PRELIMINARY RECONNAISSANCE REPORT

EL-ASNAM EARTHQUAKE, ALGERIA

10th OCTOBER 1980

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Reconnaissance Report

El-Asnam Earthquake of 10th October 1980
Algeria

Preface

On October 10, 1980 at 13:30 Algerian time (05:30 Pacific Daylight time) a destructive earthquake occurred near the town of El-Asnam, which is approximately 200 kms (125 miles) west of the city of Algiers. The Richter magnitude of this event was 7.2. The initial reports placed the epicenter of this event near the village of Beni-Rached which is 15 kms (9.5 miles) north-east of El-Asnam. The focal depth was about 10 kms and the approximate duration was between 35 to 40 secs. Preliminary field estimates place the value of peak ground acceleration at more than 40% of gravity. A major aftershock with the Richter magnitude of 6.5 occurred on the same day at 16:30 Algerian time.

Haresh Shah was contacted by the Algerian government on 10th of October to go to Algeria and help them with the post-earthquake engineering investigations. Haresh contacted EERI to mobilize the investigation team. Through the efforts of John Blume, Roger Scholl and Henry Degenkolb, a reconnaissance team made up of Nicholas Forell, Christian Mortgat, Henry Taylor and Thomas Wosser reached Algiers on 15th October. Omar Khemici, a graduate student at Stanford University from Algeria, accompanied Haresh Shah to El-Asnam. He provided invaluable help during the field investigations.

Permission to enter the El-Asnam region through military checkpoints was provided by the Organisme de Contrôle Technique de la Construction (CTC). Farouk Tebbal, the Director General of CTC provided invaluable help. Other individuals from CTC who were of great help to the reconnaissance team were Amar Chakker, Ahmed Sandjian (sic) and Braham Rezbani.
Without the logistics support provided by the CTC, the reconnaissance team could not have achieved its function of investigating this earthquake.

A second team, jointly sponsored by the EERI and the National Research Council was sent to Algeria upon the return of the first reconnaissance team. The second team consisted of Vitelmo Bertero, Max Irvine, Tom Saarinen, Peter Gergely and Marcy Wang. This team was also assisted by Farouk Tebbal and other CTC personnel. Harry Halversen of Kinematics, through their European office sent Angel Sereci with one SMA-1 to Algiers. The first two major shocks were not recorded on any strong motion accelerographs. However, the one SMA-1 installed in El-Asnam did record numerous aftershocks after 15th October 1980.

This report is the result of the observations made by all the above individuals. Since these observations are preliminary, they are subject to modifications and changes at a later date. A complete report about the El-Asnam earthquake will be published by the EERI at a later date.
Relation to Plate Tectonics - Geologic Setting of Algeria

Algeria is located within the northern half of the African continent, and is bordered to the west, south and east by other African nations, and bounded to the north by the Mediterranean Sea. The northernmost portion of Algeria has historically experienced a moderate amount of shallow (less than 70 km deep) seismic activity. In light of modern day plate tectonics, this activity is thought to be associated with plate motions and the interactions at plate boundaries.

Nearly all of the African continent lies on the African plate. To the north is the Eurasian plate, which is thought to be colliding with, and being thrust over the African plate, with some plate consumption taking place (see Fig. 1). The types of features normally associated with a "subducting" plate boundary are not observed due to the behavior of the continental lithosphere with respect to plate subduction. Rather than the formation of an arc-trench complex, a wide belt of folded mountains is produced because the continental material is too light to sink into the mantle. This collision belt makes up the Atlas Mountains of North Africa (Morocco, Algeria and Tunisia), a broad zone of crustal shortening up to 400 km wide which has been extensively folded and thrust faulted. The structures within the Atlas Mountains trend generally east-west to east-northeast, parallel to the plate boundary and normal to the direction of plate convergence (see Fig. 2).

The boundary between the African and Eurasian plates terminates to the west against the Mid Atlantic Rise, and extends to the east through North Africa and the Mediterranean Sea to Greece, at which point it becomes more complex. The plate boundary west of Spain changes from one
Figure 1  Approximate positions of presently active plate boundaries in the Mediterranean region. The arrows mark the directions of motion relative to the Eurasian plate. Boundaries creating lithosphere (spreading centers) are shown with a double line, boundaries consuming plates are shown with short lines normal to the line. 

From McKenzie, 1970
Figure 2. Map of the Atlas Mountains and the Northern Sahara, showing the general structural grain.
From Deleau, 1952
of overthrusting to one characterized by right lateral strike slip faulting (predominantly horizontal motion with the opposite side moving to the right) as determined from earthquake focal mechanisms (McKenzie, 1970).

A band of shallow seismic activity is located along this plate margin. However, only a few intermediate to deep focus earthquakes have been recorded along this zone, and so, no well defined Benioff Zone is recognizable.

Seismologic Setting

El-Asnam and the surrounding region has experienced moderate to large earthquakes at least 10 times (including major aftershocks) during the last 250 years. Table 1 shows a list of earthquakes that have occurred in Algeria between 1716 and 1980. Figure 3 shows the epicentral map of Algeria (Mortgat and Shah, 1978). Figures 4 and 5 show seismic hazard of Algeria (Mortgat and Shah, 1978). Figure 6 shows the major past events in the vicinity of El-Asnam. Of particular interest are the El-Abadia event of 1934 and the El-Asnam event of 1954. These two events were caused by the same fault system as the October 1980 event. The September 9, 1954 El-Asnam earthquake had a Richter Magnitude of 6.7 and it destroyed 20,000 homes and killed about 1300 people. Most of El-Asnam that was destroyed due to the October 10, 1980 event was built after the 1954 event. Figure shows the preliminary iso-intensity map due to the main shock of October 10, 1980. It can be seen that the highest MM intensity of XI was in the vicinity of Beni-Rached. El-Asnam experienced between IX and X.

