NEAR FIELD EXPERIMENTAL SEISMIC RESPONSE SPECTRUM ANALYSIS AND COMPARISON WITH ALGERIAN REGULATORY DESIGN SPECTRUM

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ABSTRACT :

In this study, near field experimental seismic response spectra are computed based on the main shock and numerous aftershocks recorded during and after the May 21 Boumerdes earthquake with magnitude from 3.8 to 6.8. Large strong motion data base (East- West, North-South, and Vertical) is recorded by the Algerian accelerograph network monitored by the earthquake engineering research center. Two stations, located in near field, are used for this study: Keddara and Boumerdes stations. Results show a high frequency content in near field and a clear underestimate of the RPA99 design spectra in high frequencies. A clear frequency shift is evidenced on the horizontal component compared to the vertical one. Also, a directionality effect is evidenced particularly at keddara station around 10 Hz where the north south mean spectral amplitude is higher than the east west one. Finally, a comparison between Keddara and Boumerdes East-West, North-South and vertical horizontal mean elastic response spectrum shows higher spectral amplitude in Boumerdes up to 8 Hz for both horizontal and vertical components.

KEYWORDS: Boumerdes, Earthquake, Near field, Elastic response spectra, Directionality

1. INTRODUCTION

Algeria is located on the northern edge of the African plate, which is converging with the European plate since the Mesozoic, with a shortening rate of about 4-8 mm/yr [1] (Figure 1). Northern Algeria is a highly seismic area, as evidenced by the historical (1365 to 1992) seismicity [2, 3] (Figure 2). During the last two decades, northern Algeria experienced several destructive moderate-to-strong earthquakes. Since the 1980 El Asnam earthquake (M_s 7.3), which claimed over 2700 lives and destroyed about 60 000 housings, many moderate, but destructive, earthquakes occurred, such as the Constantine October 27, 1985 (M_s 5.7), Chenoua October 29, 1989 (M_s 6.0), Mascara August 18, 1994 (M_s 5.6), Algiers September 4, 1996 (M_s 5.6), Ain Temouchent December 22, 1999 (M_s 5.6), the Beni Ourtilane November 10, 2000 (M_s 5.5) earthquakes, the Boumerdes May 21, 2003 (M_w 6.8), the Laalam march 20, 2005 (M_w=5.2).

This paper deals with the analysis of the near field experimental seismic response spectrum and the comparison with the Algerian design spectrum. Many records, obtained during the main shock and the aftershocks of the May 21 Boumerdes earthquake, are used. Two stations, located in near field, are used for this study: Keddara and Boumerdes stations.

2. THE ALGERIAN ACCELEROGRAPH NETWORK

The lack of strong ground motion data was significantly experienced when elaborating the first Algerian aseismic building code in 1976. It was therefore decided to implement a countrywide accelerometer network. The installation of 335 3-component accelerographs started in 1980, 218 of which are already installed in the free field, and 30 in structures (buildings, dams …etc.) (Figure 3). The network was acquired in three stages: (i) following the 1980 El Asnam earthquake, 90 analog SMA-1 accelerographs were installed mainly in the free field, (ii) in 1990, 80 SMA-1 analog and 40 SSA-1 digital accelerographs were acquired in order to densify the existing network, with more emphasis on structures (buildings, dams), and (iii) 125 Etna digital accelerographs, acquired in 2002-2003, are currently being installed.

