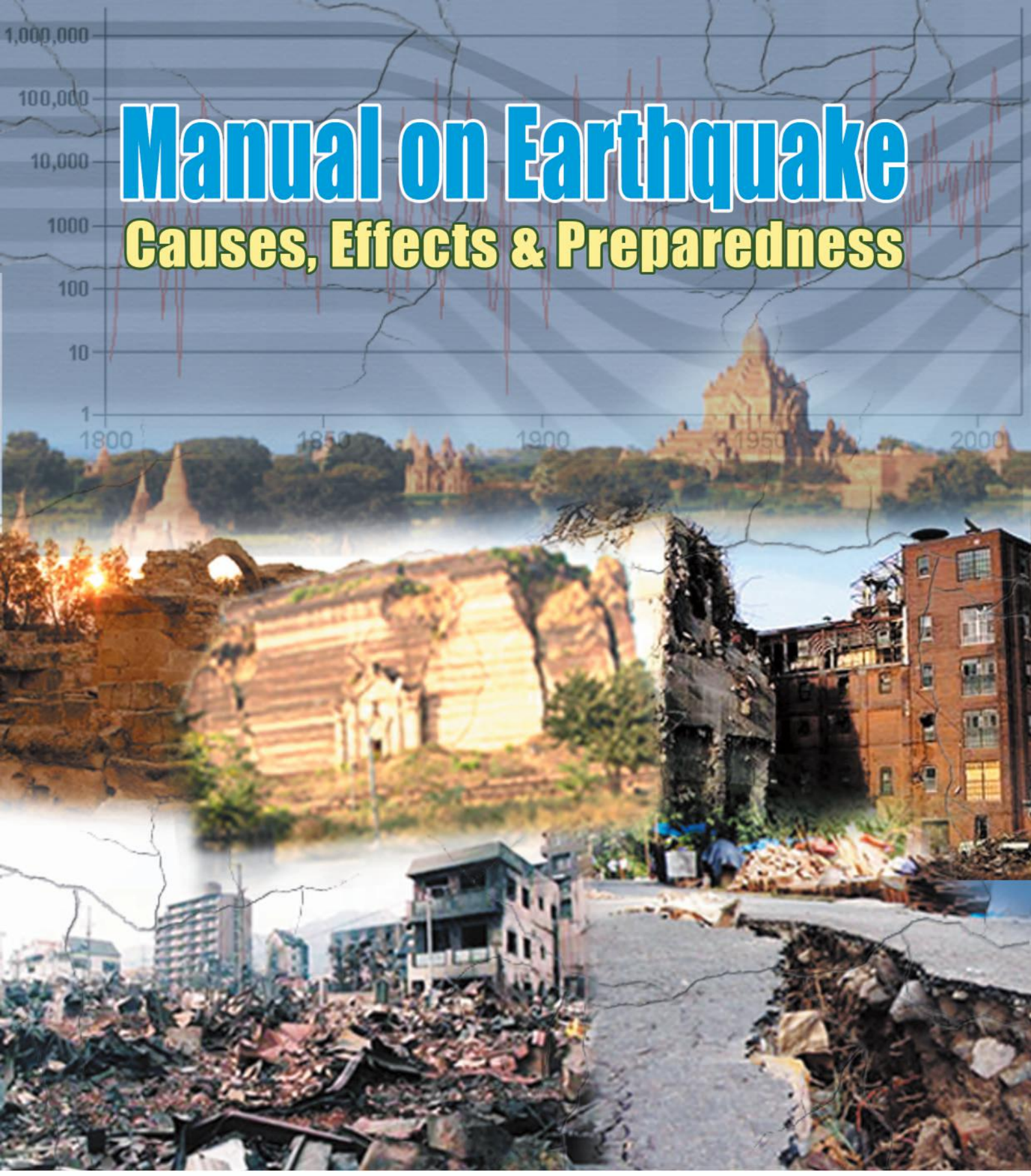
Manual on Earthquake

Causes, Effects & Preparedness



UN-HABITAT

UNDP Myanmar

Scope of the Manual

This manual is developed with wider consultations and inputs from various relevant departments/ministries, UN Agencies, INGOs, Local NGOs, Professional organizations including some independent experts in specific hazards. This is intended to give basic information on WHY, HOW, WHAT of a disaster. It also has information on necessary measures to be taken in case of a particular disaster in pre, during and post disaster scenario, along with suggested mitigation measures. It is expected that this will be used by the school teachers, students, parents, NGOs, Civil Society Organizations, and practitioners in the field of Disaster Risk Reduction.

Excerpts from the speech of Ban Ki-moon, Secretary-General of the United Nations

Don't Wait for Disaster

No country can afford to ignore the lessons of the earthquakes in Chile and Haiti. We cannot stop such disasters from happening. But we can dramatically reduce their impact, if the right disaster risk reduction measures are taken in advance.

A week ago I visited Chile's earthquake zone and saw how countless lives were saved because Chile's leaders had learned the lessons of the past and heeded the warnings of crises to come. Because stringent earthquake building codes were enforced, much worse casualties were prevented. Training and equipping first responders ahead of time meant help was there within minutes of the tremor. Embracing the spirit that governments have a responsibility for future challenges as well as current ones did more to prevent human casualties than any relief effort could.

Deaths were in the hundreds in Chile, despite the magnitude of the earthquake, at 8.8 on the Richter Scale, the fifth largest since records began. In Haiti, a less intense earthquake caused hundreds of thousands of deaths. Haiti had non-existent or un-enforced building codes, and very poor preparedness.

The lessons are universally applicable. No country is immune from disaster, be it earthquakes or floods, storms or heatwaves. More and more intense natural disasters are affecting all five continents, we believe as a result of climate change. Many of the world's poorest people live in high-risk densely populated cities in flood or earthquake zones, or both.

The culture of disaster risk reduction must spread. I am encouraged that we already have a head start in this regard. The Hyogo Framework for Action, a 10-year plan to make the world safer from disasters triggered by natural hazards, was adopted by 168 governments in 2005.Hyogo gives national authorities a blueprint to assess and reduce risks through planning, training, and better public education. For example, making sure that schools, hospitals, and other key public infrastructure meet certain safety standards.

There has been progress. Bangladesh lost more than 500,000 people during Cyclone Bhola in 1970. It subsequently built 2,500 cyclone shelters on elevated concrete platforms and trained more than 32,000 volunteers to help in evacuations. When Cyclone Sidr struck in 2007 with an enormous sea surge, the death toll was less than 4,000. Cyclone Nargis, a similar event in unprepared Myanmar in May 2008, cost 140,000 lives. Cuba weathered four hurricanes in 2008. It sustained $9 billion of physical damage but very few lives were lost.

The evidence is overwhelming. Yet the lessons of these disasters are forgotten with depressing speed. We know prevention actually saves governments money in the long run. When China spent $3.15 billion on reducing the impact of floods between 1960 and 2000, it averted losses estimated at about $12 billion. Similar savings have been recorded in Brazil, India, Vietnam and elsewhere.

Everyone has a role to play.

Governments, central and local, have to do what it takes to make communities able to cope with both continuing challenges and sudden shocks.

The Chile and Haiti earthquakes showed us once again why action *before* disasters makes all the difference. To prevent natural hazards turning into disasters, we must all act sooner and act smarter.

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Chapter 1

Introduction to Earthquake

1.1 What are earthquakes?

An earthquake is a sudden shaking of the ground due to rupture and extremely rapid shifting of rocks along ruptures called faults below the earth's surface.

