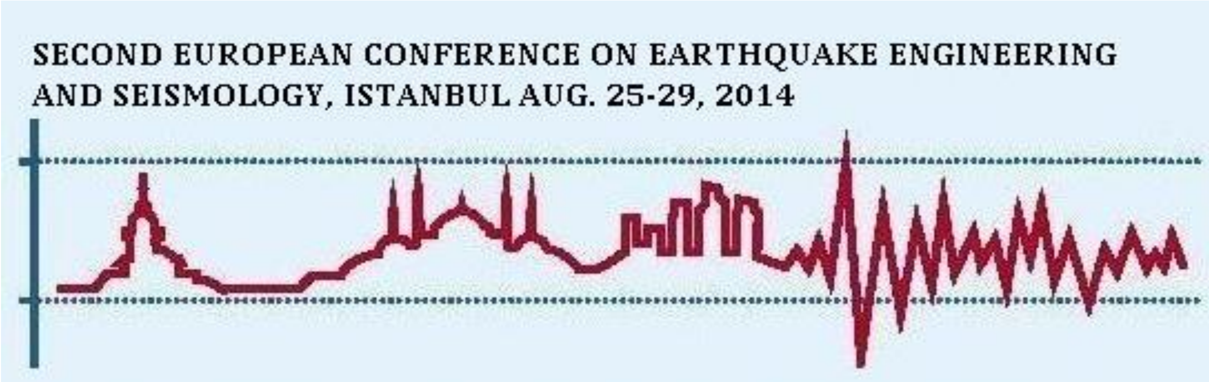

EARTHQUAKE RISK SCENARIOS OF BLİDA CİTY

Tadjer KHALIDA[1] and Bensaibi MAHMOUD[2]

ABSTRACT

Blida is located in the north part of Algeria, classified zone III, an area with high vulnerability to seismic hazard according to the Algerian Seismic Code (RPA99 version 2003). The city has known a big development within its urban, administrative, industrial, commercial, leisure and sanitary sectors during these last years. As several destructive earthquakes had already shaken the city in the past, particular attention should be made to protect the city from such hazard. Indeed, seismic disaster scenarios of the city have been investigated using the Radius (Risk Assessment Tools for Diagnosis of Urban Areas against Seismic Disaster) method to assess casualties resulting from possible earthquakes, allowing local authorities to curry out preventive actions to reduce damages. The analysis is considering both, the geological aspects of the land and the structural aspects of the urban system.

INTRODUCTION

The city of Blida is located south west of Algiers, between geographical coordinate's 36 ° 28 ' North latitude, 2 ° 50' longitude (Greenwich) at an altitude of 270 m. Its area is estimated at 5737 ha. According to the General Census of Population and Housing 1998, the population is estimated at 144,225 residents and the number of constructions at 26,357 buildings.

Blida contains several types of buildings (masonry, reinforced concrete, ..) dating from the Ottoman period till today which can show different seismic behaviour. Actually, several methods to study the seismic vulnerability of structures do exist. They are essentially based on post-seismic observations. First of all, the local or regional hazard is defined, then a survey on the state of the structures within the studied areas is established, where the state of the structures can be represented by a vulnerability index. Finally, an assessment of the damages rate, which is a combination of the hazard and the vulnerability, is calculated.

The first methods to study the seismic vulnerability were published by the Applied Technology Council (ATC) in early 80s (ATC13 and HAZUS).

The European Macroseismic Intensity scale EMS98 is considered as a standard method in Europe, it allows having a preliminary identification of the most vulnerable zones and an initial estimate of damage. The European method RISK-UE is based on the Gémitis approach and the HAZUS software method. It uses the characteristics of seven major European cities (Nice, Barcelona, Catania, Sofia, Bitola, Bucharest and Thessaloniki), in order to provide local authorities with tools assisting them to plan and prevent any crisis management.

[1] Assistant Professor, Department of Civil Engineering University Blida 1, Algeria, Khalidatadjer@yahoo.fr
[2] Professor, Department of Material and Structures, National High School of Public Works, Algiers, Algeria, bensaibim@yahoo.co.uk

Finally the RADIUS method was initiated by the UN Secretariat and aimed to provide developing countries by an efficient tool to assess the vulnerability of their cities. The aim of this study is to give seismic scenarios for the city of Blida using the RADIUS method.

