

Hanaa Mohammed



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مركز الشبكات وتكنولوجيا المعلومات

قسم التوثيق الإلكتروني



Safaa Mahmoud



جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

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Ain Shams University
Faculty of Engineering
Structural Engineering Department

Performance-based Advanced Seismic Analysis and Design of RC Structures with Vertical Irregularities

A Thesis submitted in the Partial Fulfillment for the Requirement of
the Degree of
Master of Science in Civil Engineering

(Structural Engineering)

by

Fady Magdy Istafanous Mikhail

Master of Science in Civil Engineering

(Structural Engineering)

Faculty of Engineering, Ain Shams University, 2022

Supervised By

Prof. Ayman Hussein Hosny Khalil

Dr. Mahmoud Mohamed Mahmoud El-Kateb

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Examiners' Committee

Name and Affiliation

Signature

Prof. Sherif Ahmed Mourad

Professor, Structural Department-Cairo University

.....

Prof. Ayman Abou El Fotouh Embaby

Professor, Structural Department-Ain Shams University

.....

Prof. Ayman Hussein Hosny

Professor, Structural Department-Ain Shams University

.....

**AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
STRUCTURAL ENGINEERING DEPARTMENT**

Thesis submitted by: Fady Magdy Istafanous Mikhail

**Thesis title: Performance-based Advanced Seismic Analysis and
Design of RC Structures with Vertical
Irregularities**

Supervisors:

Prof. Ayman Hussein Hosny Khalil

(.....)

Professor
Structural Engineering Department
Faculty of Engineering
Ain Shams University

Dr. Mahmoud Mohamed Mahmoud El-Kateb

(.....)

Assistant Professor
Structural Engineering Department
Faculty of Engineering
Ain Shams University

Registration date:

Examination date:

Date:

STATEMENT

This dissertation is submitted to Ain Shams University to get the degree “Master of Science in Civil Engineering (Structural)”.

The work included in this thesis has been carried out by the author in the Department of Structural Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

Name: Fady Magdy Istafanous Mikhail

Signature:

Date : / /

Researcher Data

Name	: Fady Magdy Istafanous Mikhail
Date of birth	: 02/08/1993
Place of birth	: Cairo, Egypt
Last academic degree	: Bachelor of Science in Civil Engineering
Field of specialization	: Structural Engineering
University issued the degree	: Faculty of Engineering, Ain Shams University
Date of issued degree	: 2017
Current job	: Structural design engineer

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ABSTRACT

For the past two decades, “Performance-based seismic design” is the focus of worldwide earthquake engineering research. The development of effective “preliminary design” techniques that adhere to standard design formats is a significant determinant of the success of its most current framework for the purpose to keep the progression on an acceptable rate of difficulty for specialists and also practitioners. Force-based seismic is inefficient since it constructs structures just for one main performance target which is the life safety, also additional objective for the performance will remain subject to the check of the drift followed by a design, resulting to a very repetitive procedure. Moreover, when the matter comes to irregular structures that is suspicious to local failure, the unfavourable “soft-storey” mechanism is likely to occur with the vertically irregular structures when the analysis is limited to force aspects only. The traditional seismic design approach must be adapted to meet the multi-level performance design, by adding performance measurements at the beginning, in order to be used inside the performance-based framework.

The significance of local damages in the seismic performance of vertically irregular Reinforced Concrete (RC) building structures was emphasized in post-earthquake damage reconnaissance studies. This forces earthquake engineers to focus on reducing the destructive effects of earthquakes on buildings. This matter is of increased significance especially when it comes to structures having deficiencies in the lateral resisting systems, as these irregularities will have a detrimental impact on the structure's behaviour. Non-linear analysis has been undertaken to investigate the seismic performance of RC Moment Resisting Frame (MRF) buildings with vertical irregularities in the form of transfer storey. Case study buildings were assessed using (FEMA-356, 2000) standards. Global Inter-storey Drift Ratio (IDR) limits were compared to their counterparts that are based on member-level criteria, for the prediction of the unfavourable soft-storey mechanism. Under various variables, correlations have been developed to assess different structure's predicted seismic behaviour. In this study, member-level

criteria (local damages) were employed to forecast the afore-mentioned local failures and then compared to global-level criteria to not only understand the behaviour of these irregular structures, but also to give the key criteria and limitations that should be investigated for these kinds of structures and furthermore, to be used for the development of the empirical equations embedded in the Hybrid Force-Displacement (HFD) design process.

A hybrid force-displacement design framework for steel buildings has been well-recognized for years. An analytical relationship is established between requirements of the performance also the decrease in the elasticity force for designing forces for a manner to incorporates both force-based and displacement-based techniques' benefits. To help designers design RC framed structures more quickly, this thesis, titled " Performance-based Advanced Seismic Analysis and Design of RC Structures with Vertical Irregularities", offers a "tool" that may be used in the design office. A more realistic representation of earthquake reaction is provided by the displacement demand input parameter, which avoids the iterative stages necessary to meet acceptable performance limitations in typical code design procedures. As a result of the research, it is possible to establish displacement estimation relations for RC structures that may be used as a starting point in design.

In this study, the vulnerability of unpredictable damage (unpredicted when investigated by linear and conventional methods) of vertically irregular structures in the form of buildings with transfer storey, having variable heights and stiffnesses, is investigated by applying the newly developed non-linear static analysis (Displacement-based Adaptive Pushover method), which is applicable for these types of vertically irregular RC structures as it accounts for the higher modes, material degradation, and stiffness deterioration effects. Fifteen prototype case studies, designed according to the Egyptian Code of Practice (ECP-203, 2017) and in conjunction with (ECP-201, 2012) (which are fundamentally in line with the regulations of Eurocode 8 (EN 1998-1, 2004)), are investigated considering the afore-

mentioned variables. (FEMA-356, 2000) member-level criteria were used to investigate the formation of local mechanisms at the transfer storey and compared to the corresponding global damage to assess different types of failures including the unfavourable soft-storey mechanism. Then, a performance-based seismic analysis and design is proposed for RC moment resisting frames MRFs with vertical irregularity in the form of transfer storey. Incremental Dynamic Analysis (IDA) was adapted, in this study in order to be capable of studying the predicted roof displacements of these types of irregular structures and moreover, monitoring their global and local performance in the form of the maximum Inter-storey Drift Ratio (IDR_{max}) and maximum plastic chord rotation (θ_p). These performance limitations are then used as the input for the initial step of the proposed hybrid performance/force-based design method. The approach depends on using the demand of the displacement as an input parameter that way more accurately represents real earthquake reaction that avoids the iteration involved stages needed in the conventional code design process to meet acceptable performance limitations. The final goal of this study is to study the behaviour of these types of vertically irregular structures under various variables of interest to designers, also create displacement prediction equations for adopted RC MRFs structures with transfer storey, in order to be used at the start for the design procedure, which is in the design approach core.

Keywords: “Performance-based seismic design”, Hybrid force/displacement design method, Reinforced Concrete structures, Moment-resisting frames, Non-linear analysis, Lateral resisting system, Soft-storey mechanism, Incremental Dynamic Analysis, Displacement-based Adaptive Pushover, Inter-storey drift ratio, Maximum plastic chord rotation.

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