1.2 Types of earthquakes

Based on their respective causes, there are 3 different types of earthquakes:

(1) Tectonic Earthquakes: Solid earth is composed of concerntric shells or layers, which are stacked one above the other, depending on their density. The lightest outermost rigid layer is called the earth's crust (Figure 1.1) which is broken into blocks of various sizes called tectonic plates or platelets or microplates depending on size. All the plates are moving against one another: two plates slide over, under or

Figure 1.1: Inside the Earth

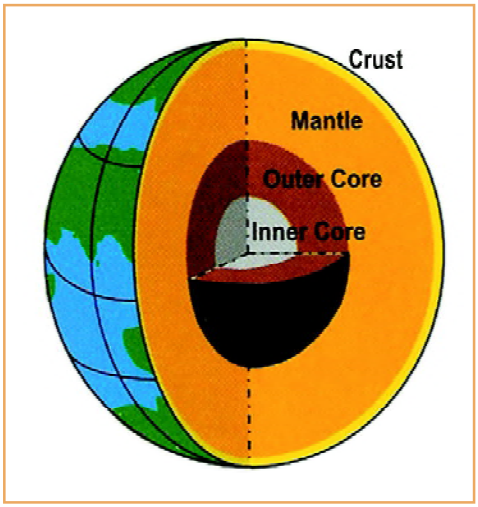
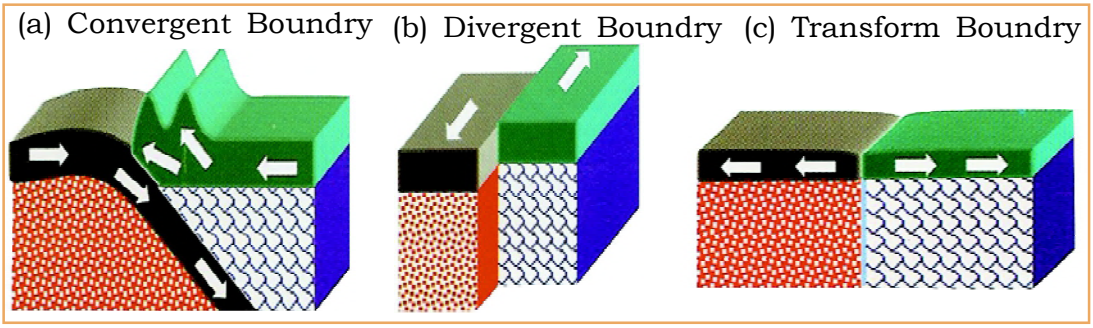
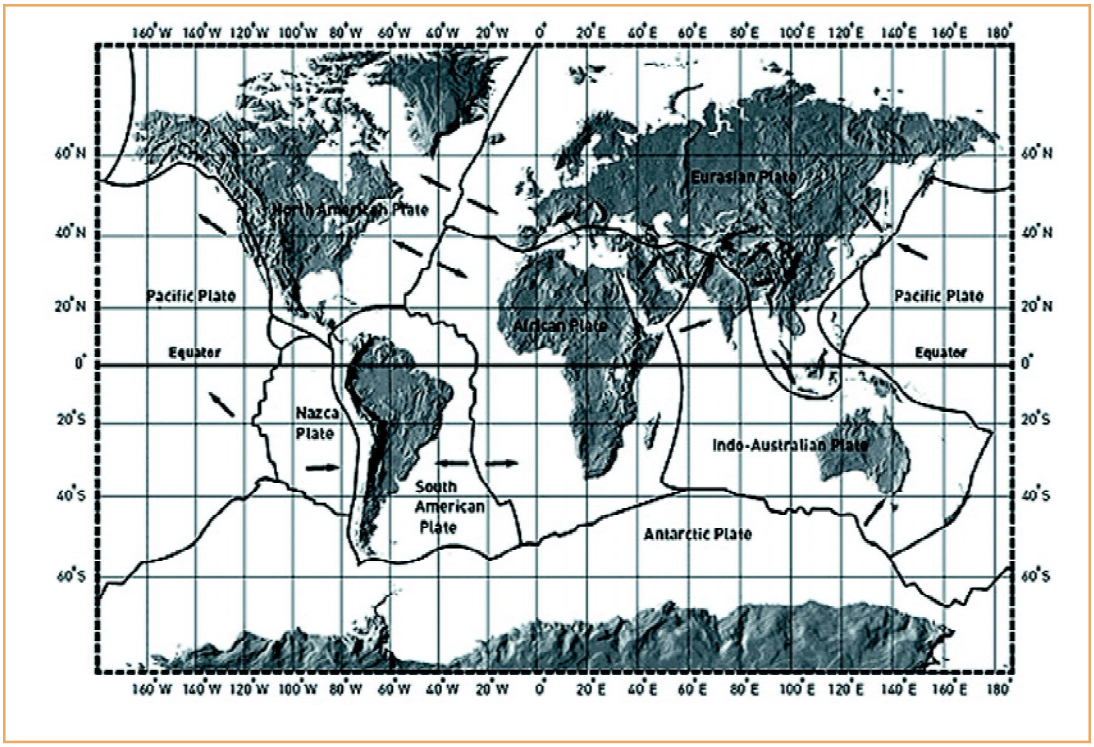


Figure 1.2: Types of plate boundries



Map 1.1: Tectonic plates of the world

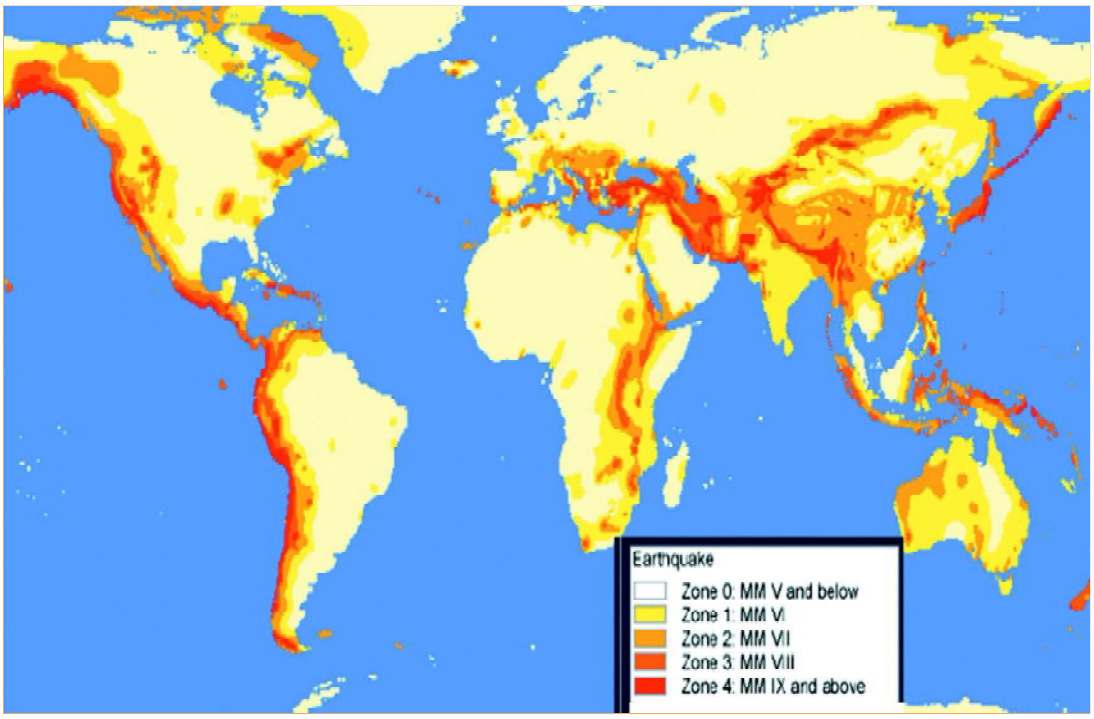


collide against each other. Tectonic earthquakes are caused by stresses set up by movements of a dozen or so huge plates that form the earth's crust. Most earthquakes occur along the boundaries of these plates, mostly within the crust and some in the upper part of the underlying mantle layer. Only a very minor proportion is scattered isolated elsewhere. Tectonic earthquakes are the most common and devastating.

(**2) Volcanic earthquakes:** Earthquakes related to volcanic activity may produce hazards which include ground cracks, ground deformation, and damage to man-made structures. They often precede or accompany volcanic eruptions.

(3) Man-made earthquakes: Earthquakes could also be formed by man-made activities. Dam induced earthquakes and those formed by nuclear bomb explosions are good examples. These types of earthquakes are noticeable but are rarely destructive.

Map 1.2: Global Seismic Hazard Map



Source: USGS 2005

1.3 Magnitude, intensity scales and related destruction

Magnitude of an earthquake is a measure of its size based on energy released. The Richter scale measures the magnitude of an earthquake instrumentally at the epicentral area of the earthquake. It is a quantified measurement of an earthquake.

An earthquake of magnitude 5 or more on the Richter scale can cause damages but there are other factors which contribute to the scale of the damages.

A classification of earthquakes based on magnitude can be seen in the table below:

Table 1.1: Classification of an earthquake based on magnitude

Sr.	Descriptive Class	Magnitude Range	Annual Average Occurrence
1.	Giant	>9.0	
2.	Great	8.0 – 8.9	1
3.	Major	7.0 – 7.9	17
4.	Strong	6.0 – 6.9	34
5.	Moderate	5.0 – 5.9	1,319
6.	Light	4.0 – 4.9	13,000
7.	Minor	3.0 – 3.9	130,000
8.	Very Minor	2.0 – 2.9	1,300,000

Source: USGS

Intensity is an indicator of the severity of ground shaking generated at a given location.