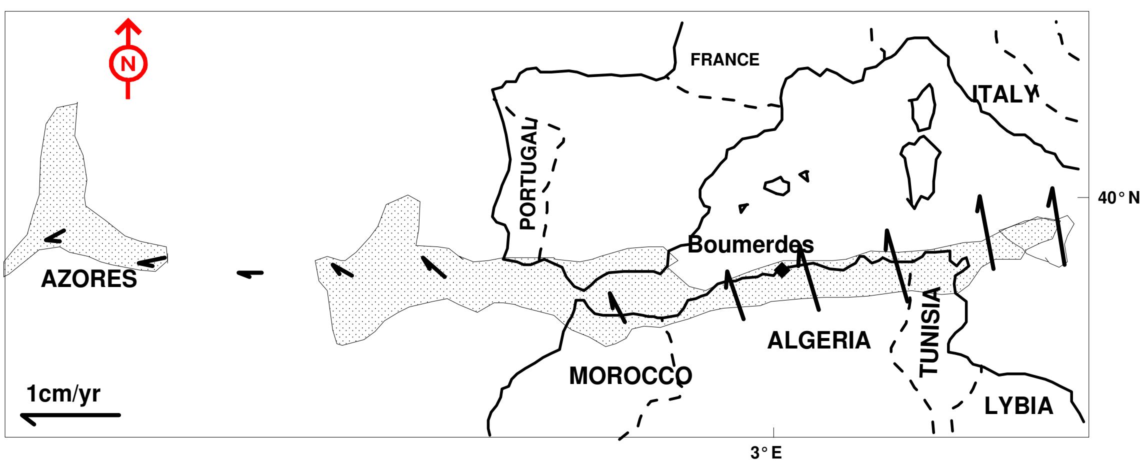

Figure 1: Map describing the convergence between the African and Eurasian plates (redrawn from [1]). The dotted zone represents the seismicity area. The arrows indicate the shortening orientation, their length being proportional to the shortening rate. The city of Boumerdes, close to the epicenter of the May 21, 2003 earthquake, is represented by a filled diamond.

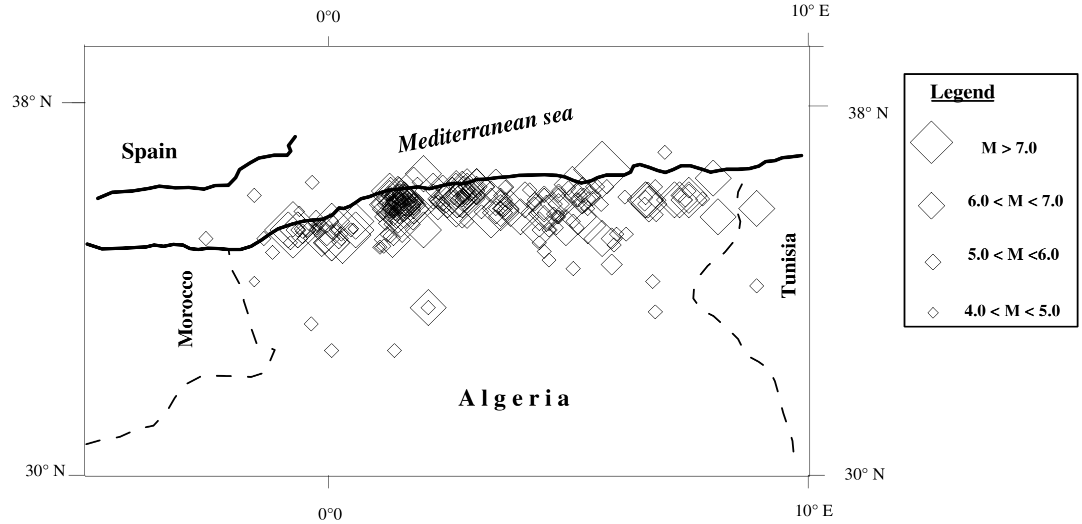

Figure 2: Seismicity map of Algeria for the period 1365-1992, after the catalogues of CRAAG [2] and Benouar [3] (Magnitudes M_s).

