SEISMIC MAPPING FOR TELECOMMUNICATION TOWERS IN MALAYSIA

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Abstract: Natural disaster like earthquake can affect the telecommunication facilities seriously. Although Malaysia is generally spared from major seismic activities, earthquakes events in neighboring countries can be felt locally. This has raised a major concern whether the existing structures being able to withstand earthquake effects in future. A proper management of telecommunication structures will allow transmission of news is not affected during the disaster strikes. Using the existing Peak Ground Acceleration (PGA) map, a seismic map locating all telecommunication towers in the country was developed. The outcome will aid in the subsequent part of the study and will also enable the researcher to identify the location of the most critical towers in the various seismic zones that may have great impact upon exposure from earthquakes events. It will also aid in defining priorities and establish programs to apply available resources for tower maintenance purposes nationwide. The necessary steps and mitigation action also can be taken to assists the relevant authority in making preparation from an emergency-management and hazard-preparedness perspective considering earthquake effects in Malaysia.

Keywords: *Earthquakes, seismic mapping, peak ground acceleration, telecommunication towers, tower maintenance.*

1.0 Introduction

Since its independence over the past 55 years, in parallel with the strong emergence of the telecommunication industry a large number of self supporting towers have been erected throughout Malaysia. With the divergence of the high speed broadband projects initiated by the Malaysian government in mid 2008, more telecommunication towers are being and erected to cater for the country's needs. Furthermore with the Government Transformation Programme (GTP) which has been launched by the Prime Minister in 2010 is an ambitious, broad based initiative aimed at addressing key areas of concern to the people while supporting Malaysia's transformation into a developed and high-income nation as per Vision 2020 (PEMANDU, 2010).

Malaysia is situated on the southern edge of the Eurasian plate within the most two seismically active plate boundaries. Several possible active faults have been delineated and local earthquakes in East Malaysia appear to be related to some of them. According to Tjia (1983), in Sabah and Sarawak historical and instrumental seismicity recorded the presence of several earthquake epicenters that reflect their present-day tectonic setting. Due to its strategic location, Malaysia is generally spared from any major active seismic activities. However, when earthquakes occur in neighboring countries, the effects can be felt locally (Jurutera, 2008). Substantial damage to buildings has also been reported as on July, 1976 and on May, 1991 in Tawau, Lahad Datu and Ranau areas respectively (Lim, 1977; Lim and Godwin, 1992). Adnan *et al*.(2005) in their study which included several items such as the tectonic setting of Sumatra, location, mechanism and size of the recent earthquake and also analysis of ground at bedrock for Penang and Kuala Lumpur using several appropriate attenuation relationships has shown that the Sumatra Earthquake did have some effect to the Malaysian Peninsular.

After the 2004 tsunami disaster that strikes Aceh, the Malaysian government has taken early initiatives to look into the impact of earthquake events originating from our neighbours. Important buildings and sensitive structures such as telecommunication towers are among the most crucial to be looked upon. The Standard Operating Procedure (SOP) for Managing Earthquake Disaster (2007) which rules out the guidelines and the responsibilities of all relevant departments and agencies in handling and managing such disaster has been drafted. This is to ensure that the operations will runs smoothly and systematically in facing such events. As mentioned by Smith (2007) the 1995 Kobe earthquake is a good example where communication facilities malfunction has given a big impact. This event was said to have prevented local governments from knowing the level and the scope of casualties caused by the disaster. According to Faridafshin *et al*. (2008) the preservation of serviceable communication infrastructure as critical links of communication or post disaster networks is essential in the event of an earthquake. In the 2011 Fukushima earthquake, communications were badly broken and knocked out where many residents are relying on the small number of surviving pay phones.

According to Kramer (1992), in a major emergency caused by an earthquake it is likely that telephone lines may be down, other alarm and telecommunications facilities are adversely affected, and a vast increase in the work load imposed upon personnel and equipment in the control centre. One distinguishing characteristics is the dramatic increase in the number of people who must make use and communicate among them. The malfunction of the communication facilities immediately after an earthquake struck other countries should be a lesson learned especially for telecommunication service providers in Malaysia.

