UNIVERSITI PUTRA MALAYSIA

SEISMIC ANALYSIS OF A 30 STORY SALEMBA APARTMENT IN JAKARTA SUBJECTED TO NABIRE EARTHQUAKE EXCITATION

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By

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ABSTRACT

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

SEISMIC ANALYSIS OF A 30 STORY SALEMBA APARTMENT IN JAKARTA SUBJECTED TO NABIRE EARTHQUAKE EXCITATION

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May 2006

Chairman: Associate Professor Dr. Jamalodin Noorzaei

Faculty: Engineering

The earthquake loading as a lateral loading should be taken into account in the analysis of a highrise building, especially for places in high seismic zones. The acceleration of ground motion of the Nabire earthquake in Indonesia will be analyzed and the response spectrum will be constructed by using DADISP software.

There are three components of Nabire earthquake record that was recorded using an accelerograph, which are the horizontal component north south direction (BHN), east west direction (BHE) and the vertical direction (BHZ). The horizontal component

north- south direction with peak ground acceleration (PGA) of about 400 cm/s^2 will be used to construct the response spectrum.

The static equivalent lateral forces analysis based on the Indonesia seismic code procedure will be used to estimate the seismic loading. The constructed Nabire response spectrum will be applied in the analysis.

The earthquake loading produced will be applied to the actual building in Jakarta (30 storey Salemba apartment) which use shear wall as structural element to resist earthquake motion.

A single cantilever critical shear wall will be analyzed and designed by using structural computation software (STAADPRO).

ABSTRAK

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

ANALISIS BEBAN GEMPA NABIRE TERHADAP BANGUNAN PANGSAPURI SALEMBA 30 TINGKAT DI JAKARTA

Oleh

MELDI SUHATRIL

Mei 2006

Pengerusi: Profesor Madya Dr. Jamalodin Noorzaei

Fakulti: Kejuruteraan

Beban gempa bumi sebagai beban horizontal seharusnya diambil kira dalam analisis bangunan tinggi, terutamanya bagi kawasan yang berada di kawasan gempa tinggi. Percepatan pergerakan tanah dan gempa bumi Nabire di Indonesia akan di analisa dan selanjutnya respons spectrum akan di bentuk menggunakan perisian DADISP.

Terdapat tiga komponen rakaman gempa bumi Nabire yang dirakam menggunakan akselerograf, iaitu komponen horizontal arah utara-selatan (BHN), arah timur-barat (BHE) dan komponen menegak (BHZ). Komponen horizontal arah utara-selatan

dengan percepatan tanah puncak kira-kira 400 cm/s^2 akan digunakan untuk membentuk respons spectrum.

Analisis daya static equivalent berdasarkan prosedur kod gempa Indonesia akan digunakan untuk menganggarkan beban gempa. Respons spectrum Nabire yang dibentuk akan diaplikasikan dalam analisis.

Beban gempa yang dihasilkan akan diaplikasikan kepada bangunan sebenar di Jakarta iaitu pangsapuri Salemba yang menggunakan dinding shear sebagai struktur elemen yang akan menahan pergerakan gempa.

Satu cantilever dinding shear yang kritikal akan dianalisa dan direkabentuk dengan menggunakan program perhitungan struktur iaitu perisian STAADPRO.

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Without all the commitment given I would not be able to complete this research project which is the condition as fulfillment of the requirement for the degree of Masters of Science at University Putra Malaysia.

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LIST OF ABBREVIATIONS/NOTATIONS/GLOSSARY OF TERMS

BS	-	British Standard
DADiSP	-	Design Analysis Display Software
NEHRP	-	National Earthquake Hazards Reduction Program
ELF	-	Equivalent Lateral Force
UBC	-	Uniform Building Code
BSSC	-	Building Seismic Safety Council
USGS	-	US geological Survey
PSHA	-	Probabilistic Seismic Hazard Analysis
ASCE	-	American Society of Civil Engineers
ACI	-	American Concrete Institute
EPA	-	Effective peak ground acceleration
MMI	-	Modified Mercally Intensity
GMT	-	Great Meridian Time
WIT	-	Eastern Indonesian Time
BMG	-	Meteorology and Geophysics Bureau
BHN	-	Horizontal earthquake component (North – South direction)
BHE	-	Horizontal earthquake component (East – West direction)
BHZ	-	Vertical earthquake component
PGA	-	Peak ground acceleration
e.g.	-	example
i.e.	-	which is
etc	-	etcetera, so on

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.

