Seismic Analysis of a 4-Storey Existing Reinforced Concrete Building in Cairo, Egypt

MTC Concrete Project Team

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Abstract*—The aim of this paper is the evaluation of an existing RC multistory building if exposed to seismic loads. The building studied is a four storey residential building in the city of Cairo, Egypt. It is constructed from reinforced concrete and designed for gravity loads only according to the Egyptian Concrete Code EGP203-2018. In the present paper earthquake loads are calculated by three different methods (Equivalent Static method, Response Spectrum method, Time History Analysis). These methods are given in the Regulations for earthquake resistant design of buildings in Egypt, (EGP203-2018). The results from the analysis due to seismic and gravity loads are compared in order to evaluate the straining actions of base shear. The bending moment and shear forces can be obtained from ETABS 17.0.1, which is usually used to perform the linear and nonlinear analysis. The results showed there is effect for seismic loads in the X direction and also the paper studied the effect of seismic loads in the Y direction. Generally Bending moments and shear forces in beams and columns due to seismic excitation showed much larger values compared to that due to gravity loads .The results obtained, show the need for additional reinforcements and increase of cross sections of the original concrete elements, in order to improve its seismic behavior.*

I. INTRODUCTION

Egypt is not free from earthquakes. It has experienced many earthquakes during the recent history, and the previous studies in this field demonstrated this argument. Egypt is generally considered a country of low seismic activity. However; recent seismic activities in different regions within Egypt warrant seismic hazard assessment of Egypt.

I. DESCRIBTION OF THE BUILDING

The building considered is a traditional residential four storey regular reinforced concrete building. It consists of ground floor and three storeys. The main dimensions in plan are 33.02 meters in X direction and 22.85 meters in Y direction. The figures below show the buildings plan view and their sections. The vertical support system of the building consists of columns and shear walls. The building has four levels over the ground. Each level has a standard height of 3.00 m while the height of the ground floor is 3.5 m. The structure system is a moment resisting RC building with solid slab, 12cm thickness, and flat slab,18cm thickness. The building was analyzed using *ETABS 17.0.1* program. Base Shear of the building was selected for the purposes of the analysis.

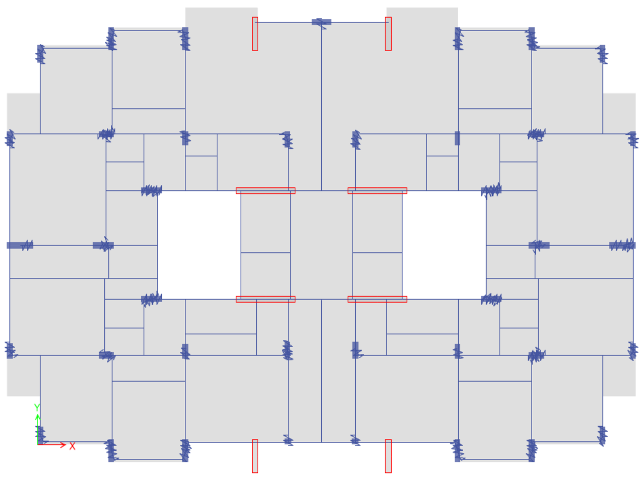

Fig.1: Plan of the studied building

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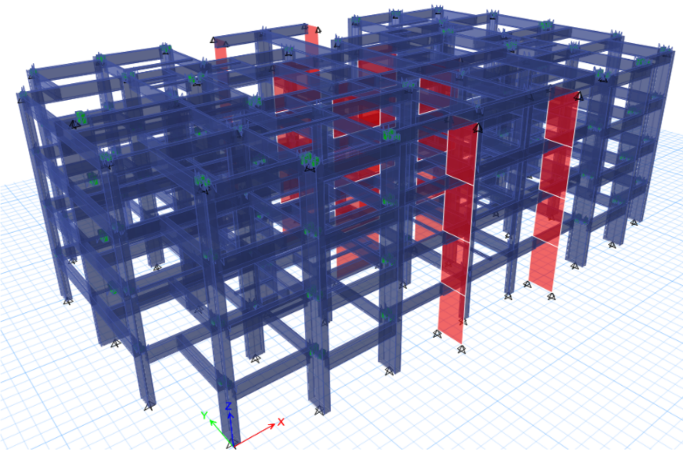

Fig.2: Sections of the building

2.1 Numerical modeling

Numerical models for the case has been prepared using *ETABS 17.0.1*. Beams and columns are modeled as frame elements while walls and slabs are modeled as shell elements. In this paper the seismic performance of the considered residential building will be evaluated using the three methods of seismic load calculations.

