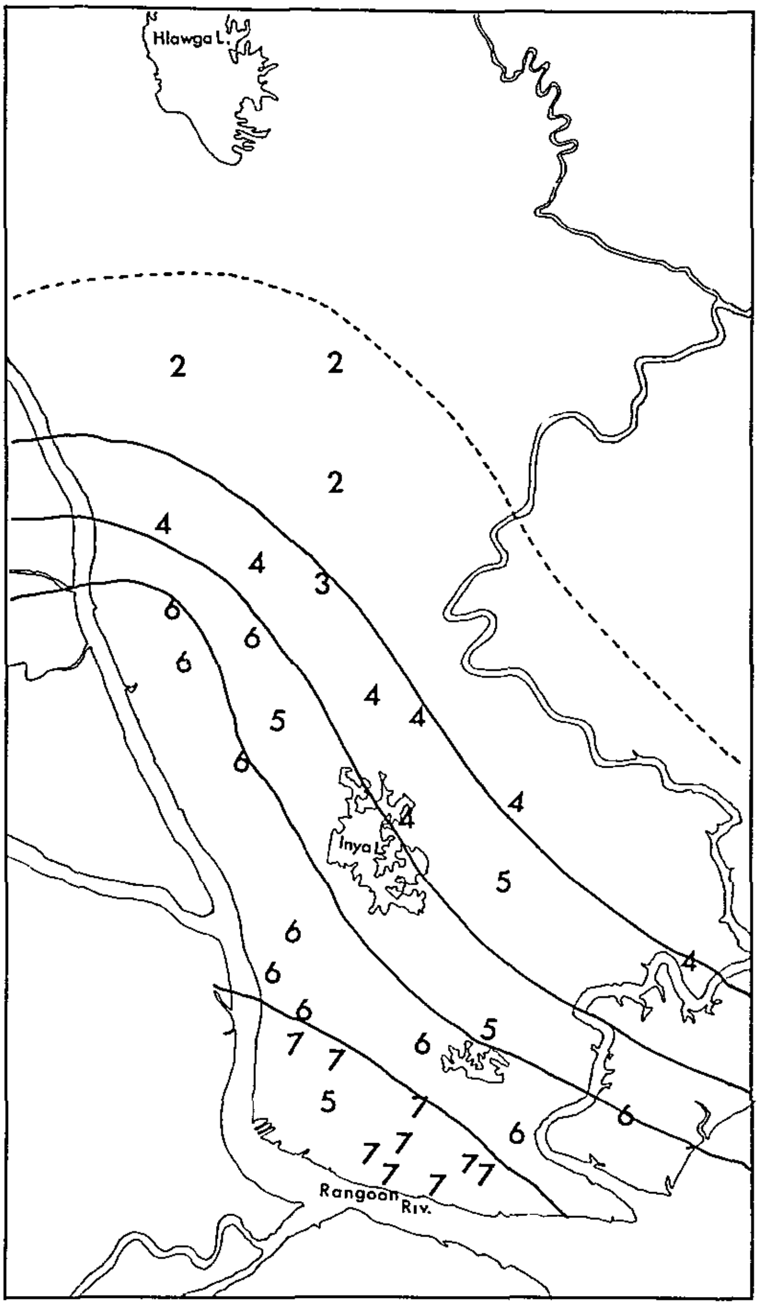


Fig. 2.1.8 Distribution of Seismic Intensities and Isoseismals for the 1970 Rangoon Earthquake

next 12 hours, etc.

The biggest aftershock took place on 12 September, after 3 days from the occurrence of the main shock, and the number of aftershocks slightly increased for a while. And then, the number of events decreased day after day. The state of the aftershock activity in time is almost similar to that of Japanese earthquakes. (Refer to Fig.I–1 (Appendix I)).

As the seismograms are too feeble to measure maximum amplitudes as well as S – P times for the aftershocks except for a few records, magnitudes of the aftershocks were difficult to evaluate by means of usual methods.

In view of both seismic intensities and duration of ground vibration recorded by the seismograph, the magnitude of the biggest aftershock may be smaller than 3 ½.

The statistical study for durations of ground vibrations recorded by the seismograph, which are closely related to earthquake magnitude, suggest that the activity of aftershocks in magnitude does not differ from the general trend of aftershock activity for big earthquakes occurring in and near Japan.

c) Earthquakes in and near Rangoon in the past

The earthquake whose magnitude is 7.3 occurred in 1930 at Pegu, 60 km northeast of Rangoon. Ancient documents on the history of Pagodas in Pegu, indicate that 32 destructive earthquakes occurred in and near Pegu during the past 2,100 years.

Unfortunately, so far as earthquakes occurring in the Rangoon area in the past are concerned, the data of the destructive earthquakes are not always satisfactory. However, according to ancient documents kept at the Shwe Dagon Pagoda, there occurred several earthquakes whose magnitudes were almost equal to that of the present event, during the period from 15 century up to the present. Remarkable contrast in seismic activities in the neighbouring areas such as Rangoon and Pegu is quite peculiar.

2.2 Public Works and Facilities in the Union of Burma and their Earthquake Resistibility

1) Design and Construction of Public Works and Facilities

Description of the public works and facilities

In Burma 889 miles of principal highway systems, 2667 miles of Railway systems, 873 miles of navigation systems on the Irrawaddy river, 31 airports and irrigation channel systems with dams are distributed over the land, but though not so densely, while long bridges are so scarce as to find only one crossing over the Irrawaddy river, the largest river in Burma having the length over 1000 miles. The Ava bridge is the only one that serves for pedestrians, vehicles and trains to cross the river in aerial spaces. The other aerial facility across the river is limited to electric power cables with four pylons at the length of 346 foot on each side bank of the river between Chauk and Lanywa near Mandalay completed last January to bring Lawpita hydro-electric power to the west side of the river.

No embankment is even found along the principal two large rivers, the Irrawaddy and Salween, however, a lot of dams for irrigation are found along small branches of these rivers.

The Baluchaung Project for hydro-electricity is aimed at providing electrical energy on a vast scale throughout the country. Started in 1953, there is at present a power station at existing Lawpita fall in the Kayah State. In this station there are three Hitachi generators each of which has a capacity of 28,000 kilowatts and Toshiba electronic-control system. The total capacity of 84,000 kilowatts will be doubled in the near future. Power transmission lines sprawl in two directions from Lawpita, one of them has 250 miles to Rangoon with sub-stations near Hlawga Lake and Toungoo, and the other has 223 miles to Mandalay with sub-stations at Kalaw, Thazi and Mandalay. Completion of these transmission lines has brought electricity to 109 towns and 287 villages out of about 60,000 districts.

This Project is brought by the Electricity Supply Board which is one of public corporations governed directly by the Government, under technical cooperation with the United Nation, and enterprises of Japan and Sweden directly. One more significant construction of the facility except the power station and power lines, is Mo bey Dam construction of which details will be mentioned in the latter paragraph 2.2(2).

In Rangoon city, the capital of Burma, public facilities such as steam power electricity stations, traffic control systems, telephone systems, water supply systems and sewerage systems are mostly furnished in the civic center and down town districts.

Design and Construction for the public works and facilities.

In Burma almost all of dams are earch fill structures and intakes and outlets of comparatively large dams are reinforced concrete structures.

Substructures of bridges are almost brick masonry structures even of the Ava bridge which is the longest bridge in Burma. Only exception is the Thaketa bascule bridge in Rangoon built under the supervision of the Government with the technical cooperation of Canadian Consultants during the period between 1962 to 1967, which consists of prestressed concrete for superstructures and reinforced concrete for substructures.

Almost all of construction of the existing public works and facilities would have been constructed under the supervision of the British code and regulation for construction, because they had been constructed during the sovereign age of British Kingdom before World War II.

Recently, Russian and Swedish techniques have been introduced for the design and construction to complete Kyetmauktaung dam and Mobey dam respectively, therefore the codes and regulation for the design and construction are also depending on each of such countries. Meanwhile, the articles of the specifications of AASHO (The American Association of State Highway Officials) have been equivalently adopted for design and construction of ordinary highway bridges.

In order to construct such structures man-power construction methods have been widely applied in Burma, recently, however, machinerized construction methods are introduced in the construction of Mobey dam but it represents few example to comprehend and evaluate the general level of standard for construction methods in Burma.

2) Typical Examples of Construction

Reflecting the state requirement for attaining a rapid industrialization, great emphasis has been placed on the completion of the construction of dams and intakes for hydroelectricity in availing the advantage of its rich natural resource of water caused by rainfall of upto 2000 mm in annual average. As the first fruit, Mobey dam is almost completing as mentioned in preceding section 2.2 (1).

Mobey dam construction began in 1967 based on the design and supervision of construction by Swedish consultants. The dam is a fill type along the Salween river, a branch of the Baluchaung river, with 22.4 m in height and 2.4 km in length. Near the right bank crossing the body of the dam a dock for navigation and gates for irrigation are arranged.

Soil for fill materials and concrete for the dam are supervised very well according to Swedish manuals, but the seepage protection between the fill part and concrete part for the dock and gate is questionable for earthquake proof because sheet piles of steel with some length stretch into the fill part from the concrete part.

At the completion of the dam, Lawpita power station will be able to get energy of water completely, and the capacity of the power station will be doubled, then the pipe line or penstock and generators will be completed soon and the existing Lawpita fall will be almost try.

3) Earthquake Resistant Design of Public Works and Facilities

In Burma, presently, there is no provision nor specifications related to design and construction of public works and facilities, likewise no testing on structural materials and soil materials is being done in the case when the government supervises the construction works.

Such a situation is not desirable and should be improved urgently overcoming such difficulties as (1) to be too much hasty for constructing structures as can not wait for the development of soft technology with usually take some time and (2) unprefer system that the design, construction and also supervision of the government project are entirely conducted by the government itself.

Only exception is found in the case of the Baluchaung Project, when the supervision of Mobey dam construction is covered with a Swedish provision completely. In this case selection, defining, testing and ensuring of the materials for the construction have been carried out by local engineers.

Through such experiences the gradual rationalization of the supervision and design of constructions would comprehended among the local engineers, then the final target of the complete rationalization in an ordinal level of world standard will be attained in the future

2.3 Buildings and Housing in the Union of Burma and their Earthquake Resistibility

1) Design and Construction of Buildings and Housing

Brick buildings and wooden houses are most popular in the Union of Burma. There are many brick buildings of 2 ~ 4-storey in the large cities, some of which has been constructed about 70 years ago. In the local towns, most buildings and houses are built of wood. Followings are the outline of the buildings and houses and their earthquake resistibility

a) Brick buildings in Burma are divided into the following three types:

i) Pure brick construction: As brick buildings have been constructed since the British Age so their construction type is british one which has wooden roof and slabs. Earthquake resistant design has not been adopted, because the British type of construction has developed where there is no concern about earthquakes.

ii) Brick-nogging construction: "Brick-nogging" is a wooden framed brick construction which is usually used for the 2-storey houses. As will be mentioned later, this type of construction is also adopted in the new housing project, which may be considered to be more earthquake resistant than the pure brick construction.

iii) Semi-pucca construction: "Semi-pucca" is a combined brick and wooden construction. In usual case, first floor is built of brick and second floor is built of wood.

b) Wooden construction: Wooden construction is used often in the dwelling houses. Sometimes, bamboo is used for finishing materials. Roof is finished with galvanized iron sheet or straw. As the wooden frame is stiff and the roof is light, it may be considered fairly earthquake resistant.

c) Reinforced concrete buildings: There is a few reinforced concrete buildings in Burma, mainly because of the shortage of the materials and the engineers. Most of them have been designed and constructed without taking into account of earthquake resistance by the foreign engineers who were unconcerned with earthquake resistant design.

2) Damage to Buildings by the 1970 Rangoon Earthquake

Several buildings in Rangoon city were damaged by the earthquake occurred on 9th September 1970. Although the mission arrived at Rangoon four months after the earthquake, the following informations on the damage could be obtained in cooperation with the Burmese Government and engineers.

Although the magnitude of the earthquake was not so large, several buildings suffered considerably severe damage and many houses were cracked, which were mainly caused by the reason that most of these buildings and houses were brick construction designed without giving almost any consideration on the earthquake resistance.

A list of the damaged buildings is shown in Table 2.3.1 based on the data provided by the Construction Corporation. Examining the damage in Table 2.3.1, however, it may be suggested that there must be many other cracked buildings and houses in the city of Rangoon. Among these damaged buildings and houses, the State House, the Rangoon General Hospital, the Grand Pharmacy Building and the Shwe Dagon Pagoda were damaged severely, for which damage will be given some explanations in the followings:

a) State House: This 3-storey brick building is a palatial mansion constructed in 1895 as shown in Photos 2.3.1 (a) and (b). As shown in Fig. 2.3.2, many cracks were observed in the main arches and the columns around the stair cases.

In spite of the relatively slighter damage in its outward appearance of the State House, it is considered that the earthquake resistibility of this building would have decreased considerably by the damage due to the 1970 Rangoon Earthquake, considering the cracks in the main arches and the dislocations formed in the connection parts between the outer walls and the main arches.

The reinforcement of this failure formed in the brick building can not be considered to be effective if the joint part between the wall and arch could not be strengthened in accordance with the most effective measures. The same consideration should also be needed for repairing and reinforcing the damaged pharmacy building which will be described in Section (c) later. The wooden slabs and frameworks of the State House building were also contributed to give illeffect for enlarging the damage, because such constructions prevented the wall to resist earthquake motions as a whole

Table 2.3.1 A List of Damaged Buildings

No	Name of Structure	Type	Stories	Damage	
1	Post Telegraph Training School	Brick	2	Cracks in the wall	Slight
2	State Middle School No. 1	"	3	Cracks at the crown of arches	"
3	Old Secretarist	"	2 or 3	Cracks in the wall	"
4	Custom House	"	4	"	"
5	Munees Building	"	4	"	"
6	ESB Chairman Office Building	"	3	"	"
7	Grand Pharmacy Building	"	2	Cracks in the wall, Inclination of wall	Severe
8	Rangoon General Hospital	"	3	Cracks at the arches	Moderate
9	SHS No. 4, Ahlone	"	2	Cracks in the wall	Slight
10	Central Women Hospital	"	3	"	"
11	Office of the Director of Agriculture	"	3	" (Window sill)	"
12	SHS No. 4, Trmwe	"	1	"	"
13	State Film Promotion Board	"	2	"	"
14	NHB Building	"	4	Cracks at the floor slab	"
15	Research Institute	"	?	Cracks in the wall	"
16	Foreign Language Insitute	"	1	Cracks in the wall	"
17	Building No. 5, Pagan Road	"	2	Vertical cracks in the wall	Moderate
18	No. 32, Chancellor Road	"	2	Cracks in the wall	"
19	Railways Central Training School	"	2	Horizontal thin crack line at sill level of the 1st floor almost the whole building	Slight
20	State House	"	3	Cracks at the arches, inclination of wall	Severe
21	RIT Building	RC	3	Cracks in the jointing wall	Slight
22	Shwe Dagon Pagoda	Brick		Inclination of the top, falling down of the bells	Moderate

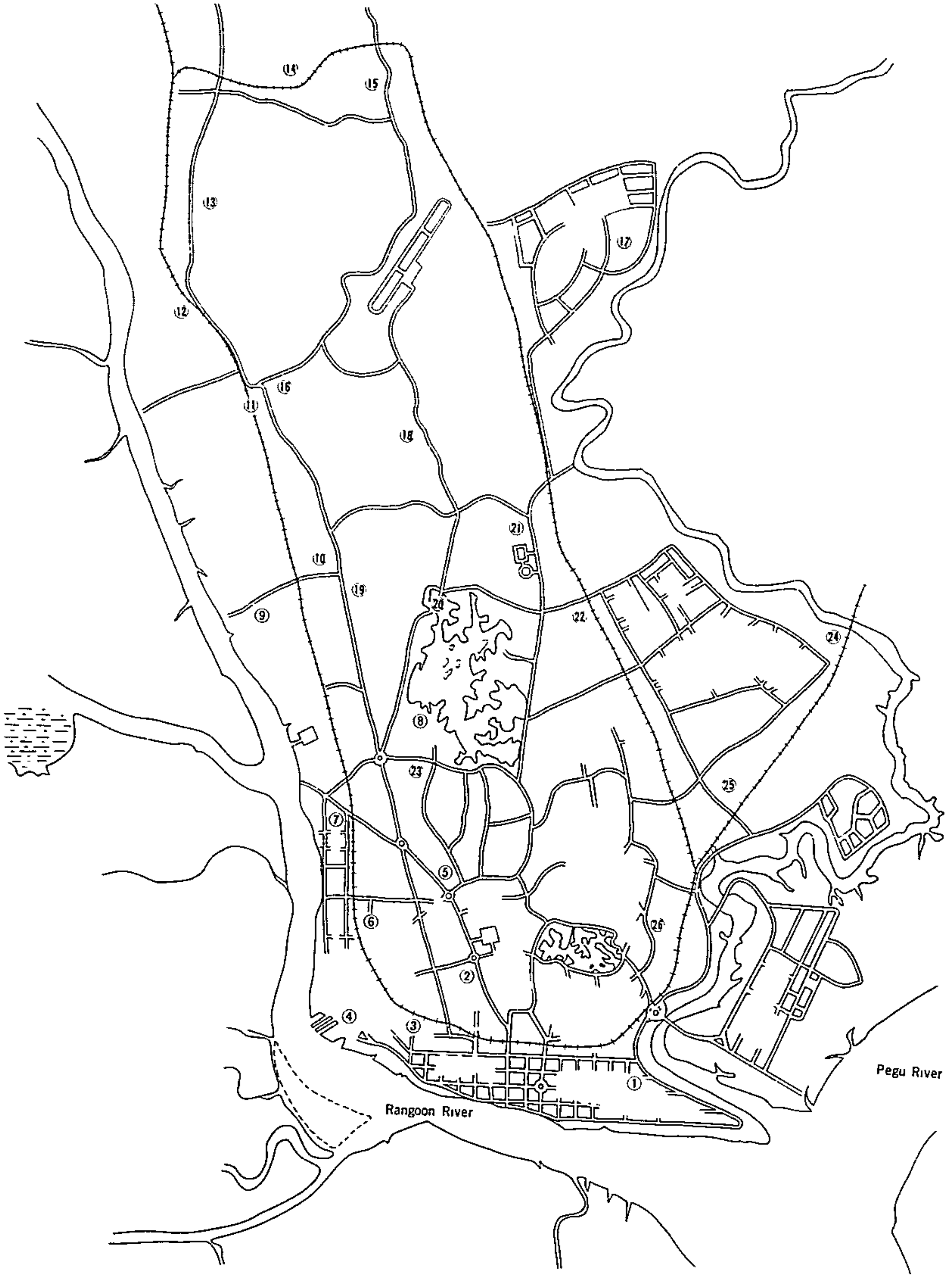


Fig. 2.3.1 Location of Buildings Damaged by the 1970 Rangoon Earthquake

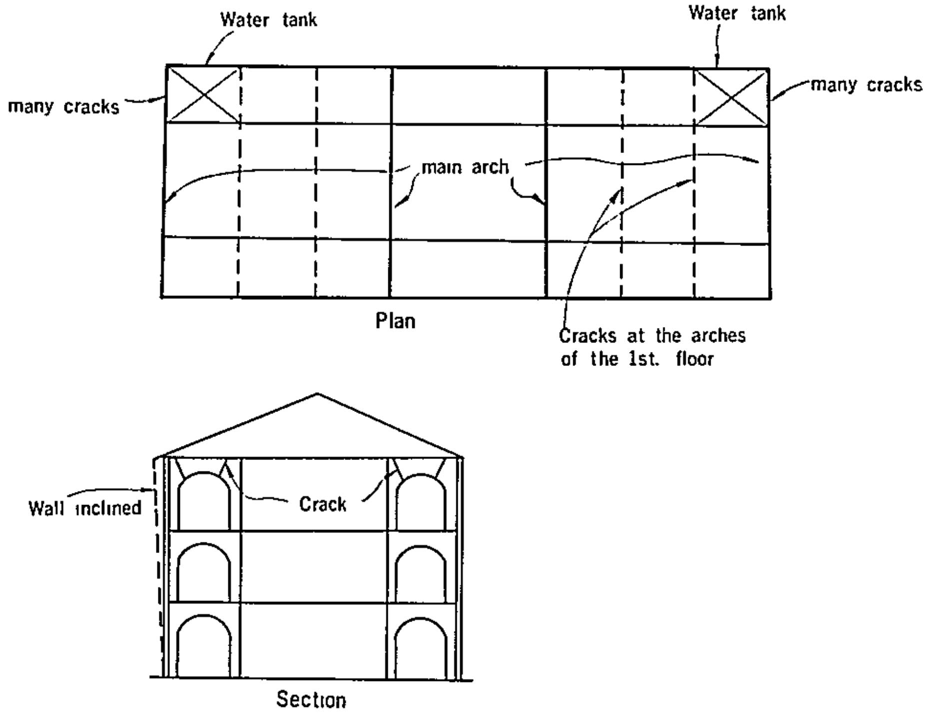


Fig. 2.3.2 State House

mass.

b) Rangoon General Hospital: This 3-storey brick building had wide openings in the exterior walls like the State House building as shown in Photos 2.3.2 (a) and (b). Type of the damage was similar to that of the State House. Main failures were observed at the arches in the 3rd storey. (see Fig. 2.3.3)

c) Grand Pharmacy Building: This 2-storey brick building of the size of 42 x 174 meters suffered considerable damage. Exterior wall was separated from the cross interior walls, which were provided in the equal distance of 7 meters along the longitudinal direction, and it inclined outward for the angle of about 1/100 as is shown in Fig. 2.3.4 and Photo 2.3.3.

The earthquake damage of these three buildings is considered to be derived from the similar causes, such as the lack of the earthquake resistibility at the joint part between the exterior wall and cross interior wall, at the wide openings etc.

d) Shwe Dagon Pagoda: As is shown in Photo 2.3.4, the structure of the golden tower of the pagoda consists of solid brick having the height of 326 feet. On the top of the tower, a steel rod of about one foot diameter is standing, surrounded by many gold and silver bells hanging around it. Due to the earthquake motions, the top part was bent and many bells fell down. As mentioned above, there are many records that pagodas in Burma have suffered damage many time in the past earthquakes. With respect to the Shwe Dagon Pagoda, there is preserved reliable record that it has been suffered earthquake damage at least seven times since 1492.

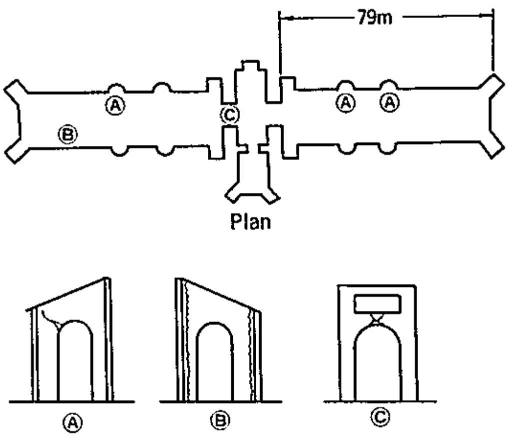


Fig. 2.3.3 Rangoon General Hospital

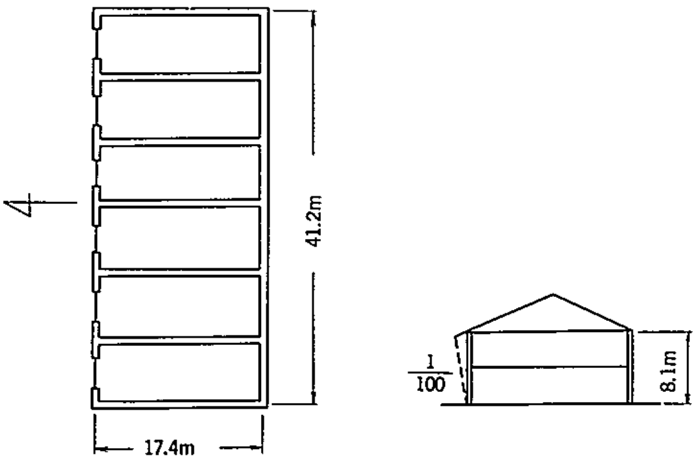


Fig. 2.3.4 Grand Pharmacy Building

Following is a simple analysis on the vibrational behavior of a pagoda during earthquake.

Assuming the shape of a pagoda to be a cone, the fundamental natural period can be expressed approximately by Eq. (1), using Mononobe's formula.

$$T \fallingdotseq 0.719 \frac{h^2}{k} \sqrt{\frac{W}{g \cdot E}} \text{ (sec)} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where, h : height of a cone

k : D/4

D : diameter of the base of a cone

w : weight of materials in unit volume

g : acceleration of gravity

E . Young's modulus of materials

Substituting $E=4\times10^{4}$ kg/cm^{2}, $w=2\times10^{-3}$ kg/cm^{3} and $g=980$ cm/sec^{2}, into Eq. (1), we obtain,

$$T \fallingdotseq 2\times10^{-3}\times\frac{h^2}{D}\ \text{(sec)} \quad \ldots\ldots\ldots\ldots \quad (2)$$

where, h and D are expressed in meters.

Considering that both h and D are in the order of one hundred meters in the case of Shwe Dagon Pagoda, the natural period can be presumed to be in the order of 0.2 sec or so. It indicates that the natural period of a pagoda is fairly short.

On the other hand, its weight in unit base area is given by,

$$f = 1.2\times h\ (\text{t/m}^2) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

From this equation, the bearing capacity of the ground at the base of Shwe Dagon Pagoda is estimated about 120 t/m^{2}. It shows that the subsoil condition can be presumed to be considerably good.

According to the earthquake response analysis, it is well known that the response acceleration of a rigid structure on hard ground may possibly amount to the value of twice or three times of the maximum ground acceleration. Furthermore, the response acceleration of such a structure as a pagoda, of which stiffness and mass decrease suddenly along its vertical axis from bottom to top, is amplified several times especially in its upper part compared to that of the structure having uniform distribution of stiffness and mass. Considering these points, it can be understood that the top of the pagoda is quite liable to suffer damage when it is subjected to severe earthquake motions. Unless the earthquake resistant design is adopted, the earthquake damage to the top of a pagoda would be repeated in the future too.

Similar earthquake damage was observed in the case of the 1968 Tokachioki earthquake in Japan. The top of the 5-storey pent house on the 3-storey reinforced concrete building was shaken severely by the earthquake and was fallen down as shown in Fig. 2.3.5.

3) Subsoil Condition in Rangoon City

Subsoil condition in Rangoon city is shown in Fig. 2.3.6, of which original data have been offered kindly from Prof. Ba Tan Haq and his graduate student. Judging from this figure, it is suggested that the west part of the city along the Rangoon river consists of soft

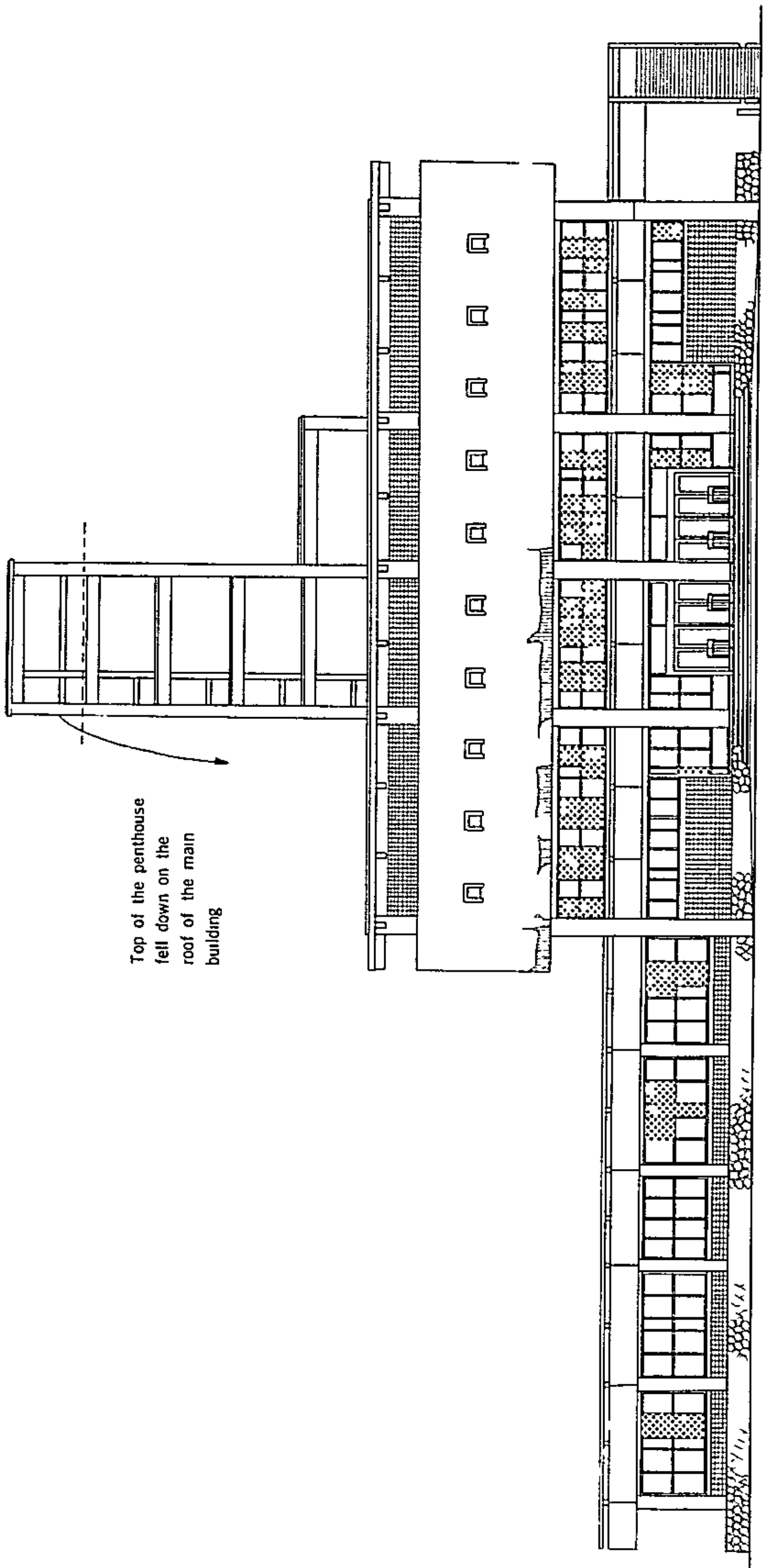


Fig. 2.3.5 Damaged Building in the 1968 Tokachi-oki Earthquake

alluvium layer and other part consists of comparatively hard sand stone or shale covered with loamy laterite. Alluvium layer spreads within the hatched portion in Fig. 2.3.7, where the arabic numerals show the depth to the sand gravel layer in feet. Numerals at another portion in Fig. 2.3.7 show the thickness of laterite layer. Fig. 2.3.8 shows the presumed section along A–A' in Fig. 2.3.7.

It is well known that the poor subsoil leads to the severe earthquake damage to buildings because of the amplification of ground motion, land slide, differential settlement of foundation and liquifaction. Fortunately, in the case of the present earthquake there was

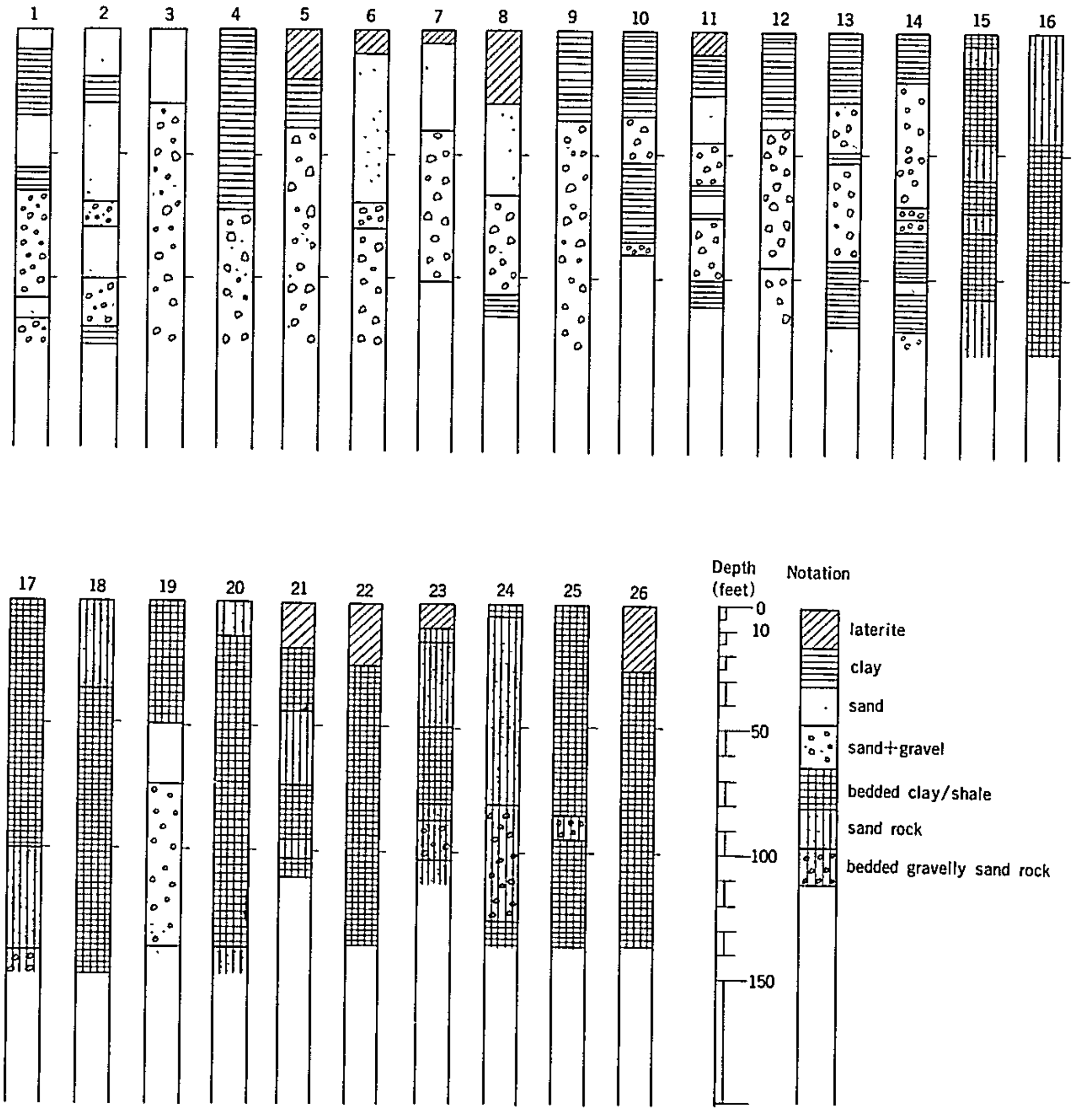
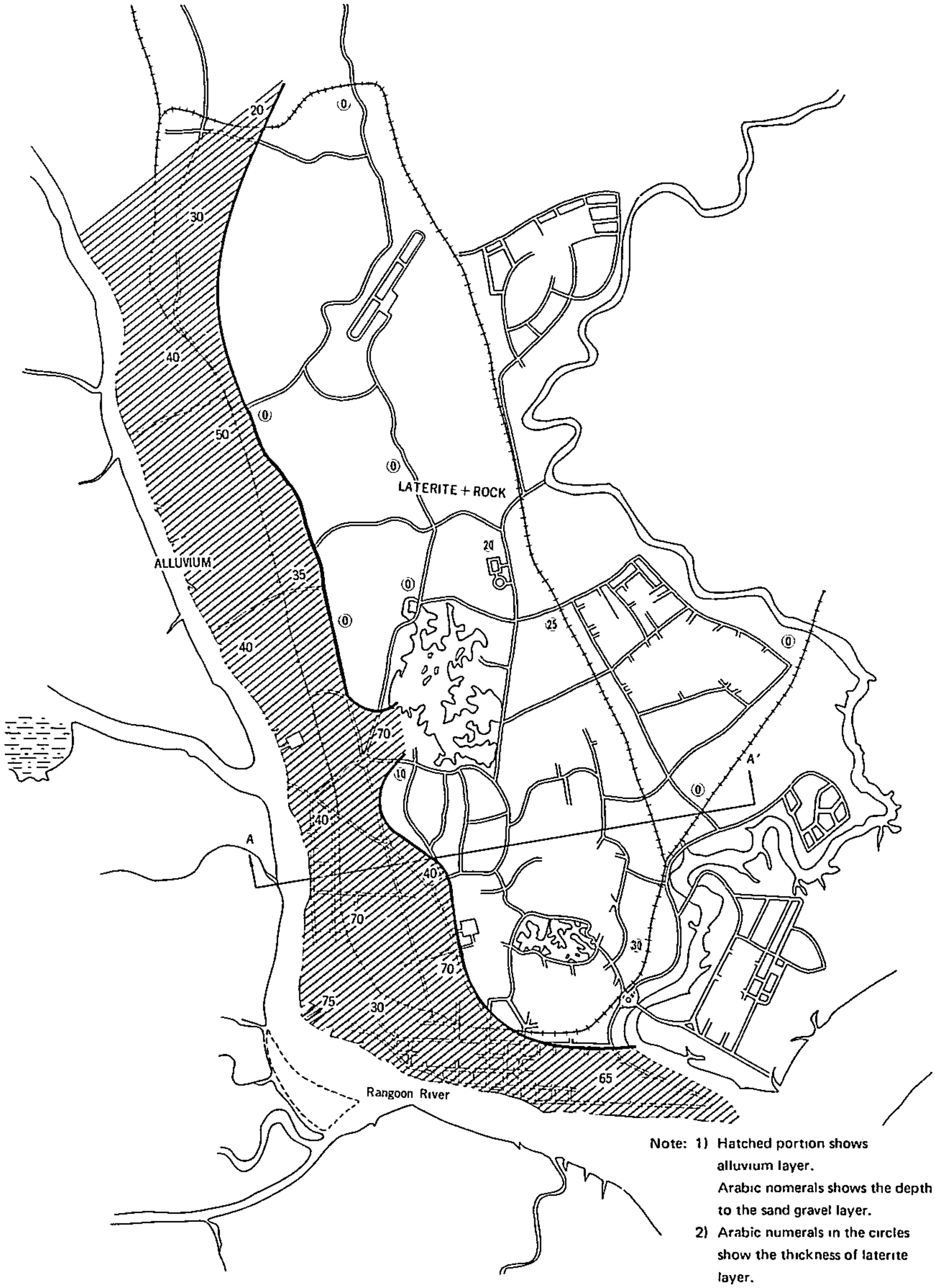


Fig. 2.3.6 (a) Boring log in Rangoon City

Fig. 2.3.6 (b) Location of Boring Test



Note: 1) Hatched portion shows alluvium layer.
Arabic nomerals shows the depth to the sand gravel layer.
2) Arabic numerals in the circles show the thickness of laterite layer.

Fig. 2.3.7 Subsoil Condition of Rangoon

observed no such damage in Rangoon. However, if a severe earthquake should attack the Rangoon city, there is a high possibility that a large scale of destructions will be caused to the buildings and houses, especially, to those that are standing on soft ground.

Furthermore, the information described here does not include the subsoil condition of the east part of Rangoon along the Pegu river, where the new town is now under construction. Judging from the data with the west part of the city, it may be reasonably suggested that the subsoil condition of this eastern part of Rangoon will be also fairly poor. In order to prevent the new houses in the new satellite town from future earthquake destruction, more precise investigations on the subsoil conditions in this area is strongly recommended.

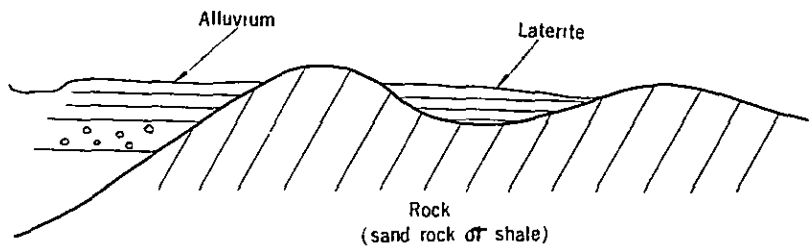


Fig. 2.3.8 Presumed Section of Subsoil in Rangoon

4) Typical Examples of Housing Projects

Mission visited several construction sites where the new housing projects have been proceeding. The outline of each project will be described in the following with our views for improving the earthquake resistibility.

a) U Wisara Housing Project. This urban housing project is to construct about 5,000 houses in the coming five years. Main structure of these houses consists of reinforced concrete frames with brick partition walls as shown in Photo 2.3 5. Structural design is based on the British Code of Practice (CP 114), which is partially modified considering the local condition in Burma. Calculation for earthquake resistant design is not adopted but some consideration for earthquake resistance are taken into account in arrangement of reinforcing bars However, since it is rather difficult and uneconomical to ensure the building to be earthquake resistant without making any suitable calculation, it is advised to carry out earthquake resistant design for the houses in this project taking into consideration a proper amount of lateral force. In this type of construction, the brick walls for partition would be expected to act as seismic walls if they are arranged uniformly in their plan and fixed into the reinforced concrete frames.

b) Chomery 34th St. Apartment House· This 4-storey apartment house consists of brick walls and reinforced concrete slabs. Earthquake resistibility to the longitudinal direction seems very poor, because there are few walls in this direction, while in the span direction there are walls located in every four meters. As shown in Photo 2.3.6, brick work is very poor. Since earthquake resistibility of the buildings, especially for brick buildings, depends greatly on the workmanships, these poor workmanships should be improved as soon as possible.

c) Thuwunna Satellite Town Project: This project is one of the new satellite town plannings presently proceeding in the suburbs of Rangoon, aiming at constructing 5,000 houses. With respect to this plan, 2,000 houses have completed. Among the finished 2,000 houses, two-third are 2-storey brick houses and others are brick-nogging. As shown in Photo 2.3.7 (a), brick houses could not be considered to be earthquake resistant structure because they have wide openings in the exterior walls. On the contrary, brick-nogging houses seemed likely to be more earthquake resistant than brick houses, because their openings were small, wooden frames were stiff and brick walls were reinforced with steel wires which connected the walls to the wooden frames tightly.

It is recommended that this type of the construction would represent presently the best way of construction to ensure such houses most earthquake resistant in Burma.

3. Present Status and Scope of Seismology and Earthquake Engineering in the Union of Burma.

3-1 Seismology and Seismological Observation

1) Present status on seismology in Burma

As it has already been touched in Section 2-1, studies on earthquake phenomena in Burma was initiated by geologists who have interested in the geology and tectonics in the regions of northeast India and Burma as early as 1880.

In spite of relatively long history of the earthquake study in Burma, striking achievement in this field has not been attained partly because, fortunately, Burma has not experienced for these many years such destructive calamity due to earthquakes as those of Tokyo in 1923 or Peru in 1970, and partly because the social circumstance of the country did give no stimulation for the progress of the study in this field.

Under these circumstances, however, several good efforts have been extended, though narrowly, in inviting Prof. G. P. Gorshkov as an UNESCO experts on seismic zoning and seismotectonics in 1959, and forwarding U Shien Shwe U to the Shillong Seismological Observatory in India in the capacity of research fellow on seismology of the Department of Meteorology, Union of Burma.

Presently through the interview of many responsible persons in the Government and universities, the Mission was able to take in the impression that many of these persons were strongly hoping to improve the study and research on seismology in this country by which most effective measures could be taken in advance for protecting the lives and properties of the Union of Burma from the large destruction due to earthquakes which might attack this country.

It is strongly hoped that these sincere desires of the persons concerned could be born fruits step by step in taking actions successfully as forwarding young people to abroad for training, electing chairs or starting the lectures in this field in the universities and institutions.

2) Seismological Observation

a) Existing Seismological Networks

The first seismological observation had been conducted at a seismological station in the University of Rangoon. Unfortunately, however, the station was destroyed during the Second World War.

Around 1960 two seismological stations were established at Rangoon and Mandalay. Both stations which belong to the Meteorological Department are equipped with two horizontal Sprengnether seismographs and a vertical Willmore seismographs.

The Mission payed a visit to the Kaba-Aye Seismological Station, which is the site of the Rangoon Seismological Observatory located in the campus of the Meteorological Department in Rangoon. Seismographs of the observatory were installed on a stable and large concrete block housed in a semi-underground building having a very thick wall which was keeping effectively fairly constant room temperature. The ground condition of the observatory, however, unfortunately did not seem proving satisfactory for seismological observation partly because the concrete blocks were obliged to be constructed on rather soft ground due to the lack of hard rock in the moderate depth, and partly because high traffic noise came from the much civilized circumstance around the observatory were disturbing so much the high sensitive observations.

In parallel to the project of constructing new stations, it is strongly recommended that the Kaba-Aye Station should be removed to some other place in the suburb of the City of Rangoon, where hard basement rock can be found, if possible, within several meters and showing fairly low ground noise level.

The Mission visited the Seismological Station of Mandalay, too. The station is situated at the foot of Mandalay Hill, and conditions of the station are more favorable than those of the Kaba-Aye Seismological Station in Rangoon. To be concrete, the station is constructed on hard bedrock (limestone), and is far from origins of local disturbances such as traffic, machinery, etc. As a matter of fact, the peak magnification of the Willmore seismograph at Mandalay is about ten times as large as compared with that at Rangoon.

Seismic observations and maintenance of instruments at the stations have been conducted by the staff of the Meteorological observatories as a side job. As it is not established a post for engaging seismological observation as their principal job, the persons in charge for seismological observations in each station are facing much difficulties in performing seismological services without trouble.

b) Seismological observation project by means of new networks of 8-station system

Dr. U Tun Kyew, the director of the Meteorological Department of the Government of Burma expressed that the Department was now planning for enforcing the seismological observation organization of Burma by establishing urgently at least six new seismological stations, in addition to the two exiting ones in Rangoon and Mandalay. The Mission wellcomed very much the Director's proposal because such a great project as to set up effective seismological networks in one country never could be completed in success if the initiative of the project should not be taken by the national authorities and if the devotion to the project should not be ensured spontaneously by the personnel in charge for seismological observations.

In reflecting the active enthusiasm of the Burmese authorities on this project, the Mission feels that it is not necessary to repeat the necessity for establishing the advanced seismological networks in Burma but only necessary to recommend here practical items urgently needed in practising such an important project.

For the successful operation of the project the most important items will be focused in such points as, firstly number and location of new stations and then secondly organizations and personnels to be engaged for the seismological observations.

i) Number and location of seismological stations to be set up in Burma

i-1) General idea

For the purpose of establishing the new seismological networks in Burma, needless to say, carefull considerations should be payed to find out the most appropriate conditions for determining the number and location of such a seismological stations.

The most appropriate conditions, however, are very difficult to settle, because criteria for fixing "the most appropriate" differs greatly in accordance with the difference of the standpoints or objectives for establishing new networks.

Taking into considerations on the present status of the Union of Burma, it is reasonably concluded that the Mission should recommend such a network as to be of direct use for providing indispensable data to minimize the loss of lives and properties which might be caused by the attack of large earthquakes to the populated area of Burma in the future

Basing upon such a standpoint, we carried out a carefull examinations on the minimum magnitude of earthquakes that are required to be detected, sensitivity of seismographs to be installed in the stations, in related to the largeness of the teritory of the Union of Burma.

Under the assumption that the current modern seismographs having nearly equal magnification with the world-wide standard seismograph could be furnished in the new seismological observatory, as the first stage, the Mission considers eight seismological stations will give the most appropriate number for the seismological observation network in Burma. In such a case, carefull examinations should be required on the detectability of such a seismological network, so, in the following section scientific examination has been extended in order to give a proof that eight-stations network system will provide satisfactory seismological observations in Burma.

i-2) Selection of the new stations

In recommending the eight stations, we are of cause in mind that the two existing stations, Rangoon and Mandalay, should be included in the new network, so it is expected to establish six new stations. As to the location of these new stations, besides such condition as to be required from purely scientific standpoint which is mainly derived from the detectability of minimum earthquakes, there should be considered many other local conditions such as accessibility to the station, possibility for using existing facilities, easiness for obtaining higher level technician for operation, possibility for finding hard rock basement and so on.

In the selection of the new location of seismological stations, it is also necessary to pay good attentions for protecting lives and properties from earthquake destructions especially those of the larger and more important cities such as Rangoon and Mandalay, etc. Therefore improved detectability unto smaller earthquakes should be secured in the area near to these cities With respect to these local conditions we were provided all necessary informations from local personnel under hearty cooperation of them. Taking into considerations of all these circumstances, we are now recommending following six locations (from No. 2 to No. 8) as sites of the new seismological stations. The priority for constructing new stations should be in the order from top to bottom.

Name of Stations for the New Seismological Observation Network in Burma

Existing stations	1.	Rangoon
	2.	Mandalay
New stations to be established	3.	Toungoo
	4.	Tavoy
	5.	Myitkina
	6.	Thyayetmgo
	7.	Kengtung
	8.	Akyab

As to the construction of these new stations, the Mission expresses it's sincere hope that the construction works should be started as early as possible, so that desirablly the first new stations could be completed in 1972, then thereafter every year completing two stations. In doing so it can be anticipated that the new seismological network of Burma having 8 stations can run into operation within three or four years. Because the seismological data will provide the most foundamental materials for the disaster prevention planning by destructive earthquakes, it must be emphasized the necessity of setting up these 8-station seismological networks with great enthusiasm, completing as quickly as possible, say within three to four years.

i-3) Detectability of the proposed new seismological networks

By means of the remarkable success of the World-wide Standard Seismograph Networks Project by the US Coast and Geodetic Survey, all earthquake having magnitude 5.5-6.0 or greater are recorded and located without slipping out from the observation networks throughout the whole earth even though they might take place in the mid-ocean or in the desert where no seismological stations could be found within a few thousand or more kilometers. Therefore the new seismological network to be constructed in Burma should be endowed with more improved detectability for smaller earthquakes, that takes place in the territory of Burma.

Assuming that each new seismological station is equipped with seismographs of which effective magnification is about 10,000 times, and that accuracy of reading for first motion of P wave at every station is within 1 second, computer simulations were carried out to evaluate the detectability of the proposed seismological network composed by 8 stations (Fig. 3.2.1).

The results obtained indicate that location of Burmese earthquakes whose magnitudes are 4.5 and larger can be detected by the network with accuracy of 10 km.

This means the detectability of the proposed network exceeds by about 1 in magnitude unit in comparison with that for the USCGS networks, and corresponds to that of the Japan Meteorological Agency for events occurring in Japan.

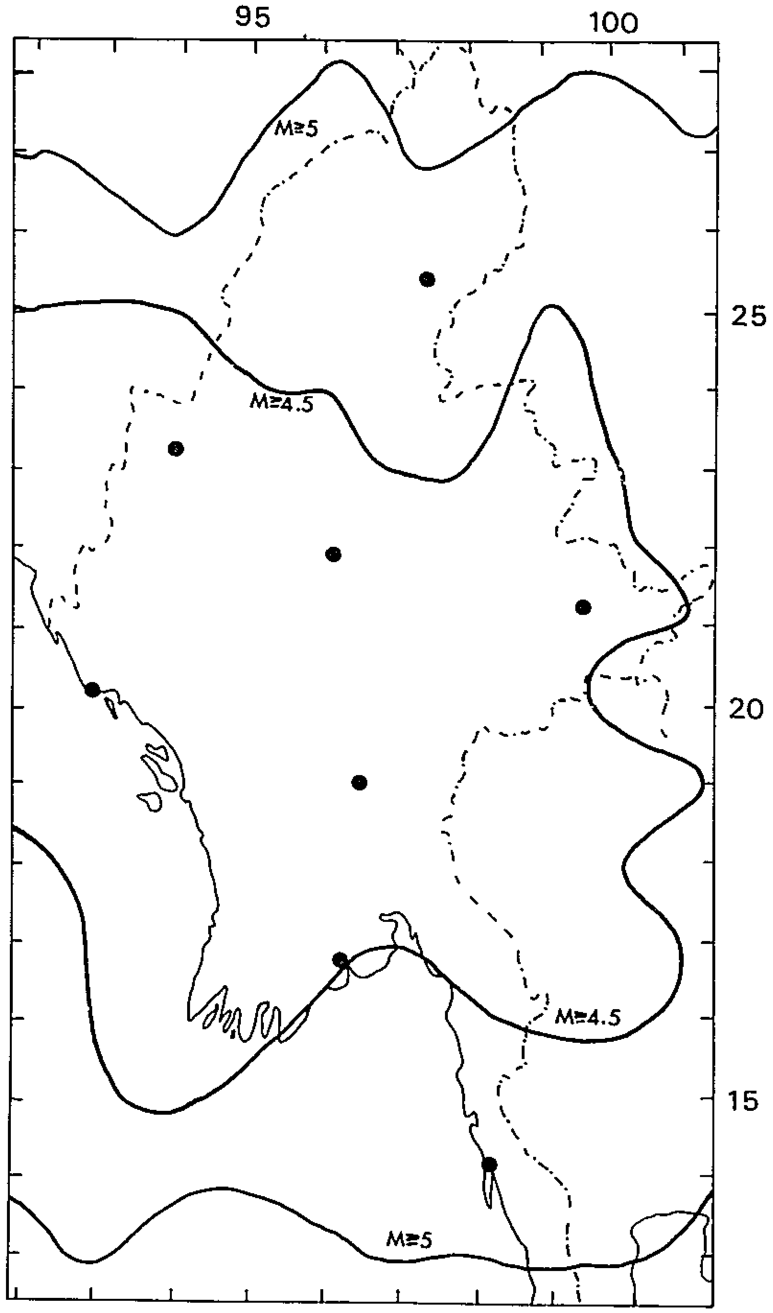


Fig. 3.2.1 Lower Limit of Earthquake Magnitude (M) which can be Detected by the Proposed Network.

i-4) Importance to have a direct link with the International Seismological Organizations.

Needless to say, seismological observation demands a strong international cooperation, by which great benefit can be brought about for the both bodies. From these reasons, it is strongly recommended that, in view of the largeness of the territory of Burma, at least one seismological station in Burma should be an international station having equipped with first class, three component, long period seismographs recording in a way internationally agreed upon and connected by the direct and strong link with the international seismological organizations, such as, (a) the International Seismological Center in Edinbrugh, UK, (ISC), (b) United States Coast and Geodetic Survey in Rockville, Washington D. C., USA (USCGS), and (c) the Bureau Central International de Séismologie in Strabourg, France, (BCIS), (d) Council of Seismology of the USSR Academy of Sciences, Moscow, USSR and so on.

According to the international understanding agreed upon on the occasion of the Intergovernmental Meeting on Seismology and Earthquake Engineering of 1964, held in Paris under the sponsorship of UNESCO, the average distance between the two neighboring international stations was about 1,000 km, so geographical location of both stations, Rangoon and Mandalay, will satisfy fairly nicely above requirement because it can be measured roughly in the order of 1,000 km from Shillong Station in India and to Chiengmai Station in Thailand.

If it could be possible for locating a new Rangoon Station at a site where resting on a hard basement rock and showing a low noise level, then the new Rangoon Station will be better to be an international station because the seismological central office together with an electronic computer facility, will be set up in the Meteorological Department in Rangoon. However, in the case when it was difficult to find a favourable site for seismological observation in the suburb of the city of Rangoon, then Mandalay Station should act as an international station.

ii) Provision for creating new posts in the Governmental organization for the experts on seismological observation

In order to have a successful running on the project of seismological observations in Burma, there are two essential elements without either of which the operation of the project would be cut off completely. These two elements are (1) seismological stations and (2) personnel in charge for the observation project.

The items (1) has already been discussed in the above Section. In this Section the Mission proposes to call upon attention of the authorities in the Government of the Union of Burma on the problem raised in items (2) above, namely, personnel in charge for the observation project.

It is a matter requests no explanation that without the personnel who devote themselves exclussively for seismological observation business, such a big project as the seismological observation could never be carried out. Therefore the creation of the posts for the personnel who will extend full time services for the seismological observation business is indispensable.

It is strongly recommended that the prompt action should be taken for creating new posts in the organization of the Meteorological Department for the personnel who would engage in the job of seismological observations.

It should also be a matter of great importance to call upon the attention of the higher level authorities in the Government that such new posts for the seismological observation personnel should be such posts as attractive enough for them promissing the future promotion up to fairly a high position, according to their capability and degree of contribution for the project.

3.2 Earthquake Engineering and its Application

1) Science and Technology related to Earthquake Engineering

i) Higher level of education

Rangoon and Mandalay are the principal seats of higher level of education and research works in Burma. There are respectively an art and science university and university-level professional institute in these cities. Moulmein has a degree-offering college while Bassein, Taunggyi, Magwe and Myitkyina have an intermediate college each.

