A PRELIMINARY MODEL OF THE EARTHQUAKE GROUND-SHAKING HAZARD IN THE ECH CHELIFF REGION

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SUMMARY

This paper presents a preliminary model of the ground-shaking hazard in the Ech Cheliff region of northern Algeria, the location of the destructive (M_s = 7.3) earthquake of 10 October 1980. Using isoseismal data from the El Asnam earthquake and other past earthquakes, an attenuation relation was determined for the region. Although the attenuation relation is imprecise, the data suggest that seismic wave energy decays more rapidly in the Ech Cheliff region than in many other regions of the World. Preliminary results of the seismic microzoning study started in May 1983 indicate that the peak ground accelerations in the Ech Cheliff region are, respectively, 0.12g, 0.24g, and 0.35g for return periods of 50, 200, and 500 years.

EL ASNAM EARTHQUAKE

On 10 October 1980, a destructive earthquake having a magnitude (M_s) of 7.3 occurred in the Oued Fodda fault zone, a system of active reverse faults that is typical in northern Algeria where the Eurasian and African plates are colliding. The epicenter was about 10 km (6 miles) east of Ech Cheliff (formerly El Asnam) the focal depth was shallow, also about 10 km. The earthquake caused extensive damage to buildings and lifeline systems in the Ech Cheliff region amounting to about $1 billion and killed about 2,700 people. The large loss of life and property was partly due to the collapse of buildings from the intense ground shaking estimated to have been between 0.5 and 1.0g. The vertical component of ground shaking appears to have been very large. Surface fault rupture, tectonic deformation, and earthquake-induced ground failure occurred in the earthquake (Refs. 1-2).

No strong ground-motion records were obtained from the main shock of the 1980 earthquake. Although about a dozen accelerograms of aftershocks having magnitudes of 4 to 5.6 and peak accelerations as great as 0.31g were recorded, historical intensity data (Fig. 1) are the primary data available to define the characteristics of ground shaking that occurred in the Ech Cheliff region. Intensity data, although limited, are available for past destructive earthquake of 1922, 1934, and 1954 and a number of smaller events. These data were used to estimate the regional seismic attenuation relation, the primary subject of this paper.

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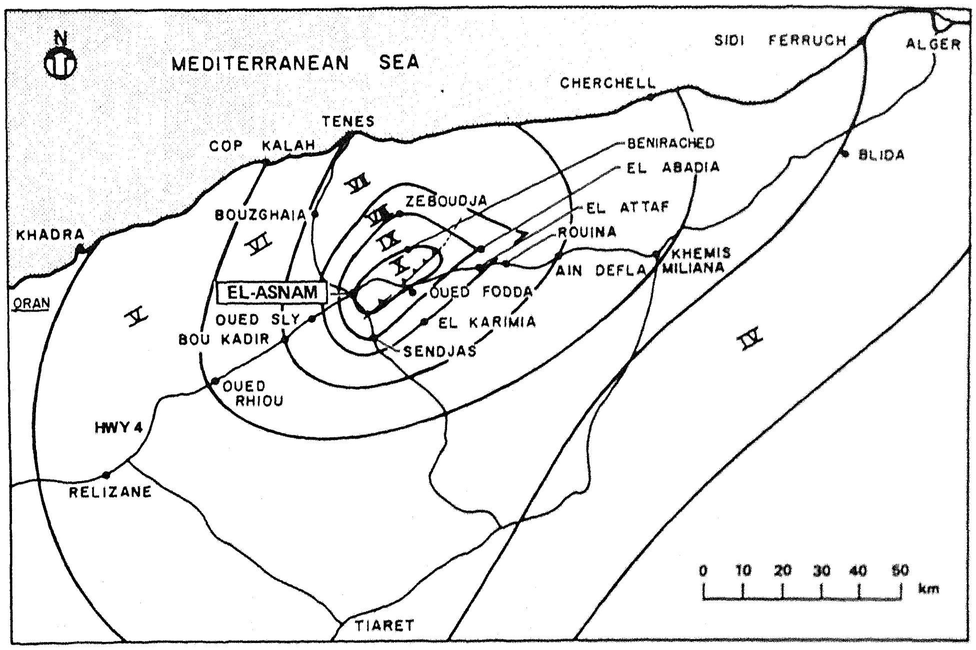


Figure 1.--Isoeseismal map of the 1980 El Asnam earthquake (Refs. 1-2).