BLIDA SEISMICITY

The city of Blida is classified in zone III according to the Algerian Seismic Code "RPA99 version 2003" so it is an area prone to seismicity. An active fault has been detected between Bouinan and Soumâa localities, Fig.1. This fault has been made in evidence by the CRAAG (Centre de Recherche en Astronomie, Astrophysique et Géophysique). In the 19-century, two seismic events hit the town. They have been estimated at intensity X and XI. Figure 2 shows the historical seismicity of the region.

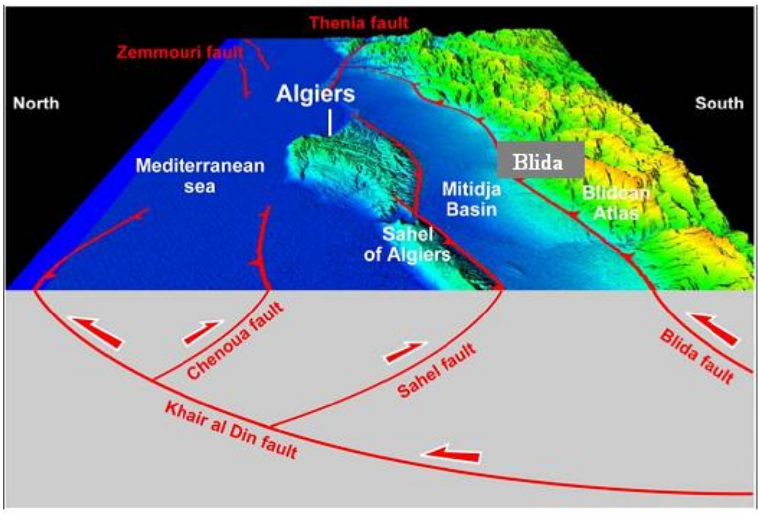

Figure 1. Active faults for Algiers and Blida region

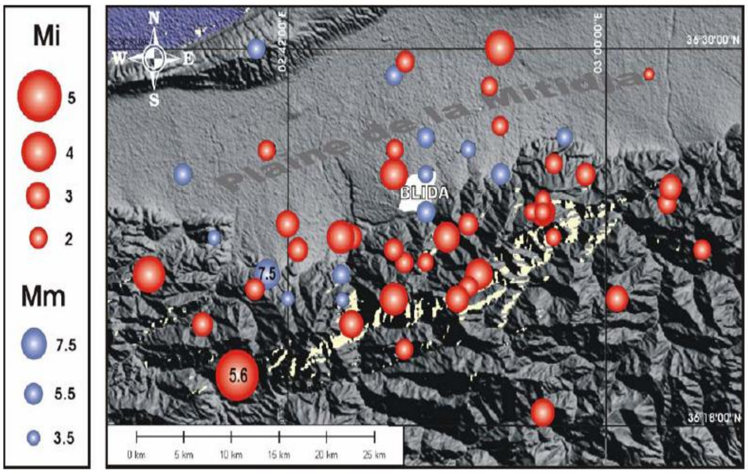

Figure 2. Blida historical seismicity between 1825 and 2005

(Mi: Instrumental magnitudes, Mm: Macroseismic magnitudes)

RADIUS METHOD

The evaluation of seismic hazard of an area is one of the main steps of the RADIUS method for conducting seismic scenarios. This stage allows choosing the seismic characteristics which are more likely to occur.

For the selection of the earthquake parameters (magnitude, epicenter, depth and time of event), reoccurrence of a past damaging earthquake or active fault earthquake is commonly considered.

For the evaluation of soil characteristics and structures, the method subdivided the area in question into mesh units. Four ground classifications are used, namely, "Hard Rock", "Soft Rock", "Medium Soil" and "Soft Soil". These classifications correspond to the amplification factors of each soil type. In addition, user may choose "Unknown" if he does not know the soil condition. "Hard Rock" corresponds to volcanic rocks, such as granite or basalt, and sedimentary rocks, such as pre-tertiary sand and mud stones. The amplification factor for "Hard Rock" is specified as 0.55, but can be changed by the user. "Soft Rock" corresponds to tertiary sand and/or mud stones and conglomerates. The corresponding amplification factor is set to 0.7. "Medium Soil" corresponds to diluvial soil and stiff alluvial soil etc. The specified amplification factor for "Medium Soil" is set to 1.00 as a standard. "Soft Soil" corresponds to soft alluvial soil, reclaimed land and landfill etc. The amplification factor for "Soft Soil" is set to 1.30. If the soil condition is unknown, 1.0 is used as the amplification factor. The value of all the amplification factors can be changed by users.

