A SCENARIO FOR ACQUIRING STRONG GROUND MOTION DATA IN NORTHERN ALGERIA

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SUMMARY

This paper presents a scenario for acquiring strong-ground motion data in northern Algeria, the location of destructive earthquakes in 1922, 1934, 1954, and 1980. Except for aftershocks of the 1980 El Asnam earthquake, no strong-ground motion records are available. The initial objective is to build a ground-motion data base that can be used to define: 1) regional seismic wave attenuation relations, and site response, 2) near-field values of ground shaking, 3) the effects of soil and rock on seismic wave attenuation and site response, and 4) duration of shaking. These data will improve earthquake engineering in Algeria.

ALGERIAN STRONG MOTION NETWORK

Prior to 1980, Algeria had intensity data, but did not have strong-ground motion data. Although Algeria is seismically active and destructive earthquakes occur fairly frequently (1922, 1934, 1954, 1980), no strong-ground motion data have been recorded except for aftershocks of the 10 October 1980, El Asnam earthquake. This damaging earthquake occurred in the Oued Fodda fault zone, a system of active reverse faults which are abundant in northern Algeria. The El Asnam earthquake caused extensive damage, partly due to the collapse of many buildings from the intense ground shaking, estimated to have been in excess of 0.5 g and to have a duration of 35-40 seconds (Refs. 1-2).

Without a knowledge of the ground shaking generated by earthquakes, it is not possible to evaluate the ground-shaking hazard in a realistic manner or to develop appropriate methods of earthquake-resistant design. The recording of strong earthquake ground motion provides the basic data for earthquake engineering. Following the destructive El Asnam earthquake of 10 October 1980, Algeria purchased 90 SMA-1 strong-motion accelerographs and is now in the process of deploying them in northern Algeria. The initial objective of the Algerian strong-motion network is to collect basic ground-motion data as rapidly as possible in order to improve the evaluation of earthquake hazards in Algeria. The required data include:

1) regional seismic-wave attenuation relations,
2) the characteristics of ground shaking near the causative fault,
3) the frequency-dependent effects of soil and rock on ground motion, and
4) the duration of shaking.

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Information on these subjects is of vital importance in seismic microzoning and in the design of major structures and facilities.

CRITERIA FOR DEPLOYMENT OF STRONG MOTION ACCELEROGRAPHS

Because Algeria has no strong ground motion data, considerable care was given to establishing criteria for deploying the instruments to record useful ground-motion data. The criteria, listed below, were selected on the basis of the fundamental physics of wave propagation (Fig. 1). Although the physics of seismic waves is complex, ground shaking can be

