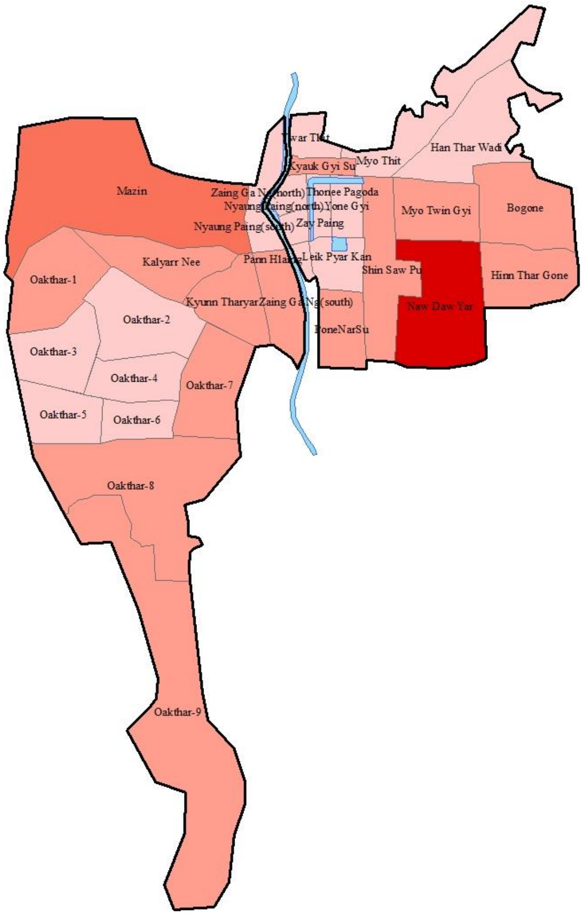
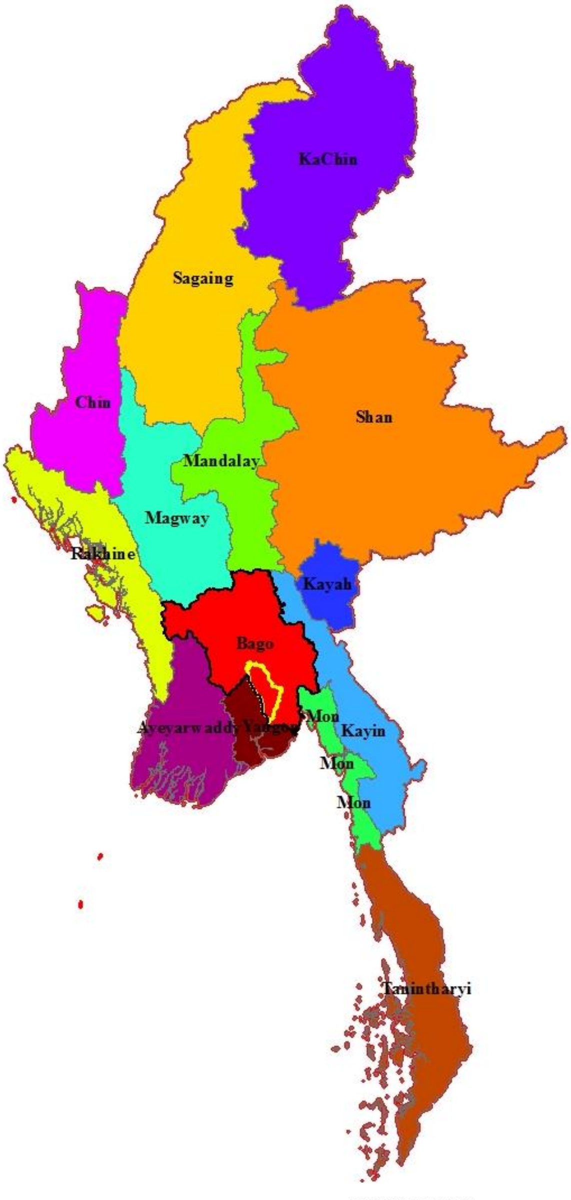
ENHANCING AND DEVELOPING SEISMIC RISK ASSESSMENT FOR BAGO CITY OF MYANMAR





Safer Costal and Urban Communities through Inclusive Disaster Risk Reduction in Myanmar