Telecommunication towers are categorised among the tallest man-made structures and can be found standing high on every part of the globe with different heights and purposes. These specifically light and slender structures are particularly sensitive to the environmental loads to which they are subjected but also to ground movements. McClure (1999) quoted a survey of the earthquake performance of communication structures that summarised documented reports of 16 instances of structural damage related to seven important earthquakes between 1949 to 1998, none of which were a direct threat to life safety. However, several towers may have been damaged or have become unserviceable without having collapsed or suffered damage visible from the ground during post earthquake inspections. Many strong earthquakes have happened since then and more damage has been reported as more telecommunication equipment is deployed worldwide.

Since Telekom Malaysia (TM) being the major telecommunication service provider in the country possessed many high structures including hundreds of telecommunication towers nationwide, therefore it is of vital importance to monitor the safety of all its tower structures due to the earthquake effects.

2.0 Mapping for Telecommunication Tower Structures

2.1 Seismic Characteristics of the Area

The safety issue of building structures including sensitive structures in Malaysia has always been of public concern and has been highlighted after the 2004 earthquake which triggered tsunami that caused a number of fatalities (Delfebriyadi, 2011). The country too experienced direct impact by seismic waves emanating from earthquakes in Sumatra. As was mentioned in the Position Paper report (IEM, 2005) a seismic hazard assessment has been carried out in the country in 2004. The outcome indicates that a PGA of 50 gals (for 500 years return period) has been determined for 'before Aceh's event' and PGA value of 100 gals has been ascertained for 'after Aceh's event'. It was also noted that the earthquake characteristic that has affected the structures here was of that with a long period of vibration. Table 1 summarises the 500 and 2500 year return period for Malaysia.

Table 1: Summary of 500 and 2500 Year Return Period Based on CIDB and PWD for Malaysia

500 Year Return Period Based on CIDB for Peninsular Malaysia	**500 Year Return Period Based on PWD for East Malaysia**
20 - 40 gals	60 - 80 gals
40 - 60 gals	80 - 100 gals
60 - 80 gals	100 - 120 gals
80 - 100 gals	-
2500 Year Return Period Based on CIDB for Peninsular Malaysia	**2500 Year Return Period Based on PWD for East Malaysia**
40 - 60 gals	160 - 180 gals
60 - 80 gals	180 - 220 gals
80 - 100 gals	
100 - 120 gals	
120 - 140 gals	
140 - 160 gals	
160 - 180 gals	

Preliminary study carried out by Adnan *et al*. (2006) on soil samples of five cities in the West coast of Peninsular Malaysia has shown that the average local soil amplification ranges from 1.4 to 3.6. Since the soil condition in many parts of the country is underlain of limestone bedrock the study implies that the local soil effect could not be neglected. Incident of sinkholes in ex-mining area with loose sand and tailings have occurred (Komoo, 2005). The geological predisposition was 'ripe' for the popping-up of sinkholes, and the earthquake tremor provided the 'triggering' factor.

Considering the current needs, immediate steps for mapping telecommunication towers on seismic hazard map will help to identify the location in the most critical zones so that necessary steps and mitigation action can be taken to assists the relevant authority in making preparation from an emergency-management and hazard-preparedness perspective.

2.2 Seismic hazard map

Most countries affected by earthquake have developed their own seismic map. One good example is Japan, which has published the "National Seismic Hazard Maps of Japan" in 2005 on the basis of a long-term evaluation of seismic activity and a strong-motion evaluation. Hiroyuki *et al*. (2006) mentioned that there are two types of hazard map being developed; one is the probabilistic seismic hazard map (PSHM) and the other is the scenario earthquake shaking map (SESM).

Malaysia has made efforts to produce its own map. There are four basic seismic maps being produced by the Construction Industry and Development Board (CIDB) and the Public Works Department (PWD). The maps are the Peak Ground Acceleration (PGA) Map for 500 and 2500 Year Return Period Based on CIDB for Peninsular Malaysia, PGA Map for 500 and 2500 Year Return Period Based on PWD for East Malaysia. These maps indicate the various peak ground accelerations in the country according to the various zones identified.

2.3. Towers for seismic mapping

In this study, all the 489 numbers of four legged type self supporting steel towers in Malaysia are mapped. There are of various heights and are mapped according to low rise, medium rise and high rise categories. Almost half of the total towers mapped in Peninsular especially in northern and central part are exposed to seismic effects from Sumatera while those in East Malaysia are exposed towards the Philippines seismic effects. Data for all the towers used in the study are fully managed by TM and are obtained from Telekom Asset Management System (TeAMS).

