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The Evaluation of the Seismic Vulnerability of Reinforced Concrete Building in Different Areas of Morocco

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Abstract : *The work is presented in the context of estimating the seismic vulnerability of reinforced concrete building by determining the maximum displacements of all levels of the studied building and stability factors, by comparing the seismic shifts in the three areas of Morocco, using seismic regulations 2000, different vulnerabilities studies allowed us to establish a new concept of the economic impact of the optimal sizing and the estimation of the construction of the building for non-risky areas compared to the critical ones in Morocco.*
Keywords - *Morocco, Vulnerability , Building, RPS2000, Seismic Area*

I. INTRODUCTION

In seismic codes or regulations, the study of the response of building structures to the effects of earthquakes is conducted using simplified methods based on spectra with response [1], to optimize the seismic design of structures. In addition, the method relies on using a procedure for calculating the maximum displacements of different levels of reinforced concrete building located on a ground referenced by type S1, ordinary class II ,according to the code of Moroccan seismic building RPS 2000 [2], which established a seismic zoning dividing the Moroccan national territory into three zones of seismicity. This zoning up places the province of Al Hoceima, along Agadir and its region, in zone 3 where the degree of seismic risk is the highest in Morocco and the two least risk areas are named zone 2 and 1.

In this essay, we propose an evaluation study of the Arbitration divergence sizing of the structure of the reinforced concrete building, on the economic impact of the construction at the spectrum of seismic elastic response to a relative damping ξ = 5% applied on a comparison of three seismic zones of Morocco on site type S1 (rock any depth).

II. ZONING AND SEISMIC STABILITY INDEX

2.1. THE SEISMIC ZONES IN MOROCCO

To simplify the calculation of structural design through large areas of Morocco, the RPS 2000 uses the approach of zones. It is about dividing Morocco into three zones of homogeneous seismicity and having approximately the same level of seismic risk probability of occurrence of 10% in 50 years.
In each area, the parameters defining the seismic risk, such as the horizontal ground acceleration is considered constant with:
Zone 1 : Amax/g = 0.01
Zone 2 : Amax/g = 0.08
Zone 3 : Amax/g = 0.16

The map of seismic zones of Morocco is shown in Figure 1

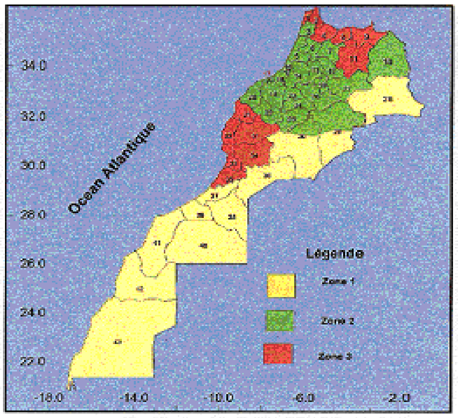


fig1 : Map of the three seismic zones of Morocco

2.2. The index of stability

The index of the roll stability in the linear case is represented by the equation [2]:

$$\Theta = KW\ Del / V\ h \qquad (1)$$

$$V = WASDI/K \qquad (2)$$

With:

Ɵ	Stability index
W	Weight above the floor considered
V	Seismic actions at the level considered
h	Storey height
Del	Relative displacement
K	Behavior factor
A	Coefficient of acceleration zone
S	Coefficient Site
D	Dynamic amplification factor given by the amplification spectrum
I	Coefficient given priority

III. Application

Description Of The Studied Building

The studied building is made out of reinforced concrete [3] - [4], for residential use (Figure 2), consisting of a ground floor under four floors. The resistant structure is composed of solid slabs of thicknesses 12cm, the main beams have a section of (25x45) cm, while the two end poles corners of cross have a section of (25x25 cm) and the other poles are sized by (30x30) cm, the building is located on a soil type S1. The concrete used is a concrete with a strength of 25Mpa, HA500 steel, the reinforcement of beams and columns is (4.8 Φ14, 12 and 8). The building is regular (to avoid twisting effect) [5] and sized according to Regulation Moroccan earthquake in 2000.

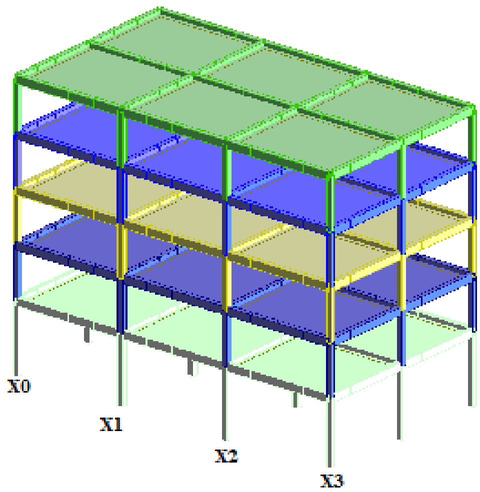


Fig 2 : Model of reinforced concrete building (R+4)

Designation	ground floor	Floor 1	Floor 2	Floor 3	Floor 4
height (m)	4	7	10	13	16

IV. Results

In order to estimate the dimensions of the design of reinforced concrete building by determining the seismic vulnerability of the building (the movement of floors of the building), an analysis of seismic simulation of three seismic regions based on movement calculations has been carried out by Autodesk software [6] and the application of the horizontal direction of the earthquake is along the axis of X.

4.1. Displacements

According to the three seismic zones of Morocco, the displacements obtained for each building height are shown on: Figures 3, 4 and 5.