Project Funded by DIPECHO

December, 2015

Background

Myanmar is prone to earthquakes. It lies on Alphide Belts, one of the two main earthquake belts of the world with a complex seismotectonic processes. The major 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, and the Kyaukkyan Fault situated west of Naungcho. The Sagaing fault is the most prominent active fault in Myanmar which extends from north of Lake Indawgyi southward along the Ayeyarwaddy River north of Mandalay and along the eastern margin of the BagoYoma to the Andaman Sea (Hazard Profile of Myanmar, Sato, 2009). According to a recent study, on relocation of historical earthquakes since 1918 along the Sagiang Fault, considering the length of the first seismic gap (~260 km), a future earthquake of up to M ~7.9 is expected to occur in central Myanmar (Nobuo Hurukawa and Phyo Maung Maung, 2011).

Besides, over the past three decades, urbanization in Myanmar has been rapidly increasing. As a result, many of Myanmar's urban cities developed in the proximity of active seismic sources and are at risk of experiencing major earthquake events. Seismic risk cannot be eliminated, but it can be effectively analyzed and possibly reduced by using proper tools and models to produce reliable and meaningful estimates of the seismic risk facing a community, and exposure. Considering the majority of the building stock in both urban and rural areas comprising of non-engineered structures such as made of wood, brick, reinforced concrete, there is an increasing concern on the potential damage to urban areas.In this regard, as a first step it has been proposed to carry out earthquake related risk assessments in three cities of Myanmar: Sagaing, Bago, and Taungoo. All three cities are lying on the Sagaing fault line, however no studies have been carried out assess their earthquake related risk.

In addition, Sagaing, Taungoo and Bago all have a population of more than 100,000 people and have also undergone recent urban developments with the construction of three storey buildings. Furthermore, Sagaing and Bago have a significant socio-economic importance, being the capitals of their respective regions. Therefore, this study tends to develop the seismic risk assessment in Bago City. The study findings will lead to develop comprehensive risk reduction programs addressing the specific vulnerabilities as well as guide the future development in the cities along with UN-Habitat's Myanmar Comprehensive Disaster Risk Reduction Programme and also with broader DRR-WG activities and those of Government. The main objective of this paper is to estimate the damages and casualties in Bago City.

Bago City

Bago City is located in Bago Region and it is bounded by Waw (east), Thanatpin (southeast), Kawa (south), Daik-U (north) Townships and Hlegu Township in Yangon Region (west and southwest). The geographic location of the study area is defined by Lat. 17˚14′ to 17˚50′ N and Long. 96˚24′ to 96˚41′E. The area is approximately 1121.66 square miles (2871.449 km^2) and the population is nearly about 300,000 people. The study area is situated on the Major Highway Car Road and Railway of Yangon-Mandalay and Yangon-Mawlamyaing. Since the area is nearly about 50 miles (80 km) from Yangon City, there is easily accessible by car and train. Figure (1) represents the location map of the study area and Famous places in Bago city are as shown in Figure (2).

