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Seismic Loss Assessment in Algeria Using the Tool QLARM

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Abstract

Beginning in 2003, QLARM (Quake Loss Assesment for Risk Management) has been used for real-time loss estimation and one hour after the M6.7 Boumerdes earthquake in 2003, we reported 1690-3660 fatalities, when the official death toll was weeks later announced as around 2270. We have estimated losses for past earthquakes in Algeria that occurred during the period 1990-2003 finding that reported values of fatalities and injured were within the range of the calculated ones. Earthquake loss scenarios for Oran, Algiers and Djidjelli assuming repeats of events that occurred in the past, but with today's population, indicates thousands of fatalities (from 5,000 to 24,000), depending on the scenario and the time of earthquake occurrence (day or night), with the number of patients expected about 4 times in average the number of fatalities. Amplifications of the accelerations due to soil conditions in different cities could increase casualty numbers by 10 to 40%, depending on the scenario.

Keywords: QLARM; Seismic risk; Algeria; Scenarios; El Asnam; Earthquakes

Introduction

Since the 1980 El Asnam earthquake, seismic events in Algeria have killed about 6,000 people, injured more than 20,000 and left more than 300,000 homeless. Economic losses were estimated to have been up to 2 billion dollars for the El Asnam event and around 5 billion dollars for the 2003 Boumerdes M6.8 earthquake. Damage to buildings is expected for events with magnitude around 5.5 and on average, one earthquake with the potential to kill people (M>5.4) happens every three years in Algeria. In order to help risk management, we built the QLARM database to estimate human losses in Algeria in the case of major earthquakes [1]. Algeria had enough historic earthquakes for building damage, intensities, fatalities or injuries were reported, such that we were able to validate our computer tool. Therefore, we feel confident that our loss estimates for future earthquakes are reasonably reliable, within the large margins of uncertainties that are associated with a scenario exercise like this.

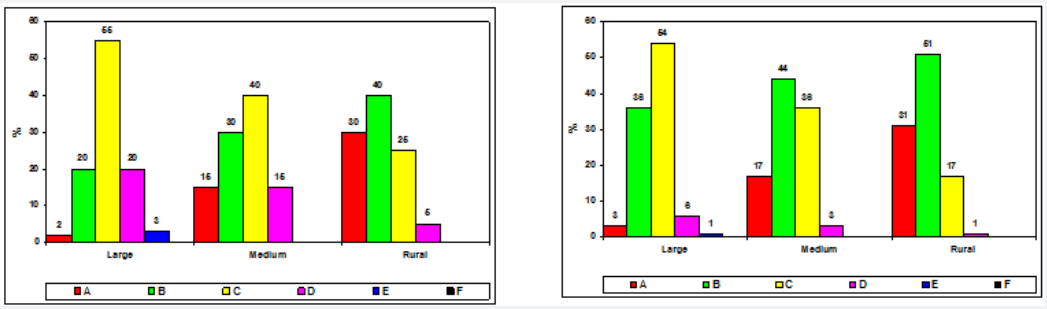

Figure 1: Distribution of population (left) and buildings (right) into vulnerability classes and city sizes in Algeria.

Seismic Wave Propagation Model

Among other intensity prediction equations used for Algeria, the Shebalin [2] one was able to fit the observations best for all the tested events-Tipaza (1989), Mascara (1994), Benian (1996), Temouchent (1999), Ourtilane (2000) and Boumerdes (2003). Site condition in each settlement of the database is approximated using V_{s30} derived from slope topography [3]. Most of the settlements (62%) are classified as soil type D (stiff soil) and others range from soft to hard rock. The amplification factor given by NEHRP [4] for each soil type is converted to an additional intensity value using the ground motion-intensity conversion equation of Wald et al. [5]. The added intensity values are 0, 0.16 and 0.32 for soil type B, C and D respectively.