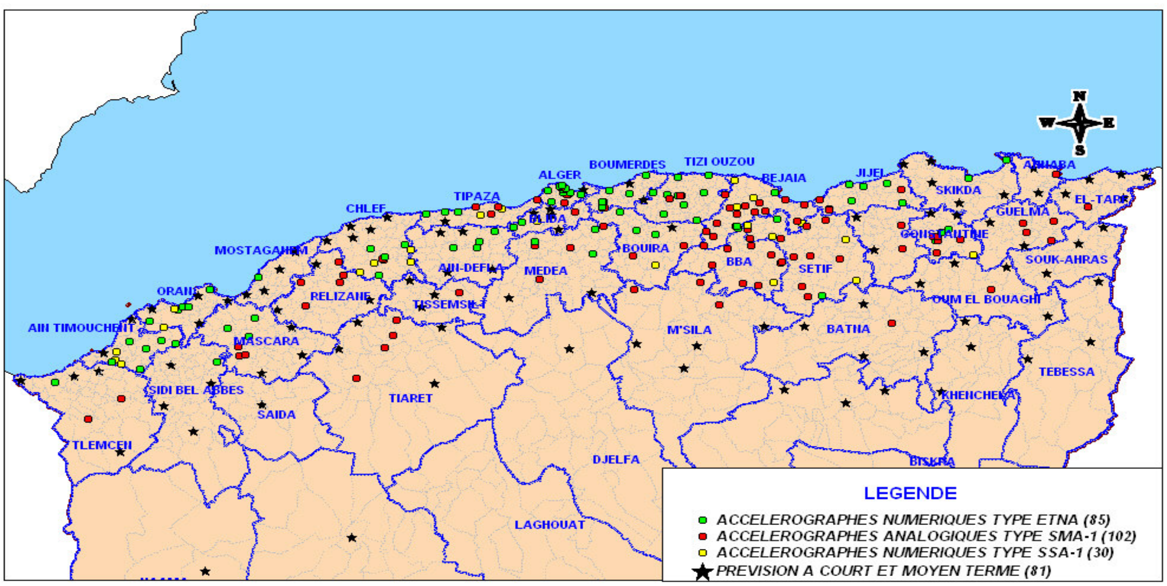

Figure 3: The Algerian accelerograph network monitored by CGS, with the regional administrative limits.

3. RECORDED DATA

The Boumerdes earthquake was felt as far as 250 km from the epicenter, where accelerations of about 0.02 g have been recorded [4]. In this study, two digital stations, Keddara station KDRA and Boumerdes station BOMD, located in near field, are used (see figure 4). For BOMD station, 09 aftershocks are considered while for KDRA station, the main shock and 10 aftershocks are considered (Table 1). The localization of these events is plotted in figure 4. From geological point of view, the soil type is firm for both stations.

Table 1: Considered events recorded bay Boumerdes and Keddara stations.

BOUMERDES STATION FIRM SOIL		KEDDARA STATION FIRM SOIL	
EVENTS	DATES	EVENTS	DATES
A1008.evt	27/05/2003	AG006.evt	21/05/2003
A1066.evt	28/05/2003	AG008.evt	21/05/2003
A1089 evt	29/05/2003	AG011 evt	23/05/2003
AI021.evt	01/06/2003	AG014.evt	27/05/2003
AL026.evt	02/06/2003	AG015.evt	28/05/2003
AQ029 evt	21/07/2003	AG016 evt	29/05/2003
AQ079.evt	11/08/2003	AI026.evt	14/07/2003
AQ133.evt	20/09/2003	AI028.evt	17/07/2003
AV022.evt	10/01/2004	AI036.evt	03/08/2003
	01/12/2004	AK002 evt	01/12/2004
	05/12/2004	AL002.evt	05/12/2004

Data has been processed with the Kinemetrics SMA [5] software. The sampling frequency is set to 200 sps. The Trifunac method [6, 7] used for data processing is based on three steps: (i) instrument correction, (ii) baseline correction of the acceleration data, and (iii) high-pass filtering of velocity and displacement, using an Ormsby filter. For instrument correction the low-pass cut-off frequency of the Ormsby filter was set 25 Hz, with a 3 Hz roll-off width.