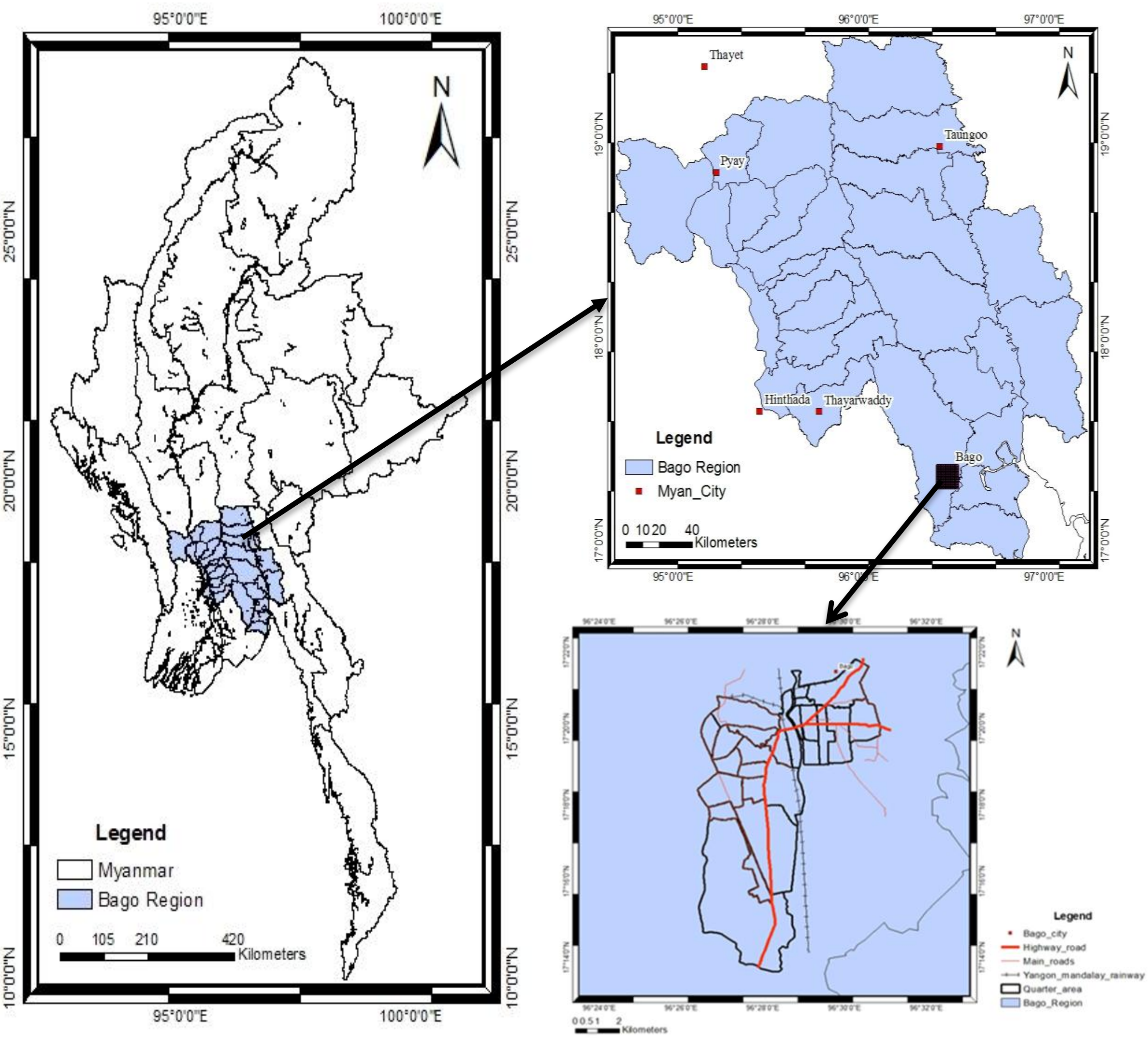


Figure (1) Location Map of the Study Area

Figure (2) Famous Places in Bago City

Active Faults of the Study Area

Bago City is situated in a highly seismically active region which has experienced many disastrous earthquakes during historical time. The well-known Bago earthquake, struck on May 5, 1930 with the magnitude of 7.3, caused 500 casualties and a certain amount of damage in Bago while caused 50 deaths and great damages in Yangon.

Bago region is also bounded by other faults such as Gwegyo Thrust fault and West Bago Yoma fault in the west, Kyaukkyan fault in the east and Papun fault in the south eastern part of the region. Based on the above mentioned, the seismic hazards for Bago City can be expected in the future. Sagaing fault is the north-south trending right-lateral strike-slip fault. The intermittent jerks along this fault caused major earthquakes at (from south to north) Bago (July 5, 1917 - M_w 7) and (May 5, 1930 - M_w 7.3), Phyu (December 3, 1930 - M_w 7.3), Swa (August 8, 1929 - M_w 7), Inwa (March 23, 1839 - M_w > 7?), Amarapura (July 16, 1956 – M_w 7), Bagan (July 8, 1975- M_w 6.8), Sagaing (July 16, 1956 - M_w 7), Tagaung (January 5, 1991 - M_w 7.3), Wuntho (September 13, 1946 - M_w 7.5), Myitkyina (January 27, 1931 - M_w 7.6) and Putao (August 31, 1906 - M_w 7). Sagaing Fault and Other Active Faults around Bago Region and Myanmar are shown in Figure (3).

