Universidade do Minho
Escola de Engenharia

Semana da Escola de Engenharia
October 24 - 27, 2011

SEISMIC VULNERABILITY ANALYSIS BY THE SPECTRUM CAPACITY METHOD

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KEYWORDS
buildings, earthquake, seismic vulnerability.

ABSTRACT

In this work, a methodology adopted for the analysis of the seismic vulnerability of various residential buildings built in Portugal before 1983 is presented. Some methods available to characterize the seismic vulnerability of buildings and the applied methodology, the "Spectrum Capacity Method", are presented. This methodology, considered as analytical or mechanical, proposes the use of a pushover analysis for the characterization of the strength of the building under study (ATC40). The values obtained in the analysis performed by the spectrum capacity method for a selected number of case studies in Lisbon are thus presented.

INTRODUCTION

One of the main concerns of a civil engineer is to ensure the safety of persons and propertys. Cities are places of great concentration of population and housing, thus becoming priority areas for the development of seismic risk studies. The presented study is a part of a PhD thesis in civil engineering (structures) that is being developed at the School of Engineering, University of Minho. The overall objective of this work is the verification of economic viability of the seismic risk mitigation in residential buildings constructed before 1983 in mainland Portugal. The part of the developed work that focuses on the vulnerability analysis of existing buildings is here presented.

METHODS OF SEISMIC VULNERABILITY ANALYSIS

Seismic vulnerability is the intrinsic characteristic of a building system that reflects its susceptibility to suffer loss or damage when affected by an earthquake (Sousa 2006). There are several methods that can be used for the analysis of seismic vulnerability:

- Methods supported by the opinion of a group of experts in analysis, design and/or structural pathology that answer to a series of questions related to the expected behavior of certain types of structures (Mendizábal and Velez 2006);
- Methods based on damage surveys after an earthquake;
- Experimental methods that use the results of laboratorial tests in building models (*e.g.* shaking table tests);
- Analytical, mechanical or mechanicist methods that are based on the comparison between seismic demand and the resistant capacity of the structure through detailed and individual numerical analysis for each type of building;
- Hybrid methods that are integrated solutions based on the methods described above, combined judiciously in order to obtain the desired results based on available data (Giovinazzi and Lagomarsino 2003).

THE CAPACITY SPECTRUM METHOD

The capacity spectrum method is adopted in this work and it belongs to the group of analytical or mechanical methods. It is based on the fact that the greater ability of a particular building has to withstand an earthquake, the lower is its vulnerability to earthquakes.

Thus, by performing a nonlinear static analysis (pushover analysis) the seismic performance of the building is verified (ATC40). The pushover analysis consists of applying static forces at given points of the structure and measuring the response in a given point of the structure (usually at the top of the building). The applied forces depend on the weight of the building and are progressively increased until there is a collapse of all or of a part of the structure. The applied forces and the recorded displacement, are plotted in a force-displacement diagram that represents the performance of the buiding as if it was a single degree of freedom

system. The diagram obtained or the capacity curve of the building, is transformed into a capacity spectrum (spectral acceleration, Sa, versus spectral displacement, Sd) to be compared with the demand spectra of the seismic action.

APPLICATION EXAMPLE

The capacity spectrum method was used in this study for determinig the resistant capacity of buildings. The method was applied to an existing residential building, with four storeys, constructed in 1949. The structure is of mixed type, with a complete system of colums, beams and slabs in reinforced concrete at the ground floor, but with only some colums and beams in the external walls at the remaining floors. The external walls are in ordinary limestone masonry and the stairwell is in clay solid brick masonry. The internal walls are in clay solid and perforated brick masonry.
The pushover analysis was carried out with the program 3Muri and took into consideration the structural elements and the walls. The uncertainty associated with the structural parameters was considered by carrying out various models of the same building and by varying the material properties. The final result is shown in Figure 1.

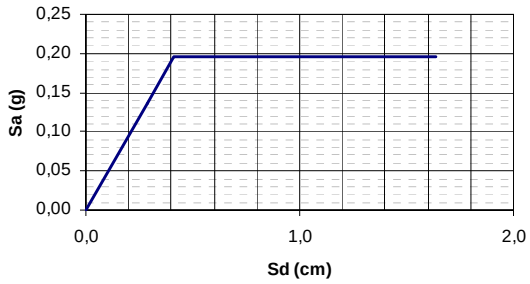

Figure 1: The Median Capacity Spectrum

CONCLUSIONS

There are several methods for the analysis of seismic vulnerability of a building, being some more expedite than others. The most expedite are usually faster and easier but based on generic information. The most detailed methods represent the building better but need complex and lengthy analysis.
The method used in this work is regarded as an analytical or mechanical method and it is called the capacity spectrum method (ATC40). This type of analysis is often used when there are no observations of damage caused by earthquakes or where there are insufficient results of tests conducted in the laboratory, which fits the reality of mainland Portugal.
The values obtained in the various tests carried out are consisten with the values obtained in other studies such (Barbat et al 2008, Kappos et al 2006).

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