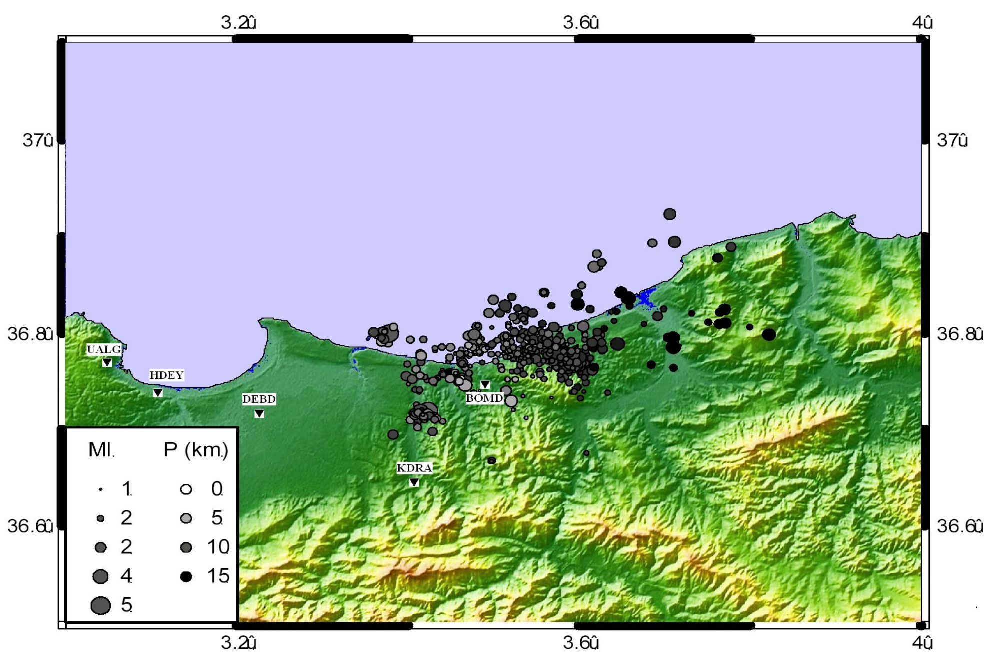

Figure 4: Stations localization and epicenter spatial distribution.

