Human Comfort Study of Medium Rise Reinforced Concrete Buildings under Wind Excitations

By

Sharehan Harby Ali El Sherif

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
Structural Engineering

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Title of Thesis:

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Key Words:
Human comfort; reinforced concrete building; wind load; wind induced vibration

Summary:
Wind induced motion in buildings may result in excessive vibrations that hinder the usage of them. Traditionally, wind loads are represented as static forces acting on the building with increased magnitudes relative to its height. Consideration of human comfort limits is not a common practice for regular designers. A parametric study is conducted to investigate the effect of different parameters on the human comfort limits of medium rise buildings. The parameters include the used structural system, number of floors, and floor height. Total of 92 models are examined using linear static and dynamic analyses to determine the acceleration and drift values under wind loading. Static analysis as well as dynamic (time history) analyses are employed in the performed parametric study.

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Abstract

Design of tall and medium rise buildings is usually governed by wind loads rather than seismic loads. Generally, designers would consider the influence of wind loads represented as static loads on the resulting straining actions and drift values. Traditional representation of wind excitation may not capture the influence on the human comfort limits which are affected by many factors including the dynamic properties of the building, usage of areas, expected wind excitations...etc.

In this research, a parametric study is conducted to investigate the influence of a number of parameters including the used structural system, number of floors, and floor height on the performance of medium rise reinforced concrete buildings under wind loading effects. Total of 92 models are examined using linear static and dynamic analyses. Human comfort limits are usually related to the acceleration values of buildings. Hence, in the current study, focus is given to acceleration and drift values as measures of the human comfort levels in the range of the studied structures. Static and dynamic time history analyses are employed in the performed parametric study.

In addition, limits and recommendations imposed by different codes and standards to satisfy human comfort requirements are explored and listed.

Chapter 1 : Introduction

1.1. Introduction

Civil structures are traditionally designed to resist static loads. They are, however, subjected to a variety of dynamic loads, including wind and earthquakes. Neglecting the dynamic nature of such loads may cause severe vibratory motion which hinders the usage of the structure.

1.2. Problem Statement

Wind loads have traditionally been modeled using static force equivalents. The procedure for applying wind loads includes determining basic wind speed value which corresponds to an extreme velocity measured at a height of 10 m and averaged over a period of 3 seconds and has a return period of 50 years. Afterwards, the basic wind speed is adjusted to account for topology, ground roughness, structure shape, and height above ground. Hence, the resulting wind speed is converted into static pressure acting upon the surface area of the structure.

However, in some cases, it is not deemed sufficient to treat wind loads as static forces. The dynamic response of structures to wind loads can be assessed analytically or experimentally. In addition, vibration effects in medium rise and high rise buildings may result in discomfort conditions for occupants.

Design codes and standards provide guidelines for the acceptable acceleration ranges for different structures. Such guidelines are usually related to the acceptable range of acceleration. Meanwhile, most common design applications focus on the strength of the building and its ability to resist the applied loads with no consideration to the dynamic nature of wind excitations.

A parametric study is carried out for the evaluation of resulting acceleration values for a wide range of medium rise reinforced concrete structures. This work focuses mainly on conventional reinforced concrete buildings for office occupancy.

1.3. Scope of the Research

The need to assess the limits of human comfort adopted in different codes and whether conventional design of reinforced concrete buildings satisfies such limits is the main point of this research work. The research program includes:

1. Investigating acceleration values for medium rise reinforced concrete buildings considering different systems.
2. Comparing response of medium rise reinforced concrete buildings under static and dynamic representation of wind loads.
3. Exploring the human comfort limits and recommendations stipulated in different codes and standards.