GIS based method to identify vulnerable urban fabrics to earthquake

A. Senouci\textsuperscript{1}; P.Y. Bard\textsuperscript{2}; E. Beck\textsuperscript{3}; M. N. Farsi\textsuperscript{4} and S. Cartier\textsuperscript{3}

ABSTRACT

In the literature related to seismic scenarios, different seismic damage mapping methods can be distinguished. For instance individual building, urban block, census tract, urban district, cell (grid system), etc. have been used as map unit. In order to meet the needs of urban planning, this paper focuses on the way to get a representation of probable damage distribution, consistent both with the statistical limitations of the losses estimated by qualitative methods (as RISK-UE and GNDT) and the urban-scale requalification aims. The first criterion takes into account the statistical significance of the estimated damage value, which cannot be considered reliable at the building level. The proposal is, therefore, to perform some aggregations of loss estimates to overcome this issue. The second one is to keep the possibility to identify variations at urban scale in view to delimitate homogenous urban zones. In order to obtain useful results for urban planning, the questions were: how to represent damage cartographically? What is the suitable urban unit to use as a cartographic representation unit?

Various aggregation strategies were tested within a GIS tool on the example of the city of Oran (Algeria): 1) block, 2) urban entity (i.e., grouped blocks with some unity in the building typology and urban function), 3) a predefined circular zone around a construction or a block. The results of this latter (3) proved to be the best compromise to provide both an appreciable visualization of physical losses and respect of the criteria cited previously listed.

Keywords: seismic scenarios, seismic damage, map unit, mapping, aggregation, urban scale, urban planning

Introduction

Since the International Decade for Natural Disaster Reduction (IDNDR, 1990-2000), convenient urban planning to seismic prone areas is widely considered as an efficient tool in the reduction of risk. Inherited or existent urban fabrics are a great concern for authorities in regard to the non-conformity of the old buildings with the standards of modern seismic codes. In this context, seismic scenarios have been used to estimate losses and guide emergency response. The use of GIS capabilities has permitted to visualize the spatial distribution of earthquake damage. Several kinds of cartography representations of losses distribution can be found in the literature of seismic scenarios. This study has inventoried nine types of graphic representation considering map unit. For instance, in recent studies [1]–[9], the following features have been used as map

\textsuperscript{1} Lecturer, Dept. of Architecture, Université des Sciences et de Technologie d’Oran, Mohamed Boudiaf, Oran
\textsuperscript{2} Research Director, ISTerre / IFSTTAR Laboratory, University of Grenoble, France
\textsuperscript{3} Lecturer, PACTE laboratory, University of Grenoble, France
\textsuperscript{4} National Earthquake Engineering Centre (CGS), Algiers,

unit: building, parcel, urban block, census tract, neighborhood, urban district, municipality, cell (grid system), isolines. From urban planning viewpoint, there is still a need to improve a cartography representation indicating the most vulnerable zones for urban planners and city managers. In this framework this study has tested some aggregations of estimated damage at the level of single building for a set of 5000 buildings using qualitative methods of vulnerability evaluation, GNDT [10], RISK-UE [11], [12] and VULNERALP [13]. GIS functionalities have been essential to implement those aggregations, particularly with buffer functions allowing aggregation items within a predefined zone by specifying a distance D.

1. Aggregation strategies

In regard to the results of the study, this paper focuses on two used aggregations in this research: a) aggregation by urban entity and b) aggregation by predefined zone around a block. As the goal of this research is to establish a method for probable losses mapping for the needs of urban requalification, urban entities; as a result of urban structure; seemed to be suitable for this purpose; however, its implementation has faced some constraints. The first one is to define what is an urban entity? In fact, different urban scales coexist at the level of the city. It is admitted that the basic urban unit and entity is the urban block which is a constructible area delimited mainly by streets. Then, to overcome this issue the hierarchy of streets (primary, secondary and tertiary) has been considered to systemize the delimitation of urban entities. In addition, in the case of Oran City, another type of street has been distinguished. It is ring roads that mark its significant urban development. The result of this application is four maps showing different sights of the same urban structure. Using the aggregation function of GIS mean value of damage of the buildings within polygons of urban entities are calculated.

Although, urban entity seems convenient for the purpose of urban planning, its implementation is not automated in GIS because it needs the operator appreciation of the hierarchy and the limits of each urban entity. Then, predefined area around urban block has been tested. Its main advantages are full automation and easy definition of standard size by choosing a distance D. Different maps have been performed by the use of the function of buffer which generate around a GIS feature a zone defined with a length. Different distances D according a geometric progression (30m, 60m, 120m, 240m, 480m, 960m) have been used to transpose the idea of different urban scales: 60m to enclose nearest neighbor blocks, and the following distances reach wider zones progressively. Similarly to the aggregation by urban entity a mean value of damage of included buildings in each buffer has been calculated.

2. Discussion

From the multiple maps obtained by the various aggregations, some have been selected in respect of two parameters: the legibility of urban structure and the representativeness of the aggregated damage of its neighboring. For example, maps with huge urban entity, resulting from ring road or primary streets delimitation tend to remove local variation of vulnerability while maps with small urban entity, as the case of tertiary streets subdivision, lack an overall sight of heavy trends of vulnerability. Then, aggregation by urban entity defined by secondary streets provides a best balance in visualization of local and global vulnerability distribution (Fig. 2). A
similar finding concerns aggregation by polygon buffer around urban block. Small values of distance, for instance 30m and 60m give a distribution dominated by local variations while high values as 240m and higher tend to the average value of the study area. A distance of 120m or between 60m and 120m offers a better compromise. Fig. 2 shows four maps organized in two columns and two rows for easy comparison. At the right column the two maps represent aggregation by: in the top, urban entity limited by secondary streets and in the bottom a map showing the aggregation by polygon buffer of 120m. At the left column, maps shows damage higher than the average value of study area. They indicate the most vulnerable zones in the perimeter.

![Figure 1. Comparison of aggregation by urban entity and polygon buffer](image1)

![Figure 2. Aggregation procedures](image2)

**Conclusions**

The mapping of probable losses of a study area in Oran city has been conducted in respect two criteria: 1) the representativeness of aggregated damage of its neighboring and 2) the legibility of substantial trends of vulnerability. The main findings of this ongoing study are: 1) the possibility of the use GIS functions to perform maps of probable damage for urban planning and urban requalification as a tool of seismic risk reduction. 2) the choice of distances of buffer has to be in relation with the characteristics of the studied urban structure. 3) the different maps for different size of buffer or size of urban entity can be considered in a complementary use because a coming and going between small and large scale can give a global picture of the distribution of vulnerability. These maps are intended to identify the most vulnerable zones and need further detailed surveys.
before undertaking real actions. Their utility is to provide a quick assessment and overall sight to engage a debate with the different actors of the city that can lead to the definition of appropriate global interventions in the most vulnerable urban fabrics.

References