To facilitate the inventory of buildings, the RADIUS method suggests to divide the city into zones, special attention must be given to the structures of collective interest such as hospitals, schools, government offices and lifelines. For buildings, the classification adopted categorizes them into 10 classes. The damage will be estimated from the hazard and the existing structures in the region using vulnerability functions Fig.3, that define the relationship between seismic intensity and the rate of damage for different structural types.

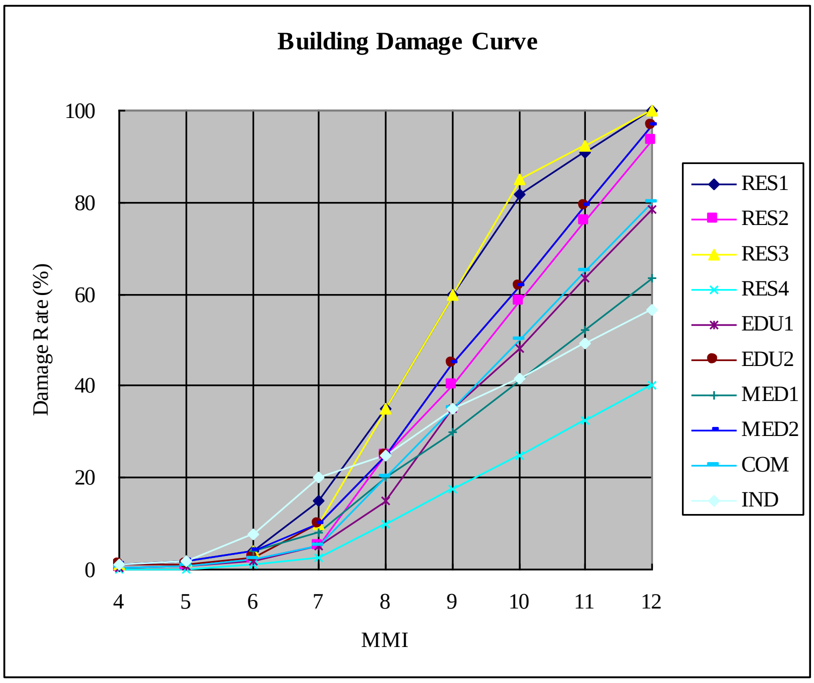

Figure 3. Vulnerability functions used in RADIUS method

Regarding the estimation of casualties, the Coburn algorithm is used (Fig.4). In this algorithm, the rate of casualties is related to relief operations.

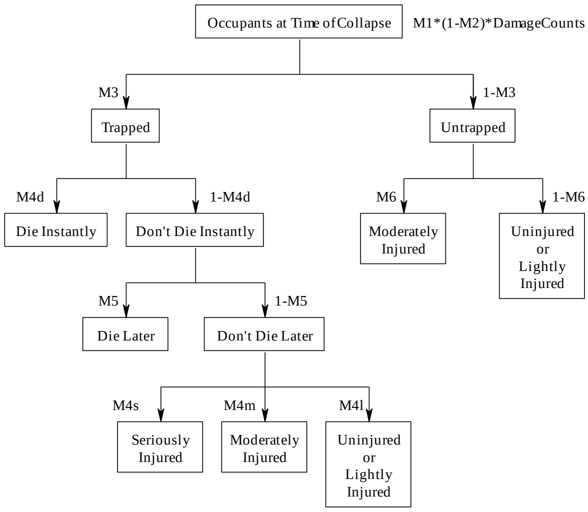

Figure 4. Coburn algorithm

APPLICATION

The study area covers a surface of 376 ha (Fig. 5) representing the central part of Blida city