2.2 Analysis

The analysis of the RC building follow the Egyptian Code for Design and Construction of RC Structures. The sustained live load associated with lateral load combinations is 25% of the total live load. There are stiffness modifiers in reinforced concrete structure.

Ieff	نوع العنصر الإنشائى
0.7 Ig	الأعمدة
0.7 Ig	حوائط القص
0.5 Ig	الكمرات
0.25 Ig	البلاطات

Fig.3: Effective inertia of structural elements

2.2.1 Method1: Simplified Modal R.S.Method (Equivalent Static Mehod)

For applying this method there are some conditions that must be in the case of study: the periodic time for the building in each direction equals or less than $4T_c$ and 2sec, the building should be regular in vertical and horizontal views.

Base Shear = Some Coeff $*S_d*$ (W/g)

The different coeffients are the importance factor (γ) which on the importance of the building and purpose of its using , Response modification factor(R): it depends on the statical system of the building , Damping factor corrected for Hz.R.S ,Sd is the acceleration of the building not the earthquake.

قيمة العجلة الأرضية التصميمية (ag)	المنطقة
0.10 g	المنطقة الاولى
0.125 g	المنطقة الثانية
0.15 g	المنطقة الثالثة
0.20 g	المنطقة الرابعة
0.25 g	المنطقة الخامسة (أ)
0.30 g	المنطقة الخامسة (ب)

Fig.4: Values of design accelerations according to zones

Cairo is of zone3

Fb= Sd(T1) . λ . (W/g)

Where W= (DL + FC + Wall + αLL)

α depends on the type of structure, in our case α=.25

SOIL TYPE A,B,C or D =	c
Type 1 or 2	1
ZONE 1,2,3,4,5A or 5B =	3
REDUCTION FACTOR (R) =	5
Total Weight of building (TON)=	4300
TOTAL HEIGHT of building (m)=	12
IMPORTANCE FACTOR 1 or 1.2 =	1
Total Number Of Stories=	4

Soil Type	S	TB	TC	TD
c	1.5	0.1	0.25	1.2

TYPES OF SOIL	S	TB	TC	TD
A	1	0.05	0.25	1.2
B	1.35	0.05	0.25	1.2
C	1.5	0.1	0.25	1.2
D	1.8	0.1	0.3	1.2
REDUCTION FACTOR (R) =	5	1		

ZONE	1	2	3	4	5A	5B
a_g	0.1	0.125	0.15	0.2	0.25	0.3
Total building WEIGHT (TON)=	4300					
ag=	0.15					
H=	12	m				
T1=Ct(H)^3/4=	0.32237098	Sec.				
IMPORTANCE=	1					
CASE1	Sd(T)=	0.02911				
CASE2	Sd(T)=	0.1125				
CASE3	Sd(T)=	0.08724				
CASE4	Sd(T)=	0.32476				
FINAL Sd(T)=	0.08724421					
I =	0.85					
Total base shear Fb =	318.877571	ton				

Fig.5: Excel sheet for calculating base shear

Then from the first method ***<u>Fb=318.877571t</u>***

2.2.2 Method 2: Multi-Modal Response Spectrum Method

This method depends on using the dynamic characteristics to find the peak values of the response and designing on it. The dynamic analysis gets mode shapes, there is periodic time for each mode.