A MODEL OF THE GROUND-SHAKING HAZARD

To evaluate the ground-shaking hazard of a geographic region requires data on: 1) the frequency of occurrence of earthquakes, 2) the characteristics of the seismic sources in the region, 3) the regional attenuation function, and 4) the response of the soil and rock to ground shaking. Each of these four elements is important, and considerable research is required to determine the median values of the various physical parameters and a statistical measure of their uncertainity. Knowledge of the regional attenuation relation, the primary subject of this paper, is especially important for deriving a model of the ground-shaking hazard. Such a model has many uses, including: 1) guiding the acquisition of strong ground motion data, 2) making deterministic and probabilistic estimates of seismic-design parameters (peak values of acceleration, velocity, and displacement; response spectra; and duration of shaking) at construction sites, and 3) producing maps of the ground-shaking hazard to establish realistic seismic design provisions of building codes and land-use practices.

Seismic Microzoning Study

A seismic microzoning study was initiated in northern Algeria in May 1983. The objective of the study, which is expected to be completed in July 1984, is to conduct geologic investigations (mapping, trenching, and age dating) along with seismological investigations of the historical seismicity and geotechnical studies. The study will define the physical

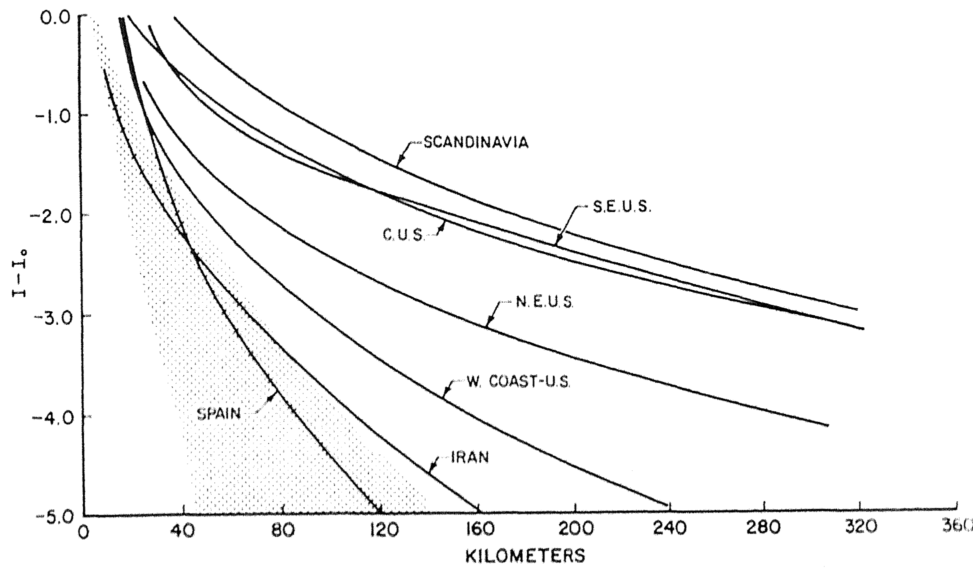


Figure 2.--Comparison of attenuation relations for different regions of the World. The relation for the Ech Cheliff region is shown by the pattern and reflects variation caused by the seismic radiation pattern and other factors.

parameters of the source, travel path, and site required to devide the region into zones. Each zone would be expected to experience the same relative severity of an earthquake hazard such as ground shaking. When completed, maps will be available for the Ech Cheliff region showing the relative severity of the hazards of ground shaking, surface fault rupture, tectonic deformation, and earthquake induced ground failure. These maps will integrate all of the geologic, seismological, geotechnical, and engineering data.