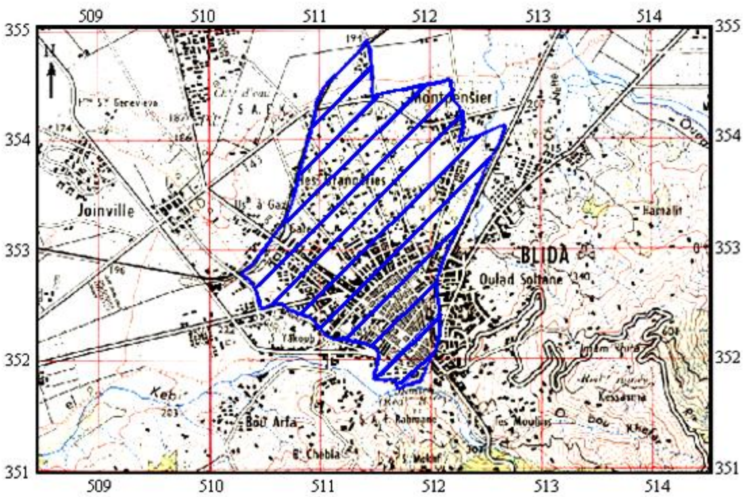

Figure 5. Study area (scale :1/50 000)

The data provided by the public authority concerning the population number and the amount of construction give an estimate of 48,900 inhabitants and 5,663 constructions.

The distinction between different types of soils is very important, since it is one of the main triggering factors of seismicity. View alluvial aspect of site Blida, site soil is considered an average soil, the corresponding amplification factor is 1.

To facilitate the estimation of the individual structures, the study area has been divided into eight districts, Fig. 6. Considering Bouinan/Soumaa fault, the characteristics of the earthquakes considered in the scenarios are:

First scenario: Magnitude 7, depth 10 km, epicentral distance 1.4 km, attenuation law: Joyner and Boore (1981) and the occurring time 8Pm.

Second scenario: Magnitude 6, depth 10 km, epicentral distance 1.4 km, attenuation law: Joyner and Boore (1981) and the occurring time 11 Am.

An inventory of buildings in the eight districts covered by the study has been completed. This was the longest and most difficult step. To this end, a technical inventory sheet describing a construction has been developed.

A computer program using Delphi language has been developed to process data to determine the percentage of the different classes of buildings for each district. Figure 7 presents the interface for the developed program.