The most common indicator to measure the intensity of an earthquake is the Modified Mercalli Intensity (MMI) Scale, ranging from I-XII levels. It is not based on measurement by instruments but on an elementary description of levels of damage to physical structures such as buildings, towers, bridges, water reservoirs, etc.

The Modified Mercalli Intensity (MMI) Scale describes the effects of the earthquake as given in Table 1.2.

Table 1.2: Classification of earthquakes based on intensity

Class of Earthquakes	Description
I	Not felt except by very few under especially favorable circumstances.
II	Felt only by few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably indoors, especially on upper floors of buildings but many people do not recognize it as an earthquake; standing motorcars may rock slightly. Vibration may be felt like that of a passing a truck.
IV	During the day felt indoors by many and outdoors by a few; at night some are awakened; dishes, windows, doors disturbed; walls make cracking sound; sensation like heavy truck striking the building; and standing motor cars rocked visibly.
V	Felt by nearly everyone; many awakened; some dishes, windows etc. broken; a few instances of cracked plaster; unstable objects overturned; disturbance to trees, poles, and other tall objects noticed and pendulum clocks may stop.
VI	Felt by all; many frightened and run outdoors; some heavy furniture moved; a few instances of fallen plaster or damaged chimneys and damage slight.
VII	Everybody runs outdoors; damage negligible in buildings of good design and construction; slight to moderate in well built ordinary construction; considerable in poorly built or badly designed structures; some chimneys broken; noticed by persons driving motor cars.
VIII	Damage slight in specially designed structures; considerable in ordinary but substantial buildings with partial collapse; very heavy in poorly built structures with panel walls thrown out of framed structures; heavy furniture overturned sand and mud ejected in small amounts; changes in well water and person driving motor cars disturbed.
IX	Damage considerable in specially designed; well designed framed structures thrown out of plinth; very heavy in substantial buildings with partial collapse; buildings shifted off foundations; ground cracked conspicuously and underground pipes broken.
X	Some well built wooden structures destroyed; most masonry and framed structures with foundations destroyed; ground badly cracked. Rails bent. Landslides. Shifted sand and mud; water splashed over banks.
XI	Few, if any masonry structures remain standing; bridges destroyed; broad fissures in ground; underground pipelines completely out of service, Earth slump; land slips in soft ground and rails bent greatly.
XII	Total damage; waves seen on ground surface; objects thrown upward into the air.

The Modified Mercalli Intensity (MMI) Scale Intensity has approximately the following relation to the magnitude.

Table 1.3: Relation between magnitude and intensity of an earthquake

Magnitude	5	6	6.5	7	7.5	8	(Richter Scale)
Intensity	VI-VII	VII-VIII	VIII-IX	IX-X	X-XI	XI-XII	(MM Scale)

1.4 Destruction caused by earthquakes

Ground shaking and ground rupture by earthquake cause the following destructions:

- Damage or collapse of buildings and bridges resulting in death, injuries and extensive property damages.
- Destruction of lifelines such as communication, transportation, power, water supply & waste disposal, industries in urban areas, etc.

Destruction depends on the following interrelated factors:—

- magnitude,
- distance from causative fault,
- depth of focus,
- duration of shaking,
- source mechanism,
- local geologic condition including type and thickness of soil and bedrock units, groundwater table, topography and general geologic structures of the area, and
- Age and type of building or structure, design, material used, and workmanship.

Damage and loss of life due to earthquakes depends on interplay between natural phenomenon as well as human decision and choice of location for structures of buildings and infrastructure.

1.5 Secondary earthquake hazards

After a big earthquake, the following secondary disasters may accompany it.

Fault rupturing: Fault rupturing is the breaking up of ground caused by an earthquake; Buildings that straddle an active fault may be damaged.

Landslide: Landslides comprise mass of soil and rocks that slide or slip down the slopes of mountains, hills or cliffs as a result of shaking due to earthquake. In severe cases, people can be buried alive.

Tsunami: Tsunamis are large ocean waves that occur when the ocean floor or coastal area is tilted or offset by a fault when a strong earthquake occurs on it. It could become a towering wall of water 15 meters high or more by the time it reaches the shore which is capable of causing much damage, possibly destroying entire coastal settlements.

Indian Ocean Tsunami, December 26, 2004

Liquefaction: Soil Liquefaction usually occurs in the area where the soil is soft, loose and saturated with

Collapse of buildings during 2001 Bhuj (India) Earthquake

water. As a result of shaking due to earthquake, the soil moves and behaves like quicksand causing structures on the surface to either sink or tilt.

In addition to the above mentioned environmental hazards, the following secondary problems may also follow an earthquake.

Fires: Damages to electric power lines, gas lines due to earth shaking can lead to fire.

Fires resulting from the Earthquake Kobe, 1995

Dam failures: Due to strong ground shaking and overflowing by water waves, dam failures may follow an earthquake, leading to wash-away and flash floods.

Lower Van Norman Dam experienced widespread liquefaction and major slope failures during the 1971 San Fernando Earthquake

1.6 Destructive earthquakes in the world

The most destructive earthquakes in the world are listed in Table 1.4.

Table 1.4: Some disastrous global earthquakes, with number of fatalities and magnitudes (from period 1970 to 2010)

Year	Place	Fatalities	Magnitude
1970	Peru	70,000	7.9
1970	China, Yunan province	10,000	7.5
1972	Earthquake, Nicaragua	5,000	6.2
1974	China	20,000	6.8
1976	Earthqake, Guatemala	23,000	7.5
1976	Earthquake, China,Tangshan	255,000	7.5
1976	Philippines, Mindanao	8,000	7.9
1976	Turkey-Iran border region	5,000	7.3
1977	Romania	1,500	7.2
1978	Iran	15,000	7.8
1980	Algeria	5,000	7.7
1980	Italy	2,735	6.5
1981	Iran, southern	3,000	6.9
1982	Western Arabian Pennisula	2,800	6.0
1985	Mexico	9,500	8.0
1986	El Salvador	1,000	5.5
1987	Colombia-Ecuador	1,000	7.0
1988	Nepal-India border	1,000	6.8
1988	Armenia, Spitak	25,000	6.8
1990	Western Iran	40,000 to 50,000	7.4 Landslide
1992	Flores region, Indonesia	2,500	7.5 + Tsunami
1993	India, Latur-Killari	9,748	6.2
1995	Japan, Kobe	5,502	6.9 Landslides, Liquefaction
1995	Sakhalin Island	1,989	7.5
1997	Northern Iran	1,567	7.3
1998	Afghanistan-Tajikistan border	2,323	5.9
1998	Same area (after 3 months)	4,000	6.6
1998	Paupa New Guinea	2,183	7.0
1999	Colombia	1,185	6.1
1999	Turkey	17,118	7.6
1999	Taiwan	2,400	7.6
2001	Gujarat, India	20,085	7.6
2003	Southern Iran	31,000	6.6
2004	Off the West coast of northern Sumatra	227898	9.1
2005	Pakistan	86000	7.6
2006	Java, indonesia	5749	6.3
2008	Eastern Sichuan, China	87587	7.9
2009	Southern Sumatra, Indonesia	1117	7.5
2010	Haiti	223,570	7.0