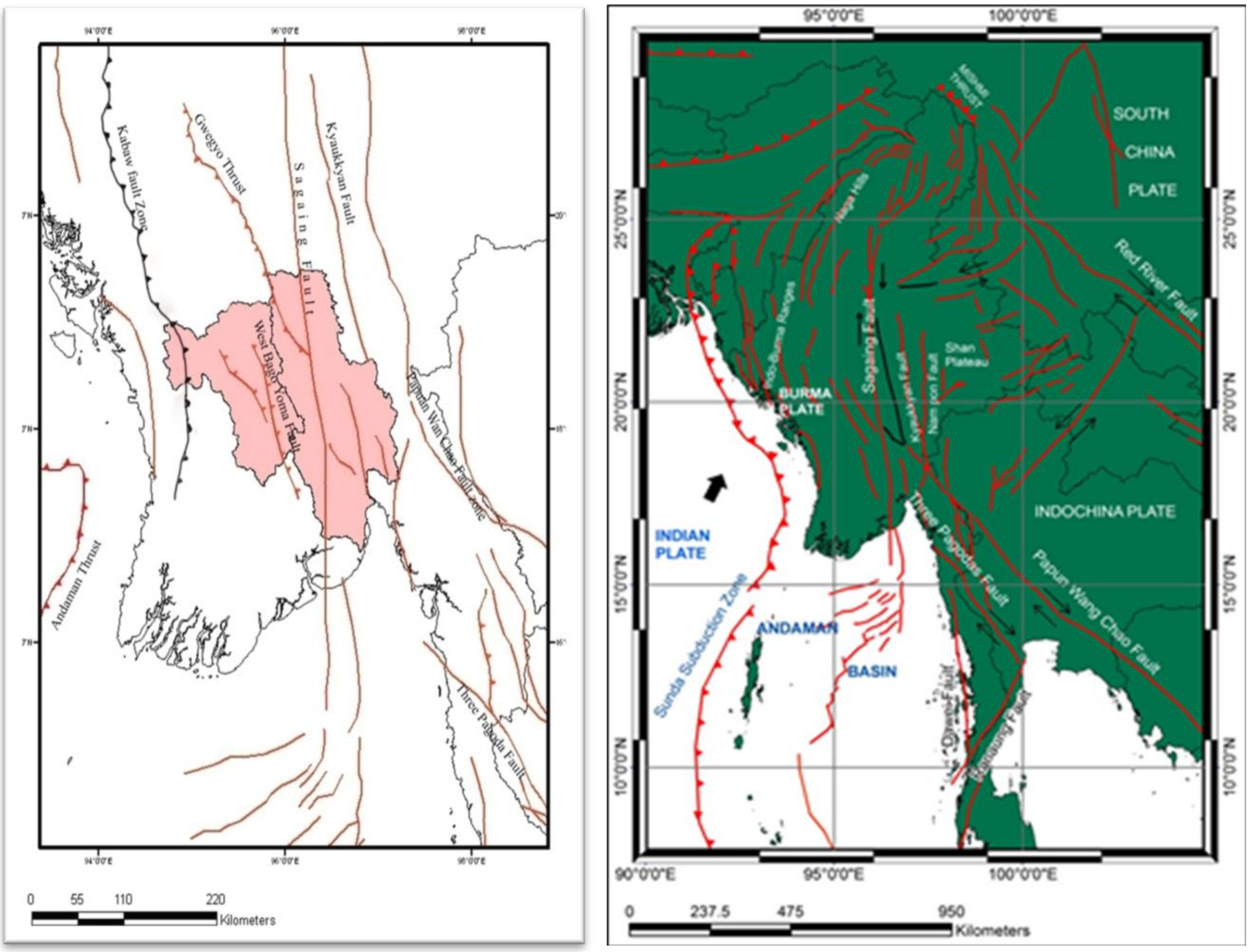


Figure (3) Sagaing Fault and Other Active Faults around Bago Region and Myanmar

Methodology

HAZUS methodology for earthquake loss estimation model is herein used for this project. The earthquake loss estimation methodology can develop the preliminary estimation of damages to prepare before disaster situation and to plan and stimulate efforts how to reduce probable risk from earthquake. Socio-economic profiling and inventory of critical infrastructures of Bago City is undertaken by surveying in the field. Perform 3D and Etabs structural software are used for the analysis of representative building types in Bago City. HAZUS and Arc GIS Softwares are used in the development of probabilistic sesismic hazard map of Bago City.