Radical changes were introduced to the system of higher level of education in Burma during the 1964-65 academic year by the Revolutionary Government established by General Ne Win in March 2, 1962. Up to date the pattern of university education is basically the same as in pre-war. The pivotal district of university-level education, science and technology has been Rangoon, while the system of the education has been reformed by the government since 1964.

Anyhow the overall direction of policy of higher education in Burma formed by the Union of Burma Central Council of University Education and Council of Academic Bodies.

With respect to the education of earthquake engineering, the Rangoon Institute of Technology provides only a Department of Civil Engineering and then a Department of Geology is instituted in the Art and Science University in each of Rangoon and Mandalay. None of Seismology department nor lecture course is provided for the university level education.

On the application of basic science and technology, the Applied Research Institute of the Union of Burma is in charge for functioning not only a liaison between academic side and the application in Burma but also an executive organization for only the progressive technology in such field as agriculture, fishery and agricultural chemistry. Presently, none of engineering problem is treated in this Institute.

ii) Vocational and Technical education

The facility of vocational and technical education is provided by the Industrial Trade Schools, State Schools of Fine Art, Drama and Music, the Government Technical Institutes at Mandalay and Insein having the polytechnic classes, the Saunders Weaving Institute at Amarapura, the Institute of Veterinary Science and Animal Husbandry at Insein, the Agricultural Institute at Pyinmana, the Technical High School at Rangoon and the Rangoon Institute of Technology.

The Rangoon Institute of Technology is situated at Gyogon in suburban Rangoon occupying the area of about 160 acres. It is a degree-offering college for architecture, civil, electrical, mechanical, chemical, textile, metallurgical, mining and agricultural engineering. When it was the Faculty of Engineering of the Rangoon University, it admitted for four-year courses only to those who passed the intermediate examinations of other colleges. Since the 1964 academic year, its admission has been extended to matriculates who must undergo a six-year degree course.

iii) Present Status of Application of Electronics Technology to Education and Research

There is none of electronic computer but some soft wares in Burma. Meanwhile a radio network sprawls over principal cities under the administration of the government and television system is provided for trial use for education.

2) Present Status on Earthquake Engineering and its Application

With respect to the lectures on structural and soil mechanic engineering at the Department of Civil Engineering and Architecture at the Rangoon Institute of Technology, those of statics and testing for materials are provided in the Divisions of Structural Mechanics and Soil Mechanics. However, it does not seem that lecture on dynamic problems on Earthquake Engineering is given in Burma.

As mentioned in the latter chapter about 10 years ago, the Burmese Government has sent two young and able gentlemen to abroad as trainees on earthquake engineering. By which measure they were taught the new knowledge in earthquake engineering and were trained how to apply these high level technology to their own country. Meanwhile, however, as they were getting higher positions and wider responsibility, such engineers became scarcely involving in earthquake engineering and its application. Therefore, it is greatly needed to send young trainees to abroad year by year so that they can master the up-to-date knowledge on earthquake engineering, which is progressing day by day, and can contribute for improving the technology of their home country.

3) Advanced Stage on Earthquake Engineering and its Application

It is a decade ago when the Government of the Union of Burma has paid an attention for promoting the status on earthquake engineering and its application in Burma in forwarding two trainees to abroad. Then in order to ensure the rapid progress and steady realization for promoting the earthquake engineering status in Burma, it will strongly be hoped that the Government authorities concerned with such problems should pay much care on the following items.

i) lectures on earthquake engineering and its application should be provided at universities,

ii) seismological observation network system by means of eight stations should be completed urgently covering the whole teritory of Burma, together with the strong earthquake motion seismographs,

iii) brains not only active engineers but also teachers in universities should be trained abroad in the field of earthquake engineering, and

iv) a long term project for establishing the codes and regulations for earthquake resistant design of structures should be established as a definite programme.

4) Earthquake Engineering of University Level

Viewing from the fact that there is a scarcity of personnel experienced in earthquake engineering and a complete lack of specialists in the field of seismology and earthquake engineering, it is greatly needed to take speedy and strong measures for inaugurating and strengthenning the training of engineers and scientists by which young engineers could be brought up into specialists in its field within short period.

The mission visited Rangoon Institute of Technology, Rangoon Art and Science University and Mandalay Art and Science University in order to obtain the informations on the education in seismology and earthquake engineering which might be conducted in these Universities and Institute.

In the following a short outline of the curriculum of the Rangoon Institute of Technology (RIT) will be described because the mission considered that the RIT would be most competent organization in Burma for carrying out the education on earthquake engineering.

Rangoon Institute of Technology is the most typical institute in the Union of Burma for educating technological experts. It consists of 8 departments on technology which are in charge of senior course of 4 years and of 4 departments on art and science which are in charge of junior course of 2 years as shown in the following.

Senior Course: Dept. of Architecture
Chemical Engineering
Civil Engineering
Electrical Engineering
Mechanical Engineering
Metallurgical Engineering
Mining Engineering
Textile Engineering

Junior Course: Dept. of Chemistry
English
Mathematics
Physics

In the junior course of two years, lectures on mathematics, physics, chemistry, English, Burmese and mechanical drawings are offered by the teaching staff of the junior course. After finishing the junior course students are moved up to the senior course of four years.

With respect to the senior course, as it was considered that the Department of Architecture and Department of Civil Engineering are representing the most suitable departments in which the lectures on earthquake engineering could be provided, so careful examination on the curriculm was made only these two departments.

Since the Department of Architecture has an objective to bring up architects according to the guide book of RIT, lectures on structural engineering for the students in this Department are offered by the staff of other departments such as Civil Engineering or Mechanical Engineering.

In the Department of Civil Engineering, the lectures on the structural engineering such as Statics, Dynamics, Building Engineering, Theory of Structures, Design of Steel and

Timber Structures, Soil Mechanics, Design of Reinforced Concrete, Construction Engineering etc. are provided, using the text books published mostly in England or United States. The equipments for obtaining practices on laboratory tests such as strength of materials or soil mechanics are fairly complete and training for laboratory tests is being carried out.

As mentioned above, while there is a fairly complete system for bringing up construction engineers, no lectures on earthquake engineering are being given presently in this Institute. As far as the mission is informed, no lecture is provided on earthquake engineering in any other universities and institutes in Burma.

Universities in Burma should be encouraged to begin preparations for providing the lectures on earthquake engineering in their curriculum. Especially, the Rangoon Institute of Technology should firstly, among all universities, include lectures on earthquake resistant design in the course of Civil Engineering and Architecture.

For an information it might be of use to describe here an outline of the present system in Japanese universities on the education in earthquake engineering for the students in the engineering courses. Since it is very important in Japan to ensure the structures against earthquake attack, in every universities a large emphasis is placed on the education in earthquake engineering and seismology for the students who will engage in the job related with structural engineering after graduation. In a faculty of Technology in universities or technological institutes, lectures on seismology are given in cooperation with the staff of Faculty of Science, and lectures on earthquake engineering are given everywhere in related with such subjects as Design of Structures or as Soil Mechanics. These lectures are given by the full time professors in the Department of Architecture and Civil Engineering, because, especially in Japan, big structures such as buildings, dams, bridges, highways etc. can not be designed and constructed without taking into considerations of the earthquake design and behavior of ground motion in the case when they are subjected to severe earthquake motions.

3.3 Present Status and Scope of Design and Construction

1) Codes, Regulation and Design Criteria

One of the objective of the mission was to make a recommendation on the regulation and code of practice for the earthquake resistant design. According to the preliminary investigation on the damage due to the past earthquakes and the seismicity in this country, it is evident that the structures in Burma should be made earthquake resistant. Inspecting the present status on the design and construction in Burma, however, it was noticed that in prior to improve the problem on earthquake resistant design it would be more important to improve the general status on the design and construction for buildings, houses and other structures, because, earthquake resistibility of structures depends greatly on such a general condition for design and construction.

In order to improve such conditions, it is important to establish not only the regulation and code but also code of practice and standard specification for each construction such as brick building, wooden house, reinforced concrete building, bridge construction, dam construction etc. Establishment of such code of practice and standard specification would be useful not only for standardizing the constructions but also leveling up the general conditions of design and construction.

As to these regulation or code, as far as the mission was informed, there is only a Building Rules of the City of Rangoon in 1922 and its proposed revision in 1956. The Building Rules, however, is describing mostly the articles on town planning and giving few room on the design of the structures. Since the design and construction of large scale public works have been mostly entrusted to foreign contructors, there is no Burmese own standard for the public works.

In Burma, it is advisable to establish firstly such a standard for individual structure as regulating the principle, method and supervision of the design and construction considering the earthquake resistance. Standard specifications for controlling the properties of materials should be also included. The uniform regulation or code should be established after such standard for individual structure could be established and effected with actual examples.

Since the government organizations are in charge for the design, construction and inspection with respect to almost all the structures in Burma, they can easily control the whole constructions if the suitable standards are established.

The followings are the outline of the standards for buildings in Japan, which would be available for establishing such standards in Burma.

In Japan, the general principle of the design and construction of buildings are defined by the Building Laws which contains naturally the articies on earthquake resistant design. Building code and code of practice for individual structure, such as reinforced concrete, steel, wooden or brick buildings are prepared by the Architectural Institute of Japan. The Institute prepares not only the design standards but also the standard specifications for improvement of the field works. The earthquake resistibility is always considered in every article of such standards. Mostly, similar system is adopted in the case of the public works. Besides these standards, a property of materials is defined with the Japanese Industrial Standard by the Ministry of International Trade & Industry.

In the hope to give a useful reference, a part of "Design Essentials in Earthquake Resistant Buildings" edited by the Architectural Institute of Japan is excepted in Appendix III, which shows the earthquake resistant design essencials for brick buildings summarized from the Building Laws, Design Code for Masonry Buildings and Standard Specification in Japan.

2) Construction Method and Equipment

As mentioned in the preceding section 3.3 (1), codes of practice of Burma is scarcely found. None of specification, provision nor code is found in Burma. In Mobey dam construction, the specification for construction method and application of machines and equipment are supervised under the specification prepared by Swedish consultants and an expert dispatched from the United Nation.

Needless to say, construction methods are affecting not only to form a nice appearance of structures but also to control the phases of their cost, rapidness, quality of structures, which in turn give a large effect on the durabilities of structures. In order to realize suitable supervision of quality of materials, a standard method for material testing should be established. Before then it would be hopefully expected that a Burmese Industrial Standard could be even tentatively adopted a metric system that has currently become to be employed worldwidely.

When such a standard is adopted, specifications of machines and equipment will also be unified or will become to link to the international standard. As the result of such a standardization, exchange of the spare parts and supplemental articles will become easy greatly with low price. In doing so finally the most efficient investiment to construction could be expected.

3) Design and Construction

It does not seem so much difficult to make up a standard on design criteria and construction methods in Burma. In order to construct structures rapidly and uniformly with low costs, the standerdization on following items should be performed as early as possible.

i) Burmese Industrial Standard,
ii) Standard Specification for Materials,
iii) Code of Practice for Specific Structures and Materials, and
iv) Regulation for Specific Structures. ..

In order to draft out each of these items, firstly preliminary versions should come out, only including minimum requirements on each item. Much effort should be extended continuously for improving the version into more complete and unified ones by the accumulation of experience of trained experts and engineers and by the elevating up of workmanships of general technicians who are concerned with the construction of structures.

4) Earthquake Resistant Regulation

In most countries, the articles concerned with earthquake resistant design are usually included in the regulations for structural design. Generally, the article shall be specified for each different structures, for example bridges, dams, buildings, etc., depending upon the difference in their nature and purposes of these structures.

In the article it is specified basically such items as magnitudes of working forces or loads during earthquake, methods of calculation for stresses and deformations under the loading, safety factors and allowable stresses. (Refer Appendix IV.)

Seismic forces and loading conditions are ordinarily specified in consideration with expected seismic intensities estimated from a seismic zoning map, mechanical characteristics of structures, subsoil conditions, the use and importance of the structure.

Methods of calculation are employed depending upon the purpose of use for example rigorous or simple systems assumed.

Generally, allowable stresses are mostly specified for estimation at the safety of structural members, but safety factors are sometimes specified for estimation at the overall stability of whole structural systems.

4. Summary

4.1 Summary of Survey of the Mission

Problems on seismology and earthquake engineering in Burma were first investigated in 1960, when a UNESCO Seismological Survey Mission of 5 members headed by Prof. V. V. Beloussov of USSR visited this country. The composition of the Mission was:

Prof. V. V. Beloussov, Head, USSR, President of International Union of Geodesy and Geophysics

Dr. K. Takeyama, Japan, Director, Building Research Institute, Ministry of Construction

Dr. G. A. Eiby, Newzealand, Research Staff, Seismological Observatory, Wellington

Dr. E. V. Karous, USSR, Institute of Physics of the Earth, Moscow

Rer. Daniel Dinehan S. J., USA, Weston Seismological Observatory, Weston, Mass.

Though it was only four days in which the UNESCO Mission stayed in Burma, the Mission carried out thorough investigations on the situation of seismology and earthquake engineering in Burma, compiling the result of their survey in a form of a report entitled "UNESCO Seismological Survey Missions, Part 1, Report of the Mission to South-East Asia; Monograph No. 15, January, 1962, International Union of Geodesy and Geophysics, UNESCO." In the report, based upon the analysis of their inspections, the Mission is giving quite pertinent recommendations for improving the then situations on seismology and earthquake engineering in Burma and suggesting the future plan to be carried out by the local people under the international cooperations.

At that moment, however, the building of the seismological observatory of Rangoon was under construction and no seismological observations were in operation in Burma.

At this present time, however, when our Mission visited Burma, it was observed a conspicuous improvement in the situation on seismology and earthquake engineering. For example, in the field of seismology there were existing two seismological stations in Rangoon and Mandalay equipped with seismographs in each of them, though the maintenance of these seismographs were problematic when the earthquake of Sept. 9, 1970 happened. In the field of earthquake engineering, the Government of the Union of Burma had sent two trainees abroad one to Bergamo Earthquake Engineering Center in Italy, in 1962, and the other to the International Institute of seismology and Earthquake Engineering, Tokyo, in Japan, in 1963, by which the Government expressed her definite desire for improving the situation in the field of earthquake engineering in Burma.

If it should be allowed to use the most straight forward expression, however, we cannot help recognizing that the speed of progress in these ten years, in the field of seismology and earthquake engineering in Burma was excessively slow as compared with the wonderfully rapid progress carried out in many other countries in the same period.

The Mission, however, found it the most delightful and took it the best fruits of the present visit to Burma that the definit desire was expressed by the people in the posts of high authority as well as responsible personnel in the Government and by the practical engineers and administration officers engaging in the actual field works.

It was clearly felt that there was a substantial difference in the volitions of local people for improving urgently the situation on the seismology and of earthquake engineering in Burma compared with those which they showed when the UNESCO Survey Mission visited Burma ten years ago.

From these basis the Mission is definitely convinced that it could reasonably be anticipated in responding to our recommendation, from now on, the seismology and earthquake engineering status in Burma would march forward exactly with a speed harmonizing with the international progress under the responsible leadership of the higher staff in the Government supported by the enthusiastic devotion of the scientific and engineering personnel engaging in the actual field works, under the hearty cooperations from all national organizations including universities, as well as helped by encouragements extended internationally from outside in case when it is necessary.

The Mission believes that the true objective of the Government of Japan, who sponsored the present Mission to Burma, is not existing for merely receiving an excellent report of survey from the Mission, but upon receiving the report and recommendations of the Mission to extend, in the framework of applicability, the most effective technical cooperation in the specialized field so that substantial improvement could actually be attained in that field in Burma.

In the case of the present Mission to Burma, though it was just only a short visit of about two weeks, making full use of the time, we visited as many organizations and stations as possible meeting almost all key persons who were carring on important activity in the respective work, by which we were able to be provided quite a complete informations to realize the current status of Burma in the field of seismology and earthquake engineering.

Above all it was extremely valuable for us that we could exchange mutual views and opinions on all the important items with the top level persons in the Government in an atmosphere of most openhearted and freindly. Through such discussions and talks we could make clear, in the field of seismology and earthquake engineering, what is the most important items to which Burma is now facing, what is the most effective approach for solving such an important problems, what is the most practicable way of cooperation that Japan can extend to Burma, and so on.

In the following Section we are going to give our recommendations on such items as (1) Establishing code and regulation for earthquake resistant design, (2) sending trainees on seismology and earthquake engineering to abroad, (3) inviting foreign experts by which the increase of the number of trained experts and engineers in Burma could be increased, (4) bringing up of the higher level field engineers on a specified construction project, (5) establishing new seismological observation stations in order to provide basic data for minimizing earthquake desasters, (6) enforcement of the curricula in the universities on seismology and earthquake engineering.

In our report, these recommendations, however, are not aimed at to show beautiful appearance describing the top-class ideal cases but are prepared to provide direct usefulness in their practical applicability for promoting the situation and to encourage the urgent built up of new facilities that are most important for the rapid progress in this field, and so on, matching most effectively with the sincere desire of the local people.

All the member of the Mission are prepared to continue their cooperation to Burma as much as they can but at the same it is our sincere desire that upon receiving the report of the Mission to Burma in the field of seismology and earthquake engineering, the Government of Japan will commence, from a higher view point, for extending most effective technical cooperations to Burma in this field through the practical channel of the Overseas Technical Cooperation Agency of Japan in the close contact with the diplomatic offices of Japan in Burma.

4.2 Recommendations

Restricting ourselves on the problems of seismology and earthquake engineering, as mentioned above, after having been carried out as much investigations on the spot as possible and exchanging views and opinions with the local authorities and personnel as most thoroughly and friendly as possible and finally, after finishing necessary arrangement with the diplomatic offices of Japan in Rangoon, Mission is presenting the following recommendations to the Government of Japan and to the Government of the Union of Burma through the Overseas Technical Cooperation Agency of Japan who took practical charge for the dispatch of the present Mission to Burma.

1) Recommendations:

Advice for the establishment of a draft on earthquake resistant design regulation for structures and on design code of practice for specific structures with different materials.

Taking into considerations on the general technical level of the construction engineering in Burma, presently, it seems too difficult in Burma to build up a complete and well balanced earthquake resistant design regulation and design code of practice within a very short time. The establishment of such a code should be started with the accumulation of the specifications of respective construction project in Burma, then in the process of such an accumulation and with a laps of time, good efforts will be born out for improving such specifications into more harmonized form. In such a way, after several years, it will become practicable for drafting somewhat a more simple design manual for different structures and for making out a design code of practice with respect to respective construction. In such a way, an earthquake resistant design regulation could be included in the design code of practice.

2) Overseas training of experts in the field of seismology and earthquake engineering

Needless to say one of the most effective and rapid way for building up the higher level experts is to send ingenious persons abroad in a definit period of time to be trained at the most pertinent institutions or schools etc. in the advanced countries. Very careful examination will be most important for the selection of training institutions abroad as well as the selection of the individuals to be sent to foreign countries. There are several famous training institutions providing facilities for the trainees from other countries such as Earthquake Engineering Research Center, UC, Berkeley, USA, Earthquake Engineering Center Bergano, Italy, and International Institute of Seismology and Earthquake Engineering (IISEE), Tokyo. It is greatly advantageous to send trainees to such training facilities following the schedule prepared under the long term planning of the Government.

The IISEE, Tokyo, is providing a course of full one year under the well organized curriculum both for seismology and earthquake engineering fields, in a very high international reputation. The participants of the IISEE are supported by the fellowship including tuitions, living and flight expences which are sponsored by either the Government of Japan or UNESCO. It is recommended that the Government of Burma will send at least two trainees to the IISEE every year, one to the seismology course and the other to earthquake engineering course.

3) Inviting foreign expertsto Burma for the training of engineers

In order to improve the general technical level of engineers in Burma it will prove one of the effective way for inviting suitable experts in that field from abroad asking them to give lectures to the young engineers in the Government organizations or to guide the way of applying new method of design and construction for some more qualified persons or to give practical training on the practical anti-seismic problems.

4) Advice for the construction practices on the specified construction project

In the case of a big construction project, to which high level Japanese experts were invited, it could be so arranged as to work a group of well qualified young engineers in the Burmese Government or other semi-official or private organizations, under the Japanese experts throughout the whole period of construction project, by which local young engineers will be able to absorb completely all technics, knowledges, and at the same time all the experiences in that field. It is only through this way of contact and guidance that young engineers could be trained and brought up into a real technical expert in one specified project.

It will be some merit to attend a class to receive lectures on a training course but the most effective and shortest way of bringing up a practically useful expert will be attained only through the direct absorption of the experiences of foreign expert by the young local engineers when the foreign expert is enthusiastically willing to and actively devotioning to educate young Burmese engineers.

5) Urgent setting up of an effective seismological observation networks and promotion of the development of seismology in Burma

It is strongly recommended to establish six new seismological stations along with the definit schedule upon year marked programme so that together with the two existing stations, 8-station networks can be expected to run into operation within a very near future.

It should be emphasized that successful completion of the new 8-station network system could only be attained with the setting up of the new attractive posts in the organization of the Meteorological Department of the Government of Burma.

It is also recommended here that in case when a destructive earthquake should take place somewhere in Burma, the Government should organize an emergency investigation team and should send it to the site in order to investigationed record all the data including causalities, damage statistics, destruction of houses and buildings, etc. Upon such a site investigation, seismic intensity map will be drawn up and detailed descriptions on the destructions caused in each individual building or house will be retained in records. Such a report of the site investigations will be greately valuable for the future development of seismology and earthquake engineering in Burma.

It is also recommended at least two sets of Strong Motion Seismographs should be set up in Burma, one in Rangoon and the other in Mandalay.

6) Establishing the new curriculum on seismology and earthquake engineering universities

The most foundamental way for improving the situation of one specific field in one country should be found in the education of students at the universities.

Presently there is no curriculum giving lectures on earthquake engineering or seismology at any university in Burma.

It is quite important, seeing from the long range programme, to create chairs on earthquake engineering in the department of construction engineering and on seismology in the department of geology or physics or elsewhere. However, as a first step it is advised that the lectures on earthquake engineering and/or seismology should be newly added in the curriculum of engineering and/or science as soon as possible. For this purpose it might be advisable for the very beginning years experts from foreign countries would be invited for giving cooperations and after several years main part of the lecture should be given by local professor trained in some way or other.

In some case such lectures in the University will be opened also for the young engineers in the Governmental and other organizations having good interest in that field for some limited period. Such lectures will be greatly valuable not only for broadening and deepning the knowledge level of engineers but also for calling upon the special interest in the higher level construction engineers and administration officers.

In order to bring all these items as mentioned above into realization, it is needless to say but should be strongly requested that the Government of the Union of Burma should wrestle with these important problems with enthusiasum, ensuring the financial necessities for all facilities and equipment, electing new posts for the effective and powerful running of these new projects, encouraging and guiding the official personnel for devoting themselves to their respective sublime job

It was the highest pleasure for the Mission to learn that the Mission could find through the present visit that the responsible persons in the Government were wall aware of this situation and completely were determined to make their best effort along this line. However it should also be necessary to mention that these targets, herewith itemized are too large to be attained by the only effort of the Government of Burma herself but also be called upon the cooperation from outside The Mission feels happily to express here that the Government of Japan is deeply solicitous so much in the rapid progress of the seismology and earthquake engineering in Burma that the Government will be pleased to extend its maximum cooperation in supplying equipment and materials and in sending experts to Burma upon the requests raised from the Government of the Union of Burma, through the channel of the Overseas Technical Cooperation Agency of Japan in so much as practicable

5. Acknowledgements

The Earthquake Survey Mission of the Government of Japan expresses its most profound gratitude to the Government of the Union of Burma in particular and to a great many people of Burma with whom members of the Mission had the privilege of contact in the period of its stay in Burma in general. Whatever success the Mission had achieved in carrying out its objective was made possible only through the generous assistance and cooperation provided by those individuals and officials of the Government organizations of Burma.

Colonel Maung Lwin, Deputy Minister of National Planning, U Chein Hai, Deputy Secretary and U Kyaw Tin, Assistant Director, Ministry of National Planning, had provided smooth and speedy access of the Mission to every Government organization related to the field of investigation of the Mission, for which excellent arrangement our deepest thanks are due. Colonel Htin Kyaw, Secretary, Ministry of Public Works and Housing, and Lieutenant-Colonel Soe Tin, Additional Secretary, Ministry of Public Works and Housing, U Maung Maung Aye, Deputy Secretary, and U San Shwe, Assistant Secretary, Ministry of Public Works and Housing, gave the Mission the full backing of their offices and extended every courtesy in providing access and informations not only in Rangoon but also in Mandalay, Sagaing, Meiktila, Pegu and Loikaw covering the areas adjacent to these cities.

U Ko Ko, the Director of Engineers of the Construction Corporation, of the Ministry of Public Works and Housing, Mr. C. X. De Souza, Additionar Director of Engineers, U Soe Aung, Deputy Director of the Construction Corporation, colleagues and staff under their jurisdiction including the Command Engineers and staff of the various Commands of the Construction Corporation in the districts of Pegu, Mandalay, Sagaing, Meiktila and Loikaw, have extended hearty cooperation and sincere assistance to our Mission in all places of inspection and investigation providing all materials and data, for all these wonderful assistance and cooperation our deepest thanks are due.

U Tun Yin, Director of the Burma Meteorological Department, Ministry of Transport and Communication and his efficient staff provided all available materials and data on seismology and seismological observations, for which kind cooperation we express our highest appreciation.

The Mission has the honour of extending its highest appreciation to Prof. Dr. Nyi Nyi, the Deputy Minister of Education as well as the Head of the National Commission for UNESCO in Burma, for his kindness in giving us an interview with him for discussing about the UNESCO fellows to be sent to IISEE, Tokyo, from Burma.

Prof. U Ba Than Haq, Head of the Geological Department, Arts and Science University of Rangoon, his colleagues and young researchers in his Department, gave us detailed explanations on the geology and tectonics of Burma and local geology of Rangoon City, providing us geological map of Burma, and related literature together with unpublished draft map showing boring data in the city of Rangoon, for all these kind cooperations we express our hearty gratitude.

To Prof. U Yone Moe, the Rector of the Rangoon Institute of Technology, Prof. Dr. Aung Gyi, Head of Civil Engineering Dept., RIT, Mr. Allen Htay, Lecturer on Soil Mechanics, RIT, and U Thein Nyunt have provided us many valuable materials. Prof. U Hla Shwe, the Rector of the Arts and Science University of Mandalay, Prof. U Thet Paw, Geology Department, ASUM, Assistant Prof. and Dr. Win Swe, Dept. of Geology, ASUM, gave valuable informations on the Sagaing faults and related problems.

Hearty cooperations and warm hospitality extended by the following people to the Mission in the investigation trip outside Rangoon are also most gatefully appreciated. They are; U Lin Gin Kho, Command Engineer, North-West Command, U Myint Thein, Assistant Command Engineer, Construction Corporation Mandalay, U Tun Aung Pru, Assistant Command Engineer of Construction Corporation in Meiktila District, Mr. D. Ghosh, Superintending Engineer, Irrigation Dept., Meiktila, U Maung Maung Kyi, Executive Engineer, IDM, U Si, Deputy Command Engineer, North-West Command, Construction Corporation Sagaing, U Nyi Kaung, Assistant Command Engineer, CCS, Mr. S. Mohindar, Assistant Command Engineer, Construction Corporation in Loikaw District, U Ohn, Project Officer, Mobye Dam site, U Kyaw Thein, Executive Engineer in charge, Mobye Dam Construction, U Tun Aung Cyaw, Executive Engineer in charge of Lawpita Hydro-electric Power Station, ESB, U Mya Aung, Assistant Command Engineer. Construction Corporation Pegu District.

U Kyaw Sein, Retired Chief Engineer and Trustee of the great Shwe Dagon Pagoda of Rangoon has given us detailed explanation on the damage caused to top portion (umbrella) of the Shwe Dagon Pagoda by the earthquake of Sept. 9, 1970. For all these cooperations we like to express our indebtedness. Our hearty gratitude goes also to Dr. Aung Khin of the Myanma Oil Corporation of Burma, Cheif Geologist U Than Nyunt and Mr. A. Umedo, who was working in the same Corporation on leave from the Japan Peteroleum Exploration Public Corporation, for their kind assistance in giving us excellent explanation on the geology of southern Burma.

By means of the thoughtful arrangement of the Government of Burma, the Mission could heartily enjoy the privilege of being attended by four competent liason officers throughout the whole period of their stay in Burma. They were:

1. U Kyaw Tun, Deputy Chief Engineer, Board of Management for the Port of Rangoon. Ministry of Transport and Communication.
2. U Soe Aung, Deputy Director of Engineers (Works), Construction Corporation Ministry of Public Works and Housing
3. U Gyaw Tun Aung, Staff Officer (II) Structural Design, Construction Corporation, Ministry of Public Works and Housing
4. U Sein Shwe U, Research Officer of the Hydrology Divison, Meteorological Department of Burma, Ministry of Transport and communication

The great success of the Mission in carrying out its activity in Burma within such a short stay of about ten days, owes greatly to the devotional and attentive assistance and excellent services extended by these four gentlemen not only in Rangoon but also in Mandalay-Sagaing District, Meiktila District, Pegu District, and Loikaw District, for all these sincere cooperation, we wish to tender our profound gratitude and hearty thanks.

The Mission takes the privilege of expressing its hearty appreciation to Messrs. A. Kuriyama, S. Uchimura, A. Ikeda of the Embassy of Japan in Burma for their prudent services to the Mission in helping the activity of the Mission in all phases, acting as an able liaison channel between the Government of Japan to the Government of the Union of Burma. The Ministry of Foreign Affairs of the Government of Japan has kindly read through the English version manuscript of our Report, giving careful corrections on its English expression. For such kind assistance the Mission expresses its highest indebtedness.

Lastly but not least our thanks go to the Overseas Technical Cooperation Agency, Japan, for the enthusiastic effort for promoting the technical cooperation to Burma in the field of seismology and earthquake engineering in dispatching the present Mission to Burma.

APPENDIX

Appendix I. Seismological Data

1) List of earthquake origins

As mentioned above, B. Gutenberg (1949), G. P. Gorshkov (1959) and U Sein Shwe U (1960) compiled lists of earthquakes which occurred in Burma and its vicinity. In particular, Gorshkov's and Sein Shwe's lists are available in investigating a seismicity in Burma.

In recent, the number of seismological stations in the world is increasing year after year, and a crystal clock and both long and short period seismographs are installed at many stations. Furthermore, use of a computer for data processing at various organizations in the world makes it possible to determine many hypocenters of earthquakes occurring all over the world within a reasonable time and with accuracy.

In the table are listed earthquake parameters such as epicenter, focal depth and magnitude given by the above mentioned authors and by the United States Coast and Geodetic Survey, and the International Seismological Center.

So far as earthquakes occurring in Burma and its vicinity are concerned, locations of earthquakes whose magnitudes are about 5½ and larger can be determined by the organizations concerned. Accuracy of determined hypocenters may be a few tens kilometers on the average.

Needless to say, accuracy for locations of earthquakes taking place before 1962 is inferior to the above-mentioned order. It is necessary to bear the difference of reliability, in mind when the data are utilized in a statistical study

2) Seismometrical data for Rangoon earthquake of 1970 and some comments for the data obtained

Owing to troubles of the seismograph and the clock which provides time marks in seismograms, difficulities occurred in reading of arrival times of P and S waves which are necessary to determine an origin of earthquake.

Furthermore, it is also difficult to read amplitudes of P and maximum waves, and their corresponding periods because of broad traces which exhibit ground vibrations due to earthquakes.

The seismograms, however, are very helpful in elucidating the state of the Rangoon earthquake, and the foreshock and aftershock activities.

In this section are given seismometrical data obtained from the seismograms at the Kaba-Aye observatory, and a few comments on the statistical study using the data.

The characteristics of the Willmore seismograph whose records were used in measuring the data given in the table are:

natural period of seismometer; about 1 second,
natural period of galvanometer; about ¼ second,
maximum magnification; about 3000, and
paper speed of recording drum; about 30 mm/second.

Table I-1 Earthquakes that Occurred in and near Burma in the Past

DATE AND TIME		LAT.	LONG.	H	M/m
	d h m	°N	°E	km	
1912	5 23 02 24	21	97.		8 0
1923	6 22 06 44	22 8	98.8		7.3
1925	12 22 05 05	21.	101.5		6.8
1927	3 15 16 56	24.5	95.		6.5
1930	5 5 13 45	17.	96.5		7 3
1931	9 6 05 38	18.5	96.		
1933	7 3 15 09	19.	97		
1934	6 2 05 54	24.5	95.	130	6.5
1935	4 23 16 45	24.	94.8	110	6 3
1936	2 21 06 20	23.	96.		
1938	4 14 01 16	23.5	95.		6.8
1938	5 6 03 41	24.5	95.	100	5.8
1938	8 16 04 27	23.5	94.3		7.2
1939	5 27 03 45	24.5	94.		6.8
1939	6 19 21 56	23.5	94		
1940	5 11 21 00	23 8	94.3		6.5
1941	5 16 07 14	24	99.		6.9
1941	12 26 14 48	21.5	99.		7.0
1946	9 12 15 17	23.5	96.		7.5
1946	9 12 15 20	23.5	96.		7.8
1950	2 2 23 33	27.	100		7.0
1952	5 19	22.6	100.0		6.5
1954	3 21	24.5	95.3	180	7.4
1955	3 22	20.5	98.5		6.5
1955	12 14	21.8	92.5		6.8
1956	2 29	23.5	94.5		6 5
1956	7 12	23.	94.5	100	6.3
1956	7 16	22 3	96.	100	7.0
1957	6 18	14 5	96.		6.4
1957	7 1	25.	94.		7.3
1962	2 20 22 02	26.1	96 8	25	(m)
1962	4 17 11 51	26.1	95.1	153	
1962	9 16 19 06	16 7	94.2	33	
1962	9 22 06 51	26.5	97 0	33	6
1962	11 16 22 45	14 0	92.8	33	
1962	11 30 16 02	24 2	94.5	175	
1962	12 18 03 51	23.8	93.5	124	
1963	1 22 15 58	22.4	93.6	88	6.1
1963	6 26 17 21	24.2	95.2	80	5.4
1963	9 28 06 00	22.9	94.5	108	5 6
1963	10 20 21 49	21 9	94.7	115	
1963	11 16 11 07	26.7	97.2	33	5.1
1964	1 15 17 39	25.6	95.4	33	4.0
1964	1 22 15 58	22.3	93 6	60	6 0
1964	2 27 15 10	21 7	94 4	112	6.4
1964	2 28 17 47	18 3	94.4	46	5.1
1964	3 20 19 00	23 4	94.4	94	5.0
1964	3 27 04 30	25.8	95.7	115	5.3
1964	6 3 02 49	25.9	95.7	121	5.4
1964	6 13 17 35	23.0	94.0	61	5.8
1964	7 12 20 15	24.9	95.3	152	5.5
1964	7 13 10 58	23.5	94 7	110	5 4
1964	8 17 14 42	24.3	94.2	158	4.8
1964	9 30 08 54	15 4	96.2	35	
1964	10 29 13 30	26 2	97.1	33	4.7
1964	11 4 15 20	25 0	96.1	24	4 9
1964	11 25 08 33	26 4	96 1	108	5.0
1964	12 1 15 10	21.2	94 5	104	
1965	1 22 12 41	20.0	94 4	80	4.8
1965	2 18 04 26	25 0	94.2	45	5 4

DATE AND TIME		LAT.	LONG.	H	m
	d h m	°N	°E	km	
1965	2 25 10 34	23.6	94.6	94	5.2
1965	5 30 08 48	26.0	95.8	88	5.8
1965	6 1 04 32	20.1	94.8	81	5.2
1965	6 11 15 43	24.7	95.3	149	4 8
1965	6 18 08 17	24 9	93.7	48	5.2
1965	6 18 18 08	25.0	93.8	46	5.9
1965	7 5 23 41	21.2	94.8	13	4.4
1965	9 22 04 24	20.8	99.3	5	5.3
1965	10 16 19 33	17.5	94 8	44	5.0
1965	12 5 22 01	23.3	94.5	97	5 0
1965	12 15 04 43	22.0	94.5	109	5.2
1965	12 17 22 46	22.0	94.5	114	5 1
1966	4 26 10 45	24.8	96.5	33	4.8
1966	5 27 14 35	27.4	96.5	51	4.8
1966	5 29 15 03	24 0	95.2	68	
1966	9 8 15 55	27.0	95.8	37	5.0
1966	9 20 23 37	24.1	97.6	28	5.2
1966	9 27 19 22	14.8	93.7	69	4 5
1966	10 2 04 31	24.4	94.8	65	5.2
1966	10 18 20 37	24.3	94.8	86	5.2
1966	10 22 03 03	23.1	94 4	68	5.3
1966	12 15 02 08	21.7	94.5	81	5.7
1967	1 4 11 26	23 4	93.9	58	5.4
1967	1 8 17 18	23.2	93.9	33	5 1
1967	1 13 14 04	23.8	94.6	91	
1967	4 23 20 18	25.0	94 7	75	4 8
1967	5 8 23 17	26 6	96 0	73	4.4
1967	6 17 13 14	23 1	94 7	120	4.5
1967	6 20 11 46	25 3	96.1	142	4.1
1967	6 27 12 28	22 7	93.9	7	4 7
1967	8 27 11 11	23.1	94.2	61	4 5
1967	10 18 00 55	23.4	94.9	54	4.8
1967	12 10 18 43	22.5	94 8	158	5.2
1968	1 18 19 57	24.3	93 2	100	4.7
1968	1 23 03 22	26 0	95.5	103	5 0
1968	2 12 22 17	22.9	95.4	23	4 7
1968	4 13 23 31	24.6	94.8	123	4 7
1968	8 9 02 24	25.2	94 4	33	4.7
1968	10 3 15 20	18.3	94.8	30	4.9
1969	1 5 18 51	26 6	96 7	53	
1969	1 25 23 34	22.9	92.3	50	5.2
1969	2 18 21 03	24.5	95.4	160	5.0
1969	4 28 12 50	25.9	95 3	50	5.2
1969	8 10 05 02	22.0	94.4	33	4.9
1969	8 29 10 02	26 3	96 1	73	5 4
1969	9 10 05 02	22.0	94.4	33	4 9
1969	9 29 10 02	26.3	96.1	73	5.4
1969	9 29 19 57	24.8	95 3	119	4.9
1969	9 30 23 13	25 6	94 7	20	5.4
1969	10 17 01 25	23 1	94.7	134	6.0
1969	10 29 22 24	23 6	94.3	76	4 6
1969	12 19 14 41	24.4	93.6	57	4 7
1970	1 19 12 57	27.0	97.0	45	4.6
1970	3 10 05 20	26.8	97.0	33	5.4
1970	3 13 18 24	24.9	93 9	62	4.9
1970	4 6 05 07	26.5	96.4	79	5.2
1970	5 29 10 33	24.0	94.1	47	5 0
1970	7 7 04 13	24.8	94.2	134	4 2
1970	7 29 10 16	26.0	95.4	59	6.5
1970	7 29 10 30	26 0	95.3	33	5.1
1970	7 29 10 31	26 2	95.1	48	5 5

Table I-2 Seismometrical Data for the 1970 Rangoon Earthquake and its Aftershocks

Occurrence Time			S–P	F–P	Amax	I
d	h	m	s	s	mm	
9	10	06				IV
	12	02	2.8	50		II
	12	04		40		II
	14	40		40		II
	15	19		40	2	I
	15	51		20		
	16	38		60	1	I
	18	58		90	11	IV
	19	31		50	4	III
	20	00	2.8	90	10	III
	21	04		35	2	III
10	00	55		25	1.5	I
	03	23	2.8	30	2	III
	04	39	3	40	9	III
	05	07		90	21	II
	15	05		20	2	I
	16	06		20	2	I
11	08	23			2	I
	08	51		20	2	I
	20	13		50		II
12	?	?		120		IV
	12	59		30		
	17	47		20	3	
	19	05		25		
13	01	48		30		
	05	50		30		
	08	25		30		
14	?	?		20	3.5	I
	?	?		70	11	IV

Table I-3 Seismometrical Data for the Foreshocks of the Rangoon Earthquake

S–P : Difference between Arrival Times of S and P Waves.
F–P: Total Duration of Earthquake Record.
Amax: Maximum Trace Amplitude.
I: Seismic Intensity in Modified Mercalli Scale at Kaba-Aye Station.

Occurrence Time			S–P	F–P	Amax	I
d	h	m	s	s	mm	
20	17	40		120		VI
	17	43	2.4	35	2.5	II
	18	00	2.4	30	3.5	II
	18	17	2.2	110		VI
	18	20	2.2	80		III
	19	45		40		II
	20	?		30		II
	20	?		20		I
	20	?		25		I
21	18	?		25		II

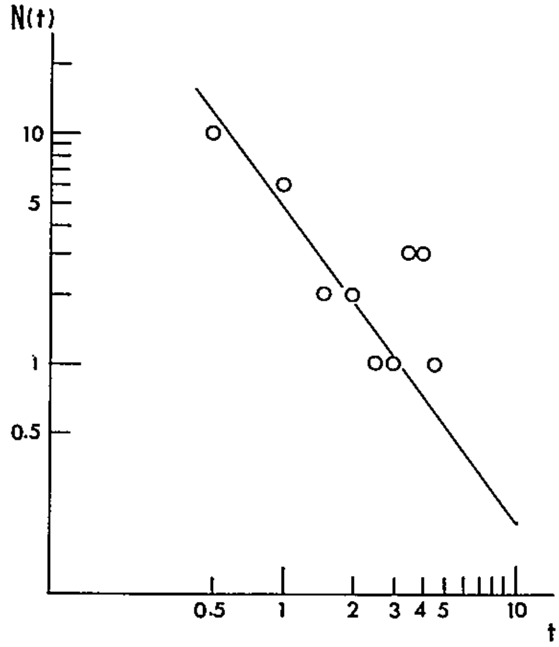


Fig. I-1 Number of Aftershocks in Every Half a Day After the Occurrence of the 1970 Rangoon Earthquake

Based on the data given in Table I-2, we will investigate the state of the aftershock activity in time and magnitude.

Fig. I-1 is a plot showing variation in the number of aftershocks taking place in every half a day immediately after the occurrence of the main shock. The line in the plot is expressed by the following equation:

$$N = 0.68\, t^{-1.36}, \qquad (1)$$

where N is the number of aftershocks occurring in a half day, t time in a half day unit.

The exponent of the variable t in the above equation for Japanese major earthquakes is about -1.3 on the average, which agrees well with that in the present event. This implies that the decrease in the number of aftershocks or a decline of the aftershock activity of the Rangoon earthquake is common to that in Japanese major events.

An important information on the aftershock activity is obtained from a study in the frequency distribution of earthquake magnitudes expressed by the following equation:

$$\log N = a + bM, \qquad (2)$$

where N is the number of events whose magnitude is M, a and b constants. Particularly, the value of b is -0.8 to -1.2 if the phenomenon concerned is tectonic, and about -3 for volcanic phenomena.

Though we have not magnitude data on the Rangoon earthquake and its aftershocks, a relation between an earthquake magnitude and a duration of ground vibration due to the earthquake, recorded by a seismograph is applicable to the above-mentioned statistical investigation.

The relationship between the above two parameters obtained by recent research, conducted by the relevant seismologists, is expressed by the following formula:

$$M = \alpha + \beta \log T, \qquad (3)$$

where M is magnitude, T duration of ground vibration, and α and β are constants. The value of β is 2.0 to 2.5.

From the two equations (2) and (3), the following equation is obtained:

$$\log N = \alpha' + \beta' \log T, \qquad (4)$$

where $\alpha' = \alpha + b\alpha$, and $\beta' = b\beta$.

Fig. I-2 shows the frequency distribution of the duration of ground vibration. The coefficient of log T in eq. (4) obtained from the plot is -1.83. The value is in good harmony with b in β given in eqs. (2) and (3).

Taking the result on the temporal distribution of aftershocks into consideration, we conclude that the activity of aftershocks accompanied by the Rangoon earthquake is ordinary in both time and magnitude, and that the aftershock activity was almost exhausted in a few weeks after the occurrence of the main shocks.

3) Lists of earthquakes in and near Pegu and Rangoon

According to U Sein Shwe U, who investigated the history of earthquake damage to pagodas in Pegu, there occurred 32 destructive earthquakes in and near Pegu during the period from B.C. 200 up to the present. Date of the earthquakes is reporduced in Table I-4.

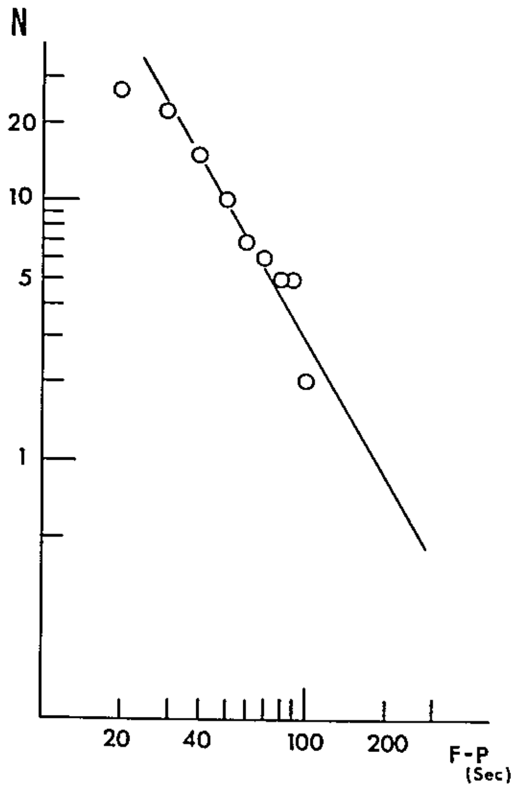


Fig. I-2 Cumulative Frequency (N) of Total Duration of an Earthquake (F – P) Recorded by Willmore Seismograph.

Table I-4 Destructive Earthquakes in Pegu in the Past

Year	Year
B.C. 197	A.D. 986
90	1059
12	1161
A D. 22	1269
64	1287
153	1348
231	1396
299	1457
387	1564
460	1570
527	1582
615	1644
625	1768
736	1913
813	1917
873	1930

Table I-5 Earthquakes near Rangoon in the Past.

Year
A.D. 1492
1566
1614
1678
1768
1880
1919
1930 (Pegu Earthquake)
1970

Earthquakes occurring near Rangoon have been studied in the same manner. Though the study is not complete, the data obtained until the present are given, too.

It is, in general, quite difficult to obtain data for earthquakes occurring in a long period of time such as more than 2,100 years, and therefore it is very interesting to study the nature of the occurrence of the large earthquakes.

From the view point was made a brief analysis of the data.

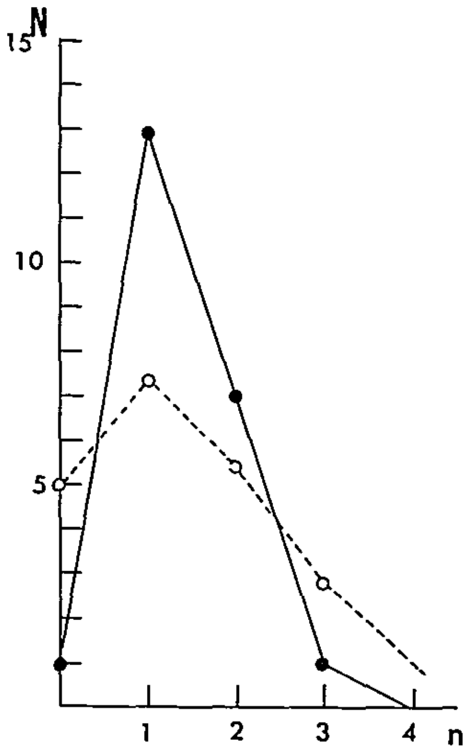


Fig. I-3 Frequency Distribution of Destructive Earthquakes in Every 100 Years, which Occurred in Pegu during the Period from 200 B.C. to 1970.

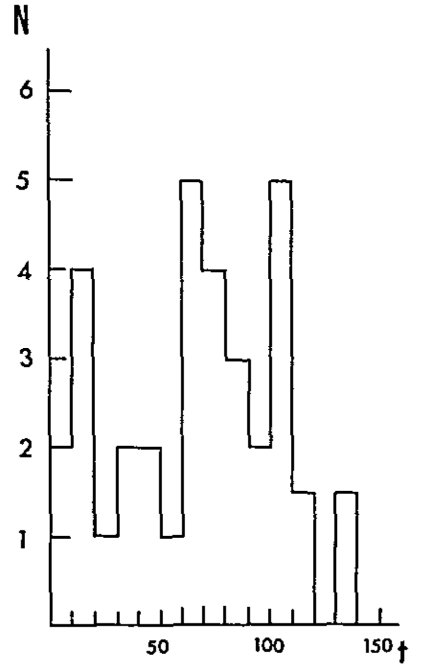


Fig. I-4 Frequency Distribution of Interval (in Year) between two Successive Destructive Earthquakes in Pegu.

Fig. I-3 shows the distribution of the number of earthquakes that occurred in every 100 years. If the occurrence of the events was independent each other, the result shown by solid lines in the plot fit the Poisson's distribution which is given by broken lines in the plot.

It is evident from the plot that the discrepancy between the observed and theoretical data is not negligible. The state of the discrepancy suggests that the occurrence of events is intermittent rather than random.

Fig. I-4 shows the frequency distribution of time intervals between successive events. It is clear that earthquakes occurred frequent with a time interval ranging from 60 years to 110 years, and the average of the time interval for all events is 65 years.

Appendix II. Geology

1 Introduction

Speaking on the geology and topography, teritory of Burma can be divided into four zones. All the boundary lines of these four zones are showing definitely similar character to run from north to south, as a result of which it comes out that the teritory of Burma are composed by four narrow zones running in parallel in the direction from north to south as will be seen in Fig.II-1. The first zone is the Shan Plateau, the second is the Central Lowland, the third is the west mountainous zone and the forth is the coastal zone that adjustant to the third zone and facing to the Bengal Bay.

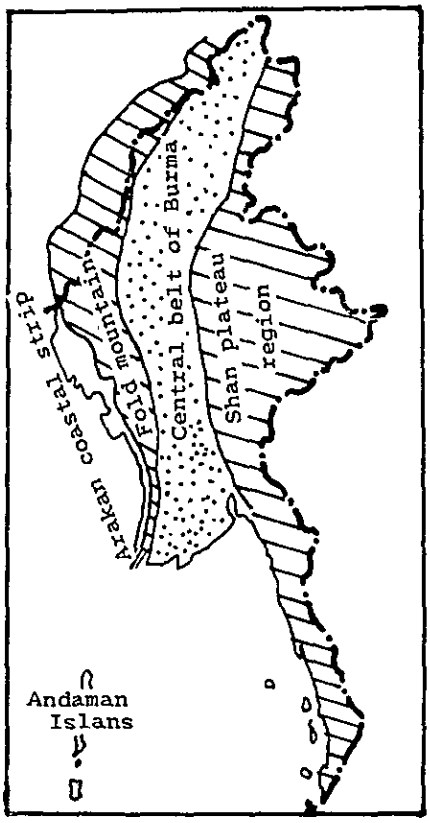


Fig. II-1 Four zones in Burma

A The first zone – Shan Plateau

This zone is composed by a long stripe of mountainous land beginning from Shan Plateau to the north then continuing to the Karenni mountain to the south which is followed by the Tenasserim hills that is locating to the west coast of the Malay Peninsula.

The Shan Plateau forms a high landmass composing mainly by rocks of the Archean, Paloezoic and Mesozoic ages, and showing definitely older geological period compared to those of the Central Low-land, which is lying west to the Shan Plateau.

Axes of the geo-syncline and anticline in this area are parallel each other having the north-south trend. Rivers that ran in this zone are forming deep narrow valleys running also in a north-south direction. Geologically it is observed that the youngest rock in this zone is Cretaceous.

B The 2nd zone – Central Low-land of Burma

The 2nd zone is represented by an area which was covered by a shallow water by the end of the Tertiary age, and presently forming a low flat land, locating in between the Shan Plateau to the east and the Arakan-Naga mountainous region to the west, forming an Old Burmese Bay.

The boundary where the Central Low-land is separated from the Shan Plateau is characterized by a sudden change of altitude, sometimes showing a difference of more than 2,000 ft. Therefore it can be considered that such a topography indicates an existence of a large clear geological fault along this boundary.

Large amount of sand and mud conveyed by the two big rivers, which later came out as the Irrawaddi River and Sittang River, continued the function of reclamation in the Old Burmese Bay until the end of the Tertiary age. As a result of these sedimentation it was formed a very thick layer composed by sand, shale and clay alternatively.

It is considered that upheaval movement began to take place gradually in this area after Tertiary. As the result of which a large low-land came out of the water forming a Central Low-land lying between the two mountain ranges of Shan Plateau and Arakan-Naga yoma.

However, in the area near to the mouth of Irrawaddi and Sittang Rivers, sedimentation has been continued without interuption even after Tertiary, so some of these areas are covered by delluvium and alluvium deposit.

The Pegu yoma and its continuation farther north into the hilly ranges were formed nearly in the same period.

C The 3rd zone – West Mountainous Zone

The West Mountainous Zone comes down from the North Assam High-land of India forming a continued mountainous high land composed by Patkai, Naga, Manple and Chin, then down to Arakan mountains.

These mountain ranges are arranged showing a definite trend running from north to south and deep valleys are formed in between the ridges of the mountain range along which many rivers are also running down in the direction from north to south.

Arakan mountains slopes down gradually to the south, then loses it's height at the coast line on the Andaman Sea, but its continuation can be noticed farther south as the Andaman Islands and Nicobal Archipalago, which are found located along a line stretching in the same direction.

These continued mountain and island chain can be traced again to the farther south as the Sumatra and Java Islands, thus composing a large Burma-Java Arc in the global seismic belt of Alps-Himalaya. It is considered in general that the West Mountainous Zone of Burma has come out upon the sea level at about late Cretaceous.

D The Forth Zone – The belt zone along the west coast of Burma

This belt zone is located in between the Arakan Mountain Range to the east and Bengal Bay to the west forming a very narrow belt of low land along the seashore running from north to south.

It is often observed that the Arakan Mountains come so close to the shore that a cliff is giving no room for making even a narrow beach. It is only in the area near to Akyab where -

relatively open area of low plain can be observed in the west coast zone. These plane is constructed by deltaic deposit of Kaladan River mainly in Tertiary age.

2 Geotectonics of the Central Low-land

2-1 Importance of the Central Low-land in related to the problems on seismotectonics

It is reasonably deduced from many reliable data that the Rangoon earthquake of 1970 has its epicenter in the Central Low-land. As it has been pointed out in the proceeding chapters, the seismotectonics in Burma is not so well studied presently, so, it might be difficult to derive a definite conclusion for relating the seismic activity in the southern Burma to the geotectonics.

Referring to the epicenter distribution maps in Chapter 2-1-1) (Figs. 2-1-2, 2-1-3 and 2-1-4), epicenters in the southern Burma are seen to be disposed to indicate north-south arrangement which shows a good harmony with the general strike of geological structures, while no established agreement is derived in the circle of scientists to relate such an arrangement of epicenters to the specific geotectonic structures in the same area.

We have already seen in the above section that there is a larger clear geological fault deviding the Shan Plateau from the Central Low-land running from north to south in the distance exceeding 500 km. Though the existence of such a geological fault is very clear even seen from the topographical view point, the dip of this fault and the continuation of the dip into the deep of the earth's crust are not yet studied so clearly, therefore it should be payed careful attention when it is intended to relate the surface distribution of epicenters to the deep structures of geological fault.

Taking into consideration of all these data, so far as we are in hand, however, the authors are in the view that the earthquake foci in the southern Burma are not arranged on the fault plane that separates the Central Low-land from the Shan Plateau.

On the contrary, we notice that earthquakes in the southern Burma are taking place in the basin of the Central Low-land as well as along the boundary between the Central Low-land and the west mountainous zone formed by mountain ranges of Arakan-Yoma and so on. However, presently, seeing from the accuracy of the epicenter determination in this area it will be difficult to step into more detailed discussions on the problems of seismotectonics.

Upon such a situation, in the following sections it will be given the geotectonic characteristics of the Central Low-land, mainly basing upon the description given in "The Geology of Burma, by H.L. Chhibber, 1934" in the hope to provide effective materials for improving discussions on seismicity and seismotectonics in the southern Burma in future.

In order to show the general geological structure covering whole area, it is reproduced in Fig. II-2 the geological map of Burma taken from above literature.

