World Academy of Science, Engineering and Technology
International Journal of Geological and Environmental Engineering
Vol:7, No:6, 2013

Vulnerability Assessment of Blida City

K. Tadjer, M. Bensaibi, and A. Chaid

***Abstract*—**The seismic vulnerability of an urban area is of a great deal for local authorities especially those facing earthquakes. So, it is important to have an efficient tool to assess the vulnerability of existing buildings. The use of the VIP (Vulnerability Index Program) and the GIS (Geographic Information System) let us to identify the most vulnerable districts of an urban area.

The use of the vulnerability index method lets us to assess the vulnerability of the center town of Blida (Algeria) which is a historical town and which has grown enormously during the last decades. In this method, three levels of vulnerability are defined. The GIS has been used to build a data base in order to perform different thematic analyses. These analyses show the seismic vulnerability of Blida.

***Keywords*—**Blida, Earthquake, GIS, Seismic vulnerability, Urban area.

Open Science Index, Geological and Environmental Engineering Vol:7, No:6, 2013 publications.waset.org/6771.pdf

I. Introduction

THE creation of large poles of economic and cultural development mainly in the cities, has led to rapid population-increase and concentration [1]. In Algeria, these urban centres have grown mainly in previous colonial and thus historical towns. The slowness in the historical buildings' urban renewal has induced the use of some structures that are not in adequacy with current seismic regulations [2]. Therefore, those in charge of urban planning and development ought to set up a seismic risk mitigation-strategy that will enable them to asses any earthquakes impact on the buildings especially on towns' buildings [3].

Several studies on seismic scenarios for different cities have been processed all over the world [5]–[6]–[8]–[7]. In these studies different methods (global ones detailed) or were used.

In this study, a method which might be at an analysis scale, considered neither as too global (typological) nor as too much detailed (requiring too many calculations), the Vulnerability Index Method was used.

This method was developed first by Benedetti for masonry buildings [16].

In order to use this method in the Algerian context, studies have been started by Bensaibi and all. The purpose being to identify structural and non-structural parameters which affect

the structures seismic behaviour and also to characterize them with coefficients [9]– [10]–[11]–[15].

K.Tadjer Is an assistant professor in Civil engineering department University Saad Dahlab, Blida, Algeria (phone: 213-25-433939; e-mail: khalidatadjeryahoo.fr).

M.Bensqibi Is a profesor in Civil engineering department, University Saad Dahlab, Blida, Algeria (e-mail: bensaibim@yahoo.cu.uk).

A.Chaid Ecole Nationale Supérieure des Travaux Publics, ENSTP, Algiers, Algeria (e-mail: k_chaid@hotmail.com).

These works have dealt with masonry structures then with reinforced concrete, steel and mixed ones [12]–[13]–[14].

The vulnerability index method for different typologies has been used in this work to assess the seismic vulnerability of an urban area, in that case, that of Blida town-centre by using a geographical information system (GIS) that allows data structuring thus both a better reading and a better analysis of the vulnerability assessment.

II. Vulnerability Assessment Method

To deal with the vulnerability index calculations of different structures types, a software called the Vulnerability Index Programme (VIP) has been developed [10]. This procedure makes the task easier and generates a considerable gain of time as far as data dealing is concerned. The data for each kind of structure are dealt with to determine its vulnerability index. All the data are then analysed through a Geographical Information System (GIS).

III. Study Area

Blida's situation (Algeria), its tectonic and geographical situation, fairly requires a vulnerability analysis of its existing buildings. Blida's is characterised by the masonry structures of its historical nuclei and its rapid extension during the last years; this extension being rather made with reinforced concrete structures.

A. Zone Delimitation

The zone under study (Fig.1) includes the historical centre considered as the oldest district where most of the buildings date from the colonial era. This area is mostly composed of single or two storied buildings of which most are in an advanced state of decay. One may find, in the same surroundings, some recent buildings and some others dating from the Turkish era.

Fig. 1 Arial vue of the zone under study

B. Sectors Division

To make the inventory draw up of the study-zone structures easier, it is better to divide the study zone into identified sectors inside the soils occupation plan as base-sectors composing the town-centre. In our case, we have chosen a sectors division including 20 analysis units each representing one area (Fig. 2) identified with a number.

