UNIVERSITI PUTRA MALAYSIA

SEISMIC ANALYSIS AND DESIGN OF RESIDENTIAL BUILDING BASED ON INDONESIAN CODE

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Thesis Submitted to faculty of Engineering, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Engineering

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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 AND DESIGN OF RESIDENTIAL BUILDING BASED ON INDONESIAN CODE

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DES 2007

Chairman: **Associate Professor Dr. Jamalodin Noorzaei**

Faculty: **Engineering**

Located in active earthquake zone, all buildings in Indonesia should be designed to follow strict building code requirements to be able to resist designated earthquake load.

The earthquake loading as a lateral loading should be taken into account in the analysis of a residential building, especially for places in high seismic zones. The analysis and design will be analyzed using SAN'S software.

The static equivalent lateral forces analysis based on the Indonesia seismic code procedure will be used to estimate the seismic loading.

The earthquake loading produced will be applied to the actual building in Pekanbaru – Riau – Indonesia for 1,2,3,and 4 storey .

ABSTRAK

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

ANALISIS DAN DESAIN BEBAN GEMPA TERHADAP RUMAH KEDIAMAN PENDUDUK BERDASARKAN KOD INDONESIA

Oleh

SAMSUL BIN SYAHRUM

DES 2007

Pengerusi: **Profesor Madya Dr. Jamalodin Noorzaei**

Fakulti: **Kejuruteraan**

Berada di daerah gempa yang aktif, semua bangunan di Indonesia harus direncanakan mengikuti persyaratan yang ketat dari peraturan bangunan sehingga mampu menahan beban gempa yang direncanakan.

Beban gempa bumi sebagai beban horizontal seharusnya diambil kira dalam analisis bangunan tempat tingal, terutamanya bagi kawasan yang berada di kawasan gempa tinggi. Analisis dan desain akan dihitung dengan menggunakan San’s software

Analisis daya static equivalent berdasarkan prosedur kod gempa Indonesia akan digunakan untuk menganggarkan beban gempa.

Beban gempa yang dihasilkan akan diaplikasikan kepada bangunan sebenar di Pekanbaru – Riau – Indonesia for 1, 2, 3, and 4 tingkat.

ACKNOWLEDGEMENT

In the name of Allah the Compassionate and Most Merciful,

First and foremost, I would like to express my sincere gratitude and appreciate to Associate. Prof.Dr. Jamalodin Noorzaei and as my supervisor who had given much concern, constant supports and guides throughout the study on this final year project with his abundance of valuable advices, strong helps and information to complete this research project

I would also like to say thanks and appreciate to Associate Prof .Ir. Dr Mohd Saleh Jafar that always support with his abundance of valuable advice, Associate Prof. Ir. Dr Mohd Razali Abdul Kadir , my parents, Hj Syahrum (alm) and Hjh Danila (alhm), very special my wife Martina , my children Cantika Putri and Muhammad Qorie, all my brothers and my sisters, and everyone who give concern and constant supports.

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.

I

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.

SAMSUL BIN SYAHRUM

Date:

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LIST OF ABBREVIATIONS/NOTATIONS/GLOSSARY OF TERMS

SNI	-	Standard Nasional Indonesia
SAN’S	-	Structure Analysis Software
ELF	-	Equivalent Lateral Force
US	-	United State
ASCE	-	American Society of Civil Engineers
ACI	-	American Concrete Institute
e.g.	-	example
i.e.	-	which is
etc	-	etcetera, so on

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CHAPTER 1

INTRODUCTION

1.1 Background

Due to the Indonesian located in active earthquake zone, the current analysis and design of all buildings has focused on seismic effect. But, if we inquire about the evidences on how far the buildings are free from earthquake hazard, nobody could provide a rational and scientific basis. Therefore, an attempt has been made to investigate the behaviour all buildings under high intensity earthquake effects.

