BEHAVIOUR OF SKYBRIDGE ADJOINS RC BUILDING TOWERS UNDER WIND EFFECT

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SUPERVISOR'S DECLARATION

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Master of Engineering (Civil – Structure).

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A project report submitted in partial fulfilment of the requirements for the award of the degree of Master of Engineering (Civil – Structure)

Faculty of Civil Engineering
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STUDENT'S DECLARATION

I declare that this project report entitled "Behaviour of Skybridge adjoins RC Building Towers under Wind Effect" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : Oh Jol Dih

Date : 9th November 2007

To my beloved mother, father and husband

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There is no doubt that this report could not have been completed without the encouragement, patience, unselfish support, and love of my husband, H K Tan. I wish to extend sincere thanks to him for his contribution in the completion of this project.

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ABSTRACTS

The report entitled "Behaviour of Skybridge adjoins RC Building Towers under Wind Effect" is to locate the most effective location of the skybridge in connecting two building towers as well as the most effective skybridge configurations. The skybridge in connecting more than a single building tower is expected to replace the need for shear wall in providing lateral restraint and overall stiffness to tall building for building towers of lower than 40 stories. In order to achieve the goal, the modeling and analysis of the building towers and the skybridge was accomplished using the MultiFrame software. The maximum horizontal deflection of the building towers at the topmost level under serviceability limit state was compared to determine the effectiveness of the skybridge in terms of location and its configuration. On the whole, this report presents the discussion and the results obtained from the research. In fact, the results obtained reveal that the effectiveness of the skybridge increases with the increase in location relative to the height of the building. Also, it is noticed that the most effective configuration is that of the truss system. The truss system is indeed the most applied structural form in the construction of bridges owing to its economical sections and ease of construction. It is hoped that this research will contribute to the construction industry.

ABSTRAK

Kertas kerja ini membincangkan kajian yang bertajuk “Behaviour of Skybridge adjoins RC Building Towers under Wind Effect”. Objektif projek ini adalah untuk mencari lokasi “skybridge” yang paling efektif dalam menghubungkan dua bangunan tinggi berserta konfigurasi “skybridge” yang paling efektif. “Skybridge” diharapkan dapat menggantikan dinding ricih dan dinding teras dalam memberikan penahanan sisi dan keteguhan struktur bangunan bagi bangunan 40 tingkat atau lebih rendah apabila terdedah kepada beban angin mendatar. Untuk mencapai objektif tersebut, model bangunan tinggi dan model “skybridge” dianalisis dengan menggunakan program “Multiframe”. Pesongan ufuk bangunan yang paling maksima pada aras tertinggi untuk had kebolehkhidmatan diperbandingkan untuk menentukan lokasi dan konfigurasi “skybridge” yang paling efektif. Secara keseluruhannya, keputusan analisis membuktikan bahawa lokasi “skybridge” yang paling efektif adalah di lokasi yang tertinggi pada tingkat bangunan apabila disamakan dengan ketinggian bangunan. Dalam lain kata, semakin tinggi lokasi “skybridge”, semakin efektif dalam memberikan keteguhan kepada bangunan tinggi. Selain itu, adalah didapati bahawa konfigurasi skybridge yang paling efektif merupakan sistem “truss”. Sistem ini sememangnya kerap digunakan terutamanya dalam pembinaan jambatan. Ini kerana sistem struktur ini adalah lebih ekonomi dan mudah dibina. Secara umumnya, matlamat kajian ini agar dapat memberi sumbangan kepada industri pembangunan yang sedang pesat membangun.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Generally, high-rise or tall building refers to building in which its height creates different conditions in the design, construction and usage compared to the conventional structures. In other words, high-rise or tall building refers to any vertical construction for which the wind effects are much more significant and are greatly emphasized compared to its structural weight or the imposed load imposed on the structure.

Today, the numbers of high-rise building are increasing expeditiously with the rapid pace of development in social and economic sectors. Besides, high-rise buildings are an increasingly common sight where land is scarce, as in the centres of big cities, because of the high ratio of rentable floor space per area of land. It also serves as an ultimate symbols of a city's economic power or a distinguish landmark such as the Petronas Twin Towers in Malaysia and the The Arch in Hong Kong.

Over the years, the developments in concrete high-rise buildings have undergone dramatic evolutionary changes. Simple structural systems such as shear wall buildings have now been transformed to various structural systems suitable for all types of building functions, i.e. residential or commercial buildings. However, several reviews paper reveals that frame buildings that rely on predominant

Vierandeel frame action is suitable only up to about 10 to 20 stories. Beyond this height, combination of structural systems is required to provide lateral stiffness and strength to the entire building.