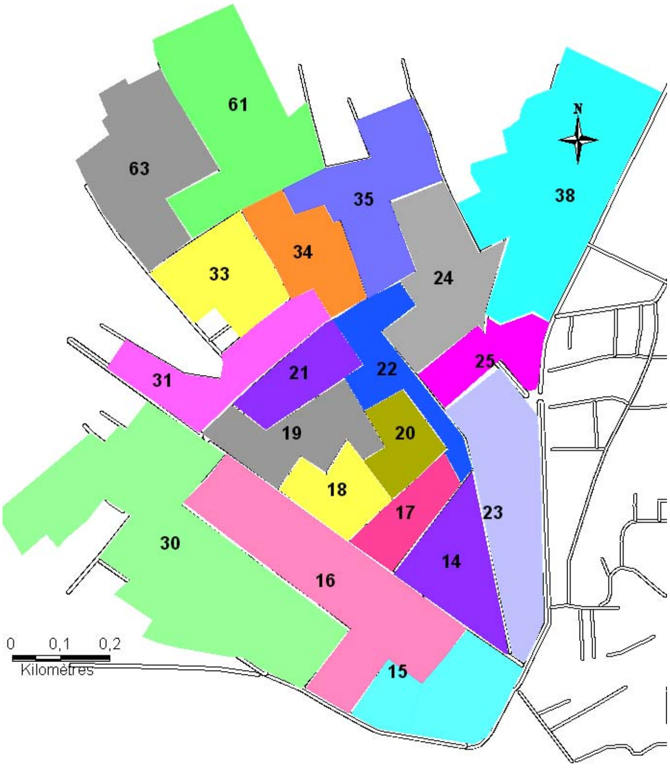

Fig. 2 Sectors division of the study zone in 20 analysis units on GIS

C. General Population and Housing Census

Population and housing data analysis needed for the present study is based on the results of the national census [4] realised by the National Statistics Office (ONS. 2008). To make the results exploitation easier, a geographical information system data base has been created. In our study zone, the total number of buildings is 2512 for a population of 14997 inhabitants.

IV. Results

A. Vulnerability Index Data

After our GIS analysis upon a total number of 310 buildings of which 300 in masonry and 70 in reinforced concrete, 78 classified as ''green'', 185 as ''orange'' and 109 as ''red''(Fig. 3, Fig. 4).

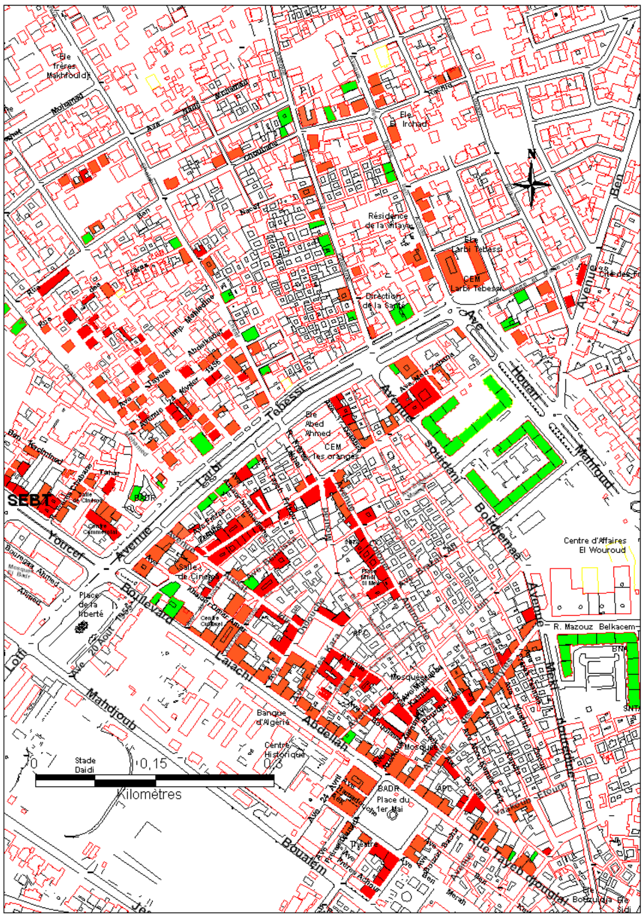

Fig. 3 Buildings classification according to their vulnerability indexes

Open Science Index, Geological and Environmental Engineering Vol:7, No:6, 2013 publications.waset.org/6771.pdf

Open Science Index, Geological and Environmental Engineering Vol:7, No:6, 2013 publications.waset.org/6771.pdf

The number proportion belonging to each class according to the total constructions number is given in Fig. 5.