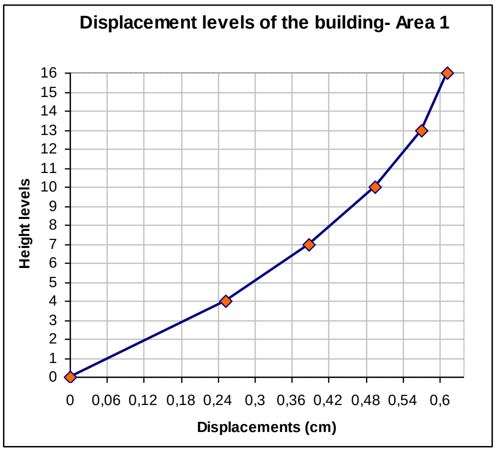


Figure 3 : The maximum displacements of each floor of the building in seismic zone 1

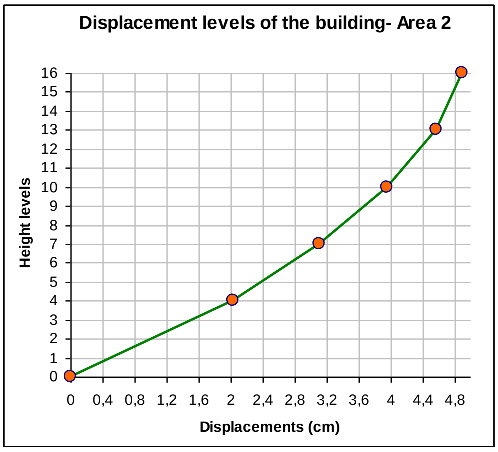


Figure 4 : The maximum displacements of each floor of the building in seismic zone 2

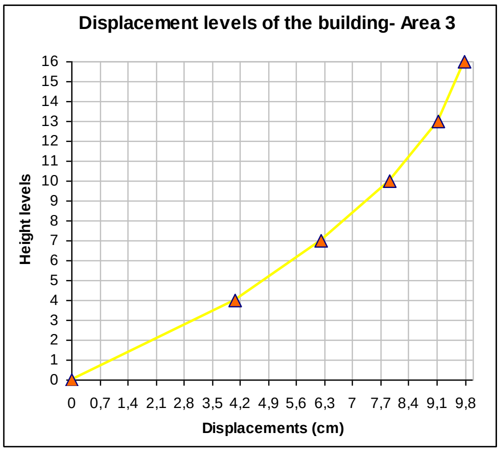


Figure 5 : The maximum displacements of each floor of the building in seismic zone 3

The calculated displacements in the three seismic zones of Morocco show that they are classified according to: Displacement (Area 1) < Displacement (Area 2) < Displacement (Area 3)
Zone 3: The displacements of the upper roof of the building reach 97.87 mm.
Zone 2: The displacements of the upper roof of the building reach 48.94 mm. with 48.93 mm represents the reduction of the calculated displacement of zone 2 calculated with respect to the zone 3.
Zone 1: The displacements of the upper roof of the building reach 6.12 mm. With 91.75 mm represents the reduction of the calculated displacement relative to zone 3 and 42.82 mm relative to zone 2.

4.2. INTERPRETATION

Values of the stability index of the structure:

Area	1	2	3
Θ	0,0063	0,0507	0,1013

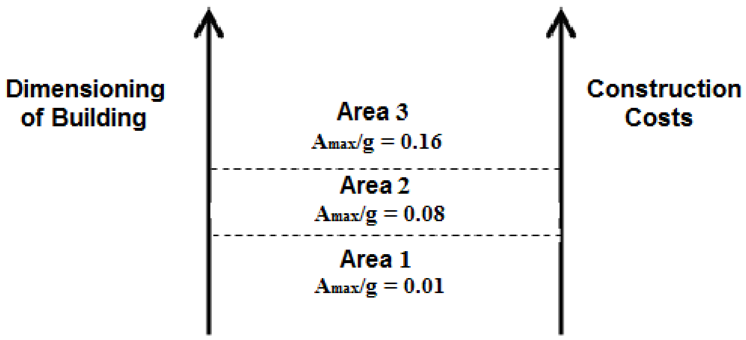
It is observed that the calculated stability index ΘZ1 < ΘZ2 < ΘZ3 for the same site (S1) and the same structure, This demonstrates that for:

Zone 1: Minimization of 42.82 mm of displacement is for zone 2, which reduces the risk of this design by 87.50% compared to zone 2 (gain on the size of the structure).

Zone2: Minimization of 48.93 mm of displacement is for zone 3, which reduces the risk of this design around 49.99% compared to zone 3 (sizing optimization).

V. CONCLUSION

We notice that the structural design of reinforced concrete building in the seismic zone Z1 is more optimized (with the lowest degree of seismic vulnerability) compared to those made in zone Z2 and Z3. Thus, the design of structures in zone Z2 is more optimized than the design in zone Z3, which justifies the high cost of construction in the seismic zone Z3 (the most critical area, northern region, Agadir region ...) of Morocco compared to zone Z1 and Z2.



Our perspective on the one hand is to integrate, in Moroccan seismic settlement, an estimation of optimization design of the building at some percentage in seismic zones. This optimization is considered in relation to one of the most critical area with the objective of integrating an impact of economic and technical knowledge for new buildings and those to strengthen.

On the other hand we consider the specifications and designs of intermediates seismic zones between the three areas mentioned by RPS2000, in order to reduce the discrepancy between the design of buildings in different seismic zones of Morocco.

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