WIND EFFECTS ON SYMMETRICAL MULTIPLE CORE WALL SYSTEM OF HIGH-RISE BUILDING

HAZWANI BINTI SAMSUDIN

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Special for

Father & mother

Samsudin Ahmad

Che Azizah Sulung

Siblings

Che Suhaili

Zukarnain

Mohd Irwan

Harun

Nur Amirah

Hanisah

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"In the Mighty Name of Allah, The Most Beneficent, The Most Merciful"

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ABSTRACT

High-rise building is one of the phenomena that is inevitable. World has seen high-rise building as a solution to maximize the use of land. High-rise building is strongly related to response of the structure due to the wind. The development of high rise building has pushesd the limit of engineering to come out with better structural systems to reduce the wind-induced responses. Core wall system is said to be the most effective systems that can be implemented to reduce the wind effects on the structures. However, the greater the size of core wall used in the building, the lesser the usable space in the building. This paper is proposing the use of multiple core walls that are located at each corner of the building to maximize the use of space in the building as well as to study the effects of multiple core walls in reducing wind response on structures. A static analysis was performed by using ETABS to obtain the displacement and maximum stress of the building. The result of the studies shows that by implementing multiples core walls system, the along wind displacement can be reduced up to 94%, 89% and 87% for 10 storey building, 20 storey building and 30 storey building respectively. Both single central core wall system and multiple corner core wall system can be used to reduce the wind effect to the building where the single central core wall is more effective in reducing the displacement but, is less effective in reducing the stresses, compared to the results obtained from the analysis of multiple corner core wall-system.

ABSTRAK

Bangunan tinggi merupakan salah satu fenomena yang tidak dapat dielakkan. Bangunan tinggi telah menjadi salah satu penyelesaian untuk memaksimumkan penggunaan tanah. Bangunan tinggi berkait rapat dengan gerak balas struktur yang disebabkan oleh angin. Pembangunan bangunan tinggi telah mencabar had kejuruteraan angin, iaitu, satu sistem struktur yang lebih baik perlu dihasilkan bagi mengurangkan tindakbalas yang disebabkan oleh angin. Sistem dinding teras dikatakan sistem yang paling berkesan yang boleh dilaksanakan untuk mengurangkan kesan angin ke atas struktur. Walaubagaimanapun, semakin besar saiz dinding teras yang digunakan dalam bangunan, semakin kecil ruang yang boleh digunakan di dalam bangunan. Kertas kerja ini mencadangkan penggunaan dinding teras berganda yang diletakkan di bucu bangunan untuk memaksimakan penggunaan ruang di dalam bangunan di samping untuk mengkaji kesan dinding teras berganda dalam mengurangkan tindak balas angin pada struktur. Analisis statik dilakukan dengan menggunakan ETABS untuk mendapatkan anjakan dan tegasan maksimum bangunan. Hasil kajian menunjukkan bahawa dengan melaksanakan sistem gandaan dinding teras, anjakan boleh dikurangkan sehingga 94%, 89% dan 87% masing-masing, bagi bangunan 10 tingkat , bangunan 20 tingkat dan 30 tingkat. Kedua-dua sistem dinding teras pusat dan sistem dinding teras berganda boleh digunakan untuk mengurangkan kesan angin untuk bangunan dengan dinding teras tunggal lebih berkesan dalam mengurangkan anjakan, tetapi kurang berkesan dalam mengurangkan tegasan jika dibandingkan dengan keputusan yang diperolehi dari analisis sistem dinding teras berganda.

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INTRODUCTION

1.1 Introduction

The increasing population and lack of space or land has eventually results in the demand for high-rise building. High-rise building has provided a solution for these problems as well as the problems regarding the reduced requirement of foundation for centralized activities, minimum material outlay for productive workmanship, maximum speed of erection as well as fabrication for cost reduction. High-rise building is a building which its height is strongly influence planning, design and use. There is no specific definition that is universally accepted. A building is categorized as high-rise when it reached certain height. This height is different for each country.

Design of high-rise or high-rise building significantly differs from the design of low-rise and medium-rise building. High-rise buildings are always related to the effects of wind. Wind is the movement of air relative to the earth. It is due to the variation of the pressure in the atmosphere which resulted from the differential solar heating over the earth's surface and forces generated by the rotation of the earth. Almost every day of the year, severe windstorm is happening somewhere on the earth and it may cause damage to the structure if the structural systems of the building fails to resist the wind load.

Recently, many researchers have put an effort to overcome the problems related to wind effects of high-rise building. The height of the building that is being constructed is increasing over the year. The building height has soared to 300 m. In several countries, the design of many structures is governed by the wind loading. The design of the structural system of high-rise building should be able to resist the lateral load that came from wind as well as earthquake. The high-rise building response dynamically to the wind load in the direction of along-wind, across-wind as well as in the torsional mode.

Generally, high-rise building can either be a of steel structure, reinforced concrete structure or a composite structure that is the combination of steel and reinforced concrete structure with the basic building model of square cross-section. Awareness of the effects of wind to the structure has produced a variety of systems that can be used in the high-rise building in order to resist the wind loads and thus have better functionality compared to the normal functions of high-rise buildings.