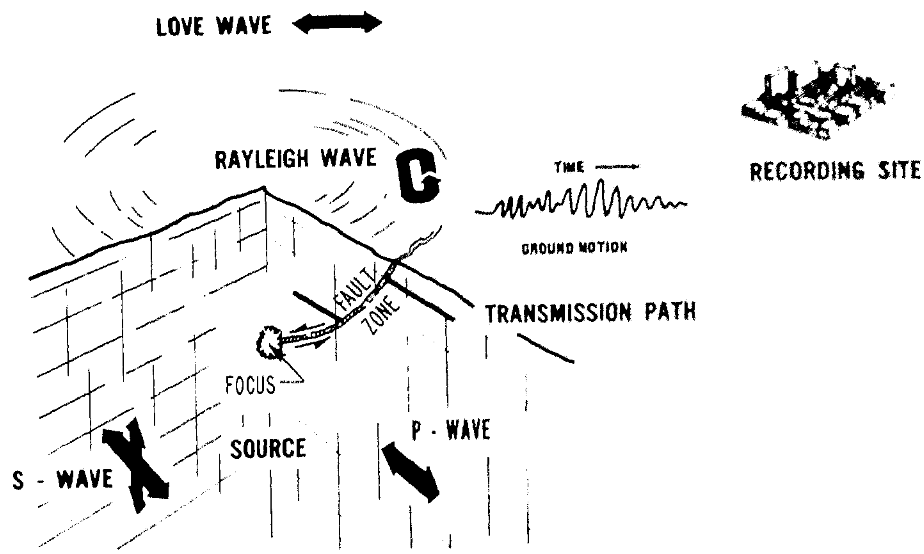

Figure 1.--Schematic illustration of the direction of vibration caused by body and surface seismic waves generated during an earthquake. When a fault ruptures seismic waves are propagated in all direction, causing the ground to vibrate at frequencies ranging from about 0.1 to 30 Hertz. Buildings vibrate as a consequence of the ground shaking; damage takes place if the buildings can not withstand these vibrations.

explained in terms of body waves (P and S) and surface waves (Rayleigh and Love). P waves are the first waves to cause vibration of a building. S waves arrive next, cause a structure to vibrate from side to side, and are the most damaging waves because buildings are more easily damaged from horizontal motion than from vertical motion. The P and S waves mainly cause high-frequency vibrations and typically cause the peak acceleration on an accelerogram; whereas, Rayleigh and Love waves arrive last and mainly cause low-frequency vibrations. In earthquake resistant-design, knowledge of the amplitude, frequency composition, and duration of shaking is needed. These quantities can be determined from strong ground motion data. The accuracy of the information depends on the criteria followed to acquire thd date. Data acquisition in Algeria emphasized the following criteria, which will be discussed below:

1) Choose locations near an active fault zone which has a high probability of generating a moderate to large earthquake in the next 10-20 years. Preference should be given, whenever possible, to sites having favorable operating conditions and located near important industrial and population centers.

2) Choose recording sites that are suitably arranged with respect to the fault plane and the projected surface fault rupture to give attenuation relations. Recording sites should be located on the same type of soil or rock to the extent possible.

3) Choose recording sites that will record ground motions close to the causative fault.

4) Choose recording sites which are likely to record ground motions having a wide range of dynamic shear strains and levels of peak ground acceleration. These sites should be underlain by a variety of soil types and rock.

Active Fault Zones

Algeria has many active faults (Fig. 2). Although it is impossible at this time to specify the location, size, and time of the next major