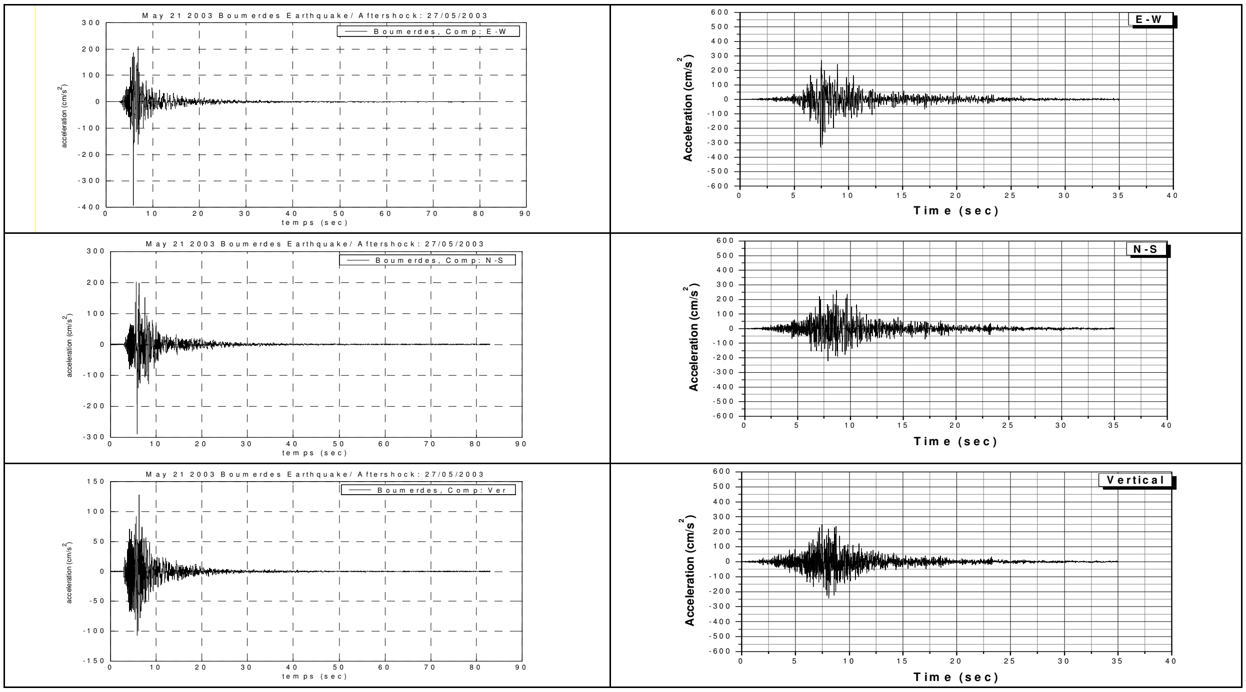

Figure 5: Accelerogramm samples recorded by the BOMD (left, aftershock) and KDRA (right, main shock) stations.

4. RESULTS AND CONCLUSIONS

For both stations, and for the considered seismic events, the pseudo acceleration normalized elastic response spectrum is computed using normalized accelerations with respect to PGA, for each component (E-W, N-S, V). Then, the statistics (mean and std) of the horizontal and vertical pseudo acceleration normalized elastic response spectra are computed.

Figure 6 shows a comparison between statistics of experimental horizontal elastic response spectra recorded at Keddara and Boumerdes with the RPA99 design spectra [8]. The plotted curves show a high frequency content in near field with a central frequency around 8 Hz and 10 Hz respectively at Boumerdes and Keddara stations. The comparison shows a clear underestimate of the RPA99 design spectra in high frequencies.

Figure 7 shows a comparison between horizontal and vertical mean elastic response spectrum at Keddara and Boumerdes stations. A clear frequency shift is evidenced on the horizontal component versus the vertical component.

In Figure 8, a comparison is made between East-West and North-South horizontal mean elastic response spectrum at Keddara and Boumerdes stations. A directionality effect is evidenced particularly at keddara station around 10 Hz where the north south mean spectral amplitude is higher than the east west one.

Finally, in figure 9, a comparison between Keddara and Boumerdes East-West, North-South and vertical horizontal mean elastic response spectrum is done. The plotted curves show higher spectral amplitude in Boumerdes up to 8 Hz for both horizontal and vertical components.

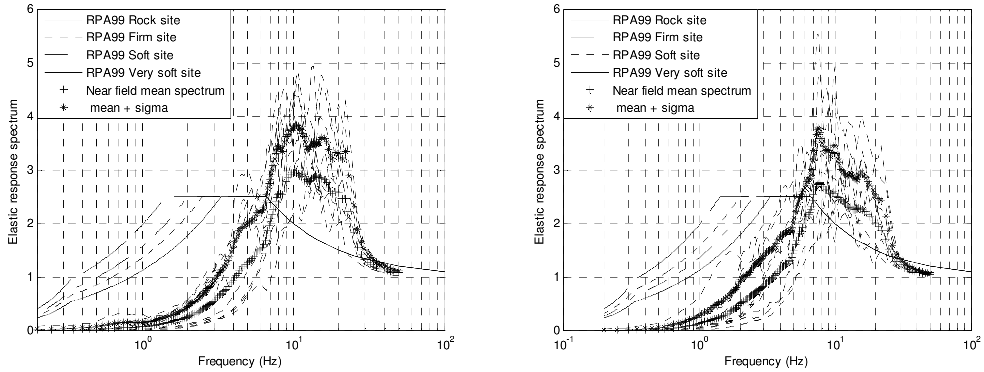

Figure 6: comparison between statistics of experimental horizontal elastic response spectra recorded at Keddara (left) and Boumerdes (right) with the RPA99 design spectra.