Source:USGS

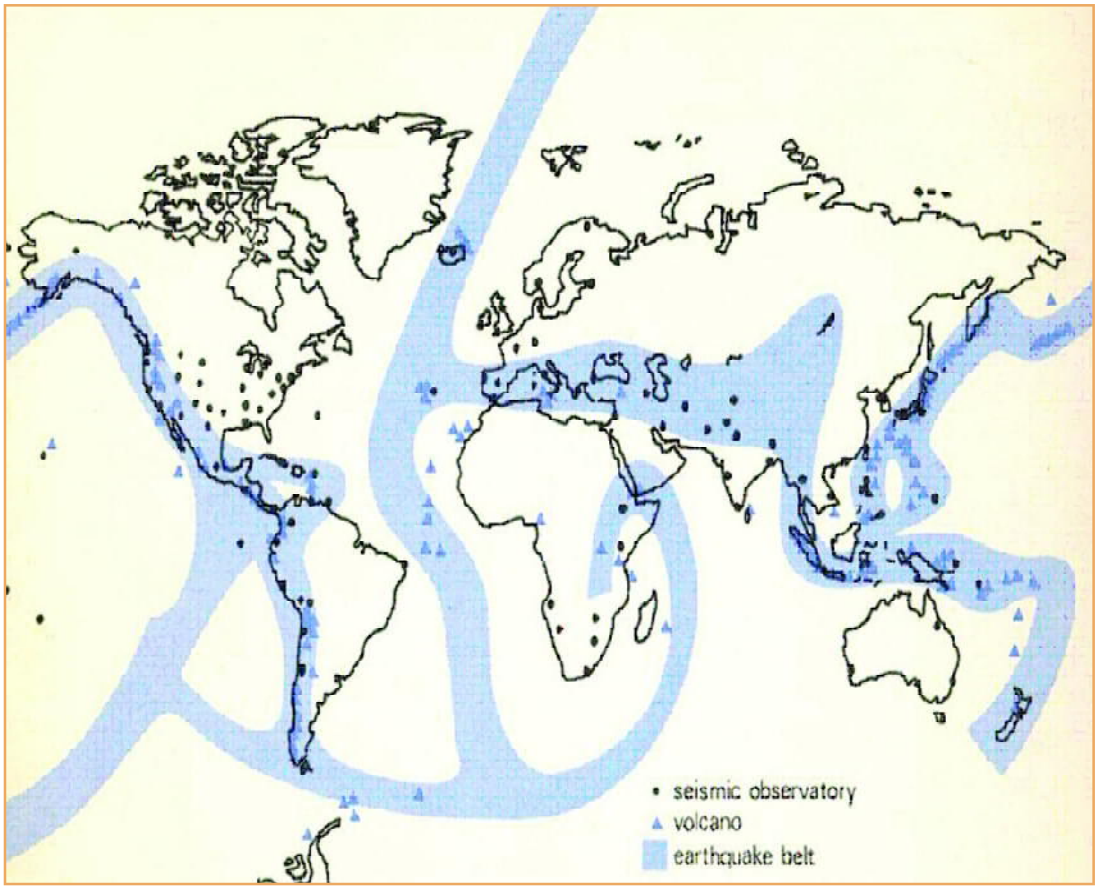
Chapter 2

Earthquake Hazard in Myanmar

2.1 Causes of earthquakes in Myanmar

Myanmar is exposed to major earthquakes since a large part of the country lies in the southern part of the Himalaya and the eastern margin of the Indian Ocean. It is situated in the Alpide Earthquake Belt, one of the two main earthquake belts of the world. The Alpide Belt starts from the northern Mediterranean Sea in the west, and extends eastwards through Turkey, Iran, Afghanistan, the Himalayas, Myanmar and finally to Indonesia.

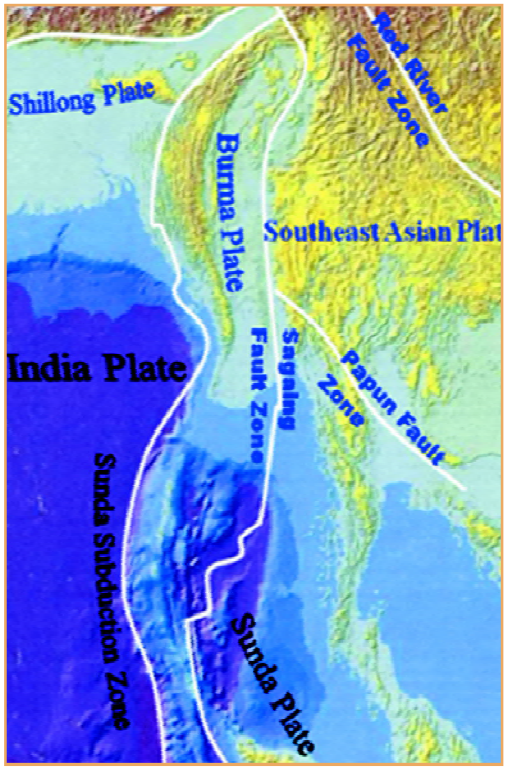
Map 2.1: Myanmar situated in the Alpide Earthquake Belt



Earthquakes in Myanmar have resulted from two main causes namely:

- Continued subduction (with collision only in the north) of the northward-moving Indian Plate underneath the Burma Platelet (which is a part of the Eurasian Plate) at an average rate of 3.5 cm/year, and
- Northward movement of the Burma Platelet from a spreading centre in the Andaman Sea at an average rate of 2.5–3.0 cm/year.

Map 2.2: The Location of Burma Plate



The major seismotectonically important faults in Myanmar are some unnamed major thrust faults in north-western Myanmar, Kabaw Fault along the Kabaw Valley in western Myanmar, the well-known Sagaing Fault close to Bago-Myitkyina railway line, and the Kyaukkyan Fault situated west of Naungcho.

2.2 Areas prone to earthquake in Myanmar

Majority of the earthquakes in Myanmar are mainly confined to three zones:

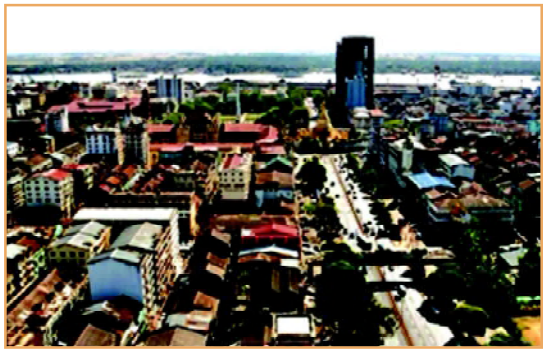
- The zone along the western fold belt of Myanmar with mostly intermediate-focus earthquakes; where the earthquake frequency is much higher in the northern part.
- The zone along the Sagaing Fault, including the offshore part in the Andaman Sea with shallow-focus earthquakes; the earthquake frequency is higher in three segments, namely (from south to north), Bago-Taungoo, Sagaing-Tagaung,and Myitkyina-Putao Segments.

- The zone in the north-eastern part of Myanmar, which is continuous with the earthquakes in southern Yunnan.

The seismic intensity zone map of Myanmar (2005) is shown in Map 2.3. The five seismic zones are demarcated and named (from low to high). The highest intensity zone designated for Myanmar is the Destructive Zone (with probable maximum range of ground acceleration 0.4 – 0.5 g), which is equivalent to Modified Mercalli Intensity (MMI) class IX. There are four areas in that most vulnerable zone; namely, Bago-Phyu, Mandalay-Sagaing-Tagaung, Putao-Tanaing, and Kale-Homalin areas. Although the later two have major earthquake hazards potential, they may be less vulnerable as they are sparsely populated. Important cities and towns that lie in Zone IV (Severe Zone, with probable maximum range of ground acceleration 0.3 – 0.4 g) are Taungoo, Taungdwingyi, Bagan-Nyaung-U, Kyaukse, Pyin Oo Lwin, Shwebo, Wuntho, Hkamti, Hakha, Myitkyina, Taunggyi, and Kunglong. Yangon straddles the boundary between Zone II and Zone III, with the old and new satellite towns in the eastern part in Zone III, and the original city in Zone II.