City Model

The dataset in QLARM for Algeria is composed of 1540 settlements. Population comes from the 1998 and 2008 census (Office National de la Statistique) and updated for 2013. The

distributions of population and buildings into vulnerability classes (Figure 1) is estimated by considering the fractions of the residential population (in %) and the peak average number of occupants per building as given by the World Housing Encyclopedia [6] and PAGER database [7]. These distributions are provided for three city sizes-large urban, medium urban and rural-2,000 and 20,000 people as limits. For rural settlements, we consider an occupancy rate of 30% during the day (6am-6pm) and 95% during the night. For urban settlements, these values are changed to 50 and 80 % respectively.

Estimated Losses in Repeat Earthquakes

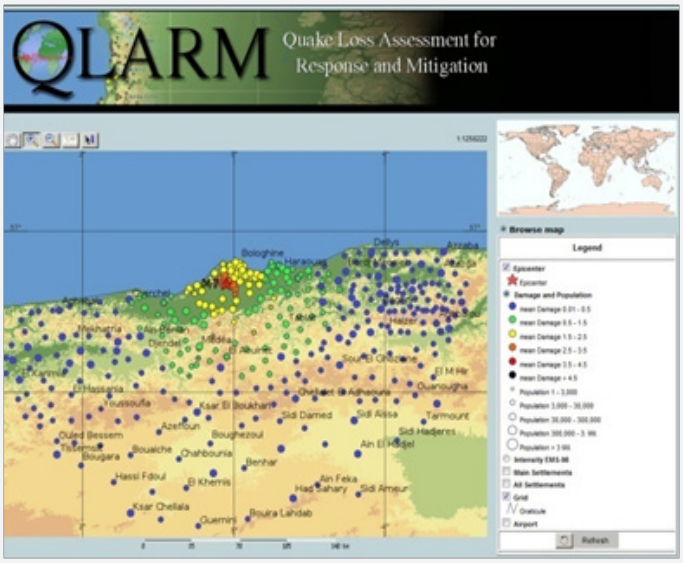

Figure 2: QLARM map in the case of a repeating M7.0 Algiers, 1716 earthquake during the day.
Each dot is a settlement. The size of the dots is proportional to its population. The colors represent the mean damage degree to the different classes of buildings. The red star locates the epicenter of the scenario (as in Table 1). It shows the mean damage to each settlement in case of a repeat of the earthquake of Algiers during the day. Estimates of killed and injured people, which are counted by thousands, are also provided for night and day occurrences. If site conditions are included, numbers for fatalities and population strongly affected are increased by about 40, 10 and 20% for Algiers, Oran and Djidjelli scenarios respectively.

Table 1: Scenarios for repeated earthquakes. Imax is the maximum calculated intensity. The population in the areas shaken at the indicated intensities is in the last three columns.

Scenario location (historic date)	Mw	Latitude (deg)	Longitude (deg)	Depth (km)	Imax	Population (million)		
						VI - VII	VIII+	VI+
Algiers (02/03/1716)	7.0	36.67	02.95	15	IX	3.80	4.38	8.18
Oran (10/09/1790)	7.5	35.70	-0.64	15	X	4.47	1.97	6.44
Djidjelli (08/02/1856)	7.3	36.70	06.08	15	X	5.98	1.26	7.33

QLARM calculates building damage divided into five degrees, mean damage grade and the range of fatalities and injuries for each settlement around the epicenter [8-10]. It also calculates the strongly affected people, those that live in the area of shaking with intensities VI+, level of shaking when damage to dwellings and injured likely result in Algeria and other regions with poor construction. After calibrating QLARM as mentioned, three scenarios that correspond to past damaging earthquakes in the vicinity of the largest cities of Algeria were selected as listed in Table 1. Populations in the areas with intensities VI plus VII and in intensities VIII+ are also shown because the damage and the casualties are significantly different (Figure 2).

Discussions

We propose a dataset and city model calibrated and validated for Algeria in QLARM in order to help in seismic risk management. It includes 1504 settlements for which population, building stock and site conditions are defined. The conclusion of this work is that QLARM can be used to calculate damage and casualties correctly to within a factor of about two. Three scenarios based on the repetition of historical earthquakes are proposed (Table 1). Our loss estimates could be refined, made more accurate and more detailed by collecting data on site amplification in the largest cities, by constructing discrete city models for important cities and by defining a set of seismic line sources but also other seismic point sources with lower magnitude.

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