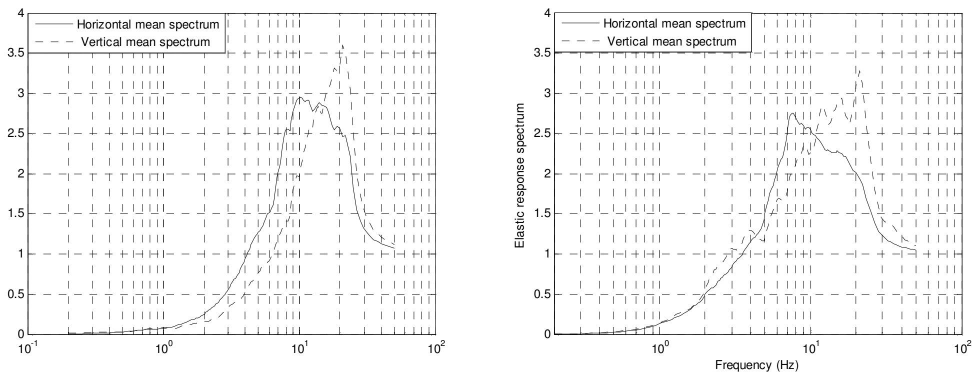

Figure 7: comparison between horizontal and vertical spectrum at Keddara (left) and Boumerdes (right) stations.

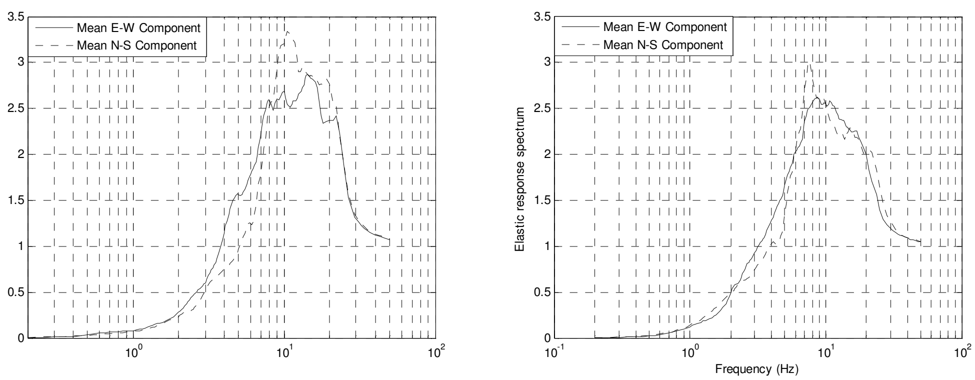

Figure 8: comparison between East-West and North-South horizontal mean elastic response spectrum at Keddara (left) and Boumerdes (right) stations

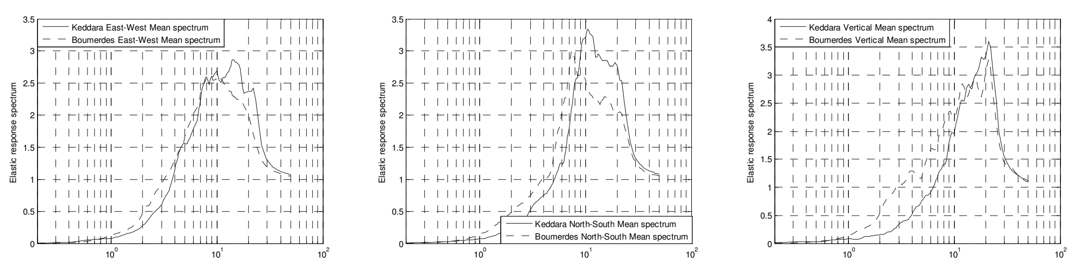

Figure 9: comparison between Keddara and Boumerdes East-West (left), North-South (centre) and vertical (right) horizontal mean elastic response spectrum.

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