MELDI SUHATRIL

Date:

APPROVAL

I certify that an Examination Committee met on **date of viva** to conduct the final examination of Meldi Suhartil on his Masters of Science degree thesis entitled Seismic analysis of a 30 story Salemba apartment in Jakarta subjected to Nabire earthquake excitation in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. the committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Masters of Science. The members of the Supervisory Committee are as follows:

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CHAPTER 1

INTRODUCTION

1.1 Background

There are many disasters in the world caused by earthquake hazards. For engineering purposes, we try to reduce seismic hazard toward infrastructure and superstructure of the building. By reducing the seismic hazards, it would mean that the number of deaths due to earthquake hazard can also be reduced.

In recent times, earthquake hazards have been happening in Peninsular Malaysia. Even though Malaysia is not in a high seismic zone but it is surrounded by countries that are in high seismic areas. Thus Malaysia can feel the vibrations as well.

Most earthquakes that can have an effect on Malaysia are from Sumatra Indonesia. Sumatra is a big island nearest to Peninsular Malaysia that is separated by the straits of Malacca. Sumatra is divided into six states (better known as provinces) which are Nangro, Aceh, North Sumatra, Riau, West Sumatra, Jambi and South Sumatra.

On 26th December 2004, the tsunami in Aceh, Indonesia had destroyed some parts of Penang. After that almost every earthquake vibration felt in Sumatra was also felt in Peninsular Malaysia. Therefore, the effects of earthquake hazard in Sumatra should be considered for all structures in Peninsular Malaysia, especially bridges and high-rise buildings.

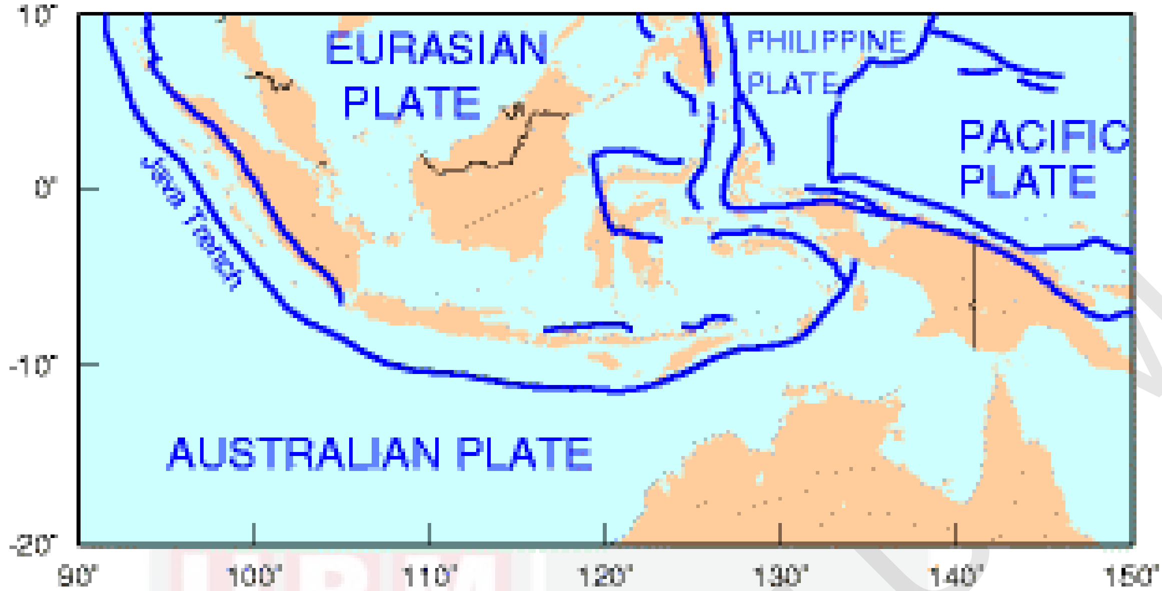

Figure 1.1: Map of tectonic plates surrounding Indonesia and Malaysia.