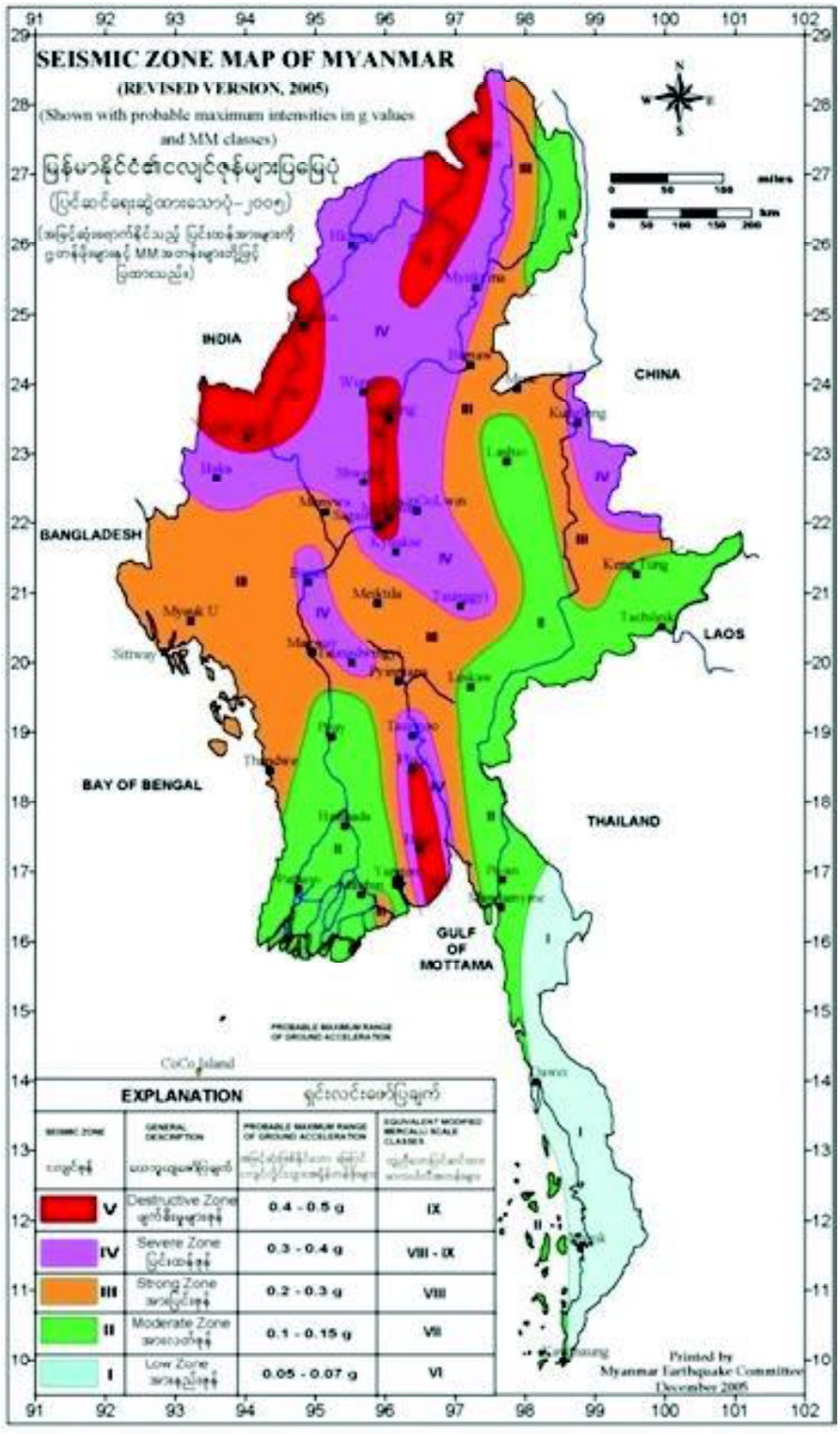
Since populated urban areas, like Yangon, Mandalay and Bago, are in the earthquake prone areas, the vulnerability increases with urbanization in cities. In other states and divisions, although they are sparsely populated, most of the dwellings are still non-engineered structures and not incorporated earthquake resistant measures, they are thus vulnerable to moderate to high intensity earthquakes.

The view of Mandalay City



The view of Yangon

Map 2.3: Seismic Zone Map of Myanmar (2005)



Source: MEC

Table 2.1: Seismic zonation in percentage: states and divisions of Myanmar

State or Division\Zone	I	II	III	IV	V
Bago Division		35	30	20	15
Chin State			55	22	23
Irrawaddy Division		95	5		
Kachin State		18	27	32	23
Kayah State		98	1		
Kayin State	30	50	20		
Magway Division		15	50	35	
Mandalay Division			45	40	15
Mon State	20	70	10		
Rakhine State		15	85		
Sagaing Division			10	65	25
Shan State		40	40	20	
Tanintharyi Division	85	15			
Yangon Division		40	23	20	17

Source: Hazard Profile of Myanmar

2.3 Major earthquakes in Myanmar with loss and damage data

According to data collected by Myanmar Earthquake Committee (MEC), the seismic records show that there have been at least 16 major earthquakes with Richter Scale (RS) ⩾ 7.0 within the territory of Myanmar during the period 1839-2008 (Table 2.2). Myanmar royal capitals were incidentally located along the Sagaing fault zone which is the principal source of seismic hazards in Myanmar. According to historical records, ancient capitals of Myanmar around the Mandalay area, Amarapura, Ava (Innwa), and Sagaing, were severely devastated by big earthquakes.

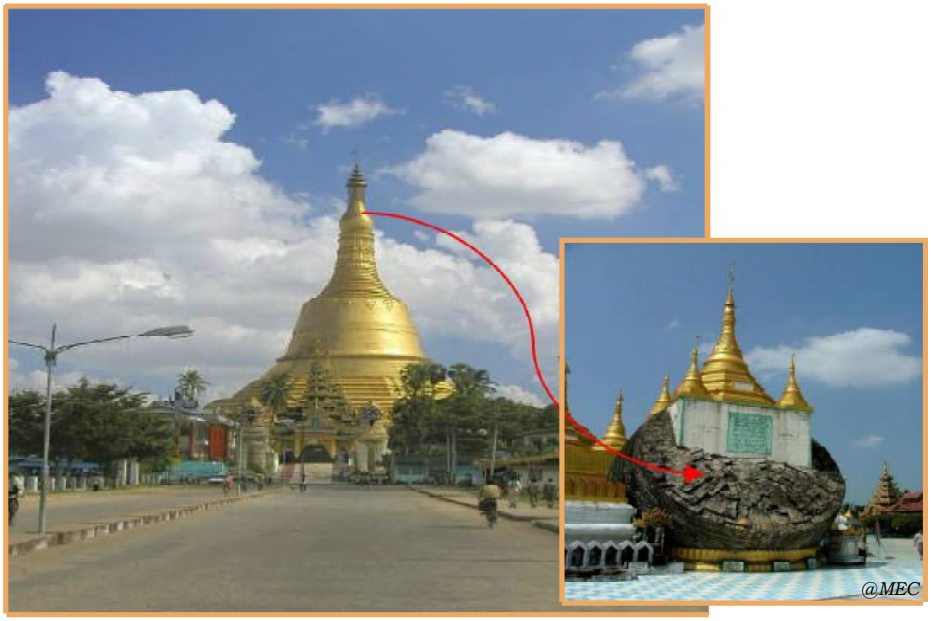
Table 2.2: Summary of Earthquake events in Myanmar (1839-2008)

Type of Earthquake	Richter Scale	Frequency	Time Range	Data Source
Great	> 8	1	1839-2008	Historical record and NEIC
Major	7-7.9	15	1839-2008	Historical record and NEIC
Strong	6-6.9	25	1950-2008	ANSS Catalogue
Moderate	5-5.9	549	1950-2008	ANSS Catalogue

Since Myanmar was very sparsely populated and most of her population lived in rural areas in the past, disasters and fatalities caused during the earthquakes were considered negligible to be officially recorded. However, Buddhist shrines, pagodas and zedis, with characteristic spires rising up were somewhat damaged or destroyed by every earthquake of moderate and larger size in the past. In a way such damages serve as records of earthquake events of the past. Some of the damages in famous ancient pagodas are shown in the following photographs.

Mingun Pagoda, severely damaged by 1839 Ava earthquake, before its completion of construction and again by 1956 Sagaing earthquake.

Top of the pagoda shaken down by the 1975 Bagan earthquake, now lying down beside the renovated original pagoda.



Top portion of Shwe Maw Daw Pagoda fallen down at the banana bud portion by 1917 Bago Earthquake. Fortunately, it was not crushed. Small pagoda was built on top of it later.

The summary record of earthquakes in Myanmar is listed in Table 2.3. Most of them occurred along the Sagaing Fault.

