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Construction of a Seismic Reaction Map of a Reinforced Concrete Structure Using Fragility Curves and Incremental Dynamic Analysis

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For centuries the science of earthquakes has emerged Earthquakes which are still considered one of the most unpredictable and devastating natural disasters that sometimes have changed the course of history especially when accompanied by other disasters such as tsunamis or landslides. So far, the lack of certainty available to seismic scientists and structural engineers does not predict all aspects and parameters of earthquake interactions in an acceptable manner. The nature of the data necessary to determine the extent of the damage and its nature in a realistic and predictable way is still not conclusive, but this can be assessed by taking appropriate measures to limit the loss and material damage caused by the tremors. earthen.

However, predicting damage to a building during an earthquake simulation and interpreting the results obtained can help us understand the response of a structure to different types of seismic actions and forces. The use of a mechanism to identify the dispersion of damage on a reinforced concrete structure according to the ranges of values and parameters calculated for several earthquakes is necessary.

Thus, Incremental Dynamic Analysis (IDA), which is a nonlinear dynamic analysis that offers a huge opportunity to assess the seismic responses of the structure while combining them, results in fragility curves to probabilistically predict the effects. of an earthquake on the structure. This work therefore makes it possible to evaluate the capacity of these indicators to predict the damage of building structures with reinforced concrete frames, by focusing mainly on the height parameters and the number of floors of a building project.

In conclusion, determine an order of magnitude of the dispersion of damage that a structure undergoes during an earthquake characterized by its indicators and parameters.

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Introduction

Despite the fact that the seismicity in Morocco remains potentially moderate and that the history of the earthquakes in Morocco does not record a large earthquake unlike other countries of the world and especially in the Mediterranean basin such as Italy, Greece, Turkey or the 'Algeria, the seismic risk nevertheless remains non-negligible.

Morocco is divided into several seismic zones ranging from low seismicity to moderate seismicity, the building itself is not excluded in the event of structural damage.

In order to better understand the reaction of a structure and to be able to predict the structural damage that may affect it, we must first identify the parameters of a structure for this it is necessary to determine The configuration of the structural system, the type, the details, the connectivity, material strength and condition of structural elements included in the structure. Data should also be obtained for all building elements that affect the forces and deformations experienced by structural elements during the earthquake response to ground motion. This data should be obtained from available drawings, specifications, and other documents for constructions, and should be completed and verified by on-site investigations, including non-destructive diagnosis and testing of construction materials and components. For several years, seismic construction standards have appeared, (RPS 2000 modified 2002 and 2011 ([1]),[2]), even at the European level (Eurocode 8 [3]); their main role is to prevent possible damage that could go as far as total destruction caused by these earthquakes, and to take these parameters into account to ensure the proper functioning of new buildings.

MODELING STRUCTURES, SITE CHARACTERIZATION AND GEOTECHNICAL INFORMATION

Knowing the data on the capacity of a building and its resistance to large earthquakes is essential as well as the state of damage and the threshold of vulnerability for a reliable analysis of the building.

Since we will use in our study the characteristics of existing buildings exploitable for seismic performance, we must extract the necessary data from the visual observations of the structure as well as any technical construction documents, soil surveys, maintenance history and documentation of the structures. manufacturers; Destructive and non-destructive examinations and tests of certain construction materials and components may be used.

With regard to the characterization of the study site, Data on the configuration of the foundations and the parameters of the ground surface and subsoil on the site must be collected from the existing geotechnical documentation, reconnaissance visualization of the site or of a geophysical reconnaissance underground investigation test. When the site needs improvement A site specific underground survey should be carried out.

When historical information indicates that a geological site is subject to a nearby hazard, a site-specific underground survey should be performed to investigate the potential for geological hazards.

Since the majority of buildings in Morocco generally do not exceed six floors. the recommended structural model is a typical building with a reinforced concrete frame structure in the form of a portico on posts, beams and bracing walls.

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Modeling of the structure close to that of reality is essential taking into account the characteristics of the materials and the soil / structure reaction and the site parameters, by faithfully modeling the structure on modeling software such as sap2000[4].

The majority of buildings in Morocco generally do not exceed six floors. The peculiarity of the Moroccan real estate park is generally a frame made of reinforced concrete in the form of portico on poles, beams and sails of bracing [5].

The building is dimensioned according to the Moroccan seismic regulation RPS 2000 [1]. A three-dimensional numerical model of this structure is modeled using sap2000 version 20 [4] and opensees [6] for comparison and verification.