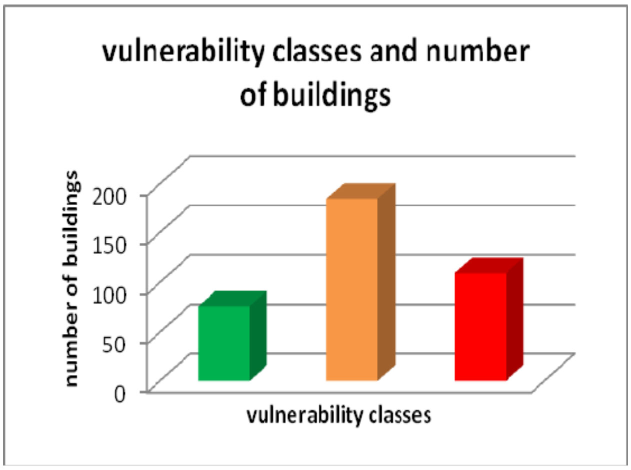

Fig. 4 Buildings proportion for each class

The number proportion belonging to each class according to the total constructions number is given in Fig. 5.

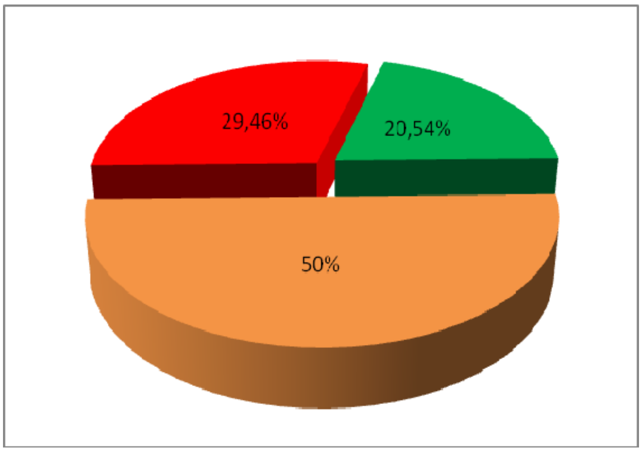

Fig. 5 Buildings proportion for each class

The proportion of ''orange'' and ''red'' classified buildings represents 79 percent of the buildings' total number, an extremely important proportion. Moreover, almost 30 percent of the constructions are classified ''red''. This leads to assert that the studied zone estate presents a very big vulnerability to earthquakes. The whole study results represented in Fig. 3 brings out the high risk-zones as well as moderated and low risk zones. Also, the outside belt appears to be of low damage risk but as you approach the central nuclei, the risk gets higher.

B. Areas Vulnerability

Areas vulnerability will be governed on one hand, by the areas' constructions vulnerability index and on the other, by the areas' population. Therefore, an area with a great number of ''red'' classified constructions and a great population density will be more vulnerable than an area with less population density, for instance. A GIS request permits to draw the analysis. The result is given in Fig. 6.

Fig. 6 Visualization of the buildings, of their vulnerability index and of the population number by area

Therefore, we retain the four most vulnerable areas according to the percentage of ''red'' classified buildings and also to the population number (Fig. 7). The area number 19 is considered as being the most vulnerable with a percentage of 55.81% concerning ''red'' classified buildings and a population of 639 inhabitants. Next comes area 33 with 48.14% of ''red'' classified buildings and a population of 832 inhabitants. At the third rank, comes area number 16 with 37.5 % of ''red'' classified buildings and a population of 760 inhabitants. The fourth and last one is area number 17 with 36.66 % and 736 inhabitants.

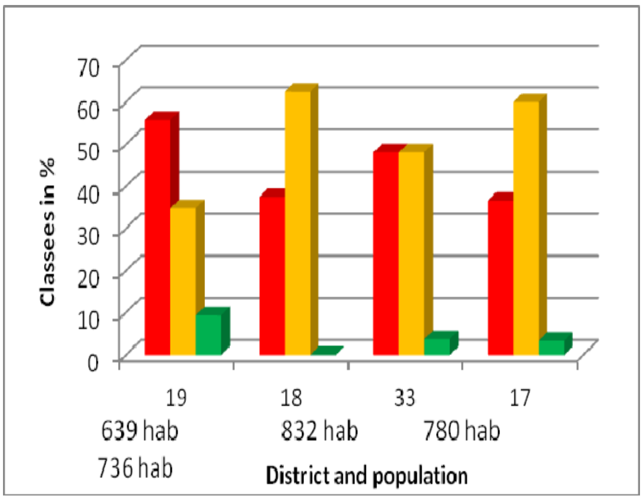

Fig. 7 Vulnerability classes according to the population number per area

Open Science Index, Geological and Environmental Engineering Vol:7, No:6, 2013 publications.waset.org/6771.pdf

Therefore, it will be advisable to focus reinforcement and rehousing interventions on these areas which shelter a population of 2987 inhabitants that is to say 20 % of our study zone population.