2.4. Seismic zones in Malaysia

Table 2 the summarises the seismic zones identified in Malaysia ranging from Zone 0 to Zone 4. The study has been conducted only in three critical zones which are Zone 1, 2A and 2B.

Table 2: Seismic Zones in Malaysia

Peak Ground Acceleration (gals)	Seismic Zone	Seismic Zone Factor (Z)
0 - 40	0	0.0
41 - 80	1	0.075
81 - 100	2A	0.15
101 - 150	2B	0.20
151 - 300	3	0.30
301 - 500	4	0.40

2.5. Mapping of TM Towers in Seismic Zones

Due to the frequent earthquake effects experienced, it is of urgent need for the country to consider on the safety of its telecommunication infrastructure. All the 4 legged type self supporting steel telecommunication towers are mapped using the existing PGA Map from CIDB and PWD including data obtained from TeAMS. The final output was a PGA Map for 500 year Return Period and PGA Map for 2500 year Return Period locating all telecommunication towers in the country.

2.5.1 Procedure of Mapping

(i) Firstly all towers information is accessed from TeAMS. The web based system for data information can be accessed via http:intra.tm.teams. Only 4 legged self supporting steel towers on ground level are selected. The summary of the towers are shown in Table 3.

Table 3: Summary of TM telecommunication steel towers for seismic mapping

Zones	States	Number of Towers
Peninsular Malaysia		
Northern	Perlis, Kedah, Pulau Pinang & Perak	92
Central	Selangor & Wilayah Persekutuan Kuala Lumpur	42
Southern	Negeri Sembilan, Melaka & Johor	69
Eastern	Kelantan, Terengganu & Pahang	81
East Malaysia	Sabah & Sarawak	205
Total		**489**

Source: TM (Data as of 2009 TeAMS)

Then the towers are categorised according to their heights. This is summarised in Table 4. The medium rise category was considered when the height of the tower lies within 19.81 meters and 73.15 meters while for the high rise category was considered when the height of tower is above 73.15 meters. No low rise category was carried out since tower under this height are located on building roof tops.

Table 4: Towers Classifications

Tower Classification	Tower Height (meter)
i) Low Rise	$H < 19.81$
ii) Middle Rise	$19.81 \leq H \leq 73.15$
iii) High Rise	$H > 73.15$

Colors indicative are assigned for easy plotting /mapping as well as identifictaion purposes.

(ii) From the Longitude and Latitude information of each tower which is in World Geodetic System 1984 (WGS84) ordinates, it is then converted to Rectified Skew Orthomorphic (RSO) and Cassini System. The WGS 84 is currently the reference system being used by the Global Positioning System. It is geocentric and globally consistent within ±1 m.

For RSO Systems and Cassini System, the Longitude and Latitude coordinates are changed to North and East ordinates. Examples are as shown in Table 5 below.

Table 5: Sample of conversion of TM tower coordinates

Longitude		**Latitude**		**Cassini System**	
North	**East**	**North**	**East**		
5° 36' 24"	100° 55'2"	620494.482	711003.369	-39580.575	31116.875
5°10'10"	100°34'0"	572310,496	286653.091	-87938.631	-7724.273
6°25'23"	**100°25'38"**	**711003.369**	**271851.621**	**50707.975**	**-23130.329**

From TeAMS, all existing towers locations which are in longitude and latitude coordinates are converted to Cassini System for plotting purposes. Figure 1 shows the method of conversion of coordinates to Cassini System.

(i) Mapping of Towers.

The coordinates are then mapped respectively on all the 4 types of existing seismic maps. There are 4 types of maps used to position the towers i.e.:-

(a) PGA Map for 500 Year Return Period Based on CIDB for Peninsular Malaysia.
(b) PGA Map for 500 Year Return Period Based on PWD for East Malaysia.
(c) PGA Map for 2500 Year Return Period Based on CIDB for Peninsular Malaysia.
(d) PGA Map for 2500 Year Return Period Based on PWD for East Malaysia.