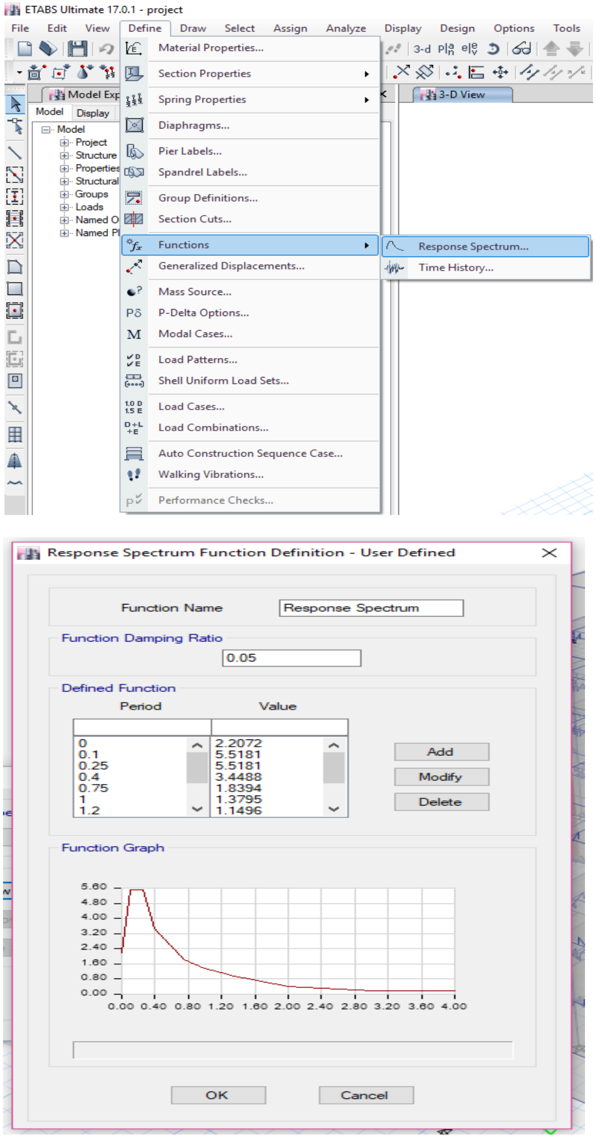

Fig.6:Defining Response Spectrum Function

Then defining the response spectrum function using the previous excel sheet and the building weight.

Response Spectrum Functions											
T1=	0	0.1	0.25	0.4	0.75	1	1.2	1.3	2	3	4
SR	0.225	0.5625	0.5625	0.3515625	0.1875	0.140625	0.1171875	0.099852071	0.04219	0.02	0.02
a	2.2073	5.518125	5.51813	3.44882813	1.839375	1.37953125	1.14960938	0.979548817	0.41386	0.1962	0.1962

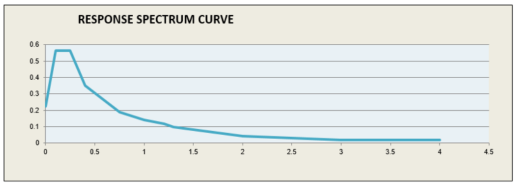

Fig.7: Entering values of time period and acceleration

Then from results of the program get the base shear

Base Reactions

Load Case/Combo	FX tonf	FY tonf	FZ tonf	MX tonf-m	MY tonf-m	MZ tonf-m	X m	Y m	Z m
Earthquakes X M...	277.5945	1.731E-06	0	7.523E-06	1665.7007	2430.5898	0	0	0
Earthquakes Y M...	3.649E-05	277.5552	0	1665.5021	0.0004	4138.3486	0	0	0

Fig.8: Getting value of base shear

<u>Base Shear =277.5552t</u>

2.2.3 Method 3: Time History Method

This method depends on analyzing the structure on a real earthquake then calculating the dynamic response of the structure using numerical integration . We use the information of 3 earthquakes at least then use the maximum force , in case of using seven earthquakes or more we can take the average of the internal forces. Time History Analysis is nonlinear approach to calculate time varying responses.