Below is a list of a few earthquakes with the epicenter in Sumatra, which caused vibrations in Peninsular Malaysia.

No.	Location	Magnitude (RS)	Date
1	North Sumatra	8.7	March 28, 2005
2	Sumatra-Andaman Island	9.0	Dec 26, 2004
3	Sumatra	7.4	Nov 2, 2002
4	Bengkulu- Sumatra	6.5	June 4 ,2000

Table 1.1 :The latest Indonesia earthquakes with the epicenter in Sumatra

1.2 Nature of problem

Seismic analysis should be taken into account for the structural analysis which exist in high seismic zone. The providing of necessary criteria and guidance for the performed based seismic analysis and design is required by using the seismic analysis and design code.

(Malaysia as a country near to high seismic zone area) Malaysia is not in a high seismic zone but it is surrounded by countries that are in high seismic areas and Malaysia can feel the vibrations as well. Hence the effect of earthquake loading must be considered to guaranty the safety of the structure, especially for high-rise building and long span bridge.

1.3 Factors that determine earthquake intensity

These are some factors that influence earthquake intensity:-

- Earthquake Magnitude - larger earthquakes cause more damage than smaller earthquakes.
- Distance from focus - earthquake waves get weaker as the distance from the focus increases. Thus the most damage usually occurs near the focus.
- Type of foundation material - rigid materials will withstand shaking better than soft materials. Buildings built on lake sediments, marine mud, or fill fare much worse than buildings built on hard rock such as granite.
- Regional geology - the rigidity of rocks in the region will determine how fast earthquake waves are attenuated (weakened). In areas of hard bedrock, the waves can travel great distances without being weakened. In areas of soft or hot rocks the wave energy decreases rapidly.
- Building style - The size, shape, and materials used in construction will determine how the building responds to shaking. If the natural frequency of the building is equal to the frequency of shaking, resonance will occur and causes shaking to be amplified. Tall buildings have a low natural frequency whereas short buildings have a higher frequency. Elastic buildings of steel generally do better than rigid buildings of brick and mortar.

- Duration of shaking - large earthquakes can cause the ground to shake for up to several minutes. The longer the duration of shaking the greater the damage.

1.4 Structure factor consideration

There are four factors that must be considered to reduce the effect of earthquake hazard toward long span bridges and high-rise buildings. The factors are stated below

1.4.1 Earthquake loading.

In structural design, especially for areas in the seismic zone, earthquake loading must be taken into account. There are a lot of seismic design codes that are in use all over the world, like: India, Iran, Indonesia, U.S.A and so on.

Earthquake loading consists of the inertial forces of the building mass that result from the shaking of its foundation by a seismic disturbance. Earthquake resistant design concentrates particularly on the translational inertia forces, whose effects on a building are more significant than the vertical or rotational shaking components.

Other severe earthquake forces may exist, such as those due to land sliding, subsidence, active faulting below the foundation, or liquefaction of the local subgrade as a result of vibration. These disturbances, however, which are local effects, can be so massive as to defy any economic earthquake-resistant design, and their possibility may suggest instead the selection of an alternative site.

Where earthquakes occur, their intensity is related inversely to their frequency of occurrence; severe earthquakes are rare, moderate ones occur more often, and minor ones are relatively frequent. Although it might be possible to design a building to resist the most severe earthquake without significant damage, the unlikely need for such strength in the lifetime of the building would not justify the high additional cost. Consequently, the general philosophy of earthquake-resistant design for buildings is based on the principles that they should

1. Resist minor earthquakes without damage
2. Resist moderate earthquakes without structural damage but accepting the probability of nonstructural damage
3. Resist average earthquakes with the probability of structural as well as nonstructural damage, but without collapse

Some adjustments are made to the above principles to recognize that certain buildings with a vital function to perform in the event of an earthquake should be stronger. The magnitude of earthquake loading is a result of the dynamic response of the building to the shaking of the ground. To estimate the seismic loading two general approaches are used, which take into account the properties of the structure and the past record of earthquakes in the region.