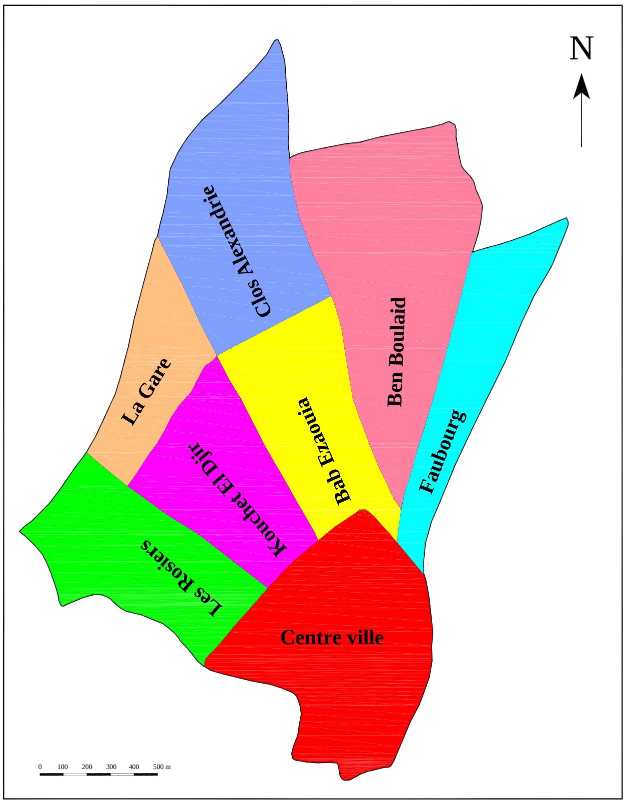

Figure 6. Subdivision of the study area

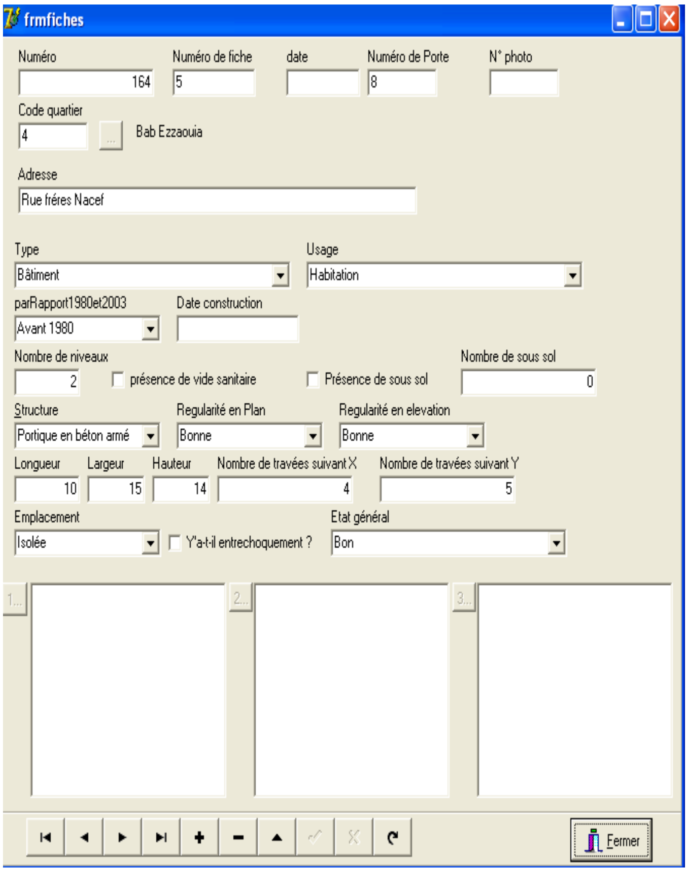

Figure 7. Interface page

RESULTS

FIRST SCENARIO

The map for the building damage is represented on figure 8. Il was find that the rate of loss is around 32% for the entire study area. In table 1, the loss repartition by district is given.

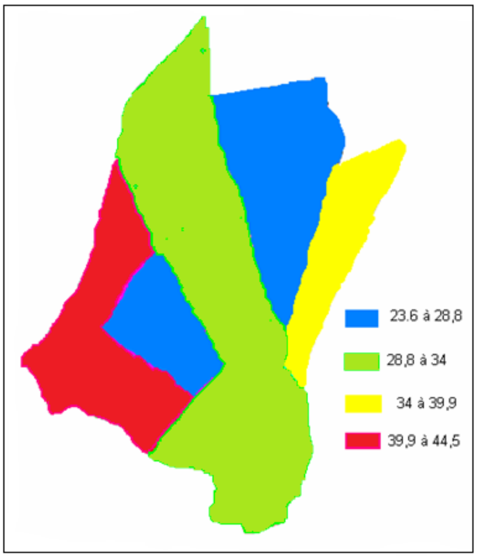

Figure 8. Rate of damage for buildings, scenario 1

Table 1. Rate of damage by district, scenario 1

District	**Constructions**	**Damaged constructions (collapsed)**	**Percentage**
The centre town	1 446	446	30,8
Faubourg	301	115	38,0
Ben boulaid	904	213	23,6
Bab ezzaouia	783	228	29,2
Clos alexandrie	572	190	33,3
Couchet eldjir	663	190	28,7
Rosiers	693	279	40,3
Gare	301	134	44, 5
Total	5 663	1795	31, 7

In order to give a financial estimation of the losses, it's assumed that in average, each construction has five (05) dwellings each one with an area of 60 m^2. If the cost of a square meter is assumed about 40,000.00 D.A, the obtained results are as following:

Table 2. Cost assessment

District	Nb. of damaged dwellings	Damaged area (m²)	Cost (D.A)
The centre town	2226	133560	5342400000
Faubourg	571	34260	1370400000
Ben boulaid	1066	63960	2558400000
Bab ezzaouia	1143	68580	2743200000
Clos alexandrie	952	57120	2284800000
Couchet eldjir	951	57060	2282400000
Rosiers	1396	83760	3350400000
Gare	669	40140	1605600000
Total	8974	538440	21537600000

With a rate of 1 euro= 104.19 D. A, established by the period of October 2013, the total losses are estimated at 207000000 euro.