2-2 Characteristic nature of the geotectonics in the Central Low-land

Wide area extending to the west of the Shan Plateau had already been formed through the period of Archean and Palaeozoic as a part of the old Gondwana landmass, then it began to subside starting in the later period of Permian continuing through the ages of Triassic and Cretaceous, though intermittently.

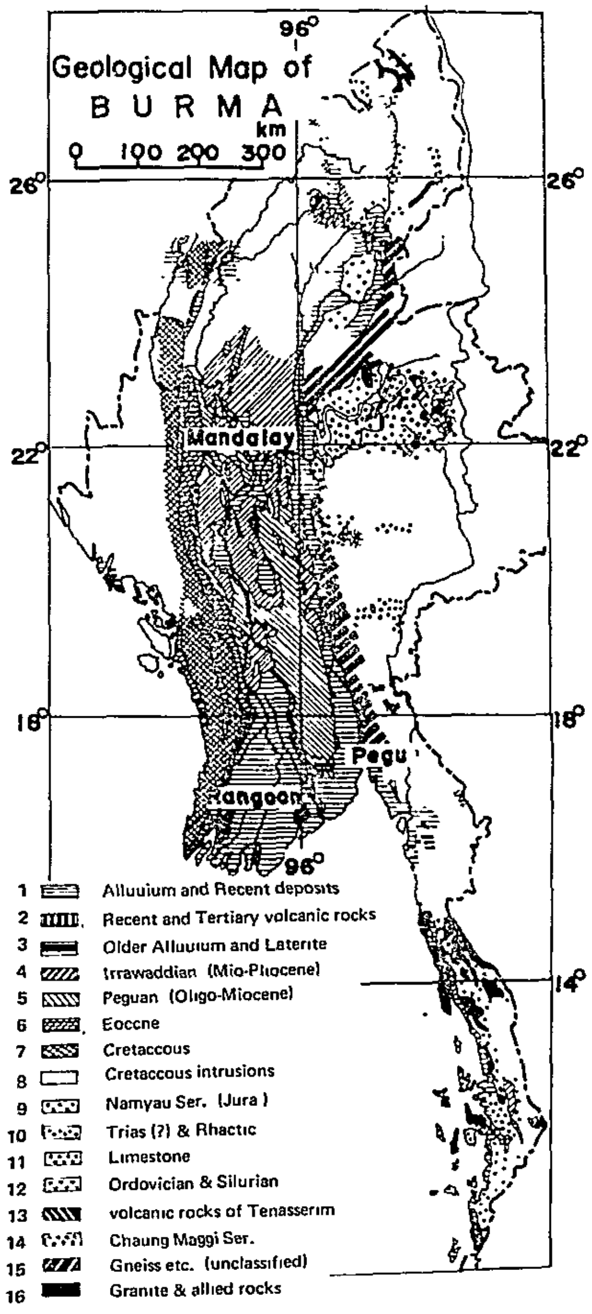


Fig. II-2 Geological map of Burma
(After Chhibber)

At the time of the global Laramide Revolution which took place in the period of the very later stage of Cretaceous or early stage of Tertiary, under the influence of such a global movement the whole area of Burma too showed a remarkable upheaval movement building up the Shan Plateau in the east and the Arakan-Naga hills in the west. Such a remarkable upheaval movement was accompanied by a movement giving lateral pressure directing from east to west which made develop anticlinal and synclinal structures in these high lands having axes stretching in the direction from north to south.

In parallel to the upheaval in the high lands in the east and west, the Central Low-land that was lying between the two high lands, underwent a continued subsidence forming a large scale of geosyncline in the thick sediment layers covered by shallow water of Old Burmese Bay which was penetraiting farther north into inland than the coast line we see today.

The subsidence of the shallow Burmese Bay continued throughout the period of Eocene, Oligicene and upto Mid-Miocene, accumulating a large amount of deposit forming very thick seidment layers. The lateral force acted simaltaneously from east to west with the subsidence of the Low-land worked to construct a large scale geocyncline in the thick sediment layer.

Again at the time of the global Cascadian Revolution, which took place in the period of Pliocene, especially in the later stage of Pliocene, the Low-land covered by Old Burmese Bay changed its movement and turned into upheaval movement.

At this same period, the area was again layed under the effect of lateral pressure pressing it from east to west resulting to from geosyncline and anticline alternatively in the thick sediment layer having axes in the direction from north to south.

One of the evidence of such a movement as explained above will be given by the Pegu ridge and its hilly north continuation that are covered by rather hard marine sediments.

It should be noticed again here that in the case of this movement which took place in the period of later Pliocene, it was observed that the geological structure having definite trend directing from north to south were predominant throughout the whole land indicating the greatest characteristics of the Burmese tectonics.

3 Remarks

In preparing this chapter the authors of the present report were accessible to the following literatures: Detailed and general geology of Burma is described in "The Geology of Burma, by H.L. Chhinbber, Macmilan, 1934". Recent researches are given in "Geology and Hydrocarbon Prosepcts of the Burma Tertiary Geosyncline, by U Aung Khin and U Kyew Uin, Union on Burma Journal of Science and Technology Vol. 2, April 1969, No. 1, pp.53–82."

Geology and fault structure in the Sagain area is seen in "Strike-slip Faulting at the Sagaing-Tagaung Ridge by Wine Swe, Dept. Geology, Arts and Science University of Mandalay, 1970, pp.14–24."

In preparing the present chapter, the authors indebted greately for the generous help and cooperation extended by Prof. Batan Hai of the Department of Geology, Arts and Science University of Rangoon and his colleagues, for which our hearty thanks are due.

Table II-1. STRATIGRAPHIC SUCCESSION AND OROGENESIS OF BURMA

(After Prof. Batan Hai)

AGE	STRATIGRAPHIC SUCCESSION	EARTH MOVEMENTS	EFFECTS	MINERALISATION
RECENT	Newer Alluvium	XII Minor Movement	Raising and tilting of Uru beds.	
PLEISTOCENE	Older Alluvium	XI 3rd phase of HIMALAYAN	Folding of Irawaddian and faulting. Shearing and Retrogressive metamarphic cut across Kabaing Granite Raising of Himalaya and hightlands of Burma to present heights.	
PLIOCENE-PONTIAN	Irawaddy System-interbeded lavas and Tuff			
LOWER AND MIDDLE MIOCENE	Upper Pegu System: Obogon alteration, Kyaukkok Sandstone, Pyawbwe clays	X 2rd phase of HIMALAYAN	Folding of Peguan. Thrusting intrusion of Kabaing Granite and other fine grained dry granite. Thruting and formation of nappes of Himalaya.	COPPER-and minor LEAD-mineralisation
OLIGOCENE	Lower Pegu System: Okhmintaung Sandstone, Padaung, Shwezettaw stage		Cassiterite bearing Pegmatite and aplite intrusion	TIN-TUNGSTEN Veins
EOCENE	Yaw Stage Pondaung Sandstone Tabyin Clays Tilin Sandstone Laungshe Shales with Paunggyi Conglomerate Cor dita Bumonti beds		Intrusion of alaskitic Suite of rocks and mafic rocks	URANIUM-mineralisation
CRETACEOUS	Upper Axial: Globotruncana Limestone, Orbitolina Limestone Kalaw Red Beds (Cretaceous Rocks)	IX 1st phase of HIMALAYAN	Majorfolding and extensive metamorphism. Intrusion of younger granite. Tin granite and ultrabasic Pising of Shan-Tenessarim and North Arakan	TIN-TUNGSTEN mineralisation (minor-URANIUM, LEAD, COPPER) NICKEL-Chromium-Platinum
JURASSIC	Loi-an Coal Measures Namyau Series	VIII Minor Movement	Folding of Loi-an beds intrusion of Tin bearing granite (135m)	
RHAETIC	Napeng Beds (Kamawkala limestone)	VII Minor Movement	Intrusion of monazite bearing (175-190m)	MONAZITE and THORIUM Rare earth mineralisation
TRIASSIC	Pango Evaporites (Daonella bed of Arakan) Na Hkyan Beds	VI Minor Movement		
PERMIAN CARBONIFEROUS DEVONIAN	Upper Plateau Limestone Lower Plateau Limestone Zibingyi Beds	V HEPCYNIAN	Gentle folding and Warping of Plateau Limestone Intrusion of older granite	IRON and MANGANESE mineralisation Minor Lead-Zinc mineralisation
SILURIAN	Namshin Sandstone Nyaung baw Limestone (Orthoceras beds) (MOGOK SERIES)	IV CALEDONIAN	Pre-Plateau Limestone folding and tilting	LEAD-ZINC-SILVER-ANTIMONY (minor Copper) mineralisation Assosiated with Barite Veins Major Lead-Zinc mineralisation
ORDOVICIAN	Naungkangyi= Mawson (MOGOK SERIES)	III TACONIAN	Pre-Silurion folding and tilting of rocks of Southern Shan States and Kayah State	IRON mineralisation
CAMBRIAN	Pangyun Series, Bawdwin Volcanics } Combrian Rocks of S.S.S. (MAWCHI-HERGUI SERIES)			
PRE-CAMBRIAN	Younger Chaungmagyi (MAWCHI-HERGUI SERIES)	II CHARNIAN	Pre-Ordovician Folding and lowgrade metamorphism Intrusion of granite and Quartz veins	COPPER little LEAD mineralisation with Quartz veins
	Older Chaungmagyi (MAWCHI-HERGUI SERIES)	I GRENVILLE of SATPURA	Folding and metamorphism of older Chaungmagyi Intrusion of granite and Quartz veins	GOLD-COPPER

In closing this chapter we take the privilage of reproducing a table (Table II-1) showing the stratigraphy and orogenesis of Burma, compiled by Prof. Batan Hai, representing an important summary in discussing the geology of Burma.

The authors express their heighest appreciation to Prof. Batan Hai for his kind permission to reproduce his unpublished table in our Report.

Appendix III. Earthquake Resistant Design Essentials for Brick Buildings in Japan.

The following is an excerption from "Design Essentials in Earthquake Resistant Buildings", by permission of the editor, Architectural Institute of Japan.

MASONRY CONSTRUCTION

13.1 General

13.1.1 Structural Characteristics

Masonry construction refers to structures that have walls that are constructed by laying brick, stone, concrete blocks, etc. with joint mortar and it excludes those in which other members support principal loads as in the case of steel framed brick construction. For construction which is reinforced by inserting steel bars in the wall in order to supplement the strength of wall, requirements will be explained in Chapter 14.

Masonry construction resists earthquake forces by shear resistance of the walls in the direction of the plane of wall in the same way as the reinforced concrete wall construction, but while it has great weight and large compressive strength, its strength for tension, bending, shear, etc. is less for its rigidity. Besides, if the work is poorly executed, joints connecting each unit becomes structurally weak points. In the light of these facts, masonry construction is disadvantageous against earthquakes. Since this construction had been developed originally in countries where there is no concern about earthquakes, it has suffered considerable damages in past earthquakes. Observing from the standpoint of earthquake damage, the following facts have been observed:

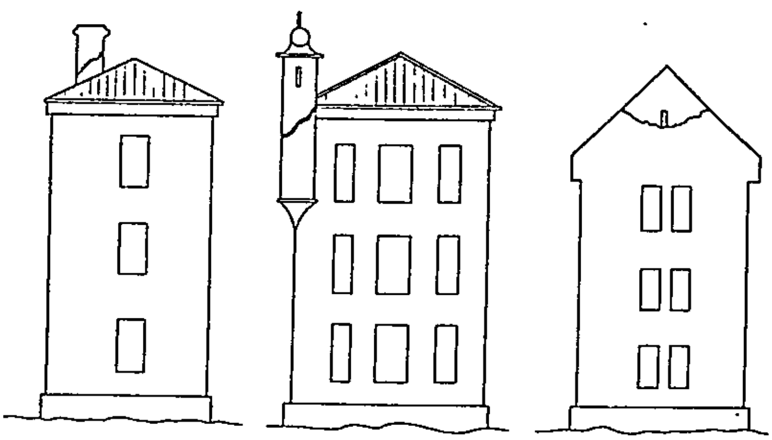


Fig. 13.1

(1) Parts projecting from the body of wall are apt to be destroyed. Chimnies, towers, gable walls, parapets, etc. come under this heading and destruction of them causes cracks in the wall (Fig. 13.1).

(2) When the roof and floors are of timber construction, wall is destroyed as a bending member loaded in horizontal direction and tension cracks occur vertically at the center, ends or corners of the wall. Longer the wall and larger the openings, and in the upper stories, more prominent is the damage (Fig. 13.2).

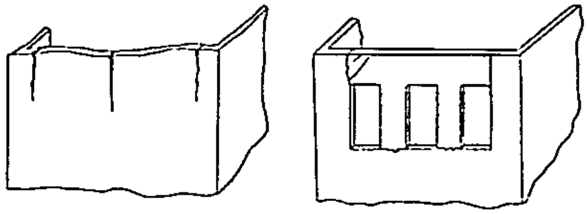


Fig. 13.2

(3) Shear cracks occur diagonally in walls. Subjected to vibrations parallel to the plane of the wall, cracks occur in the lower story in staggered steps diagonally along the joints. Although these occur even in a rigid floor, they are especially noticeable when the work is poorly executed (Fig. 13.3).

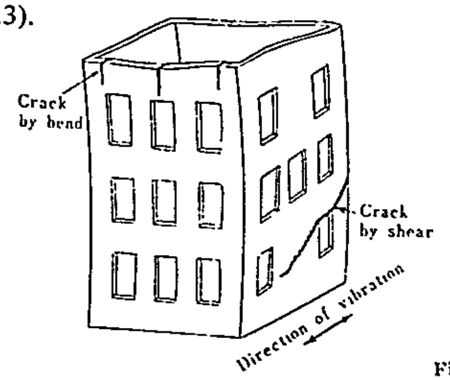


Fig. 13.3

(4) In some cases, the entire wall falls down as a fence wall does, producing horizontal cracks near the base as in the case of a cantilever (Fig. 13.4).

To avoid these damages, there are such means as an increase of wall thickness, alteration of plan, etc, but these have limitations within themselves and it is difficult to raise the degree of earthquake resistance of masonry construction as one wishes. Consequently, it is not feasible with masonry construction to design an aseismic building that above a certain level. In such a case, it is recommended that reinforced concrete block construction, reinforced concrete construction or steel construction be used instead.

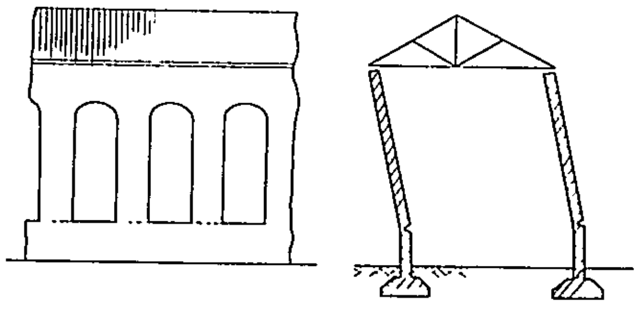


Fig. 13.4

13.1.2 Earthquake Damage

The use of masonry construction in this country extends about one hundred years since the beginning of the Meiji era, and it suffered considerable damage at the time of the Kanto Earthquake of September 1, 1923. Examples are shown in Photo, 13.1, 13.2, and 13.3 Patterns of damage indicate such characteristics as has been explained in the preceding paragraph.

In structural planning of masonry construction at present considerations based principally on the experiences of past earthquake damages, are given so that it may attain earthquake resistance.

Photo 13.1 Damage Example of a Brick Warehouse at the Time of the Kanto Earthquake in 1923

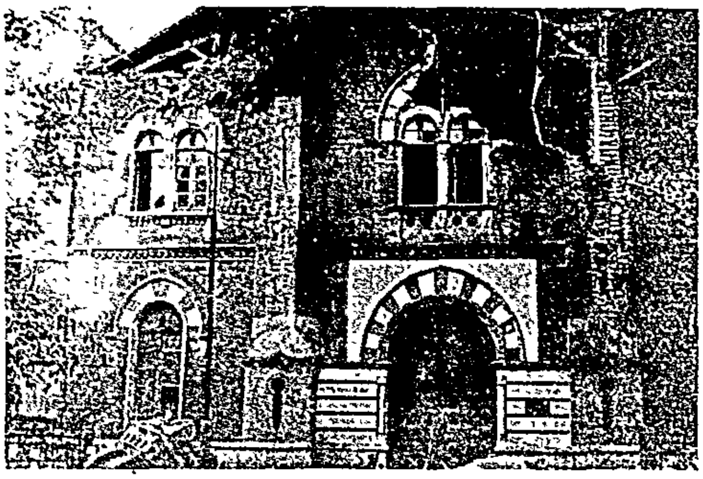


Photo 13.2 Damage Example of a Brick Building at the Time of the Kanto Earthquake in 1923

Photo 13.3 Damage Example of a Brick School Building at the Time of the Kanto Earthquake in 1923

13.2 Structural Planning

13.2.1 Principles of Structural Planning

To make masonry construction secure against earthquakes, the following principles are indispensable:

i) Masonry construction be used only for small scale buildings as far as possible;

ii) The shape of the building, disposition of walls, etc., should be made in a balanced manner, and the stresses are distributed as uniformly as possible to the whole structure;

iii) That tension, bending and shear developed in walls be as small as possible (for example, such as by proper limitation of the wall height, length, opening, etc.);

iv) That the work should be properly done so that the strength of joints may well be secured.

There are the "Standard for Structural Design of Masonry Construction" and "Japan Architectural Standard Specifications (JASS) 7 and 9" as the standards for design and execution of the masonry construction and Articles 51 through 61, Chapter 3 of the Building Standard Law Enforcement Order also apply. The following construction is regarded in this country as being earthquake resistant masonry construction.

Roof and floors may be of timber construction or of reinforced concrete construction. However, timber construction does not possess high earthquake resistance so that all floors and roof of buildings of two stories or more should be made of rigid reinforced concrete.

At the top of walls of each story, cast-in-place reinforced concrete collar beams (refer to par. 13.3.2) should be provided. Its purpose is to reinforce the upper part of the wall and make it resist earthquake force acting perpendicular to the wall. Consequently, it may possibly be omitted in case there is a cast-in-place reinforced concrete floor. As for footings, continuous footing of cast-in-place reinforced concrete should be provided under the wall. In this manner, the walls of masonry construction are reinforced from both top and bottom, by the floor slab or collar beams at the top and continuous footing at the bottom. It is so constructed that the building become one solid body. As the walk, it is necessary to give consideration so that the building become an earthquake resistant structure, by limiting the size of openings and the thickness of the wall (Fig. 13.5).

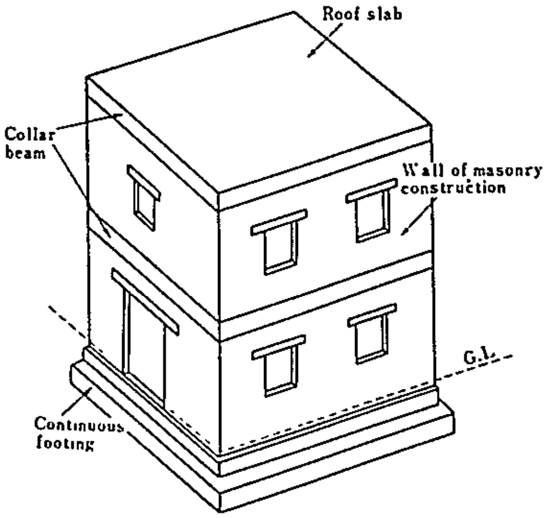


Fig. 13.5

Also a structure in which small reinforced concrete columns are built at each corner of the wall of a building is conceivable and masonry construction after completion of wall, thus enclosing entire building by reinforced concrete frame and restraining walls. This is a kind of mixed use of reinforced concrete frame construction and masonry construction wherein most of the forces are resisted by the masonry wall while a slender framing increases the effectiveness of the walls. This is an example where the weak point of masonry construction is effectively reinforced.

13.2.2 Kinds of Masonry Construction

Masonry construction is classifed by the kind of material that constitute the wall, and called stone construction, brick construction, concrete block construction, etc. The concrete block construction is classified into two kinds, A and B, by the kind of concrete blocks used. Their classification based on the strength is shown in Table 13.1. A stone is strong as a unit but bonded joints become the weak point, therefore, it is treated as being equal to class A concrete block. Brick shows, a strength in general, of 100 kg/cm^2 or more by the standard test and is considered to be equal to class B concrete block. Therefore, the masonry construction is roughly classified into two kinds for their strength as shown in the table, and the former is considered as being somewhat inferior.

Table 13.1

	Kinds	Material	Remark
I	Stone construction	Stone	
	Class A concrete block construction	Block having a compressive strength of 60 kg/cm^2 or more for gross sectional area at 4 weeks	
II	Class B concrete block construction	Block having a compressive strength of 100 kg/cm^2 or more for gross sectional area at 4 weeks	Hollow block is not included
	Brick construction	Brick	

Also, in case where different kinds of material are used in combination in a structure, it is interpreted as being that of the weaker material because the strength of the building is dependent on the weaker material. For example, a structure of brick construction in which stones are used in combination is treated as being of stone construction.

13.2.3 Size

Although limitations on the height of buildings established by the Building Standard Law and by the AIJ Structural Design Standard are as shown in Table 13.2, it is recommended that the number of stories be made two at the most, because masonry construction is not earthquake resistant

Table 13.2

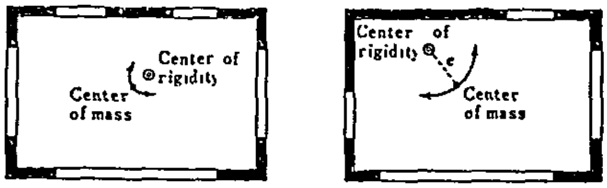
	Height limitation	Height limitation in case roof truss is used
Stone construction Class A concrete block construction	6m (9m in case the wall is especially thick*)	9m, eaves height 6m
Class B concrete block construction Brick construction	9m	13m, eaves height 9m only for the case where roof truss is on the reinforced concrete roof slab

Note:
* Refer to par. 13.3.1.

13.2.4 Disposition and Length of Wall, Enclosed Area, etc.

a) Disposition

It is a rule to make the building resist earthquakes as an unit by connecting walls of masonry construction at their top by collar beam and floor slabs. Therefore, it is necessary that the walls be arranged uniformly and appropriately on the building plan. If the distribution of walls is one-sided, a distance between center of mass and center of rigidity of the building become very large; consequently, large stresses will be caused in the walls on the other sides, or the building will be subjected to torsion and become dangerous. These are the common phenomena in all of the wall construction and an appropriate judgement of the design engineer is necessary.



(a) Acceptable (b) Unacceptable

Fig. 13.6

b) Enclosed Area

As masonry construction is a structure like a box, the smaller the box, the stronger it is; and also in case it is large, the more partitions are provided, the stronger it is. For this reason and for the purpose of preventing unbalanced distribution of walls, the maximum limits of room areas enclosed by walls, for the building of two stories or above, are established as shown in Table 13.3. For buildings of large floor area, they must be partitioned by walls and each area of partition must be so proportioned that they come within these limits (Fig. 13.7).

Table 13.3

	Maximum partitioned area (m^2)
Stone construction Class A concrete block construction	40 (but, 60 in case the wall is especially thick*)
Class B concrete block construction Brick construction	60

Note:
* Refer to par. 13.3.1.

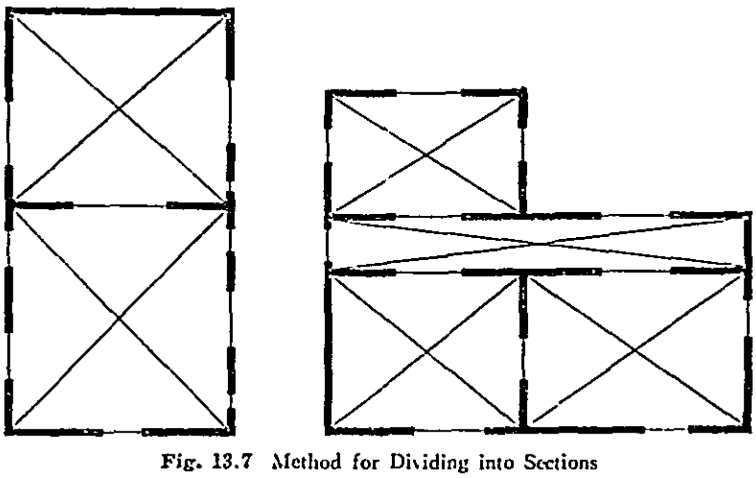


Fig. 13.7 Method for Dividing into Sections

c) Maximum Length of Wall

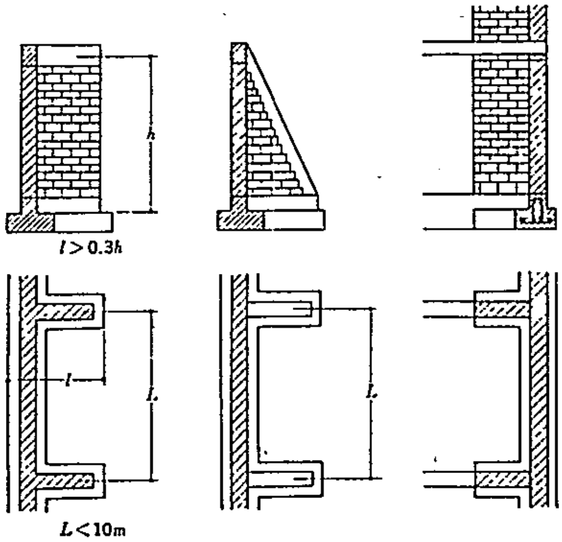


Fig. 13.8 Buttress and Adjoining Wall Details

It is not desirable to have long walls because they are weak against bending and twisting not in the plane of the wall if length of each wall is very long. In this county, the maximum length is limited to 10m. The length of a wall is defined as the distance between two other walls ("adjoining walls") that are joined to the wall at right angle and facing each other. In case there is need to make a wall long, it must be divided into sections of 10m or less by providing buttresses in between as shown in Fig. 13.8.

13.3 Structural Notes

13.3.1 Walls

a) Thickness

As for the wall thickness, it is necessary to have a thickness equal to or more than the value shown in Table 13.4 correspondingly to the wall lengths and number of stories. These thickness do not include the finish.

The wall thickness should also be 1/15 or more of the height of the wall in that story. As the partition walls in general have less openings, a wall thickness 10cm less than that of ordinary walls is permissible for them. However, it should not be under 20cm. For the boundary wall of a multi-unit building, it is desirable to use the wall of the same thickness as that of the exterior walls.

Table 13.4 Thickness of Wall

Length of wall / Number of stories	5m or under	above 5m
Building of 2-stories or more	30 cm	40 cm
One-story building	20 cm	30 cm

The definition of "in case the wall is especially thick" mentioned in Table 13.2 or 13.3 refers to the case where the thickness of the wall is made equal to 1.5 times the values shown in Table 13.4 or more. This is a special bonus given because of the increased thickness of the wall. In case double walls are used, either one of the walls must meet the above requirement. The wall, in general, should not be made thinner than that of the story above.

b) Openings

Openings should be kept as small as possible for keeping earthquake resistance of a building unimpaired, because shear resistance of a wall is decreased if it has openings. For each one of the divided partition of a building as shown in Table 13.3, sum of the width of opening should be made less than or equal to 1/2 of the sum of the wall length in respective directions of the length and the width of the building. Also, for the whole building, total sum of width of opening of each story should be made less than or equal to 1/3 of the total sum of the length of walls. The length of the wall between adjoining openings, and that between the edge of opening and center of the "adjoining wall" should be made more than or equal to twice the wall thickness (Fig. 13.9).

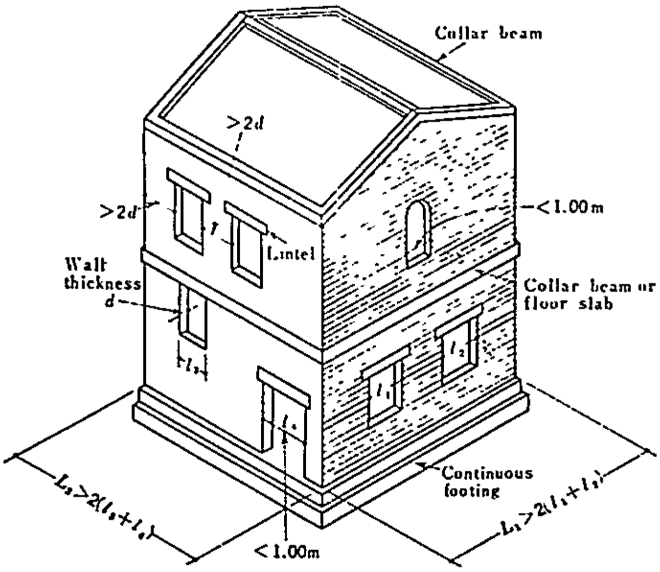


Fig. 13.9

Extruding window or balcony of masonry construction is dangerous, and such must be either made of reinforced concrete or reinforced by steel framing.

c) Reinforcement of the Upper Part of Openings

In the upper part of opening, brick arch or stone lintel has been used in the traditional construction; but as these are apt to get cracks and even fall down in case of earthquakes, their use should be limited only for small windows having opening width of 1m or less and they should be sufficiently reinforced with metal pieces. For the upper part of opening having a width more than 1m, lintel of precast or cast-in-place reinforced concrete should be used and it is necessary to provide sufficient bearing area in the wall of both sides of opening (Fing. 13.10).

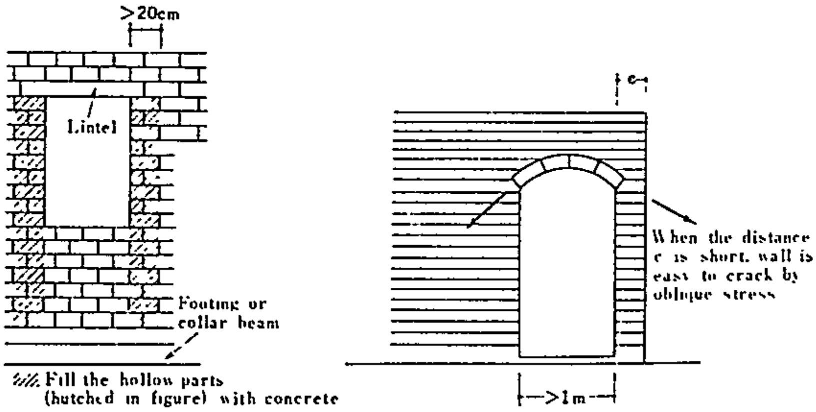


Fig. 13.10

13.3.2 Collar Beams

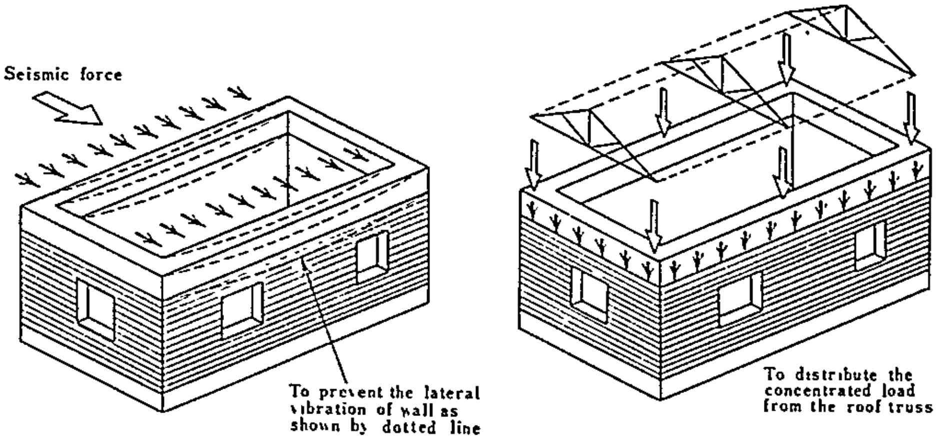
At the top of wall in each story, continuous beams of cast-in-place reinforced concrete are provided. These are called collar beams. As the collar beam serves to reinforce the wall top, transmitting positively earthquake forces normal to the plane of wall to the "adjoining walls", and making the building resist as one body, it should be provided without fail for masonry construction which is weak in bonding strength. However, in case where cast-in-place floor slabs are provided adjoining the top of walls, collar beams can be omitted as the slabs serve to maintain rigidity of the top of wall and take over the transmission of horizontal forces. Although the law and regulations permit the omission of collar beams for one-story building when the thickness of the wall is equal to or more than 1/10 of the height of wall, and even when the length of the length of the wall is 5m or less, it is desirable to have them when horizontal force due to earthquake is large. Collar beams should be of reinforced concrete construction having reinforcements in both top and bottom faces, and also on both sides (Fig. 13.11).

Section of collar beam is determined by the distance between "adjoining walls" and also controlled by the vertical load in case there is a large opening immediately below. Even when no collar beam is required, steel or reinforced concrete bearing piece must be provided at the top of the wall for the concentrated load of roof truss, etc. in order to distribute that load.

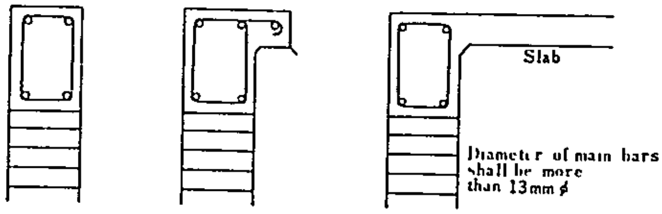
Projecting walls above the uppermost collar beam or floor slab such as gable wall, parapet, etc. receive large earthquake forces, and it is prohibited under the law and regulations to make them of masonry construction. In this case, however, nothing interferes provided the top of these wall is further reinforced by reinforced concrete collar beams.

13.3.3 Floor and Roof

Floor slabs having high rigidity increase earthquake resistance of the building of distributing horizontal forces due to earthquake uniformly to each wall and bringing the shear resistance of each wall together. For this purpose, for the roofs and floors of a building of two stories or more which are made of masonry construction, it is recommended that they have slabs of cast-in-place reinforced concrete construction or of rigid precast reinforced concrete construction except for the base story floor. It is necessary for these slabs that they be designed and constructed so as to be well bonded with the walls (Fig. 13.12).



(a) Function of collar beam



(b) Collar beam section details

Fig. 13.11

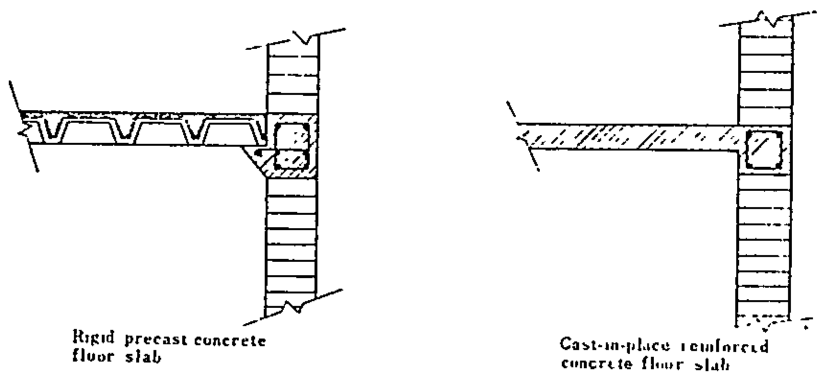
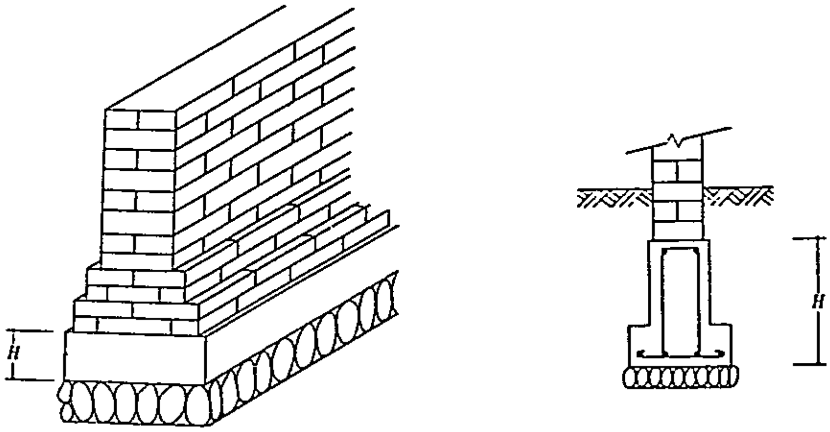


Fig. 13.12

13.3.4 Footings

For the purpose of making the masonry construction earthquake resistant, it is most appropriate to use rigid and continuous footings or footing beams and to connect the bottom of each wall into one body. This has been proven by great earthquakes in the past and by full scale model experiments. Continuous footings are effective not only in case of earthquakes but also against the vertical loads under ordinary conditions in preventing development of cracks due to irregular settlement of the building. Continuous footings should ordinarily be made of cast-in-place reinforced concrete, provided continuously under the walls, and connected by footing beams where openings occur in the above. Continuous footing should be reinforced both in the top and the bottom faces; the width of footing base should be made wide enough so that the contact soil pressures are made as uniform as possible; and the depth of footing under ground level should be determined in consideration of effects at the time of earthquake, frost heave, and other conditions. In case the building is of one-story and the supporting soil is good, continuous footing of plain concrete is also acceptable. In case where opening or entrance in the wall is large and clear down to the ground level, the section of the footing beam or the continuous footing should be so determined that it is adequate against the stresses due to the contact soil pressure and earthquake forces. The height of continuous footing and footing beam should be equal to or more than 1/18 of the building height but not less than 40 cm, except for one-story buildings in which it should not be less than 30 cm (Fig. 13.13).



Footing of plain concrete   Footing of reinforced concrete

H : Height of footing≥1/18 of height of structure and 40cm (30cm in 1 story bldg.)

Fig. 13.13 Footing Details

13.4 Remarks on Structural Calculations

The masonry construction is a type of wall construction and its stress calculation is not simple. Also as the body of the wall which is made by bonding is not homogeneous, it is not clear if the stresses are transmitted as calculated. Consequently, a design standard is established based ordinarily on examples of the past or rough calculations on proper assumptions; and if the articles and numerical values in tables of the standard are applied, a generally reasonable design is obtained. An outline of these requirements have been desdribed, but one should have knowledge of structural calculation to some degree in order to be able to cope with particular cases which may possibly develop. Especially, as the design standard is made for buildings whose scale is not too large, some checking by calculation is necessary in case of designing a large scale building (such as those having large building area or large story height).

13.4.1 Method of Calculations

a) Rough Calculation by Wall Rates

In general, the calculation method for wall construction, calculations are made for the permanent stress due to vertical loads and for the temporary stress, which is the sum of the permanent stress and that of the earthquake force, for every wall, exclusive of non-bearing walls, divided by every one of openings in it is defined as the bearing wall* and if these are found to be

* Refer to Par. 10.1.1, Chapter 10 Reinforced Concrete Wall Construction.

within the allowable unit stresses mentioned in the following paragraph, it is considered to be all right. In this case, with regard to the temporary stress, only an average shear unit stress in the wall is checked for.

For increasing the earthquake resistance of a building, the longer the total length of the bearing wall of the building is, the more advantageous it is. Although another way is to increase the thickness of wall, as the wall in its principal nature resists horizontal forces in the direction of the length of wall, for those walls having the same horizontal section area, the longer the wall is, the greater becomes the earthquake resistance.

For that reason, in wall construction, the values of the respective sums of bearing wall length of each story in widthwise and lengthwise direction divided by the floor area of the story is called the wall rates, and its numerical values are made the bases for judging earthquake resistance of the building. That is to say, the wall rate is the length of wall in a certain direction per unit floor area. If an investigation of the above-mentioned shear unit stress in a wall is to be shown by use of the wall rate, the required wall rate l_0 is expressed by the following formula:

$$l_0 \geqq \frac{Q \cdot \alpha}{f_s \cdot t}$$

where

Q : story shearing force per unit floor area of the story concerned

f_S : allowable shearing unit stress of wall, explained in the next paragraph

t : thickness of the wall

α : concentration coefficient of shearing stress

Concentration coefficient of shearing stress increases the story shearing stress in expectation of possible stress concentration in particular walls as the result of unbalanced wall arrangement. If there is no unbalance in the arrangement of walls, $\alpha = 1.0$, but ordinarily it takes values of $1.5 \sim 2.0$. Also, in case where thickness of each wall is not the same, the method of application of the above formula changes slightly but the formula can be used generally by taking the thinner wall thickness.

b) Alternate Method

In this case, the frame calculation is carried out treating the above-mentioned bearing wall as a kind of wall-column. Based on the shearing force distribution coefficients to be calculated from stiffness ratio of each wall-column, shearing stress, bending moment and axial stress are calculated. Method of stress calculation is similar to that of the reinforced concrete wall construction of chapter 10 (refer to paragraph 10.3). As for these stresses, it is ascertained that they are respectively within the allowable unit stresses for shearing, compression and tension. However, as the tensile resistance of the wall of masonry construction is especially small, it is recommended that it be designed so as to cause no tensile stress in the section if feasible.

For such portions of reinforced concrete construction as collar beams or continuous wall footings excepting the wall itself, sections are determined based on the calculated stresses mentioned above and in accordance with the design of reinforced concrete members.

13.4.2 Allowable Unit Stresses

As to the strength of masonry construction, there are differences in each one of masonry units, and it is usual that there be considerable difference depending on quality of jointing work and type of bonding. Besides, in masonry construction, it is characteristic that the strength of bonded body as a whole is remarkably low compared with that of the masonry unit. The ratio of decrease in strength because of bonding is called bonding factor and regarding this, various experimental studies have been made, and the strength is generally reduced to the neighborhood of one half or thereabouts. Taking these facts into consideration, a larger safety factor for allowable unit stresses must be taken compared with those of the other types of construction. The allowable unit stresses of the wall fixed by the standard of this country are shown in Table 13.5 in which, for example, such figures as 1/8 or 1/12 of the strength of the masonry unit for the allowable compressive unit stress for the permanent loading may seem to be too small, but it cannot be avoided considering the character and dependability of execution in masonry construction.

Table 13.5 Allowable Unit Stresses of Masonry Construction Wall

Allowable unit stresses / Kinds	Allowable unit stresses for the permanent stress		Allowable unit stresses for the temporary stress
	Compression	Tension & Shear	Compression, Tension & Shear
Brick, Solid concrete block	1/8 of the compressive strength of the unit, but not more than 15 kg/cm²	1/80 of the compressive strength of the unit, but not more than 1.5 kg/cm²	1.5 times, the values for the permanent stresses
Hollow brick Hollow concrete block	Using net sections, 1/12 of the compressive strength of the unit, but not more than 10 kg/cm²	Using net sections, 1/80 of the compressive strength of the unit, but not more than 1.5 kg/cm²	

13.5 Precautions for Workmanship

In masonry construction, workmanship is especially important. Precautions are required as there are not a few examples in which great damage was suffered at a time of disaster in spite of good design practice, because the expected strength of the building was not attained on account of poor workmanship.

13.5.1 Materials

a) Bricks

As to the common bricks used in masonry construction, a standard of quality and size is given by JIS R 1250. The strength of a given unit is 100 kg/cm^2 or more. There are two kinds, ordinary burnt and high grade burnt, the latter having a better quality. The size of 210 x 100 x 60mm is made the standard. For ones to be used for arches and cornices, special shape bricks matching the design are available.

b) Concrete Blocks

As for hollow concrete blocks, there is a standard given by JIS A 5406*; in which 3 kinds of

* Refer to Par. 14.2.2, Chapter 14 Reinforced Concrete Block Construction.

concrete blocks–A, B and C in order of increasing strength beginning from the weakest–are available, but it is desirable in masonry construction to use (Class C) ones having a compressive strength of 100 kg/cm^2 or more as in the case of ordinary bricks.

c) Joint Mortar

For the mortar for bonding, a mix of 2.5 ~ 3 sand to 1 cement (volume ratio) is used. For finishing joints, a special mix of 1:1 is used. As the strength of mortar has great influence on the strength of bonded member, mortar of leaner mix than this should not be used. As the mortar mixed with lime reduces the strength, precautions are required when it is used for structural purposes.

13.5.2 Laying

a) Wetting

As bricks, stones and concrete blocks have water absorbability, their joint surfaces must be thoroughly washed with water prior to bonding in order to give moisture. If it is not wetted sufficiently, moisture in the joint mortar is absorbed and the hardening condition of mortar becomes unfavorable and separation of joint surface may result. Precautions are required also to avoid excessive wetting, because excessive water will under such a condition cause bleeding of joint mortar.

b) Joints

In laying units, bedding, buttering and pouring of mortar should be done with sufficient care and precautions should be taken especially to the vertical joints so that no void is left in the joints. For the case using hollow concrete blocks, refer to the chapter on reinforced concrete block construction. For the thickness of joint, 10 mm is the standard.

c) Laying

Straight joint should be avoided because it reduces considerably the strength of bonded member (Fig. 13.14).

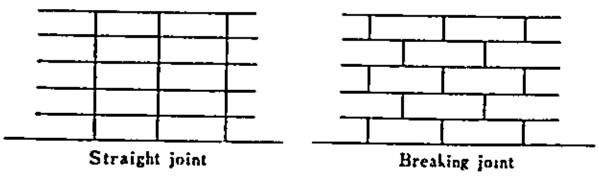


Fig. 13.14

Although there are various kinds of bonds, those in which straight joint is avoided and units may be laid with regularity are recommended. For brick construction, English bond, Flemish bond, etc. are often used (Fig. 13.15). Each part should be laid equally as much as possible. A day's laying height should generally be limited to within 1.2m and unfinished edge should be raked and toothed edge should be avoided.

13.5.3 Others

Buildings of masonry construction have reinforced concrete collar beams, continuous wall footing, lintels, etc. Also there are cases where steel frame is used in part for reinforcement.

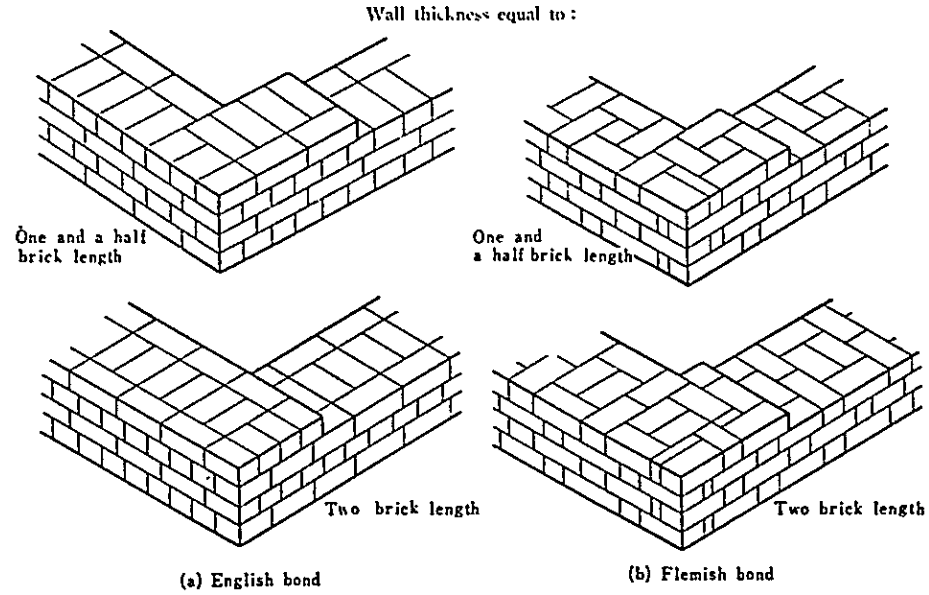


Fig. 13.15·

In each one of the construction methods, those precautions required for the execution of respective construction should be followed. In regard to masonry construction, however, precautions should be taken so the masonry construction are well connected because these connections made with other types of construction are apt to become weak points. In some cases, metal reinforcements are sometimes used.

Appendix Ⅳ. Excerpt from the Earthquake Resistant Regulations A World List 1970

A brief introduction on earthquake resistant regulations for Bulgaria, India, Japan and Turkey which are excepted from the Earthquake Resistant Regulations A World List 1970 compiled by the International Association Earthquake Engineering, November 1970.

BULGARIA

STATE COMMITTEE FOR BUILDING AND ARCHITECTURE
MINISTRY OF CONSTRUCTION
BULGARIA
CODE FOR BUILDINGS IN EARTHQUAKE REGIONS
Sofia 1964

Bulgarian Code for Building in Earthquake Regions

Part I

General Indications

1. Scope of Application, Building Regions and Selection of Building Sites

1.1 This code determines the requirements to which the dwellings, the public, industrial agricultural and hydrotechnical buildings and equipments, which are built in seismic regions of VII, VIII and IX degree, must conform.

1.2 The degree of the seismological regions is determined with the map for formation of seismic regions of the People's Republic of Bulgaria (Application 1) or with the list of the settlements (Application 2).

When the building site is located on the boundary between regions with different seismic degrees the lower degree is accepted.

When a selection of regions is made, which are destinated for enlargement of settlements, for new settlements or for big industrial enterprises seismic division into regions of the selected regions and their nearest neighbourhood should be performed.

1.3 When a selection of a building site is made one should bear in mind that:

a) Favourable to seismic aspect are unevaporated rocks as well as dense gravels which are not too humid.

b) Unfavourable and unsuitable sites for building are considered as the following; sites exposed to sliding and collapsing or which have already undergone sliding and collapsing; sites located in regions which have undergone deformations due to earthquakes or other tectonic phenomena, slopes - more steep than 1:3, excluding sites located on rocks; sites near the ends of the seats; water saturated and marshy soils from group 4 on Table 3 ;

NOTE : In cases when it is necessary to build in such places, it is recommended that eventual cleaning, draining and strengthening etc. should be performed before beginning the work.

1.4 When designing buildings and equipments in seismic regions it is recommended to use the following; simple forms in plan with uniformly and symmetric distribution of the volumes, the masses and the rigidities of the load bearing elements; direct transfer of the vertical and horizontal (seismic) loadings towards the foundation; spatial action of the constructions by joining of the horizontal monolithic floor braces with vertical load-bearing elements; small dead weight of the buildings and the equipments by using lightweight effective materials.

1.5 The assembled constructions should be realized from as big elements as possible, well fastended in the places of the joining. Connections which cause concentration of stresses in the different areas of the elements (especially in the wall and floor panels) should be avoided as far as possible.

1.6 Buildings and equipments with a difference in the height of 10 m of the individual parts are divided with anti-earthquake joints which, if possible should coincide with the dilatation joints.

1.7 Securing of the buildings and the equipments against earthquake is achieved by:

a) Selection of building sites suitable in seismic respect.
b) A correct selection of the designing and constructive scheme.
c) A suitable selection of the building materials.
d) High quality of the construction work.

Because in mutual action of the fundamental and the additional loads and the seismic forces, the buildings and the equipments have a negligible safety, in order to prevent destruction in case of earthquakes the building in seismic regions must be carried out in full accordance with the requirements for the quality of the construction work and the building materials.

Part 2

Indications for Static Calculations

1. Main Points for Determination of Seismic Forces

1.1 The buildings and equipments, which are built in seismic regions, are designed taking the action of the seismic forces into account.

1.2 According to their significance, the seismic degree of the buildings and of the equipments is determined from Table 1.

Table 1

Seismic Degree of the Buildings and the Equipments according to Their Significance

Category of the Buildings and the Equipments	Characteristic of the Buildings and the Equipments	Seismic Degree of the Buildings and the Equipments in Regions of Seismic Degree of VII	VIII	IX
A	Monumental buildings and equipments with national significance, monuments and buildings with special historical significance, theatres with halls with more than 1200	VIII	IX	IX^{x}

A	seats, important government buildings, radio stations - buildings on which the economic life of the country depends.	VIII IX IX^{x}
B	Production buildings for main production-stores with goods with important national significance, cinemas, theatres not included in category A; museums and libraries, railway reception buildings, post offices, tram, troley and bus depots, dwellings, hostels, barracks, schools, high educational institutions, scientific and cultural institutes, kindergardens, creches, baths, hospitals and the like, engineering equipments, masts, factory chimneys, scaffold bridges, elevator towers silos, water towers, reservoirs, bridges, viaducts, etc.	VII VIII IX
C	Subsidary production buildings on which the main production does not depend; stock-breeding buildings of farms, multi-storey garages, energetics with local significance.	VII VII VIII
D	Stock-breeding buildings excluding those included in category B, stores excluding those included in category B, garages not included in category B, temporary buildings and equipments.	not secured

x - The seismic forces for buildings and equipments from category A in IX seismic degree are accepted as IX degree increased with 30 %.

1.3 When designing the structures of the buildings and the equipments it should be taken into account that the seismic forces might have arbitrary direction in space. When calculating the buildings and the equipments as a whole (the separate blocks of the buildings, towers, masts etc.) or as the separate elements (frame walls etc.), the seismic forces as a rule are accepted to act horizontally in direction of the longitudinal or transverse axis; as far as balconies roofs and other similar protruding parts are concerned, it is accepted that the forces act in vertical direction according to indications in Part 3.1. The action of the seismic loads in both directions is considered separately.

1.4 The seismic forces in combination with other loads are related to the particular combinations. The calculation is made for simultaneous action of the seismic forces, the dead load of the construction, loads from snow and useful loads on the floor constructions. The coefficients of overloading in this case are taken according to Table 2.

Table 2

Coefficients of Overloading taking into account the Seismic Forces

No.	Kind of loading	Coefficient of overloading
1	Dead load of the construction (incl. permanent equipment)	1
2	Loading with snow	0.8
3	Useful floor loads for :	
	a) repositories, stores	1
	b) dwellings and public houses	0.8
	c) industrial buildings (excluding the permanent equipment)	0.8
4	In all remaing cases	0.8

In case of a sufficient argumentation, the coefficients of overloading for the useful loads could be reduced.

1.5 Loadings from wind, dynamic loads from machines and equipments, spiral and sideways forces from crane movement as well as inertia forces of loads hanged on flexible suspenders are not taken into account when calculating the constructions of the seismic forces. For production buildings calculated with mounting loadings, the seismic forces are determined on the basis of the actual exploitation loads.

When bridge cranes are available the seismic forces are determined as: when the loads is hanged on a rope - only by the dead weight of the crane.

When the useful load is rigidly hanged - by the whole weight. In the industrial buildings with many halls when several bridge cranes are available, for the calculation of the seismic force in the coloumns situated in a transverse axis, one crane is accepted which is the heaviest one.

Note: When calculating the equipments on seismic effects, in case that the wind is the main load (mastics, towers, chimneys etc.), it is taken in the calculations as 30 % of the magnitude.

1.6 The calculating seismic force S_k in any point K of the equipment, where the mass with weight Q_k is concentrated, is determined by formula (1)

$$S_K = \Psi \beta \eta K_c Q_k \qquad (1)$$

Q_k - loading concentrated in k, causing the inertia force consisting of the dead load of the construction, the loading of the floor constructions and the snow accepted with the coefficient of overloading in Table 2.

K_c - seismic coefficient which is taken from Table 3 for the seismic degree of the building (equipment) established according to Table 1.

β - dynamic coefficient according to the formula $\beta = - \frac{0.9}{T}$

where T is the period of the natural oscillations of the equipment; β is accepted as not greater than 3 and not smaller than 0.60.
For the first frequency of the oscillations T can be determined by the following approximate formulas :
For dwellings, cultural buildings, hospitals and other buildings with a reinforced concerte frame without braces with height of 3 to 15 stories

$$T = 0.19\, n \text{ (n - the no. of the stories)} \qquad (2)$$

For buildings with 1 and 2 stories with reinforced concrete frame without braces according to the rules of building mechanics :
For buildings with rigid constructive system (braces or reinforced concrete frame with singular braces)

$$T = \text{approx. } 0.09 \frac{H}{\sqrt{B}} \qquad (3)$$

where H is the height of the building (block) between two dilatation joints and B the breadth. H and B are taken in meters :
For equipments whose periods T of the first frequency are larger than 1.5 sec. a check is also needed for the higher forms of oscillation. The use of these formulas does not exclude the application of more precise methods for determination of T.

η_K - coefficient of the form of oscillation which depends on the form of the deformed axis of the equipment (building) in case of free oscillations and on the magnitude of the load (Q) ; η_K is determined here by formula 4 for the corresponding frequency of the oscillations

$$\eta_K = x_K \frac{\sum_{j=1}^{n} Q_j x_j}{\sum_{j=1}^{n} Q_j x_j^2} \qquad (4)$$

where x_k and x_j are the horizontal displacements of points k and j at a corresponding frequency of the free oscillations of the equipment from the initial position ;
n - number of the points where as it is accepted that the loads Q are concentrated.