Table 2.3: Earthquakes in Myanmar

Date	Location	Magnitude and/or brief description
868	Bago	Shwemawdaw Pagoda fell
875	Bago	Shwemawdaw Pagoda fell
1429	Innwa	Fire-stopping enclosure walls fell
1467	Innwa	Pagodas, solid and hollow, and brick monasteries destroyed
24 July 1485	Sagaing	3 well-known pagodas fell
1501	Innwa	Pagodas, etc. fell
13 Sept. 1564	Bago	Pagodas including Shwemawdaw and Mahazedi fell
1567	Bago	Kyaikko Pagoda fell
1582	Bago	Umbrella of Mahazedi Pagoda fell
9 Feb 1588	Bago	Pagodas, and other buildings fell
30 Mar 1591	Bago	The Great Incumbent Buddha destroyed
23 June 1620	Innwa	Ground surface broken, river fishes were killed after quake
18 Aug. 1637	Innwa	River water flush
10 Sept. 1646	Innwa	
11 June 1648	Innwa	
1 Sept. 1660	Innwa	
3 April 1690	Innwa	
15 Sept. 1696	Innwa	4 well-known pagodas destroyed
8 Aug. 1714	Innwa	Pagodas, etc. fell; the water from the river gushed into the city
4 June 1757	Bago	Shwemawdaw Pagoda damaged
2 April 1762	Sittwe	M=7 RS; very destructive violent earthquake felt over Bengal, Rakhine up to Calcutta.
27 Dec 1768	Bago	Ponnyayadana Pagoda fell
15 July 1771	Innwa	
9 June 1776	Innwa	A well known pagoda fell
26 Apr 1830	Innwa	
21 Mar 1839	Innwa	Old palace and many buildings demolished;
23 Mar 1839	Innwa	pagodas and city walls fell; ground surface broken; the river's flow was reversed for sometime; Mingun Pagoda shattered; about 300 to 400 persons killed
6 Feb 1843	Kyaukpyu	eruption of mud volcanoes at the Rambye (Ramree) Island
3 Jan 1848	Kyaukpyu	The civil line and other buildings were damaged
24 Aug 1858	Pyay	Collapsed houses and tops of pagodas at Pyay, Henzada, and Thayetmyo and felt with some damages in Innwa, Sittwe, Kyaukpyu and Yangon

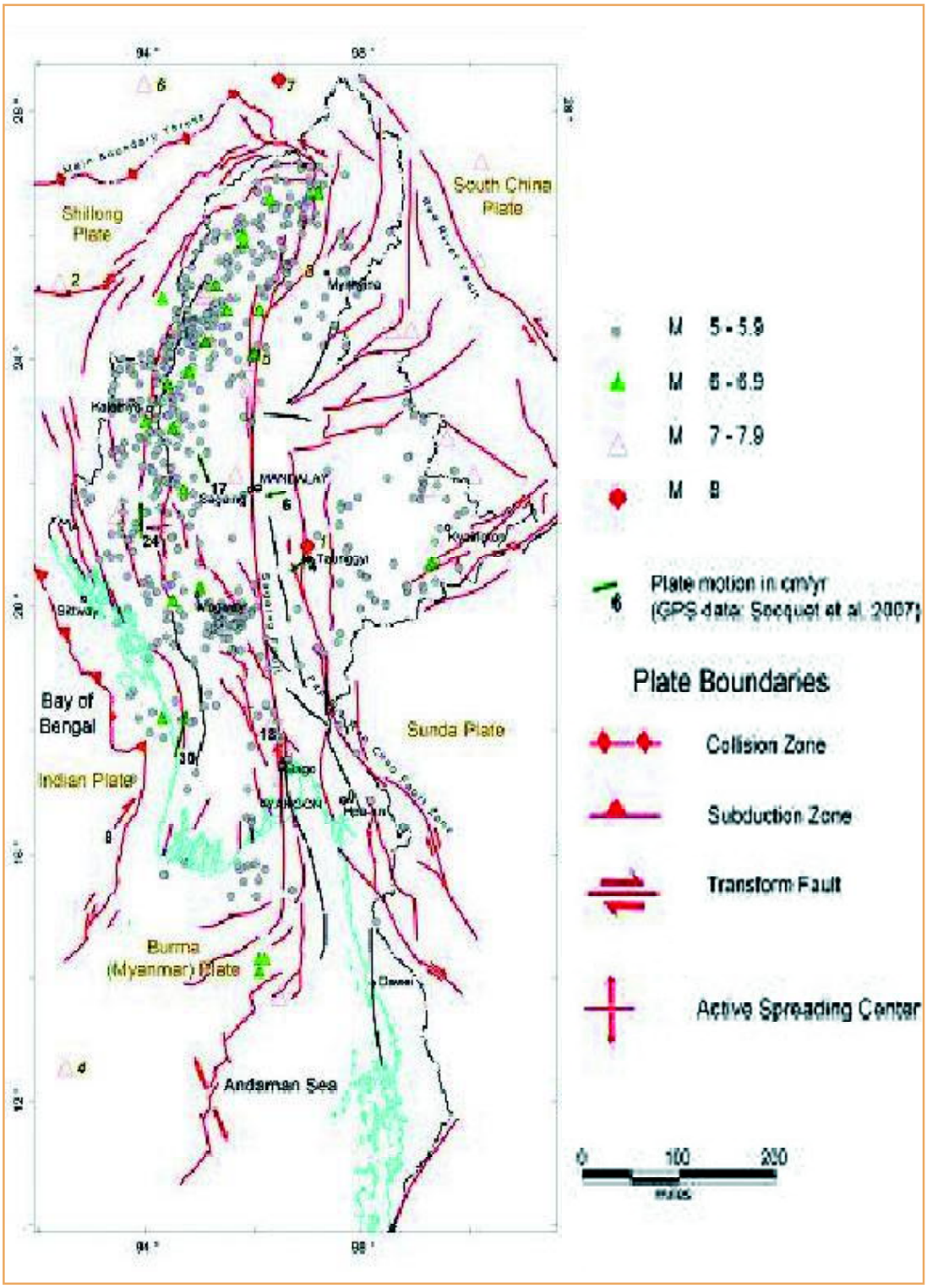
Date	Location	Magnitude and/or brief description
8 Oct 1888	Bago	Mahazedi Pagoda collapsed
6 Mar 1913	Bago	Shwemawdaw Pagoda lost its finial
5 July 1917	Bago	Shwemawdaw Pagoda fell
10 Sep 1927	Yangon	
17 Dec 1927	Yangon	M=7 RS; extended to Dedaye
8 Aug 1929	Near Taungoo	Bent railroad tracks, bridges and culverts collapsed, and loaded trucks overturned (Swa Earthquake)
5 May 1930	Near Khayan	M=7.3 RS, Imax=IX; in a zone trending north-south for 37 km south of Bago (on the Sagaing Fault line); about 500 persons in Bago and about 50 persons in Yangon killed
3 Dec 1930	Nyaunglebin	M=7.3 RS; railroad tracks twisted (Pyu Earthquake); about 30 persons killed
27 Jan 1931	East of Indawgyi	M=7.6 RS, Imax=IX; numerous fissures and cracks (Myitkyina Earthquake)
10 Aug 1931	Pyinmana	
27 Mar 1931	Yangon	
16 May 1931	Yangon	
21 May 1931	Yangon	
12 Sept. 1946	Tagaung	M=7.5 RS
12 Sept.1946	Tagaung	M=7.75 RS
16 July 1956	Sagaing	M=7.0 RS; Several pagodas severely damaged (40 to 50 persons killed)
8 July 1976	Bagan	M=6.8 RS; Several pagodas in Bagan Ancient City were severely damaged (only 1 person killed)
22 Sept. 2003	Taungdwingyi	M=6.8; RS Severe damaged to rural houses and religious buildings (7 persons killed)

Source: Myanmar Geosciences Society

Fissures formed during 2003 Taungdwingyi Earthquake, central Myanmar

Collapsed primary school during the Taungdwingyi earthquake

Map 2.4: Location of large earthquakes in Myanmar



Source: MEC

2.4 The current status of earthquake vulnerability in Myanmar

MYANMAR is located in the earthquake prone region of the Alpide Belt, one of the two main earthquake belts of the world. Earthquake belts are areas of interaction between tectonic plates of the earth. There are a number of faults in Myanmar territory, some of which are active and some, possibly active. Among them, Sagaing Fault is the most active one and the past earthquakes recorded in Myanmar occurred along this fault. In addition, the faults appear to be locked and stress is accumulating in those segments because some large segments of the active faults have not exhibited any significant seismic activity in the past 50 to 75 years. These factors indicate that there is possibility of a big earthquake occuring in Myanmar at any time.

Vulnerability to Earthquake is also increasing in Myanmar compared to the past earthquakes in history. The population of Myanmar has considerably increased, from 15 million in 1930, at the time of the Bago earthquake, to 57.5 million in 2008[1]. Lifestyles are changing from that of rural agricultural life to that of crowded urban areas with industries.These include congested high-rise buildings supported by sophisticated and potentially hazardous infrastructure like electricity and water supply, waste and sewage disposal, communication and transportation systems; and dams, bridges, air-fields, oil storage tanks, all required for modern living. More importantly, the big cities, Yangon, Mandalay and Bago are located along the active Sagaing Fault. In the rural areas, the non-engineered structures and dwellings are vulnerable to moderate to high intensity earthquakes.