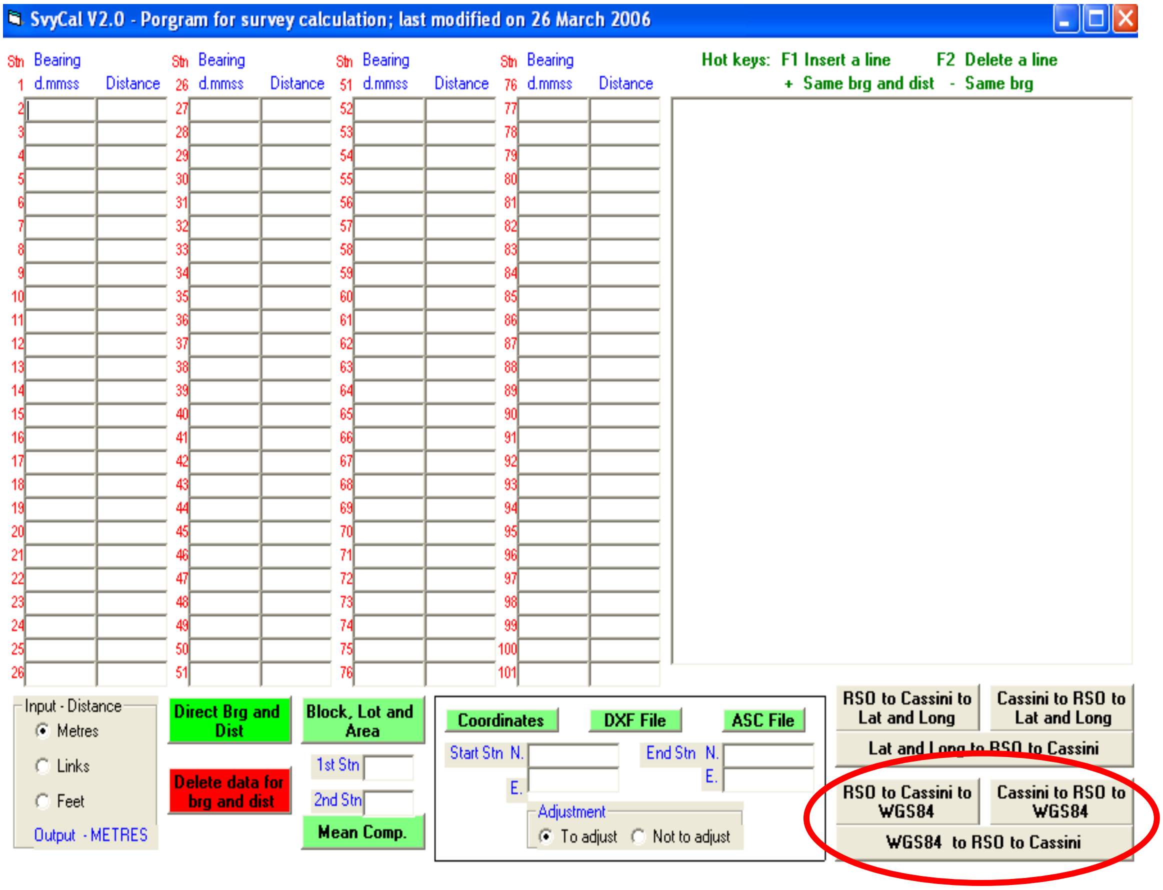

Figure 1: Conversion of coordinates to Cassini System

2.6. *Output on Seismic Mapping of Telecommunication Towers for Malaysia*

The final outputs of the seismic mapping for all of the towers are as shown below. (Refer Figure 2 to Figure 5).