1.2 High-rise building structures

World has been experiencing a trend of activity in the design and construction of high-rise buildings. For the past few decades, trends in constructing high-rise building has got an overwhelming response where a lot of appealing high-rise building has become a symbol and landmark for several countries over the world. In fact, numerous buildings that are either still under construction or in planning to be built are nowadays having the height of more than 300 m (Irwin, 2009). The development of high-rise building began in United State of America in the late nineteenth century. Nowadays, high-rise buildings have become worldwide phenomena where Asian countries such as China, Korea, Japan and even Malaysia have dominated the rank of top ten high-rise building (Ali and Moon, 2007). The development of high-rise buildings has increased rapidly all over the world.

According to Ali and Moon (2007), the function of high-rise building was traditionally a commercial office building. As the development of high-rise building is rapidly emerged, the function of high-rise building began to change as well. High-rise building is currently served as residential, hotel accommodation as well as multi-purpose building. As reported by Council on Tall Building and Urban Habit (CTBUH, 2013), as of September 2013, Burj Khalifa, Dubai that was completed in 2010 is recognized as the tallest building according to height of architectural top with the height of 828 m. Despite the buildings are getting higher, most of the buildings are still using planetary boundary layer model that has been developed in 1960s. The validity of this traditional model is doubtful when dealing with building of height 300 m and above (Irwin, 2009).

Steel buildings, reinforced concrete buildings and composite buildings are basic types of high-rise building. A building is considered as steel buildings when the main vertical and lateral structural elements and floor systems are constructed from steel. In addition, if the main vertical and lateral structural elements are constructed from concrete, it is considered as concrete buildings. The combination of both materials is considered of composite. A steel building with a concrete core is considered as composite high-rise buildings that utilizes a combination of both steel and concrete acting compositely in the main structural elements (CTBUH, 2013).

All these three types of buildings are having the same structural system. It is classified based on the basic reaction mechanism or structural behavior for resisting lateral loads. The basic structural systems of high-rise building are frame systems, braced or shear wall systems and tube systems. These types of structural systems can be expanded based on the purpose of the building (Gunel and Ilgin, 2006). Some innovations of the structural system that exist nowadays are core wall, outrigger, belt wall, tube in tube and megacolumn.

High-rise building structures deal with two main problems that are the dynamic response due to the wind and the movement of the structures that is due to the wind or lateral load. The wind effect on the structures is the main concern in the engineering of high-rise building. Design and selection of structural system for high-rise building is important in order to reduce the response due to the wind. The system must be able to withstand the extreme weather and reduce the effect due to the lateral load.

1.3 Problem statement

High-rise buildings have emerged rapidly ever since it was introduced to the worldwide. The emergence of high-rise building as well as the increasing height of the -building have given challenges in wind engineering. As the height of the building is increasing, the structure is exposed to high velocity of wind that induced large value of lateral force. Lack of knowledge and misunderstanding of the behavior of the building may cause failure to the building. Advancement in the knowledge of high-rise buildings has come out with the structural system that uses high strength material in order to reduce weight of the building, but results in more flexible building. However, flexible high-rise buildings are sensitive to wind-induced excitations. Thus, the need of identifying the effective structural system that can help in reducing the wind-induced effect on the building is necessary.

According to a study by Roslida (2008), the use of core wall system is the most effective system in reducing the building responses induced by wind. By increasing the outer dimension of the core wall, the ability of the structure to resist the lateral load due to the wind becomes more efficient. The displacement of the building reduced significantly when the size of the core wall is greater but the size of core wall is limited to 50 percent of the dimension of the building. The use of larger core wall consequently reduces the usable space of the building. Thus, the use of space in the building is limited whilst high-rise building is developed to provide space due to the limited land.

1.4 Objectives

The main purpose of this study is to analyse the wind effect on the structures. The analysis will be accomplished based on the several objectives that are:

1. To determine the variation of maximum displacement and stress of the building that implements multiple core walls system.
2. To determine the variation of maximum displacement and stress of the building that implements a single central core wall system.
3. To study the effectiveness of multiple core walls systems compared to single core wall system in reducing the maximum displacement of the building.
4. To study the effectiveness of multiple core walls systems compared to single core wall system in reducing the stress in the building.

1.5 Scopes

The scope of this project is to study the effect of wind on high rise structures by performing a static analysis of high-rise building. The analysis is performed by using structural software. A typical 10, 20 and 30 storey of square high-rise building will be studied for this research. The dimension of the building is constant for this research. Since the effectiveness of the single core wall systems has been studied by Roslida (2008), this study is embarked to review the behavior and effectiveness of using multiple corner core wall system. Four different dimensions for each system: single central core wall and multiple corner core wall, were used. The thickness of the core wall is kept constant. The parameters that were studied in this research are along-wind displacement and stress of the building. A 3-dimensional linear static analysis is performed by using ETABS.

The buildings studied are located in Malaysia. Malaysia wind profile is categorized as benign wind environment. Static wind load is used for this analysis to obtain responses of the building. The parameters that will be obtained from the analysis are along-wind displacement and maximum stress of the building.

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