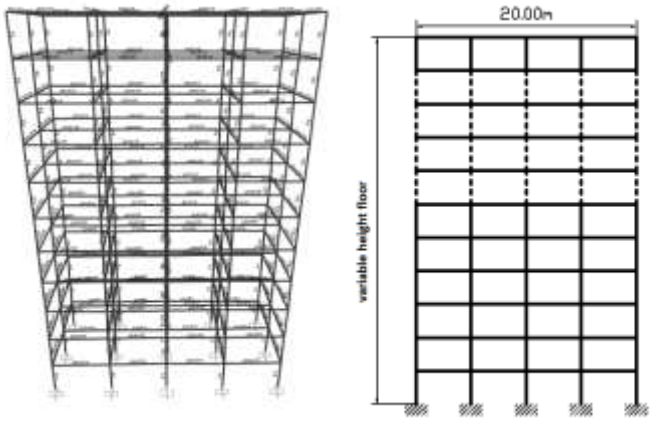


Fig. 1. Three-dimensional design of the finite element model of the structure on [4].

Probabilistic evaluation of seismic performance

the methodology used consists in introducing a probabilistic evaluation of the seismic performance which identifies the response of a structure taking into account the uncertainties associated with seismic events and subsequent structural

responses. The limit state, which is denoted by the damage state (DS), the probability of the seismic risk assessment, is defined by equation (1) assuming that the seismic intensity demand (Q) and structural capacity (R) are random variables [7].

$$P_{LS} = \sum_x P[DS|Q = x].P[Q = x] \quad (1)$$

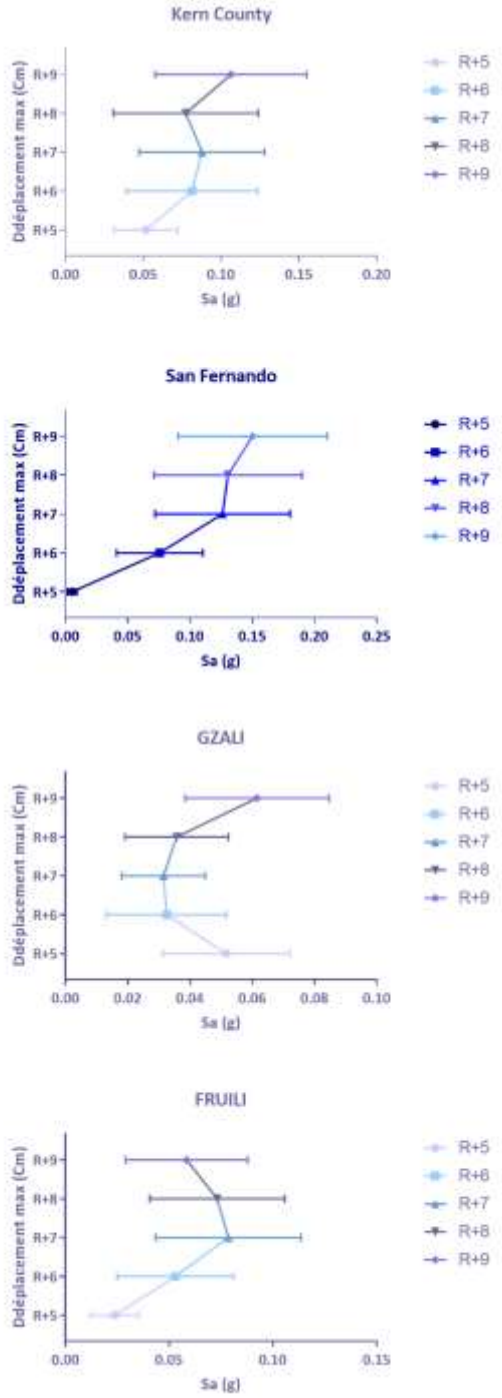
Where P[DS|Q=x] represents the seismic fragility of the structure and P[Q=x] represents the seismic hazard.
Fema 356 [8] provides three levels of structural performance: Collapse Prevention (CP), Life Safety (LS), and Immediate Occupancy (IO). Corresponding maximum allowable displacement ratios of 5%, 2.5% and 0.7%. We also consider other damage limit states as 0.2% for Slight Damage, 0.5% for Moderate Damage, 1.0% for Extensive Damage, and 2.5% for Complete Damage.
Fragility F (x) is estimated as a lognormal distribution indicating the probability of exceeding the different levels of damage Equation 2 [7].

$$\mathrm{F_r(x)} = \Phi\left[\left(\ln \mathrm{x} - \ln \widehat{\mathrm{S_a}}\right)/\beta_\mathrm{R}\right] \quad (2)$$

Where $\widehat{\mathrm{S}}_\mathrm{a}$ the mean of the fragility values of the S_a unit structure, β_R is the lognormal standard deviation of the frailty system. The dispersion parameter β_R, which reflects the uncertainties, associated with the seismic demand.
The authors should give in this section of the report a detailed account of the procedure that was followed in completing the experiment(s) discussed in the report.