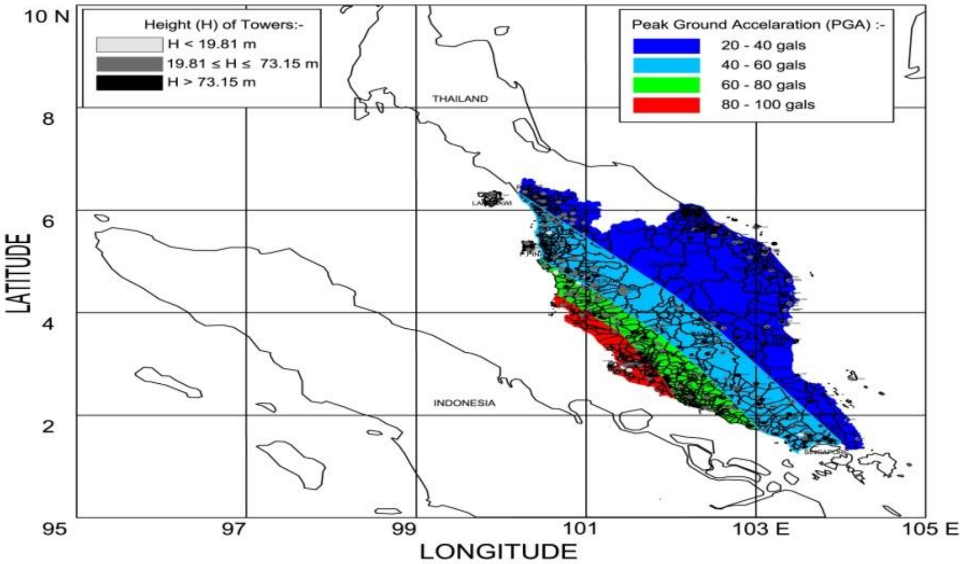

Figure 2: Seismic mapping for telecommunication towers for 500 year return period for Peninsular Malaysia

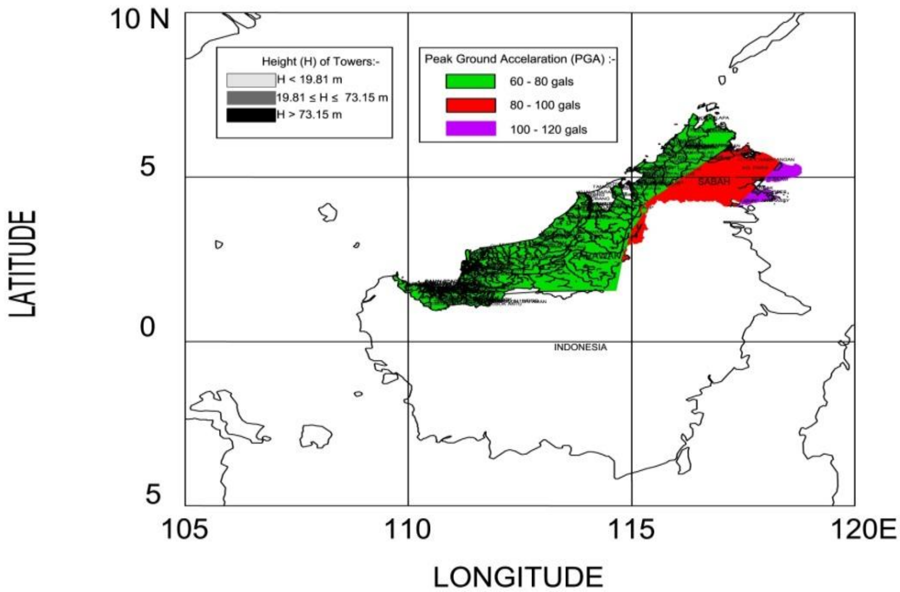

Figure 3: Seismic mapping for telecommunication towers for 500 year return period for East Malaysia

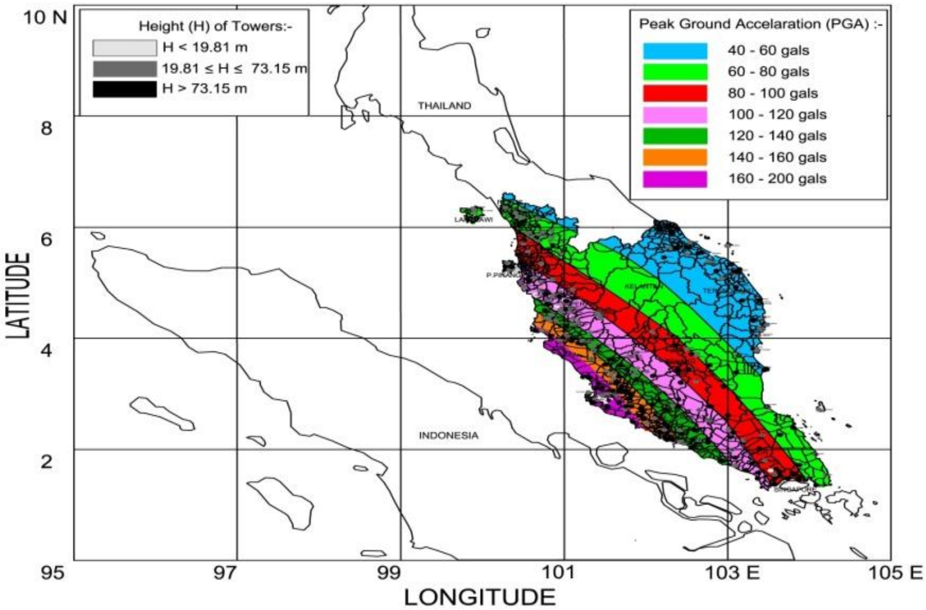

Figure 4: Seismic mapping for telecommunication towers for 2500 year return period for Peninsular Malaysia

