# THE APPLICATION OF BRACED AND UNBRACED FRAMES IN REINFORCED CONCRETE STRUCTURES

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# THE APPLICATION OF BRACED AND UNBRACED FRAMES IN REINFORCED CONCRETE STRUCTURES

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*To my beloved mother.*

*To my late father (23 May 2013),*
*May Allah bless his soul and place it*
*in the highest heaven.*

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*Nur Wahida Bakhtiar*

# ABSTRACT

Many designers are uncertain whether a building with a certain height should be designed with shear walls. Some believe that the buildings of up to about ten storeys height need to be provided with shear wall. This project was carried out to study the suitability of reinforced concrete structures to be designed as braced or unbraced. The analysis was done on two series of identical model buildings with five, ten and 15 storeys each. Both series were subjected to the same vertical and horizontal loads. The analysis was carried out using Orion 18 software. The performances of the structures were measured in terms of bending moment carried by the members and the quantity of steel reinforcement required from which comparisons between the braced and unbraced buildings were made. The opinion from the practicing structural engineers on the matter was also sought through questionnaires sent to them. The results show that in the low rise buildings the moments in the major structural elements and the quantity of steel reinforcement required in braced and unbraced buildings are about the same. For higher rised buildings the difference becomes significant with larger value found in the unbraced buildings. The results also suggested that the buildings of up to 12 storey height can still be designed as unbraced structures, while those taller than 12 storeys should be designed as braced structures.

# ABSTRAK

Ramai perekabentuk tidak pasti samada sesebuah bangunan dengan ketinggian tertentu perlu direkabentuk dengan dinding ricih. Sesetengahnya percaya bahawa bangunan-bangunan dengan ketiggian sehingga 10 tingkat tidak perlu disediakan dinding ricih. Projek ini dijalankan untuk mengkaji kesesuaian struktur konkrit bertetulang direkabentuk sebagai struktur dirembat atau tidak dirembat. Analysis dilakukan ke atas dua siri bangunan yang serupa dengan ketinggian lima, 10 dan 15 tingkat bagi setiap siri. Struktur di dalam kedua-dua siri tersebut dikenakan dengan beban-beban pugak dan ufuk yang sama. Analisis dilakukan menggunakan perisian Orion 18. Prestasi struktur- struktur tersebut diukur dari segi moment lentur didalam element struktur utama, di mana perbandingan di antara bangunan-bangunan dirembat dan tidak dirembat dilakukan dan kuantiti bahan yang diperlukan. Pandangan daripada jurutera luar dalam perkara ini turut dikumpulkan melalui soalselidik yang dihantar kepada mereka. Keputusan kajian menunjukkan bahawa di dalam bangunan-bangunan rendah, moment lentur di dalam anggota-anggota struktur dan kuantiti tetulang keluli yang diperlukan adalah hampir sama bagi struktur dirembat dan tidak dirembat. Bagi bangunan-bangunan yang lebih tinggi, perbezaan diantara keduanya menjadi lebih ketara dengan nilai yang lebih besar diperolehi bagi bangunan tidak dirembat. Keputusan juga mencadangkan bahawa bangunan dengan ketinggian sehingga 12 tingkat masih boleh direkabentuk sebagai struktur tidak dirembat, manakala bangunan-bangunan dengan ketinggian melebihi 12 tingkat perlu direkabentuk sebagai bangunan dirembat.

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| | |
|---|---|
| $G_k$ | Dead load |
| $Q_k$ | Live load |
| $W_k$ | Wind load |
| $f_{ck}$ | Characteristic of concrete |
| $f_{yk}$ | Characteristic of Steel |
| L | Length of building |
| B | Width of building |
| H | Height of building |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

A frame is a structure used to resist vertical forces from gravity loading and lateral forces from wind load and earthquake. They are use to resist rotations in the structures. In the frame of multi-storey, multi-bay building, the effect of the wind may be small compared to other loads and in this case it is sufficiently accurate to divide the horizontal shearing force between the columns on the basis that an end column resists half the amount on an internal column. They are braced and unbraced frame in building structural design.

Braced frame are frames in buildings constructed with bracing elements. Bracing elements are designed to carry the horizontal forces on the whole building. Consequently the horizontal forces are not carried by the frames, or in other words the frames carry only the vertical loads from the dead and live loads. Shear wall is the most common type of bracing element used in reinforced concrete structures.

## 1.2 Problem Statement

Before a building is designed, one has to decide whether the building will be a braced or an unbraced structure. The frames (beams and column) in a braced structure carry vertical loads only because the horizontal load is carried by shear walls or other types bracing elements. On the other hand, the frames in an unbraced structure carry both vertical and horizontal loads because no shear wall or other bracing members is provided in the building. Some designers assume that low and medium rise buildings need not be provided with shear walls because the effect from the wind load is small. Consequently the horizontal forces are ignored in the analysis and the calculation is done by considering the vertical loads only using the method used for braced structures.

The structural members in a braced frame might require smaller sizes and hence reduces the cost, but the addition of shear wall requires extra materials and costs, while the frames in an unbraced structure require larger element sizes because they carry larger loads and thus the cost might also be high. Furthermore medium and tall buildings require lift. The lift need specific well, and so does the staircase. The walls that enclose the lift and stairs can therefore be designed as shear walls. This should be provided irrespective of whether the building is designed as braced or unbraced. So the supposedly extra cost due to the presence of these walls of cannot to be avoided, because this is one of the main requirements of the building and not an alternative.

The height of the building is significant factor; the taller the buildings the larger is the horizontal loads caused by the wind, consequently the preference of brace or unbraced structures has to be decided in the design, that is whether the building is to be designed as braced or unbraced structures. Some designers believe that low and medium rise building need not to be braced. Many assume that such a limit is about 10 storeys which means that the building taller than about 10 storeys should be design as braced while those with height less than 10 storeys, while be

design as unbraced. A thorough look at this issue would be able to ascertain whether such perception is correct or otherwise. A study in this respect is therefore worthwhile. The results of the study will serve as a guide particularly to new structural engineers. It will also enable designers to choose a more economical and safe design for a particular size of building.

## 1.3 Objective of Study

In general, this project is carried out to evaluate the resulting forces and effect of braced and unbraced structures of various heights. In more specific terms the objectives of the project are as follows:

a) To analyse and compare the forces in the corresponding part of the structures in the braced and unbraced buildings of similar height.

b) To determine the more economical type of structure in terms of the weight of steel reinforcement required (in braced and unbraced buildings).

c) To determine the maximum height of the building that can be built as unbraced structure.

## 1.4 Scope of Study

The study was carried out within the following scope of limitation.

a) The study was carried out on two identical modeled buildings having identical sizes of corresponding structural elements.

b) One of the buildings was provided with shear walls, while the other was without shear walls.

c) Both types of buildings were subjected to the same vertical and horizontal loadings.

d) The basic wind speed considered was 40m/sec.

e) The height of the building considered in each series of braced and unbraced structures were 5, 10 and 15 storeys with the storey height of 3.5meters.

f) The analysis and design of the structural members was in accordance with Eurocode 2: MS EN 1992-1-1: 2000.

g) The analysis of wind loading was in accordance with MS 1553: 2002.

h) Orion software was used as the tools for analysis and design

i) The evaluation of the advantages or disadvantages of the structural system were based on forces carried by the structural members and the total amount of reinforcement required.

## 1.5 Significant Of Study

The result of the study could be used as guidance for structural engineers in adopting a suitable type of frame building of a particular height. The study could also show the importance of providing the bracing in medium and tall building.

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