REGIONAL SEISMIC ATTENUATION RELATION

Isoseismial maps and intensity data from the El Asnam earthquake (see Fig. 1) and about a dozen past earthquakes were used to derive an attenuation relation for the Ech Cheliff region. This relation is shown on Fig. 2, not as a single line, but as a band that depicts the variation caused by the seismic radiation patterns, the focal depths, and inelastic deformation of soils as a function as the size of the earthquake. Comparison of the attenuation relation for Algeria with the relations for other regions (simplified as a single line representing the median value) suggests that the seismic wave energy decays more rapidly in the Ech Cheliff region as distance from the causative fault increases than in other geographic regions of the World. The attenuation relations for the Ech Cheliff region is similar to that for Spain. These results suggest that the area of severe ground shaking (and the potential for damage to buildings) in the Ech Cheliff region is smaller than for many other geographic regions of the World (e.g., Eastern United States, Scandinavia).

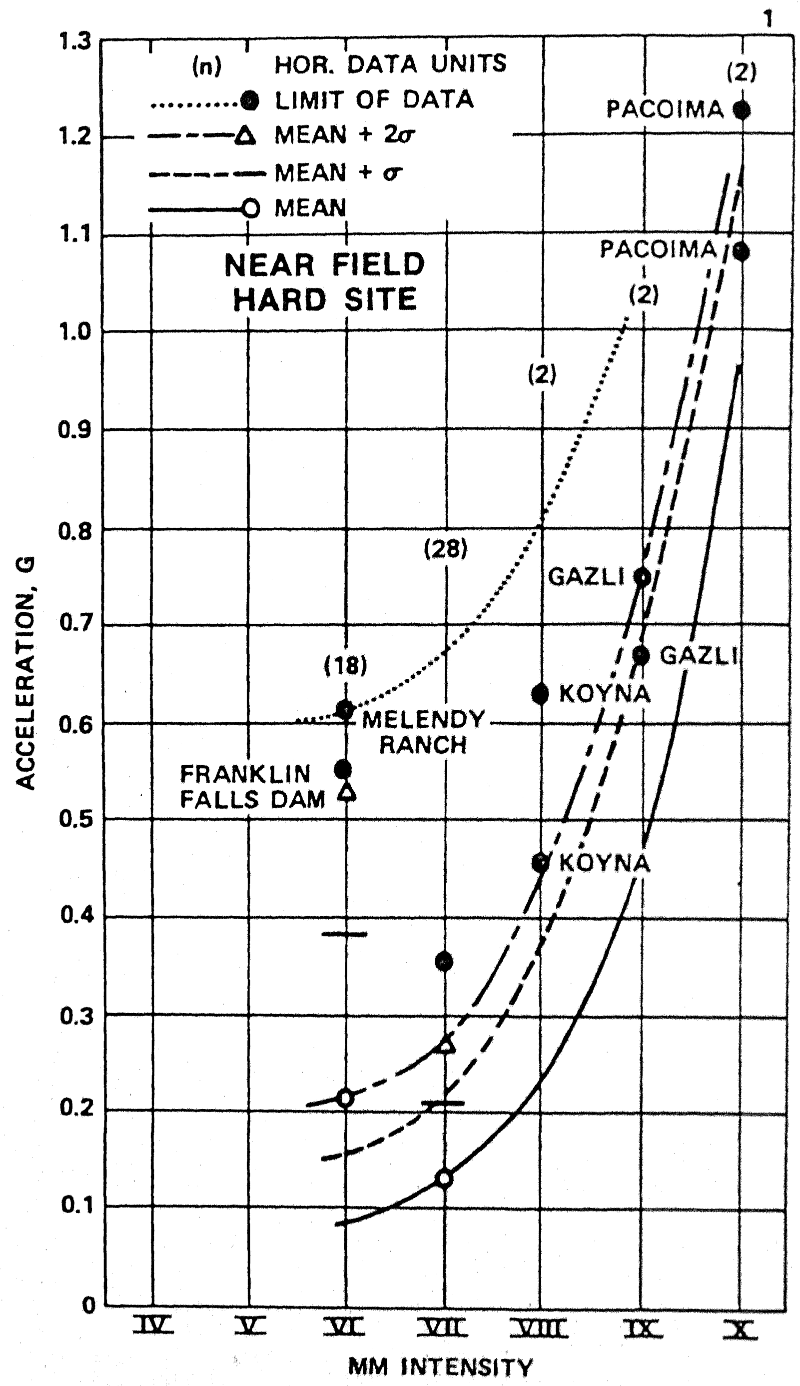


Figure 3.--Acceleration as a function of Modified Mercalli Intensity (Ref. 3).

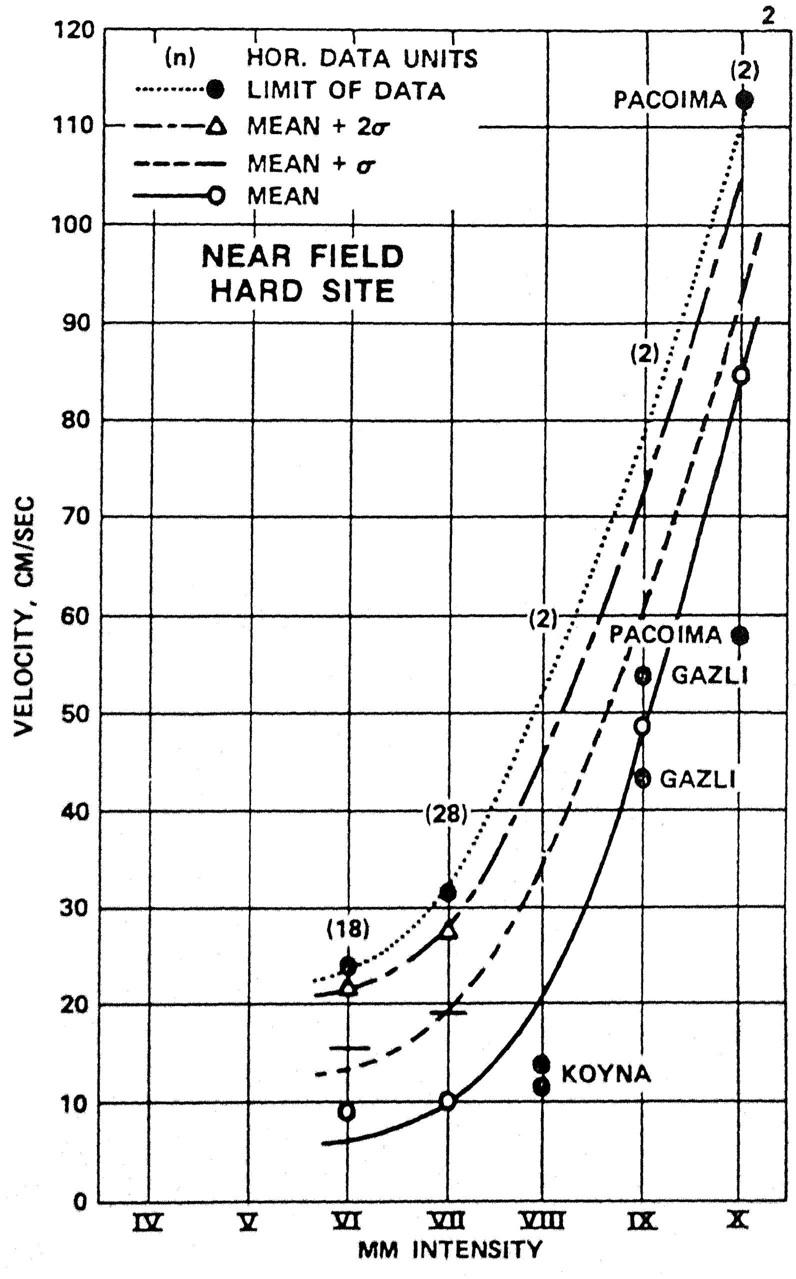
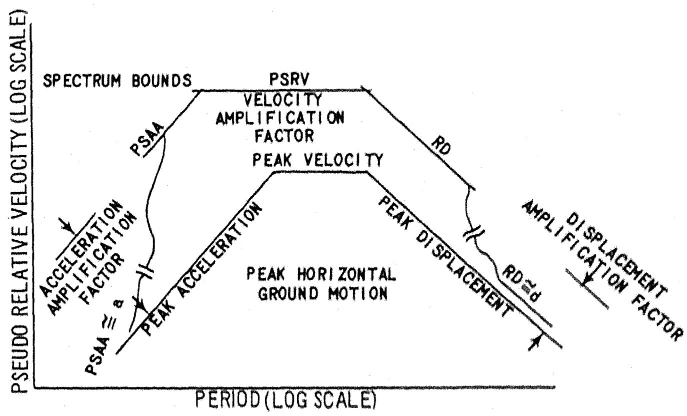