The casualties are presented in Fig.9 and Fig.10 :

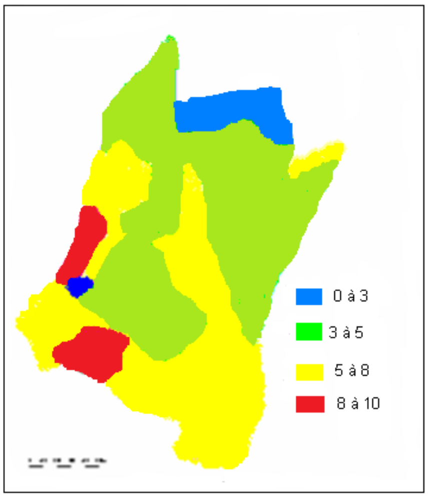

Figure 9. Number of death persons, scenario 1

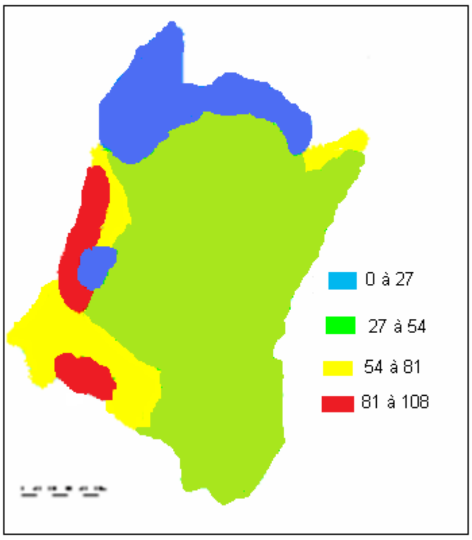

Figure 10. Number of injured persons, scenario 1

It can be seen that the most vulnerable district is 'Gare' followed by 'Rosiers' this is because of the high density of population.

Taking into account the allowance given by the Algerian government after the last earthquake of Boumerdes (21st may 2003) for the family. This allowance was of 700,000 D.A for each death. The estimated amount is around 314300000 D.A equivalent to 3500000 Euro. Then the total cost will reach the sum of 211 million euro.

SECOND SCENARIO

The map for the building damage is represented on figure 11. Il was find that the rate of loss is around 19 % for the entire study area. In Table.3, the loss repartition by district is given.

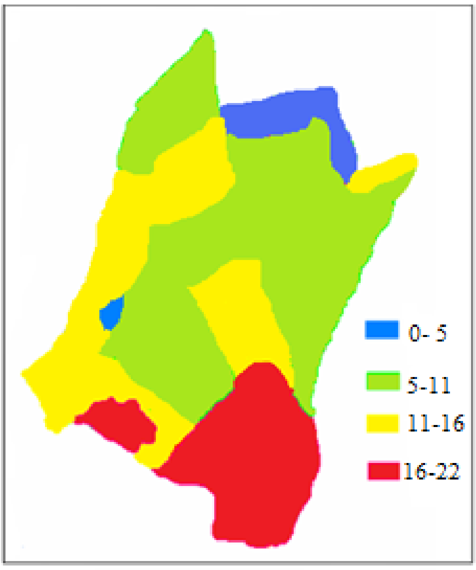

Figure 11. Rate of damage for buildings, scenario 2

Table 3. Rate of damage by district, scenario 2

District	Constructions	Damaged constructions (collapsed)	Pourcentage
The centre town	1 446	265	18,3
Faubourg	301	71	23,7
Ben boulaid	904	128	14,2
Bab ezzaouia	783	135	17,5
Clos alexandrie	572	113	19,7
Couchet eldjir	663	114	17,2
Rosiers	693	166	23,9
Gare	301	79	26, 1
Total	5 663	1072	18, 9

The total losses of this scenario are estimated at 125000000 euro.
The casualties are presented in Fig.12 and Fig.13 :