Earthquake response is a result of dynamic response of a building due to the shaking of the ground. The differences between loadings on high-rise buildings and low-rise buildings are mainly due to the loading accumulation over height that can cause very large gravity and the lateral forces within the structural system. Most seismic building codes require that structures be designed to resist specified “static” lateral forces related to the properties of the structure and the seismicity of the region (Chopra, 1995). Based on an estimated fundamental natural vibration period of structure, formulas are specified for the base shear and the lateral force distribution over the height of building.

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, and Malaysia is surrounded by seismically active countries: Indonesia & Philippines

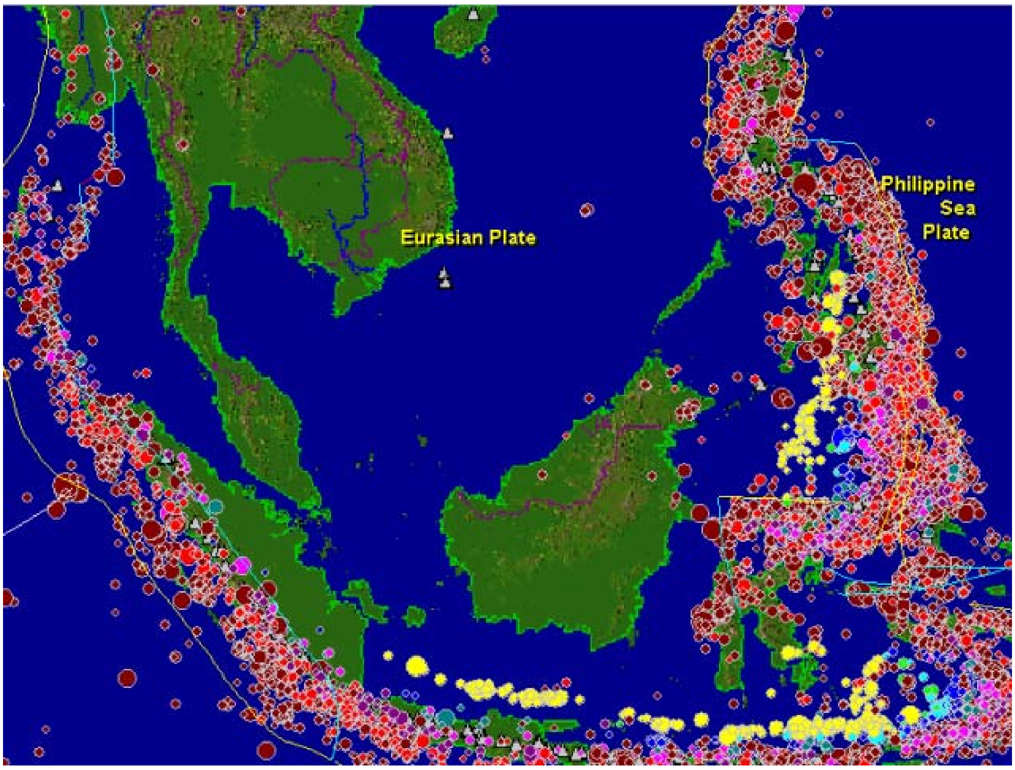

Figure 1.1: Map of seismic serrounding Malaysia.

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

No	Location	Magnitude(in Ritcher scale)	Date of occurance
1	West Sumatra	>7	March, 2007
2	North Sumatra	8.7	Dec. 2006
3	Sumatra-Andaman Island	9.0	Dec 26- 2006
4	Sumatra	7.4	Nov. 2-2002
5	Bengkulu	6.5	June, 2000

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

1.2 Objective

The objective of the research is:

To analyze and design residential building in Pekanbaru – Riau – Indonesia based on Indonesian seismic code (SNI – 1726 - 2002)

1.3 Scopes of Work

This research can be divided into three main areas:

(I) The seismic analysis and design only consider 1, 2, 3, and 4 storey's.