Figure 4.--Velocity as a function of Modified Mercalli Intensity (Ref 3.).

By using empirical correlations (Figs. 3-4; Ref. 3), the values of intensity expected at various distances can be converted into values of peak acceleration and velocity. These values are shown below for an El Asnam type of earthquake.

Distance (km)	Intensity	Peak Acceleration (g) (See Fig. 3)	Peak Velocity (cm/s) (See Fig 4.)
0-10	IX - X	0.5 - 1.0	50 - 85
20	VIII - IX	0.24 - 0.45	20 - 55
30	VII - VIII	0.14 - 0.3	10 - 25
40	V - VII	0.05 - 0.2	5 - 15
50	IV - V	0.02 - 0.14	2 - 6

Although these empirical correlations have some uncertainity, they provide a regional basis for estimating the levels of peak ground motion expected at various distances in future large earthquakes. These values can also be used to estimate the smooth response spectrum for a construction site (Fig. 5).



	AMPLIFICATION FACTOR		
DAMPING %	ACCELERATION	VELOCITY	DISPLACEMENT
0	6.4	4.0	2.5
0.5	5.8	3.6	2.2
1	5.2	3.2	2.0
2	4.3	2.8	2.0
5	2.6	1.9	1.8
7	1.9	1.5	1.4
10	1.5	1.3	1.2
20	1.2	1.1	1.0

Figure 5.--Schematic illustration of the procedure for obtaining a smooth response spectrum. The values of peak ground motion are multiplied by the amplification factors for a given value of damping (Ref. 4).

PROBABILISTIC ESTIMATES OF PEAK ACCELERATION

Preliminary results of the seismic microzoning study provide a basis for estimating the peak ground acceleration in the Ech Cheliff region for return periods of 50, 200, and 500 years. These values are, respectively, 0.12 g, 0.24g, and 0.35g. They correspond to sites underlain by stiff soil and have a 90 percent probability of nonexceedance. The seismic design provision of building codes typically are based on the value of acceleration for a 500 year return period. These values were obtained by integrating the geologic studies (mapping, trenching, and age dating) and studies of the historical seismicity.

The key to extending and improving probabilistic estimates of peak acceleration is to improve the definition of each of the three primary components required to generate the values; namely, the historical seismicity, the seismic source zone and the regional attenuation function. The ground motion produced by earthquake is a complex function of the tectonic province, the earthquake source mechanism, the geology of the travel path, and the soil and rock column site underlying the site. Additional data are needed to answer the many technical questions that still exist.

CONCLUSIONS

Although uncertainity exists at this time in the determination of the physical properties of the source, travel path, and site in the Ech Cheliff region, sufficient data exist to make a preliminary model of the ground-shaking hazard. This model provides useful insight for a number of applications. The model will be improved as ground motion records and response spectra are obtained from Algerian earthquakes by the Algerian strong motion network. The strategy for deploying the strong motion instruments in Algeria will be to acquire specific information about: 1) the seismic attenuation relation, 2) near-field values of ground shaking, 3) the effect of soil and rock on ground motion attenuation and site response, and 4) duration of shaking.

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