C. Districts Vulnerability

In order to determine the seismic vulnerability of the existing buildings per districts we retain in our zone of study the following districts (Fig. 8):

- Town centre district
- Kouchet el djir district
- Bab ezzaouia district

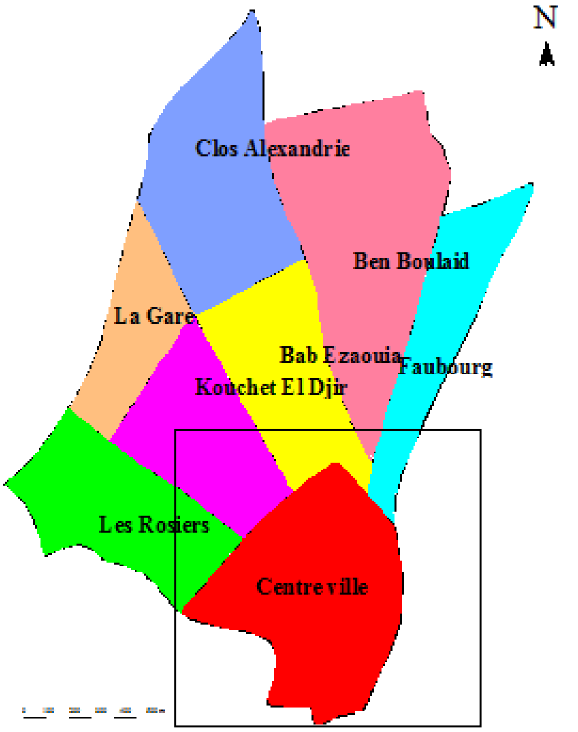

Fig. 8 Zone of study and districts of Blida city centre

A GIS request has allowed us to obtain the buildings percentage for each class of vulnerability (Table I).

TABLE I
CLASSES OF VULNERABILITY PER DISTRICT

Areas	*Classes of vulnerability*		
	Green	*Orange*	*Red*
Centre ville	20.1 %	45.32 %	35.58 %
Kouchet El Djir	9.18 %	60.21 %	30.61 %
Bab Ezzaouia	31.91 %	65.96 %	2.13 %

Without the slightest doubt, the city centre district has proved to be the most vulnerable. We have noticed that the most vulnerable buildings are situated inside the district nuclei which most important characteristics are: a very great constructions density and narrow streets; in addition to that, ‘’green’’ classified buildings are mainly situated in the outskirts of the district (Fig. 9).

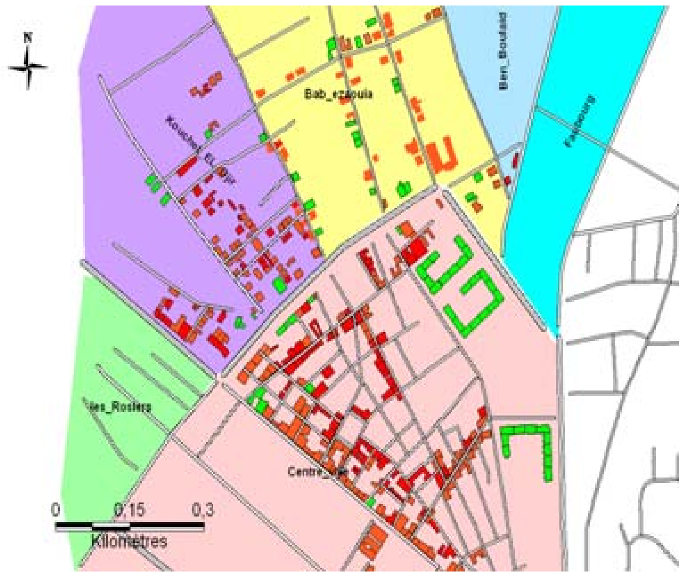

Fig. 9 Classes of vulnerability of buildings by district

V. CONCLUSION

The use of The VIP in this study has proved to be a quite efficient tool as far as the exploitation of the in situ collected data is concerned and the determination of the vulnerability index for buildings.