Unlike other natural disasters, earthquakes do not occur frequently in a region and people may not experience such big earthquakes in their life time. Usually, people have little awareness on the disasters they never encounter before. If people do not have awareness of potential earthquakes in their own area and have no preparation of counter-measures for prevention and mitigation of earthquakes, there will be huge losses caused by earthquake.

[1]Statistical Year Book 2009

It is not possible yet to predict exactly when an earthquake will occur in a particular place at a particular time. Instead, based on the information on well-understood fault lines, patterns of earthquakes, seismic hazard assessment maps, the probability of an earthquake of a given size in a given location over a certain number of years can be estimated. Since early warning of an earthquake is not yet available, the best way forward is to have preparedness and mitigation measures adopted and applied in earthquake prone countries like Myanmar.

Chapter 3

Preparedness and Mitigation Measures for Earthquake

3.1 Mitigation Measures

Earthquake mitigation is the measures taken prior to the impact of an earthquake to minimize its effects. It needs the government's intervention and enforcement as well as community participation for implementation. These measures can be undertaken in two ways: ***Structural and Non-structural*** mitigation measures. *Structural Mitigation* includes retrofitting of buildings, construction of earthquake resilient infrastructures, and other hard ware interventions. *Non-Structural* measures include awareness generations, building codes and regulations, and other preparedness measures at all levels.

3.1.1 Structural Mitigation Measures

Few suggested steps are mentioned below as a part of the structural mitigation to ensure that adequate measures have been taken to withstand an earthquake.

a) Retrofitting of structures

A large portion of Myanmar people lives in self-designed non-engineered houses. Such houses are very vulnerable to horizontal accelerations generated by earthquakes. These houses can be considerably strengthened against earthquakes by some simple and inexpensive retrofitting methods.

b) Construction of earthquake resilient infrastructures and buildings

Earthquakes never kill people, it is the building and infrastructure which causes heavy damage to lives and livelihoods. Thus, earthquake resilient features are needed to be incorporated into any new infrastructures that are created considering the seismic zones of a particular area.

3.1.2 Non-structural Mitigation Measures

The following measures should be taken up for earthquake mitigation. Few suggested steps are mentioned below:

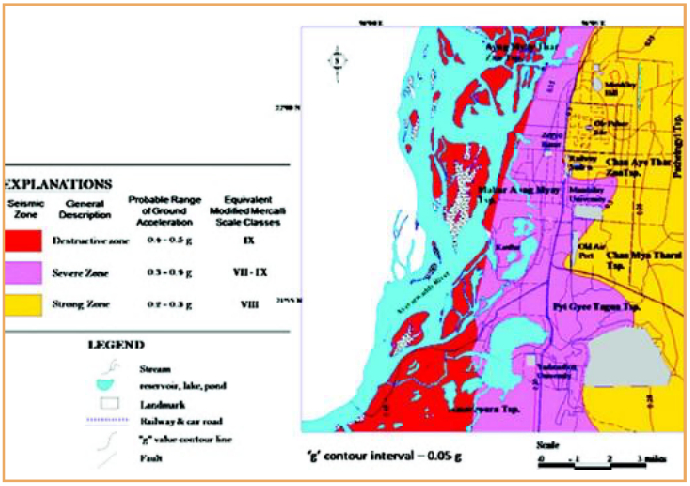
a) Land-use and settlement planning

Mitigation measures need to be considered in land use and site planning activities. At national level, when a new human settlement project is to be implemented, the land use consideration for an open field area should be proportionate to the number of inhabitants in case of evacuation and shelter in the time of disaster including earthquake. These open areas can be used as recreation parks, playgrounds for public during normal times. At the community and village level, an existing open field area should be identified for evacuation and safe shelter in case of an earthquake. This should also be informed to the community.

b) Micro-zonation map

For major cities located in earthquake-prone areas, it is important to have micro-zonation maps, which are useful in constructing earthquake resistant structures. These maps basically depict anticipated accelerations at ground surface in different spectral frequencies.

Map 3.1. Seismic micro-zone map of Mandalay-Amarapura area



Source: Eyn Keey, 2006

c) Building codes for earthquake resistant structures

The building codes for earthquake resistant structures should be identified and the appropriate enforcement should be laid down by the concerned authorities or agencies. The application of these building codes by the architects, engineers, masons, carpenters in constructions of new structures, buildings and dwellings make the community resilient from earthquakes.

d) Insurance

Insurance is a potentially important mitigation measure in disaster-prone areas as it insures the property damaged in the aftermath of an earthquake. It brings quality in the infrastructure, consciousness and a culture of safety by its insistence on following building codes, norms, guidelines, quality materials in construction. Disaster insurance mostly works under the premise of 'higher the risk higher the premium, lesser the risk lesser the premium', thus creating awareness towards vulnerable areas and motivating people to settle in relatively safe areas.

e) Public awareness

Public education and mass awareness can substantially reduce the loss of lives in case of an earthquake. Thus various Information, Education and Communication (IEC) materials through various forms can help disseminate the basic do's and don'ts (safety tips) to enable saving of valuable lives and assets.

Some examples of IEC materials on earthquake

f) Training and sensitization

Training and capacity building of various stakeholders that include local authorities, city development authorities, architects, engineers, town planners, carpenters, masons and artisans and other professional bodies like engineering and architect associations will build the understanding of earthquake vulnerability reduction through incorporating their skills into respective work lives.

Workshop on DRR at Mandalay, Sept.2009

g) Policy regulations/acts

Various policy regulations, acts and techno-legal regimes will ensure abiding the law on new construction guidelines and practices ensuring less risk to the lives of the people.

h) Earthquake preparedness and response measures

There is also a strong need for development of earthquake preparedness and response plans at all levels to ensure that a well documented plan is in place in order to respond to any earthquake hazard in an organized manner. These plans can be taken up at city, district, township, and village level to effectively respond immediately aftermath of an earthquake. This will also ensure better preparedness at individual, family and community level.

3.2 Earthquake Preparedness at Community Level

Disaster Preparedness includes all activities that will ensure prompt and effective action at all levels to save lives, reduce suffering, and minimize damage to property.

a) Community-based Organization on Disaster Risk Reduction

It is best practice for a given community to form a Community-based Organization (CBO) on Disaster Risk Reduction. If such an

organization does not exist, the community should organize a CBO comprising stakeholders in the community. Under this initiatives, a number of sub-groups or teams should also be formed to cater on different disaster management activities such as early warning dissemination, evacuation, search and rescue, first aid, and relief operation, etc.

b) Community-based Disaster Management Plan

The community should prepare the Community-based Disaster Management Plan with the help of government departments, NGOs, community leaders and with the participation of the community members. In the plan, the list of activities which the community members have to perform for earthquake preparedness should be included. It should also identify the duties and responsibilities to be carried out by individuals in the community so that they are aware of their specific responsibilities when an emergency warning is received. Once the Plan is prepared, it should be shared with the community through different ways, such as informing in the community assembly, posting it on the notice board of village/ ward Peace and Development Council, monasteries/churches, markets, etc. with the end result of the community people being fully informed and thoroughly understanding all contents of the plan. The plan should also be evaluated on its effectiveness through drills and actual experience when the disaster strikes the community. It should be updated periodically or regularly at predetermined intervals so that it will reflect and adapt the changing conditions of the community, climate and natural environment.

c) Identification of vulnerability and risk assessment

The community should find out whether the area is located in a seismic zone, in which seismic zones, who are the vulnerable people, what are the vulnerable buildings and other infrastructures and so on. This assessment should be developed through community participation. The result and findings of the assessment should be well informed to the community so that all community members are well aware of the vulnerability of their community. It will help in the community preparedness measures and initiatives.

d) Public Awareness

If the community has no past experience on any kind of disaster during their lifetime, they are usually less aware on it. They may think that such disasters may not occur in the area they reside. Earthquakes have a distinct characteristic that the time interval between the big ones in an area is much longer, perhaps that of a man's lifetime. For example, the last big earthquake in the area was the 1956 Sagaing Earthquake preceded by the 1839 Innwa Earthquake. The time interval between the two was 117 years. The worst case scenario is for people to be caught by surprise by disasters such as earthquakes and tsunamis. Therefore, public awareness on earthquake in Myanmar communities, especially in earthquake prone urban areas should be strongly and regularly emphasized.