Ψ - coefficient accounting the damping of the oscillations in the construction.
Characteristic meanings of the coefficient Ψ;
$\Psi = 1.0$ - for ordinary rigid buildings with comparatively large damping (brick buildings, buildings without frames with braces which take over fully the seismic forces etc.) and other ordinary rigid equipments. For rigid buildings with monolithic reinforced concrete frame, the coefficient can be reduced to half.
$\Psi = 1.5$ - for flexible equipments with small damping (towers, masts, chimneys, radio and TV aerials etc.)

1.7 For dwellings, cultural buildings, hospitals, office buildings etc. the distribution of the whole seismic force along the height of the building, for the first frequency of the oscillations, could be done by using the rule of the triangle with a base at the peak η_K = 1.35 instead of using formula 4.

1.8 When calculating the walls and the wall's filling of the frame buildings as well as their attachment to the frames for local seismic loading perpendicular to their plane, the seismic force is taken as $2K_cQK$ where Q_k is the weight of the wall. When calculating balconies, vizors over entrances and other protruding parts of the building (the equipment) which are not elements from the general lead-bearing constructive system, the seismic force is accepted to be acting in a vertical direction and equals $5K_cQK$. The bay-window's protrudings are calculated for vertical seismic force without any increase. When calculating the part's constructions which are raised above the building and which have small cross sections and negligible mass in comparison with the main part of the building, as for instance parapets, atticks etc. the seismic forces are taken in horizontal direction and are equal to $4K_cQK$ where QK is the weight of each part.

1.9 For supporting walls the seismic force is determined from the dead load of the wall and the weight of the soil which lies on the main projection of the foundations. The angle of the inner friction of the soils, when determination of the soil's pressure is carried out, decreases : in seismic regions of VII and VIII degree of intensity by 3^0 and in seismic regions of IX degree - by 6^0. The angle of friction between the back of the wall and the soil is equal to zero.

Table 3

Seismic Coefficients K_c

Group	Building soil Name, density, consistence	Seismic Degree VII	VIII	IX
1	Rock	-	-	0,050
2	Semi-rock building soil, coarse and middle-sized gravel, rigid clay	-	0,033	0,067
3	Fine and clayish gravel; gravel sand and coarse sand - compacted and semi-compacted; middle sized and fine sand - compacted; clayish sand and sandy clay - rigid, semi-rigid and rigid-plastic; clay - semi-rigid and rigid - plastic	0,025	0,050	0,100
4	Middle-sized and fine sand - semi compacted; Fine sand - compacted and semi-compacted; joint soils (clayish sand with coefficients of the pores and 0,7 with sandy clay $\varepsilon < 1,0$ and clay with $\varepsilon < 1,1$) semi plastic and softly plastic, loess	0,033	0,067	0,133

Notes:

1. The names of the soils are given in accordance with the grading, the relative density and the consistence according to Bulgarian State Standard 676-57 "Building Soils. Classification" and Bulgarian State Standard 2761-57 "Building Soils. Physical Properties".

2. On embankments in seismic regions building is not allowed to be constructed without taking the special measures.

3. Additional indications for the static investigation and for the dimensioning of the constructions.

3.1 For the given level the due seismic forces of the separate vertical load-bearing systems (braces, frames etc.) of the buildings (equipments) are determined by the distribution of the horizontal forces as follows;

a) for walls with frameless large-panel buildings with rigid monolithic or fastened floor constructions - by leveling the displacements in the uppermost level and in the first level of all vertical load-bearing systems;

b) for floor constructions which do not act as rigid washers (joists etc.) - proportional to the vertical loads for the given level belonging to the separate vertical load-bearing systems.

c) for all remaining cases - according to the rules of building mechanics.

The connections between the separate constructive elements of the buildings and the equipments of the type of the anchor bolts of coloumns, studs, frames etc.; also the attachment of the water reservoirs and towers, balconies, sheds of a vizor's type parapets etc. as well as joint connections and monolithic connections of prefabricated buildings and equipments are calculated at the joints under the action of the seismic forces on the whole equipment or on its separate parts (i.e. without an increase).

When calculating welded connections of steel and reinforced concrete elements in prefabricated buildings, the effects of the seismic forces increase by 25 %.

3.2 When determining the inner effects of the elements and the construction, the seismic loadings are also taken into account and the dimensioning is performed in the following way;

a) according to the method of the "allowable stresses" - the stresses increase by 50 %;

b) according to the method "at the stage of destruction" - the coefficients of safety are accepted for the combination - basic, additional and particular loadings;

c) by the method of the "boundary conditions" - the calculating resistance for the reinforced concrete constructions increase 1.5 times for the concrete and the steel.

For prestressed reinforced concrete constructions, the coefficient for term of work is accepted as 1.20. When the seismic forces are taken into account these constructions are not checked for crack resistance.

3.3 The coefficient of safety against overturning and sliding of the buildings and the equipments when the earthquake forces are taken into account must be at least 1.20.

3.4 For dimensioning of the main plane of the foundations, in case the seismic forces are taken into account, the calculating soil loading can be increased up to 4 times for the soils from groups 1 and 2, up to 3 times for the soils from group 3 and 2 times for the soils from group 4, given in Table 3 of these regulations. The foundations must be dimensioned in order to accept the increased reaction of the soil.

Part 3

Building-constructive Indications for Dwellings, Public, Industrial and Agricultural Buildings

1. General Conditions

1.1 For securing of the buildings against seismic forces architectural-planning and building-constructive solutions must be provided. These should have mutual connection, strength and stability.

Because of this, as enumerated in the following paragraphs, undertakings are to be carried out as cross and transverse walls, frames, floor constructions, anti-seismic belts, shoulders for floor constructions and walls, roof coatings, connection between the separate elements etc. are to be used.

When calculating one-story and two-story buildings which are designed and realised according to the indications in Part 3 to 2.13 of these regulations, the seismic forces might not be considered. The constructive undertakings enumerated in this part might not be applied if the designer proves with calculations that the accepted constructions are secured against the action of seismic forces even without these undertakings.

1.2 In the seismic regions of VIII and IX degree, the length of the connected part of the buildings in a quarter at final building should not exceed 100 m. Buildings with big basic areas or lengths are divided by anti-earthquake joints according to Table 4.

Table 4

Spacing between the Anti-earthquake Joints in the Buildings

No.	Kind of building	Seismic regions VII VIII IX spacing between the joints in m.
1	With reinforced concrete or steel frame and large panel and other prefabricated buildings	the same as for the non-seismic regions
2	With brick walls and vertical and horizontal belts and single columns and beams	100 90 80
3	With brick walls and single reinforced concrete columns and beams	60 50 40-building area up to 500 m^2

Note: Under the term "frame" the load-bearing reinforced concrete or steel frame construction is assumed as well as the system of reinforced concrete columns and beams which wholly carry the vertical loads and for the taking over of the horizontal loads transverse and longitudinal braces could be included. The anti-earthquake joints must separate the adjacent blocks of the buildings along the whole length till the upper edge of the foundation. Their width is determined by constructive considerations and should not be less than 3 cm. The anti-earthquake joints in frame buildings are realized by double columns. In buildings with brick or stone load-bearing walls - with double walls each one of which can be exchanged with a reinforced concrete or steel frame.

1.3 The blocks of the buildings between the anti-earthquake joints must have mainly rectangular, circular or other similar simple outline in plan.

The buildings with a reinforced concrete or steel frame and the buildings with load-bearing walls with vertical and horizontal belts might have a complex horizontal outline in seismic regions of VII and VIII degree. The frameless large-panel buildings and the buildings with load-bearing brick walls and with strengthened corners with constructive coloumns or reinforcement might have a complex outline only in seismic region of VII degree.

Note: The strengthening of the inner corners of the frameless buildings with complex outlines is performed with a reinforcement at least 4 ø 6.5 mm which enters in the horizontal joints of the masonry - 1 m at both sides of the inner corner across 1 m along the height. When the reinforcement is of cold-drawn wire 4 ø 5 mm could be used.

1.4 If a provision is made for basements in the seismic regions of IX degree these must take up the whole space under the building without an interuption between 2 anti-earthquake joints. Partial erection of basements is allowed only in seismic regions of VII and VIII degree when the building soils are strong and when the height of the buildings of the corresponding block is the same.

1.5 The greatest height of the buildings and the number of stories depending on the construction and the material are given in Table 5.

Table 5

Maximum Allowable Height of the Buildings and
Number of Stories based on the Construction and the Material

Construction and material of the building and of the equipments	Seismic regions VII	VIII	IX
	Height no. of stories	Height no. of stories	Height no. of stories
1. With steel or reinforced concrete frame and large-panel and other prefabricated buildings from reinforced concrete elements	as for the non-seismic regions		
2. Dwellings, cultural buildings, offices and other similar buildings with load-bearing brick walls and vertical and horizontal reinf. coner. belts realized in accordance with 5.2 with monolithic floor constructions	4	3	2
3. The same as point 2 but with prefabricated floor constructions and wooden beams	3	-	-
4. Load bearing brick walls	3	2	2
5. Wooden frame	not limited		
6. Chimeys (detached)			
a) reinforced concrete chimneys	the height is not limited		
b) metal with strainers	the height is not limited		
c) brick chimneys with outer rings, longitudinal ribs or other strengthening	50	30	25
d) ordinary brick chimneys	20	12	not allowed

1.6 The foundations of the blocks of the buildings between the anti-earthquake joints must be attached as a rule at the same level.

1.7 If the foundations of two adjacent blocks of masonry are placed at different levels, they must be attached at equal depth - at least 1 m on both sides of the anti-earthquake joint.

The passage from the wider parts of the foundations towards the more shallow ones is made by retreats with a slope 1:2 as the height can be 50 cm at most.

1.8 The smallest depth of the foundations for buildings up till 5 m in all earthquake regions and for higher buildings in seismic regions of VII and VIII degree must be 1 m and for buildings higher than 5 m in seismic regions of IX degree - 1.30 m.

1.9 The mortars for stone and brick masonry of the foundations in seismic regions of IX degree must not be lower than 25 and in regions of VII and VIII degree - 10.

1.10 The foundations of the large-panel buildings in seismic regions are made from monolithic concrete with reinforced belt under the first slab.

2. Load-bearing Walls

2.1 The thickness of the load-bearing walls is determined according to the Code for designing and realizing of masonry and in accordance with the heat-technical requirements, but it should not be less than 25 cm.

2.2 The load-bearing walls between 2 anti-earthquake joints must be, if possible, from one material and must have the same construction.

2.3 It is recommended in the upper stories the load-bearing and non-load-bearing walls to be made of lighter materials.

2.4 The thickness of the load-bearing walls in the basement must be at least 13 cm more than the walls on the first stories. In case of concrete walls this is not necessary.

2.5 The strength of the buildings with load-bearing walls must be secured by a system of longitudinal and transverse walls or frames which take over the horizontal forces. The spacing between the axis of the walls or of the frames is determined from the calculation but it must not exceed the values given in Table 6.

Table 6

Maximum Spacings between the Axis of the Transverse Walls in m.

Construction and materials of the buildings	Seismic regions VII	VIII	IX
Buildings made of bricks or of equivalent natural or artificial stones with regular forms with floors between the stories made of wood, steel or reinforced concrete beams and with anti-earthquake belts	15	10	8
Same, but with reinforced concrete slabs	20	15	10

2.6 Walls with thickness of 1 brick or more, not reaching the foundation are allowed in seismic regions of IX degree only in case these lie on reinforced concrete frame constructions and in seismic regions of VII and VIII degree - in case these lie on beams which rest on parts of walls between opennings with sizes according to 2.11.

2.7 For building with load-bearing brick walls the following cavities and projections are allowed:

a) along the transverse walls in seismic region ot of IX degree - not more than the thickness of the wall; For regions of VIII degree - at most 1 m.

b) projections which do not tally with the innei transverse walls are allowed in regions of VIII and IX degree - not more than the thickness of the wall provided the corners are strengthened with reinforcement as indicated in the note in 1.3.

2.8 Main cornices from reinforced concrete connected with anti-earthquake belts or with reinforced concrete roofs can be protruded 1 m at most.

If the main cornice is wooden it could be protruded forward 1 m at most if it is attached to the roof construction which is anchored in the uppermost anti-earthquake belt.

When the cornices protrude over 1 m their connection with the remaining construction is calculated as their whole vertical load is increased by 30 % in regions of VII seismic degree and 50 % in regions of VIII and IX degree.

2.9 Blank walls with height over 2 m, measured from the upper end of the main cornice as well as frontons and atticks are secured by reinforced concrete columns which must be connected with an anti-earthquake belt.

2.10 The biggest width of the opennings in brick walls in seismic regions of VII and VIII degree might be up to 3 m; For IX degree - 2.5 m. For frame buildings this width is not limited. For brick walls the final openning must be at least 1.50 m from the outer edge of the building except in the cases when at the end a reinforced concrete column is placed with minimum dimensions 25/25 cm and reinforcement 4 ø 12 mm joined above and below with anti-seismic belts.

Opennings with larger sizes are allowed if they are shouldereo with closed reinforced concrete frames connected with the masonry and the anti-earthquake belts.

2.11 The width of the walls between the opennings (doors, windows, etc.), for buildings with load bearing brick masonry with story-height up to 6 m in seismic regions of VII and VIII degree and up to 5 m in regions of IX degree, must not be less than that shown in Table 7.

Table 7

Width of the Walls between the Opennings in Meters

Buildings	VII	VIII	IX
Brick masonry of mortar according to 3.4	0.75	1	0.50

Independently from the requirements in Table 7 the width of these walls must be at least :

a) In seismic regions of VII degree - 33 % of the bigger adjacent openning.
b) In seismic regions of VIII degree - 50 % of the bigger adjacent openning.
c) In seismic regions of IX degree - 75 % of the bigger adjacent openning.

2.12 Walls between opennings with width smaller than that given in Table 7 must be made from reinforced concrete or reinforced masonry.

2.13 Superstructures of existing buildings with heights given in Table 5 are allowed according to the following conditions;

a) the volume weight of the new masonry must not be more than the volume weight of the old one.
b) the construction of the building must conform the requirements of this Code after the superstructure is completed.
c) above all the walls over which building will be carried out, a continuous anti-earthquake belt must be placed - if there's no such belt.
d) over existing buildings (up till 2 stories insl.) which are not secured against seismic forces, superstructures can be of 1 more stories even without securing the whole building according to letter "B" of this paragraph - but this should be done only in the cases in which the building is necessary for forming of street silhouettes according to the approved street-facade plans.

For existing buildings with 3 or more stories with the same conditions the building of 2 more stories is allowed. The whole building including the superstructure must conform with all constructive requirements from the other acting building instructions. For particular cases in forming of street silouhettes the problem is solved by the State Committee for Building and Architecture.

2.14 When ground floors are reconstructed for shops and other similar premises in existing buildings which are not secured against seismic forces, constructive arrangements must be provided for, and these increase the security of the reconstructed building.

In such cases it must be proved that for seismic forces the reconstructed building has at least the same security as the non-reconstructed one.

3. Frames and Their Realization

3.1 The reinforced concrete or steel frame of the building must consist of frames calculated as the seismic forces have been taken into account. The action of the brick masonry in the taking over of the horizontal seismic forces must be taken into account when the calculations are made. The walls with thickness of 25 cm and more must be so arranged in the building that these could take over the seismic forces in the best possible way. The brick walls shouldered with reinforced concrete beams and columns can be included in the taking over of the seismic forces even in case they are made of lime mortar.

For dwellings with monolithic reinforced concrete frame it could be accepted without proving by calculation, that 25 % of the horizontal seismic forces are taken over by the reinforced concrete frame, which is dimensioned for them.

3.2 It is recommended that the walls for steel or reinforced concrete frames should be made of lightweight bricks (hollow, porous etc.) lightweight stone masonry, lightweight concrete and other lightweight materials.

3.3 The connection between the monolithic frames and the masonry is secured by casting of the concrete parts after the finishing of the masonry. For prefabricated frames the additionally built walls must be connected well with the beams and the columns of the frame by sealing of the joints with cement mortar - and in more special cases - by reinforcement.

3.4 In constructing and realization of reinforced concrete frame buildings the following rules must be observed:

a) to reduce the dead load of the construction by use of lightweight building materials, by reduced thickness of the walls, elements etc.

b) to carry out strict technical control for observing the prescribed constructive measures for the qualitative performance of the reinforced concrete works, masonry works and other constructive works which are of importance for the security of the construction against earthquake.

c) to use vertical braces from masonry or concrete for taking over of the horizontal forces. For such braces symmetrically situated walls of staircases and lift shafts could be used.

d) to avoid big bay-window's protruding parts of the building.

e) the blank walls, frontons and other protruding parts must be shouldered with reinforced concrete belts and columns and must be anchored to the construction.

f) independently from the way of calculating, the beams and the frame must be well connected with the final columns of the frames. The longitudinal reinforcement of the beams must be anchored in the supports with length which must not be smaller than 20 ∅ of the rods.

g) the longitudinal reinforcement of the columns in the places of splicing over the floor constructions must overlap at least 20 % from the floor height. In this zone the stirrups must be close to one another. In the zones in which the columns are crossed by the beams, the stirrups are placed at a distance not more than 15 cm. When concrete is casted in the lower and upper end of the coloumn, the design position of the stirrups must be secured.

h) all walls of the building must be well anchored in the frame. For this purpose it is recommended that the masonry should be realized before the casting of the concrete in the columns and the beams. The mortar for the masonry is with a brand not less than 10 for buildings in the VII and VIII seismic regions and brand 25 for buildings in the IX seismic region.

i) the functional joints for concrete works in earthquake regions must be carefully made. Before laying of the new concrete they must be furrowed (by hammering), cleaned and well washed with water.

The pouring of cement milk over the functional joints is forbidden.

j) between the anti-earthquake reinforced concrete belts and the masonry of the walls as well as in the masonry itself a good cohesion must be secured or a suitable anchoring of the belts in the masonry.

k) the anchoring of the connecting parts in the elements of the prefabricated reinforced concrete constructions as well as the weldings of the steel parts and the fastening with concrete or mortar of the joints, the splicings and the connections must be realized with special care. A good cohesion beteen the new concrete (mortar), the old one and the reinforcement must be secured.

4. Prefabricated Constructions and Large-panel Buildings

4.1 When designing and realizing prefabricated constructions in seismic regions besides observing the arrangements given in 1 - Part 3, the followings are necessary;

a) the rigidities of the vertical diaphragms with same direction must, if possible, be equivalent. The center of the rigidities as a rule must coincide with the centre of the masses (weight). The greatest rigidity of each diaphragm must not exceed more than twice the average rigidity of the other diaphragms. The rigidities of the diaphragms can be determined by the horizontal displacement of the level of the last slab. The centre of the weight of the whole building must be, if possible, low.

b) in case of loading with seismic forces, the performance of the load-bearing vertical and horizontal diaphragms must secure mutual special work of the building construction. In the multi-story buildings the lintels above the opennings of the inner diaphragms must take over the shearing effects and the bending effects when deformation of the diaphragm takes place. The special work of large-panel frameless buildings in earthquake regions is secured by connection of the separate panels with concrete dowels, concrete connecting parts, pouring of mortar or concrete with brand not less than 200 over the joints situated between the separate panels. In order to achieve savings in the use of steel it is recommended that the skidding effects between the separate elements should be taken over by concrete dowels with corresponding reinforcement.

c) the panels from the vertical diaphragms must be joined by connections; Their number and cross section are determined by calculation. Connections uniformly distributed over the contour of the panels which allow good fastening of the construction must be preferred. Rigid connections concentrated in small sections of the panels which might cause concentration of stresses must be avoided.

d) the panels of the floor construction must term rigid horizontal diaphragms these must be interconnected and must also be connected with the wall panels along the whole contour by welding of concreted metal parts or by fastening of the protruding reinforcement.

e) the panels of the lowermost story must be anchored to the lower monolithic construction by connections which take over the shearing effects without taking into account the friction.

Note : The friction can be taken into account in the lower part of the building provided there's a continuous reinforced concrete beam or belt.

f) for all steel connecting parts full protection from corrosion must be secured by covering with concrete or mortar - with thickness of the covering not less than 1 cm.

g) for large panel buildings the indications in 3.4 must also be taken into account.

5. Anti-Earthquake Belts

5.1 The anti-earthquake reinforced concrete belts are made in all floors beneath the lower edge of the joist or under (above) the reinforced concrete slabs on all external and internal load-bearing walls of buildings.

5.2 In buildings with reinforced concrete slabs when the height is over 1 story in seismic regions of IX degree and when the height is over 2 stories in regions of VII and VIII degree the anti-earthquake belts are connected in vertical direction with constructive anti-earthquake columns placed in suitable places at a distance not more than 7 cm. These columns are reinforced with at least 4 rods ø 12 mm and with 5 stirrups with diameter of 6.5 mm - per meter.

5.3 The section of the anti-earthquake reinforced concrete belts must have height at least 25 cm (the slab incl.) and width equal to the thickness of the wall. The longitudinal reinforcement must have a common section at least 0.13 % of the section of the belt, but not less than 4 rods with diameter 10 mm, in seismic region of VIII degree, situated in the 4 corners of the belt. When steel of higher brand is used, the diameter of the rods is determined from the section of these 4 rods multiplied by $\frac{2100}{Ra}$ where Ra is the calculating resistance of the steel.
The stirrups must be closed, with diameter of 6.5 mm and must be placed at a distance of 30 cm.

5.4 The anti-earthquake belts in the brick masonry or in the stonework can have opennings for passing through of vertical ventilation tubes and canals. The weakened places in the belt must be strengthened with additional reinforcement equal to that in the weakened part.

6. Lintels

6.1 The lintels in buildings with reinforced concrete and steel frames must be made from the frame's material and if the opennings are bigger than 2 m, they must be connected with the columns or the beams of the frame.

6.2 The lintels in buildings with walls of bricks or stone masonry must be made from reinforced concrete with width equal to the thickness of the wall. In seismic regions of VII and VIII degree the end of the lintels must lie 30 cm in the masonry and in seismic regions of IX degree - 40 cm. For small building wooden lintels can be used.

7. Balconies and Terraces

7.1 The balconies in brick or stone buildings can be protruded 1 m at most.

7.2 The balconies in brick and stone buildings must be a continuous extension of the floor construction. Exceptions are allowed for balconies which are protruded with 0.75 m provided they're joined with anti-earthquake belt. If anti-earthquake belts are lacking in seismic regions of VII and VIII degree balconies are allowed. These are connected with correspondingly calculated partial reinforced concrete belts. The construction of the balconies must be, if possible light.

8. Staircases and Partition Walls

8.1 Principally the staircases are constructed and calculated as spatial constructive system. In seismic regions of VII and VIII degree fixing of the steps in the walls is allowed if their length is up to 1.20 m; For larger length the fixing is performed by belts calculated for torsion at ordinary loading.

When the steps are constructed and are calculated as consoles the longitudinal distributing reinforcement must not be less than 5 ϕ 6.5 mm/m. It must pass continuously through the staircase shoulder and the landings, and must be anchored in the transverse beams of the staircase.

8.2 When the walls are brick-layed, the beams of the staircase landings must lie at least 25 cm in the wall.

9. Floor Constructions

9.1 The floor constructions must be well jointed with all walls in order to transmit the horizontal forces from the longitudinal walls to the transverse walls and vice versa. All the beams of the floor joists in brick and stone buildings must lie in the wall - 2/3 of its thickness (but not less than 12 cm). If the walls have thickness of 25 cm, under the walls a reinforced concrete belt is placed.

In seismic regions of IX degree all the beams must be anchored in the wall. In regions of VIII degree the beams are anchored leaving out one and in regions of VII degree - leaving out two. The end beams must be anchored to their parallel walls with steel or other connections placed at a distance not bigger than 1 m. For outer walls with thickness 38 cm and more, the distance between the heads of the wooden beams and the outer plane of the walls must not be less than 12 cm.

9.2 If strainers are available,the brick, stone and concrete arches and arches with an arrow 1/6 of the openning without strainers - 1/3 of the openning are allowed in regions of VII and VIII degree. In regions of IX degree such as are allowed only in basements.

10. Roofs

10.1 The roofs must be of lightweight materials: The roofings from tiles or slabs must weight 120 kg/m^2 at most without the cladding.

10.2 The load-bearing floor construction must be resistant to horizontal forces and must be connected with an anti-earthquake belt or with the load-bearing frame.

The horizontal forces in the construction must be taken over by a strainer. The reinforced concrete beams of the last story could be used as strainers.

10.3 The stability of the cantilever roofing systems in perpendicular direction must be secured by connection of the frames with suitable connections.

11. Plasters and Claddings

11.1 Stone cladding of the walls is not recommended: The cladding of the ceiling with heavy slabs is forbidden. If stone cladding is necessary the slabs must be thin and must be well anchored in the walls. The loads of the cladding (horizontal and vertical) must be taken into account in the static calculations with all their effects.

11.2 The thickness of the masonry on cornices of external walls is allowed to be 2-3 cm at most.

11.3 Cornices from masonry in premises are allowed in VIII and IX seismic regions only on metal net with thickness of the layer 3 cm at most.

Part 4

1. Special Technical Arrangements (Heating, Ventilation and Electricity Conduits)

1.1 The weakening of the walls due to the chimneys, the ventilation and other canals in VIII and IX seismic region must be compensated by a corresponding strengthening of the walls.

1.2 Chimneys and brick-layed ventilation canals in internal walls must be at least 1 m apart from the inner side of the external wall.

1.3 Lightweight reservoirs for water heating can be placed on the ceiling but on the beams of reinforced concrete slabs or at the places where the inner walls are crossing.

1.4 The electricity conduits and cables must have a provision for elongation at seismic oscillations.

Part 5

1. Bridges

1.1 Stone and concrete pillars separated from columns are not recommended in the VII and VIII seismic region if they're not parts of frames; In IX region they are not allowed.

1.2 For prefabricated constructions of reinforced concrete pillars and building of bridges, complete fastening must be secured after the assembly.

1.3 Arch bridges are allowed only in case of safe building soils. When designing such bridges the heels of the arches must rest on massive pillars as low as possible.

1.4 The groundwork building for bridges must be as light as possible.

1.5 The steel and reinforced concrete upper beam cqnstructions must be protected from eventual bouncing from their abutments in case of earthquakes.

Part 6

1. Hydrotechnical Equipments

1.1 For hydrotechnical equipments which are of great importance for water-supply, supply of electric power, irrigation and other agricultural purposes as well as for dams with height over 20 m and storage volume over 1 million/m^3 which are designed and built in earthquake regions of VII, VIII and IX degree, micro-seismic investigations must be carried out.

In these investigations account must be taken not only of the tectonics, the engineering-geological and hydro-geological conditions but also of the changes which will take place after actuation of the equipments - as for example the raising of the sub-soil waters, the reduction of the inner friction, the lowering of the security of the slopes of the walls, lowering of the cohesion, danger of sliding, suffusion and other phenomena.

1.2 For equipments of I class, the seismic degree is increased with 1 mark.

1.3 The hydrotechnical equipments in seismic regions of IX degree are calculated for complex conditions of exploitation as additional anti-seismic undertakings are also provided.

The hydrotechnical equipments of II and III class which are not mentioned in 1.1 and whose destruction might cause big material losses and human victims, must conform with the requirements of this Code.

1.4 The temporary equipments are not calculated for seismic actions.

1.5 The seismic forces acting on the equipments are determined by the formula:

$$S = 1.5\,QK_c \qquad (5)$$

Q - load, causing inert force acting on the equipment - dead load of the parts and the mechanisms.

Kc - seismic coefficient

The seismic force acting on part of the equipment is determined by the formula:

$$S = KcQ\left(1 + 0.5\frac{X_k}{X_o}\right) \qquad (6)$$

where X_k is the distance from the base to the centre of weight of the discussed part of the equipment.

X_o - the distance from the base to the centre of weight of the whole equipment.

1.6 For dam walls and water pipes in the calculations the force of the seismic pressure of the water is also taken.

$$Q_b = K_c\, y\, K_e \frac{0.875\sqrt{h\,y}}{1 - 3.38\left(\frac{h}{1,000}\right)^2}\ (t/m^2) \qquad (7)$$

where h is the greatest depth of the water in meters y is the distance between the water level and the section in question.

K_e - coefficient which depends on the inclination of the water side of the equipment - it is accounted according to graph on Fig. 1.

1.7 For canals, locks and other equipments with width of β 3h, the seismic pressure of the water is determined by the formula:

$$q' = \varepsilon Q_\beta \qquad (8)$$

where Q_β is determined by formula (7) and depends on the ratio $\beta : h_r$

β/h	0,5	1,0	1,5	2,0	3,0
	0,4	0,7	0,8	0,9	1,0

1.8 When calculating the active and the passive soil pressure of the earth so far as the dam walls and abutments walls are concerned the seismic acceleration is taken into account according to the formula:

$$E \text{ act. pas.} = (1 \pm 2K_c \operatorname{tg}\Psi) E \text{ act. pass.} \tag{9}$$

where : E - is earth pressure without seismic influence
Ψ - angle of inner friction in the soil
the mark + for active pressure
the mark - for passive pressure

1.9 For dams and embankments for the investigation of the security of the slopes, the horizontal forces due to the seismic acceleration in the most disadvantageous profiles and sliding planes are taken into account. These must be resistant under the action of the main loads and the seismic forces at a reduced coefficient of inner friction.

In the earth-filled walls the position in the depression line must be as low as possible and not less than 2.5 m from the open slope. The slopes must be weightened by stone blocks and prisms from stone blockages must be arranged at their heels.

1.10 In seismic regions building of earth-fill and stone-fill walls of dams with rigid screens or diaphragms is not recommended. For the safety of the earth-fill walls of dams, in case of earthquake of exceptional significance, the density of the embankment, the resistance against sliding and the danger of resonance are important. The shearing modulus must be bigger than 200 kg/cm^2 and the density must be greater than the critical, corresponding to the volume immutability.

The angle of the natural slopes and the angle of the inner friction due to the acceleration of the embankment from seismic forces decreases and is determined by the formula:

$$\operatorname{tg}\cdot\beta_c = \frac{\operatorname{tg}\beta - K_c}{1 + K_c \operatorname{tg}\beta} \tag{10}$$

1.11 The walls of the dams are investigated for seismic forces as follows;

a) the walls of the dam; which are of the type "gravity walls": - when the dam is full and seismic forces from the walls and the water action in direction of the flow, the vertical action of the seismic forces is not the greatest load, the massive walls of dams and other equipments built in seismic regions must be made on strong base rocks sufficiently digged according to their height.

b) arch dam walls - the investigations are carried out as for the gravity walls as well as for action of the seismic forces in direction of the chord. The seismic forces are determined by the formula:

$$S = d\gamma K_c \left[1 + 0.5\frac{x}{x} \cos\left(\frac{\pi}{2} - \frac{\Psi}{\Psi_o}\right)\right](t/M^2) \tag{11}$$

where - d is the thickness of the discussed section
- is the volume weight of the material of the wall x is the distance from

the base to the centre of weight.

Ψ_o - 1/2 of the central angle of the corresponding arc

Ψ - angle to the considered point (Fig. 2)

The examination for stability of the wall is made when the dam is empty and the seismic forces are in direction of the chord and are determined by the formula:

$$S = d \gamma K_c$$

1.12 The seismic water pressure on the arch wall is determined by the formula:

$$q = \alpha \cdot q_B$$

where depends on Ψ:

for direction of the flow $\alpha = 0.5 + \frac{\Psi}{2\Psi_o}$

for transverse direction $\alpha = \frac{\Psi}{2\Psi_o}$

1.13 The hydrotechnical equipments must be also investigated for the appearance of resonance.

1.14 For the big dam walls and high equipments as for example water towers, chimneys etc. the natural oscillations of the base must be determined in site by seismographs or by other methods. When the periods of the base and these of the natural oscillations of the equipments are similar there's danger that resonance will appear which should be prevented by suitable measures.

Part 7

1. Water-supply

1.1 In seismic regions of VIII and IX degree, for the water-supply of big settlements (over 25,000 inhabitants) and of industrial enterprises in which the interruption of the water-supply might cause damages or considerable losses, the following is recommended:

a) Use of at least 2 water-sources independent from each other. Sources from which water for anti-fire purposes can be secured are prefered. If subsoil waters are used as a main source for water-supply, as a second source the water of open reservoirs, springs, rivers, lakes or water-basins must be used. If it is impossible or if it is technically and economically unexpedient to use 2 independent water sources or if the building is performed in stages, water should be taken from 2 points of the used water source with separate pipe-lines, which, if possible, should be far apart from each other.

b) The water-supply equipments, reservoirs etc. which have similar destination must be decentralized by positioning in different points of the territory of the site which is to be supplied with water.

c) Systems with a lowered pressure in the external pipeline and net should be prefered (zoning, use of anti-fire and water-supply systems with low pressure etc.)

d) Tower-reservoirs should be avoided ; In case of suitable terrain conditions they should be replaced by reservoirs situated on the ground, placed in high points of the territory. In case of independent railway water-pipelines, tower reservoirs should also be avoided.

e) If possible, the connections of the separate water-supply nets for drinking water, for anti-fire and industrial purposes should be made available - especially in the case when the water supply is stopped in any of them. The designs for connections of the separate water-supply nets and also the possibility for water-supply with non-cleansed water which is chlorinated must be coordinated with the State Sanitary Inspection.

1.2 If one source for water-supply is used in the seismic regions of VIII and IX degree the following measures should be taken :

a) The useful water sources situated in the settlement and its neighbourhood must be intercepted and must be maintained. Periodically the physical-chemical and bacteriological properties of the water should be checked.

b) The industrial enterprises must have their own basin with a reserve of water in order to prevent harms in the production in case of damages in the pipeline due to earthquake.

1.3 The floors of the pumping stations in seismic regions of VIII and IX degree must be placed at a depth not smaller than 1 m. (From the surface)

The walls of the buildings in plan must not have bendings. The floor (bottom) of the station must be, if possible, uniform.

1.4 It is recommended that the water-purifying stations should be made with one story and their technological elements must be made, if possible into sections. In the seismic regions of VIII and IX degree the arrangements for depositing must be of reinforced concrete and the filters must be made from reinforced concrete or metal.

1.5 For water-purifying stations in seismic regions of VIII and IX degree there should be accesory lines for feeding of the network with water so that the water-purifying equipments can be controlled in case of damage. In this case the most simple installation for chlorinating of the water sent into the network should be available.

1.6 It is recommended that the water-reservoirs in seismic regions of VIII and IX degree should be made from reinforced concrete with a circular form.

The underground reservoirs from bricks, crushed stone and concrete are allowed in seismic regions of VII and VIII degree.

The joint must be filled with a mortar with a brand not lower than 50 ; The brand of the concrete must not be lower than 75.

1.7 In settlements with over 15,000 inhabitants situated in seismic regions of VIII and

IX degree, at pressures of 10 atm. it is obligatory to use steel tubes connected by electric welding.

1.8 A dense laying of tubes in the walls and the foundations of the equipments is not allowed. The opennings through which the tubes pass, must have dimensions which secure free space between the tubes and the masonry.

1.9 When pipe-lines pass under foundations or equipments at the places of connection with pumps, reservoirs and wells and also at the places of connection of the vertical tubes in the tower-reservoirs with horizontal tubes, connections must be provided for flexibility in torsional and longitudinal directions (sockets in the form of funnels connected with rubber tighteners, enlarging connections etc.).

At the places with an abrupt change of the profile of the tracing for the pipeline elastic connections should be provided. For agricultural pipe-lines at such places instead of elastic connections a strengthened welded connection is allowed.

1.10 The water-supply, distributing networks in seismic regions of VIII and IX degree must be made with circulation.

1.11 The depths at which the water mains must be placed in seismic regions are given in Table 8.

Table 8

Minimum Depth for Placing of Water Mains in Seismic Regions

Pipelines	Minimum depths for placing the bottom of the tube in m in seismic region					
	External pipeline		Main lines		Distributing networks and heatings	
Seismic region - degree	IX	VII & VIII	IX	VII & VIII	IX	VII & VIII
Steel	1.70	1.50	1.70	1.50	1.50	1.20
Cast iron & asbestos cement	2	1.70	2	1.70	1.70	1.50
Reinforced concrete -under pressure	2	1.70	2	1.70	1.70	1.50

Note :

1. The depth for placing of tubes given in the table is valid for tubes with diameter up to 300 mm (incl.) ; For tubes with diameter 350 - 800 mm the depth must be increased with 20 - 30 cm, for tubes with a diameter over 800 mm - with 40 - 50 cm ; The distance from the surface of the terrain to the upper edge of the tube must be at least 0.50 m, if according to other requirements a greater covering is not needed.

2. If highly compacted gravel or sandy layer is used, whose thickness is over 3 m, and also in case of laying of secondary lines which it excluded for longer periods, of time will not cause trouble, the depth can be reduced with 20 - 25 %.

3. In rocky terrain the depth for laying of tubes is not standardized.

1.12 If possible the placing of external water-mains and main lines should be avoided in :

a) embankment - independently from the humidity

b) sections in which the pipe-line might cross terrains greatly different in seismic characteristics.

c) sections in which there are traces from tectonic damages.

When it is unavoidable to place the external water-mains and magistral lines in accordance with the above conditions in seismic regions of VIII and IX degree, steel tubes should be used.

1.13 The fire hydrants, the external water-distibuting instalation and the stopping cranes must be placed so that the possibility for burying in case of destruction of the surrounding buildings and equipments could be smallest.

This Code becomes effective from the day of promulgation by "State Magazine" and cancels the Code for anti-seismic building promulgated in "Izvestia", no.78 from 29. IX. 1961.

INDIA

INDIAN STANDARD IS: 1893—1966

CRITERIA FOR

EARTHQUAKE RESISTANT DESIGN OF STRUCTURES

(First Revision)

INDIAN STANDARDS INSTITUTION

MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG

NEW DELHI 1

Indian Standard

CRITERIA FOR EARTHQUAKE RESISTANT DESIGN OF STRUCTURES

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 19 October 1966, after the draft finalized by the Earthquake Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Himalayan region, Indo-Gangetic plain, Kutch and Kathiawar regions are geologically young and unstable parts of India and have been visited by some of the devastating earthquakes of the world. It has been a long felt need to rationalize the earthquake resistant design of structures taking into account seismic data from studies of these Indian earthquakes, particularly in view of the heavy construction programme at present all over the country. It is to serve this purpose that the IS : 1893 - 1962 'Recommendations for earthquake resistant design of structures' was published.

0.2.1 As a result of additional seismic data collected in India and further knowledge and experience gained since the publication of this standard the Sectional Committee felt the need to revise the standard incorporating many changes, such as revision of various maps in the light of additional data collected and the occurrence of earthquakes during this period, a more rational approach for design of buildings and substructure of bridges, and in the criteria for a seismic design of buildings provision for drift, torsion and modal analysis.

0.3 It is not intended in this standard to lay down regulations so that no structure shall suffer any damage, during earthquake of all magnitudes. It has been endeavoured to ensure that, as far as possible, structures are able to respond, without structural damage to shocks of moderate intensities and without total collapse to shocks of heavy intensities. While this standard is intended for earthquake resistant design of normal structures, it has to be emphasized that in the case of special and important structures detailed investigation should be undertaken.

0.3.1 Though the basis for the design of different types of structures is covered in this standard, it is not implied that structural analysis should be made in every case. There might be cases of less important and relatively small structures for which no analysis need be made, provided certain simple precautions are taken in the construction. For example, suitably proportioned diagonal bracings in the vertical panels of steel and concrete structures add to the resistance of frames to withstand earthquake forces. Similarly, in highly seismic areas, construction of a type which entails heavy debris and consequent loss of life and property; such as masonry, particularly mud masonry and rubble masonry, is best avoided in preference to construction of a type which is known to withstand seismic effects better, such as well-braced timber-framed structures. For guidance on precautions to be observed in the construction of buildings, reference may be made to the Indian Standard code of practice for earthquake resistant construction of buildings which is under preparation.

0.4 Attention is particularly drawn to the fact that the intensity of shock due to an earthquake could greatly vary locally at any given place due to variations in the soil conditions. With the present knowledge it is not possible to lay down in quantitative terms the actual variations for different types of soils. However, for the guidance of designers, design-seismic coefficients have been recommended for hard, average and soft soils.

0.5 It is also important that a study of losses incurred in earthquakes indicates that the considerable part of the losses is generally due to fires which break out soon after earthquakes. It is, therefore, important to design the structures to be safe against fire. Attention to the relevant Indian Standards dealing with fire safety is, therefore, invited.

0.6 It is important that the seismic acceleration or in other words, the seismic coefficient, used in the design of any structure is dependent on many variable factors and it is an extremely difficult task to determine the correct seismic acceleration in each given case. It is, therefore, necessary to indicate broadly the seismic coefficients that could generally be adopted in different parts or zones of the country though, of course, a rigorous analysis considering all the factors involved has got to be made in the case of all important projects in order to arrive at suitable seismic accelerations for design. The Sectional Committee responsible for the formulation of this standard has attempted to include a seismic zoning map (*see* Fig. 1) for this purpose. The object of this map is to divide the country into a number of zones in which one can reasonably forecast the intensity of earthquake shock which will occur in the event of a future earthquake. For each zone, an upper limit of intensity has been fixed for purposes of design but these upper limits need not necessarily be always the highest intensity that would occur anywhere within a given zone. It is possible in some cases that earthquakes of much higher intensities may occur at any particular spot which is unpredictable. The probabilities, however, are that a structure designed on the assumption that intensity indicated for each zone is about the maximum that is likely to occur, would ensure a reasonable amount of safety.

0.6.1 The Sectional Committee has appreciated that there cannot be any statistical approach to the problem of earthquake intensity and an entirely scientific basis for zoning is also not possible in view of the scanty data available. Though the magnitudes of different earthquakes which have occurred in the past are known to a reasonable amount of accuracy, the intensities of the shocks caused by these earthquakes have so far been mostly estimated by damage surveys and there is little instrumental evidence to corroborate with the conclusions arrived at. Maximum intensity at different places can be fixed on a scale only on the basis of the observations made and recorded after the earthquake and thus a zoning map which is based on the maximum intensities arrived at, is likely to lead in some cases to a wrong conclusion in view of (a) incorrectness in the assessment of intensities, (b) human error in judgement during the damage survey, and (c) variation in quality and design of structures causing variation in type and extent of damage to the structures for the same intensity of shock. The Sectional Committee has, therefore, considered that a rational approach to the problem would be to arrive at a zoning map based on known magnitudes and the known epicentres (*see* Appendix A) assuming all other conditions as being average, and to modify such an average idealized isoseismal map in the light of tectonics (*see* Appendix B), lithology (*see* Appendix C), and the maximum intensities as recorded from damage surveys, etc. The Sectional Committee has also reviewed such a map in the light of past history and future possibilities and also attempted to draw the lines demarcating the different zones so as to be clear of important towns, cities and industrial areas, after making special examination of such cases, as a little modification in the zonal demarcations may mean considerable difference to the economics of a project in that area.

0.7 The Sectional Committee responsible for the preparation of this standard has taken into consideration the views of seismologists, technologists and others who are interested in this field and has related the standard to the prevailing practices in the country. Due weightage has also been given to the need for international co-ordination among the standards and practices prevailing in different countries of the world.

0.7.1 Acknowledgements are also due to the Indian Meteorological Department, Geological Survey of India and the University of Roorkee who have prepared the various maps and given a lot of information contained in this standard.

1. SCOPE

1.1 This standard deals with earthquake resistant design of structures and is applicable to buildings; elevated structures; bridges; concrete, masonry and earth dams; embankments and retaining walls.

1.2 This standard does not deal with the construction features relating to earthquake resistant design in buildings and other structures.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Critical Damping — The damping beyond which the motion will not be oscillatory.

2.2 Damping — The effect of internal friction, imperfect elasticity of material, slipping, sliding, etc, in reducing the amplitude of vibration and is expressed as a percentage of critical damping.

2.3 Epicentre — The point on the surface of earth immediately above the centre of shock from where the earthquake shocks emanate.

2.4 Intensity of Earthquake — The intensity of an earthquake at a place is a measure of the effects of the earthquake, and is indicated by a number according to the modified Mercalli Scale of Seismic Intensities (*see* Appendix D).

2.5 Magnitude of Earthquake (Richter's Magnitude) — The magnitude of an earthquake shall be the logarithm to base 10 of the maximum trace amplitude, expressed in microns, with which the standard short period torsion seismometer (with a period of 0·8 seconds, magnification 2 800 and damping nearly critical) would register the earthquake at an epicentral distance of 100 km. The magnitude '*M*' is thus a number which is a measure of energy released in an earthquake.

2.6 Seismic Coefficient — The ratio of the design acceleration due to earthquake and the acceleration due to gravity.

3. GENERAL PRINCIPLES AND DESIGN CRITERIA

3.1 General Principles

3.1.1 Earthquake shocks cause a movement of ground on which the structure is situated. This movement causes the structure to vibrate. The vibrations may be resolved in any three perpendicular directions and the design of structures made safe for the components of vibrations in the three directions acting simultaneously shall be considered safe unless otherwise specifically stated. The predominant direction of vibration is horizontal.

3.1.2 The vibration intensity of ground expected at any location depends upon the magnitude of earthquake, the distance of the location from the source of disturbance and the strata on which the structure stands. The important structures shall be designed for the maximum vibration intensity expected at the place.

3.1.3 The response of the structure to the ground vibration is a function of the nature of foundation soil; materials, form, size and mode of construction of the structure; the duration and the intensity of ground motion. This standard specifies design acceleration for structures standing on soils which will not settle appreciably due to vibration lasting for a few seconds.

3.1.4 Seismic coefficients specified in **3.4.1** correspond to the maximum acceleration that may be expected in any horizontal direction. In the case of structures designed for horizontal seismic forces only it shall be considered to act in any one direction at a time. Where both horizontal and vertical seismic forces are taken into account, horizontal force in any one direction at a time may be considered simultaneously with the vertical force as specified in **3.4.4**.

3.1.5 The vertical seismic force shall be considered only in the case of structures in which stability is a criterion of design except as otherwise stated in the relevant clauses.

3.2 Assumptions — The following assumptions shall be made in the earthquake resistant design of structures:

a) Resonance is not likely to occur since the earthquake causes impulsive ground motion which is complex and irregular in character, changing in period and amplitude, and lasting for short duration.

b) Earthquake and wind are not likely to occur simultaneously.

3.3 Permissible Increase in Stresses

3.3.1 *Permissible Increase in the Material Stresses* — Whenever earthquake forces are considered along with other normal design forces, assuming that earthquake and wind are not likely to occur simultaneously, the permissible stresses in materials may be increased by one-third, or the load factors in ultimate load design reduced in the ratio 1:1·333, unless otherwise specified in relevant Indian Standards. For prestressed concrete work, the stress in the steel should be limited to a maximum of 85 percent of its ultimate strength. In steel structures the maximum stress in steel shall in no case exceed the yield stress.

3.3.2 *Permissible Increase in the Allowable Bearing Pressure of Soils* — When earthquake forces are included, the allowable bearing pressure of soils may be increased as follows:

Nature of Soil	*Permissible Increase in Allowable Bearing Pressure, Percent*
Soil Type I having a bearing pressure greater than 45 t/m^2	50
Soil Type II having a bearing pressure greater than 20 t/m^2 and equal to or less than 45 t/m^2	30

Nature of Soil	*Permissible Increase in Allowable Bearing Pressure, Percent*
Soil Type III having a bearing pressure greater than 10 t/m^2 and equal to or less than 20 t/m^2 provided that the standard penetration value (*see* IS : 2131-1963*) is equal to or greater than 10	30

However, if any increase in bearing pressure has already been permitted for forces other than seismic force, the increase in bearing pressure when seismic force is also included shall not be more than 50 percent.

3.3.2.1 In loose sands, with standard penetration value (*see* IS : 2131-1963*) less than 10, the vibrations caused by earthquake may cause liquefaction or excessive total and differential settlements. In important projects, this aspect of the problem need be investigated.

3.4 Seismic Coefficient for Different Zones

3.4.1 For the purpose of determining the seismic coefficients, the country is divided into seven zones as shown in Fig. 1 and unless otherwise stated, seismic coefficients in different zones shall be taken as follows:

Zone No.	*Horizontal Seismic Coefficient* (α_h)		
	Soil Type I	Soil Type II	Soil Type III
VI	0·08	0·10	0·12
V	0·06	0·08	0·10
IV	0·05	0·06	0·08
III	0·04	0·05	0·06
II	0·02	0·03	0·04
I	0	0·01	0·02
0	0	0	0

3.4.2 The seismic coefficients for some important towns and cities are given in Appendix E.

3.4.3 Buildings provided for accommodating essential services which will be of post earthquake importance, such as hospitals, emergency relief stores, foodgrain storage structures, power stations, waterworks and water towers shall be designed for one and a half times the seismic coefficient specified in **3.4.1.**

3.4.4 The vertical seismic coefficient where applicable (*see* **3.1.5**) may be taken as half of the horizontal seismic coefficient given in **3.4.1.**

*Method for standard penetration test for soils.

4. BUILDINGS

4.1 Design Live Loads

4.1.1 For various loading classes as specified in IS : 875-1964*, the horizontal earthquake force shall be calculated for the full dead load and the percentages of live loads as given below:

Load Class	*Percentage of Design Vertical Live Load*
200, 250, 300, Stairs and balconies	25
400, 500, 750 and 1 000, Garage, light and heavy	50

NOTE 1 — The proportions of the live load indicated above for calculating the horizontal seismic forces are applicable to average conditions. Where the probable loads at the time of an earthquake are more accurately assessed, the designer may alter the proportions indicated or even replace the entire live load proportions by the actual assessed load.

NOTE 2 — The reduction in live load specified in **3.1.2** of IS : 875-1964* on account of number of floors shall further apply when the live load proportions given above are considered for working out the earthquake force.

NOTE 3 — If the live load is assessed instead of taking the above proportions for calculating horizontal earthquake force, only that part of the live load shall be considered which possesses mass. Earthquake force shall not be applied on impact effects.

NOTE 4 — The percentages of the design vertical live load specified in this clause are only for purpose of calculating earthquake force. For working out stresses due to the live loads themselves for combining with the stresses due to earthquakes, the full value of the design live loads specified in IS : 875-1964* shall be considered.

4.1.2 For calculating the earthquake force on roofs, the live load may not be considered.

4.2 Design Factors for Buildings

4.2.1 For buildings not exceeding 40 m in height the method suggested in **4.2.1.1** to **4.2.1.3** may be used for calculating the earthquake forces.

a) For buildings greater than 40 m in height and up to 30 storeys, modal analysis is recommended. However, the method suggested in **4.2.1.1** to **4.2.1.3** can also be used for the design of structures in this category in Zones 0 to IV.

b) For buildings taller than 30 storeys in Zones other than 0 and I, dynamic analysis shall be made.

c) Check for drift and torsion according to **4.2.3** and **4.2.4** is desirable for all buildings, being particularly necessary in cases of buildings greater in height than 40 m.

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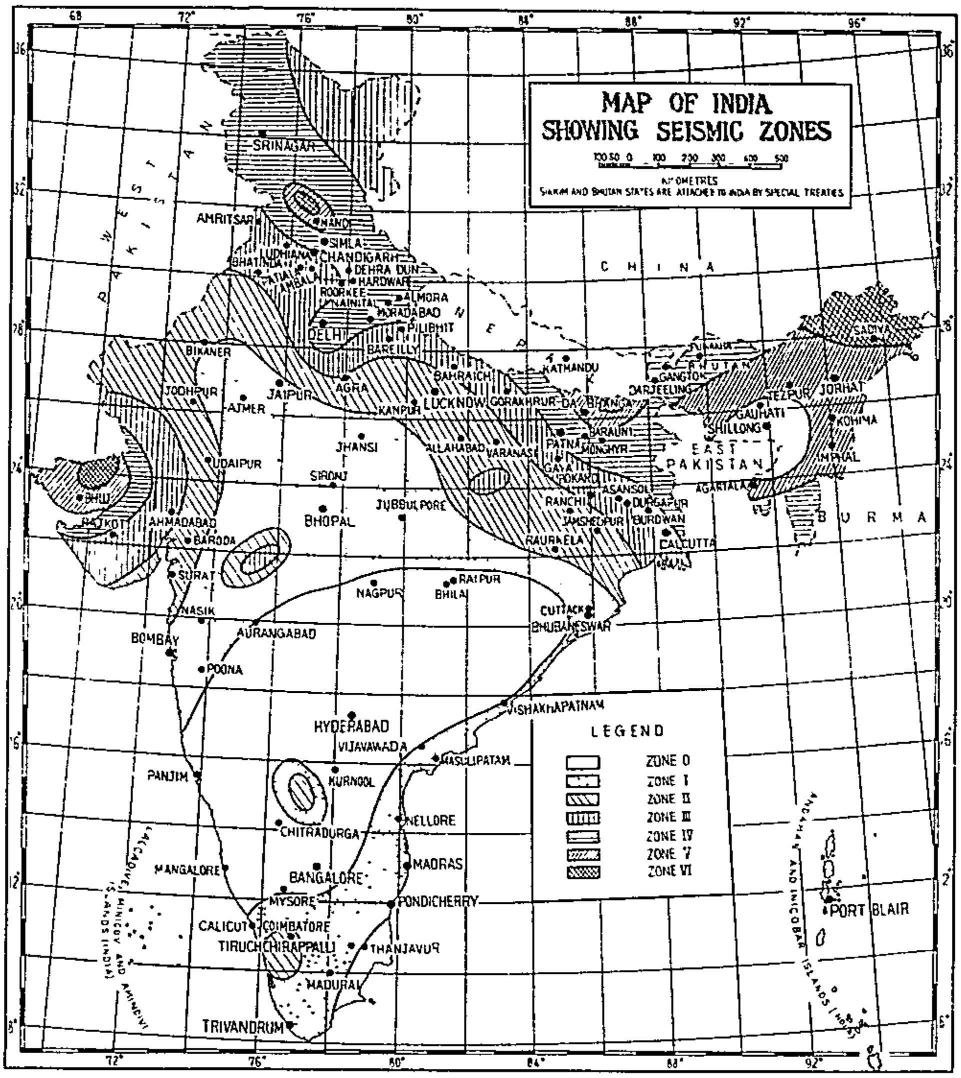
*Code of practice for structural safety of buildings: Loading standards (*revised*).


MAP OF INDIA
SHOWING SEISMIC ZONES
KILOMETRES
SIKKIM AND BHUTAN STATES ARE ATTACHED TO INDIA BY SPECIAL TREATIES
LEGEND
ZONE 0
ZONE I
ZONE II
ZONE III
ZONE IV
ZONE V
ZONE VI
CHINA
BURMA
PAKISTAN
EAST PAKISTAN
NEPAL
SRINAGAR
AMRITSAR
SIMLA
CHANDIGARH
DEHRA DUN
HARDWAR
ROORKEE
NAINITAL
MORADABAD
PILIBHIT
DELHI
BAREILLY
BIKANER
JODHPUR
AJMER
JAIPUR
AGRA
KANPUR
LUCKNOW
BAHRAICH
KATHMANDU
DARJEELING
GANGTOK
TEZPUR
JORHAT
SADIYA
SHILLONG
GAUHATI
KOHIMA
IMPHAL
AGARTALA
JHANSI
ALLAHABAD
VARANASI
PATNA
MONGHYR
BARAUNI
GAYA
BOKARO
RANCHI
ASANSOL
DURGAPUR
JAMSHEDPUR
BURDWAN
CALCUTTA
RAURKELA
UDAIPUR
SIRONJ
BHOPAL
AHMADABAD
BARODA
RAJKOT
SURAT
NAGPUR
RAIPUR
BHILAI
CUTTACK
BHUBANESWAR
NASIK
AURANGABAD
BOMBAY
POONA
HYDERABAD
VISHAKHAPATNAM
VIJAYAWADA
MASULIPATAM
PANJIM
KURNOOL
NELLORE
CHITRADURGA
MANGALORE
BANGALORE
MADRAS
MYSORE
PONDICHERRY
CALICUT
COIMBATORE
TIRUCHCHIRAPPALLI
THANJAVUR
MADURAI
TRIVANDRUM
PORT BLAIR
ANDAMAN AND NICOBAR ISLANDS (INDIA)

4.2.1.1 The base shear V_B is given by the following formula:

$$V_B = C\, \alpha_h W$$

where

C = a coefficient defining the flexibility of structure with the increase in number of storeys (*see* Note),

α_h = seismic coefficient as defined in **3.4.1**, and

W = total dead load + appropriate amount of live load as defined in **4.1**.

NOTE — 'C' is equal to $\frac{9}{n+5}$ provided that it is not greater than 1·0 for framed buildings and 1·33 for buildings having load bearing walls:

where n = number of storeys including basement floors.