The GIS has obviously allowed us to conduct required relevant requests to find, from the analytic and spatial point of view, the nearest vulnerability index.

A first analysis has enabled us to draw the conclusion that this city centre is mostly constituted with masonry structures which are quite vulnerable whereas the remaining estate presents, because of its rather new reinforced concrete structures, a low seismic vulnerability. Masonry buildings special study shows that most structures do not project beyond two storeys and this kind has proved the most vulnerable. Also, we must mention that ground floor houses present two classes of vulnerability: one which has a vulnerability index value approaching 0.2 value (0.2 is the ‘’green’’ upper value limit); a second one which presents a very high vulnerability level.

Finally, we have been able, through a spatial analysis, to geographically locate the structures and their vulnerability, their typology and their storey number.

This spatial analysis has offered valuable data, which favours decision making that is to say in situ interventions either under the form of reinforcement operations or rehousing ones.

Open Science Index, Geological and Environmental Engineering Vol:7, No:6, 2013 publications.waset.org/6771.pdf

Let us confirm that the most vulnerable areas are area 19 and area 18 and 33 and it would be advisable to start concentrating efforts on these areas to avoid or at least to reduce human losses in case of a much foreseeable earthquake.

REFERENCES

[1] URBA (Centre d'étude et de réalisation en urbanisme), (2004). "PDEAU du grand Blida analyse et diagnostic phase1",.Algeria.

[2] CGS (Centre Génie Parasismique) . (2003). "Réglement Parasismique Algérien Version 2003 (RPA99 version 2003" . Algeria.

[3] AFPS (Association Française du Génie Parasismique). (2005). "Vulnérabilité sismique du bâti existant , Approche d'ensemble . Cahier technique n° 25". France.

[4] ONS (office national des statistiques) . (2008). "Recensement général de la population et de l'habitat (RGPH) ", Algeria.

[5] Lang, K.. (2002). "Seismic Vulnerability of Existing Buildings". Doctorate thesis, Swiss Federal institute of technology, Zurich, Swiss.

[6] Lantada, N. Pujades, L.G. and A.H. Barbat. (2004), "Risk Scenarios for Barcelena, Spain". 13th World Conference on Earthquake Engineering. paper N°. 423, Canada.

[7] Moquera Machado, S. (2002) . "Analyse multi-aléas et risque naturels dans le département du Chocó (nord-ouest de la Colombie). Doctorate thesis N° 3351. Genève.

[8] Tadjer , K . (2007). "Scenario Catastrophe Sismique du Centre Ville de Blida". Master thesis. University Saad Dahlab Blida. Algeria.

[9] Boukri, M. (2003). "Détermination de l'Index de Vulnérabilité Pour les Constructions en Maçonnerie de la Ville d'Alger". Master thesis. University Saad Dahlab Blida. Algéria.

[10] Bensaibi, M., Djaalali, F., Belheouane, F I., Amellal, O,. and Yousfi, N. 7-8 Mars 2011. "Seismic Vulnerability Index Method - Algerian case studies". 8 th International Conference on Urban Earthquake Engineering, Tokyo Institute of Technology, Tokyo, Japon,

[11] Bensaibi, M., Djaalali, F., Belheouane, F I., and Bourahla, Nourredine. (2011). " Vulnerability Index Method" – Algeriers case study. Seventh National Conference of Earthquake Engineering.

[12] Belheouane, F. I., (2006). "Détermination De L'indice De Vulnéranilité Pour Les Bâtiments En Béton Armé". Master thesis, University Saad Dahlab Blida, Algéria.

[13] Amellal, O. (2008). "Évaluation De L'indice De Vulnéranilité Pour Les Structures En Charpente Métallique". Master thesis University Saad Dahlab Blida, Algéria.

[14] Yousfi, N . (2010). "Estimation De L'indice De Vulnéranilité Des Structures Mixtes". Master thesis University Saad Dahlab Blida, Algéria.

[15] Belheouane , F I., Bensaibi, M. (2011). "Evaluation De l'Indice De Vulnérabilité Sismique Des Structures En Béton Armé, Cas D'étude : Structures En Béton Armé En Algérie". Actes du 8em Colloque National AFPS, Paris, France.

[16] Benedetti, D. and Petrini, V. (1984). "On the seismic vulnerability of masonry buildings: proposal of year procedure evaluation". The Industry of Construction,18, 66-78.