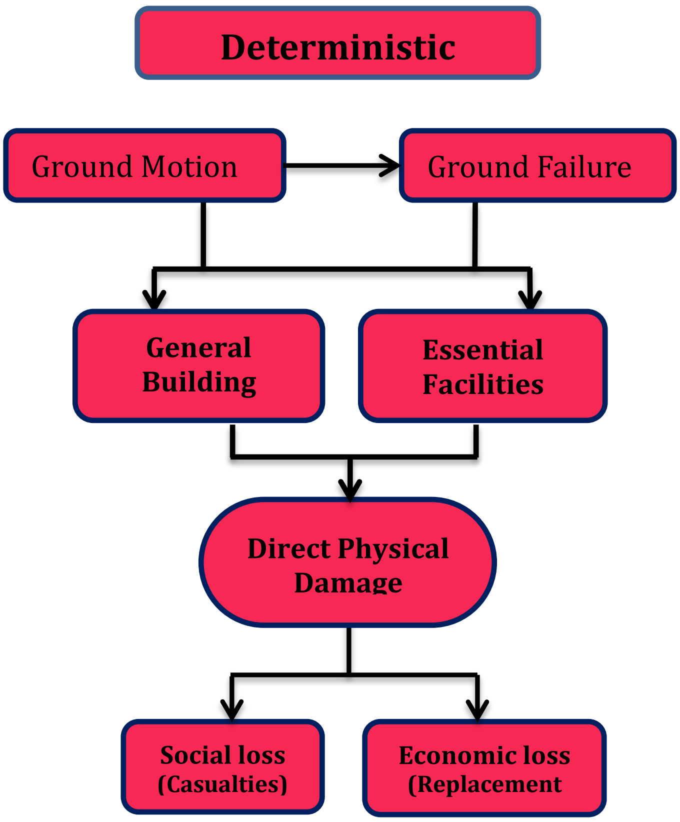


Figure (4) Flow Chart of the Earthquake Loss Estimation Methodology adopted by HAZUS

Building Inventory

This section deals with the general building stock, essential facilities, and high potential loss facilities.

General Building Stock

Inventory data for general building stock are prepared for each occupancy classes as per HAZUS requirement. Building count data by occupancy class for each ward is collected from the field. Square footage is the total floor area (per 1000 ft2) in which estimated floor area multiplied by the number of story and divided by 1000. Replacement value (per $1000) is the estimated local PAE rate ($ per ft2) for specific structure type multiplied by square footage for each occupancy class and divided by 1000, which can be done by using occupancy matrix. Content value (per $1000) is the percentage of replacement cost as per HAZUS. Demographic data is taken from local government office and prepared as per HAZUS attribute format. Occupancy Mapping for this area is developed by the on street survey data.

$$\text{Square Footage } (\text{ft}^2 \text{ per } 1000) = \frac{\text{Estimated floor area } * \text{ No. of Story}}{1000}$$

$$Replacement\ cost\ (\$\ per\ 1000) = \frac{\text{Estimated PAE rate} * \text{ square footage}}{1000}$$

$$Content\ cost\ (\$\ per\ 1000) = \%\ of\ Replacement\ Cost$$

The general building stock (GBS) includes residential, commercial, industrial, agricultural, religious, government, and educational buildings. The geographical size of the Bago city is 12.56 square miles and contains 31 census tracts (wards). There are over 50 thousand households in the region with a total population of 296,098 people (Ward Level Census data). The inventory information required for the analysis to evaluate the probability of damage to occupancy classes is the relationship between the specific occupancy class and the model building types. This can be computed directly from the specific occupancy class square footage inventory. The distribution of Structural and Occupancy Type is provided in Table (2) and (3). There are an estimated 40 thousand buildings in the study area with a total building replacement value (excluding contents) of 803 (millions of dollars). Approximately 90.00 % of the buildings (and 80.00% of the building value) are associated with residential housing. All these data is collected from study area by visiting the ward level officers through General Administrative Department. Estimated PAE rate ($ per sqft) for Replacement cost is collected from City Development Organization and Local construction site. From field survey data, there are five different types based on structural behavior as shown in Table (1).

Table 1 Definition of Structural Type

Timber (W1)	Timber, Light Frame (< 5,000 sq. ft.)
Brick-nogging (RML)	Unreinforced Masonry Bearing Walls with Wood Diaphragms
Brick Masonry (URML)	Unreinforced Masonry Bearing Walls
Reinforced Concrete (RC)	Concrete Frame with Unreinforced Masonry Infill Walls
Mixed-use (MH)	Other Type of Building or Mixed use buildings

Reinforced Concrete Building (RC)

Bricknogging Building (RML)

Mixed-use Building (MH)