4.2.1.2 Distribution of forces along with the height of the building is given by the following formula:

$$Q_i = V_B \cdot \frac{W_i\, h_i^2}{\sum_{i=1}^{i=n} W_i\, h_i^2}$$

where

Q_i = lateral forces at roof or floor i,

V_B = the base shear as worked out in **4.2.1.1**,

W_i = the weight considered to be acting at the level of the roof or floor i,

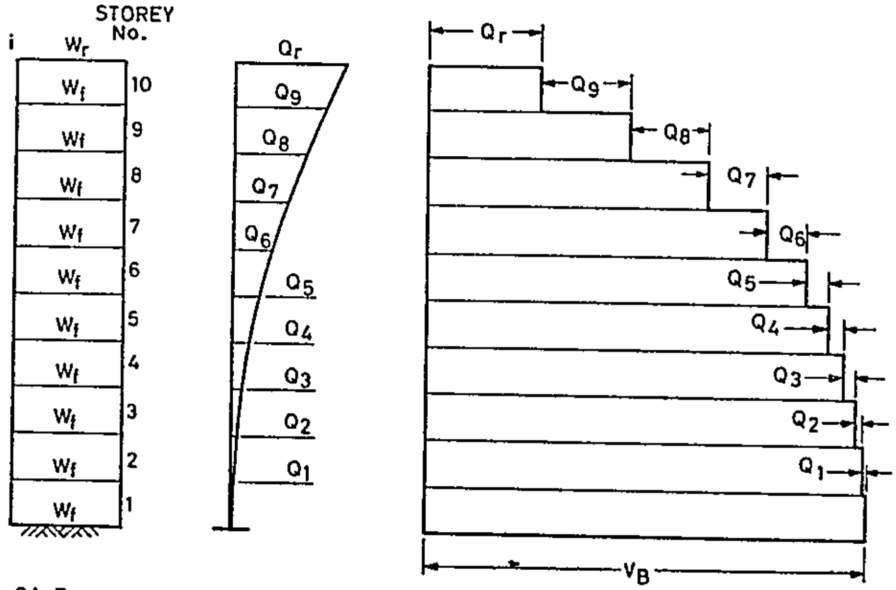
h_i = height of the roof or floor i above base of building, and

n = number of storeys including the basement floors.

NOTE 1 — For calculating weight at the level of the roof or floor, the weight of walls and columns in any storey is assumed to be shared half and half between the roof or floor at top and the floor or ground at bottom, and all weights are assumed to be concentrated at the level of the roofs or floors.

NOTE 2 — Towers, tanks (including contents), chimneys, smoke stacks, and penthouses when connected to or a part of a building will be treated as special structures and these appendages will be designed for 1·5 times the seismic coefficient given in **3.4.1**.

4.2.1.3 The force and shear distributions for a ten-storey building are illustrated in Fig. 2.



2A Frame 2B Distribution of Forces 2C Distribution of Shears

$$C = \frac{9}{10+5} = 0{\cdot}6 \qquad Q_i = \frac{W_i\, h_i^2\, V_B}{\sum\limits_{i=1}^{i=n} W_i\, h_i^2} \qquad V_j = \sum_{i=j}^{i=n} Q_i$$

$$V_B = 0{\cdot}6\, \alpha_h\, (W_r + 9W_f)$$

where V_j = Shear in jth storey

Note — For other notations, *see* **4.2.1.1** and **4.2.1.2.**

Fig. 2 Force and Shear Distributions for Ten-Storey Building

4.2.2 *Modal Analysis* — The load acting at any floor level i due to the mode of vibration $Q_i^{(r)}$ is given by the following equation:

$$Q_i^{(r)} = W_i\, \phi_i^{(r)}\, C_r\, \frac{S_a^{(r)}}{g}$$

where

W_i = weight of the floor i as given in **4.2.1.2**

$\phi_i^{(r)}$ = mode shape coefficient obtained from free vibration analysis at floor i,

C_r = mode shape factor,

$S_a^{(r)}$ = spectral acceleration value corresponding to the appropriate natural period of vibration and damping in cm/sec^2, and

g = acceleration due to gravity in cm/sec^2.

4.2.2.1 The mode shape factor C_r may be given by the following equation:

$$C_r = \frac{\sum_{i=1}^{i=n} W_i \; . \; \phi_i^{(r)}}{\sum_{i=1}^{i=n} W_i \; [\phi_i^{(r)}]^2}$$

where

i, W_i, $\phi_i^{(r)}$ are same as defined in **4.2.2**, and

n = total number of storeys as defined in **4.2.1.1**.

4.2.2.2 The total load Q_i acting at any floor level i could be assumed to be equal to the root mean square value of first three modes of vibration as given below:

$$Q_i = [(Q_i^1)^2 + (Q_i^2)^2 + (Q_i^3)^2]^{\frac{1}{2}}$$

where

Q_i^1, Q_i^2 and Q_i^3 are the values of load for first three modes of vibrations respectively.

4.2.3 *Drift* — The maximum horizontal relative displacement due to earthquake forces between two successive floors shall not exceed 0·004 times the difference in levels between these floors.

4.2.4 *Torsion of Buildings* — Provision shall be made for the increase in shear resulting from the horizontal torsion due to an eccentricity between the centre of mass and the centre of rigidity. The design eccentricity shall be taken as 1·5 times the computed eccentricity between the centre of mass and the centre of rigidity. Negative torsional shears shall be neglected.

4.3 Miscellaneous

4.3.1 Parapets, balconies and chimneys attached to buildings and projecting above the roofs and other vertical cantilever projections, shall be designed for five times the seismic coefficient for which the structure is designed. However, compound walls need not be designed for increased seismic coefficient except where the environmental circumstances indicate that their collapse may lead to serious consequences.

4.3.2 All horizontal projections including those of balconies shall be designed to resist a vertical force equal to five times the vertical seismic coefficient multiplied by the weight of the projection. The vertical seismic coefficients shall be assumed to be equal to half of those specified in **3.4.1**.

5. ELEVATED STRUCTURES

5.1 General

5.1.1 The elevated structures covered by these provisions include elevated tanks, refinery vessels and stack-like structures, such as chimneys of normal proportions that are not covered under **4.3**. In the case of elevated structures of unusual proportions, more detailed studies will have to be called for.

5.1.2 Elevated structures in zones 0 to IV may be designed for the seismic coefficient as specified in **3.4.1** or **3.4.3** as the case may be. Water towers and other similar independently standing structures in zones V and VI whose height is less than 10 m may also be designed for the seismic coefficient specified in **3.4.1** or **3.4.3** as the case may be. For elevated structures in zones V and VI whose height is more than 10 m, it is advisable to make a dynamic analysis of the structure. One such method using the average spectrum curves is outlined in **5.2**.

5.2 Elevated Tower-Supported Tanks

5.2.1 For the purpose of this analysis, elevated tanks shall be regarded as systems with a single degree of freedom with their mass concentrated at their centres of gravity.

5.2.2 The damping in the system may be assumed at 2 percent of the critical for steel structures and 5 percent of the critical for concrete (including masonry) structures.

5.2.3 The free period T, in seconds, of such structures shall be calculated from the following formula:

$$T = 2\pi \sqrt{\frac{\delta}{g}}$$

where

δ = the static deflection in cm at the top of the tank under a static horizontal force equal to its own weight W acting at the centre of gravity. In calculating the period of steel tanks, the members may be assumed to be pin-joined with only the tensile members of the bracing regarded as active in carrying the loads. No pre-tension shall be assumed in the bracing rods, and

g = acceleration due to gravity in cm/s^2.

5.2.4 The weight W used in the design (*see* **5.2.3**) shall include the dead load of the tank and its contents when full and one-third of the weight of staging.

5.2.5 Using the period as indicated in **5.2.3**, the spectral acceleration shall be read off from the spectrum corresponding to the appropriate damping coefficient (*see* Fig. 3) and the design acceleration by multiplying it with a suitable factor N which depends upon the size of the anticipated earthquake (*see* **F-3.1**).

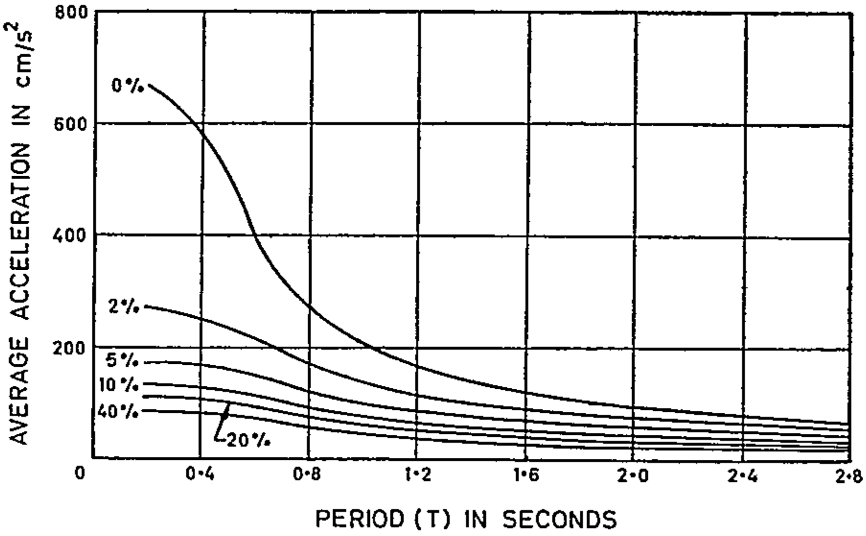


FIG. 3 AVERAGE ACCELERATION SPECTRUM CURVES

5.2.6 The lateral force shall be taken equal to $a_h W$, where a_h is the seismic coefficient given by the following:

$$a_h = \frac{\text{Design acceleration } (see\ \mathbf{5.2.5})}{\text{Acceleration due to gravity } (g)}$$

This force shall be assumed to be applied at the centre of gravity of the tank horizontally in the plane in which the structure is assumed to oscillate for purposes of carrying out the lateral load analysis.

NOTE — For a detailed spectral analysis, *see* Appendix F.

5.2.6.1 The lateral force calculated in accordance with **5.2.6** is applicable to structures founded on soil Type III in Zone VI (*see* **3.3.2**). For structures n Zone V and founded on other types of soils, the lateral force so calculated shall be reduced in proportion to the appropriate seismic coefficient specified in **3.4.1**.

5.2.7 In the case of tank walls, the hydrodynamic forces due to earthquake may cause an increase of the order of 15 percent of the lateral stresses in the side of container and this should be taken note of in the design of containers.

5.3 Stack-Like Structures

5.3.1 Stack-like structures are those in which the mass is more or less uniformly distributed along the height. Refinery vessels and chimneys are examples of such structures.

5.3.2 *Uniform Stacks*

5.3.2.1 The design shear force, V, for stack-like structures in Zone VI on soil Type III (*see* **3.3.2**) and at a distance x from the top, shall be calculated by the following formula:

$$V = \frac{W}{12kh} \sqrt{\frac{E \cdot g}{w}} \left[\frac{5}{3}\left(\frac{x}{h}\right) - \frac{2}{3}\left(\frac{x}{h}\right)^2 \right]$$

where

W = total weight of structure, in kg,
E = modulus of elasticity of material in kg/cm^2,
g = acceleration due to gravity in cm/s^2,
k = slenderness ratio of structure,
h = height of structure in cm, and
w = unit weight of material in kg/cm^3.

NOTE — The slenderness ratio k of structure is given by the following formula:

$$k = \frac{h}{r_e}$$

where

h = height of structure in cm, and
r_e = radius of gyration of section of structure at base in cm.

For structures in other zones and on other types of soils, the value obtained by the above formula shall be reduced in proportion to the appropriate seismic coefficient specified in **3.4.1**.

5.3.2.2 The design bending moment, M, at a distance x from the top, shall be calculated by the following formula:

$$M = \frac{W}{16\,k} \sqrt{\frac{E \cdot g}{w}} \left[0{\cdot}6 \left(\frac{x}{h}\right)^{\frac{1}{2}} + 0{\cdot}4 \left(\frac{x}{h}\right)^4 \right]$$

where

W, E, g, k, w and h are as defined in **5.3.2.1**.

The value obtained is for uniform stacks in Zone VI and on soft soils (*see* **3.3.2**). For stacks in other zones and on other types of soils, this shall be reduced in proportion to horizontal acceleration specified in **3.4.1**.

5.3.3 Tapering or Battered Stacks

5.3.3.1 For tall battered or tapering stacks, it is sufficiently accurate to use the following formula for the design bending moment and shear at any section:

$$M = M_u \left(\frac{W\bar{x}}{W_u\bar{x}_u}\right); \text{ and}$$

$$V = V_u \left(\frac{W}{W_u}\right)$$

where

M = bending moment at the section,

M_u = bending moment at the same section for a uniform stack of the same height and base-radius,

W = weight of the given stack above the section,

$\bar{x}$ = distance from the section to the centre of gravity of portion of stack above the section,

W_u = weight of the uniform stack above the section,

$\bar{x}_u$ = distance from the section to the centre of gravity of the portion of the uniform stack above the section,

V = shear at the section, and

V_u = shear at the same section in the uniform stack of the same height and base-radius.

5.3.3.2 In cases where the period of vibration of the uniform stack of the same base radius and height is very different from that of the tapered or battered stack, the dimensions of an equivalent uniform stack of the same period may be substituted for the given structure and the analysis carried out.

6. BRIDGES

6.1 General

6.1.1 Bridge as a whole and every part of it shall be designed and constructed to resist stresses produced by lateral forces as provided in the standard. The stresses shall be calculated as the effect of a force applied horizontally at the centres of mass of the elements of the structure into which it is conveniently divided for the purpose of design. The forces shall be assumed to come from any horizontal direction.

6.1.2 Bridge and its members in the superstructure and substructure shall be proportioned to resist the forces and moments caused by worst combination of loads given in the relevant Indian Standards.

6.1.3 In the case of less common type of bridges, such as suspension bridge and bascule bridge, special studies should be undertaken.

6.1.4 Earthquake force shall be calculated on the basis of depth of scour caused by mean annual flood. The design of earthquake and discharge, greater than the mean annual flood may be assumed not to occur simultaneously.

6.2 Lateral Force

6.2.1 The lateral force to be resisted shall be computed as follows:

$$F = \alpha_h W$$

where

F = lateral force to be resisted in kg,

α_h = seismic coefficient as specified in **3.4.1**, and

W = weight of the mass under consideration ignoring reduction due to buoyancy or uplift in kg.

NOTE — For portions below the scour depth (*see* **6.1.4**), α_h shall be assumed to be zero.

6.3 Superstructure

6.3.1 Superstructure shall be designed to resist the lateral force specified in **6.2.1**. The seismic force due to live load shall be ignored when acting in the direction of the traffic but shall be taken into consideration when acting in the direction perpendicular to traffic.

6.3.1.1 The seismic force due to live load shall be based on 50 percent of the design live load for railway bridges and 25 percent of the design live load for road bridges specified in the relevant Indian Standards. These percentages are only for working out the magnitude of the seismic force. For calculating the stresses due to live load and their impact, 100 percent of the design live load for railway bridges and 50 percent of the design live load for road bridges specified in the relevant Indian Standards shall be considered at the time of the earthquake.

6.3.2 The superstructure of the bridge shall be properly secured to the piers to prevent it from being dislodged off its bearings during an earthquake.

6.4 Substructure

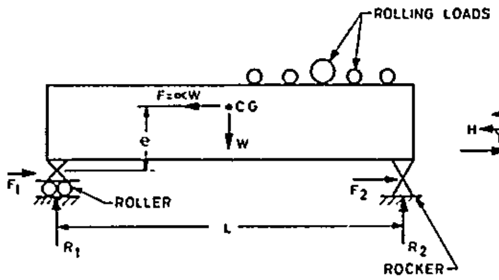
6.4.1 The seismic forces on the substructure above the scour depth (*see* **6.1.4**) shall be as follows:

a) Horizontal seismic forces in all zones according to **3.4.1** and vertical seismic forces in zones IV, V and VI only according to **3.4.4** both due to self-weight applied at the centre of mass ignoring reduction due to buoyancy or uplift.

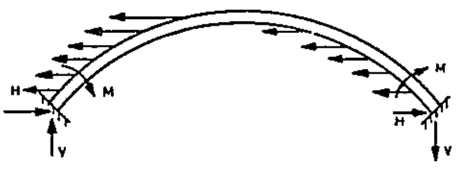
b) Hydrodynamic force as specified in **6.4.2** acting on piers and increase in the earth pressure due to earthquake given in **8.1.1** to **8.1.4** acting on abutments.

c) Horizontal seismic forces in all zones according to **3.4.1** and vertical seismic forces in zones IV, V and VI only according to **3.4.4** due to dead load of superstructure and live load as specified in **6.3.1** and **6.3.1.1** applied at the centre of their mass and considered to be transferred from superstructure to the substructure through the bearings as shown in Fig. 4.

6.4.1.1 Piers shall be designed for the seismic forces given in **6.4.1** assuming them to act parallel to the current and traffic directions taken separately.



4A Girder Span



4B Arch Span

R_1 and R_2 are reactions at the two supports after being modified due to moment (Fe)

Change in vertical reactions $= \pm Fe/L$

$F_1 = \mu R_1$ (if $\mu R_1 < F/2$)
$F_1 = F/2$ (if $\mu R_1 > F/2$) $F_2 = F - F_1$

FIG. 4 TRANSFER OF FORCES FROM SUPERSTRUCTURE TO SUBSTRUCTURE

6.4.1.2 In the case of piers, oriented skew either to the direction of current or traffic, they shall be checked for seismic forces acting parallel and perpendicular to pier direction.

6.4.2 For submerged portions of the pier, hydrodynamic force (in addition to earthquake force calculated on the mass of the pier) shall be assumed to act in a horizontal direction corresponding to that of earthquake motion. The total horizontal force V shall be given by the following formula:

$$V = A\, \alpha_h W$$

where

A = a coefficient (*see* Table 1)

α_h = the horizontal seismic coefficient as given in **3.4.1**, and

W = the weight of the water of the enveloping cylinder (*see* Fig. 6).

TABLE 1 VALUES OF A

HEIGHT OF SUBMERGED PORTION OF PIER (H)/RADIUS OF ENVELOPING CYLINDER (a)	A
1·0	0·390
2·0	0·575
3·0	0·675
4·0	0·730

6.4.2.1 The pressure distribution will be as shown in Fig. 5.

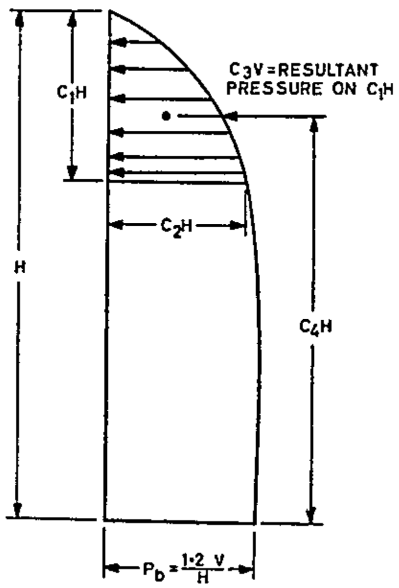


FIG. 5 DIAGRAM SHOWING PRESSURE DISTRIBUTION

Coefficients			
C_1	C_2	C_3	C_4
0·1	0·410	0·026	0·915
0·2	0·673	0·093	0·865
0·3	0·832	0·184	0·802
0·4	0·922	0·289	0·752
0·5	0·970	0·403	0·694
0·6	0·990	0·521	0·638
0·8	0·9997	0·760	0·532
1·0	1·0	1·0	0·428

6.4.2.2 Some typical cases of submerged portions of piers and the enveloping cylinders are illustrated in Fig. 6.

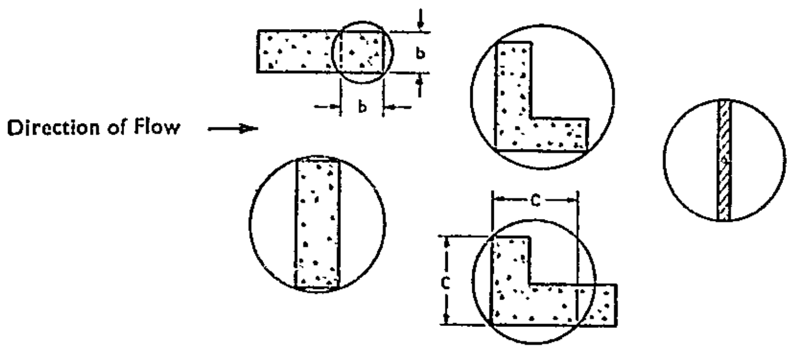


FIG. 6 ENVELOPING CYLINDER

6.5 Submersible Bridges — For submerged superstructure of submersible bridges, the hydrodynamic pressure shall be determined by the following equation:

$$p = 875\ a_h\ \sqrt{Hy}$$

where

p = hydrodynamic pressure in kg/m^2,
a_h = horizontal seismic coefficient,
H = height of water surface from the level of deepest scour (*see* **6.1.4**) in m, and
y = depth of the section below the water surface in m.

6.5.1 The total horizontal shear and moment per metre width about the centre of gravity of the base at any depth y, due to hydrodynamic pressure are given by the following relations:

$$V = 2/3\, py$$
$$M = 4/15\, py^2$$

where

V = hydrodynamic shear in kg/m, and
M = hydrodynamic moment in kgm/m.

7. DAMS AND EMBANKMENTS

7.1 General — In the case of important dams it is very essential that detailed investigations are made and the effect of local crustal adjustments because of reservoir load is considered before fixing the seismic coefficients. However, in the case of minor works and for preliminary design of major work, the horizontal seismic coefficient a_h may be taken as specified in **7.1.1** and **7.1.2**.

The vertical seismic coefficient may be assumed as half of the horizontal seismic coefficient at any point.

7.1.1 For concrete and masonry dams, α_h may be taken as twice the seismic coefficient specified in **3.4.1** applied uniformly along the height. Wherever feasible a dynamic analysis of the structure is desirable.

7.1.2 For earth dams α_h may be taken equal to three times the seismic coefficient specified in **3.4.1** applied at the top of the earth dam and reduced parabolically at the bottom to 25 percent of value at the top as given below. Wherever feasible a dynamic analysis of structure is desirable.

Distance Below Top of Dam (x) / Height of Earth Dam (h)	*Seismic Coefficient at a Distance x Below Top* / Seismic Coefficient at Top
0·0	1·00
0·1	0·99
0·2	0·97
0·3	0·93
0·4	0·88
0·5	0·81
0·6	0·73
0·7	0·62
0·8	0·52
0·9	0·39
1·0	0·25

NOTE — It is general practice to design concrete and masonry dams for both vertical and horizontal accelerations and acting simultaneously and earth dams for horizontal acceleration only. However, earth dams may also be designed for horizontal and vertical acceleration at the discretion of the designer.

7.2 Concrete and Masonry Dams

7.2.1 *Earthquake Forces* — In the design of concrete and masonry dams the earthquake forces specified in **7.2.1.1** to **7.2.1.6** shall be considered.

7.2.1.1 *Effect of horizontal earthquake acceleration on horizontal component of reservoir and tail water load* — Due to the horizontal acceleration of the foundation and dam there is an instantaneous hydrodynamic pressure exerted against the dam in addition to the hydrostatic forces. The direction of this hydrodynamic force is opposite to the direction of the earthquake acceleration. Based on the assumption that water is incompressible, the pressure at depth y below the reservoir surface shall be determined as follows:

$$P_e = C \,.\, wh\, \alpha_h$$

where

P_e = hydrodynamic pressure in kg/m² at depth y,
C = coefficient which varies with shape and depth,
w = unit weight of water in kg/m³,
h = maximum depth of reservoir in m, and
a_h = horizontal seismic coefficient (*see* **7.1**).

The variation of the coefficient 'C' with shapes and depths are illustrated in Appendix G. For accurate determination, these values may be made use of; however, approximate values of 'C' may be obtained as follows:

$$C = \frac{C_m}{2}\left[\frac{y}{h}\left(2-\frac{y}{h}\right)+\sqrt{\frac{y}{h}\left(2-\frac{y}{h}\right)}\right]$$

where

C_m = maximum value of C obtained from Fig. 7,
y = depth of the section below the water surface in m, and
h = maximum depth of reservoir in m.

The total shear and moment about the centre of gravity of the base of a section due to hydrodynamic pressure are given by the relations:

$$V_e = 0{\cdot}726\,P_e y$$
$$M_e = 0{\cdot}299\,P_e y^2$$

where

V_e = hydrodynamic shear in kg/m at any depth y, and
M_e = moment in kg·m/m due to hydrodynamic force at any depth y.

7.2.1.2 *Concrete or masonry inertia force due to horizontal earthquake acceleration* — The horizontal inertia force of concrete or masonry weight due to horizontal earthquake acceleration acting at any horizontal section of the dam is the product of the weight above the section and the seismic coefficient:

$$V_i = a_h\ W$$

where

V_i = horizontal inertia force of concrete or masonry in kg,
a_h = horizontal seismic coefficient, and
W = dead load above the section under consideration in kg.

This inertia force also acts in a direction opposite to the direction of the earthquake acceleration, and it acts at the centre of gravity of the mass above the section. It causes an overturning moment, above the horizontal section, adding to that caused by the hydrodynamic force.

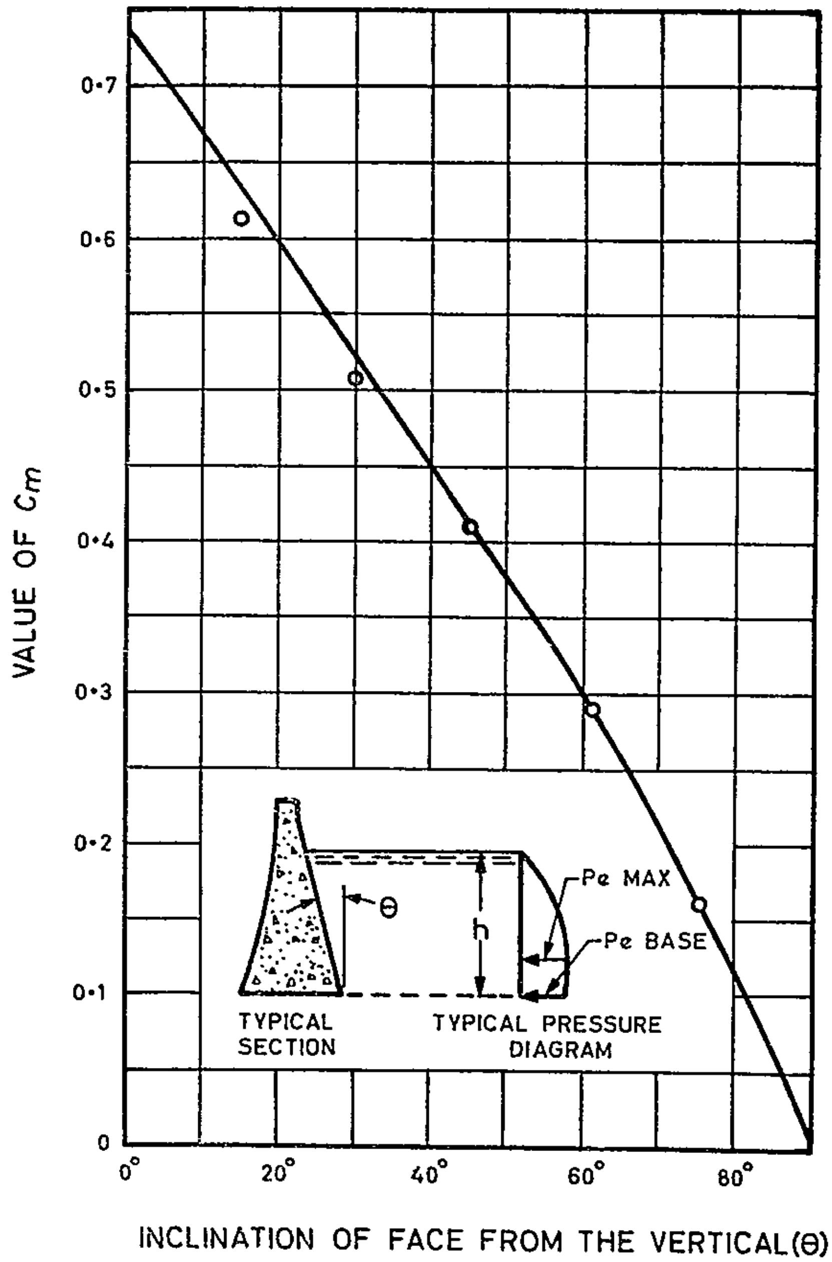


FIG. 7 MAXIMUM VALUE OF THE PRESSUE COEFFICIENT (C_m) FOR CONSTANT SLOPING FACES

7.2.1.3 *Effect of horizontal earthquake on the vertical component of reservoir and tail water load* — In **7.2.1.1** the effect of horizontal earthquake acceleration on the horizontal component of water load has been described, the force at any section being designated V_e. However, the hydrodynamic pressure P_e acts normal to the face of the dam. There shall, therefore, be a vertical component of this pressure if the face of the dam against which it is acting is sloping, the magnitude at any horizontal section being:

$$W_e = (V_{e1} - V_{e2}) \tan \phi$$

where

W_e = increase in vertical component of load in kg due to hydrodynamic force,

V_{e1} = total shear in kg due to horizontal component of hydrodynamic force at the elevation at which the slope of the dam face commences,

V_{e2} = total shear in kg due to horizontal component of hydrodynamic force at the elevation of the section being considered, and

ϕ = angle between the face of the dam and the vertical.

7.2.1.4 *Effects of vertical earthquake acceleration on the vertical and horizontal components of concrete or masonry weight* — The effect of vertical earthquake acceleration (*see* **7.1**) is to change the unit weight of water and concrete or masonry. An acceleration upwards increases the weight and an acceleration downwards decreases the weight. Vertical and horizontal forces and moments computed for the analysis without earthquake effects are multiplied by the factor $(1 \pm \alpha_v)$ to include the effect of vertical acceleration.

7.2.1.5 Effect of earthquake acceleration on uplift forces at any horizontal section is determined as a function of the hydrostatic pressure of reservoir and tail-water against the faces of the dam. During an earthquake the water pressure is changed by the hydrodynamic effect. However, the change is not considered effective in producing a corresponding increase or reduction in the uplift force. The duration of the earthquake is too short to permit the building up of pore pressure in the concrete and foundations. Normal uplift force is assumed to have an intensity that at the line of drains exceeds tail-water pressure by one-third the differential between head-water and tail-water head. The pressure gradient is extended to head-water and tail-water in straight lines, the pressure is assumed to act over 100 percent of the area.

7.2.1.6 *Effect of earthquake acceleration on dead silt loads* — Experimental and analytical methods both indicate that an earthquake acceleration is only about one-half as effective in silt or soil masses as it is in water. This is due to the internal shear resistance of the silt. Since the unit weight of water is also approximately one-half that of silt, it is sufficient to determine the increase in silt pressure due to earthquake as if the water extended to the base of the dam. This increase is then added to the static silt pressures.

7.2.2 *Load Combinations* — Designs should be based on the most adverse combination of probable load conditions but should include only loads having reasonable probability of simultaneous occurrence. Combinations of transient loads each of which has only a remote probability of occurrence at any given time have negligible probability of simultaneous occurrence and cannot be considered as reasonable basis for design. For example, maximum earthquake should not be combined with maximum designed floods. Gravity dams should be designed for the most adverse standard load combinations (*see* Appendix H).

7.2.3 *Shear Friction Factor* — For gravity dams, the shear friction factor of safety should not be less than four for the most adverse standard load combinations and one, that is to ensure stability, when tested for extreme load combination (*see* Appendix H).

7.3 Earth and Rockfill Dams and Embankment

7.3.1 Although it is generally recognized that an earth dam or embankment will vibrate when subject to ground motion during an earthquake, requiring thereby a dynamic analysis of the structure, nevertheless, currently accepted design procedures are based on the assumption that the structure is rigid. This is largely on account of the fact that a dynamic analysis, besides being a considerably more complicated procedure, involves data which is seldom, if at all, available, and regarding which there is much uncertainty. The seismic coefficient method as applied to masonry dams shall, therefore, be adopted.

7.3.2 *Stability of Upstream Slope*

7.3.2.1 The stability of the upstream slope of an earth or rockfill dam shall be tested with reservoir level at full operating elevation with horizontal earthquake acceleration acting in a downstream direction and vertical earthquake acceleration acting in a direction which yields most adverse conditions of stability. The maximum drawdown condition shall not be combined with earthquake forces.

The stability of the upstream slope may also be tested with reservoir level depleted to the minimum operating elevation under steady state seepage conditions for the earthquake accelerations mentioned above.

7.3.2.2 The hydrostatic reservoir load shall be reduced to the extent of hydrodynamic pressure determined as described in **7.2.1.1** and modified on account of vertical earthquake acceleration as in **7.2.1.4**.

7.3.2.3 An additional horizontal inertia force due to horizontal earthquake acceleration shall be applied to the earth mass above the plane of the slip acting in a direction towards the reservoir. The unit weight of the soil mass above the plane of the slip for computing the inertia force shall be the saturated weight of the soil mass lying below the phreatic line and the moist or dry weight of the soil mass lying above the phreatic line.

7.3.2.4 For determining the normal and tangential forces along the plane of the slip, the unit weights of the soil mass above the plane of the slip as adopted for the non-seismic analysis shall be increased or decreased to account for the vertical earthquake acceleration as described for concrete and masonry in **7.2.1.4**.

7.3.2.5 Pore pressures shall be assumed to be unaffected on account of the short duration and transient nature of earthquake forces.

7.3.2.6 The values for cohesion and the angle of internal friction of the soil to be used for the seismic analysis shall be the same as adopted for the static analysis. Some change in the static soil properties is to be expected for transient dynamic loads. However, further corroboration of the degree to which the properties are changed is necessary.

7.3.2.7 For the conditions stated in **7.3.2.1** to **7.3.2.4**, a factor of safety of one shall be accepted as being adequate for ensuring stability of the upstream slope.

7.3.3 *Stability of Downstream Slope*

7.3.3.1 The stability of the downstream slope shall be tested with reservoir level at normal operating elevation as for the non-seismic analysis. The soil mass above the assumed plane of slip shall be subjected to a horizontal earthquake acceleration in an upstream direction and a vertical earthquake acceleration which yields most adverse conditions of stability.

7.3.3.2 For determining the horizontal inertia force applied in a downstream direction, the saturated unit weight of the soil mass lying below the phreatic line and moist or dry unit weights of the soil above the phreatic line shall be adopted.

7.3.3.3 Provisions in **7.3.2.4** to **7.3.2.7** shall also apply in determining the stability of the downstream slope.

7.3.4 *Miscellaneous* — Earthquake forces shall not be normally included in stability analysis for the construction stage or for the reservoir empty condition. However, where the construction or operating schedule requires the reservoir empty condition to exist for prolonged periods, earthquake forces may be included. Provisions in **7.3.2** and **7.3.3** modified to suit the conditions of empty reservoir shall apply for testing the stability of the upstream and downstream slopes.

8. RETAINING WALLS

8.1 Lateral Earth Pressure — The pressure from earth fill behind retaining walls during an earthquake shall be as given in **8.1.1** to **8.1.4**.

NOTE — For the design of retaining walls, the vertical earthquake acceleration shall be neglected.

8.1.1 *Active Pressure Due to Earth Fill* — The general conditions encountered for the design of retaining walls are illustrated in Fig. 8A. The active pressure exerted against the wall shall be:

$$P_a = \tfrac{1}{2} \cdot w \cdot h^2 \cdot C_a$$

where

P_a = active earth pressure in kg/m^2,

w = unit weight of soil in kg/m^3 for dry or saturated as the case may be (for submerged soils use buoyant unit weight),

h = height of wall in m,

$$C_a = \frac{\cos^2(\phi-\theta-\alpha)}{\cos\theta\,.\cos^2\alpha\,.\cos(\phi_1+\alpha+\theta)} \times \left[\frac{1}{1+\left\{\frac{\sin(\phi+\phi_1)\,\sin(\phi-\delta-\theta)}{\cos(\alpha-\delta)\,\cos(\phi_1+\alpha+\theta)}\right\}^{\frac{1}{2}}}\right]^2$$

ϕ = angle of internal friction of soil,

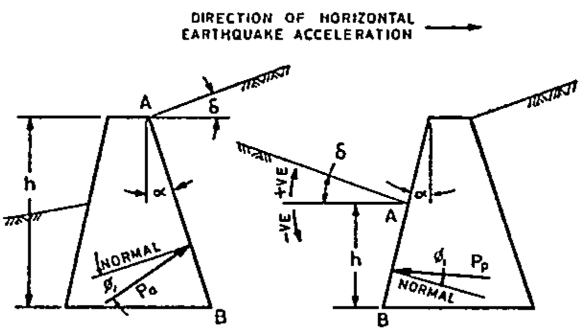
θ = $\tan^{-1}\alpha_h$

α = angle which back face of the wall makes with the vertical,

ϕ_1 = angle of friction between the wall and earth fill,

δ = slope of earth fill, and

α_h = horizontal seismic coefficient (*see* 3.4.1).



8A ACTIVE PRESSURE 8B PASSIVE PRESSURE

FIG. 8 EARTH PRESSURE DUE TO EARTHQUAKE ON RETAINING WALLS

8.1.1.1 The active pressure may be determined graphically by means of either of the two methods described in Appendix J.

8.1.1.2 *Point of application* — From the total pressure computed as above, subtract the static active pressure by usual methods. The remainder is the dynamic increment. The static component of the total pressure shall be applied at an elevation h/3 above the base of wall. The point of application of the dynamic increment shall be assumed to be at an elevation 2h/3 above the base of the wall.

8.1.2 *Passive Pressure Due to Earth Fill* — The general conditions encountered in the design of retaining walls are illustrated in Fig. 8B. The passive pressure against the wall shall be given by the following formula:

$$P_p = \tfrac{1}{2} \cdot w \cdot h^2 \cdot C_p$$

where

P_p = passive earth pressure, and

$$C_p = \frac{\cos^2(\phi+a-\theta)}{\cos\theta \cdot \cos^2 a \cdot \cos(\phi_1-a+\theta)} \times \left[\frac{1}{1-\left\{\dfrac{\sin(\phi+\phi_1)\ \sin(\phi+\delta-\theta)}{\cos(a-\delta)\ \cos(\phi_1-a+\theta)}\right\}^{\frac{1}{2}}}\right]^2$$

and w, h, a, ϕ, ϕ_1 and δ are as defined in **8.1.1**.

8.1.2.1 The passive pressure may be determined graphically by means of either of the two methods described in Appendix K.

8.1.3 *Active Pressure Due to Uniform Surcharge* — The active pressure against the wall due to a uniform surcharge of intensity 'q' per unit area of the inclined earth fill surface shall be:

$$(P_a)_q = \frac{q \cdot h \cos a}{\cos(a-\delta)} \cdot C_a$$

8.1.3.1 *Point of application* — The active pressure due to uniform surcharge shall be applied at mid-height of the wall.

8.1.4 *Passive Pressure Due to Uniform Surcharge* — The passive pressure against the wall due to a uniform surcharge of intensity 'q' per unit area of the inclined earth fill shall be:

$$(P_p)_q = \frac{q \cdot h \cos a}{\cos(a-\delta)} \cdot C_p$$

8.1.4.1 *Point of application* — The passive pressure due to uniform surcharge shall be applied at mid-height of the wall.

8.2 Effect of Saturation on Lateral Earth Pressure

8.2.1 For saturated earth fill the saturated unit weight of the soil shall be adopted in the formulæ described in **8.1.**

8.2.2 For submerged earth fill the buoyant unit weight of soil shall be adopted and the angle θ shall be modified as follows:

$$\theta = \tan^{-1} \frac{\gamma_s}{\gamma_s - 1}\ a_h$$

where

γ_s = apparent specific gravity or specific mass gravity of the saturated soil, and

a_h = horizontal seismic coefficient (*see* **3.4.1**).

8.2.3 Hydrodynamic pressure on account of water contained in the saturated earth fill shall not be considered in design of retaining walls.

8.3 Concrete or Masonry Inertia Force — Concrete or masonry inertia force due to horizontal earthquake acceleration acting at any horizontal section of the wall is the product of the weight above the section and the seismic coefficient specified in **3.4.1**. This inertia force causes an over-turning moment about the horizontal section adding to that caused by the active earth pressure calculated in **8.1.1**.

JAPAN

STANDARDS OF ASEISMIC CIVIL ENGINEERING
CONSTRUCTIONS IN JAPAN

* * * * *

BUILDING STANDARD LAW
BUILDING STANDARD LAW ENFORCEMENT ORDER
MINISTRY OF CONSTRUCTION NOTIFICATION No. 1074

STANDARDS OF ASEISMIC CIVIL ENGINEERING CONSTRUCTIONS IN JAPAN

Chap. 1. Introduction

As for watwerworks, harbor constructions, bridges and dams, aseismic designs are standarized in "Aseismic Constructions of Waterworks (1966)", "Design Manual of Harbour Structures in Japan (1968)", "Design Specifications for Steel Railway Bridges (1955)", "Design Specifications for Steel-Highway Bridges (1957)", "Standard Specifications for Concrete by the Japan Society of Civil Engineers (1955)", "Design Specifications for Plain Reinforced Concrete Structures by the Japan National Railway (1951)" and "Design Standards of Dams (1957)" respectively. These specifications have not a legal force, but are used authoritatively. Details of these specifications are described in the paper "Earthquake Resistant Design for Civil Engineering Structures, Earth Structures and Foundations in Japan," compiled by the Japan Society of Civil Engineers, 1968. Outlines of these specifications and their references are mentioned in the followings.

Chap. 2. Waterworks

1. Every key installation constituting a water supply system shall have its structure determined through a reasonable computation based on due evaluation of the effects of an earthquake.

2. For such installations which may not be sufficiently protected against an earthquake due to financial limitations, the following precautions shall be exercised:

(1) To adopt means to confine damages caused by an earthquake to a certain extent.

(2) To apply devices to facilitate recovery of the earthquake-damaged units.

(3) To provide measures to prevent secondary effects of the earthquake damages.

3. Such installations which are especially important, which are liable to earthquake damages due to structural characteristics, which may develop damages not easily detectable, or which will present difficulties in or demand a long duration for recovery from the earthquake damages, shall not be built as an integral unit, but either divided into two separate units or equipped with an emergency installation.

4. It is desirable to place the installations on a solid uniform foundation. In order to ascertain the quality of a ground, characteristics of the ground, height of ground water level, bearing capacity etc. shall be examined carefully through an examination of geological structures, and with the above result earthquake-proof measures shall be adopted in construction of each installations.

When placing them on a soft ground due to inevitable circumstances, the ground shall be treated to make a solid uniform foundation by pile driving, soil replacing, tightening, consolidation by drying, solidifying and other suitable measures.

5. The installations shall not be built of such materials as wood or brick, stone etc., as a rule they shall be built of steel or reinforced concrete.

6. For such installations which require water-tightness sufficient care shall be exercised in design and construction about mix of concrete, thickness of wall, waterproof measures, expansion joint so that the water-tightness may not be impaired by an earthquake.

7. When connecting the structures of exceedingly varying rigidities, the earthquake-proof joints shall be placed between them.

8. Whenever so specified, only the standardized items shall be used.

9. The surrounding conditions shall be studied in advance to determine the construction site of adequate safety, for the earthquake damages occurring at the neighborhood (namely, collapse, failure or other types of destruction) are apt either to affect safety of the installation or hinder effective operation of the system. When and where such precautions are impossible, a protection work shall be provided.

10. The design and practice of plain and reinforced concrete structures shall comply with Standard Specifications for Concrete (1956), Japan Society of Civil Engineers.

11. The Earthquake-proof computation and details of construction of buildings shall comply with Building Codes (Act 201, May 24, 1950), Provisions for Building Codes (Ordinance 338, November 16, 1950) and various criteria of structural computation established by Architectural Institute of Japan.

1.2. CRITERIA OF EARTHQUAKE-PROOF DESIGN

1.2.1. Design Seismic Coefficient

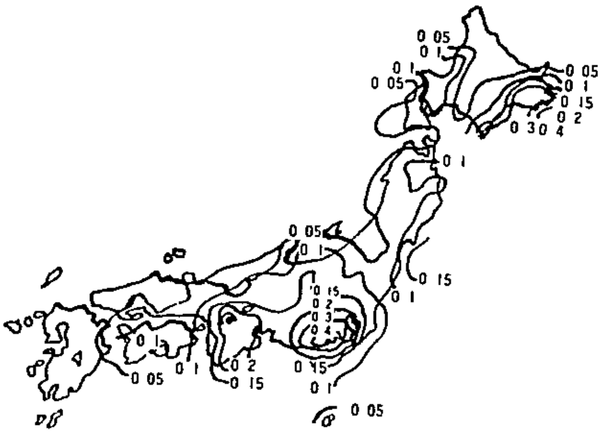
1. The earthquake forces shall be determined by multiplying the dead load (fixed and surcharge loads) by a design seismic coefficient.

2. The standard horizontal coefficient shall be carefully determined for each province by considering the characteristics of regional geographical settings and within the ranges shown in Fig. 1. However, the values thus determined shall on no account be less than 0.1.

3. The design seismic coefficient for structures shall be obtained by multiplying the standards coefficient by the ratios classified in Table 1 for each type of foundation and installation. However, when the resultant value is less than 0.1, the design coefficient shall be assumed at just 0.1, and when it exceeds 0.3, it may be modified to be just 0.3. For tower-shaped structures, aqueducts and other special types of structure, however, this value shall be over 0.4.

Table 1. Multipliers for Seismic Coefficient vs. Types of Foundation and Installation

Type of foundation	Water purification installation and open channel	Tower shaped structure and aqueduct	Subsoil pipeline
Rock foundation and solid sand gravel layer	0.4	0.5	0.3
Dilluvial layer	0.7	0 7	0.7
Alluvial layer	1	1	1
Soft foundation	2	2	2


0 05
0 1
0 1
0 05
0 05
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0 15
0 2
0 3
0 4
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0 05
0 1
0 15
0 15
0 2
0 3
0 4
0 1
0 1
0 05
0 1
0 2
0 15
0 15
0 1
0 05

Fig. 1

1.2.2. Unit Weights

The unit weights of materials to be used for designing shall refer to the values shown in the following table, with exception of some special items:

Table 2. Unit Weight

Materials	Unit Weight (kg/m^3)	Materials	Unit Weight (kg/m^3)	Materials	Unit Weight (kg/m^3)
Water	1,000	Steel	7,850	Stone	2,600
Reinford Concrete	2,400	Cast Steel	7,850	Gravel or Rock Fragment	1,900
Plain Concrete	2,300	Cast Iron	7,250	Sand	1,900
Mortar	2,100	Cast Iron Pipe	7,200	Soil	1,600
Brick	2,000	Wrought Iron	7,800	Timber	800
Prestressed Concrete	2,450	Lead	11,400		
		Copper	8,900		

Unit weight of sand, gravel or rock fragment, 1,900 kg/m^3, is that in case saturated with water.

1.2.3. Allowable Stress

1. Allowable stresses of concrete and metals shall be determined making reference to Standard Specifications for Concrete, Japan Society of Civil Engineers, Design Specifications for Steel Road Bridge, Japan Road Association, Building Codes, Provisions for Building Codes and various criteria of structural computation, Architectural Institute of Japan.

2. The allowable stress of a foundation shall be determined by Table 3, through an examination of geological structures in site. However for such structures which are especially important, actual loading test shall be exercised.

Allowable stresses under earthquake conditions shall be the same values as those in Table 3 for foundations except rock foundation, and 1.5 times these values for rock foundations.

Table 3. Allowable Stresses of Foundations
(cf. Provisions for Building Codes, Ordnance No. 93)

Fondation		Allowable stresses (t/m^2)	Remarks
Hard rock bed	A bed of igneous rocks, such as granite, diorite, gneiss, basalt, etc., or hard conglomerate rocks, etc.	400	
Soft rock bed	A bed of aqueous rocks, such as slate, schist, etc.	250	
	A bed of shale, mudstone, etc.	100	
Gravel		30	
Mixture of gravel and sand		20	
Sandy clay, or loam		15	
Sand or clay		10	

For the foundations not specified in the table above, the allowable stresses shall be determined analogously to the specified foundations of a similar nature.

3. The allowable bearing capacity of the foundation piles shall be determined by a loading test. For simpler types the values may be less than those computed from Table 4.

These same values shall also be used when an earthquake shock is taken into consideration.

Table 4. Allowable Bearing Capacity of Foundation Pile (cf. Provisions for Building Codes, Ordnance No. 93)

Method of Pile Driving	Long Time Allowable Bearing Capacity	Short Time Allowable Bearing Capacity
Drop Hammer or Single Acting Hammer	$R=\frac{WH}{5S+0.1}$	2 times Long time Allowable Bearing Capacity
Double Acting Hammer	$R=\frac{F}{5S+0.1}$	

Denotation: R = allowable bearing capacity of a pile (t)
W = weight of a hammer (t)
H = drop height of a hammer (m)
F = shock energy of a double acting hammer (t−m)
S = final penetration depth of a pile (m)

1.3. METHODS OF EARTHQUAKE-PROOF COMPUTATION

1.3.1. Principles of computation

The computation of the stresses which develop in the structure during an earthquake is carried out under the assumption that the external force, i.e., the mass of the structure multiplied by the design seismic coefficient, acts statically in a horizontal direction. It is also assumed here that the magnitude of the coefficient is uniform for the entire members of the structure. For the structures which are apt to reasonate at the time of earthquake, however, the coefficient shall be somewhat magnified at the upper level.

1.3.2. Earth pressure during earthquake

As to the earth pressure occurring in time of earthquake the computation of positive and resisting earth pressure is exercised on the assumed condition that the combined masses of the foundation and superstructures, with the entire weights magnified by $(1+K/2)$ times, revolve toward the danger side by an angle

$$\theta=\tan^{-1}K \quad (K\text{: seismic coefficient})$$

against the ordinary perpendicular direction. The Zimmerman's diagrammatical method based on the Coulomb's soil wedge theory is recommended as convenient for determining the each pressure in practice.

1.3.3. Water pressure during earthquake

The increment of water pressure against a containing wall occurring due to earthquake is given by the formula:

$$p=\frac{7}{8}Kw\sqrt{Hy}$$

where: p =increment of water pressure due to earthquake, (kg/m^2),

K=seismic coefficient,

w=weight of a unit volume of water (kg/m^3),

H=water depth (m),

y =depth below surface at the acting position of p(m).

The water pressure may also be obtained hydrostatically on the assumption that in time of earthquake the free surface exists at an imaginary level h above the estimated high-water level, as shown by the following formula:

$$h=2K^2H \quad (m)$$

1.3.4. Earthquake-proof computation of a retaining wall

In the earthquake-proof computation of a retaining wall the forces acting on the wall surface shall include the earth pressure in time of earthquake, the weight, earthquake force and buoyancy of the wall, the resisting pressure of the soil in front of the wall, the difference of the water levels before and behind the wall, the weight of and earthquake effects of the surcharge load on the surface of the retained soil.

The combined horizontal component of these forces shall not exceed the frictional resistance of the wall foundation; the maximum pressure occurring at the bed shall not exceed the allowable stress of the foundation during earthquake, and the resultant vector of these forces shall not fall beyond 1/4 of the base length from the center of the base. However, this proportion may be increased up to 1/3 for a strong foundation.

Chap. 3. Harbor Constructions

Standards for aseismic design were legislated in "Design Manual of Harbour Structures in Japan, " by the Japan Port and Harbour Association, and revised in 1968.

3.1. Earthquake Load

(1) Calculation of Earthquake Load

The earthquake load is obtained by multiplying dead loads and live loads by the seismic coefficient, and assumed to act horizontally. The live loads here only mean the weight of crane which is travelling on the rail on the quaywall, and the earthquake load of which has influence upon the stability of quaywall.

(2) Determination of Seismic Coefficient

According to "Design Manual of Harbour Structures in Japan", it is described that the seismic coefficient is determined by the following formula, taking into consideration the regional probability of occurrence of earthquake, condition of foundation soil and importance of the structure.

Seismic coefficient = Regional seismic coefficient x Factor for subsoil Condition x Importance factor.

Seismic coefficient is calculated down to two places of decimals and the last place larger than or equal to 0.08 is counted as 0.1, that between 0.07 and 0.03 as 0.05 and cut away the rest.

As the exception, it is determined that a flexible structure such as a large pier made of piles or a tall structure should be designed by dynamic procedure.

(A) Regional seismic coefficient

Regional seismic coefficient based on the regional probability of occurrence of earthquake is assigned as shown in Table 5 and Fig. 2.

Table 5 Regional Seismic Coefficient

A region	Hokkaido (Nemuro, Kushiro, Tokachi) Kanto (Chiba, Tokyo, Kanagawa) Chubu (Shizuoka, Aichi) Kinki	0.15
B region	Hokkaido (Hidaka, Ishikari, Iburi, Shiribeshi, Hiyama, Oshima, Rumoi) Tohoku Kanto (Ibaragi) Chubu (Niigata, Toyama, Ishikawa, Fukui) Chugoku (Tottori, Okayama, Hiroshima)	0.10

C region	Hokkaido (Soya, Abashiri) Chugoku (Shimane, Yamaguchi) Kyushu	0.05

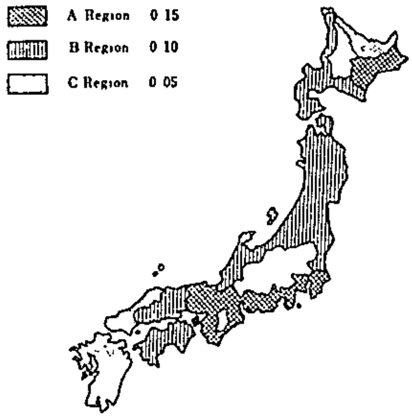


Fig. 2 Seismic Zoning Map for Harbour Structures

(B) Factor for subsoil condition

Factors determined by the kinds of subsoils are assigned as shown in Table 6. Classification of subsoil is illustrated as shown in Table 7 considering the thickness of the quaternary deposit. In the classification of subsoil illustrated in Table 6, sand stratum, N value of which is less than 4, and clay stratum, q_u value of which is less than 0.2 kg/cm^2, are soft ground.

Table 6 Factor for Subsoil Condition

Classification	1st kind	2nd kind	3rd kind
Factor	0.8	1.0	1.2

Table 7 Classification of Subsoil

Thickness of quaternary deposit	Gravel	Sand or clay	Soft ground
Less than 5 m	1st kind	1st kind	2nd kind
5 ~ 25 m	1st kind	2nd kind	3rd kind
More than 25 m	2nd kind	3rd kind	3rd kind

(C) Factor depending on the importance of structures

Importance factor is determined depending upon the importance of the facilities and the range of its value is from 0.5 to 1.5.

Degrees of importance of the structures are determined refering to the following items.

(i) Effect of the damage of the structure upon the social living.
(ii) Effect of the loss of the port function due to the damage of structure upon the reconstruction of environs.
(iii) Cost and time required to the reconstruction of structures.

(3) Apparent Seismic Coefficient

Seismic coefficient in the air should be increased in the water due to buoyancy. This increased coefficient is called "apparent seismic coefficient" and given by the following equation.

$$k' = \frac{\gamma}{\gamma - 1} k \qquad \ldots.(1)$$

where, k': apparent seismic coefficient in the water
k : seismic coefficient in the air
γ : unit weight of the mass in the air
(for soil, it should include the weight of water which is saturating soil)

Since Eq. (1) is based on the simplified assumption that relative movement of water and soil particles during earthquake is prevented by frictional resistance of soil particles.

3.2. Lateral Earthpressure and Dynamic Water Pressure in Earthquakes

(1) Lateral Earthpressure in Earthquakes

Lateral earthpressure of sandy soil in earthquakes is computed by using the Mononobe-Okabe Formula which is derived from Coulomb's formula by statically applying a seismic force to the mass in question. For horizontal ground surface, the formula is given by the following expression.

$$p = (w + \Sigma\gamma \cdot h)K \qquad \ldots.(2)$$

$$K = \frac{\cos^2(\varphi \pm \psi - \theta)}{\cos\theta \cdot \cos^2\psi \cdot \cos(\delta + \psi \pm \theta)\left[1 \pm \sqrt{\frac{\sin(\varphi \pm \delta)\sin(\varphi - \theta)}{\cos(\delta + \psi \pm \theta)\cos\psi}}\right]^2} \qquad \ldots.(3)$$

$$\cot\zeta = \mp\tan(\varphi \pm \delta \pm \psi) + \sec(\varphi \pm \delta \pm \psi)\sqrt{\frac{\cos(\psi + \delta \pm \theta)\sin(\varphi \pm \delta)}{\cos\psi\sin(\varphi - \theta)}} \qquad \ldots.(4)$$

where, p : intensity of lateral earthpressure in earthquakes (t/m^2)
w: intensity of uniform load on the ground surface (t/m^2)
φ : angle of internal friction of sandy soil (°)
for general case ....30°
for particularly good backfill....40°

γ : unit weight of soil (t/m^3); buoyed unit weight should be used below water level and the followings are the standards
above water table in backfill 1.8 t/m^3
below water table in backfill .. 1.0 t/m^3

h : depth from the ground surface (m)

K: coefficient of lateral earthpressure

ψ : angle between wall surface and the vertical (°)

δ : angle of friction between soil and wall (°); usually $|\delta|<15°$

θ : angle given by the following equations, $\theta=\tan^{-1}k$ or $\theta=\tan^{-1}k'$

ζ angle between failure surface and horizon (°)

In eqs. (3) and (4), upper signs are for active case and lower signs for passive case.