The most severely affected (intensities VIII, IX, X and XI) communities were El-Asnam (IX to X), El Abadia (X), Beni-Rached (X to XI).
<table>
<thead>
<tr>
<th>Date</th>
<th>Intensity/Magnitude/Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 3rd, 1716:</td>
<td>Intensity X in Algiers</td>
<td>numerous casualties</td>
</tr>
<tr>
<td>October 9th, 1790:</td>
<td>Intensity X at Oran</td>
<td>3000 victims</td>
</tr>
<tr>
<td>March 2nd, 1825:</td>
<td>Intensity X at Blida</td>
<td>7000 deaths</td>
</tr>
<tr>
<td>February 9th, 1850:</td>
<td>Intensity VIII at Zamora El Guenzet</td>
<td></td>
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<tr>
<td>November 22nd, 1851:</td>
<td>Intensity VII-VIII at Mascara</td>
<td></td>
</tr>
<tr>
<td>August 22nd, 1856:</td>
<td>Intensity IX at Jijel, VIII at Bejaia</td>
<td></td>
</tr>
<tr>
<td>January 2nd, 1867:</td>
<td>Intensity X-XI at Mouzaia</td>
<td>about 100 deaths</td>
</tr>
<tr>
<td>November 16th, 1968:</td>
<td>Intensity IX at Biskra</td>
<td></td>
</tr>
<tr>
<td>January 19th, 1885:</td>
<td>Intensity VIII at N'Gaous</td>
<td></td>
</tr>
<tr>
<td>January 8th, 1887:</td>
<td>Intensity VIII at Mansoura</td>
<td></td>
</tr>
<tr>
<td>November 29th, 1887:</td>
<td>Intensity IX-X at Kala</td>
<td>20 deaths</td>
</tr>
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<td>January 6th, 1888:</td>
<td>Intensity VIII at Mouzaia</td>
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</tr>
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<td>January 15th, 1891:</td>
<td>Intensity X at Gouraya</td>
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<td>March 11th, 1908:</td>
<td>Intensity VII-VIII at Blida</td>
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<td>August 4th, 1908:</td>
<td>Intensity VIII, Magnitude 5.1 at Constantine</td>
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<td>June 24th, 1910:</td>
<td>Intensity X, Magnitude 6.4 at Masqueray</td>
<td></td>
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<td>August 6th, 1912:</td>
<td>Intensity VI, Magnitude 5.3 at Oued Marsa</td>
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<td>August 25th, 1922:</td>
<td>Intensity X at Bordj Abou Hassan</td>
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<td>March 16th, 1924:</td>
<td>Intensity IX, Magnitude 5.6 at Batna several deaths</td>
<td></td>
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<tr>
<td>November 5th, 1924:</td>
<td>Intensity VIII, Magnitude 5.0 near Algiers</td>
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<td>June 10th, 1925:</td>
<td>Intensity VIII near Boghar</td>
<td></td>
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<td>August 24th, 1928:</td>
<td>Intensity VIII, Magnitude 5.4 at Oued Rhiou 4 deaths</td>
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Table 1 (Cont.)

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<thead>
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<th>Month</th>
<th>Date</th>
<th>Intensity</th>
<th>Magnitude</th>
<th>Location</th>
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<tbody>
<tr>
<td>August</td>
<td>15th, 1931</td>
<td>VIII</td>
<td>4.9</td>
<td>at Djebel Dira</td>
</tr>
<tr>
<td>September</td>
<td>7th, 1934</td>
<td>IX</td>
<td>5.0</td>
<td>at El Abadia</td>
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<tr>
<td>September</td>
<td>19th, 1935</td>
<td></td>
<td>5.1</td>
<td>near Chetaibi</td>
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<tr>
<td>February</td>
<td>10th, 1937</td>
<td>VIII</td>
<td>5.4</td>
<td>near Guelma</td>
</tr>
<tr>
<td>April</td>
<td>16th, 1943</td>
<td>IX</td>
<td>4.0</td>
<td>near Mansoura</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>numerous victims</td>
</tr>
<tr>
<td>February</td>
<td>12th, 1946</td>
<td>VIII-IX</td>
<td>5.6</td>
<td>in the Hodna Mtns.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>246 deaths</td>
</tr>
<tr>
<td>August</td>
<td>6th, 1947</td>
<td>VIII-IX</td>
<td>5.3</td>
<td>at Oued-Hama Mine</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>many victims</td>
</tr>
<tr>
<td>March</td>
<td>13th, 1948</td>
<td>VIII</td>
<td>4.9</td>
<td>at Asla, 1 death</td>
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<tr>
<td>February</td>
<td>17th, 1949</td>
<td>VIII</td>
<td>4.9</td>
<td>near Kerrata</td>
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<td>April</td>
<td>20th, 1950</td>
<td>VI-VII</td>
<td>5.1</td>
<td>near Aflou</td>
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<tr>
<td>July</td>
<td>5th, 1953</td>
<td>VIII</td>
<td></td>
<td>near Ain Bessam</td>
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<tr>
<td>August</td>
<td>29th, 1953</td>
<td>VIII-IX</td>
<td></td>
<td>in the Hodna Mtns., 1 death</td>
</tr>
<tr>
<td>September</td>
<td>9th, 1954</td>
<td>X</td>
<td>6.7</td>
<td>at El-Asnam</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1,243 deaths, 20,000 houses destroyed</td>
</tr>
<tr>
<td>September</td>
<td>10th, 1954</td>
<td>IX</td>
<td>6.2</td>
<td>aftershock at El-Asnam</td>
</tr>
<tr>
<td>February</td>
<td>4th, 1955</td>
<td>VIII</td>
<td></td>
<td>aftershock at El-Asnam</td>
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<tr>
<td>May</td>
<td>8th, 1955</td>
<td>VIII</td>
<td></td>
<td>at Beni Baoua</td>
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<tr>
<td>June</td>
<td>5th, 1955</td>
<td>VIII</td>
<td>5.7</td>
<td>at Beni Rached</td>
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<tr>
<td>February</td>
<td>14th, 1956</td>
<td>VI-VII</td>
<td>5.9</td>
<td>at Bordj Bou Hassar</td>
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<td>June</td>
<td>28th, 1957</td>
<td>VII</td>
<td>5.0</td>
<td>at Sendjas</td>
</tr>
<tr>
<td>May</td>
<td>24th, 1959</td>
<td>VII, VIII</td>
<td>5.5</td>
<td>at Zamora El Guenzet</td>
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<tr>
<td>November</td>
<td>7th, 1959</td>
<td>VIII</td>
<td>5.5</td>
<td>at Bou Medfa</td>
</tr>
<tr>
<td>February</td>
<td>21st, 1960</td>
<td>VIII</td>
<td>5.6</td>
<td>at Melouza</td>
</tr>
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<td></td>
<td></td>
<td></td>
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<td>47 deaths and 88 injured</td>
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Table 1 (Cont.)