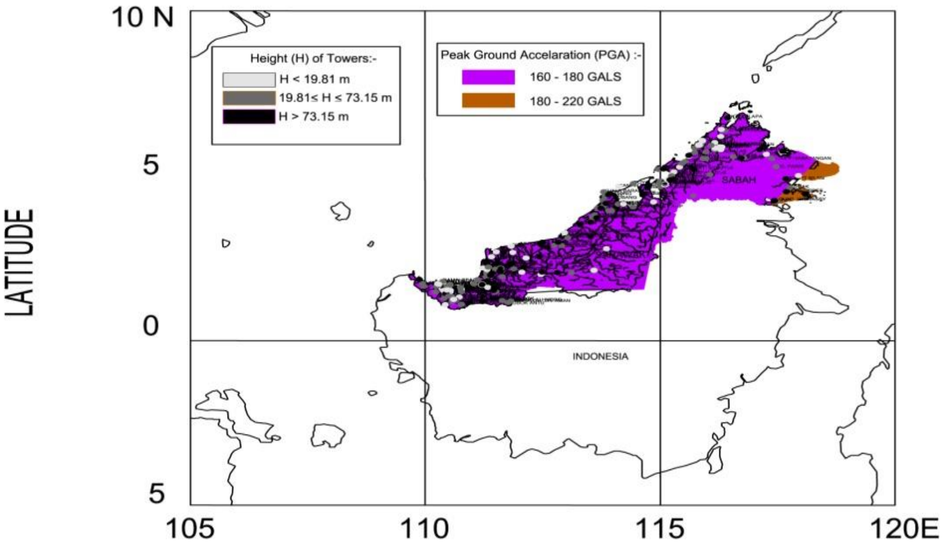

Figure 5: Seismic mapping for telecommunication towers for 2500 year return period for East Malaysia

The simplified work process for developing the TM towers map is summarized as shown in Figure 6 below.

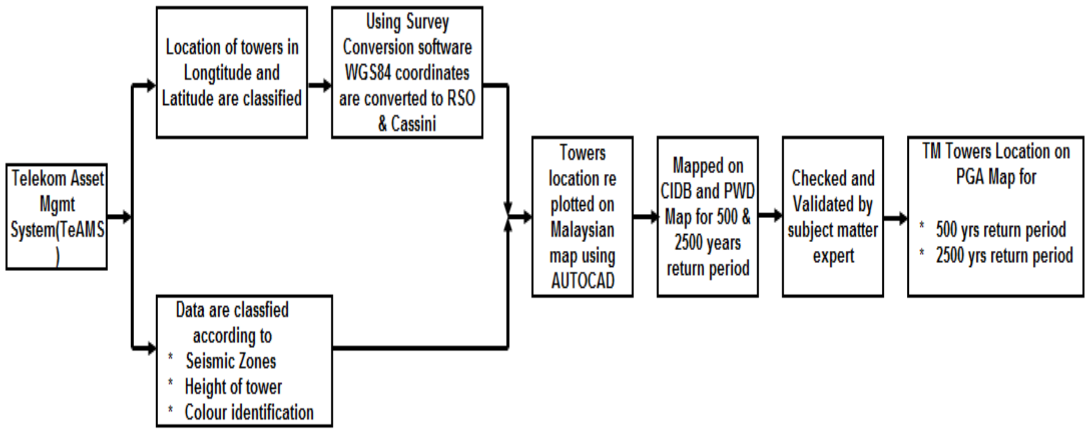

Figure 6: Simplified Process of Seismic Mapping for TM Telecommunication Towers in Malaysia

3.0 Conclusions

Through the maps, there is an ease to locate all the telecommunication towers on each seismic zone in the country. The location is very important since this will help in subsequent part of the study and will also enable the researcher to identify the location of the most critical towers in the various seismic zones that may have great impact upon exposure from earthquakes events. Besides that, it will aid in define priorities and establish programs to apply available resources for maintenance purposes nationwide. The necessary steps and mitigation action also can be taken to assists the relevant authority in making preparation from an emergency-management and hazard-preparedness perspective considering earthquake effects in Malaysia.

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