The first approach, termed the equivalent lateral force procedure, uses a simple estimate of the structure's fundamental period and the anticipated maximum ground acceleration, or velocity, together with other relevant factors, to determine a maximum base shear. Horizontal loading equivalent to this shear is then distributed in some prescribed manner throughout the height of the building to allow a static analysis of the structure. The design forces used in this equivalent static analysis are less than the actual forces imposed on the building by the corresponding earthquake. The justification for using lower design forces includes the potential for greater strength of the structure provided by the working stress levels, the damping provided by the building components, and the reduction in force due to the effective ductility of the structure as members yield beyond their elastic limits. The method is simple and rapid and is recommended for unexceptionally high buildings with unexceptional structural arrangements. It is also useful for the preliminary design of higher buildings and for those of a more unusual structural arrangement, which may subsequently be analyzed for seismic loading by a more appropriate method. This will be more explained in the methodology chapter.

The second, more refined, procedure is a modal analysis in which the modal frequencies of the structure are analyzed and then used in conjunction with earthquake design spectra to estimate the maximum modal responses. These are then combined to find the maximum values of the responses. The procedure is more complex and longer than the equivalent lateral force procedure, but it is more accurate as well as being able to account approximately for the nonlinear behavior of the structure. This will also be more explained in the chapter methodology

1.4.2 The arrangement of structure position.

In high- rise building design:

a) The building must have simple, symmetrical shape.

b) Buildings narrowing towards the base are considered unsuitable from the seismological point of view.

c) The distribution of the mass along the buildings height must be uniform and has continuity.

d) The building must have sufficient stiffness.

e) Plastic behavior must occur in the horizontal element first compared to the vertical element

1.4.3 Simple and symmetrical shape

Based on damaged structures experienced due to earthquakes, it has been proven that the structure that has a simple and symmetrical shape is stronger against earthquakes. There are five main reasons for this statement:

1. Our ability to understand all structural behavior is still at simple structure level compared to complicated structures.
2. Our ability to understand the detailing of the structure is still in simple detailing, more research is still needed for complicated detailing.
3. Non-symmetrical structures can cause torsion effect, therefore buildings should have a symmetrical plane, the greater part of the mass should be located in the lower storey and eccentricities of larger loads should be avoided.
4. Buildings should have large torsional rigidity. Considerable torques can be expected in buildings with located cores and stiffening walls.

5. The main structural system should have approximately the same rigidity in all direction.

1.4.4. Non-narrowing building shape

Longitudinal buildings do not usually satisfy such conditions; the wind load in transverse direction is distinctly greater than that in the longitudinal direction. Seismic loads in both these directions are practically the same.

Figure 1.2 : Wisma 46 in Jakarta

1.5 OBJECTIVE:

1. To collect and analyze Nabire ground acceleration motion earthquake record and construct design response spectrum.
2. To analyze and design a model of 30 story Salemba apartment in Jakarta subjected to seismic loading from Nabire earthquake.

1.6 SCOPE OF STUDY

The scope of study includes:

a) The available acceleration ground motion earthquake record in Indonesia is limited (from Badan Meteorology dan Geofisika Indonesia), so the Nabire earthquakes were chosen to be analyzed to construct a response spectrum.

b) DADISP software will be used to analyze the Nabire earthquake record.

c) STAADPRO software will be used to analyze a 30 story Salemba apartment.

d) Salemba apartment in Jakarta will be applied with the earthquake loading obtained from the Nabire earthquake.

1.7 ORGANIZATION OF REPORT

The research contains results of the study as outlined in section 1.6. In addition to this introductory chapter, this report is organized as follows:

- Chapter 2 presents an overview of the analysis procedure, basis of design and structural system for the seismic design of the building. The seismic analysis and design detail is based on NEHRP provision for seismic regulations for new buildings and other structures (FEMA 302) and has been modified to become seismic design code for buildings (TI-809-04) by the US Army Corps of Engineers.

- Chapter 3 presents the collection of acceleration of ground motion earthquake record data from Indonesia. It also present the procedure of equivalent static lateral forces as seismic analysis based on the Indonesia earthquake code.

- Chapter 4 presents the analysis of the earthquake record and the construction of the design response spectrum from the earthquake record. It also presents the seismic analysis (equivalent static lateral forces based on Indonesia earthquake code) by using the constructed design response spectrum. It is then applied to a 30 storey Salemba apartment in Jakarta for analyzing and designing using computer implementations.

- Chapter 5 presents the conclusions and recommendations.

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