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<tr>
<th>Date</th>
<th>Event Description</th>
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<tbody>
<tr>
<td>December 2nd, 1961:</td>
<td>Magnitude 5.5 felt at Annaba (at sea)</td>
</tr>
<tr>
<td>September 4th, 1963:</td>
<td>Magnitude 5.7 near Setif, 1 death and 100 injured</td>
</tr>
<tr>
<td>January 1st, 1965:</td>
<td>Magnitude 5.5 at M'Sila, 5 deaths, 24 injured and 1,304 houses destroyed</td>
</tr>
<tr>
<td>13th, 1967:</td>
<td>Intensity VII, Magnitude 5.1 near Sig, 10 deaths and 15 injured</td>
</tr>
<tr>
<td>February 28th, 1968:</td>
<td>Intensity VIII, Magnitude 4.9 at El Alen, 1 death and 4 injured</td>
</tr>
<tr>
<td>February 5th, 1971:</td>
<td>Magnitude 5.9 in Ames</td>
</tr>
<tr>
<td>February 23rd, 1971:</td>
<td>Magnitude 4.9; Intensity VIII at Rouina</td>
</tr>
<tr>
<td>February 25th, 1971:</td>
<td>Magnitude 5.4 at Asla</td>
</tr>
<tr>
<td>25th, 1973:</td>
<td>Magnitude 5.7 off the coast near Tenes</td>
</tr>
<tr>
<td>November 24th, 1973:</td>
<td>Intensity VII; Magnitude 5.1 at B.B. Arrerridj; 4 deaths</td>
</tr>
<tr>
<td>November 25th, 1973:</td>
<td>Intensity VII; Magnitude 4.9 at Guenzet</td>
</tr>
<tr>
<td>July 28th, 1974:</td>
<td>Intensity VII; Magnitude 5 at Setif</td>
</tr>
<tr>
<td>November 9th, 1974:</td>
<td>Intensity VIII; Magnitude 4.1 south of Bejaia</td>
</tr>
<tr>
<td>July 11th, 1975:</td>
<td>Intensity VIII; Magnitude 5 at Setif 1 death, 18 injuries</td>
</tr>
<tr>
<td>October 10th, 1980:</td>
<td>Magnitude 7.5; Intensity X to XI Beni-Rached (El-Asnam)</td>
</tr>
<tr>
<td>November 8th, 1980:</td>
<td>Magnitude 6.5 Beni-Rached (El-Asnam)</td>
</tr>
<tr>
<td>November 30th, 1980:</td>
<td>Magnitude 5.6 El-Asnam (Beni-Rached)</td>
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</tbody>
</table>

Taken from "Design of a Strong Motion Instrument Network for Algeria" by Omar Khemici, Engineer's thesis, Dept. of Civil Engineering, Stanford University, February 1980
Figure 3. (Taken from Mortgat and Shah, 1978)
Figure 4. Taken from Mortgat and Shah, 1978
Figure 5. Acceleration Zone Graph for Major Cities in Algeria (taken from Mortgat and Shah, 1978)
Figure 6: Recent Past Seismic History Around El-Asnam
Figure 7. Iso-Intensity Map (Preliminary) due to October 10, 1980 El-Asnam Main Shock.
Sendjas (IX), El-Attaf (VIII), Rouina (VIII). The attenuation of intensity was quite rapid. Algiers, about 200 kms (125 miles) east of the epicenter experienced between V and VI. Oran, about the same distance west of the epicenter also experienced similar intensity levels. Figure 8 shows the long period motion recorded at the University of California Berkeley Seismographic Station due to the main shock.

Surface Faulting

Figure 9 shows the two main faults that ruptured during the earthquake. The main shock was produced by displacement on a northeast-trending thrust fault that dips northwestward; this fault has subsequently been named the Oued Fodda fault after the closest principal city along its surface trace. Numerous secondary fissures and normal faults occur on the upthrown block of the main thrust within a zone that extends up to 2 km from the main trace. Surface faulting also occurred along the Beni Rached fault, which is a normal fault that may also be a secondary fault.

Surface faulting occurred along the Oued Fodda fault, which is located south and east of El Asnam; the closest distance of the surface trace to El Asnam is about 7 km. The surface faulting occurred along a zone that extends at least 30 km from a point 5 km north of Sendjas northeastward through the village of Zababdja, along the northwest side of Oued Fodda valley to a point about 4 km west of El Abadia. Secondary normal faulting and ground cracking suggests that the primary thrust surface fault rupture may extend an additional 2 km to the southwest and 4 km further eastward to El Abadia; suggesting an overall length of 35 km. In most places, the primary fault is a low angle thrust that dips 10 to 20 degrees northwest-
TRACED FROM
BERKELEY HORIZONTAL COMPONENT (NE-SW)
OF ULTRA LONG PERIOD SEISMOGRAM

$T_0 = 100$ SEC

$T_g = 300$ SEC

COURTESY OF SEISMOGRAPHIC STATIONS
UNIVERSITY OF CALIFORNIA, BERKELEY

Figure 8.
Figure 9.
ward. Locally, the dip of the primary fault steepens to form a reverse fault that dips as steeply as 55 degrees.

The primary fault is typically expressed as a series of low scarps and compression ridges (Figure 10) that have various surface patterns, generally occur as either subparallel enechelon breaks, or in an anastomosing pattern where the scarps branch and reconverge. Both left and right stepping fracture patterns were observed and apparent left and right lateral displacement were measured. In a few places the primary thrust occurs as a single fault scarp. Typically, the vertical displacement on individual scarps is about a meter or less, and the cumulative displacement across the zone of primary faulting is generally not more than and-one-half to two meters. The maximum vertical displacement measured along the fault was 2.6 m; at this location the fault intersects a sloping surface and produced a scarp 4.2 m high (Figures 11 and 12). The dip of the fault could not be measured at this location; however, the morphology of the scarp is similar to other locations where the fault dips steeply (45 to 55 degrees). Assuming a 50 degree dip, the dip slip displacement would be 3.4 m.

Extensive fissures and normal faulting occurred on the upthrown block of the primary thrust (Figures 11 and 13) and occurred as far as 2 km from the trace of the primary thrust. Both down-to-the-southeast and down-to-the-northwest displacement occurred. In most places, the displacement on the secondary high angle normal faults produced scarps that are more pronounced than those along the primary thrust fault. Vertical displacements of about a meter are common on these normal faults and in some localities produced scarps 2 to 3 m high.
Figure 10. Compression Ridges Along the Surface Trace of Oued Fodda Fault Southwest of Zabadja. At this Location the Main Fault is a Low Angle Thrust Dipping 10 to 20 Degrees to the Northwest. View is Northeast.

Figure 11. Oued Fodda Fault North of Sendjas View is Northward.
Figure 12. Fault Scarp Along the Oued Fodda Fault North of Sendjas. The Scarp is 4.2 M high and was produced by 2.6 M of vertical displacement on a reverse fault dipping approximately 50 degrees to the northwest. View is southwest.

Figure 13. Secondary Normal Faults on Upthrown (Northwest) Block of Oued Fodda Fault South of Oued Chelif. View is southwest.
Based on our preliminary analysis, it appears that displacement on the Oued Fodda fault was the principal source of the seismic energy released during the El Asnam earthquake.