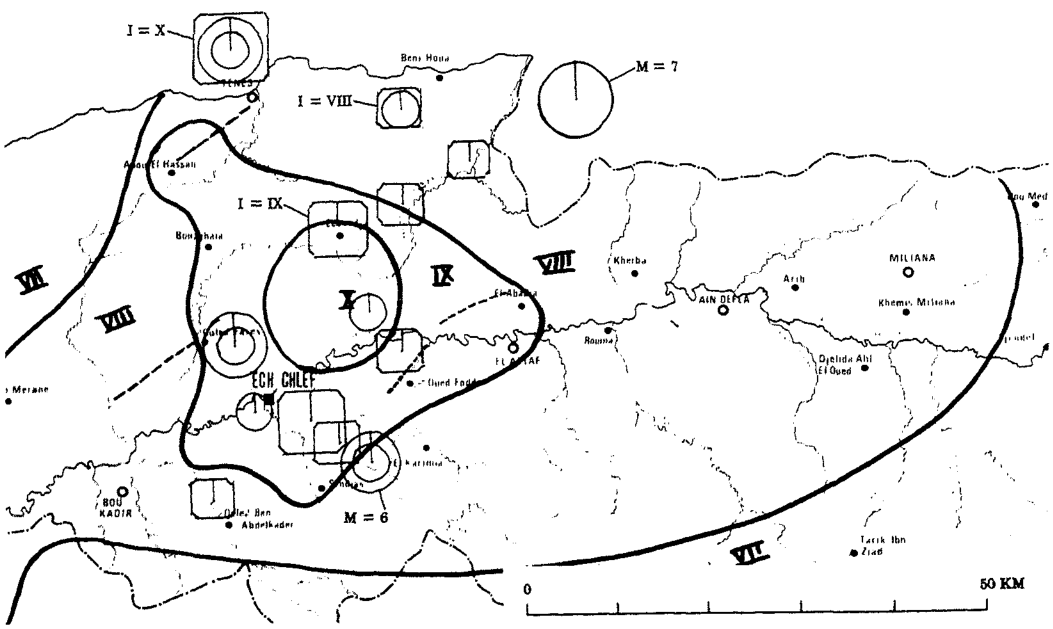

Figure 2.--Maps showing Ech Cheliff region. Active faults (Oued Fodda, Ouled Fares, Beni Rached) are shown as dashed lines. Epicenters of past earthquakes and contours of the maximum historic intensity are shown.

earthquake in northern Algeria, it seems reasonable that one or more of the known active faults in the Ech Cheliff region, such as Oued Fodda, Ouled Fares, and Beni Rached, will produce earthquakes having significant levels of ground motion. Therefore, instruments are being deployed in the Ech Cheliff region.

Geologic investigations (mapping, trenching, and age dating) are underway to determine the rate of activity of these faults and others. The goal of these investigations is to define the "seismic cycle" of each active fault. The concept of the seismic cycle is that strain is continuously stored near the boundaries of slowly moving sections or plates of the Earth's crust (e.g., the Eurasian and African plates). The strain is relased suddenly by slippage along faults at interplate boundaries giving rise to earthquakes such as the 1980 El Asnam earthquake. The interplate boundaries have characteristics that vary with location. Some regions are characterize by long intervals between large earthquakes, other regions by more frequent and less severe earthquakes, the net energy released remaining the same in both cases.

Seismic Wave Attenuation

First priority is being given to establishing instrument arrays that will obtain data to define seismic-wave attenuation relations in the Ech Cheliff region. A preliminary estimate of the regional attenuation relation (Fig. 3) has been made on the basis of historic isoseismal maps (Ref. 3). This

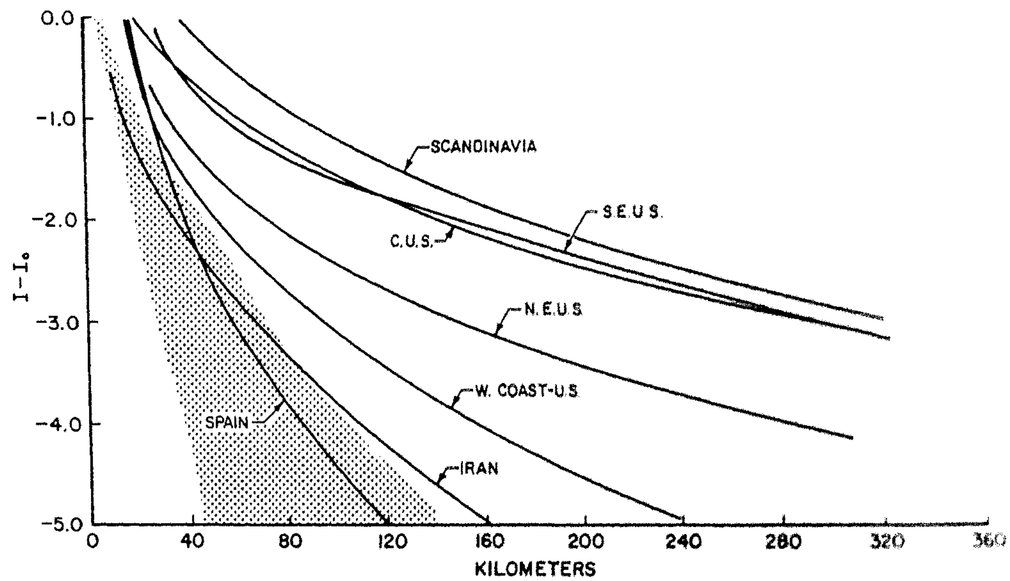

Figure 3.--Comparison of seismic-wave attenuation relations for various regions of the World based on Modified Mercalli intensity data. The preliminary relation for Algeria is shown by shading and reflects the uncertainity. The median value for Algeria is not known at this time.

preliminary relation must be improved in order to improve the accuracy of the estimates of the ground-shaking hazard in northern Algeria. Improving the knowledge of the seismic-wave attenuation relation (and the uncertainity in the median value) is the best way to improve the preliminary estimates that are being produced in the seismic microzoning study, now underway in Algeria.