(2) Dynamic Water Pressure in Earthquakes

Dynamic pressure of water in backfill is not taken into consideration in current design procedure, because dynamic water pressure in earthquakes is to be included in lateral earthpressure in earthquakes, when the latter is computed by employing the apparent seismic coefficient given in Eq. (1) which is based on the assumption of combined movement of water and soil mass. Dynamic pressure of water in front of a wall is not taken into consideration, because it is recognized that the effect of dynamic water pressure in front of the wall is compensated by the other factors in the whole course of design calculation. As to the water in or between structures of a quaywall, mass force of the water due to earthquake should be considered instead of dynamic water pressure.

Chap. 4. Sub- and Super- Structures of Bridges

The design codes of seismic coefficient for the sub-and super-structures of the highway bridges and the railway bridges, are prescribed in the following specifications, respectively.

1) The Design Specification for Steel Highway Bridges (1957)
2) The Design Specification for Steel Railway Bridges (1955)
3) The Standard Specification for Concrete and Reinforced Concrete by the Japan Society of Civil Engineers
4) The Design Standards for Concrete and Reinforced Structures (tentative)

The seismic acceleration is written in Article 21st in the Specification for Steel Highway Bridges "The effect of earthquake force only in case of no-loaded condition is taken into consideration. The horizontal acceleration of earthquake force must be standardized as 20% of the acceleration of gravity and for the vertical one, 10% the acceleration of gravity, but they can be increased or decreased in consideration of local conditions".

For the design of the railway bridges, Article 14th of the Specification for Steel Railway Bridges is used. "The effect of earthquake force is considered for the case of no-load or of uniformly distributed load prescribed in Article 6th. (1) Horizontal seismic coefficient = 0.2, (2) Vertical Seismic coefficient = 0.1. But these values may be increased or decreased in consideration of local conditions".

Regarding design for a concrete bridge, a pier, and so on, the Standard Specification for Concrete, and the Design Standard for concrete and Reinforced concrete structures (tentative), are used for highway bridges and railway bridges, respectively. The latter is mentioned only, because there are many points of similarity between the two. In Article 19th, it is stipulated that the effect of the earthquake force on the dead load, the earth pressure and the water pressure shall be taken into consideration. The horizontal seismic coefficient is generally given in Fig. 3 and the vertical seismic coefficient value to be used is a half of the value of the horizontal seismic coefficient.

In the Explanatory Notes, the details of the design of earthquake-proof structures are provided as follows:
"In the design of a structure, it is assumed that the force determined by use of the horizontal seismic coefficient value given in Fig. 3, acts statically on the structure, the earth and etc. This acceleration value is such a one that it can produce some amount of statical force which is big enough to cause the same deformation of the structure and the foundation as the actual earthquake force will make. The acceleration values given in Fig. 3 can be modified by use of Table 8(a) and 8(b), according to the locality of the structure, the type of site soils, the kind of structure, the computation for strength of structure or for stability of structure, the respective vibrational characteristics of the structure and the foundation".

Table 8(a)

Type of Calculation / Region / Kind of Foundation	Strength Calculation of a structure which vibrates freely						Stability calculation of a structure which vibrates freely and strength and stability calculations when the effect of each earth pressure is taken in consideration		
	massive structures			slender structures					
	A	B	C	A	B	C	A	B	C
Class I	0.35	0.25	0.20	0.20	0.15	0.10	0.20	0.15	0.10
Class II	0.25	0.15	0.10	0.30	0.20	0.15	0.25	0.20	0.15
Class III	0.15	0.10	0.10	0.30	0.20	0.15	0.30	0.20	0.15
Class IV	0.15	0.10	0.10	0.30	0.20	0.15	0.35	0.25	0.20

(b)

Class	Kind of Bed
I	The surface is an Alluvium formation 2 meters or less in thickness and directly underneath exists a hard stratum of the third or earlier era extending over a fairly wide area
II	The surface is of the Diluvium formation, whose thickness ranges from 3 to 15 meters or of the Alluvium formation whose thickness ranges from 2 to 10 meters
III	The surface is of the Diluvium formation, 15m or more in thickness or of the Alluvium formation, whose thickness ranges from 10 to 25 meters
IV	Remarkably soft and weak bed, or the surface is of the Alluvium formation, 25 meters or more in thickness

Allowable stress for the stress computed under consideration of seismic force is prescribed as following table.

Table 9 Extra percentage of allowable stress

	Steel Railway Bridge	Steel Highway Bridge
Main load and seismic load	75%	80%
Seismic load	75%	80%

As stress culculated in earthquake according to the specification becomes larger than the one at normal condition but as the allowable stress can be increased up to 175% or 180% of the allowable stress in usual time, the shortage of cross-sectional area due to seismic load, may scarecely occur, but the want of strength of lateral member may sometimes arise.

The next table shows the necessary extra percentage of the allowable stress of plain concrete and reinforced concrete structure.

Table 10

State of loading	Extra Percentage	Notes
Dead load and live load	100%	railway bridge only
Dead load only	50%	both railway and highway bridge

The formula developed by Dr. N.Mononobe is generally used, in order to determine the length of well foundation under ground for earthquake. The following equation is Dr. N. Mononobe's formula which is given on the assumption that the distribution of earth pressure applying on the well is parabolic.

$$CD_0 w l^3 - 3 k w_0 l^2 - 9 H l - 12 H h_0 = 0$$

Where

- C : earthpressure in an earthquake
- D_0: diameter of the well
- w : specific gravity of soil
- k : seismic coefficient
- w_0: weight of the well per unit length
- H : horizontal force
- h_0: height of the horizontal force from the surface
- l : length of the well under ground

Besides this formula, the other modified formulae are obtained, taking into consideration the side friction and the bearing pressure at the bottom and used in certain cases.

The formula for earth pressure charged on abutment and retaining wall is the one developed by Dr. N. Mononobe, which is the same as explained in Chap. 3.

Chap. 5. Dams

In Japan, there were many earth dams to irrigate rice field, but it has been 20 years since concrete dams of large scale was started to build. As for the aseismic design of concrete dams, Dr. N. Mononobe published in 1925 his paper "Principles involved in the Design of Gravity Dams for Reservoirs", and concrete dams have been designed by his theory since 1925.

His theory shows that the stress distribution in a dam is computed statically assuming that the external loads acting upon the dam body are the dynamic water pressure and the inertia force, that is, mass multiplied by maximum acceleration of an earthquake.

In 1957, Design Standards for Dams was established by the Domestic Committee of High Dam Conference, in which some stipulations on aseismic design are included. In the standard, seismic force will act horizontally and the seismic coefficient will be decided within limits shown below, under consideration of the condition of the foundation and the importance of the dam concerned and so on.

The table shown below is used for dams which is full of water and when empty, 50% of the values prescribed in the table are used. It is also stipulated that in design, an earthquake does not happen simultaneously with an extraodinary large flood, and the dynamic silt pressure during an earthquake is not taken into consideration, but the dynamic water pressure which was developed by Dr. Westergaard is estimated in design.

Nothing about the increase of the allowable stresses in an earthquake is prescribed, but recently it is common that the allowable stress of concrete during earthquake is increased by 15% of that at normal time. It is recommended to consider the lowering of the angle of repose, when the slope of a rock-fill dam is designed. In checking the sliding of a dam, the seismic mass force and the dynamic water pressure, are considered as the new external horizontal loads during earthquake.

The stability of the slope of an earthdam is generally computed by the sliding circle method, in which seismic force is taken as statical inertia force.

The examples of seismic coefficients of the concrete dams recently constructed are shown in the table, where shows the dams for which the allowable stress of concrete is increased as much as 15%.

Concrete dams have never been seriously damaged by the past earthquakes. There is no damage to the Ohashi Dam (h=73m) which is located about 400 km from the epicenter of the Nankai Earthquake (M=8.1). The dam body (h=18m) was not damaged by the Kanto Earthquake, even if the building of the generating plant was collapsed and there were serious damages around the dam. However the gate pier of plain concrete was cracked at its footing, and carried away by the later flood.

Arch dams as well as hollow gravity dams have no experience of seismic damage, as they have been recently constructed.

There were many examples of seismic damages of earth dams, but the modern investigation shows that the earthdams whose seismic acceleration is smaller than 300 gal have not been damaged. Damages of earthdams are considered to be happened by the percolation of water, being accompanied with the sliding of the slope. Cracks are usually happened parallel to the dam axis.

The aseismicity of the earthdams will be partly decided by the inclination of the slope, but mostly by the composing material, from the experience of the seismic damages happened in the past.

Compiled by the Earthquake Engineering Research Committee, Japan Society of Civil Engineerings.

Table 11

Region / Kind of Dams	South-western Part of Tohoku, Kanto, Chubu, Kinki, South Shikoku	North-eastern Part of Tohoku, Hokkaido, Chugoku, North Shikoku, Kyushu
Concrete and Rock-fill Dam	0.12-0.20	0.10-0.15
Earth-dam	0.15-0.25	0.12-0.20

Table 12

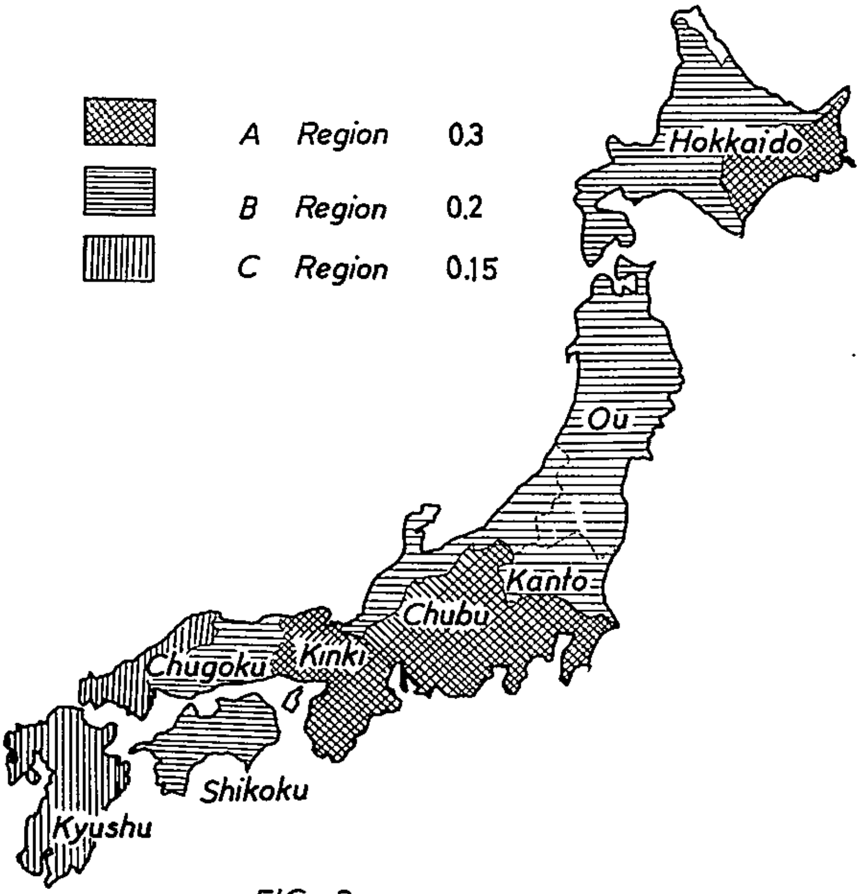
Seismic coefficients used in the design of the famous dams in Japan

Name of Dam	Height of Dam (m)	Seismic Coefficient	Type of Dam
Yakuwa	97.00	0.12	solid
Sudagai	73.50	"	"
Ikawa	100.00	"	hollow dam
Asahi	83.00	"	solid
Arimine	140.00	"	"
Omaezawa	190.00	"	arch dam
Maruyama	96.50	0.15	solid
Miura	81.50	"	"
Tonoyama	62.00	0.12	arch dam
Sasanami	62.00	"	"
Omorigawa	70.00	"	hollow dam
Kamishiba	107.00	"	arch dam
Tsukabaru	83.50	"	solid
Morozuka	56.00	"	hollow dam
Sakuma	150.00	"	solid

Table 13

Some Example in which extra percentage of allowable stress was used for earthquake

Name of Dam	Height of Dam (m)	Allowable stress at normal time	Extra percentage
Omaezawa	190	84 kg/cm^2	15
Sasanami	82	55 "	15
Sakuma	150	50 "	15
Nukabira	76	50 "	15
Tagokura	145	50 "	15



FIG・3

MAP OF SEISMIC COEFFICIENT FOR BRIDGES.

CHAPTER II

(Strength of Construction)
Article 20. The building shall be safely designed to stand against the external forces such as dead load, live load, snow load, wind pressure, earth pressure and water pressure as well as against earth-quake or other vibrations, and shocks.

2. In preparing plans and specifications regarding the buildings as referred to in Article 6 paragraph 1 item (2) or item (3), the safety of the construction concerned shall be ascertained by the structural calculation thereof.

(Principal Structural Parts of Building of Larger Scale)
Article 21. No principal structural parts (excepting floor, roof and stairs) or the buildings exceeding 13 meters in height, 9 meters in eaves height or 3,000 sq. meters in total floor area shall be of wooden construction.

2. No principal structural parts (excepting floor, roof and stairs) of the buildings exceeding 13 meters in height or 9 meters in eaves height shall be built as stone construction, brick construction, concrete block construction, plain concrete construction or others of the similar construction. However, in the case where special measure for reinforcement has been taken and where the safety of the construction concerned has been ascertained by the structural calculation thereof, the same shall not apply.

(Limit of Height)
Article 57. The height of buildings in residential zone shall not exceed 20 meters and in zone of district other than residential zone not 31 meters; provided that the same shall not apply to the cases which fall under the following items and where the permit has been granted by the administrative agency concerned:

(1) The case where there are around the building a large park, square, wide roads and other open spaces, and deemed to have no objections from standpoint of traffic, safety, fire-protecting and sanitation:

(2) The case deemed to be indispensable on account of the use of building such as industrial building and the like.

Section 8 Structural Calculation

Clause 1 General Provisions

(Application)

Article 81. Structural calculation of buildings mentioned in the provisions of Article 20 paragraph 2 of the Law shall be conducted according to the provisions of this Section excluding the case under the provision of Section 9, excepting the case where structural calculation is carried out by the accurate method of structural calculation recognized as equal or superior to that prescribed in the provisions of this Section by the Minister of Construction.

(Principle of Structural Calculation)

Article 82. Structural calculation under the preceding Article shall comply with the requirements of the following items:

(1) Calculate the stress developed in principal part for structural strength of building caused by loads and external forces specified by the provisions of Clause 2;

(2) Permanent and temporary stresses at principal part of structural strength mentioned in the preceding item shall be calculated by combining and summing up stresses by using the following table;

Kind of Stress	Conditions estimable regarding loads and external forces	General case	Case of Snow district
Permanent stress	Normal time	G+P	G+P+S
Temporary stress	Snow season	G+P+S	G+P+S
	Storm*	G+P+W	G+P+W G+P+S+W
	Earthquake	G+P+K	G+P+S+K

Where
G stands for stresses due to dead load prescribed in Article 84.
P stands for stresses due to live load prescribed in Article 85.
S stands for stresses due to snow load prescribed in Article 86.
W stands for stresses due to wind load prescribed in Article 87.
K stands for stresses due to seismic force prescribed in Article 88.
* For checking of overturning of building or pulling-out of column, live loads shall be reduced in accordance with actual conditions of the building.

(3) To check and ascertain that the stresses of permanent and temporary stresses of preceding item do not exceed the allowable stress for permanent and temporary cases according to the provisions of Clause 3;

(4) When necessary, to check and ascertain whether the deformation of the principal structural part gives objectionable effect on the use of building or not.

Clause 2 Loads and External Forces

(Kind of Load and External Force)

Article 83. Loads and external force acting on a building shall be considered in accordance with those mentioned in the following items:

(1) Dead Load;
(2) Live load;
(3) Snow load;
(4) Wind load;
(5) Seismic force.

2. In addition to those given in the preceding paragraph, earth pressure, water pressure, vibration and impact shall be considered in calculation, according to the actual condition of the building concerned.

(Dead Loads)

Article 84. Omitted.

(Live Loads)

Article 85. Live load at each part of a building shall be determined according to actual condition of building concerned. However, live loads on floor given in the following table may be taken from the value as determined for each item concerned for calculation:

Kind of room	For structural calculation on different cases: kg. per sq. m.		
	(a) On calculating floor strength	(b) On calculating strength of girders, columns or footings	(c) On calculating for seismic forces
1) Ordinary room of residential building, sleeping room & patient's room of other than residential buildings.	180	130	60
2) Office room	300	180	80
3) Class room	230	210	110
4) Sales room in department store or shop	300	240	130

5) Seatings or assembly room of theatre, cinema, entertainment hall, grandstand, public hall, assembly hall or building available for other similar use	300	270	160 Fixed seats
Do, other than fixed seats	360	330	210
6) Garage and passageway for automobiles	550	400	200
7) Corridor, vestibule or stairways	For room connected to those item(3) to item(5), the value of other than fixed seats of item(5) is to be taken		
8) Open space on roof or balcony	Value of item(1) to be used. However, for buildings used as school or department store, take the value in item(4).		

(Seismic Force)

Article 88. Seismic force shall be calculated by multiplying sum of dead and live loads (snow load in addition in heavy snow district prescribed in Article 86 paragraph 3) with coefficient of horizontal force.

2. Coefficient of horizontal force acting on a building above the ground level shall be greater than the value given in the following table according to the height above ground level:

Building or its part	1) Part less than 16m. in height	2) Part exceeding 16m. in height	3) Wooden building in district where soil is exceedingly soft
Horizontal force	0.2	Add to value in column (1) 0.01 for increase of every 4m. in height	0.3

3. Special administrative agency shall, on the basis of the standard set forth by Minister of Construction, designate the district where ground is soft and bad as prescribed in 3) of the table in the preceding paragraph.

4. Coefficient of seismic force acting on water tank, chimney projected from roof and the like shall be 0.3 or over.

5. The values in the table of paragraph 2 and those of the coefficient of seismic force prescribed in the preceding paragraph may be reduced by 1/2 or less in accordance with the standards as may be fixed by the Minister of Construction in consideration (1) of (A) the construction of the building or of the water tank, chimney or the like projecting upward from a roof and (B) the foundation or (2) of (A) the extent of damage caused by earthquakes as shown in past earthquake records and (B) the condition of seismic activities and the nature of earthquakes in the district concerned.

Clause 3 Allowable Unit Stresses

(Steel Member)

Article 90. The value of allowable unit stresses of steel and iron shall be in accordance with the value given in the following table:

Kind of steel members	Allowable unit stress for permanent load kg. per sq. cm.						Allowable unit stress, temporary load kg. per sq. cm.					
	Compression	Tension	Bending	Shearing	Side-pressure	Contact	C	T	B	S	SP	C
For general structural steel	1,600	1,600	1,600	900	3,000	4,600	1.5 times the allowable unit stress tension, bending, shearing, side-pressure or contact for permanent load					
Rivet steel	—	1,600	—	1,200	—	—						
Bolts black	—	800	—	—	—	—						
Bolts finished	—	1,000	—	1,200	—	—						
Cast steel	1,600	1,600	1,600	900	3,000	4,600						
Cast iron	1,000	—	—	—	—	2,800						
Reinforcement bars in reinforced concrete	1,600	1,600	—	—	—	—						

(Concrete)

Article 91. The value of allowable stress per sq. cm. of concrete shall be in accordance with the value given in the following table:

Allowable unit stress for permanent stress in kg/cm^2				Allowable unit stress for temporary stress in kg. per sq. cm.			
Compression	Tension	Shearing	Bond*	Compression	Tension	Shearing	Bond
1/3 of compressive strength at 28 day age for concrete used, and less than 70 kg/cm^2	1/10 of allowable unit compressive stress		7 kg/cm^2	2 times the allowable unit stress tension, shearing, or contact for permanent stress			

*6 kg/cm^2 for light-weight aggregate concrete

(Welding)
Article 92. Allowable unit stress of the weld through throat shall be in accordance with the value given in the following table:

Method of operation	Type of joints	Allowable unit stress for permanent stress kg. per sq. cm				Allowable unit stress for temporary stress kg/cm^2			
		Compression	Tension	Bending	Shearing	Compression	Tension	Bending	Shearing
In the case of work positioned for flat welding, by means of universal jig, positioner or the like etc.	Butt	1,400	1,400	1,400	800	1.5 times the allowable unit stress tension, bending, or shearing for permanent stress			
	Fillet	800	800	800	800				
Other than above cases	Butt	1,200	1,200	1,200	700				
	Fillet	700	700	700	700				

(Soil and piles)
Article 93. Allowable bearing power of soil, excepting the case of determining by loading test soil mechanics test or soil investigation, the values in the following table shall be used:

Soil		Allowable bearing power for permanent load ton/m²	Allowable bearing power for temporary load
Hard rock	Granite, Senryokugan, gneiss, andesite, etc. or bed rock of igneous and conglomerate rocks	400	2 times the allowable bearing power for permanent load
Soft rock	Bed rock of sedimentary rocks such as sheet and flake rocks	250	
	Bed rock such as shale hard-pean	100	
Gravel bed		30	
Mixed gravel and sand		20	
Clay mixed with sand or loam		15	
Sand or clay		10	

2. Regarding kind of soil not shown in the table of preceding paragraph shall be determined according to the similar type of soil respectively.

3. Bearing power of foundation pile shall, excepting the case of determining by loading test or adequate static formula, be less than the value obtained by calculation under the following formulas for different cases respectively:

Method of driving of pile	Allowable bearing power for permanent load	Allowable bearing power for temporary load
By drop hammer or Single acting steam hammer	$R = \frac{WH}{5S + 0.1}$	2 times the allowable bearing power for permanent load
Double acting steam hammer	$R = \frac{F}{5S + 0.1}$	

R = Bearing power of pile in ton
W = Weight of hammer in ton
H = Height, hammer dropped from in cm.
F - In case of double acting steam hammer, the energy of impact in ton-cm.
S = Amount of last penetration of pile in cm.

MINISTRY OF CONSTRUCTION NOTIFICATION NO.1074

July 25, 1952

(Standards for Designation of Districts where Ground is Soft and Bad.)

1. The ground shall be designated as soft and bad when it falls in one of the following categories:

   a. Alluvium consisting of soft delta deposits, topsoil, mud, or the like (including heaping up, if any), whose depth is about 30 meters or more.

   b. Land obtained by reclamation of a marsh, muddy sea bottom, etc., of which the depth of the reclaimed ground is about three meters or more and where thirty years have not yet elapsed since the time of reclamation.

(Standards for Reducing Coefficient of Horizontal Force)

2. The coefficient of horizontal force prescribed in Article 88, paragraph 2 or 4, of the Order may be reduced down to the said value multiplied by the factor in Table I in cases falling under Table I, or by the factor in Table II in cases falling under Table II, or by the product (0.5 where its value from the tables is less than 0.5) of the factors in both tables in cases falling under Tables I and II.

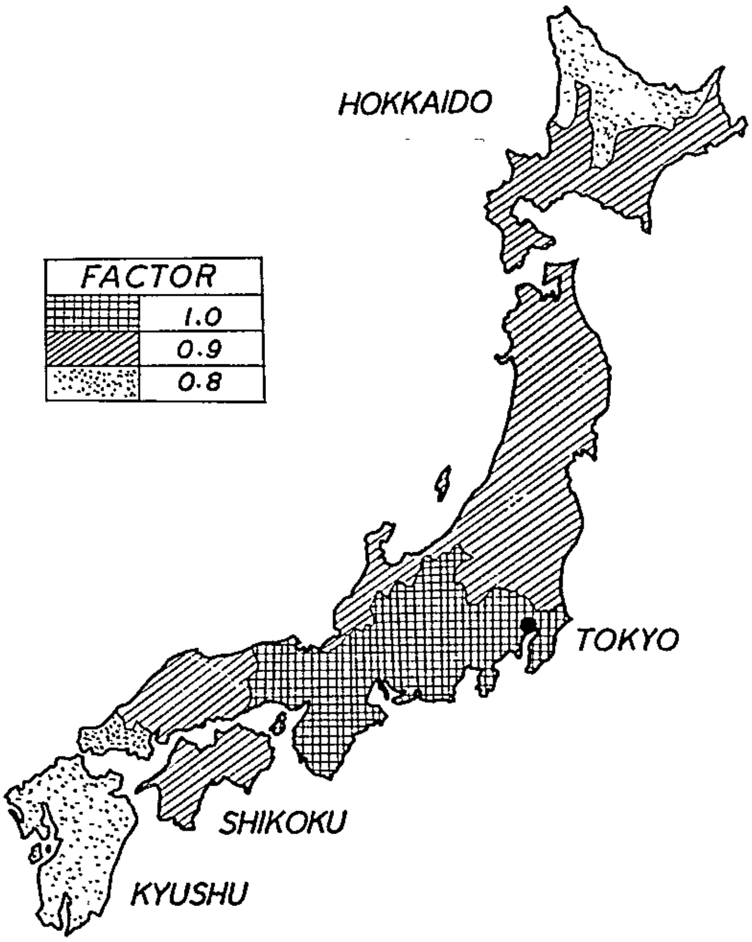
Table I.

Type of construction / Kind of ground	Wooden construction	Steel framed construction	Reinforced concrete construction, steel-frame and reinforced concrete construction, or steel-concrete composite construction
Kind I. Ground consisting of rock, hard sandy gravel, etc. classified as Tertiary or older strata over a considerable area around the structure.	0.6	0.6	0.8
Kind II. Ground consisting of sandy gravel, sandy hard clay, loam, etc. classified as diluvial, or gravelly alluvium, about 5 meters or more in thickness, over a considerable area around the structure.	0.8	0.8	0.9

Table II.*

Districts	Numerical value
(1) In Hokkaido: Asahikawa-shi, Kitami-shi, Abashiri-shi, Rumoi-shi, Wakkanai-shi, Uryu-gun, Nakagawa-gun (Teshio-koku), Kamikawa-gun (Teshio-koku and Ishikari-koku), Monbetsu-gun, Tokoro-gun, Abashiri-gun, Shari-gun, Soya-gun, Esashi-gun, Rishiri-gun, Rebun-gun, Teshio-gun, Tomamae-gun, Rumoi-gun and Mashike-gun; Yamaguchi Pref., Fukuoka Pref., Saga Pref., Nagasaki Pref., Kumamoto Pref., Oita Pref., Miyazaki Pref., Kagoshima Pref.	0.8
(2) In Hokkaido; districts other than those mentioned in (1); Aomori Pref., Akita Pref., Iwate Pref., Miyagi Pref., Yamagata Pref., Fukushima Pref., Ibaragi Pref., Tochigi Pref., Gumma Pref., Niigata Pref., Toyama Pref., Ishikawa Pref., Fukui Pref., Tottori Pref., Shimane Pref., Okayama Pref., Hiroshima Pref., Tokushima Pref., Kagawa Pref., Ehime Pref., Kochi Pref.	0.9

* See attached Map.



REDUCTION FACTORS FOR SEISMIC FORCES

TURKEY

REGULATION FOR BUILDINGS
IN DISASTER AREAS

* * * * *

THE CRITERION TO BE TAKEN INTO CONSIDERATION
FOR THE EARTHQUAKE EFFECTS
IN THE DESIGN OF DAMS

* * * * *

THE PROCEDURES OF THE GENERAL DIRECTORATE OF HIGHWAYS
FOR THE PROJECTS IN THE REGIONS OF EARTHQUAKE

* * * * *

THE PROCEDURES OF THE DEPARTMENT
OF RAILROAD AND HARBOR CONSTRUCTION
FOR THE PROJECTS IN THE EARTHQUAKE REGIONS

REGULATION FOR BUILDINGS IN DISASTER AREAS

Section 1.

About the law number 7269, on which this regulation bases

Section 2.

The places to construct or not to construct buildings; materials of construction and workmanship

Item 4. The area inconvenient to construction
In the cities, towns and villages-shown in law number 7269, item 2, where the technical specialists see danger, it is not allowed to build houses

Item 5. Determination of allowable bearing stresses of the ground
The allowable stress of the foundation ground will be determined by well-known methods.
If the buildings have some technical properties, it is necessary to check the foundations against horizontal forces in calculations

Item 6. The buildings will be built in accordance with Turkish Standard, the instructions for the buildings released by Department of Buildings of the Ministry of Public Works, technics and art requirements regarding both materials of construction and workmanship

Section 3.

In all buildings, taking the necessary steps against the fire

Section 4.

The buildings which will be built in the regions expected to be subjected to torrent effect

Section 5

The buildings which will be built in the earthquake regions. These buildings will be according to given items "in Section 2, Section 3" besides given requirements, also the conditions will be in accordance with the following items.

General Principles: The buildings which will be built in earthquake regions must be designed in as possible as by light materials of construction and kept the center of weight of buildings near ground level.

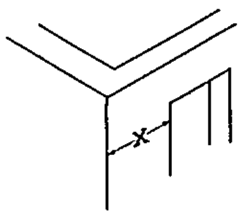
Item 9. In structures of the buildings which will be built in earthquake regions, it is not allowed to use soft iron or similar brittle materials, as like defective wood and not to use soft iron, monolithic stone and similar brittle material on lintels or lintels will not be built by masonry and bricks made supporting stone and brick arches.

Item 10. Building foundations:
The foundations of a block of a building must be a system connected together The foundations of a building will be set in deep according to the height of building. Connection of foundations; if isolated footings or if the foundation is on piles, reinforced concrete bindings must have bar as a results of structural calculation, however R.C. binding beams must have the cross sectional area of minimum 30 cm x 30 cm and reinforcement of 4ϕ16 with stirrups ϕ6/25 cm If the ground is rock or hard clay 4ϕ14 are enough instead of 4ϕ16.

Item 11 Foundations and basement walls
All the foundation walls and outer basement walls will be stone, and will be minimum 30 cm higher than the highest ground level or than the levelled ground. The walls of the garden which was built by stone will not be height of 1.00 m higher than the trotuvare level. Minimum thickness will be 50 cm.

Item 12 Window or door spans of the buildings which have no R.C., steel or timber frame.

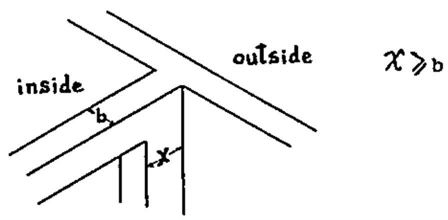
a)



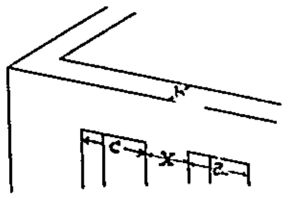
x: 1st. degree earthquake regions $\geqslant$ 1.50 m.
If the height of building $\leq$ 7.50 m and width of façade 6.00 m.
$x \geqslant$ 1.00 m.
(excepted kerpiç construction)

In 2nd degree earthquake regions $x \geqslant$ 1.00 m, if the height of building $\leq$ 7.50 m and width of façade $\leq$ 6.00 m, $x \geqslant$ 0.80 m
However, in case of it is incovenience to keep high dimension of x in designing architectural projects in 1st and 2nd degree earthquake regions, x may be reduced to 0.70 m, setting the columns at the corners, which must have the cross sectional area of minimum 20 cm x 20 cm by prefering reinforced concrete and timber columns. And bracings and connections both in 2 directions will also be built

b) Interior walls



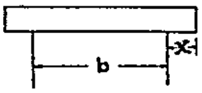
c)



$a > c$
$x \geqslant 1/4\ a$
$x \geqslant 3$ brick length in kerpiç construction $x > 1.50$ m.
But if the buildings are reinforced by timber column, upper binding and bracings may be reduced to 1 00 m in kerpic constructions.

d) The total amount of openings must not be more than 40% façade surface.

Item 13. Lintels of window or door.



$x \geqslant 30$ cm. $x \geqslant 0.20\ b$

If the lintels are not connected by continous binding, it is proper to connect the lintel to the upper binding

Item 14 Supporting arches:
In earthquake regions it is not allowed to construct supporting stone arches and vaults.

Item 15. Supporting slabs: on the walls where the slabs support, there will be continuous bindings and the slabs will be connected to these bindings. If some beams exist, they must be connected firmly to the bindings.
Furthermore as a result of statical calculations,if necessary, R.C. supporting beams must be used. Anchorage between binding materials and supporting elements must be made according to the building standards.
In the slabs other than R.C., must be bound in each 2.00 meters. (slab beams). The length of these slab beams which support on the walls will not be less than 23 cm.
The beams of adjacent rooms must be connected on the wall.
In the slabs with iron beams, these beams will support on the supporting walls by means of iron beams or R C beams

Item 16. Console parts of structures
In the structures other than R.C or steel framed structures console shaped.

a) Staircases are not wider than 1.50 m.

b) Balconies and eaves are not wider than 1.10 m. Console staircases, eaves of doors which are not continuation of slabs or beams, must be connected continuation to a beam in the wall which is supporter wall. In buildings with R.C. or steel frame, the length of consoles are not restrained by regulation. They will be constructed conformable to the dimensions based on statical calculations according to item 30.

Item 17. Partitions and filling walls.
Partition walls will be joined to the perpendicular walls. If these walls are brick of 11 cm thickness, the mortar must contain minimum 250 kg/m^3 cement. The height of the wall is not more than 3.00 m.
If R.C. or steel framed buildings have brick filling walls sized of one brick width are not higher than 3.00 m. If it is necessary to built the brick filling walls in the height of more than 3.00 m, either interval upper binding must be used or the thickness of the wall must be done thick.
In framed structures, it is proper to connect and join the filling walls to the members of framed structures.

Item 18. Roofs and terraces:
Roof truss must resist earthquake forces as a whole and must be joined to the buildings. Only the roof trusses of the buildings without structural skeleton must be designed with tie string not to transport horizontal forces to the walls excepted the case of earthquake and wind.

Item 19. Parts of buildings on the roof slab
Only followings are allowed:

a) Grates of terraces made by metallic or wooden, roof story which was built by partitions walls with light material, roof windows, staircase space, water tanks.
On the buildings with roof, if the roof surface is larger than 1/3 of building surface, that construction built on the roof is considered a story.

b) Chimneys
The chimneys will be conformed to the general principals furthermore in earthquake region, if they are built in the height of 1.50 m or more from the level of roof slab, measures will be taken into consideration to prevent overturning of the chimney.
Basic walls not be weaken due to chimneys.

c) Sidewalls, having a condition attached to necessary dimensions and connecting to the roof construction if resistant to earthquake forces.

Section 6.

Specials remarks about buildings.

Item 20. Structures with R.C or steel skeleton. The height and story number of these kind of structures are not limited because of earthquake.

Item 21. Masonry block constructions, Item 22 half masonry structures, Item 23 wooden framed structures, Item 24 karpiç buildings have already been explained in regulation of Ministry of Public Works.

Section 7

Reparation

Item 25 The buildings which were damaged by disaster will be modified and repaired conformable to preceding section of this regulation, to resist future disaster.

Item 26. Different part of buildings is explained being Item 31, Item 27 Buildings with R C. or steel skeleton being Item 32; Item 28 Archeological, historical and architectural structures and monuments being Item 33 in the regulation of Ministry of Public Works.

Section 8.

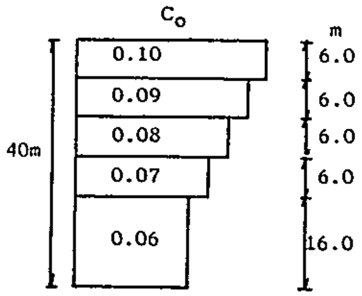
Project and calculation
Principles

Item 29. In designing architectural and structural projects the structures must be as symetric as possible according to the axes of building, in order to alleviate torsion effects during earthquake. The mentioned symmetry is not only in the shape but also with respect to masses and rigidities
Horizontal sections of buildings must be, as possible as, simple and preferably form a closed rectangle or square.
Rectangular type or L,U,E,H, or T sectioned buildings which are near to each other partly or completely, built in different times, or built at the same time, but with different structure systems and on the different kind of grounds, must be separated from each other by expansion joints at least 3 cm in the shape of rectangular blocks of convenient sizes
Supporting walls in each story will be on the similar walls of the down story.

Item 30. Structural calculation principles of buildings.
Structures must be investigated for horizontal effects of earthquakes, other than normal vertical loads
It will be assumed that horizontal earthquake effect act to the structure in the direction of two perpendicular axes, but not at the same time.
Any part of the structure must resist to the horizontal earthquake effect, that will be calculated according to the formula
$H = C \cdot (G + n \cdot P)$

A) Where C is earthquake coefficient and $C = C_o \cdot n_1 \cdot n_2$

	n_1 Coefficient	
	Building Types	
Soil Classification	Steel	R.C.
I	0.6	0.8
II	0.8	0.9
III	1.0	1.0



After 40 m, C_o will be increased by 0.01 steps per 3 00 meters.

Soil types:

I) Hard and monalithic rock
II) Sand, graval, strong and compact soils such as clay with sand, rocks fissured and easily seperated into layers
III) Less strong soils other than mentioned.

Earthquake Regions	n_2 Coefficient
1st Degree	1 00
2nd Degree	0.60
3rd Degree	0.60

B) n coefficient of live load

a) In buildings that will be utilized as public meeting places and labour places such as cinema, theatre, hotel, coffee house, factory n = 1.00

b) In other buildings n = 1/2

C) G is the total of dead loads acting to the part of structures, including its own weight.
P is the total live load acting to the part.

D) In earthquake calculation, either complete earthquake and half wind effect (G+P+E+W/2) or only complete wind effect (G+P+W) will be considered. The ultimate calculation will be made according to the case,

which gives unfavourable results.
The allowable stresses for materials will be increased by 50% in the earthquake calculation.

E) In statical calculations, the weight carried by consoles will be increased by 50%. (The weight means only live load.)

F) In retaining walls, the effective slope angle of the soil will be decreased by 6° in 1st degree areas, and by 3° in 2nd degree areas.

G) The footing width of buildings calculated against earthquake force must be determined and designed so that no tensile effect be produced.

Item 31. The projects of buildings of more than 6 storeys, approval of which is made by municipalities must be submitted to Ministry of Reconstruction and Resettlement, for ultimate approval.

The projects, from which Ministry of Public Work is responsible, are excluded of this command.

THE CRITERION TO BE TAKEN INTO CONSIDERATION

FOR THE EARTHQUAKE EFFECTS IN THE DESIGN OF DAMS

THE STABILITY analysis of dam is to be made in the following cases:

1 - Earthquake during construction

2 - Earthquake at full reservoir

3 - Earthquake at instantaneous drawdown of reservoir

In the first degree earthquake regions, horizontal earthquake load at the value of 0.20 g and vertical earthquake load at the value of $\frac{1}{3} \times 0.20$ g are taken into account and safety factors corresponding to those two cases are computed.

In the second degree earthquake regions, horizontal earthquake load at the value of 0.10 g and vertical earthquake load at the value of $\frac{1}{3} \times 0.10$ g are taken into account and safety factors corresponding to those two cases are computed.

In the case of earthquake, the safety factor will not be less than unity. The hydro-dynamic effects created by reservoir water during the earthquake are not taken into consideration for earth dams. The stability analysis is made with the Modified Swedish Slip-Circle method. In that analysis, the effects of the above mentioned earthquake loads are considered.

Because of lack of seismographic surveys, we can not know the features of earthquake waves and the characteristics of materials and then, we can not make resonance analysis of the embankment.

For the earth dams located in earthquake regions, the following considerations are taken into account:

1 - Because of the cohesionless material may become unstable during the earthquake, the embankment volume of that kind material is to be at least. To prevent the movement of cohesionless material, the zone of that kind material is covered by cobble fill, rock fill, riprap, etc.

2 - The volume of impervious core is increased to prevent the leakage of water through the fissures which might be caused by the earthquake.

3 - The camber at the crest of dam is to be increased in earthquake regions against the overtopping of water which might be caused by settlements due to earthquakes.

4 - The rocks on the surface of ground are cracked or will be cracked due to earthquake in the earthquake regions. Therefore, the cut of trench which is going to be excavated in the rock, has to be taken even deeper to prevent the seepage of water (to 15 m depth at the places close to the faults).

THE PROCEDURES OF THE GENERAL DIRECTORATE OF HIGHWAYS

FOR THE PROJECTS IN THE REGIONS OF EARTHQUAKE

For the highway bridges, loads are classified into two groups. Dead loads, live loads, impact loads, temperature and shrinkage stresses, ice pressure, hydrostatic uplift, earth pressures, longitudinal forces, centrifugal forces, surcharge loads, stream loads are of group A. The assemblage forces and the earthquake loads are of group B.

For the verification, the actual stresses computed according to the loads of group A are compared with the allowable unit stresses. Where the earthquake effects are considered, the actual stresses found from the combined effects of the loads of groups A and B, are to be compared with the allowable unit stresses increased by 50 percent. If it is required, the sizes designed with the loads of group A is increased. They are not decreased considering the findings of the combined loads of groups A and B. The earthquake loads computed according to the standards and codes given in the instructions for the building to be constructed in the earthquake regions.

In the determining earth pressures, the angle of repose of the material is decreased with the value given in the related publications.

Retaining walls are designed with the same principals.

The earthquake effects are not considered for the embankment of highways.

THE PROCEDURES OF THE DEPARTMENT OF RAILROAD AND HARBOR CONSTRUCTION

FOR THE PROJECTS IN THE EARTHQUAKE REGIONS

1 - For the building: "The instructions for the building to be constructed in earthquake regions" released by Department of Buildings of the Ministry of Public Works are to be applied.

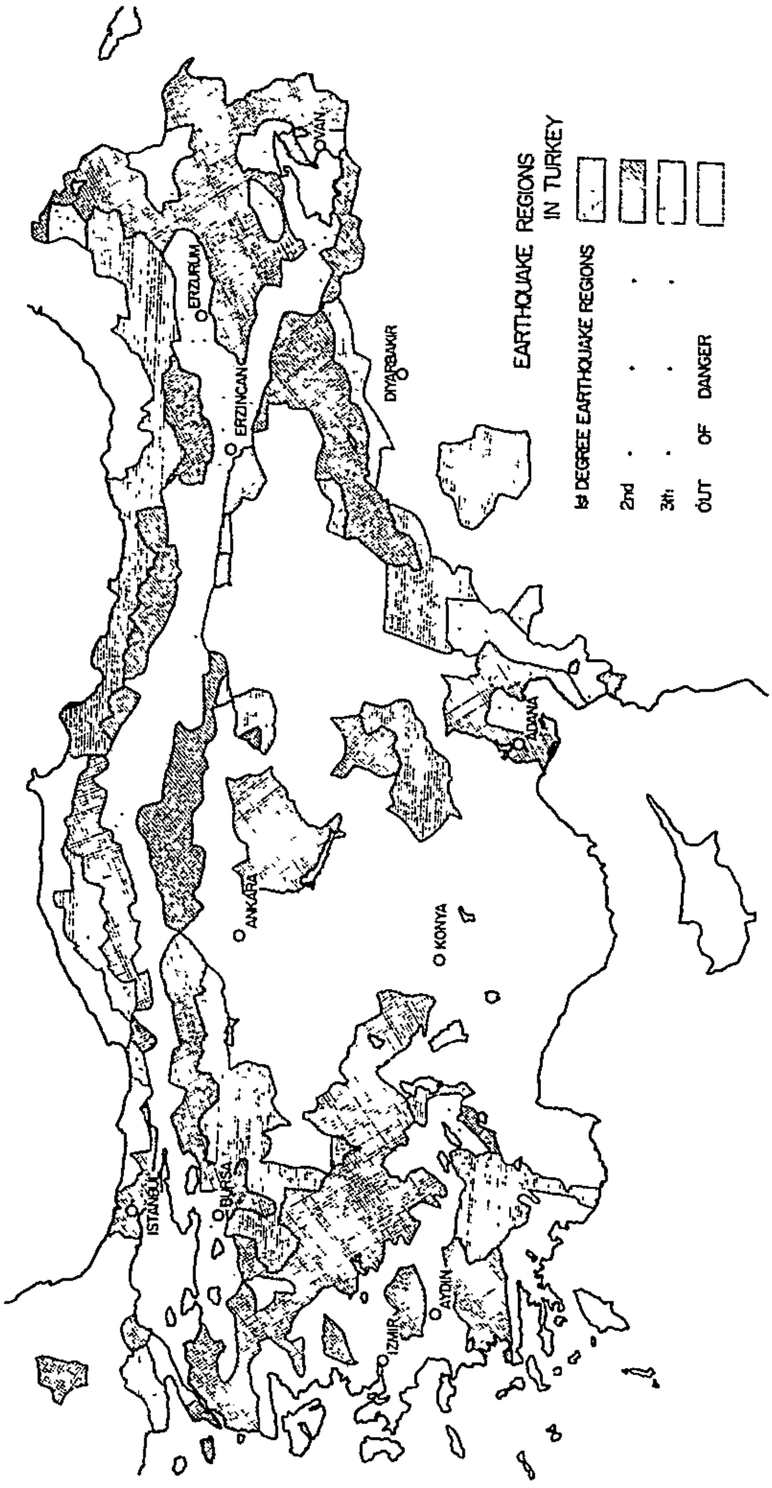
2 - For Bridges: The stability analysis of foundations and the verification of stresses are made according to the assumptions that the various loads of maximum values affects at the same time as combined and that the maximum allowable unit stresses are $\frac{1}{3}$ of ultimate strength. Computation made with these combined loads including earthquake effects show that the actual unit stresses are less than the allowable unit stresses. No damage has been occurred on the bridge located in the severe earthquake regions.

3 - For other structures: Retaining walls, etc. are designed at quite big sizes according to rough computations which do not include earth effects but which are satisfactory from the standpoint of earthquake. Existing structures prove that the assumption is suitable. It is assured that the tunnels are not subject to the earthquake effects as they are completely underground structures.

4 - For quays: The quays are designed according to the horizontal uniformly distributed load at 2-4 ton/m as shipboard force and to the individual horizontal load of 25-75 ton as the tension force of bollard.

Because of earthquake load is less than the above mentioned forces, any verification from the standpoint of earthquake is not required. The building of harbor are designed according to the instructions for the buildings to be constructed in the regions of earthquake of Department of Buildings.

For example, all buildings of Fethiye city were destroyed at the earthquake, but no damage has been appeared on the quay supported by reinforced concrete piles.


EARTHQUAKE REGIONS
IN TURKEY
1st DEGREE EARTHQUAKE REGIONS
2nd
3th
OUT OF DANGER
ERZURUM
VAN
ERZINCAN
DIYARBAKIR
ADANA
ANKARA
KONYA
ISTANBUL
BURSA
IZMIR
AYDIN

Appendix V. List of Donated Books

In view of the importance for the Scientific and technical literatures in the field related, the Mission brought as many new books and publications as possible that are directly related for the practical problems in the field of seismology and earthquake engineering.

These books and publications were presented to the Government of the Union of Burma through Col. Maung Lwin, Deputy Minister of National Planning, on January 29, 1971 at his Office, in the hope these literatures be of good help in advancing the knowledge and development of the study of the experts who are actually extending their best effort in the problems on earthquake engineering and seismology in their home country. In the following a list of these books and papers presented to the Government is reproduced.

Table V–I

A LIST OF BOOKS AND PAPER PRESENTED TO THE GOVERNMENT OF THE UNION OF BURMA FROM THE TECHNICAL COOPERATION MISSION OF JAPAN ON SEISMOLOGY AND EARTHQUAKE ENGINEERING

SUBJECT	COMPILED BY	PUBLISHED BY	REMARKS	NUMBER OF COPIES
1. EARTHQUAKE RESISTANT REGULATIONS A WORLD LIST 1970	INTERNATIONAL ASSOCIATION FOR EARTHQUAKE ENGINEERING, DECEMBER 1970	GAKUJUTSU BUNKEN FUKYU-KAI (ASSOCIATION FOR SCIENCE DOCUMENTS INFORMATION) OH-OKUYAMA, MEGUROKU, TOKYO	SIZE A–4 PAGE 400 ISSUE DECEMBER 1970	3
2. SOME RECENT EARTHQUAKE ENGINEERING RESEARCH AND PRACTICE IN JAPAN	JAPANESE NATIONAL COMMITTEE OF THE INTERNATIONAL ASSOCIATION FOR EARTHQUAKE ENGINEERING, TOKYO, JAPAN.	ASSOCIATION FOR SCIENCE DOCUMENTS INFORMATION (GAKUJUTSU BUNKEN FUKYU-KAI) c/o T.I.T., OH-OKUYAMA.	SIZE A–4 PAGE 178 ISSUE DECEMBER 1968	2
3. SOILS AND FOUNDATIONS. VOL.10 NO.2 JUNE 1970	J.S.S.M.F.E.		(DAMAGE DUE TO THE EARTHQUAKE OF 1968)	1
4. EARTHQUAKE RESISTANT DESIGN FOR CIVIL ENGINEERING STRUCTURES, EARTH STRUCTURES AND FOUNDATIONS IN JAPAN	THE JAPAN SOCIETY OF CIVIL ENGINEERS 1968	JAPAN SOCIETY OF CIVIL ENGINEERS 1-CHOME YOTSUYA, SHINJUKU-KU TOKYO, JAPAN.	PRICE, ¥1600 ($5.50) SIZE A–4 PAGE 150 ISSUE, NOVEMBER, 1968	2
5. SPECIFICATIONS FOR PRESTRESSED CONCRETE HIGHWAY BRIDGE MARCH 1968	JAPAN ROAD ASSOCIATION	JRA		1

SUBJECT	COMPILED BY	PUBLISHED BY	REMARKS	NUMBER OF COPIES
6. SPECIFICATIONS FOR HIGHWAY BRIDGES 1968	JAPAN ROAD ASSOCIATION	JRA		1
7. DESIGN ESSENTIALS IN EARTHQUAKE RESISTANT BUILDINGS	ARCHITECTUAL INSTITUTE OF JAPAN	MARUZEN (TOKYO)	(1. In Japanese) (1. In English)	1 1
8. AIJ STANDARDS	ARCHITECTUAL INSTITUTE OF JAPAN	AIJ		1
9. OUTLINE OF THE JAPAN HOUSING CORPORATION	JAPAN HOUSING CORPORATION	JHC		1
10. THE ANNUAL REPORT OF JAPAN HOUSING CORPORATION	JAPAN HOUSING CORPORATION	JHC		3
11. SOME EXPERIMENTAL DATA ON THE ANTISEISMICITY OF BUILDING OF LARGE CONCRETE PANELS WITHOUT A FRAME IN JAPAN	K. HIRAGA	BUILDING RESEARCH INSTITUTE		3
12. BULLETIN OF EARTHQUAKE RESISTANT STRUCTURE RESEARCH CENTER NO.3 DECEMBER 1969	THE INSTITUTE OF INDUSTRIAL SCIENCE UNIVERSITY OF TOKYO		REPORT ON THE 1968 TOKACHI-OKI EARTHQUAKE	1
13. PHOTO SLIDES ON THE EARTHQUAKE DAMAGE OF REINFORCED CONCRETE BUILDINGS IN JAPAN	DR. TSUNEO OKADA		(1912–1964) 139 Sheets	1 set
14. MANUAL OF SEISMOLOGICAL OBSERVATIONS (PART 1. OBSERVATION PRACTICES), 1967	JAPAN METEOROLOGICAL AGENCY	JMA	(IN JAPANESE)	1
15. MANUAL OF SEISMOLOGICAL OBSERVATIONS (PART 2. DETAILED INSTRUCTIONS) 1968	JAPAN METEOROLOGICAL AGENCY	JMA	(IN JAPANESE)	1

	SUBJECT	COMPILED BY	PUBLISHED BY	REMARKS	NUMBER OF COPIES
16.	MANUAL OF SEISMOLOGICAL OBSERVATORY PRACTICE	INTERNATIONAL SEISMOLOGICAL CENTRE, EDIN-BURGH, SCOTLAND, 1970.	ISC		1
17.	DETERMINATION OF THE RICHTER GUTENBERG'S INSTRUMENTAL MAGNITUDES OF EARTHQUAKES OCCURING IN AND NEAR JAPAN	Ch. TSUBOI	GEOPHYS, NOTES (TOKYO) 4, (1951) No.5 P.I.		1
18.	SOME PROBLEMS IN STATISTICAL SEISMOLOGY	K. AKI	(JOUR. JAPAN SEISMOLOGICAL SOCIETY) VOL.8, (1956) P.205 to 228	(IN JAPANESE)	1
19.	REGIONAL STUDY ON THE CHARAC-TERISTIC SEISMICITY OF THE WORLD PART II FROM BURMA DOWN TO JAWA	T. SANTO	BULL. EARTHQUAKE RESEARCH INSTITUTE, VOL.47 (1969) PP 1049 – 1061		3
20.	METEOROLOGI-CAL SERVICE IN JAPAN	JAPAN METEOROLO-GICAL AGENCY, 1968	JNA		1
21.	PREDICTION OF EARTHQUAKES PROGRESS TO DATA AND PLAN FOR FUTURE DEVELOPMENT.	EARTHQUAKES PREDICTION RESER-CH GROUP, 1962			1

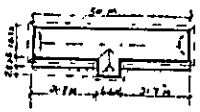
Appendix Ⅵ Earthquake Damage Investigation Cards filledup to the Damage of Buildings caused by the 1970 Rangoon Earthquake.

The following investigation cards had been prepared by the Mission and were filled up by the Burmese engineers.

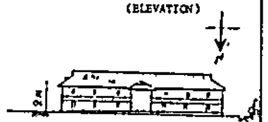
EARTHQUAKE DAMAGE INVESTIGATION CARD		(STRUCTURE)	NO / - /
1 NAME of STRUCTURE	POST & TELEGRAPH TRAINING SCHOOL	14 INVESTIGATOR	
2. ADDRESS	Lower Pazundaung Road RANGOON BURMA	15. DATE	
3. OCCUPANCY	RESIDENT FACTORY SCHOOL ✓ / APT HOUSE HOTEL THEATER / OFFICE DEPT STORE OTHERS( ) / SHOP HOSPITAL		
4. TYPE of STRUCTURE	W SRC / B ✓ OTHERS( ) / SC / RC(PC . PS)		
5. DIMENSION	SUPER STRUCTURE 2 FL / SUBSTRUCTURE Nil FL / PENT HOUSE(EX NO) Nil FL		
	FLOOR AREA 755 m^2 / TOTAL FLOOR AREA 1510 m^2 / HIGHT 9 M		
6 FOUNDATION	INDIVIDUAL / COMPOSITE DEPTH of FOUNDATION from G.L. / CONTINUOUS / RAFT		
7 FOUNDATION	SPREAD / PILE(W. R C. PIER.R.C STEEL)		
8. DESIGN STRENGTH	SPREAD t/m2 / PILE t/PILE		
9 SOIL CONDITION	SAND SOFT / CLAY ✓ GOOD / ROAM FIRM / ROCK OTHERS( )		
10 DESIGNER	11 CONSTRUCTOR	12 DATE of COMPLETION 1965	

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW)



(ELEVATION)



EARTHQUAKE DAMAGE INVESTIGATION CARD		(DAMAGE) NO / - 2
16 CRACK	BEAM(BEND SHEAR) COLUMN(BEND. SHEAR) WALL ✓ SLAB CONNECTION	25 CAUSE
17.BUCKLING FAILURE	NIL	FOUNDATION MOVEMENT
18.RUPTURE	NIL	LAND SLIDE, FISSURE, DIFFERENTIAL SETTLEMENT
19 DAMAGE	GLASS PANE, INTERIOR ✓, CLADDING EXTERIOR ✓, FACILITIES, FIXTURE	DEFORMITION, COLLISION, POOR STRENGTH
20 PEELING FAILURE	INTERIOR ✓, EXTERIOR ✓	DIFECTIVE CONSTRUCTION
21 SETTLE MENT	YES (APPROX. cm PLACE) Nil	VIBRATION ✓
22 INCLINATION	Nil "	
23.MATERIAL FALLEN	Composite Plaster From walls	
24.OTHER	2cm to 4cm Cracks occured vertically at Middle of Building from ceiling to Ground Level	
26 COMMENT — DAMAGE	Due to Earth Quake On 9.9.70.	
CAUSE		
POSSIBILITY of REPARATION	✓ Repairable	
CIRCUMSTANCES of the STRUCTURE	In use at Present where Not Damaged. Damaged Portion Under Repair.	