The Beni Rached fault is a high angle normal fault that appears to be a secondary splay of the Oued Fodda fault (Figure 9). The relationship between this fault to the seismic energy release during the main shock and subsequent aftershocks has not yet been determined. In most places, the surface faulting along the Beni Rached fault is expressed as a single well-defined fault scarp (Figures 14 and 15). The vertical displacement on the fault is typically about 1 m. Numerous small graben and extensional cracks occur on the downthrown side along the base of fault scarp. Both right and left lateral offsets of approximately 0.5 to 1.0 m were measured locally along the fault.

There is abundant geomorphic and geologic evidence that the zone of surface faulting along the Oued Fodda fault occurred along a pre-existing fault zone that has slipped repeatedly during the Holocene (approximately the past 10,000 years). However, due to the irregular pattern and the subdued nature of scarps produced by thrust faults, and to the relatively rapid rates of erosion of these scarps, the specific locations of individual surface fault ruptures would have been extremely difficult to have accurately predict prior to the earthquake.

Accounts from the villagers who were living in the vicinity of Beni Rached at the time of the September 9, 1954, magnitude 6.7 earthquake, and report by Rothe (1955), indicate that surface faulting occurred along parts of the Beni Rached fault during the 1954 earthquake. There is no evidence that indicates surface faulting occurred along the Oued Fodda fault during the 1954 earthquake.
Figure 14. Normal Fault Scarp Near Beni-Rached

Figure 15. Fault Break Along Beni-Rached Fault
Geotechnical Aspects

A large number of stone houses and adobe huts that were either on the fault or within 50 meters of the fault collapsed in the village of Beni Rached. See Figure 16. However, a number of houses and a mosque unreinforced masonry or adobe with loose tiled roofs) sustained surprisingly very little to no damage even though they were within 50 meters of the fault. See Figures 17 and 18.

A railroad, the main road from Algiers to El Asnam and an irrigation water main 1 meter in diameter cross the Oued Fodda fault at about 80°. Just at the time of the earthquake and fault rupture, a train going from El Asnam to Algiers was on the fault; the train was completely thrown off from the rails (Figure 19). The road was also heavily broken up. underground (about 2 meters below ground surface) irrigation water main was also ruptured at two places (Figures 20, 21 and 22).

In all the heavily damaged communities, no obvious bearing failures of foundations were observed. The numerous tilted buildings which initially gave an impression of liquefaction, were the result of "short column" failure or "soft story" failure. No evidence of sliding, rocking or uplift of structures could be observed.

Settlement of structures may have occurred, particularly in fill areas. Most backfills behind bridge abutments settled (some as much as three feet). Bridge abutments were battered and retaining walls were tilted due to dynamic backfill loads.

Numerous slope failures were noticeable in the mountains, some involving the whole side of hills in the area of fault movements. No
Figure 16. Collapsed Stone and Adobe Huts

Figure 17. Adobe Hut with Thatched Roof did not Collapse. Note the Ground Failure in the Foreground. This Hut is Barely 30 Meters from the Fault Break
Figure 18. Unreinforced Masonry House with Loose Tiles did not Suffer Major Damage. Note the Fault Rupture in the Background.

Figure 19. Overturned Train. Note the Fault Break
Irrigation Water Main was Ruptured by a Secondary (Normal) Trace of the Oued Fodda Fault.

Figure 20.

Inside of Irrigation Water Main Where it Crosses the Main Trace (Thrust) of the Oued Fodda Fault. Compression has Shortened the Steel Reinforced Cement Pipe About 0.5 M Where Two Pipe Segments Join.

Figure 21.
major slope failures were apparent in the city of El-Asnam. There was one massive landslide visible on a 1,000 meter mountain just to the north of El Abadia.

There was great amounts of soil liquefaction in the flood plain of Oued Chelif, particularly in the region of Oued Fodda, El Abadia and El Attaf. Numerous (hundreds) of sand boils were visible in this region (Figure 23). Some of these were four meters in diameter. Unconfirmed eyewitnesses reported that the geysers were triggered by the aftershock with water gushing up in fountains tens of meters high. Ground cracks, fissures, and fault-like scarps (Figure 24) are common in areas where lateral spreading due to liquefaction occurred. Relatively little damage occurred as a result of liquefaction, because most of the areas susceptible to liquefaction have not been developed "yet" and are primarily used for agriculture.

A large (approximately two square kilometers) lake formed southeast of the canyon mouth where Oued Fodda and Oued Chelif join and flow northwestward through the uplands on the upthrown block of the Oued Fodda fault (Figure 25). This lake appears to be the result of a combination of factors including: 1) tectonic downwarping of the downthrown block parallel to the fault; 2) uplift of the fault block on the northwest (tectonic damming of the river); and 3) subsidence due to differential settlement and possibly liquefaction.

Behavior of Buildings and Structures

The effects of the earthquake were noted on buildings as far as the city of Alger where in isolated cases spalling at separation joints between part of buildings that moved relative to each other was noted, but no significant damage was observed farther than 60 km from El-Asnam.

Approaching the epicentral region, damage to tile roofs, cracking or partial collapse of adobe or rubble masonry farm buildings became more pronounced. The town of El Attaf, 37 km east of El-Asnam, sustained
Figure 22. Close View of Damaged Irrigation Main Shown in Figure 21.

Figure 23. Sand Boils Due to Liquefaction
Figure 24. Fissures and Fault-like Scarps Produced by Lateral Spreading of the Alluvium Towards the Channel of Oued Chelif.

Figure 25. Earthquake Lake
substantial damage to both modern and older construction. However, the city seemed to function with basic utilities intact.

El Abadia, 5 km. north of El Attaf, appeared virtually destroyed and most major buildings were partially or totally collapsed. However, older one story masonry structures, although severely cracked, survived the earthquake. No modern buildings were observed in El Abadia. It was reported that 600 people were killed by collapsing structures. (Figure 26)

The village of Beni Rached and farm houses in the vicinity which were directly in faulting zone at the epicenter presented a strange phenomena. The buildings in this region were generally one story adobe or masonry buildings with heavy tile roofs. Except where ground faulting actually went through the structure, the damage pattern was sporadic and not severe. Cracks in masonry walls and displaced or fallen roof tile were common but total collapse was rare. It was not unusual to find a part of a building that was not destroyed by the ground rupture virtually undamaged.

The damage in El Asnam was tremendous. A preliminary assessment by C.T.C. estimated that up to 50% of the buildings in the city were totally or partially collapsed or were damaged to a degree that would require their demolition. 10% to 20% of the buildings were judged to have survived with only minor architectural or non-structural damage. The remaining 30% to 40% of the buildings will require an in-depth evaluation to determine if the damage sustained is repairable or if the buildings should be condemned and demolished.