Research on seismic wave attenuation is expected to proceed slowly because it takes time to record strong ground motion for earthquakes having a wide range of magnitudes. Also, it is difficult to select recording sites that are underlain by the same thickness and type of soil or rock.

Near-Field Ground Motions

Instruments are being deployed close to active faults in order to increase the probability of recording strong ground motion close to the fault rupture zone. Because such data are lacking throughout the World, considerable controversy exists about how intense the peak ground acceleration is close to the causative fault. Controversy also exists about the question of saturation of peak acceleration with magnitude.

Characterization of the ground motion close to the fault is one of the most difficult as well as important parts of the scientific problem connected with evaluating the ground-shaking hazard. Close to the fault, the ground motion is strongly influenced by the dynamics of the fault rupture. In Algeria, the Eurasian plate is being thrust over the African plate, causing physical complications that must be considered when deploying the strong motion instruments. As strong ground motion is recorded near the fault in future Algerian earthquakes, the preliminary estimates of the ground-shaking hazard in the Ech Cheliff region will be improved.

The Effects of Soil and Rock on Ground Motion

Strong-motion instruments are being deployed at sites in the Ech Cheliff region underlain by a variety of soil types and rock. The goal is to record ground motion having a wide range in levels of peak ground acceleration and dynamic shear strain. The level of dynamic shear strain can be estimated by taking the ratio of the peak partical velocity recorded by a strong-motion instrument and the value of the shear-wave velocity of the soil. On the basis of geologic and geotechnical investigations in the Ech Cheliff region, it is known that soils have values of shear wave velocity that range from about 200 m/sec to about 800 m/sec and that the thickness varies from a few meters to several hundred meters. Fill material, present at some urban centers in the region may also amplify the motion (Fig. 4)

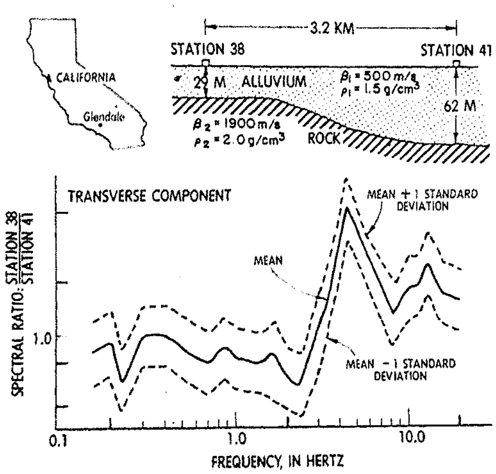

Figure 4.--Examples of site amplification possible in Algeria.

Amplification of ground motion at sites underlain by various types of soil is a controversal subject (Ref.4). It has been recognized and documented since the early 1900's that soils can amplify ground motions and modify the response spectrum in a narrow range of frequencies related to the natural period of the soil layer. The goal of the Algerian strong motion program is to record empirical data that will resolve the controversy.

Duration of Shaking

As strong ground motion data are acquired to address the subjects listed above, data about duration of shaking will also be acquired (Fig. 5).