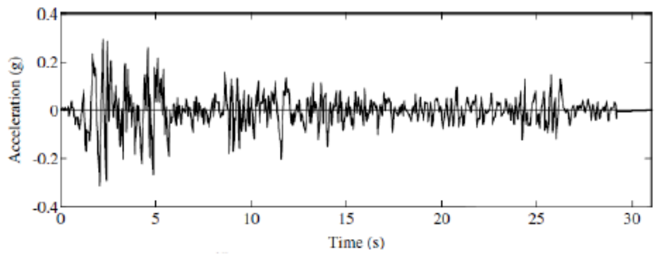

Fig.9: Relation between acceleration over time

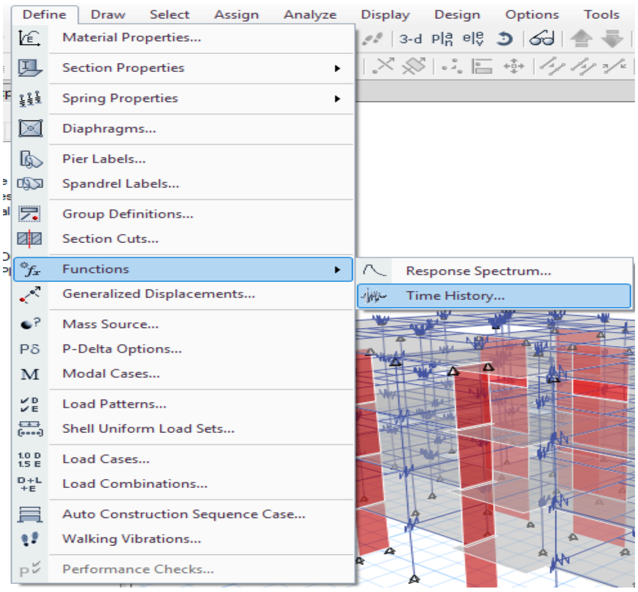

Fig.10: Defining Time History Function

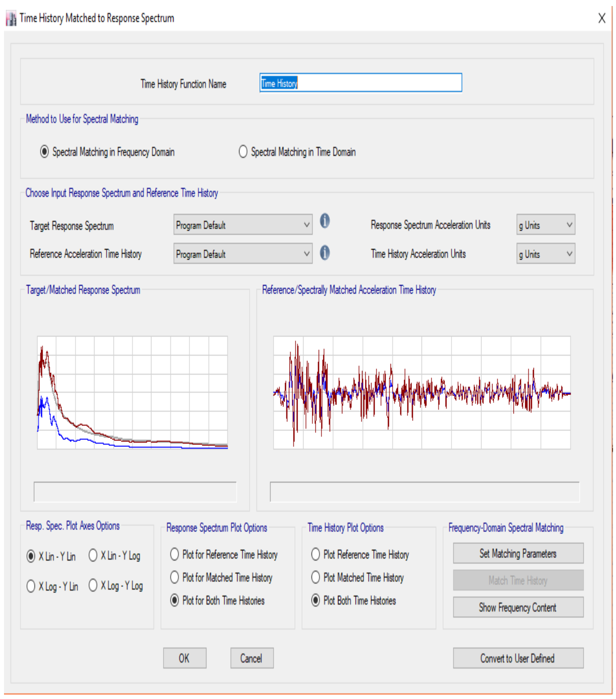

Fig.11: Insert the data of earthquakes or data matched to the response spectrum modal

Then define load cases of time history

Time History Case X	Nonlinear Modal History
Time History Case Y	Nonlinear Modal History

Fig.12: Load cases of Time History Analysis

Base Shear = 246.2061t

DISCUSSION

The results of the analysis indicated that the shear forces and bending moments increased in columns and beams due to seismic loads.

CONCLUSION

The results obtained from the analysis of the 4 storey reinforced concrete building in Cairo city, lead to the following conclusion The values of shear forces due to gravity and seismic loads in the different methods are approximately the same.

REFERENCES

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[2] Egyptian Code for Design and Construction of Reinforced Concrete Structures , Research Center for Housing, Building and Physical Planning, Giza, Egypt , 2003

[3] Modeling Cracked Section Properties for Building Analysis ETABS Computers and Structures, inc

[4] Diaphragms Shells, CSI ETABS help