The buildings found in El Asnam can be roughly divided into the following categories:

Buildings that survived the 1954 earthquake, some of which were reinforced and strengthened after the quake.
Figure 26. Collapsed 1-Story Masonry Structures in El-Asnam
2. Buildings that were built after 1954 under French rule.
3. Construction since the independence of Algeria in 1962.

The buildings in category one are generally unreinforced masonry buildings with massive walls and tile roofs. These buildings performed no differently than has been observed in other earthquakes. Where configuration was poor or walls inadequately braced by cross walls, substantial damage and partial collapse was common. Where adverse conditions did not exist the performance was generally good, although deep cracks in walls were not uncommon. Damage to heavy tile roofs was frequent but without definable patterns. A number of multistory buildings which had been reinforced with an externally applied concrete frame, performed very well with only non structural damage. See Figure 27.

Buildings in category 2, built during the French period were dominantly concrete frame buildings with masonry infill. It is assumed that many civic and governmental buildings as well as the four story hotel belong into this category. The performance of these buildings was poor with many total collapses such as the hospital, the courts buildings, the schools, the hotel etc. These buildings appear to have no rational system of lateral resistance. Detailing of concrete elements was poor with common use of smooth reinforcing bars and few, if any, confinement steel. Collapse was most likely hastened by poor configuration and structural discontinuities such as soft stories. In general, the behavior of these buildings was no different from what has been observed in the past with possible exception of the magnitude of destruction and loss of life. Figures 28 through 39 show some of the collapsed buildings of category two and three from the above classification.

Buildings in category 3, recently constructed, are of special interest. The government of Algeria has in recent years embarked on housing construction program on an enormous scale.
Figure 27. Upgraded and Strengthened Structure with Reinforced Concrete Frame after the 1954 Earthquake in El-Asnam. It had Very Minor Damage Due to October 10, 1980 Earthquake
Ain Nasser Market. About 3000 People were Feared Dead Under this Collapsed Structure Due to Buried Bodies, Pancaked Floors had to be Lifted Carefully and Slowly.

Figure 28. Ain Nasser Market. A Huge Shopping Mall and Apartment Complex Covering One Large Block of El-Asnam Collapsed.

Figure 29. Ain Nasser Market. About 3000 People were Feared Dead Under this Collapsed Structure Due to Buried Bodies, Pancaked Floors had to be Lifted Carefully and Slowly.
Figure 30. The Rescue Operation to Recover Bodies from Ain Nasser Market. Note the Complete Collapse of the Three Story Complex.

Figure 31. The Disaster Planning and Firestation was in Ruins.
Figure 32. The City Hall was Completely Collapsed.

Figure 33. The Police Headquarters and the Mayor's Office.
Figure 34. This Apartment had Four Stories. Many Casualties were Reported Here

Figure 35. This Apartment Lost Two Stories. Soft Story was the Cause of Failure Again, Many Casualties.
These were Two Story Reinforced Concrete Houses with Hollow Unreinforced Brick Masonry Walls. Bad Details, Terrible Concrete, and Lack of Lateral Load Resisting System Resulted in Failures.

Figure 36.

A Store and an Apartment House. No Lateral Load Resisting System in These Collapsed Structures was Evident.

Figure 37.
Figure 38. A Collapsed High School. Note the Beam-Column Connection and the Lack of Ties in Columns

Figure 39. The New Clinic under Construction and Almost Complete was Collapsed. Soft First Story Failed Resulting in this Tilted Position
It is our understanding that the current goal is the construction of 100,000 - 3 room units per year. The type of buildings observed in El Asnam and El Attaf are generally 3 or 4 stories tall, although 1 and 2 story developments were also being constructed.

A typical type of construction which dates back from the French period is especially noteworthy. The apartment buildings of this type are generally 3 or 4 stories tall. Construction consists of a two-way concrete frame with a 3 meter module. A typical building may be 3 bays wide (9 meters) by 10 bays long (30 meters). Cast in place beams of approximately 75 cm. on centers span between the frame beams (frequently pin-wheeled). These subframing beams support hollow precast concrete elements approximately 30 cm. wide, installed flush top and bottom with the supporting beams. The floor assembly is topped with an unreinforced slab 4 to 5 cm. thick. Exterior and interior walls are hollow masonry infill. The entire structure has at its base a crawl space called the "Vide-Sanitaire" which is generally one meter high. This vide-sanitaire provides for plumbing and ventilation under the first floor slab. Infill between the perimeter stub column is non-structural, either masonry or a minimal unreinforced concrete wall. On a typical building as described above, the entire lateral load is, therefore, transmitted by the first floor slab acting as diaphragm to 4 x 11 = 44 one meter high stub columns, which are generally 25 cm. wide and 30 cm. in cross section. See Figures 40 & 41.

It is not surprising that these buildings failed at this level and dropped the entire building up to one meter. A great number of these buildings are tilted, but no pattern in the direction of failure was found. The condition of the affected buildings above the vide-sanitaire was frequently good, with very little damage to frame and infill. Apparently the failure of the crawl space level absorbed a sufficient amount of energy to protect the upper levels.
Figure 40. A Typical Frame Construction with "Vide Sanitaire" or Sanitary Space (Crawl Space). Note the Short Column. This Picture was Taken in Algiers. However Most of These Types of Buildings Lost the 1 Meter Short Column in El-Assnam.

Figure 41. A Building under Construction with "Vide Sanitaire". Note the Short Columns.
The use of this type of construction was widespread in the past, and is unfortunately still continuing. C.T.C.'s authority is apparently limited and has not succeeded in eliminating or drastically improving this type of construction.

This type of building presents a major problem on two counts. First, there is the question of whether the damaged buildings, which are numerous, can be leveled, raised, underpinned and repaired. Secondly, a decision will have to be made as to what is to be done about the large number of buildings of this type of construction throughout the country. Since their inability to resist seismic forces has been convincingly demonstrated, they represent a serious problem.

Throughout the outskirts of El Asnam, large housing projects have been completed or are under construction. Building types vary from 1 story single family units to 4 story apartment buildings. Generally the structural system consists of concrete columns and beams, concrete or composite concrete slabs with masonry exterior infill and interior partitions. Some use of concrete shear walls was noted in recent construction under the control of C.T.C. These buildings performed under seismic forces as can be expected. Where vertical discontinuities in stiffness occurred as was dramatically demonstrated by a series of 2 story buildings, collapse in many instances was total. In cases where infill was of substance and buildings had regular configuration, damage was limited. As observed in previous earthquakes, many anomalies in building behavior were observed Figure 42.)