27. DATA	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING		✓		
STRENGTH CALCULATION LIST		✓		
BORING LOG		✓		
MICRO TREMOUR		✓		

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST) NO / - 3

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

PHOTO NO 2 AND NO 3.
DISTANCE OF CRACKS FROM CRACKS WALL APPROXIMATELY 1.5M TO 2.5m POSITION OF CRACKS ALIGNED ON HORIZONTAL LINE

29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1	NO 2		11		
2	No 3		12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

30

REMARK

NO 6. No Data Available on Type of Foundation Depth of Foundation is Assumed To Be About 1 M Or Thereabout.

NO 7. No DATA Available

No 8. Bearing capacity Estimated To Be Not More Than 2.75 Metric Tons / M^2

(ဆိုင်း)
ဦးဝင်း/တာ(က)
ဒုဦးစီးအင်ဂျင်နီယာ
ဆောက်လုပ်ရေးကော်ပိုရေးရှင်း(၁၀)
Maintenance (2) Foreign Command Construction Corporation

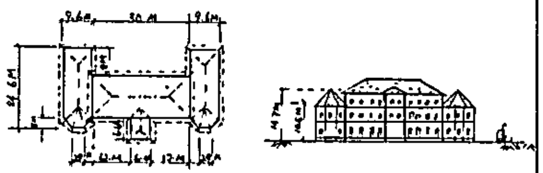
NO 2-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1 NAME of STRUCTURE	STATE MIDDLE SCHOOL, NO I BOTATAUNG.	14. INVESTIGATOR
2 ADDRESS	Thein Byu Road RANGOON BURMA	15. DATE
3. OCCUPANCY	RESIDENT, FACTORY, SCHOOL ✓, APT.HOUSE, HOTEL, THEATER, OFFICE, DEPT.STORE, OTHERS( ), SHOP, HOSPITAL	
4 TYPE of STRUCTURE	W, SRC, B ✓, OTHERS( ), SC, RC(PC . PS)	
5. DIMENSION	SUPER STRUCTURE: 4 FL; SUBSTRUCTURE: Nil FL; PENT HOUSE(EX NO): Nil FL; FLOOR AREA 879 m^2; TOTAL FLOOR AREA 2167 m^2; HIGHT 14 m	
6. FOUNDATION	INDIVIDUAL, COMPOSITE, CONTINUOUS, RAFT; DEPTH of FOUNDATION from G.L.	
7. FOUNDATION	SPREAD, PILE(W, R.C, PIER, R C, STEEL)	
8. DESIGN STRENGTH	SPREAD t/m^2; PILE t/PILE	
9. SOIL CONDITION	SAND ✓, SOFT, CLAY, GOOD, LOAM, FIRM, ROCK, OTHERS( )	
10 DESIGNER	11 CONSTRUCTOR	12 DATE of COMPLETION

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) (ELEVATION)



NO 2-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND, SHEAR), COLUMN(BEND, SHEAR), WALL ✓, SLAB, CONNECTION	25 CAUSE
17. BUCKLING FAILURE	Nil	FOUNDATION MOVEMENT
18 RUPTURE	Nil	LAND SLIDE
19 DAMAGE	GLASS PANE, INTERIOR ✓, CLADDING EXTERIOR ✓, FACILITIES, FIXTURE	FISSURE; DIFFERENTIAL SETTLEMENT; DEFORMITION
20. PEELING FAILURE	INTERIOR ✓, EXTERIOR ✓	COLLISION; POOR STRENGTH
21. SETTLE MENT	YES (APPROX. cm PLACE) Nil	DIFFECTIVE CONSTRUCTION
22 INCLINATION	Nil "	VIBRATION ✓
23 MATERIAL FALLEN	COMPOSITE PLASTER FROM WALLS AT places.	
24. OTHER	3cm to 4cm Cracks Occured Vertically at crown of Arches.	

26 COMMENT

DAMAGE	DUE TO EARTH QUAKE ON 9.9.70.
CAUSE	
POSSIBILITY of REPARATION	REPAIRABLE
CIRCUMSTANCES of the STRUCTURE	IN USE AT PRESENT. WHERE NOTDAMAGED. DAMAGED PORTION UNDER REPAIR.

27 DATA

	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING		✓		
STRENGTH CALCULATION LIST		✓		
BORING LOG		✓		
MICRO TREMOR		✓		

NO 2-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

PHOTO NO 5.

DISTANCE OF CAMERA FROM CRACKED WALL APPROXIMATELY 1.5 M.

TO 2.5M. POSITION OF CAMERA ALIGNED ON HORIZONTAL PLANE

29. PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1	105		11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

30.

REMARK

NO 6. NO DATA AVAILABLE ON TYPE OF FOUNDATION. DEPTH OF FOUNDATION ASSUMED TO BE ABOUT 1.5 M OR THERE ABOUT.

NO 7. NO DATE AVAILABLE

NO 8. BEARING CAPACITY ESTIMATED TO BE NOT MORE THAN 18 METRIC TONS / M^2

(၁၉၇၀)

မြို့မ်ဆင်/ယခု(က)
ပြုပြင်ထောင်ထောင်
ထိန်းသိမ်းရေးအမှတ်(၃၀)

Assistant Command Engineer
Maintenance (30) Rangoon Command
Construction Corporation

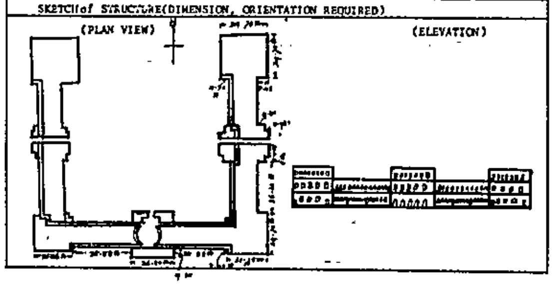
NO 3-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1 NAME of STRUCTURE	OLD SECRETARIAT		14 INVESTIGATOR	
2. ADDRESS	OLD SECRETARIAT, RANGOON, BURMA.		15. DATE	
3. OCCUPANCY	RESIDENT FACTORY SCHOOL	APT HOUSE HOTEL THEATER	OFFICE ✓ DEPT STORE OTHERS(	SHOP HOSPITAL)
4 TYPE of STRUCTURE	W SRC	B ✓ OTHERS(	SC	RC(PC . PS))
5. DIMENSION	SUPER STRUCTURE: Two in some places ~~Three in some places~~	SUBSTRUCTURE: NIL FL	PENT HOUSE(EX NO): NIL FL	
	FLOOR AREA: 9644.00 m^2	TOTAL FLOOR AREA: 25086.00 m^2	HIGHT: 12 M 18 M	
6. FOUNDATION	INDIVIDUAL	COMPOSITE DEPTH of FOUNDATION from G.L.	CONTINUOUS	RAFT
7 FOUNDATION	SPREAD	PILE(W. R C. PIER.R.C. STEEL)		
8. DESIGN STRENGTH	SPREAD t/m^2	PILE t/PILE		
9. SOIL CONDITION	SAND ✓ SOFT	CLAY ✓ GOOD	ROAM FIRM	ROCK OTHERS( )
10 DESIGNER	11 CONSTRUCTOR	12 DATE of COMPLETION 1892		

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) (ELEVATION)



NO 3-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND SHEAR) COLUMN(BEND SHEAR) WALL ✓ SLAB CONNECTION	25 CAUSE
17. BUCKLING FAILURE	NIL	FOUNDATION MOVEMENT
18 RUPTURE	NIL	LAND SLIDE
19 DAMAGE	GLASS PANE INTERIOR ✓ CLADDING EXTERIOR FACILITIES FIXTURE-	FISSURE DIFFERENTIAL SETTLEMENT DEFORMITION
20 PEELING FAILURE	INTERIOR ✓ EXTERIOR	COLLISION POOR STRENGTH
21 SETTLE MENT	~~Yes~~ NIL (APPROX. cm PLACE)	DIFECTIVE CONSTRUCTION
22. INCLINATION	NIL	VIBRATION ✓
23 MATERIAL FALLEN	NIL	
24. OTHER	-	

26 CONTENT	
DAMAGE	DUE TO EARTHQUAKE
CAUSE	" " "
POSSIBILITY of REPARATION	REPAIRABLE.
CIRCUMSTANCES of the STRUCTURE	IN USE, DAMAGED PORTIONS UNDER REPAIRS.

27. DATA	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING		✓		
STRENGTH CALCULATION LIST		✓		
BORING LOG		✓		
MICRO TREMOUR		✓		

NO 3-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

PHOTO NO. 1.

POSITION OF CAMARA ON HORIZONTAL PLAIN IS 1.5 M TO 2.5 M FROM OBJECT.

29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1	NO.1.		11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

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NO. 6. FOUNDATION WILL MOST PROBABLY BE SPREAD FOUNDATION AT THE DEPTH OF ABOUT NOT LESS THAN 2 M OR THERE ABOUT.

NO. 7. ALREADY MENTIONED ABOVE FOR NO. 6.

NO. 8. NO DATA AVAILABLE BUT IT IS ASSUMED TO BE NOT MORE THAN 18 - METRIC-TON/ m^2

Township Engineer, Construction Corporation

Assistant Engineer

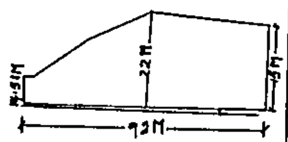
NO. 4-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

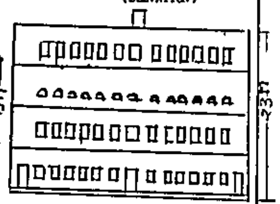
1. NAME of STRUCTURE	CUSTOM HOUSE .		14. INVESTIGATOR
2. ADDRESS	NO. 124, STRAND ROAD, RANGOON, B U R M A .		15. DATE
3 OCCUPANCY	RESIDENT FACTORY SCHOOL	APT HOUSE HOTEL THEATER	OFFICE ✓ DEPT STORE OTHERS( ) SHOP HOSPITAL
4 TYPE of STRUCTURE	W SRC	B ✓ OTHERS(STEEL BEAMS)	SC RC(PC , PS)
5 DIMENSION	SUPER STRUCTURE: FOUR FL	SUBSTRUCTURE: NIL FL	PENT HOUSE(EX NO): NIL FL
	FLOOR AREA: 1581.00 m^2	TOTAL FLOOR AREA: 6323.00 m^2	HIGHT: 23.00 M
6 FOUNDATION	INDIVIDUAL DEPTH of FOUNDATION from G.L.	COMPOSITE	CONTINUOUS RAFT
7. FOUNDATION	SPREAD	PILE(W, R C PIER, R.C, STEEL)	
8 DESIGN STRENGTH	SPREAD t/m2	PILE t/PILE	
9. SOIL CONDITION	SAND SOFT	CLAY ✓ GOOD	ROAM FIRM ROCK OTHERS( )
10 DESIGNER	11. CONSTRUCTOR	12 DATE of COMPLETION	

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW)



(ELEVATION)



NO. 4-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BLND SHEAR) COLUMN(BLND, SHEAR) WALL ✓ SLAB CONNECTION	25 CAUSE
17. BUCKLING FAILURE	NIL	FOUNDATION MOVEMENT
18 RUPTURE	NIL	LAND SLIDE
19. DAMAGE	GLASS PANE INTERIOR ✓ CLADDING EXTERIOR FACILITIES FIXTURE	FISSURE DIFFERENTIAL SETTLEMENT DEFORMITION COLLISION POOR STRENGTH
20. PEELING FAILURE	INTERIOR ✓ EXTERIOR	DIFECTIVE CONSTRUCTION VIBRATION ✓
21. SETTLE MENT	Y/S NIL APPROX. cm PLACE)	
22 INCLINATION	NIL "	
23. MATERIAL FALLEN	NIL	
24 OTHER	"	

26 COMMENT

DAMAGE	DUE TO EARTHQUAKE
CAUSE	" "
POSSIBILITY of REPARATION	REPAIRABLE .
CIRCUMSTANCES of the STRUCTURE	IN USE, SINCE THE BUILDING IS STRUCTURALLY SAFED .

27. DATA

	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING		✓		
STRENGTH CALCULATION LIST		✓		
BORING LOG		✓		
MICRO TREMOUR		✓		

NO. 4-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

29 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

PHOTO NO. 10 .

POSITION OF CAMARA ON HORIZONTAL PLAIN IS 1.5 M TO 2.5 M FROM OBJECT .

28 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1	NO.10		11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

30

NO. 6 - NO DATA AVAILABLE .

NO. 7 - " " "

NO. 8 - " " "

Assistant Command Engineer, Maintenance (30) Rangoon Command, Construction Corporation

Construction Corporation

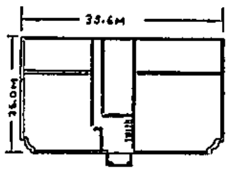
NO 5-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

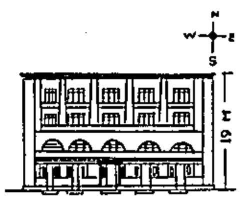
1. NAME of STRUCTURE	MINER'S BUILDING	14. INVESTIGATOR
2. ADDRESS	NO. 50, SHAFRAZ ROAD, RANGOON, BURMA .	15. DATE
3. OCCUPANCY	RESIDENT / FACTORY / SCHOOL / APT.HOUSE / HOTEL / THEATER / OFFICE✓ / DEPT.STORE / OTHERS( ) / SHOP / HOSPITAL	
4. TYPE of STRUCTURE	W / SRC / B✓ / OTHERS(STEEL BEAMS / SC / RC(PC .PS)	
5. DIMENSION	SUPER STRUCTURE: FOUR FL / SUBSTRUCTURE: NIL FL / PENT HOUSE(EX FO): NIL FL	
	FLOOR AREA: 878.00 m^2 / TOTAL FLOOR AREA: 3514.00 m^2 / HIGHT: 19.00 M	
6. FOUNDATION	INDIVIDUAL / COMPOSITE / CONTINUOUS / R.FT / DEPTH of FOUNDATION from G.L.	
7. FOUNDATION	SPREAD / PILE(W. R. C. PIER.R. C. STEEL)	
8. DESIGN STRENGTH	SPREAD t/m^2 / PILE t/PILE	
9. SOIL CONDITION	SAND / SOFT / CLAY / GOOD / LOAM / FIRM / ROCK / OTHERS( )	
10. DESIGNER	11. CONSTRUCTOR	12. DATE of COMPLETION 1928

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW)



(ELEVATION)



NO 5-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16. CRACK	BEAM(BEND. SHEAR) / COLUMN(BEND. SHEAR) / WALL✓ SLAB CONNECTION	25. CAUSE: FOUNDATION MOVEMENT / LAND SLIDE / FISSURE / DIFFERENTIAL SETTLEMENT / DEFORMATION / COLLISION / POOR STRENGTH / DEFECTIVE CONSTRUCTION / VIBRATION
17. BUCKLING FAILURE	NIL	
18. RUPTURE	NIL	
19. DAMAGE	GLASS PANE / INTERIOR✓ / GLADDING EXTERIOR / FACILITIES / FIXTURE	
20. PEELING FAILURE	INTERIOR✓ / EXTERIOR	
21. SETTLEMENT	YES (APPROX. cm PLACE) / NIL	
22. INCLINATION	NIL "	
23. MATERIAL FALLEN	NIL	
24. OTHER	-	

26. COMMENT

DAMAGE	DUE TO EARTHQUAKE
CAUSE	" " "
POSSIBILITY of REPARATION	REPAIRABLE .
CIRCUMSTANCES of the STRUCTURE	IN USE .

27. DATA

	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING		✓		
STRENGTH CALCULATION LIST		✓		
BORING LOG		✓		
MICRO TREMOUR		✓		

PC 5-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28. SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

PHOTO NO. 11 .

POSITION OF CAMARA ON HORIZONTAL PLAIN IS 1.5 M TO 2.5 M FROM OBJECT .

29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1	NO. 11.		11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

30

NO. 6 - DATE NOT AVAILABLE .
NO. 7 - " " "
NO. 8 - " " "

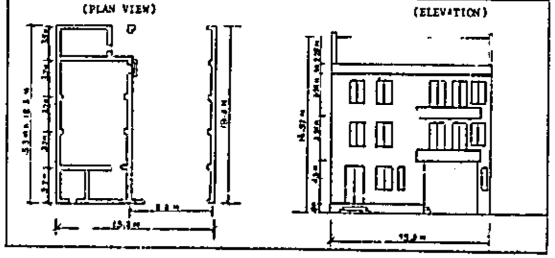
NO | 6-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1. NAME of STRUCTURE	E.S.B (Electric Supply Board) Chairman office Bldg:	14. INVESTIGATOR
2. ADDRESS	No: 197/199 Lower Kemmendine Road, Ahlone	15 DATE
3. OCCUPANCY	RESIDENT FACTORY SCHOOL / APT HOUSE HOTEL THEATER / OFFICE ✓ DEPT.STORE OTHERS( ) / SHOP HOSPITAL	
4. TYPE of STRUCTURE	W SRC / B OTHERS( ) / SC ✓ / RC(PC PS)	
5 DIMENSION	SUPER STRUCTURE 15.3m x 18.3m L / SUBSTRUCTURE FL / PENT HOUSE(EX NO) FL	
	FLOOR AREA 840 m² / TOTAL FLOOR AREA m² / HIGHT m	
6 FOUNDATION	INDIVIDUAL ✓ COMPOSITE CONTINUOUS RAFT; DEPTH of FOUNDATION from G.L = 2 m.	
7. FOUNDATION	SPREAD ✓ PILE(W, R.C, PIER, R.C, STEEL)	
8 DESIGN STRENGTH	SPREAD t/m² / PILE t/PILE	
9 SOIL CONDITION	SAND SOFT / CLAY ✓ GOOD / ROAM FIRM / ROCK OTHERS( )	
10 DESIGNER	11 CONSTRUCTOR	12. DATE of COMPLETION

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) (ELEVATION)



NO | 6-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND SHEAR) COLUMN(BEND, SHEAR) WALL ✓ SLAB CONNECTION	25 CAUSE: FOUNDATION MOVEMENT; LAND SLIDE; FISSURE; DIFFERENTIAL SETTLEMENT; DEFORMITION; COLLISION; POOR STRENGTH; DIFECTIVE CONSTRUCTION; VIBRATION ✓
17 BUCKLING FAILURE	-	
18 RUPTURE	-	
19. DAMAGE	GLASS PANE; INTERIOR ✓; CLADDING EXTERIOR; FACILITIES; FIXTURE	
20. PEELING FAILURE	INTERIOR ✓ EXTERIOR	
21 SETTLE MENT	YES (APPROX. cm PLACE)	
22. INCLINATION	-	
23 MATERIAL FALLEN	mortar	
24 OTHER	-	

26 COMMENT

DAMAGE	
CAUSE	
POSSIBILITY of REPARATION	Yes
CIRCUMSTANCES of the STRUCTURE	

27 DATA

	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING		-		Revolutionary Govt. of the Union of Burma
STRENGTH CALCULATION LIST		-		
BORING LOG		-		
MICRO TREMOR		-		

NO | 6-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

Nil

29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1	Nil		11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

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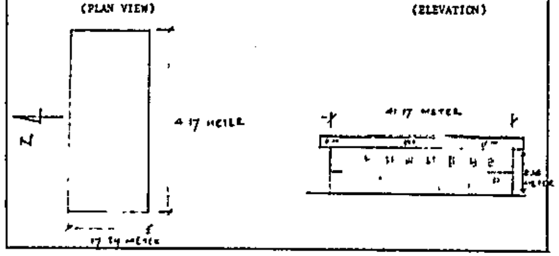
		NO | | | 7 | – | 1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1. NAME of STRUCTURE	DRUGS AND INSTRUMENTS SHOP NO(18) PAZEDAN REGIONAL TRADE.	14 INVESTIGATOR
2. ADDRESS	NO 432 / 441, SHWEBONTHA STREET, RANGOON, BURMA	15. DATE
3. OCCUPANCY	RESIDENT / FACTORY / SCHOOL / APT HOUSE✓ / HOTEL / THEATER / OFFICE / DEPT.STORE / OTHERS( ) / SHOP✓ / HOSPITAL	
4. TYPE of STRUCTURE	W / SRC / B✓ / OTHERS(WOODEN FLOOR) / SC / RC(PC PS)	
5. DIMENSION	SUPER STRUCTURE: TWO FL / SUBSTRUCTURE: — FL / PENT HOUSE(EX NO): — FL	
	FLOOR AREA: 716 00 m^2 / TOTAL FLOOR AREA: 1432 00 m^2 / HIGHT: 8 14 m	
6. FOUNDATION	INDIVIDUAL / COMPOSITE / CONTINUOUS / RAFT / DEPTH of FOUNDATION from G.L.	
7. FOUNDATION	SPREAD / PILE(W. R.C. PIER.R.C. STEEL)	
8 DESIGN STRENGTH	SPREAD t/m^2 / PILE t/PILE	
9 SOIL CONDITION	SAND✓ / SOFT / CLAY / GOOD / ROAM / FIRM / ROCK / OTHERS( )	
10 DESIGNER	11 CONSTRUCTOR	12 DATE of COMPLETION

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) (ELEVATION)



		NO | | | 7 | – | 2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND, SHEAR) / COLUMN(BEND, SHEAR) / WALL✓ SLAB CONNECTION✓	25 CAUSE
17 BUCKLING FAILURE		FOUNDATION MOVEMENT
18 RUPTURE		LAND SLIDE / FISSURE
19 DAMAGE	GLASS PANE / INTERIOR✓ / CLADDING EXTERIOR / FACILITIES / FIXTURE	DIFFERENTIAL SETTLEMENT / DEFORMITION / COLLISION / POOR STRENGTH
20 PEELING FAILURE	INTERIOR✓ / EXTERIOR	DIFECTIVE CONSTRUCTION
21 SETTLE MENT	YES (APPROX. cm PLACE) NIL	VIBRATION✓
22. INCLINATION	0·08 METER	
23 MATERIAL FALLEN	LIME PLASTER	
24 OTHER		

26 COMMENT	
DAMAGE	DUE TO EARTHQUAKE ON 9 9.70
CAUSE	
POSSIBILITY of REPARATION	UNDER INVESTIGATION
CIRCUMSTANCES of the STRUCTURE	WOODEN RAKING SHORES PROVIDED. APARTMENT PORTION IN USE BY TENANT

27. DATA	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING		✓		
STRENGTH CALCULATION LIST		✓		
BORING LOG		✓		
MICRO TREMOUR		✓		

		NO | | | 7 | – | 3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

30.

NO (6) NO DATA AVAILABLE HOWEVER FOUNDATION ASSUMED TO BE INDIVIDUAL AT DEPTH OF ABOUT NOT LESS THAN ONE METER

NO (7) ASSUME TO BE SPREAD

NO (8) SPREAD ASSUME TO BE NOT MORE THAN (8) METER TON/M^2

TOWNSHIP ENGINEER (A)
PAZEDAN UNIT,
MAINTENANCE (30)

Assistant Command Engineer
Maintenance (30) Rangoon Command
Construction Corporation

NO 8-1

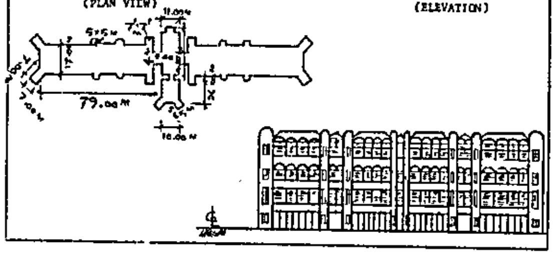
EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1 NAME of STRUCTURE	RANGOON GENERAL HOSPITAL	14. INVESTIGATOR	
2. ADDRESS	RANGOON, BURMA	15. DATE	
3 OCCUPANCY	RESIDENT FACTORY SCHOOL · APT.HOUSE HOTEL THEATER · OFFICE DEPT.STORE OTHERS( ) · SHOP HOSPITAL ✓		
4 TYPE of STRUCTURE	W SRC · B ✓ OTHERS( ) · SC · RC(PC , PS)		
5. DIMENSION	SUPER STRUCTURE 4 FL	SUBSTRUCTURE NIL FL	PENT HOUSE(EX NO) NIL FL
	FLOOR AREA 5689.00 m²	TOTAL FLOOR AREA 14756.00 m²	HIGHT 21 M
6 FOUNDATION	INDIVIDUAL · COMPOSITE · CONTINUOUS · RAFT; DEPTH of FOUNDATION from G.L.		
7 FOUNDATION	SPREAD · PILE(W, R C PIER,R.C. STEEL)		
8 DESIGN STRENGTH	SPREAD t/m²	PILE t/PILE	
9. SOIL CONDITION	SAND ✓ SOFT · CLAY GOOD · LOAM FIRM · ROCK OTHERS( )		

10 DESIGNER	11 CONSTRUCTOR	12. DATE of COMPLETION
		6-5-1905

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) (ELEVATION)



NO 8-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND SHEAR) COLUMN(BEND, SHEAR) WALL ✓ SLAB CONNECTION	
17 BUCKLING FAILURE	NIL.	
18 RUPTURE	NIL.	
19. DAMAGE	GLASS PANE, INTERIOR ✓, CLADDING EXTERIOR, FACILITIES, FIXTURE	
20 PEELING FAILURE	INTERIOR ✓ EXTERIOR	
21 SETTLE MENT	YES NIL (APPROX. cm PLACE)	
22 INCLINATION	NIL "	
23 MATERIAL FALLEN	Composite plaster from walls at places and from arches at places	
24. OTHER	—	

25 CAUSE: FOUNDATION MOVEMENT · LAND SLIDE · FISSURE · DIFFERENTIAL SETTLEMENT · DEFORMITION · COLLISION · POOR STRENGTH · DIFECTIVE CONSTRUCTION · VIBRATION ✓

26. COMMENT

DAMAGE	Due to earthquake on 9-9-70
CAUSE	
POSSIBILITY of REPARATION	Repairable
CIRCUMSTANCES of the STRUCTURE	Undamaged portions of the building are in use and the damaged portions are under repairs

27. DATA	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING		✓		
STRENGTH CALCULATION LIST		✓		
BORING LOG		✓		
MICRO TREMOUR		✓		

NO 8-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28. SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

Photo No. 6 and Photo No. 7
Distance of Camera from Cracked wall approximately 1.50M to 2.50M. Position of Camera aligned in horizontal plane.

29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1	No 6		11		
2	No 7		12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

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Remarks
No 6. No data available on type of foundation. Depth of foundation is assumed to be about 2.75 M or thereabout.
No. 7. No data available.
No. 8. No data available.

Township Engineer (B), Maintenance (30) Insein Area, Construction Corporation, Insein

Assistant Command Engineer, Maintenance (30) Rangoon Command, Construction Corporation

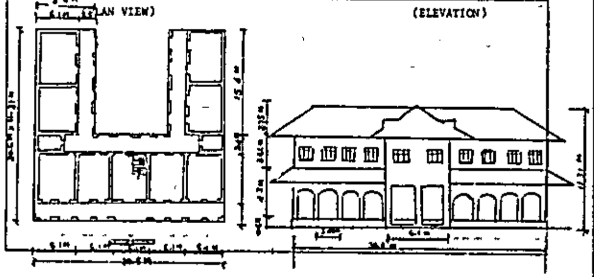
NO 9-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1 NAME of STRUCTURE	S.H.S No:4, AHLONE (OLD CUSHION HIGH SCHOOL)	14. INVESTIGATOR	
2. ADDRESS	No 42/46 LOWER KEMMENDINE RD	15. DATE	
3. OCCUPANCY	RESIDENT FACTORY SCHOOL ✓ / APT.HOUSE HOTEL THEATER / OFFICE DEPT.STORE OTHERS( ) / SHOP HOSPITAL		
4. TYPE of STRUCTURE	W SRC / B ✓ OTHERS(/ SC / RC(PC PS))		
5. DIMENSION	SUPER STRUCTURE: 30×6m×11.3(m) 2×15.4m×8.6(m) / SUBSTRUCTURE FL / PENT HOUSE(EX NO) FL		
	FLOOR AREA 1320 m^2 / TOTAL FLOOR AREA – m^2 / HIGHT – – m^2		
6 FOUNDATION	INDIVIDUAL ✓ COMPOSITE CONTINUOUS RAFT; DEPTH of FOUNDATION from G L. = 1.52 M		
7. FOUNDATION	SPREAD ✓ PILE(W, R.C, PIER R.C STEEL)		
8 DESIGN STRENGTH	SPREAD t/m^2	PILE t/PILE	
9 SOIL CONDITION	SAND SOFT / CLAY ✓ GOOD / ROAM FIRM / ROCK OTHERS( )		
10 DESIGNER –	11 CONSTRUCTOR –	12 DATE of COMPLETION	

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) (ELEVATION)



NO 9-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND, SHEAR) COLUMN(BEND, SHEAR) ✓WALL SLAB CONNECTION	**25 CAUSE**: FOUNDATION MOVEMENT; LAND SLIDE; FISSURE; DIFFERENTIAL SETTLEMENT; DEFORMITION; COLLISION; POOR STRENGTH; DIFFECTIVE CONSTRUCTION; VIBRATION ✓
17 BUCKLING FAILURE		
18 RUPTURE		
19.DAMAGE	GLASS PANE; INTERIOR ✓; CLADDING EXTERIOR; FACILITIES; FIXTURE	
20 PEELING FAILURE	INTERIOR ✓ EXTERIOR	
21 SETTLE MENT	YES (APPROX. cm PLACE)	
22 INCLINATION		
23 MATERIAL FALLEN	BRICKS AND MORTAR	
24 OTHER		

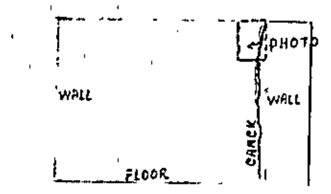
26 COMMENT	
DAMAGE	
CAUSE	
POSSIBILITY of REPARATION	YES
CIRCUMSTANCES of the STRUCTURE	

27 DATA	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING		✓		REVOLUTIONARY GOVT OF THE UNION OF BURMA
STRENGTH CALCULATION LIST		✓		
BORING LOG		✓		
MICRO TREMOUR		✓		

NO 9-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER



29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1	12/M29		11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

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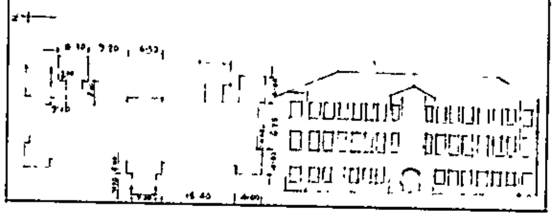
NO. 10-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1. NAME of STRUCTURE	CENTRAL WOMEN HOSPITAL.			14. INVESTIGATOR	
2. ADDRESS	CENTRAL WOMEN HOSPITAL RANGOON. BURMA			15. DATE	
3 OCCUPANCY	RESIDENT FACTORY SCHOOL	APT HOUSE HOTEL THEATER	OFFICE DEPT.STORE OTHERS( )	SHOP HOSPITAL ✓	
4. TYPE of STRUCTURE	W SRC	B ✓ OTHERS(	SC	RC(PC , PS)	
5. DIMENSION	SUPER STRUCTURE 3 FL	SUBSTRUCTURE NIL FL	PENT HOUSE(EX NO) NIL FL		
	FLOOR AREA 500-00 m²	TOTAL FLOOR AREA 1500.00 m²	HIGHT 12.00 m		
6 FOUNDATION	INDIVIDUAL	COMPOSITE DEPTH of FOUNDATION from G L	CONTINUOUS	RAFT	
7. FOUNDATION	SPREAD	PILE(W, R C PIER R.C, STEEL)			
8 DESIGN STRENGTH	SPREAD t/m²	PILE t/PILE			
9. SOIL CONDITION	SAND ✓ SOFT	CLAY GOOD	LOAM FIRM	ROCK OTHERS( )	
10 DESIGNER	11 CONSTRUCTOR	12 DATE of COMPLETION			

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) (ELEVATION)



NO. 10-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND SHEAR) COLUMN(BEND SHEAR) WALL ✓ SLAB CONNECTION	25 CAUSE: FOUNDATION MOVEMENT; LAND SLIDE; FISSURE; DIFFERENTIAL SETTLEMENT; DEFORMITION; COLLISION; POOR STRENGTH; DIFECTIVE CONSTRUCTION; VIBRATION ✓
17 BUCKLING FAILURE	NIL	
18 RUPTURE	NIL	
19 DAMAGE	GLASS PANE; INTERIOR ✓; CLADDING EXTERIOR; FACILITIES; FIXTURE	
20. PEELING FAILURE	INTERIOR ✓ EXTERIOR	
21 SETTLE MENT	YES (APPROX cm PLACE) NIL	
22 INCLINATION	NIL	
23 MATERIAL FALLEN	LIME PLASTER FROM WALL AND LATHE PLASTER FROM CEILING AT PLACES	
24 OTHER		

26 COMMENT	
DAMAGE	DUE TO EARTHQUAKE ON 9.9.1970
CAUSE	
POSSIBILITY of REPARATION	REPAIRABLE
CIRCUMSTANCES of the STRUCTURE	IN USE AT PRESENT WHERE NOT DAMAGED DAMAGED PORTIONS UNDER REPAIR

27 DATA	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING		✓		
STRENGTH CALCULATION LIST		✓		
BORING LOG		✓		
MICRO TREMOUR		✓		

NO. 12-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

24 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

PHOTO Nº 8 AND Nº 9
DISTANCE OF CAMERA FROM CRACKED WALL
APPROXIMATELY 1.50 M TO 2.50 M POSITION OF CAMERA
ALIGNED ON HORIZONTAL PLANE

29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1	Nº 8		11		
2	Nº 9		12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

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REMARKS.

Nº 6 NO DATA AVAILABLE ON TYPE OF FOUNDATION DEPTH OF FOUNDATION IS ASSUMED TO BE ABOUT 1.83 M OR THEREABOUT

Nº 7 NO DATA AVAILABLE.
Nº 9 NO DATA AVAILABLE.

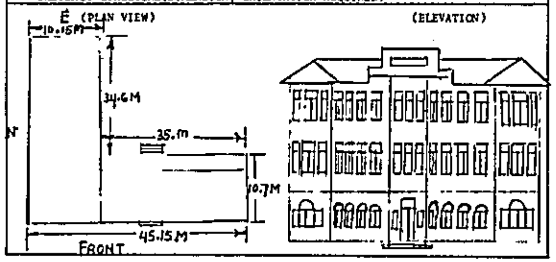
Assistant Command Engineer
Mandalay (?) Rangoon Command
Construction Corporation

NO. 1/1-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1. NAME of STRUCTURE	D A B (Director of Agriculture, Burma)	14 INVESTIGATOR
2 ADDRESS	No. 74, Shwedagon Pagoda Road, Burma	13. DATE
3. OCCUPANCY	RESIDENT / FACTORY / SCHOOL / APT HOUSE / HOTEL / THEATER / OFFICE ✓ / DEPT STORE / OTHERS( ) / SHOP / HOSPITAL	
4 TYPE of STRUCTURE	W / SRC / B ✓ / OTHERS( ) / SC / RC(PC PS)	
5 DIMENSION	SUPER STRUCTURE: 45.15x10.7m, 34.6x10.6m FL; SUBSTRUCTURE: FL; PENT HOUSE(EX NO): FL; FLOOR AREA: 2503 m²; TOTAL FLOOR AREA: m²; HIGHT: m²	
6 FOUNDATION	INDIVIDUAL ✓ / COMPOSITE / CONTINUOUS / RAFT; DEPTH of FOUNDATION from G L = 2 m	
7 FOUNDATION	SPREAD ✓ / PILE(W, R.C PIER R C STEEL)	
8 DESIGN STRENGTH	SPREAD t/m² / PILE t/PILE	
9 SOIL CONDITION	SAND / SOFT / CLAY ✓ / GOOD / ROAM / FIRM / ROCK / OTHERS( )	
10 DESIGNER: -	11 CONSTRUCTOR: -	12 DATE of COMPLETION: -

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)



NO. 1/1-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND SHEAR) / COLUMN(BEND SHEAR) / WALL ✓ / SLAB / CONNECTION	25 CAUSE: FOUNDATION MOVEMENT / LAND SLIDE / FISSURE / DIFFERENTIAL SETTLEMENT / DEFORMITION / COLLISION / POOR STRENGTH / DEFECTIVE CONSTRUCTION / VIBRATION ✓
17 BUCKLING FAILURE	-	
18 RUPTURE	-	
19 DAMAGE	GLASS PANE / INTERIOR ✓ / CLADDING EXTERIOR / FACILITIES / FIXTURE	
20 PEELING FAILURE	INTERIOR ✓ / EXTERIOR	
21 SETTLE MENT	YES (APPROX. cm PLACE)	
22 INCLINATION		
23 MATERIAL FALLEN	Mortar	
24 OTHER		

26 COMMENT	
DAMAGE	
CAUSE	
POSSIBILITY of REPARATION	YES
CIRCUMSTANCES of the STRUCTURE	

27. DATA		YES	NO	NOT CLEAR	NAME of OWNER
	DRAWING		✓		Revolutionary Govt of the Union of Burma
	STRENGTH CALCULATION LIST		✓		
	BORING LOG		✓		
	MICRO TREMOUR		✓		

NO. 1/1-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1	15/m.59		11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

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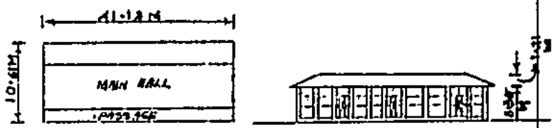
EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE) NO 1/2-1

1. NAME of STRUCTURE	SH S No:4, TAMWE (OLD ST: FRANCIS GIRL'S HIGH SCHOOL)		14 INVESTIGATOR	
2. ADDRESS	No 133, KYAIKKASAN STREET KYAUKMYAUNG.		15 DATE	
3 OCCUPANCY	RESIDENT FACTORY SCHOOL ✓	APT HOUSE HOTEL THEATER	OFFICE DEPT STORE OTHERS( )	SHOP HOSPITAL)
4 TYPE of STRUCTURE	W SRC	B ✓ OTHERS(	SC	RC(PC , PS))
5. DIMENSION	SUPER STRUCTURE 41.12×10.61 m 1 FL	SUBSTRUCTURE FL	PENT HOUSE(EX NO) FL	
	FLOOR AREA 436 m²	TOTAL FLOOR AREA m²	HIGHT m	
6 FOUNDATION	INDIVIDUAL ✓	COMPOSITE DEPTH of FOUNDATION from G.L. =0.9 m	CONTINUOUS	RAFT
7 FOUNDATION	SPREAD ✓	PILE(W, R C PIER R C STEEL)		
8 DESIGN STRENGTH	SPREAD t/m²	PILE t/PILE		
9 SOIL CONDITION	SAND SOFT	CLAY ✓ GOOD	ROAM FIRM	ROCK OTHERS( )
10 DESIGNER -	11 CONSTRUCTOR -	12 DATE of COMPLETION 1937		

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) (ELEVATION)



EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE) NO 1/2-2

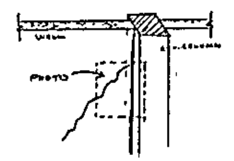
16 CRACK	BEAM(BEND SHEAR) COLUMN(BEND, SHEAR) WALL ✓ SLAB CONNECTION ✓	25. CAUSE
17 BUCKLING FAILURE	-	FOUNDATION MOVEMENT
18 RUPTURE	-	LAND SLIDE
19. DAMAGE	GLASS PANE INTERIOR ✓ CLADDING EXTERIOR FACILITIES FIXTURE	FISSURE DIFFERENTIAL SETTLEMENT DEFORMITION COLLISION POOR STRENGTH
20 PEELING FAILURE	INTERIOR ✓ EXTERIOR	DIFECTIVE CONSTRUCTION
21 SETTLE MENT	YES (APPROX. cm PLACE)	VIBRATION ✓
22 INCLINATION	"	
23 MATERIAL FALLEN	MORTAR	
24 OTHER	-	

26 COMMENT	
DAMAGE	
CAUSE	
POSSIBILITY of REPARATION	YES
CIRCUMSTANCES of the STRUCTURE	

27 DATA	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING		✓		
STRENGTH CALCULATION LIST		✓		REVOLUTIONARY GOVT: OF THE UNION OF BURMA
BORING LOG		✓		
MICRO TREMOUR		✓		

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST) NO 1/2-3

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER



29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1	14/M29		11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

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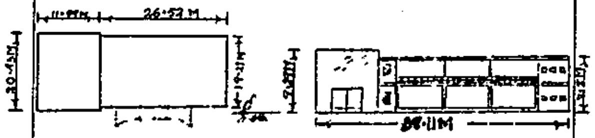
NO 1/13-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1. NAME of STRUCTURE	SFPB. STATE FILM PROMOTION BOARD		14. INVESTIGATOR	
2. ADDRESS	No 50, GOLDEN VALLEY, RANGOON		15. DATE	
3. OCCUPANCY	RESIDENT / FACTORY / SCHOOL / APT. HOUSE / HOTEL / THEATER / OFFICE ✓ / DEPT. STORE / OTHERS(STUDIO & LAB) ✓ / SHOP / HOSPITAL			
4. TYPE of STRUCTURE	W / SRC / B ✓ / OTHERS( ) / SC / RC(PC PS) ✓			
5. DIMENSION	SUPER STRUCTURE: 11.50 x 20.43 M, 26.57 x 10.37 FL	SUBSTRUCTURE: FL	PENT HOUSE(EX NO): FL	
	FLOOR AREA: 1496 m^2	TOTAL FLOOR AREA: m^2	HIGHT: m^2	
6. FOUNDATION	INDIVIDUAL ✓ / COMPOSITE / CONTINUOUS / RAFT; DEPTH of FOUNDATION from G.L = 1.21 M			
7. FOUNDATION	SPREAD ✓ / PILE(W. R C PIER R C. STEEL)			
8. DESIGN STRENGTH	SPREAD: t/m^2	PILE: t/PILE		
9. SOIL CONDITION	SAND / SOFT / CLAY ✓ / GOOD / ROAM / FIRM / ROCK / OTHERS( )			
10. DESIGNER: -	11. CONSTRUCTOR: -	12. DATE of COMPLETION: 1953		

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) (ELEVATION)



NO 1/13-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND, SHEAR) COLUMN(BEND SHEAR) WALL ✓ SLAB CONNECTION ✓	25 CAUSE: FOUNDATION MOVEMENT / LAND SLIDE / FISSURE / DIFFERENTIAL SETTLEMENT / DEFORMATION / COLLISION / POOR STRENGTH / DEFECTIVE CONSTRUCTION / VIBRATION ✓
17 BUCKLING FAILURE	-	
18 RUPTURE	-	
19. DAMAGE	GLASS PANE ✓ INTERIOR ✓ CLADDING EXTERIOR FACILITIES FIXTURE	
20 PEELING FAILURE	INTERIOR EXTERIOR ✓	
21 SETTLE MENT	YES (APPROX cm PLACE)	
22 INCLINATION	-	
23 MATERIAL FALLEN	MORTAR	
24 OTHER		

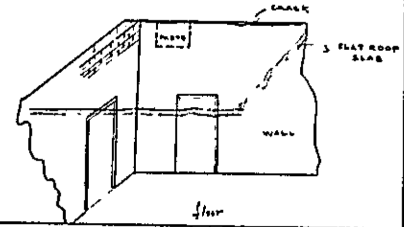
26 COMMENT	
DAMAGE	
CAUSE	
POSSIBILITY of REPARATION	YES
CIRCUMSTANCES of the STRUCTURE	

27. DATA		YES	NO	UNCLEAR	NAME of OWNER
	DRAWING		✓		
	STRENGTH CALCULATION LIST		✓		REVOLUTIONARY GOVT: OF THE UNION OF BURMA
	BORING LOG		✓		
	MICRO TREMOUR		✓		

NO 1/13-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER



29 PHOTO LIST

	FILM NUMBER			FILM NUMBER
1	13/m 29		11	
2			12	
3			13	
4			14	
5			15	
6			16	
7			17	
8			18	
9			19	
10			20	

30

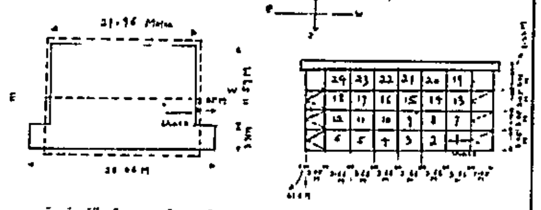
NO 1.4-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1. NAME of STRUCTURE	N H B. Building.		14 INVESTIGATOR	U HA MG TEA YANKIN
2 ADDRESS	Building no 230/1. Yankin.		15. DATE	12-1-71
3. OCCUPANCY	RESIDENT ✓ FACTORY SCHOOL	APT HOUSE HOTEL THEATER	OFFICE DEPT.STORE OTHERS( )	SHOP HOSPITAL
4 TYPE of STRUCTURE	W SRC	B ✓ OTHERS( )	SC	RC(PC PS)
5. DIMENSION	SUPER STRUCTURE ✓ FL	SUBSTRUCTURE FL	PENT HOUSE(EX NO) FL	
	FLOOR AREA 235.4 m²	TOTAL FLOOR AREA m²	HIGHT 15.42 M m²	
6. FOUNDATION	INDIVIDUAL ✓	COMPOSITE DEPTH of FOUNDATION from G L. 1.52 M	CONTINUOUS	RAFT
7 FOUNDATION	SPREAD	PILE(W R.C. PIER R.C. STEEL)		
8 DESIGN STRENGTH	SPREAD t/m²	PILE t/PILE		
9. SOIL CONDITION	SAND SOFT	CLAY ✓ GOOD	ROAM FIRM ✓	ROCK OTHERS( )
10 DESIGNER		11 CONSTRUCTOR		12 DATE of COMPLETION

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) scale: 1 cm = 4.6 m (ELEVATION)



NO 1/41-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND SHEAR) COLUMN(BEND SHEAR) WALL SLAB ✓ CONNECTION	25 CAUSE
17 BUCKLING FAILURE		FOUNDATION MOVEMENT
18.RUPTURE		LAND SLIDE FISSURE
19 DAMAGE	GLASS PANE INTERIOR ✓ CLADDING EXTERIOR FACILITIES FIXTURE	DIFFERENTIAL SETTLEMENT DEFORMITION COLLISION POOR STRENGTH
20 PEELING FAILURE	INTERIOR ✓ EXTERIOR	DEFECTIVE CONSTRUCTION ✓
21 SETTLE MENT	YES (APPROX. cm PLACE)	VIBRATION ✓
22 INCLINATION	parallel to longitudinal axis.	
23 MATERIAL FAILEN	plaster	
24 OTHER		

26 COMMENT	
DAMAGE	floor crack
CAUSE	Earth-quake vibration.
POSSIBILITY of REPARATION	Replace with 1:3 cement mortar
CIRCUMSTANCES of the STRUCTURE	N.H.B Buildings & Roads

27 DATA	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING				
STRENGTH CALCULATION LIST				
BORING LOG				
MICRO TREMOUR				

NO 1/41-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28. SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

1st floor

angle of photo horizontal to the building is parallel to longitudinal axis

Film number 17/H 28 YANKIN.

29. PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

30.

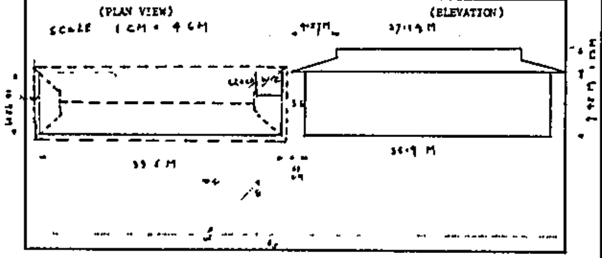
NO	1/15-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1 NAME of STRUCTURE	Metallurgy department			14 INVESTIGATOR U MAMH TEA YANKIN
2 ADDRESS	Research Institute Kanbe Road			15. DATE 12-1-71
3. OCCUPANCY	RESIDENT ✓ FACTORY ✓ SCHOOL	APT HOUSE HOTEL THEATER	OFFICE DEPT.STORE OTHERS( )	SHOP HOSPITAL
4. TYPE of STRUCTURE	W SRC	B ✓ OTHERS( )	SC	RC(PC . PS)
5 DIMENSION	SUPER STRUCTURE ✓ FL	SUBSTRUCTURE FL		PENT HOUSE(EX NO) FL
	FLOOR AREA 368.45 m²	TOTAL FLOOR AREA m²		HIGHT 10.11 M m²
6. FOUNDATION	INDIVIDUAL ✓	COMPOSITE	CONTINUOUS	RAFT
	DEPTH of FOUNDATION from G.L. 1.22 M			
7. FOUNDATION	SPREAD	PILE(W. R C, PIER,R.C, STEEL)		
8 DESIGN STRENGTH	SPREAD t/m²	PILE t/PILE		
9. SOIL CONDITION	SAND SOFT	CLAY ✓ GOOD ✓	ROAM FIRM	ROCK OTHERS( )
10 DESIGNER	11. CONSTRUCTOR	12 DATE of COMPLETION		

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) (ELEVATION)



NO	1/15-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND SHEAR) COLUMN(BEND SHEAR) WALL ✓ SLAB CONNECTION	23 CAUSE
17 BUCKLING FAILURE		FOUNDATION MOVEMENT
18 RUPTURE		LAND SLIDE FISSURE
19. DAMAGE	GLASS PANE INTERIOR ✓ CLADDING EXTERIOR FACILITIES FIXTURE	DIFFERENTIAL SETTLEMENT DEFORMITION COLLISION POOR STRENGTH
20 PEELING FAILURE	INTERIOR ✓ EXTERIOR	DIFECTIVE CONSTRUCTION
21 SETTLE MENT	YES (APPROX. cm PLACE)	VIBRATION ✓
22 INCLINATION	perpendicular to longitudinal axis	
23 MATERIAL FALLEN	plaster	
24. OTHER		

26 COMMENT	
DAMAGE	wall crack
CAUSE	earth-quake vibration
POSSIBILITY of REPARATION	Replaced with 1:3 cement mortar
CIRCUMSTANCES of the STRUCTURE	Factory and Dept. store.

27. DATA	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING				
STRENGTH CALCULATION LIST				
BORING LOG				
MICRO TREMOUR				

NO	1/15-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28. SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

position of crack shown in plan
angle of the photo vertical to the wall
Film no: 13/4/79 YANKIN

29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

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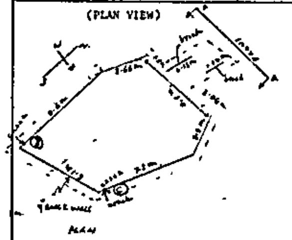
NO 116-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

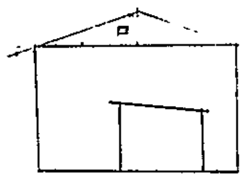
1. NAME of STRUCTURE	FOREIGN LANGUAGE INSTITUTE	14. INVESTIGATOR U HTUN MAING TELAY KAMAYUT
2. ADDRESS	UNIVERSITY AVENUE ROAD KAMAYUT	15. DATE 12 1 71
3. OCCUPANCY	RESIDENT / FACTORY / SCHOOL ✓ / APT HOUSE / HOTEL / THEATER / OFFICE / DEPT STORE / OTHERS( ) / SHOP / HOSPITAL	
4 TYPE of STRUCTURE	W / SRC / B ✓ / OTHERS( ) / SC / RC(PC PS)	
5. DIMENSION	SUPER STRUCTURE FL / SUBSTRUCTURE FL / PENT HOUSE(EX NO) FL FLOOR AREA 78 m² / TOTAL FLOOR AREA m² / HIGHT 4.87 m m²	
6. FOUNDATION	INDIVIDUAL ✓ / COMPOSITE / CONTINUOUS / RAFT DEPTH of FOUNDATION from G.L. ~~[illegible]~~ .79 m	
7. FOUNDATION	SPREAD / PILE(W, R.C, PIER R C STEEL)	
8 DESIGN STRENGTH	SPREAD t/m² / PILE t/PILE	
9. SOIL CONDITION	SAND / SOFT / CLAY ✓ / GOOD ✓ / ROAM / FIRM / ROCK / OTHERS( )	
10 DESIGNER	11. CONSTRUCTOR	12 DATE of COMPLETION

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW)



(ELEVATION)



NO 116-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

		25 CAUSE
16 CRACK	BEAM(BEND, SHEAR) COLUMN(BEND, SHEAR) WALL ✓ SLAB CONNECTION	FOUNDATION MOVEMENT
17. BUCKLING FAILURE		LAND SLIDE
18 RUPTURE		FISSURE
19 DAMAGE	GLASS PANE INTERIOR CLADDING EXTERIOR FACILITIES FIXTURE	DIFFERENTIAL SETTLEMENT DEFORMITION COLLISION POOR STRENGTH
20 PEELING FAILURE	INTERIOR EXTERIOR	DIFECTIVE CONSTRUCTION
21 SETTLE MENT	YES (APPROX cm PLACE)	VIBRATION ✓
22. INCLINATION	vertical	
23 MATERIAL FALLEN	Nil	
24. OTHER		

26 COMMENT	
DAMAGE	crack in wall
CAUSE	Earthquake vibration
POSSIBILITY of REPARATION	remove loose plaster and replace it with new 1:3 plaster.
CIRCUMSTANCES of the STRUCTURE	

27. DATA		YES	NO	NOT CLEAR	NAME of OWNER
	DRAWING				
	STRENGTH CALCULATION LIST				
	BORING LOG				
	MICRO TREMOUR				

NO 116-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

Position of crack shown on plan (C) and similar crack at (D)

Angle of photo vertical

Film No No 19 m 25

29. PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

30

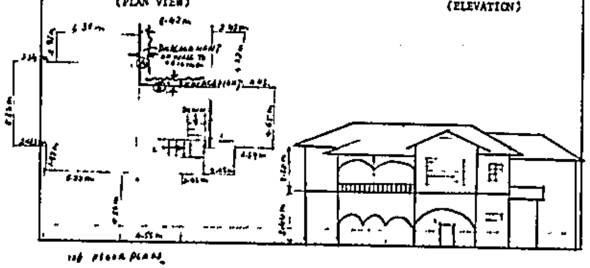
NO 17-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1 NAME of STRUCTURE	No 5 Mosan Road Residential Chancellor Road	14. INVESTIGATOR [illegible]
2 ADDRESS		15. DATE 14.1.81
3. OCCUPANCY	RESIDENT ✓ FACTORY SCHOOL / APT.HOUSE HOTEL THEATER / OFFICE DEPT.STORE OTHERS( ) / SHOP HOSPITAL	
4. TYPE of STRUCTURE	W SRC / B ✓ OTHERS( ) / SC / RC(PC . PS)	
5. DIMENSION	SUPER STRUCTURE ✓ FL; FLOOR AREA 106 m² / SUBSTRUCTURE FL; TOTAL FLOOR AREA m² / PENT HOUSE(EX NO) FL; HIGHT 6.82 m m²	
6. FOUNDATION	INDIVIDUAL ✓ COMPOSITE CONTINUOUS RAFT; DEPTH of FOUNDATION from G.L 1.14 m.	
7. FOUNDATION	SPREAD PILE(W. R.C. PIER R C. STEEL)	
8. DESIGN STRENGTH	SPREAD t/m² / PILE t/PILE	
9. SOIL CONDITION	SAND SOFT / CLAY ✓ GOOD ✓ / ROAM FIRM / ROCK OTHERS( )	
10 DESIGNER	11 CONSTRUCTOR	12 DATE of COMPLETION

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) (ELEVATION)



1st FLOOR PLAN

NO 17-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND SHEAR) COLUMN(BEND, SHEAR) WALL ✓ SLAB CONNECTION	25 CAUSE
17 BUCKLING FAILURE		FOUNDATION MOVEMENT
18 RUPTURE		LAND SLIDE, FISSURE
19. DAMAGE	GLASS PANE INTERIOR CLADDING EXTERIOR FACILITIES FIXTURE	DIFFERENTIAL SETTLEMENT, DEFORMITION, COLLISION, POOR STRENGTH
20 PEELING FAILURE	INTERIOR EXTERIOR	DIFECTIVE CONSTRUCTION
21 SETTLE MENT	YES (APPROX. cm PLACE)	VIBRATION ✓
22 INCLINATION		
23 MATERIAL FALLEN		
24 OTHER		

26 COMMENT	
DAMAGE	Vertical crack in wall
CAUSE	Earthquake vibration
POSSIBILITY of REPARATION	Remove loose plaster and brick and repair it by laying new brickwork and plaster.
CIRCUMSTANCES of the STRUCTURE	

27. DATA	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING				
STRENGTH CALCULATION LIST				
BORING LOG				
MICRO TREMOUR				

NO 17-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

Photo of Displacement shown on plan @ point (E)

Photo No 18 M 81.