Results and discussion

to analyze the structure model and using a range of seismic data recommended on the basis of a selective approach including site factors, seismic intensity and duration. Incremental dynamic analyzes are used on the structures of several buildings of varying heights. The fragility curves which result from the exploitation of the maximum displacements of the tops of stages and the maximum inter-stage displacements are constructed as a function of the spectral accelerations obtained by the fundamental period of each structure.
The SAP2000 software makes it possible to carry out dynamic chronological analyzes (THA) on structures by exploiting the seismic data of the recommended recordings, in order to evaluate the maximum displacement of structures under the effect of several earthquakes by integrating the incremental method with the analysis and multiplying each time the earthquakes by factors.
The following figure illustrates the standard derivation of the maximum displacements resulting from the nonlinear dynamic analysis by specifically using the time history analysis by exploiting the data of the seismic recordings recommended for this study, the analysis was carried out on a structure of a reinforced concrete building of variable height ranging from R + 5 to R + 9.



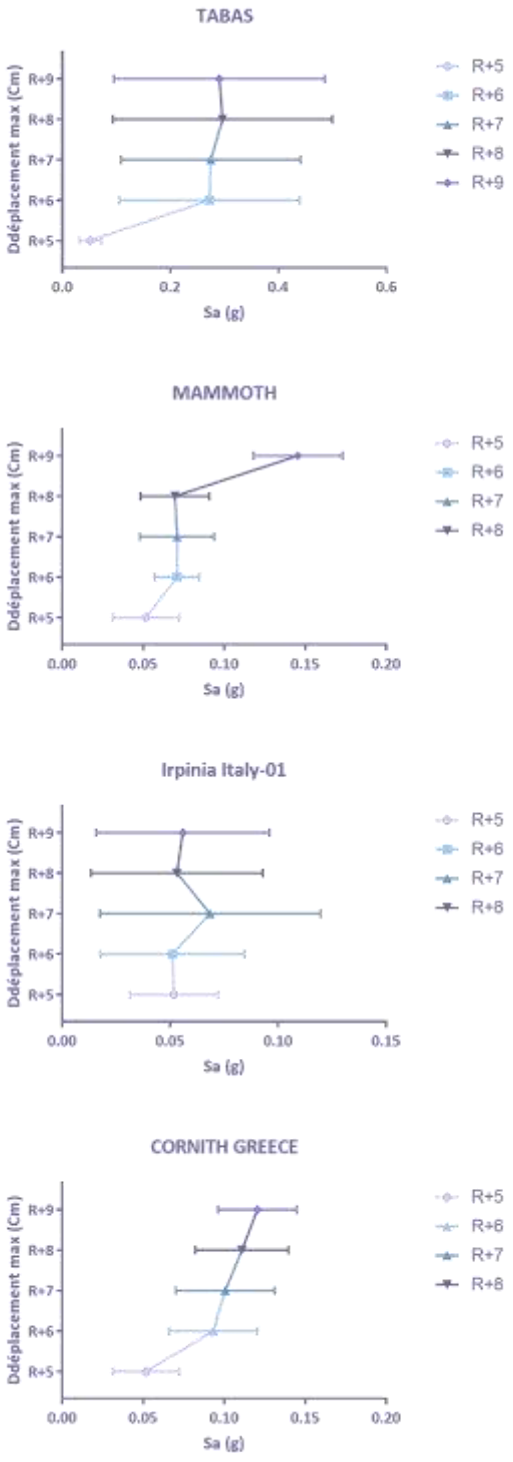


Fig. 2. Mean SD Maximum displacement curves as a function of the acceleration spectra for each earthquake of each structure height.

The fragility curves obtained from the analysis of the structure by varying the height of the building and the application of the incremental dynamic analysis show a noticeable variation between the curves of each level of height and presents some irregularities by comparing the even the performance levels as shown in Figures 3 and 4.

By using the incremental dynamic analysis data and by basing ourselves on the maximum displacements at the top, we were able to deduce the probability of reaching or exceeding several levels of damage which can go up to the ruin of the structure, the results obtained shows that:

- The fields of occurrence of a state of damage remain limited in terms of seismic intensity and that the probability of superposition of two performance levels remains limited,
- Interpolation from a sigmoidal standard curve allows the curve to be uniform and to give a continuous and meaningful appearance leading to more reliable results.