In one housing development of eight apartment buildings under construction, only one experienced structural damage. The units are 3 and 4 stories tall, constructed with concrete frames and slab and masonry
exterior infill and interior partitions. The exterior infill walls which have relatively small and regular penetrations and the numerous interior walls appear to have been capable of absorbing the energy of the earthquake with nominal damage. Reinforcement and concrete in this project also appeared to be somewhat higher quality. The damaged building evidenced column compression failure at the corner column as well as a shear crack at the first floor level. Since this project is constructed on a hillside, it is suspected that subsoil conditions account for the difference in behavior.

In addition to poor design practices, poor detailing, inappropriate configuration and changes in stiffness, poor quality of construction was a dominant factor in building behavior. For example, at a housing project under construction at El Attaf, concrete mixing equipment and concrete ingredients were inspected by the reconnaissance team. The mixing equipment was new, the cement seemed of standard quality and the coarse aggregate was good crushed rock, but the sand was badly contaminated with dirt and of poor quality. Reinforcing steel laps at construction joints were way below minimum standard and the joints themselves were dirty and full of rock pocket. It is doubtful that proper attention is given to concrete placement, consolidation and curing. The poor quality of the concrete is demonstrated by the disintegration of the concrete when overstressed. It was stated that obtained concrete compressive strength falls frequently as low as 60% of design strength, which is generally 3000 psi. The quantity of construction apparently overtaxes the availability of competent contractors, skilled workers and quality control personnel.

Recent and modern non-housing construction performed equally badly if not worse. The most tragic example was the collapse of the Ain Nasser
market. This complex of shops and housing constructed with a waffle slab system collapsed completely burying in the debris an estimated 3,000 people most of which died. Two nearly completed hospital and clinic buildings and a governmental building under construction were totally destroyed. In the case of these buildings adverse configurations and changes in structural stiffness added to the previously noted deficiencies in design and construction. The team had the opportunity to view the plans and a model of a 600 bed hospital for which construction had just started. The complexity of the building and lack of shear walls as primary lateral bracing system raises grave concern about the structure's ability to resist major earthquakes.

Many of the light industrial buildings in the vicinity of El-Asnam are constructed with steel framing. No sign of damage was noted in any of these buildings.

Life Lines

In the city of El-Asnam, all utility services - power, telephone, water, gas and sewer systems were out of operation at least until the 20th of October (10 days after the earthquake). The road was interrupted due to fault rupture and damage to bridges. However, the army engineers had immediately constructed alternate routes. The railroad was bent at many places and at one location west of Oued Fodda, a train had overturned. The rail communication between Algiers and El-Asnam was out of service for 9 days. (Figure 43.)

The communication building in El-Asnam was severely damaged. Its contents were totally destroyed. Overturned transformers were observed. (Figure 44.) The water supply to the city was cut off. This was due to
Figure 42. Building in Foreground Collapsed. The Buildings in Background had Shear Walls and Good Inspection and Quality Control Program. They Performed Very Well

Figure 43. The Rails were Bent Between El-Asnam and Oued-Fodda
Figure 44. Overturned Transformer and Other Electrical Equipment

Figure 45. This Elevated Water Tank Collapsed in El-Abadia
many breaks in the underground pipes. Water was brought to the survivors (more than 125,000 were evacuated and temporarily housed in tents outside of El-Asnam) by means of army water tank truck convoys. Elevated concrete water tanks, with one exception survived without collapse. See Figure 45. However, damage at concrete joints and column bases were found in most cases. A section of an irrigation aqueduct constructed of half circular precast concrete sections and supported above ground on concrete columns, collapsed in the city. There appeared to be no positive connection between the precast concrete sections and the columns. See Figure 46. Underground irrigation pipes (1 to 1.5 meter in diameter) of precast concrete were sheared at the fault crossing. See Figure 20

A number of highway and railway bridges were examined. Settlement of abutments and the battering of concrete due to hammering was noted. One major bridge across the river Chelif had its abutment move horizontally one meter with respect to the bridge structure. There was also considerable damage to the end supports. See Figure 47.

The sewer system in El-Asnam was completely out of service. With the population of 125,000 survivors, this posed a major sanitary and health problem. The population was inoculated with cholera and typhoid injections to prevent a major epidemic.

A detailed analysis of lifelines is not available at this time. It is anticipated that further information will be included in the final report.

**Program of Action by C.T.C.**

Soon after the earthquake in El-Asnam, the Ministry of Housing and Construction directed C.T.C. to investigate the engineering aspects of
Figure 46. Elevated Irrigation Channel

Figure 47. The Abutments Moved About One Meter with Respect to the Bridge Structure. End Supports Also Failed
the earthquake. Specifically, C.T.C. was asked to investigate the behavior of buildings due to this earthquake and to assess the reasons for specific response.

In response to the above directive, C.T.C. gathered a team of engineers to investigate the behavior of structures. Haresh Shah, in consultation with C.T.C. engineers and with the help of an ATC study and an EERI document on "Learning from Earthquakes", developed the "Damage Evaluation Form". See Appendix I for English and French versions. The city of El-Asnam was divided into ten sectors and each sector was further divided into ten zones. See Figure 48. One hundred engineers from C.T.C. and other governmental and private firms in Algiers were gathered to form the field investigative team. Each sector had ten engineers. Each team of ten engineers has one leader and one deputy leader. This team's task is to investigate every building in El-Asnam and fill out the form given in the appendix. The first use of the results of this field investigation would be to classify all the buildings into the following three categories:

Green Category: Very little damage. The building can be reoccupied immediately

Orange Category: These buildings need further study before they can be either occupied or condemned.

Red Category: These buildings are condemned and should be demolished.

Further analysis of the field survey would be essential in understanding the behavior of various types of construction under seismic loading. The method of upgrading or repairing the structures and the codes and regulations necessary to rebuild El-Asnam would be dependent on the results of this field survey. It is anticipated that a comprehensive analysis
of the results would be conducted when all the forms are in. As of 31st October, the investigative team had completed a survey of 1000 separate structures. It is estimated that by the end of November, all the surveys would be complete.

Conclusions

From the preliminary survey conducted so far, it seems like 50% to 60% of all the engineered structures in El-Asnam will have condemned (red category). About 30% to 35% of the buildings will need further study before a final recommendation can be made about their fate (orange category). Only about 10% to 15% of the buildings seem to have survived without any appreciable damage (green category). These buildings could be reoccupied again.

The main causes of the bad behavior of engineered structures seems to be as follows:

- **Bad architectural concepts**
  
  Examples of this include short columns, soft stories, irregularity in plan and elevation, use of different types of materials in the same building without properly understanding their behavior.

- **Bad structural design concepts**
  
  Examples of this include inadequate seismic resistant criteria for design, providing lateral load resisting system in only one direction, terrible structural joint designs, utter disregard to detailing.
• Bad materials of construction, very poor supervision
  and quality control
  Example of this include extremely bad quality of concrete, poor quality control and insufficient supervision.
• Negligence and probable dishonesty of some contractors and engineers.*
  Examples of this include the use of inferior quality of material and not allowing approved plans

As the 1954 earthquake recommendations for seismic-resistant construction were suggested. These were published as Recommendations AS 1955 (see IAEE, 1973) and in 1969 they were revised. Again the recommendations were revised in 1973, but they were never enforced. In 1979 the government decided to enforce the existing recommendations, but after a brief period the government declared that the seismic-resistant construction recommendations were not compulsory.

Since 1976 the CTC has been active by attempting to improve the existing seismic-resistant code recommendations to enforce their application, but without much success. In 1976 CTC reached an agreement with Stanford University requesting first the development of a seismic zoning map for Algeria, and secondly the formulation of a seismic-resistant code for buildings. Although most of this work has been completed, the Stanford recommendations have not yet been put into practice. To summarize, very few new buildings have been designed and constructed using seismic-resistant code provisions.

Algerian engineers do not receive an adequate education in their universities in seismic-resistant construction. Only a few young engineers have acquired sufficient knowledge in this field. The consequences of failure to

*As per CTC Report #2, 20 October 1980, to Ministry of Construction and Housing, Government of Algeria.
follow code standards and to educate in seismic-resistant design and construction is evident in the inadequate performance of the engineered structures during this earthquake.

No new lessons were learned from the performance of buildings during this earthquake. The observed performances reaffirmed perhaps stronger than in any previous earthquake the following concepts: it is essential that the design of a building structure is done according to the basic principles governing seismic-resistant design and that proper seismic-resistant construction practice is used. Unless these two concepts are observed, the use of strong and potentially ductile structural material such as reinforced concrete, can be an expensive disappointment. As noted previously, the collapse of these buildings did not occur because they were not engineered structures, or because attempts were made to economize the use of structural materials. The collapse occurred due to the fact that the buildings were not architecturally designed and engineered for the effects of strong earthquake ground motions, resulting in a waste of the material used. It is believed that by proper conceptual design, proportioning and detailing of the structural as well as non-structural elements, and careful construction, it would have been possible to significantly reduce the damage and number of casualties without any significant increase in cost. To achieve this in the future in the seismic regions of Algeria, the following points should be considered:

1. To review seismic-resistant regulations suggested by Stanford University (Zsutty and Shah, 1979) in the light of knowledge and experience gained analyzing the effects of this earthquake as well as others that have occurred in the past.

2. To enforce these new seismic-resistant regulations as well as those code building provisions for normal loading conditions through capable inspection of not only the design computations but particularly the construction in the field.
3. To increase the seismic consciousness of the public and particularly of the people involved in the field of building construction, through a process of continuous education. Programs for training technicians, building inspectors, and local contractors should be developed. Special registration and professional examination requiring necessary knowledge in seismic-resistant design and construction of engineers and architects who will be involved in the design and construction of seismic-resistant structures, would be highly desirable.

4. Algerian universities should offer courses in earthquake engineering for their regular architectural and engineering students and also develop and provide a program of continuing education in this field
REFERENCES


APPENDIX

Damage Evaluation Form
**DAMAGE EVALUATION FORM**

**C.E.T.C.**

**EL-ASNAH**

**IDENTIFICATION OF STRUCTURE:**

<table>
<thead>
<tr>
<th>Sector:</th>
<th>Zone:</th>
<th>Structure Designed for Earthquake Resistance:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address or Means of Identification:</td>
<td>School</td>
<td>Yes - No</td>
</tr>
<tr>
<td></td>
<td>Hospital</td>
<td>Inspected</td>
</tr>
<tr>
<td></td>
<td>Commercial Recreation</td>
<td>Construction: Yes - No</td>
</tr>
</tbody>
</table>

**STRUCTURE USE**

- Residential
- Administrative
- Socio-Cultural
- Others (describe):

| Sanitary Crawl Space: Yes - No ( ) |
| Basement: Yes - No ( ) |
| Exterior Independent Elements: (stairs, shed, covered walkways) |

**SUMMARY OF DAMAGE**

- Approximate Age:
- Number of Stories:
- Number of Separation Joints: in elevation in plan of superstructure

**SOIL PROBLEMS AROUND STRUCTURE**

- Faulting: Yes - No
- Liquefaction: Yes - No
- Subsidence - Uplift: Yes - No
- Landslide: Yes - No

**FOUNDATIONS - SUPERSTRUCTURE**

- type of foundation:
- type of damage
  - settlement: Yes - No
  - sliding: Yes - No
  - overturning: Yes - No

**Superstructure (for the case of sanitary crawl space or Basement)**

- continuous concrete wall: 1-2-3-4-5
- concrete columns with infill: 1-2-3-4-5

**VERTICAL LOAD CARRYING ELEMENTS**

- masonry walls: 1-2-3-4-5
- concrete walls: 1-2-3-4-5
- concrete columns: 1-2-3-4-5
- steel columns: 1-2-3-4-5
- wood columns: 1-2-3-4-5
- others: 1-2-3-4-5

**LATERAL LOAD RESISTING ELEMENTS**

- masonry walls: 1-2-3-4-5
- concrete walls: 1-2-3-4-5
- reinforced concrete frames: 1-2-3-4-5
- steel frames: 1-2-3-4-5
- cross-braced frames: 1-2-3-4-5
- others: 1-2-3-4-5

**FLOORS - FLAT ROOF**

- reinforced concrete: 1-2-3-4-5
- steel joists: 1-2-3-4-5
- wooden joists: 1-2-3-4-5

**SLOPED ROOF**

- steel truss: 1-2-3-4-5
- wood truss: 1-2-3-4-5
- tile roof: 1-2-3-4-5
- Asbestos cement sheet roof: 1-2-3-4-5
- corrugated metal roof: 1-2-3-4-5

( ) Encircle the appropriate description, in the case of numbers: one or more numbers can be encircled.