(II) Generation of static equivalent force procedures based on Indonesian seismic code

(III) SAN'S structural software will be used to analyze and design the structures.

1.4 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 Indonesian Code for seismic, Japan Seismic Code, and US Seismic

- 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 load and the construction of the design building from the earthquake load. The seismic load will calculate using equivalent static lateral forces based on Indonesia earthquake code. It is then applied to a 1, 2, 3, and 4 storey in Pekanbaru-Riau-Indonesia. For analyzing and designing using computer implementations and controlling by manually .

- Chapter 5 deals the conclusions

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Seismic codes are unique to a particular region or country. The main code provide outline for calculating seismic design force. This force depends on the mass and seismic coefficient of the structure and the latter in turn depends on properties like seismic zone in which structure lies, importance of the structure, its stiffness, the soil on which it rests, and its ductility. Whole the code centres on the calculation of base shear and its distribution over height. Depending on the height of the structure and zone to which it belongs, type of analysis i.e., static analysis or dynamic analysis is performed.

Earthquake motion causes vibration of the structure leading to inertia forces. Thus a structure must be able to safely transmit the horizontal and the vertical inertia forces generated in the super structure through the foundation to the ground. Hence, for most of the ordinary structures, earthquake-resistant design requires ensuring that the structure has adequate lateral load carrying capacity. Seismic codes will guide a designer to safely design the structure for its intended purpose.

2.2 Seismic analysis procedure

There are four basic analytical procedures for seismic analysis of the building:

1. Linear Elastic Static Procedure. (Equivalent Lateral Force (ELF))
2. Linear Elastic Dynamic Procedure. (Modal Analysis)

3. Nonlinear Static Procedure.

4. Nonlinear Dynamic Procedure (response-history analysis)

Limitations on this chapter only focus on the first analysis. In general, a building should be modeled, analyzed, and evaluated as a three-dimensional assembly of elements and components. Three-dimensional mathematical models shall be used for analysis and evaluation of buildings with plan irregularity. Two-dimensional modeling, analysis, and evaluation of buildings with stiff or rigid diaphragms is acceptable if torsional effects are either sufficiently small to be ignored or indirectly captured.

2.3 Linear Elastic Static Procedure

This procedure is also known as the Equivalent Lateral Force (ELF) Procedure. The required calculations are relatively simple and can be performed by hand, although a number of computer programs are available to facilitate the analysis. The results of the linear static analysis procedure can be very inaccurate when applied to buildings with highly irregular structural systems, unless the building is capable of responding to the design earthquake(s) in a nearly elastic manner.

2.3.1 Based on US Code SEI/ASCE 7-02

For this procedure the seismic base shear is represented as $V = C_S W$ and the seismic response coefficient, C_S, is determined in accordance with the following equation:

$$C_s = \frac{S_{DS}}{R/I} \quad 2.1$$

$$C_s \leq \frac{S_{DS}}{T(R/I)} \quad 2.2$$

$$C_s \leq 0.044\, S_{DS}\, I \quad 2.3$$

$$C_s \geq \frac{0.5S_1}{(R/I)} \text{ For structure in Seismic Design Category E and F} \quad 2.4$$

Where

S_{DS}: design spectral response acceleration in the short period range (units of g).

R = Response modification factor

$$S_{DS} = \frac{2}{3} F_a S_S \quad 2.5$$

S_{D1}: design spectral response acceleration at a period of 1 second (units of g).

S_S: mapped maximum considered earthquake spectral response acceleration at short periods (units of g).

S_1: mapped maximum considered earthquake spectral response acceleration at period of 1 second (units of g).

F_a and F_v: site coefficients (Table 2.1).

R: response modification factor (Table 2.2).

I: occupancy factor (Table 2.3).

T: fundamental period of the structure (seconds):

$$T \leq C_u T_a \quad 2.6$$

C_u: coefficient for upper limit on calculated period (Table 2.4).

T_a: approximate fundamental period of structure: