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THE MOST EFFICIENT CONTRIBUTION OF SHEAR WALLS IN DUAL STRUCTURAL SYSTEMS IN MEDIUM HEIGHT BUILDINGS

MEISAM ANSARI

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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May 2011

I declare that this thesis entitled *"the most efficient contribution of shear walls in dual structural systems in medium height buildings"* is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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To my beloved family

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ABSTRACT

For the purpose of understanding the behavior of dual structural system consists of steel moment frames and reinforced concrete shear walls, the effect of different percent of participation of shear wall in lateral resistance of building is discussed. Meanwhile for the purpose of efficiency in the design of moment frame in dual structural system optimum participation of beams and columns in lateral resistance of a moment frame subjected to earthquake force is represented in terms of lateral displacement of stories. Optimum participation of shear walls in dual systems depends on height of the building. As the height increases optimum participation of shear wall decreases and contribution of moment frame goes up. Steel moment frames with and without shear walls shorter than 100m subjected to earthquake load are modeled in ETABS to work on and present the real structures. Since the lateral displacement is usually the main concern in the design of medium height buildings, the smaller lateral displacement is the favorable result and the structure with the smallest lateral displacement is desired in this paper. Relative tables are presented and general advices in the design of dual structural system are given which can be applied in the design of proposed structural system.

ABSTRAK

Untuk tujuan pemahaman kelakuan struktur sistem berganda yang mengandungi kerangka momen dan dinding ricih, kesan daripada perbezaan peratusan penglibatan dinding ricih dalam rintangan lateral bangunan telah dibincangkan. Sementara itu, untuk tujuan keberkesanan dalam rekabentuk kerangka momen dalam struktur sistem berganda dengan penglibatan rasuk dan tiang dalam rintangan lateral kerangka momen yang dikenakan beban gempa dipersembahkan dalam bentuk pemindahan lateral. Penglibatan optimum dinding ricih dalam system berganda bergantung pada ketinggian bangunan. Dengan ketinggian yang meningkat, penglibatan optimum dinding ricih mengurang dan sumbangan kerangka momen menunjukkan peningkatan. Kerangka momen keluli dengan dan tanpa dinding ricih lebih rendah daripada 100m dikenakan beban gempa telah dimodelkan dalam ETABS yang dikerjakan pada dan mewakili struktur sebenar. Oleh sebab pemindahan lateral selalunya sebagai keutamaan dalam merekabentuk bangunan tinggi yang medium, lebih kecil pemindahan lateral adalah keputusan yang dikehendaki dan struktur dengan pemindahan lateral terkecil adalah yang dikehendaki dalam kertas kerja. Carta dan jadual relatif akan dipersembahkan dan panduan umum dalam rekabentuk struktur sistem berganda akan diberikan.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The tallest building around the world has reached to more than 800 m height. It means that a building with around 100 m height is not called a tall building anymore; in fact that is a medium height building. By drastic increase in height of tall buildings and consequently improvement of knowledge of engineering which results after construction of each of them, medium height buildings have become more and more popular and easy to construct. Nowadays the owners of the typical buildings have a tendency to construct a building higher than normal buildings without the special requirements of tall buildings. The popularity of medium height buildings have made the structural designers to work on the behavior of efficient structural systems and consequently the innovative method which helps the designers to consider the final sections of structural elements easier and faster is becoming favorable. Generally, the need of improved knowledge of engineering about medium height buildings has become more essential. Due to this fact, the main concern of this research is medium height buildings.

The combination of moment frames and shear cores which can be reinforced concrete shear wall or any kind of steel bracing frame is quite well-known as a structural system to provide lateral resistance of a building. Between the several types of shear cores, reinforced concrete shear wall is selected to discuss. In fact, while the shear capacities of reinforced concrete shear walls are significant, they can also provide the considerable stiffness for controlling the lateral displacement of the

building. Since the lateral displacement is a primary concern in the design of a tall building subjected to lateral forces, reinforced concrete shear walls are usually the most efficient structural systems for them. Hence, the dual structural systems consist of steel moment frames and reinforced concrete shear walls are the chosen structural system in this research for medium height buildings.

If the designer knows the behavior of each of the shear walls and moment frames individually and also knows the effect of each one on the other one and be aware of efficient contribution of each part in lateral resistance of the building, the result of design will be totally adequate and also economic.

1.2 Problem Statement

Generally, when designers are going to design a structural system due to lateral forces two requirements must be satisfied. The first one is providing enough sectional resistance to carry the shear and flexural forces resulted from lateral loads. The second one is providing enough resistance against lateral displacement induced by wind or earthquake loads. Despite of the fact that lateral displacement usually governs the process of design of a tall building, the sectional resistance can be crucial when a dual structural system is used.

Different contribution of shear walls in sectional resistance of a structure can result in the different amount of construction materials which are going to consume. It can also affect the lateral resistance of the building. What does it mean by different contribution of shear walls? It means that how many percentage of lateral forces is going to carry by shear walls and how many by moment frames. For example it can be divided in a way that 70% is carried by shear walls and the rest of it by moment frames.

Practical codes such as Eurocode 8 have introduced some guidelines in the field of the design of dual structural systems. These provisions sometimes are not clear enough for the designer to use. In some cases, it has been seen that the given advices in the codes are not practical.

One idea is to design the shear walls for full of lateral forces and to design the moment frames for only vertical loads. As long as the response of the building does not reach the limitation of elastic behavior, the idea can be useful because the elastic response of a dual structural system to lateral forces is mainly governed by the shear wall response. But when the structure is in inelastic stage or when the process of design considers the inelastic behavior of members, the response of moment frames cannot be neglected. From the other point of view, in inelastic stage contribution of

moment frames in lateral resistance of the building increase and if these elements are not capable enough to carry the increased loads, then the structure will easily collapse. Therefore the above idea needed to be worked on, it can be changed into the contribution of both of the shear walls and moment frames in lateral resistance of a building.

The required contribution of each of the shear walls or moment frames in resistance against lateral forces has been changed over the time by several practical codes. Nevertheless, it is still a problem in the design of dual structural systems. In most of the cases, designers tend to try different contribution of shear walls and moment frames to realize which one can lead the design to the most economic building.

Controlling the lateral displacement by only shear walls can result in thick walls which increases the weight of the building drastically and it raises the base shear. High contribution of moment frames makes the shear walls inefficient and useless and leads to the beams and columns with huge sections. Since most of the vertical loads are carried by the beams and columns, so the moment frames cannot be designed to carry the significant part of the wind or earthquake forces. On the other hand, the shear cores have more capacity to carry the lateral forces and this is one of the reasons that most of the practical codes in the past suggested designing the shear walls for full of the lateral forces and leave the moment frames to carry the only vertical forces.

As it mentioned earlier, the efficient contribution of shear walls in dual structural systems is still open to be discussed. In this research the contribution of different part of dual structural system in lateral resistance of the building will be discussed.

1.3 Aims and objectives

The main aim of this research is to understand the behavior of a dual structural system in order to design it efficiently and economically. Realizing how different parts of a dual structural system can govern the final behavior of building is favorable. The main objectives of this research are:

1. To study the optimum ratio of stiffness of beam-to-column in order to have the most stable and economic moment frame in dual structural system.

2. To study the change in the contribution of shear walls in the proposed structural system when shear walls are included.

1.4 Scope of study

This project report focuses on developing a method by which designers come out the final section as efficient as possible and in the shortest time. Discussion of the study will look into the behavior of moment frame and then the final behavior of a structural system consists of moment frame and shear wall.

Dual structural system consists of steel moment frames and reinforced concrete shear walls, is going to cover in this research. Since medium height buildings are the main concern of this study therefore the height of the building is limited to 100 m. The typical span of beam in buildings is considered between 4 m and 6 m and span of 5 m length is selected as an average. The story height of 3.6 m is also an average height between 3 m and 4.2 m as usual story height of author experiences.

A second order elastic analysis (including P-delta effect) is favorable and the structures will be analyzed with the stiffness method. The structures are subjected to carry the earthquake load estimated by using Eurocode 8 and it is assumed that all of the structures are located in high seismicity zone (A=0.35g). All of the structural elements will be designed based on Eurocode 3. Reinforced concrete shear wall will be designed to BS8110-1:1997. ETABS is the main software to analyze and design the structures.

1.5 Importance of the study

The method which is introduced can be applied to design a moment frame structural system and a dual structural system. This method guides the designer to find the optimum section of columns and beams and also optimum thickness of shear wall fast and accurately.

Comparative tables can show a clear picture of behavior of moment frame as an important part of dual structural system. Efficiency in terms of usage of steel can be important in regard to save nature.