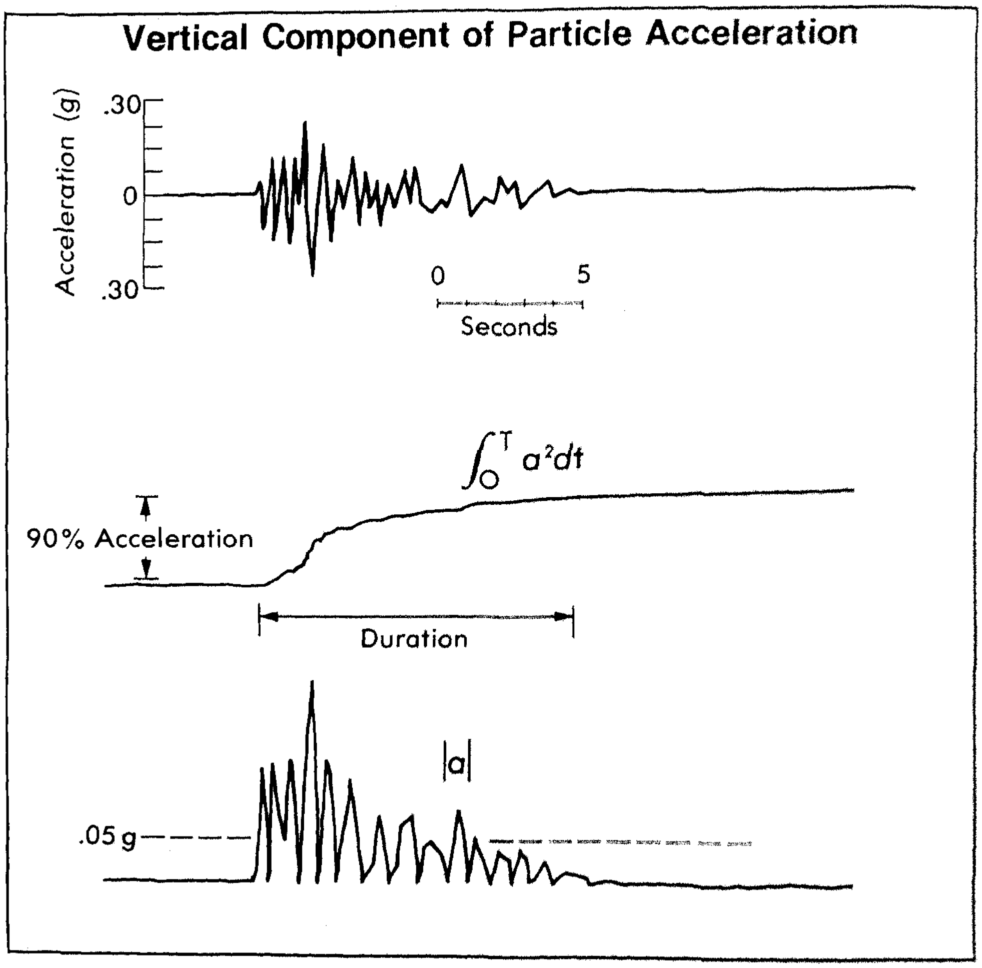

Figure 5.--Illustration showing how duration of ground motion is determined from a strong motion accelerogram. Bracketed duration (the time that the ground shaking exceeds a threshold of 0.05g) is the most commonly used definition of duration. The integral definition is also used.

Duration of shaking is one of the most important parameters of ground motion for causing damage. The 1980 El Asnam earthquake had an estimated duration of 30-40 seconds, the level expected for magnitude 7.3 earthquakes. The goal of the Algerian strong motion program is to record accelerograms in Algeria that can be used to define the relation between duration of shaking and magnitude.

CONSLUSIONS

Ninty strong motion accelerographs are being deployed in Algeria to provide data to define the regional seismic-wave attenuation relations, near-field ground motion levels, the response of soil and rock to ground motion, and the duration of shaking. These data will compliment preliminary results being produced in the seismic microzoning study initiated in northern Algeria in May 1983. The objective of the microzoning study, is to divide the Ech Cheliff region into zones which are expected to experience the same level of earthquake ground-shaking.

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