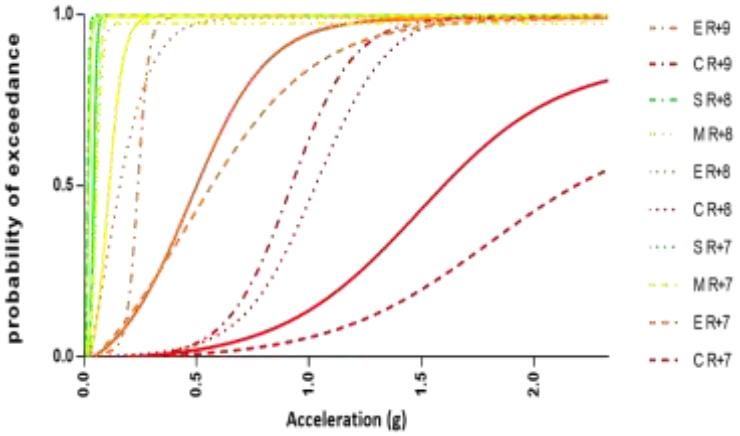


Fig. 3. Fragility Curves for Damage Levels classification (Slight; Moderate; extensive; complete damage) For each structure. height.

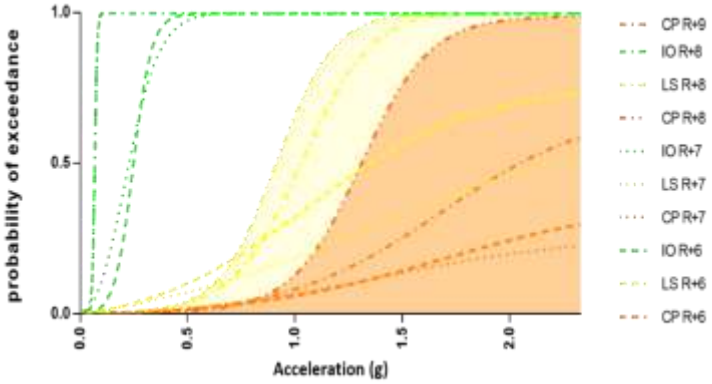


Fig. 4. Fragility Curves for Damage Levels classification (IO ; LS ; CP) For each structure height.

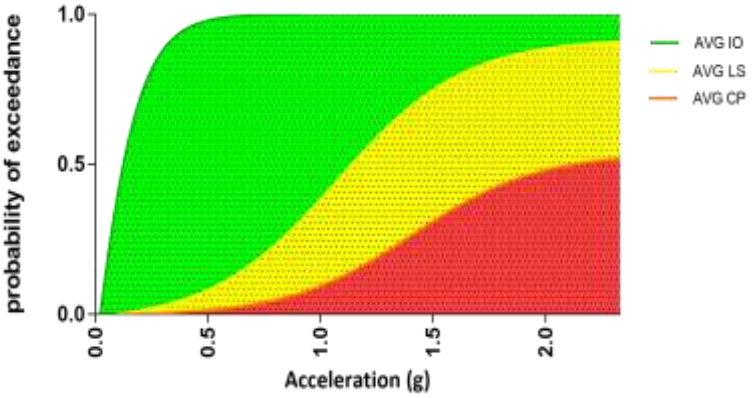


Fig. 5. Fragility Curves for Average Damage Levels classification (IO; LS; CP).

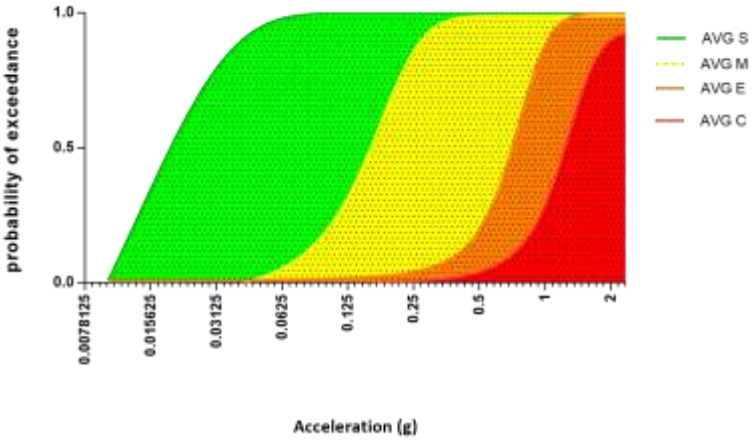


Fig. 6. Fragility Curves for Average Damage Levels classification (Slight; Moderate; extensive; complete damage).

Conclusions

the results obtained from the averages of seismic performance levels show that we can effectively delimit a particular level of damage and create a prediction field of structural damage as a function of a seismic intensity and give an interval of probabilities of possibility of occurrence of certain damage based on the previous graphs in figures 5 and 6 which allowed us to illustrate a map of probability fields, which can subsequently be used to locate a reaction pair (probability of occurrence of damage / seismic intensity) and thus build a basic model which can be used to establish a seismic regulation integrating a reliability study of the data by classifying the seismic zones according to the intensities obtained and thus predicting the reaction of structures facing such intensities.

Our perspective for this study is to try to exploit these data to be able to exploit them in the update of the Moroccan seismic regulations thus adopting a more realistic and reliable nonlinear dynamic aspect giving a clearer vision on the seismic phenomenon and on the reaction of structures.

References and notes

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