A lot of information is available indicating what to do before, during and after an earthquake in order to reduce vulnerability against it. This knowledge should be widely disseminated at the community level. Workshops, seminars and talks on earthquakes should be organized in earthquake prone areas. Public awareness programmes may also include essay, poster, cartoon, debate competitions, quiz contest, street plays, drama or song on Do's and Don'ts of disasters, photo exhibition or display of newspaper clipping on earthquake events. Moreover, radio and television programmes on earthquake hazard would be a strong media tool for generation of public awareness.

e) Drills

Drills or simulation exercises are an important part of the community preparedness on earthquake. Drills can be organized by the the Community-based Organization on Disaster Risk Reduction with participation of the larger community. The community should be well informed about the drills, such as why it is organized, who should be involved, what they have to perform during the drills. Moreover, the evacuation routes, the open areas (safe location) which are identified in advance should also be

informed to the community, through the drills. In this way, the community will also get a practical opportunity of learning do's and don'ts during an earthquake. A mock drill for earthquake should be organized one or two times a year: one drill can be well informed in advance and the other can be a surprise one. After each mock drill, evaluation should be done to get feedback.

f) Training and capacity building

Training is important to enhance capability of community-based organization and community members to reduce disaster risks. The aim of training is to enable the community-based organization and other community members to understand the disaster risk reduction activities on their own. All members of the community including children, women, the differently-abled and the elderly should know how to behave and what to do during and after a disaster. Moreover, the volunteers and the members of the Community-based Organization on Disaster Risk Reduction and sub-teams should be given trainings on specific relief and response activities. The following topics may be included in the training.

- Disasters and their consequences.
- Warning signals and how to disseminate them
- Evacuation
- Safe shelter
- Search and Rescue
- First Aid
- Relief Operation

3.3 Earthquake Preparedness at Household Level

The smallest unit of a community is the family. Each member of the family should share the knowledge and information on earthquakes and other disasters. If they live in an earthquake prone area, the family members should prepare the following items:

- A plan for earthquake harzards should be discussed and developed.
- Do's and Don'ts during an earthquake should be well understood by the family members.
- Safe places inside the house during an earthquake should be identified.
- The open field and the evacuation route to that place should be identified.
- The earthquake resistance of the building/house should be checked and retrofitting should be done if required.
- The furniture and other heavy things inside the house should be secured to prevent from falling down during an earthquake.

Heavy objects like framed painting and photos should not be hung or placed where they could fall on the people, eg. on top of the bed.

Chapter 4

Safety Tips on Earthquake

4.1 Before an earthquake

- Make sure that every family member knows how to react in case of an earthquake.
- Know the safe spots in each room - (under a sturdy table or desks, against the interior wall or a column, under a door frame).
- Practice DROP, COVER, & HOLD in each safe spot _ Drop under a sturdy desk or table, hold on to its leg, and protect your eyes and head by pressing your face against your arms. Practicing will make these actions an automatic response. When there is an emergency, many people hesitate and forget what they are supposed to do. Responding quickly and automatically will help to protect from injury.
- Know the danger spots - near windows, mirrors, hanging objects, unsecured furniture, shelves holding heavy objects.
- Locate safe places outdoors - In the open place, away from buildings, bridges, trees, telephone and electric post and lines and overpasses.
- Identify exits and alternative exits - Always know all the possible ways to leave the house and work place in emergency situations. Practice getting out of the home or building; check and see if the planned exits are clear of obstacles.
- Know the location of the shutoff valves for water, gas, and electricity. Learn how to operate those valves.
- Learn first aid.

- Develop an emergency communication plan - in case family members are not together during the earthquake, that is, when adults are at work and children are at school.

Make the home a safe place by doing the following:

- Secure heavy furnishings such as cupboards and bookcases against walls to prevent them from falling and injuring persons.
- Keep large, heavy object and breakables on lower shelves to prevent from serious injuries caused by falling objects.
- Store all flammables or hazardous liquids outside the house, in their proper containers, away from structures since earthquakes may trigger fires or explosions within the building.
- Hang heavy items such as pictures and mirrors away from beds, couches, and places where people sit.
- Brace overhead light fixtures to prevent them from falling during the earthquake.
- Pull down and close shutters or draw curtains, as protection from flying glass, especially for windows that are near the bed in the event of an earthquake occurring at night while people are asleep.

Ensure that a stock of appropriate supply of the following is kept handy:

- Food and drinking water.
- First-aid kit and essential medicine.
- Flashlight with extra batteries, keep them in several locations.
- Portable radio with extra batteries. Radio will be the best source of information following the earthquake especially if the electricity goes out.
- Don't forget to store adequate supplies in each vehicle in case you are driving when a tremor occurs.

4.2 During an earthquake

STAY CALM. If indoors, stay indoors. If you are outdoors, stay outdoors. Many injuries occur when people enter or leave buildings.

If you are indoor:

- Stay inside. Move away from windows, doors, tall cabinets, breakables or heavy objects that could fall. Take cover under a sturdy desk or table and hold on or stay against an interior wall or column. Remember that most fatal injuries are head wounds, therefore, DROP, COVER AND HOLD.

Taking propered and safe place during an earthquake through DROP, COVER AND HOLD.

- If one must leave a building, do so in an orderly manner. Rushing to get out can result in injuries. Do not use the elevator. As a precaution against possible fires, use the stairs.

If you are outdoors:

- Move to a clear area away from the trees, signs, buildings, electrical wires and poles. DROP AND COVER your head until the shaking stops.

If you are in a vehicle:

- Stop and remain inside until the shaking stops. Avoid buildings, overpasses, bridges, power lines, and roads beside ravines and cliffs in which landslides may occur. Be cautious of possible road damages while proceed.

After an earthquake, bridges, overpasses could be damaged. Avoid passing through them.

4.3 After an earthquake

- Check yourself for injuries. Protect yourself from further injuries caused by broken objects.
- After an earthquake, expect aftershocks.
- Check the buildings for damages. You may have to leave the building if it is seriously damaged or prone to collapse during the aftershock.

After an earthquake, if your building is damaged and prone to collapse during the aftershocks, leave the building immediately, move to an open field.

- Keep away from buildings, electricity wires, stairs and walls which are liable to collapse.
- If there is fire, call the fire department and try to extinguish the fire.
- If there is heavy smoke, crawl to get out of the building; fresh air will be close to the floor.
- Do not use matches, turn off electrical switches and use battery-operated flashlights. Light sparks can trigger fire or explosion if there is gas leak.

- Inspect the utilities in the buildings. Shut off their valves if there is damage.
- If water pipes are damaged, avoid using water from the tap as it may be unsafe.
- Clean up spilled medicine, gasoline or other inflammable liquids immediately.
- Leave the area if you smell gas or fumes from other chemicals.
- Check others for injuries, give first aid. Do not attempt to move seriously injured persons unless they are in danger.

Providing quick first aid after an earthquake.

- Be prepared for aftershocks. Plan on where you will take cover when they occur. Each time you feel one, DROP, COVER and HOLD.

- If your area is close to dams and reservoirs, there is possibility of damage and leakage of dams. Be alert for the flood due to leakage of dams. If there is flood, evacuate to a safe location.
- If your area is close to dams and reservoirs, there is possibility of damage and leakage of dams. Be alert for the flood due to leakage of dams. If there is flood, evacuate to a safe location.

References:

ADPC. 2004. *Community-based Disaster Risk Management: Field practitioners' Handbook*.

ADPC. 2006. *CBDRM for Local Authorities*.

ADPC.et al. 2009. *Hazard Profile of Myanmar.*

ADPC. *Living with Earthquakes*.

C.V.R.Murty. March 2005. *Earthquake Tips: Learning Earthquake Design and Construction.* National Information Center of Earthquake Engineering Indian Institute of Technology Kanpur.

Central Board of Secondary Education, Delhi. 2007. *Together towards a Safer India – I, An Introduction to Disaster Management for Class VIII.*

Dr. Win Swe. Sept 2009. "*An overview of earthquake and earthquake hazards in Myanmar*", Power Point Presentation at DRR workshop, Mandalay

John Twigg, March 2004, *Good Practice Review, Disaster risk reduction, Mitigation and preparedness in development and emergency programme.*

National Disaster Management Division, GoI, MHA. *Hazards, Disasters and Your Community.*

NDMA, GoI. 2007. *National Disaster Management Guidelines : Management of Earthquakes*.

http://earthquake.usgs.gov/

www.geo.mtu.edu/volcanoes/hazards/primer/eq.htmlv

http://quake.wr.usgs.gov/prepare/factsheets/RiskMaps/

http://www.redcross.org/services/disaster/be prepared/

http://www.fema.gov/library/prepandprev.s htm#earthquakes

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MANUAL ON EARTHQUAKE

Causes, Effects & Preparedness

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