1.2 Aim And Objectives

Structural engineering is in fact the field of civil engineering particularly concerned with the design of complex structural systems such as buildings, bridges, retaining walls, dams and tunnels. Therefore, it is the responsibility of the structural engineers to ensure that their designs satisfy a given design intent predicated on safety and on serviceability (i.e. floor vibration and building sway are not uncomfortable to occupants). Safety in this context refers to the fact that the structures do not collapse without due warning whereas serviceability refers to the comfort of the occupants with respect to floor vibration and building sway. In addition, structural engineers are responsible for making efficient use of funds and materials to achieve these over-arching goals.

In view of this responsibility and the increasing demand of high rise construction, this analysis project study on the consequences of the inclusion of skybridge in adjoining building towers under wind effect. As mentioned in the preceeding ***Section 1.1***, combination of structural systems is required to provide lateral stiffness and strength to the entire building for buildings exceeding 20 stories. For that reason, this project is aimed to investigate the feasibility of skybridge structures in providing lateral stiffness to the frame buildings and thus the possibility to eliminate the need to construct shear or core wall in buildings of up to 40 stories height.

On the whole, the proposed research aims at studying the wind effect on a thirty storeys and a forty storeys building structures of merely frame system without combinations of other structural system such as shear wall, core wall, etc. Also, the behaviour of the skybridge under wind effect from various directions are monitored and analysed. Next, the behaviour of the overall building structure with the inclusion of the skybridge under wind effect are studied. The effect arises from the various configurations of the skybridge as well as under various load conditions are also analysed. All these study would lead to achieving the goal of this research which is the study of the effectiveness of location of the skybridge in controlling the overall structure against allowable drift in a frame structure.

1.3 Importance Of Study

The importance of this project is to reduce the construction cost and duration by eliminating the construction of the shear or core wall in building towers of less than 40 stories height with the substitution of a skybridge. As the skybridge can be pre-casted or pre-assemble prior to installation at site, this will reduce the construction time length. Besides, the skybridge can serve as passageways between two or more connected buildings and at the same time, allows vehicular passage beneath the skybridge. This is particulary useful especially at project sites with area limitations.

1.4 Scope And Limitation Of Project

In this analysis, it is assumed that the structural members and structural arrangements are ideal in transferring vertical loads. Therefore, only lateral loads play the most significant part throughout the analysis with the wind speed at 80km/hr – a requirement for serviceability check. Apart from that, the analysis considered only building of 30 storeys and 40 storeys in height. The towers were then connected by the skybridge at three different locations, at quarter-height, mid-height and three-quarter height. In addition to that, the analysis was also accomplished with three skybridge simultaneously link the building towers to study the difference in their behaviour under wind effect and the influence on the building towers. In terms of the skybridge configurations, the analysis was carried out using the reinforced concrete continuous beam-slab system, the composite system with steel beams and concrete slabs as well as the truss system.

In general, the frame system modelled in the analysis composed of columns and beams only. On the other hand, secondary elements such as slabs, brickwall and staircase could be modelled as bracing to the frame structure. Nevertheless, this was not carried out due to the limitations of the capability of the software, Multiframe. The software has limitations to the virtual memory and thus restrict the structural analysis and the inputs.

1.5 Epiloque Of Reports

In general, the subsequent chapters and sections would introduce the reader to the thesis proposal entitled "Behaviour of Skybridge Adjoins RC Building Towers under Wind Effect". Overall, this project report consists of nine chapters.

Chapter 1 of the report is the introduction to the research project. Also included in this chapter is the aims and objectives of the research, the importance of the study as well as the scope and limitation of the project.

Subsequently, Chapter 2 covers the literature review of the research which includes the behaviour of high rise building, structural systems, wind effects, the skybridge and finally, the structural analysis.

On the other hand, Chapter 3 describes the methodology carried out in completing the research. This includes the description of the computer modeling and analysis of Multiframe, the preliminary analyses, the computer simulation of initial and final analysis.

In Chapter 4, the analysis specifications and parameters are discussed herein. This includes the material of construction, the various structural loads, the design parameters, the structural sizes, the deflection limits and the assumptions made in the analysis.

Chapter 5 and Chapter 6 introduce tall building and the skybridge briefly and also explain on the building towers and skybridge analysed in this proposed research.

Finally, Chapter 7, Chapter 8 and Chapter 9 illustrate, discuss and conclude the findings obtained from the research. Additionally, Chapter 9 included recommendations for future research.