Angle of photo Horizontal

29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

30

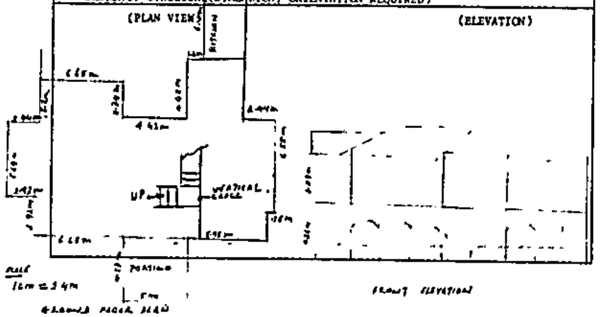
NO 18-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

1 NAME of STRUCTURE	NO 82 CHANCELLOR ROAD ARTS AND SCIENCE UNIVERSITY	14 INVESTIGATOR U HTUN NAING
2 ADDRESS -		15. DATE 12 1 91
3 OCCUPANCY	RESIDENT FACTORY SCHOOL / APT.HOUSE HOTEL THEATER / OFFICE DEPT.STORE OTHERS( ) / SHOP HOSPITAL	
4 TYPE of STRUCTURE	W SRC / B OTHERS( ) / SC / RC(PC PS)	
5. DIMENSION	SUPER STRUCTURE: FL; FLOOR AREA 814 m^2 / SUBSTRUCTURE: nil FL; TOTAL FLOOR AREA m^2 / PENT HOUSE(EX NO): nil FL; HIGHT 8.15 m m^2	
6 FOUNDATION	INDIVIDUAL ✓ COMPOSITE CONTINUOUS RAFT; DEPTH of FOUNDATION from G.L. 1.14 m	
7 FOUNDATION	SPREAD PILE(W, R C, PIER,R.C STEEL)	
8 DESIGN STRENGTH	SPREAD t/m^2 / PILE t/PILE	
9. SOIL CONDITION	SAND SOFT / CLAY GOOD ✓ / ROAM ✓ FIRM / ROCK OTHERS( )	
10 DESIGNER	11 CONSTRUCTOR	12 DATE of COMPLETION

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW) (ELEVATION)



NO 18-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND SHEAR) COLUMN(BEND, SHEAR) WALL ✓ SLAB CONNECTION	25 CAUSE
17 BUCKLING FAILURE		FOUNDATION MOVEMENT
18 RUPTURE		LAND SLIDE
19 DAMAGE	GLASS PANE INTERIOR CLADDING EXTERIOR FACILITIES FIXTURE	FISSURE / DIFFERENTIAL SETTLEMENT / DEFORMITION / COLLISION / POOR STRENGTH
20 PEELING FAILURE	INTERIOR EXTERIOR	DIFFECTIVE CONSTRUCTION
21 SETTLE MENT	YES (APPROX. cm PLACE)	VIBRATION
22. INCLINATION		
23 MATERIAL FALLEN		
24 OTHER		

26 COMMENT	
DAMAGE	crack in wall vertically
CAUSE	earthquake vibration
POSSIBILITY of REPARATION	Remove loose bricks and plaster and relay the bricks and put new plaster.
CIRCUMSTANCES of the STRUCTURE	

27 DATA	YES	NO	NOT CLEAR	NAME of OWNER
DRAWING				
STRENGTH CALCULATION LIST				
BORING LOG				
MICRO TREMOUR				

NO 18-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER

The position of crack is shown in the plan.
Angle of photo vertical
Film No 20 m/m

29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

30.

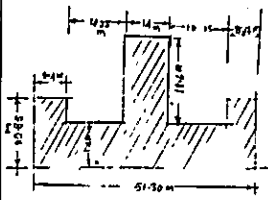
NO 19-1

EARTHQUAKE DAMAGE INVESTIGATION CARD (STRUCTURE)

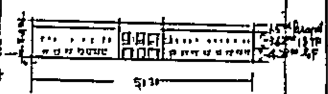
1. NAME of STRUCTURE	Railway Central Training School, bldg.			14. INVESTIGATOR T E(A) INSEIN
2. ADDRESS	INSEIN			15. DATE 20-1-71
3 OCCUPANCY	RESIDENT FACTORY SCHOOL	APT HOUSE HOTEL THEATER	OFFICE DEPT. STORE OTHERS(Hostel)	SHOP HOSPITAL
4. TYPE of STRUCTURE	W SRC	B ✓ OTHERS(	SC	RC(PC . PS))
5. DIMENSION	SUPER STRUCTURE	SUBSTRUCTURE	PENT HOUSE(EX NO)	
	Two FL	FL	FL	
	FLOOR AREA	TOTAL FLOOR AREA	HIGHT	
	2527.28 m^2	5054.56 m^2	8.4 m	
6 FOUNDATION	INDIVIDUAL	COMPOSITE	CONTINUOUS ✓	RAFT
	DEPTH of FOUNDATION from G.L. 1.2 m.			
7. FOUNDATION	SPREAD ✓	PILE(W, R.C, PIER R C, STEEL)		
8 DESIGN STRENGTH	SPREAD		PILE	
	t/m^2		t/PILE	
9. SOIL CONDITION	SAND SOFT	CLAY ✓ GOOD ✓	ROAM FIRM	ROCK OTHERS( )
10 DESIGNER	11 CONSTRUCTOR	12 DATE of COMPLETION		
Burma Rlys	Shwebo Trading, ~~Corp~~ Co.	29.5.64		

SKETCH of STRUCTURE(DIMENSION, ORIENTATION REQUIRED)

(PLAN VIEW)



(ELEVATION)



NO 19-2

EARTHQUAKE DAMAGE INVESTIGATION CARD (DAMAGE)

16 CRACK	BEAM(BEND SHEAR) COLUMN(BEND, SHEAR) WALL ✓ SLAB CONNECTION	25 CAUSE
17 BUCKLING FAILURE		FOUNDATION MOVEMENT
18 RUPTURE		LAND SLIDE
19 DAMAGE	GLASS PANE INTERIOR CLADDING EXTERIOR FACILITIES FIXTURE	FISSURE DIFFERENTIAL SETTLEMENT DEFORMITION COLLISION POOR STRENGTH
20 PEELING FAILURE	INTERIOR EXTERIOR	DIFECTIVE CONSTRUCTION
21 SETTLE MENT	YES (APPROX. cm PLACE)	VIBRATION ✓
22 INCLINATION		
23 MATERIAL FALLEN		
24 OTHER		

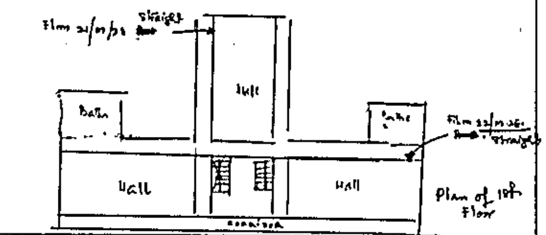
26 CURRENT	
DAMAGE	~~Rough~~ Horizontal thin crack line at sill level of the 1st floor almost the whole building.
CAUSE	Result of the earthquake on 9.9.70.
POSSIBILITY of REPARATION	
CIRCUMSTANCES of the STRUCTURE	The building situates near Locomotive Workshop and Prome rail line

27 DATA		YES	NO	NOT CLEAR	NAME of OWNER
	DRAWING				
	STRENGTH CALCULATION LIST				
	BORING LOG				
	MICRO TREMOLR				

NO 19-3

EARTHQUAKE DAMAGE INVESTIGATION CARD (PHOTO LIST)

28 SKETCH THE POSITION and ANGLE of THE PHOTO WITH FILM NUMBER



29 PHOTO LIST

	FILM NUMBER			FILM NUMBER	
	~~21/m~~	~~Sketch A-19~~	11		
	~~22/m~~	~~Sketch A-20~~	12		
			13		
1	21/m/28	Horizontal crack on wall	14		
10	22/m/08	— do —	15		
			16		
			17		
			18		
			19		
11			20		

30

APPEN-DIX VII Guide to Burma

A brief introduction on Burma which is excepted from "a handbook on BURMA" published by the Directorate Information, Rangoon, revised edition 1968.

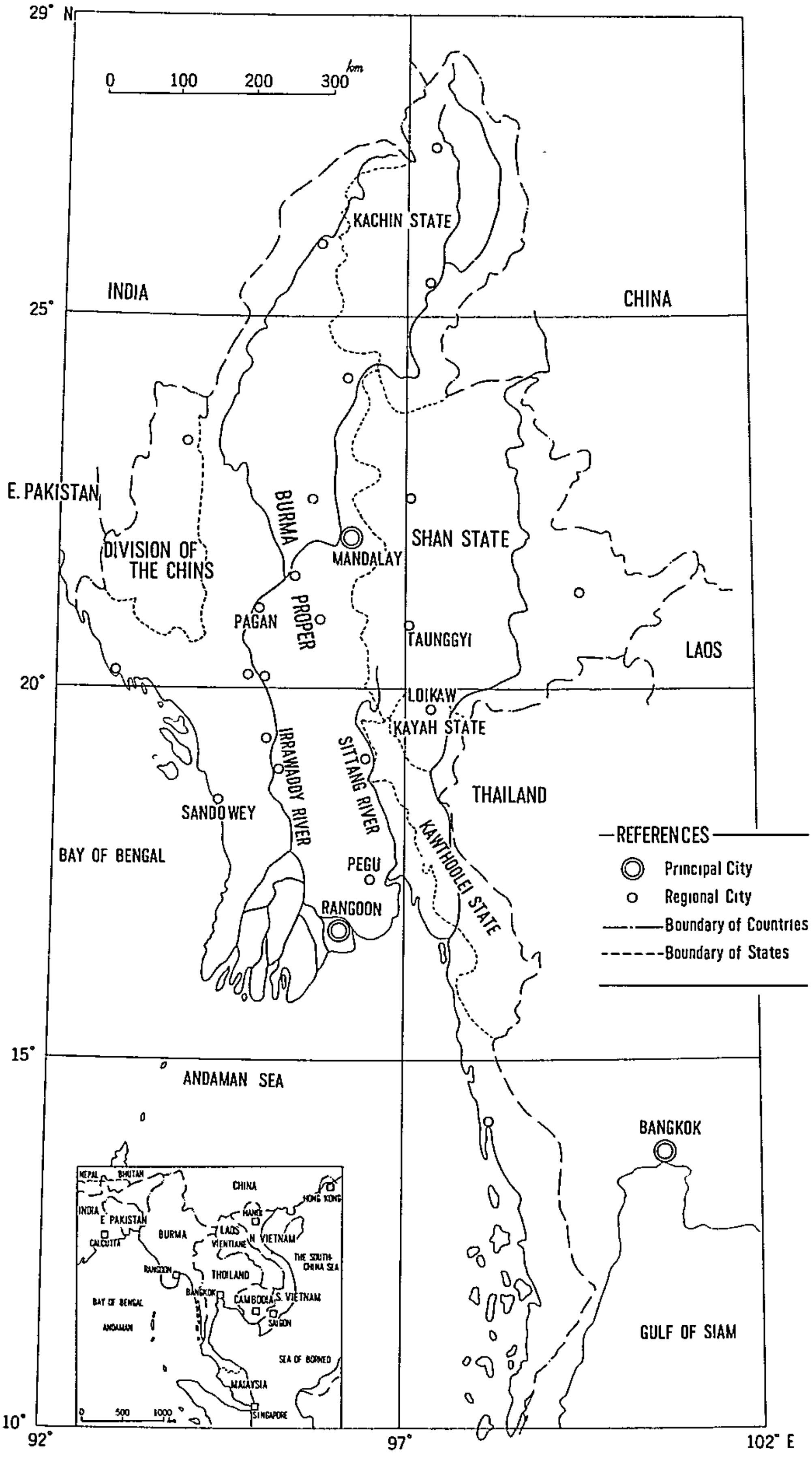


Fig. VII-1 Map of Burma

1. The Land and Climate in Burma

1) The Land

Physically, Burma falls into three well-marked geomorphological divisions: the Western Hills, the Central Belt and the Shan Plateau in the east with a southward continuation of the highland in the Tenasserim strip. The sea washes Burma on her western, southern and south-eastern coast lines, serrated and rocky for the most part, and covering a distance of about 1,200 miles from the Naaf Estuary in Arakan to Victoria Point in Tenasserim, which merges with Thailand and the Malay Peninsula.

Western Hills. The Western Hills stem from the vast mountain knot in the Tibeto-Chinese borderlands and swing southward through the Naga and Chin Hills and the Arakan Yomas in a great arc some 700 miles along the sea to Cape Negrais, just west of the Irrawaddy Delta. In the north, a continuation of the Tibetan mountains through the Kachin Hills forms a semicircular arc capping the northern tip of the country.

Central Belt. The Central Belt consists of the valleys of the Irrawaddy, Chindwin and Sittang Rivers. This belt forms a great structural through between the Shan Plateau and the Arakan Yomas and is now filled with a great mass of sediment brought down by the rivers. It ends with the Irrawaddy Delta, storing the wealth of Burma and considered one of the greatest rice granaries in the world.

Shan Plateau. In the east of Burma lies a great table-land of massive limestone and crystalline rocks forming the Shan Plateau. This table-land with an average elevation of about 3,000 feet is deeply dissected by the gorges of the Salween River, which has its source far north in the upper reaches of Tibet. The Shan Plateau is the southern continuation of the plateau of Yunnan and itself continues southward in the form of a number of parallel ranges, known collectively as the Tenasserim Yomas.

Mountains. The mountain system of Burma consists of north-south off-shoots of the Tibetan mountains and is shaped in the form of a horse-shoe. These mountain ranges bordering Burma's land frontiers in the west, north and east, thus serve as towering natural barriers.

On the west, mountain ranges stretch from the Naga Hills and the Chin Hills in the north to the Arakan Yomas in the south. Forming a massive wall 700 miles long and 150 miles broad, they consist of numerous north-south ridges with striking features of parallelism. The highest point is the sometimes snow-clad Saramati, 12,553 feet. The Naga and Chin Hills in the centre of the arc reach about 8,000 feet, while in the south the Arakan Yomas are much lower.

In the northern extreme of Burma are a continuation of the snow-bound mountains of Tibet. Here, even the passes are well over 10,000 feet. On the east are the Kachin Hills, the Shan Plateau, the Karenni Hills and the Tenasserim Yomas, with an average elevation of 3,000 – 5,000 feet.

In the heart of Burma are the Pegu Yomas, at the southern extremity of which on the last spur stands the famous Shwedagon Pagoda in the capital city of Rangoon. The Pegu Yomas, though nowhere very high, are sharply marked off from the plains and form one of the leading timber (teak) producing areas of the country.

Rivers. Besides the great mountain ranges, Burma comprises a series of river valleys and two coastal strips. The valleys run along the Irrawaddy, Chindwin, Sittang and Salween Rivers. while the coastal strips are those bordering the Arakan and the Tenasserim Yomas.

Irrawaddy. The valley of the Irrawaddy River constitutes Burma proper. This river rises in Tibet and runs down the middle of Burma from the extreme north to enter the sea near Rangoon after covering a distance of over 1,000 miles. It is navigable for about 900 miles and flowing through the most fertile part of the country is considered the life-line and also the main highway of Burma.

From the confluence of its headwaters just north of Myitkyina, the Irrawaddy flows south to the neighbourhood of Mandalay and then bears briefly westward and then again south, being shortly joined by the Chindwin River, which comes south from the Hukawng Valley in north-western Burma. Along the banks of the Irrawaddy stand many an erstwhile capital of Burmese kingdoms–Tagaung, Mandalay, Amarapura, Sagaing, Ava, Pinya, Pagan and Prome.

Delta. The lower Irrawaddy pursues its way southwards to the sea to form the vast flatness of its delta below Prome. This fertile delta sprawls over an area of some 13,000 square miles, untidily broken up into a network of creeks and rivulets.

In the delta, the Irrawaddy now branches out into eight main tributaries. Rangoon, the capital of Burma, is itself not on the Irrawaddy but stands about 20 miles from the sea on the Hlaing River, which rises in the Pegu Yomas and follows a course parallel to the eastern side of the Delta traiangle. As a point of interest, it is the confluence of the Hlaing and Pegu Rivers that helps to give Rangoon its superb water nodality.

Apart from the innumerable creeks rippling through the flat land, the Delta forms a vast expanse of paddy. At the beginning of ancient Burmese history, more than 12 or 13 centuries ago, it is believed that much of the lower delta was probably still under the sea.

Chindwin. The main tributary of the Irrawaddy, the Chindwin is navigable for about 500 miles and joins the Irrawaddy near the town of Pakokku. Between the upper Irrawaddy and the Chindwin is a region of wooded hills in the north and of open, scrubby rolling country farther south.

Sittang. South of the Mandalay elbow, the Sittang River carries on the previous line of the Irrawaddy, which once flowed down this corridor until it was captured by a tributary of the earlier Chindwin cutting back. The Sittang and the lower Irrawaddy are separated by the low-wooded hills of the Pegu Yomas. Recently extinct volcanoes, such as the legend-haunted Mount Popa attest to the extreme geological youth of this region.

The Sittang River, rising in the Shan Hills, south-east of Mandalay, flows parallel to the lower Irrawaddy through the rich timber area of Toungoo southwards to the sea. After a distance of about 250 miles, it opens out into a wide estuary, noted for its tidal waves, and empties its waters into the Gulf of Martaban. This estuary is about midway between Rangoon and the town of Moulmein in the Tenasserim.

Salween. The wild Salween River, which cuts the Shan Plateau, also rises in Tibet. It is, in fact, a torrent walled in on either side by high banks whose turbulent waters race over crags and down deep chasms to enter the sea near Moulmein. The Shan State of Burma extends east of the Salween and the Mekong River forms the boundary with Indo-China. Ferry villages on the Salween are perched high above the streams to escape floods of 60 to 90 feet. Like the Sittang, the Salween is also locally navigable by country craft, but their main importance lies in their valuable use as timber chutes.

Coast. West of the Arakan Yomas, the coastland along the Bay of Bengal is known as the Arakan Coast. It is deeply intersected by bays, gulfs and islands. South of the Salween estuary, Burma slims into a narrow coast about 600 miles long lying between the sea and the borders of Thailand on the eastern side of the Tenasserim Yomas. This coast ends at Victoria Point at the mouth of the Pakchan River. Many islands off this coast in the south form part of the well-known Mergui Archipelago.

Lakes. The largest lake in the country is a beautiful sheet of water with floating islands, in the Shan State named Inle Lake. Here the celebrated Intha-leg-rowers of Burma can be seen. Near Mogaung and Myitkyina is the imposing Indawgyi Lake nearly 44 square miles in area.

2) The Climate

Burma is for the greater part within the tropics, lying roughly between the 28th and 10th degrees of latitude and the 92nd and 101st degrees of longitude. Much of Burma's economic resources are derived from her climate. Agricultural and forest products are practically all the result of favourable weather conditions.

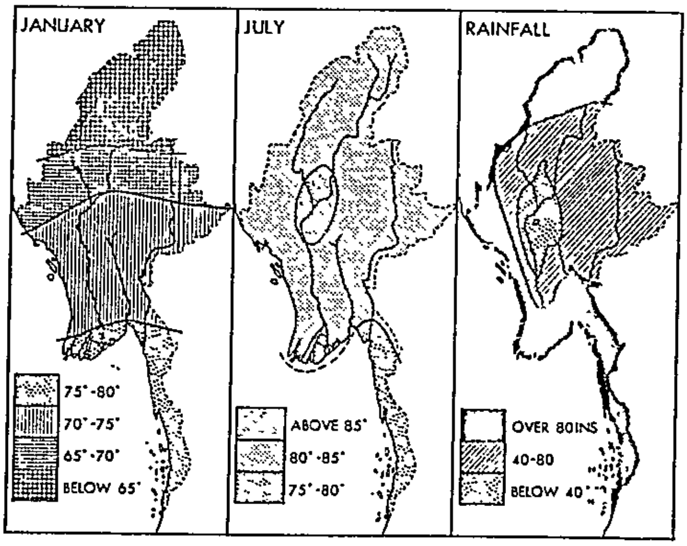


Fig. VII-2 The climate of Burma

Seasons. The three seasons, the rainy or wet, the cold and the hot seasons, all contribute to the growth of the different products. Such climatic conditions are highly conductive to the production of rice and tropical fruits and vegetables. And as the climate appears to dominate the country, so does agriculture dominate the economic life of the people.

Rainy Season. There is a well-defined rainy season as a result of the south-west monsoon from the middle of May to mid October. Rain at other seasons is rare. The coastal regions of Arakan and Tenasserim and the mountains in the extreme north have a high rainfall of about 200 inches annually. The Irrawaddy Delta has an average annual rainfall of 100 inches, and the hills of the east average about 80. The Arakan Yomas cut off Central Burma from the monsoon and hence this area, appropriately known as the Dry Zone, has an annual rainfall of only 25 to 45 inches.

Cold Season. During the cold season from November to January, the temperature in southern Burma may fall within the neighbourhood of 60 degrees Fahrenheit, while in the Dry Zone and in northern Burma the cold is more intense. The Delta and the coastlands are humid at all times of the year.

Hot Season. The hot season comes preceeding the rains and lasts from February to April. In this season, a shade temperature of 100 degrees is not uncommon in the Delta, while the Dry Zone may run to a few degrees above 100.

The tropical climate of Burma provides for interesting fauna and flora in the country, Elephants, tigers, leopards, wild boars, deer and many other animals and birds continue to fascinate those who are interested in wild life.

Interesting varieties of orchids are also found in Burma. Burma timber, notably teak, has won world acclaim, while tropical fruits including the mango, papaya, guava, durian, banana and mangosteen, are in abundance.

2 The People, History and Religion in Burma

1) The People

The inhabitants of Burma are the descendants of three major migrations from Tibet and from Central Aisa, the cradle of the human race. Of Mongoloid stock, the people of Burma are thus closely allied to the Chinese, Japanese, Koreans, Tibetans, Thais, Malays, and other inhabitants of eastern Asia. The members of this stock found in Burma are derived from three main branches: the Mon-Khmer group, the Tibeto-Burman group and the Thai-Chinese group.

Mon-Khmers. The first migration during a remote period in history indicates a wave of migration into Burma of a large group of people from Central Asia. These are the Mons of Burma and the Khmers of Indo-China. Of this first migration, a few thousand Mons are still to be found in Lower Burma, while of the Khmers no distinctive tribe exists today, with only the Angkor Wat and other relics in Indo-China remaining to bear testimony to the passage of the Khmers. Of this group in Burma, the descendent tribes in Burma today are the Mons, Wa, La, Palaung, Pale, Miao, Yao, Riang, Padaung, Yinbaw and Zayein.

Tibet-Burman. Pressing on this first migration came a second group of people known as the Tibeto-Burman group from Central Asia through Tibet. This group included three main subgroups: the Burmese and proto-Burmese, the Chin-Kachin and the Lolo. The first sub-group includes besides the Burmese proper, Arakanese, Tavoyans, Merguese, Yanbye, Kadu, Hpon, Maru, Lashi, Asi, Nung, Daru, Taungnyo, Taman, Yaw, Mro, Chaungtha, Myaingtha, Intha and Danu. Besides the Chins and Kachins, the second sub-group includes the Naga, Gauri and Duleng. The Lolo group includes the Lolo, Lisu or Yawyin, Lahu, Muhso, Kwi, Kaw and Ako.

The Chins moved into the western hills and the Kachins following later halted in the triangle near the head-waters of the Irrawaddy. The Lolos came down the Mekong valley and small groups settled on the eastern fringe of Burma. The principal wave of the Burmese and proto-Burmese moved southwards leaving small settlements as they came to form minor tribes of their stock in northern Burma.

Thai-Chinese. The third pressing wave of migration, composed chiefly of the Thai-Chinese race, came into Burma between the 13th and 14th centuries from Yunnan, where since the 7th century they had formed the kingdom of Nanchao.

At this period, fusion and intermingling between the first two waves of migration, through the medium of Buddihism, has resulted in the emergence of one culture, one religion and one history. But the Thai-Chinese group did make its presence felt by the end of the 14th century. This third group includes the Shans, Karens, Shan-Burma, Shan-Tayok, Taungthus and the Tais.

Fusion. From the 14th century until the annexation of Burma by the British in mid-19th century, a process of unification between the three main groups of migrants progressed rapidly in the country through the spreading of the civilizing factor of Buddhist culture. Until the British arrived, only the people in the outlying hills remained untouched by the civilizing media of Buddhism. The rest of the people of Burma embraced Buddihism, thus leading to the growth of but one culture, one written language and one literature in the country.

The term "Burman" may be traced through gold plaques with particular Buddhist motifs and inscriptions found near Prome to a period between the 6th and 8th centuries A.D., although the chronicles record the city state of Shrikitshara (near Prome) in the 8th century B.C. and the existence of two earlier city states in the north. Today, the main races in Burma besides the Burmese, are the Kachins, Kayahs, Karens, Chins and Shans.

According to the estimates of the latest census, out of a total population of about 25,246,000 inhabitants of the country, 644,000 belong to the Kachin State, 106,000 to the Kayah State, 743,000 to Kawthoolei (formerly known as the Karen State), 331,000 to the Chin Special Division, and 2,550,000 to the Shan State, leaving 20,872,000 to Burma Proper. The major racial groups comprise about 15,644,000 Burmese, 2,005,000 Karens, 1,723,000 Shans, 655,000 Chins, 290,000 Kachins and 51,000 Kayah (formerly known as Karenni).

Burma Proper. The Burma Proper occupies an area of about 150,433 square miles out of the total area of 261,228 square miles of the country. The Burmese settled in the Dry Zone area of Central Burma since the 9th century and it is here that the sites of their ancient capitals of Pagan, Ava and Mandalay may be found.

It is the Dry Zone which remains the true home of the Burmese in Lower Burma is a development of the last hundred years, arising chiefly out of the growth of the rice industry in Burma. By religion, the Burmese are predominantly Buddhists. Agriculture is the primary industry of Burma and the Burmese are thus essentially a people with the realistic and unsophisticated outlook of those who live close to the soil.

The Mons settled first in the Irrawaddy Delta and later in what are now Thaton and Amherst Districts in the Tenasserim. Like the Burmese, the Mons are also Buddhists.

Kachins. The Kachins live chiefly in the districts of Bhamo and Myitkyina which form the Kachin State. High mountains, some rising to 19,000 feet, rim the northern and eastern boundaries of the State. Excepting the wide flat Hukawng Valley, the northern part of the State is mostly mountains, while the southern part is hilly with vast stretches of flat country, particularly along the Irrawaddy.

According to ethnographers, the original name of the Kachin race is Jighpaw belonging to the Tibeto-Burman subfamily. The five parental groups of Jinghpaw are generally recognised as the Lahpai, Lahtawng, Marip, Maran and N'Hkum.

The majority of the Kachins are Animists (Nat-worshippers). A considerable number also embraces Christianity and Buddhism.

The Kachin State, with its administrative headquarters at Myitkyina, has an area of 34,379 square miles approximately.

Kayahs. Formerly called Karenni or Red Karens, the Kayahs inhabit the Kayah (formerly Karenni) State lying on the eastern slopes of the ranges which are dominated by Mt. Nattaung to the east of Toungoo in Central Burma and just south of the Shan State.

Ethnically, the Kayahs belong to the Mon-Khmer branch of Mongoloid stock. Besides the Kayahs, the Kayah State is inhabited by many other ethnic groups which comprise the Padaung, Shan, Bre, Bwe, Geba, Geko, Taungthu, Manu Manaw, Paku, Yintalaing, Yinbaw and Intha, each group speaking its own language or dialect.

The Kayah State consists of the three sub-states of Kantarawadi, Bawlake and Kyai-pho-gyi and covers an area of 4,529 square miles approximately.

Although the smallest in size of the constituent States of the Union, the Kayah State is rich in natural resources, such as hardwoods, wolfram, antimony, lead, zinc, tin and precious stones. The world-famous Mawchi Mines and the Baluchaung Hydro-electric Power Plant are located within the State.

The administrative headquarters of the Kayah State is Loikaw, about 88 miles south of Taunggyi.

Karens. The Karens, of Thai-Chinese origin, settle in large numbers in the eastern Toungoo District, in the Irrawaddy delta and the Tenasserim Division. Karens may be divided into two main classes, the Plains and the Hill Karens. The former comprising the Pwo and Sgaw Karens, form the bulk of the Karens and are found near Toungoo, in the delta and in the Tenasserim Division.

Hill Karens are mostly Buddhists, while there are many Christians amongst the Pwos and Sgaws. Though Christianity has found a more receptive audience amongst the Karens than any other race in Burma, the Karens remain preponderantly more Buddihist than Christian.

The Kawthoolei or Karen State with administrative headquarters at Pa-an, 33 miles north of Moulmein, covers an area of approximately 11,731 square miles. It comprises Papun Township, Hlaingbwe Township, Pa-an Township, Kawkareik Township, Kya-in Township and Thandaung Township.

Chins. The Chins occupy the hilly areas known as the Chin Hills and the Hill Tracts of Arakan between the Chindwin River and the borders of India and Pakistan.

The Special Chin district consists of narrow valleys and steep mountains, several rising to over 9,000 feet. The area of the Division is about 13,907 square miles.

The Chins belong to the Tibeto-Burman branch of Mongoloid stock. The principal ethnic groups in the Division are Lai, Simbbrin, Kumi, Cho, Siyin and Matu.

The majority of the Chins are Animists, while Christians and Buddhists number roughly about 30 per cent of the population.

The administrative capital of the Division is Falam, about 86 miles north of Kalewa town on the Chindwin.

Shans. The Shans inhabit the eastern part of Burma known as the Shan plateau which occupies about 56,000 square miles. Under the British, the Shans in Burma, through the system of a federation, retained their old feudal institutions through "Sawbwas" or feudal lords. But in April 1959, the Sawbwas or Saophalongs voluntarily renounced their hereditary rights.

The Shans belong to the same ethnic group as the Thais of Thailand, Viet-Nam, Laos and Cambodia.

The Shan State with an area of 60,155 square miles originally comprised 34 sub-states. The administrative capital of the State is Taunggyi.

Under the Revolutionary Government's policy for complete racial equality, a new procedure was introduced for classification of the various national races in the country. Such terms as "racial monorities" or "nationalities" are removed from official usage. Also abolished was the order of precedence in listing of the races according to population strength. With effect from the Union Day, February 12, 1964, the official list of races was proclaimed according to Burmese alphabetical order.

Foreigners in Burma. Burma has a substantial population of foreign residents, chiefly those hailing from the two big neighbouring countries of India and China.

The origins of their settlement in Burma date back to the earliest times. However, the vast majority of the present Indian and Chinese communities are the second or third generations of those who immigrated here in continual and swelling waves during the British regime.

Occupational pursuits of the Indian and Chinese communities embrace a wide range, but their preponderance was in the fields of commerce and industry.

The foreign population as of September 1966 is estimated to total 54,584 Indians, 80,057 Chinese, 16,092 Pakistanis and 11,699 other nationals.

It is known that about one-third of the pre-war Indian population in Burma did not return from India where they evacuated during the World War II. After Burma's independence, progress of Burmanization in trade and industry narrowed the scope for foreign enterprise in this country. Hence, there has since been a steady annual decrease of foreigners in Burma. Also, their numbers have been reduced by many Indians, Pakistanis and Chinese adopting Burmese citizenship.

Further drop in foreign population in Burma followed the nationalization of private business establishments in the last three years. The numbers of foreigners who have left Burma up to June 30th 1966 totalled 146,006 Indians, 13,855 Pakistanis, 2,934 Chinese and 5,786 other nationals.

2) Historical Background

The political history of Burma presents a clear perspective only after the first forging of the bond of political unification within the country in the 11th century. Prior to that, the history of Burma was largely the history of migration of different ethnic groups from Central Asia, Tibet and China into Burma, in parts interwoven with legend and folklore.

Burmese Monarchy. The 11th century is renowned as the golden age of Burmese political unity and cultural progress. King Anawrahta (1044–77), founder of the Pagan Dynasty welded the former group of independent Burmese states into one kingdom. From his capital at Pagan in Central Burma Anawrahta extended his control over the Irrawaddy Delta, the Thaton area and the hills east of the Sittang. Through his initiative and influence also spread throughout Burma the Theravada form of Buddhism to replace the Mahayana form.

Pagan, visited by famous foreign travellers like Marco Polo, was in its heyday known as the city of four million (4,486,733) pagodas and is still considered today as one of the famous ruined cities of the world. It remained the capital of the Pagan Dynasty till the 13th century when the Mongols under Kublai Khan overthrew the Burmese kings and sacked the city. Burma then split into small principalities, governed partly by Shan and Mon chiefs until in the 16th century when Kings Tabinshwehti (1531–1550) and Bayinnaung (1550–1581) again established unity which lasted till the early 18th century.

At the turn of the 17th century, there arose an interlude of political disunity caused by the Mon chiefs of the Irrawaddy Delta who regained their independence and also conquered a large part of Central Burma. But in the years 1752–58, Alaungpaya, an erstwhile headman of the Shwebo area, rallied the Burmese to re-establish a united Burmese kingdom again. Alaungpaya's Ava Dynasty lasted till 1885. During this period, under Bodawpaya (1782–1819) the Burmese empire attained its widest expansion, stretching from the hills of Assam to the coastline of Tenasserim.

Alaungpaya, in his campaigns against the Mons, occupied their ancinet citadel of Dagon and renamed it "Yangon", meaning the end of strife, to serve today under the modern international name of Rangoon as the capital city of Burma.

Colonial Period. Alaungpaya's successors soon became involved in wars with the British in India (1824 and 1885). Finally, the Third Anglo-Burmese War of 1885 led to the capitulation of King Thibaw and annexation of the whole of Burma to British India.

Military defeat failed to subdue and demoralize the freedom loving Burmese into tame acceptance of the accession of their country to British India. From the outset, Upper Burma, regarded as the cradle of the Burmese race, offered stubborn resistance to the British forces and it took over five years for the well-equipped British army of 35,000 strong to "pacify" this region. Not to be forgotten was the early uprisings of Shans, Kachins, Chins and other ethnic groups against the British. These as well as much later uprising in Lower Burma, notably the Tharrawaddy Rebellion led by Saya San in 1930, demonstrated that the people could never be reconciled to any form of alien rule.

In succeeding decades, Burmese political upsurgence assumed legal forms expression. These activities from time to time succeeded in wresting constitutional reforms from the colonial authority. Though on a restricted scale, parliamentary democracy was introduced in Burma, gradually broadening in scope, through pressure of political agitation. The small legislature set up in 1897 was twice enlarged in 1909 and 1920. Burma was elevated from a province under a Chief Commissioner to that under a Lieutenant-Governor. In 1920, the "dyarchy" system introduced in India under the Montagu-Chelmsford Reforms was extended to Burma, allowing her a new Legislative Council in which 79 out of 103 seats were filled by election (for the most part from popular constituencies). Burma was permitted some degree of independent authority in her internal affairs but important matters classified as "central subjects" remained under the control of the Government of India.

Such political concessions fell short of Burmese objectives in the light of growing political awareness. They failed to restrain the political disaffection which resulted in a demand for separation of Burma from British India. Response to this demand came in the enactment of the Government of Burma Act of 1935 which enabled Burma in April 1935 which enabled Burma in April 1937 to become a separate and distinct political unit. Under the new constitution provided by this Act, a bicameral legislature was set up, consisting of a half-elected, half-nominated 36-member Senate and a House of Representatives, the latter having 132 seats chiefly filled on the basis of wider franchise for a five-year term. It also provided for a Council of not more than ten Ministers to advise and aid the Governor.

General elections–the only one held under the new constitution–in November 1936 enabled Dr. Ba Maw, leader of the Sinyetha Party, to form the government and become the first Premier of Burma. Labour unrest and political disorders such as student strikes and racial riots led to the fall of the Ba Maw Government in February 1939. It was succeeded by the government of U Pu who resigned in 1940 and was replaced by U Saw of the Myochit Party. U Saw remained Premier till January 1942 when he was arrested and interned on grounds of connections with the Japanese. The next Premier was Sir Paw Tun.

The country was still dissatisfied with the successive constitutional reforms which did not really give the people the voice and power to settle their own affairs. Parts of Burma like the states were kept out of control of the Government in Rangoon, even though some of them were financed from the central budget. The Ministers' Council remained purely advisory and the authority of the Governor was supreme even over the legislature. These obstacles to political advancement found resentful reaction among the people. Spurred by the renaissance of nationalism then mounting in tempo, all political parties were united in demanding full independence. Of these, the most revolutionary in character and militant in outlook was the "Thakin Party" or, to give its formal name, Dobama Asiayone. Thakin (later famous as Bogyoke, meaning General) Aung San was among the outstanding leaders of this organization which was a rallying point for patriotic youths to fight for the liberation of their motherland.

Such an uncompromising stand against colonialism and militancy of attitude towards national liberation became manifest in a nation-wide movement at the beginning of World War II. Several nationalist leaders were jailed but Thakin Aung San and 29 other youths, later prominent as the "Thirty Comrades" succeeded in slipping out of the country. While the British Empire in South-east Asia tottered under the blows of the Japanese, Thakin Aung San and his comrades, after a period of military training in Japan, accompanied the Japanese army into Burma and quickly organized the Burma Independence Army to liberate the country. When the British forces evacuated from Burma in May 1942, the Governor, together with the Premier, Finance Minister and some senior officials accompanied them to India where they kept a Government of Burma in being with headquarters at Simla.

Final stage of Freedom Struggle. During the Japanese occupation, a Burmese civil administration was established in March 1942 under the Japanese Military Administration. On July 24, the Burma Independence Army was demobilized, to be reorganized and formally installed as the Burma Defence Army on August 26 with Thakin Aung San, now holding the rank of Major-General, as its commander.

In August 1943, "Independence" was proclaimed for Burma and a new constitution came into force under which Dr. Ba Maw became the Adipadi of Head of State But by now Burmese opinion had turned decisively against the Japanese, whose real motives and attitudes were becoming increasingly apparent. A clandestine organization known as the Anti-Fascist Organization formed under General Aung San and Thakin Mya in August 1943 circulated a secret manifesto avowing its aims to liberate Burma from all foreign domination and calling upon the people to sabotage the war effort and to attack the "fascist Japanese marauders". As proved by subsequent events, this clarion call received a wide response from all races of Burma, enabling the organization of an effective underground resistance movement. Open resistance broke out on March 27, 1945, when patriotic partisans struck the Japanese in the Prome area while British forces were swooping down on Upper Burma. Thereafter followed the Japanese rout from Burma and British reoccupation of Rangoon on May 5. By this time the AFO had become a popular front embracing all political groups including the racial groups and in August changed its name to the Anti-Fascist People's Freedom League.

British Governor Sir Reginald Dorman-Smith returned to Burma in October 1945 and military administration was replaced by a civil government. A deadlock ensured between him and the AFPFL in mid-1946 on the composition of the proposed Governor's Executive Council. Nationwide agitation followed, accentuated by a wave of strikes. He was recalled and his successor, Sir Hubert Rance, on September 27 reached an agreement with the AFPFL on the formation of the Executive Council with General Aung San as Deputy

Chairman (equivalent to Prime Minister) and six out of nine members of the council nominated from the AFPFL.

The AFPFL supremacy in the new council signified the Burmese determination and impatience for independence. Convinced of this significance, on December 20, 1946, British Premier Clement Attlee invited a Burmese delegation to London to negotiate with the British Cabinet on details of transfer of power. On January 1, 1947, General Aung San led the delegation to London. It talks with the British Government led to the successful conclusion of the Aung San-Attlee Agreement on "methods by which the people of Burma may achieve their independence either within or without the Commonwealth as soon as possible."

Skepticism was voiced in some interested, including foreign quarters, on the willingness of frontier races to become merged in a single independent state on attainment of the country's independence. However, thanks to the fraternal spirit prevailing among the frontier people and statesmanship displayed by General Aung San at the conference of all Burmese nationalities held at Panglong in the Shan State on February 12, 1947, representatives of the Kachin, Kayah, Karen, Chin, Shan and other races spoke with one voice in opting for merger of their areas with Burma Proper in a single state. Their reactions were also studies by a nine-menter Frontier Areas Enquiry Committee headed by British Member of Parliament, Mr. D. R. Rees-Williams.

Elections to the Constituent Assembly, provided under the independence agreement, took place on April 7, 1947. Of the 255 seats filled, 210 were for Burma Proper (including 24 for Karens and 4 for the Angle-Burman community) and 45 for the frontier areas as recommended by the Enquiry Committee. The outcome of the elections was an overwhelming support for Bogyoke Aung San, with candidates on his AFPFL ticket winning more than 170 of the noncommunal seats in the Constituent Assembly.

The Constituent Assembly which began its first session on June 10, 1947, passed a historic resolution, moved by Bogyoke Aung San, providing for proclamation of Burma as an independent republic. It next proceeded on its task of drafting the constitution.

While the country stood on the threshold of freedom, Bogyoke Aung San, supreme architect of Burma's independence, together with his Cabinet colleagues on July 19, 1947, fell at the hands of assassins. This tragedy shocked the nation but his successor U Nu was able to form a Cabinet overnight and give the lead in finalization of arrangements for Independence.

The new Constitution of the Union of Burma was unanimously adopted by the Constituent Assembly on September 4, 1947. A final pact, necessitated by change of Burmese government, the Nu-Attlee Treaty, was signed in London on October 17, 1947. A Bill to provide for the Independence was passed in the British Parliament, receiving royal assent on December 10, 1947. Accordingly, the long-cherished Burmese goal was realized when on January 4, 1948, aimed ceremony and international felicitations, Burma took her place within the comity of free and sovereign nations.

3) Religion

Buddhism, the teachings of the Buddha, is professed by the great majority of the people of Burma. The Buddhism that prevails in Burma is the Theravada Buddhism, which is to be found also flourishing in other countries like Ceylon, Thailand, Cambodia and Laos.

The main tenets of the Theravada Buddhism as embodied in the Theravada Buddhist literatures of the three Pitakas are: – The Four Noble Truths, The Noble Eight Fold Path, The Seven Bojjhanga, the Law of Karma and the law of The Dependent Origination, The Theory of Anatta, the Four Paramattha Truths, The Four Stages of Ariyas, and the realization of the different Bodhis, like Savaka-bodhi, Pacceka-bodhi and Sammasam-bodhi.

Buddhism, being the religion of the majority, is predominant and outstanding in the social life of Burma. Noteworthy in this connection are the programmes for promotion of Buddhism sponsored by various agencies under the Ministry of Religious Affairs.

Soon after its taking over the administration, the Revolutionary Government started to reorganize the structure and to streamline the operations of the Buddha Sasana Council with the object of making it more effective in contributing to the moral, intellectual and spiritual development of the people.

The council engages itself in such activities as translating and publishing the original Pali Pitaka Texts and their commentries; compiling "Tipitaka Pali-Burmese Dictionary" and "Guide to Tipitaka", establishing Buddhist Missionary centres, especially with the aim of liquidating illiteracy; holding of annual examinations at varying grades on Buddhist Texts; rendering aids to various meditation centres; and providing pre-requisites to the monks engaged in religious studies. Twenty seven volumes of the 40 original Pali texts have been translated and published. One hundred and thirty-two missionary centres in remote hill tracts areas have been opened and there are altogether 336 registered meditation centres all over Burma.

Advanced Buddhistic Studies. The composite circular building standing in the quiet and attractive grounds of the Kaba-Aye (World Peace) Pagoda at Rangoon, houses the International Library for Advanced Buddhistic Studies. Opened in 1955, it is a centre of postgraduate research study in Theravada Buddhism, as well as in the deeper aspects of Burmese culture and Eastern philosophies. Its facilities are also open to interested visiting foreign scholars. Its evolution is directed towards the eventual formation of a composite World Buddhist University. Among its facilities are its rich and rare museum and library collections, including historically authentic information on Burmese religious edifices such as pagodas and monasteries.

Classes of post graduate nature at seminar level centre around (1) Pali language, (2) Abhidhamma Studies and (3) Buddha's Basic Teachings and Kammatthana Practices, enriched further by the allied subjects like Philosophy, Psy-chology and Literature together with Library, Museum and Research facilities. The collections of the Institute are 8076 English volumes, 5386 Periodicals, 5070 Burmese volumes, 8072 sets of Palm-leaf and rare manuscript and 1542 museum objects.

Other Institutions. The Tipitakadara Selection Board annually holds Pali University and Dhammacariya Department each year holds Pali University examinations for which degrees, certificates and prizes are awarded to successful examinees. Under this Department there are over 83 monasteries where hundreds of students are studying the doctrine of

Buddhism. A tradition dating back to 1875 of holding Pali Patamabyan examinations, is being perpetuated every year by the Pali Education Department.

While promoting the purification and elevation of the Buddha Sasana the policy of the Revolutionary Government is also to uphold the principle of freedom of worship in respect of all religions. State grants are therefore also made towards other religions professed in Burma, such as Christianity, Islamism and Hinduism.

3 The Government and its Policy in Burma

1) Government

The Revolutionary Council, headed by General Ne Win and composed of leaders of the highcommand of the Defence Services, took over the administration of Burma on March 2, 1962.

It formed a Council of Ministers also headed by Revolutionary Council Chairman General Ne Win.

Shortly after, on April 30, 1962, it declared its policy to the country under the title of the Burmese Way to Socialism, to build a new state with a socialist economy compatible with Burmese thought and traditions. The philosophy is aimed at the social and economic well-being and advancement of the workers and peasants who are to constitute the main force for its realization.

Under the Revolutionary Council policy, mass opinion finds ample opportunity for expression through various processes of construction of socialist democracy. Most prominent and widespread among such opportunities are seminars of peasants and workers held often at village, township of district levels. The mammoth peasant seminars at Ohndaw, Duya, Popa, Kabaung and Kyaikkasan were attended by hundreds of thousands of rural forlks. Here, for the first time in the life of the rural community, it was enabled to give free and frank expression to its views and discuss problems on agriculture as well as its own socio-economic progress. These seminars are attended by Revolutionary Council members and heads of ministries and departments. In May 1964, the Workers' Seminar at Chauk and in 1965 and 1966 at Kyaikkasan were attended by workers' representatives from all over Burma.

Since that time, further political progress was achieved by the formation in 1968 of the Central Peoples' Workers' Council (CPWC) and in 1969 of the Central Peoples' Peasants' Council (CPPC). These two top-level political organizations are housed at the six-storeyed building formerly known as the New Secretariat in Merchant Street, Rangoon. These Councils form the system whereby peasants and workers of the country will themselves take the leading role in increasing production, improving working discipline and enhancing their own interests and walfare.

The official translation of the Revolutionary Council's policy declaration reads:

2) The Burmese Way to Socialism

Our Belief

1. The Revolutionary Council of the Union of Burma does not believe that man

will be set free from social evils as long as pernicious economic systems exist in which man exploits man and lives on the fat of such appropriation. The Council believes it to be possible only when exploitation of man by man is brought to an end and a socialist economy based on justice is established; only then can all people, irrespective of race or religion, be emancipated from all social evils and set free from anxieties over food, clothing and dhelter, and from inability to resist evil, for an empty stomach is not conducive to wholesome morality, as the Burmese saying goes; only then can an affluent stage of social development be reached and all people be happy and healthy in mind and body.

Thus affirmed in this belief the Revolutionary Council is resolved to march unswervingly and arm-in-arm with the people of the Union of Burma towards the goal of socialism.

Fundamentals of Our Policy

2. In setting forth their programmes as well as in their execution the Revolutionary Council will study and appraise the concrete realities and also the natural conditions peculiar to Burma objectively. On the basis of the actual findings derived from such study and appraisal it will develop its own ways and means to progress.

3. In its activities the Revolutionary Council will strive for self-improvement by way of self-criticism. Having learnt from contemporary history the evils of deviation towards right or left the Council will with vigilance avoid any such deviation.

4. In whatever situations and difficulties the Revolutionary Council may find itself it will strive for advancement in accordance with the times, conditions, environment and the ever changing circumstances, keeping at heart the basic interests of the nation.

5. The Revolutionary Council will diligently seek all ways and means whereby it can formulate and carry out such programmes as are of real and practical value for the well-being of the nation. In doing so it will critically observe, study and avail itself of the opportunities provided by progressive ideas, theories and experiences at home, or abroad without discrimination between one country of origin and another.

Socialist Economy

6. The fundamental concept of socialist economy is the participation of all for the general well-being in works of common ownership, and planning towards sufficiency and contentment of all, sharing the benefits derived therefrom. Socialist economy aims at the establishment of a new society for all, economically secure and morally better, to live in peace and prosperity.

7. Socialist economy therefore opposes any pernicious economic system in which man exploits man, and self-interest and self-seeking are the motivating forces.

8. Socialist economy does not serve the narrow self-interest of a group, an organization, a class, or a party, but plans its economy with the sole aim of giving maximum satisfaction to material, spiritual and cultural needs of the whole nation.

9. Socialist economy is the planned, proportional development of all the national productive forces.

"Productive forces" is the collective term for natural resources, raw materials, instruments of production, accumulated capital, peasants, workers, intelligentsia, technicians, know-hows and experiences, skills, etc.

Socialist economy proportionally plans, on the basis of the population and productive forces, for sufficiency and abundance of consumer goods. While improving the standard of living and increasing the purchasing power of the nation it also expands production. Socialist economy thus solves the problem of unemployment and ensures security of a means of livelihood for every individual.

10. In order to carry out socialist plans such vital means of production as agricultural and industrial production, distribution, transportation, communications, external trade, etc., will have to be nationalized. All such national means of production will have to be owned by the State or co-operative societies or collective unions. Amongst such ownerships State ownership forms the main basis of socialist economy. State ownership means ownership by the whole nation itself, whereas ownership by co-operatives or collectives means group-ownership by respective concerns. But as all forms of ownership will have to operate within the framework of socialist national planning they are interdependent.

11. In building up an economy according to socialist plans every able individual will have to work according to his ability. The material and cultural values that accrue will be distributed in accordance with the quantity and quality of labour expended by each individual in social production.

12. In our Burmese socialist society equalitarianism is impossible. Men are not equal physically and intellectually in the respective quantity and quality of service they render to society, and differences are therefore bound to exist. But at the same time social justice demands that the gaps between incomes are reasonable, and correct measures will be taken to narrow these gaps as much as possible.

State Organization

13. A socialist democratic state will be constituted to build up a successful socialist economy. A socialist democratic state is based on and safeguards its own socialist economy. The vanguard and custodian of a socialist democratic state are primarily peasants and workers, but the middle strata and those who will work with integrity and loyalty for the general weal will also participate.

14. Parliamentary democracy called "The People's Rule" came into existence in history with the British American and French Revolutions against feudalism. It happens to be the best in comparison with all its preceding systems.

But in some countries the parliament has been so abused as to have become only the means by which the opportunists and propertied people deceive the simple masses.

In the Union of Burma also, parliamentary democracy has been tried and tested in furtherance of the aims of socialist development. But Burma's "parliamentary democracy" has not only failed to serve our socialist development but also due to its very defects, weaknesses and loopholes, its abuses and the absence of a mature public opinion, lost sight of and deviated from the socialist aims, until at last indications of its heading imperceptibly towards just the reverse have become apparent.

The nation's socialist aims cannot be achieved with any assurance by means of the form of parliamentary democracy that we have so far experienced.

The Revolutionary Council therefore firmly believes that it must develop, in conformity with existing conditions and environment and ever changing circumstances, only such a form of democracy as will promote and safeguard the socialist development.

These then are the fundamentals of socialist economy.

3) Programme for Transition to Socialism

15. (a) Reorientation of views

In marching towards socialist economy it is imperative that we first reorientate all erroneous views of our people.

Fraudulent practices, profit motive, easy living, parasitism, shirking and selfishness must be eradicated.

We must so educate the people that to earn one's living by one's own labour and to see dignity in one's own work, comes into vogue. We must educate, lead by example and guide the people away from the base notion that it is beneath one's dignity to work by the sweat of one's brow.

Attempts must be made by various correct methods to do away with bogus acts of charity and social work for vainglorious show, bogus piety and hypocritical religiosity, etc., as well as to foster and applaud bona fide belief and practice of personal morals as taught by ethics and traditions of every religion and culture. We will resort to education, literature, fine arts, theatre and cinema, etc., to bring into vogue the concept that to serve others' interest is to serve one's own.

(b) Administrative machinery

In our road to socialism the existing bureaucratic administration is a big stumbling block. To achieve our socialist aims with this effete machinery is impossible. Steps will have to be taken to remove this bureaucratic machinery and lay firm foundations for a socialist democratic one.

(c) Defence Services

The existing Defence Services will also be developed to become national armed forces which will defend our socialist economy.

(d) Economy

The Union of Burma is an economically backward agricultural country. The national productive forces need to be continually developed to build up socialist economy. That is why various productions that would be compatible with existing conditions and time will have to be planned and developed. While modernizing the agricultural production which forms the main basis of the national economy such industries as would be commensurate with the natural resources and capabilities of the country will also be developed. In doing so national private enterprises which contribute to national productive forces will be allowed with fair and reasonable restrictions.

On the full realization of socialist economy the socialist government, far from neglecting the owners of national private enterprises which have been steadfastly contributing to the general well-being of the people, will even enable them to occupy a worthy place in the new society in the course of further national development.

The Question of Nationalities

16. As the Union of Burma is a country where many indigenous racial groups reside, it is only when the solidarity of all the indigenous racial groups has been established that socialist economy which can guarantee the welfare of every racial group can be achieved. In striving towards fraternity and unity of all the races of the Union we will be guided by what General Aung San, our national leader, said at the A.F.P.F.L. conference held at the middle terrace of the Shwedagon Pagoda on January 20, 1946:

"A nation is a collective term applied to a people, irrespective of their ethnic origin, living in close contact with one another and having common interests and charing joys and sorrows together for such historic periods as to have acquired a sense of oneness. Though race, religion and language are important factors it is only their traditional desire and will to live in unity through weal and woe that binds a people together and makes then a nation and their spirit a patriotism."

We, the peoples of the Union of Burma, shall nurture and hug a new patriotism as inspired by the words of General Aung San.

Social Service

17. (a) Education. The Revolutionary Council believes that the existing educational system unequated with livelihood will have to be transformed. An educational system equated with livelihood and based on socialistic moral values will be brought about. Science will be given precedence in education.

Our educational target is to bring basic education within the reach of all. As regards higher education only those who have promise and enough potentialities and industriousness to benefit from it will be specially encouraged.

(b) Health, Culture, etc. The Revolutionary Council believes that other social services such as Health, Culture, etc., shall flourish in direct proportion to the tides of socialist success like the lotus and the water's height, and will accordingly work towards this end.

(c) Religion. The Revolutionary Council recognises the right of everyone freely to profess and practise his religion.

Organizational March

18. In marching towards the goal of socialism the Revolutionary Council will base its organization primarily on the strength of peasants and other working masses who form the great majority of the nation. It will march also hand-in-hand with those who will work with integrity and loyalty for national interest and well-being of the people.

19. The Revolutionary Council will therefore carry out such mass and class organizations as are suitable for the transitional period, and also build up a suitable form of political organization.

20. When political organizational work is carried out socialist democratic education and democratic training will be given to the people so as to ensure their conscious participation. (The Revolutionary Council believes and hopes that there will come about democratic competitions which will promote socialist development within the framework of socialism.)

The aforesaid are in outline, the belief and policy of the Revolutionary Council of the Union of Burma.

Responsibility of the People

21. The Revolutionary Council has faith in the people, and in their creative force.

The Revolutionary Council believes that the people will, with an active awareness of their duties and responsibilities, play their part in full in this national revolutionary progressive movement and programme under the leadership of the Revolutionary Council.

The Revolutionary Council reaffirms and declares again that it will go forward hand-in-hand with the people to reach the goal of socialism.

Let us march towards socialism in our own Burmese way !

Reference

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