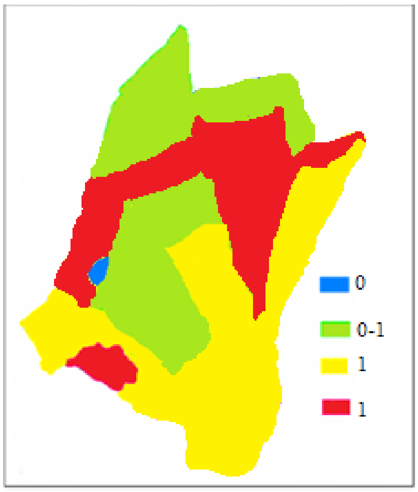

Figure 12. Number of death persons, scenario 2

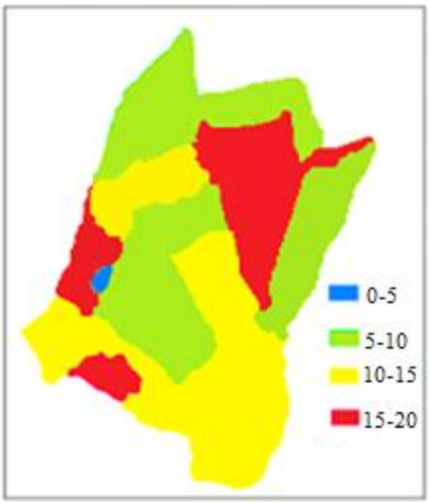

Figure 13. Number of injured persons, scenario 2

As it can be seen in this scenario, the most vulnerable districts are «   Gare and Rosier, for the two scenarios.

Taking the same assumption as on scenario one, the total cost of this second scenario will reach the sum of 126 million euro. There is a difference of 40% between the two scenrios.

CONCLUSION

The study of the seismic scenario for the city of Blida by the RADIUS method has been achieved. However, the estimates provided by this tool are approximate.

Economic losses presented above represent only an estimation of what could result from an established seismic scenario. The results showed that the risk is potential, in terms of costs.

Through this analysis it was also possible to know the weaknesses of the city (the most vulnerable districts). This information is very important for taking effective measures to reduce seismic risk, including preparedness and reconstruction activities, because the budget and the efforts that are available to make effective measures to reduce the seismic catastrophe are often limited.

REFERENCES

Association Française du Génie Parasismique (AFPS), "*Vulnérabilité sismique du bâti existant : Approche d'ensemble, Cahier Technique n°25* ", France, July 2005

Recherches Géologiques et Minières (BRGM), "Connaissance analyse et prévention du risque sismique en France ", *Dossier de presse,* December 2004.

Centre d'étude et de réalisation eu urbanisme (URBA BLIDA) , "Plans Directeurs d'Aménagement Urbain du grand Blida analyse et diagnostic", Report, June 2004.

Centre de Recherche en Astronomie Astrophysique et Géophysique(CRAAG),"*Étude géologique géophysique et géotechnique des piémonts Est et Ouest de la ville de Blida*", *Rapport,* December, 2005.

National Centre of Applied Research in Earthquake Engineering, 2003. "Réglement Parasismique Algérien (RPA99, version 2003)", Algeria.

A.W. Coburn, R.J.S.Spence, and A. Pomonis, "*Factors determining casuality levels in earthquakes: mortality prediction in building collapse*", 10th WCEE, Madrid, Spain 1992

S. Del Carmen, "*Analyse multi-aléas et risques naturels dans le département du Chocó (nord-ouest de la Colombie)* ", doctorat thesis, University of Geneva, 2002.

P.C. Thenhaus, K.W. Campbell, N. Gupta, D.F. Smith and M.M. Khater "A Consistent Cross-Border Seismic Hazard Model for Loss Estimation and Risk Management in Canada", 15th WCEE, Lisboa, Portugal , 2012.

S.Refas, M.Bensafi, F.Benslafa-Kazi Aoual and M.Mouli, "Contribution a l'amélioration de la gestion du risque sismique en Algérie (région oranaise)", 1st International Conference on Sustainable Built Environment Infrastructures in Developing Countries, ENSET, Oran Algeria, October 12-14, 2009

A. Bendito, J. Rozelle and D. Bausch, "Developing Seismic Risk Maps for Mérida State, Venezuela " Faculty of Engineering, Universidad de Los Andes, Venezuela.,15th WCEE, Lisboa, Portugal , 2012.

D. Mckenzie, "*Active tectonics of the mediterranean region*",.J. R. Ast. Soc. London. 1972.

OYO Corporation, "RADIUS Méthodology ", IDNDR, 1999.

Office national des statistiques (ONS), "Recensement général de la population et de l'habitat", Algeria,1998.