Evaluating Equation of Braced and Un-braced building in Egyptian Code

By

Marco Fayek Fouad Khaier

A Thesis submitted to the

Faculty of Engineering at Cairo University

In Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

In

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Title of Thesis:

Evaluating Equation of Braced and Un-braced building For Egyptian Code

Key Words: Braced building, un-braced building, Frame system, shear wall system, parameters, beam inertia, column inertia, displacement, modeling calculation, manual calculation.

Summary:

Thesis presents a comparative study on the effect of Frame system on braced and un-braced building equation of Egyptian code of practice. The effect of FEM modeling assumptions and code provisions on frame system of RC buildings is studied.

These assumptions are: (i) height of floor, (ii) Column inertia, (iii) Beam inertia,

(iv) number of floors, (v) number of bays, (vi) length of bays. The effect of frame system on the code equation of braced and un-braced building equation on RC buildings is studied. Importance of contribute the frame system in equation of braced and un-braced was demonstrated.

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Eng. Marco Fayek

ABSTRACT

The main objective of the current research is the assessment of the current Egyptian Code equation for determining if the building is braced or un-braced. The ECP takes into account only the shear walls as the main structural elements in its equation for braced and un-braced buildings.

FEM analysis is used to evaluate contribution of the frame structural system (Slab, Beams and Columns) and investigate its reflection on ECP equation for braced or un-braced building. Analytical study is performed to explore the possibility of having the building braced without shear walls. Different parameters are studied and it is concluded that frame system can be used efficiently to brace the building. Proposal for modified equation to be in corporate in the code is presented.

$$\propto = \boldsymbol{H_b}\sqrt{\frac{\boldsymbol{3}}{\boldsymbol{h^3}}}\sqrt{\frac{\sum \boldsymbol{N}}{\sum \boldsymbol{k_t}}}$$

Considering $\sum K_t = \sum K_w + \sum K_f$

$\sum \boldsymbol{k_w}$: Sum of the flexural rigidities of Shear walls or cores.

$\sum \boldsymbol{k_f}$ **:** Sum of the flexural rigidities of frame system.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1

INTRODUCTION

1.1 General

In the Egyptian code, the building is considered braced or un-braced, by taking contribution the shear walls only and excludes the effect of frames, which is claimed here to be significant. Case studies are created that represent comparison between shear wall system and frame structural system; which shows the importance of the frame system as an essential structural element, which can contribute to the equation of ECP for braced, and un-braced building, thus leading to more economical designs.

1.2 Motivation And Objectives

The primary goal of the code equation for braced and un-braced building is determination of building mode (sway or non-sway) and this is reflected on the design of columns. The equation of Egyptian code for braced and un-braced used only for buildings with shear walls. Therefore, the shear wall inertia is the main factor to give decision for braced or un-braced structure. However, frame system also has its effect, which is neglected in the equation of code.

Braced and un-braced building equation in Egyptian code is mainly used only when the building has shear walls as follows.

$$\propto = H_b \sqrt{\frac{\sum N}{\sum EI}} < 0.6 \text{ for } (n \geq 4). \qquad (1.1)$$

$$\propto = H_b \sqrt{\frac{\sum N}{\sum EI}} < 0.2+0.1n \text{ for } (n<4). \qquad (1.2)$$

α: Bracing factor.

H_b: height of the building in meters above foundation.

∑N: Sum of all un-factored vertical loads of the building (total working gravity loads).

n: Number of storeys.

ΣEI: sum of the flexural rigidities of all shear walls stiffing elements under study direction.

The main objectives of current research are as follows:

1. Investigate the behavior of both shear wall system and frame system under lateral load, get the displacement for each system and assess the contribution of both of them in bracing the buildings.

2. Investigate the effect of frame parameters (length of bay, height of floors, columns and beams inertia, number of bays, and number of floors) on the lateral stiffness of the building.

3. Study the possibility of considering the frame action contribution of frame system in ECP equation for braced and un-braced building.

1.3 Research Methodology

The chronological steps for a comparative study of the effect of frame systems on the equation of ECP for braced and un-braced building are described below

Step 1: literature Survey, Collecting Data and Study effect of frame system on the equation of ECP.

The collection of relevant information related to research work previously done by other researchers is emphasized in this stage. The code applied effect of frame system on the equation of ECP.

Step 2: Technique for Finite Element Modeling for Analysis and Design Purpose.

To study the performance of buildings, Finite Element Modeling is used for structural analysis, which consists of linear elastic analysis. The computer software, SAP2000 and Etabs are used for static linear analysis. Applying static linear analysis, buildings performance under lateral loads is studied.

Step 3: Performance of Reinforced Concrete Buildings.

The comparative study of the effect of modeling assumptions on frame system and shear wall system is investigated. A frame structural system is selected to investigate the braced and un-braced building equation according to the Egyptian code. It is used to study the different parameters that affect the lateral stiffness. The specific issues to be investigated in a comparative format are the relative effects of the frame structure system on the braced and un-braced equation according to Egyptian code.

Step 4: Discussions and Conclusions

The final step presents the summary and conclusions of the whole study, which h includes discussions and recommendations to improve the research.

1.4 Organization of the thesis

After the introduction Chapter, a literature review is provided in Chapter 2 of this thesis. This review includes some of published studies and researches related modeling and seismic analysis.

Chapter 3 presents collected data about prove that the frame system should be integrated into original equation of braced and un-braced building which is mentioned in the Egyptian code of practice. The assumptions and parameters concerning the case study problems are listed.

Chapter 4 presents a parametric study considered in the thesis for frame structures system. There are certain parameters that have a considerable effect on the frame system, the procedure adopted is to study an initial 2D model with constant parameters (Length, Height, no of bays, moment of inertia for column, moment of inertia for beam and number of floors),which will be loaded on a frame with certain lateral load. The n by changing the value of each parameter, the displacements are obtained.

Chapter 5 presents the results of the parametric study and the effect of different parameters on lateral displacements. Each parameter was studied while