---

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### Secondary Damage

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<th>Stairways</th>
<th>Exterior Wall Panels</th>
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<tbody>
<tr>
<td>- concrete: 1-2-3-4-5</td>
<td>- masonry: 1-2-3-4-5</td>
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<tr>
<td>- steel: 1-2-3-4-5</td>
<td>- precast concrete: 1-2-3-4-5</td>
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<tr>
<td>- wood: 1-2-3-4-5</td>
<td>- corrugated metal: 1-2-3-4-5</td>
</tr>
<tr>
<td>Other Interior Elements</td>
<td>- others: 1-2-3-4-5</td>
</tr>
<tr>
<td>- ceilings: 1-2-3-4-5</td>
<td></td>
</tr>
<tr>
<td>- partitions: 1-2-3-4-5</td>
<td></td>
</tr>
<tr>
<td>- glass: 1-2-3-4-5</td>
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<table>
<thead>
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<th>Exterior Elements</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>- railings: 1-2-3-4-5</td>
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</tr>
<tr>
<td>- overhang: 1-2-3-4-5</td>
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</tr>
<tr>
<td>- parapets-cornices: 1-2-3-4-5</td>
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<td>- chimneys: 1-2-3-4-5</td>
<td></td>
</tr>
<tr>
<td>- others: 1-2-3-4-5</td>
<td></td>
</tr>
</tbody>
</table>

### Influence of Adjacent Structures

| The structure endangers another structure: | Yes - No |
| The structure endangered by another structure: | Yes - No |
| The structure may be a support for another structure: | Yes - No |
| The structure may be supported by another structure: | Yes - No |

### Victims

Yes - No - Maybe - if yes, how many?

### Comments Concerning the Nature and Probable Cause of Damage

<table>
<thead>
<tr>
<th>Traverse Direction</th>
<th>Longitudinal Direction</th>
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<tr>
<td>- plan symmetry:</td>
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</tr>
<tr>
<td></td>
<td>good - average - poor</td>
</tr>
<tr>
<td>- elevation regularity:</td>
<td>good - average - poor</td>
</tr>
<tr>
<td></td>
<td>good - average - poor</td>
</tr>
<tr>
<td>- redundancy of bracing elements:</td>
<td>good - average - poor</td>
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<tr>
<td></td>
<td>good - average - poor</td>
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</tbody>
</table>

### OTHER Comments

**Final Evaluation**

<table>
<thead>
<tr>
<th>General Level of Damage</th>
<th>Color to be Assigned</th>
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<tbody>
<tr>
<td>1-2-3-4-5</td>
<td>GREEN ORANGE RED</td>
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</tbody>
</table>
(DAMAGE LEVELS)

1. NO DAMAGE:

Except for overturned furniture and broken glass.

2. LIGHT DAMAGE:

Cracked interior partitions
Cracked ceilings
Damage in plumbing, electrical, lighting systems.
In summary, isolated non-structural damage.
Remarks: Take the most unfavorable case and make comments if necessary.

3. MODERATE DAMAGES:

Significant damage for the non-structural elements and slight damage for the structural elements.
* Non-Structural Elements:
All the architectural elements and those elements which are not part of the structural system.
Structural Elements:
Load bearing system (walls, frames with infilled walls, or combinations of these)
Remark: For the case of the collapse of the short columns of the sanitary crawl-space, and if the building has settled or tilted due to this support failure, even if the super-structure is undamaged, this damage should be classed as Category 4.

4. MAJOR DAMAGE:

Very significant non-structural damage and considerable structural damage.
X-cracking in shear walls, and spalling in beam-column joints.
Remarks: Be sure to accurately choose between the levels 3 and 4. Do not hesitate to ask the opinion of other engineers.

5. CONDEMNED OR COLLAPSED BUILDINGS:

For example: - a story has pancaked
- a building tipped over
- too many beam-column joints are fractured

In general, buildings to be condemned are those which have experienced too much deformation, or where the repair cost would be equal to the initial cost of the structure.

Conclusion:

Green color: ....................... Level 1 and 2
Orange color: ....................... Level 3 and 4
Red color: ......................... Level 5
## IDENTIFICATION DE LA CONSTRUCTION

<table>
<thead>
<tr>
<th>Secteur:</th>
<th>Zone:</th>
<th>Construction calculée au séisme: Oui - Non</th>
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<tbody>
<tr>
<td>Adresse ou éléments d'identification:</td>
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<td>Construction contrôlée: Oui - Non</td>
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## USAGE DE LA CONSTRUCTION

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<th>Logement</th>
<th>Scolaire</th>
<th>Commercial</th>
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<tbody>
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<td>Hospitalier</td>
<td>Industriel</td>
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<tr>
<td>Socio-culturel</td>
<td>Sportif</td>
<td>Réservoir d'eau</td>
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<tr>
<td>Autres (à préciser):</td>
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## DESCRIPTION SOMMAIRE

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<tr>
<th>Age approximatif:</th>
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<tbody>
<tr>
<td>Nombre de niveaux:</td>
<td>Sous-sol: Oui - Non</td>
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<tr>
<td>Nombre de joints de dilatation</td>
<td>Eléments extérieurs indépendants (escaliers, auvent, passage couvert)</td>
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<td>- en élévation:</td>
<td></td>
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<tr>
<td>- en infrastructure:</td>
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## PROBLEMES DE SOL AUTOUR DE LA CONSTRUCTION

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<tr>
<th>Faille: Oui - Non</th>
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<td>Glissement: Oui - Non</td>
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## FONDATIONS - INFRASTRUCTURE

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<th>Infrastructure (dans le cas VS ou 5/3)</th>
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<td>- voûte béton continu: 1-2-3-4-5</td>
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<td>- type de dommages:</td>
<td>- poteaux béton avec remplissage: 1-2-3-4-5</td>
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<td>- tassement uniforme: Oui - Non</td>
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<td>- glissement: Oui - Non</td>
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<td>- bascullement: Oui - Non</td>
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## STRUCTURE RESISTANTE

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<tr>
<th>Eléments porteurs (charges verticales)</th>
<th>Eléments de contreventement</th>
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<tr>
<td>- murs en maçonnerie: 1-2-3-4-5</td>
<td>- murs en maçonnerie: 1-2-3-4-5</td>
</tr>
<tr>
<td>- voûtes béton: 1-2-3-4-5</td>
<td>- voûtes béton: 1-2-3-4-5</td>
</tr>
<tr>
<td>- poteaux béton: 1-2-3-4-5</td>
<td>- portiques béton armé: 1-2-3-4-5</td>
</tr>
<tr>
<td>- poteaux métalliques: 1-2-3-4-5</td>
<td>- portiques métalliques: 1-2-3-4-5</td>
</tr>
<tr>
<td>- poteaux bois: 1-2-3-4-5</td>
<td>- palées triangulées: 1-2-3-4-5</td>
</tr>
<tr>
<td>- autres: 1-2-3-4-5</td>
<td>- autres: 1-2-3-4-5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Planchers - Toiture terrasse</th>
<th>Toiture inclinée</th>
</tr>
</thead>
<tbody>
<tr>
<td>- béton armé: 1-2-3-4-5</td>
<td>- charpente métallique: 1-2-3-4-5</td>
</tr>
<tr>
<td>- solives métalliques: 1-2-3-4-5</td>
<td>- charpente bois: 1-2-3-4-5</td>
</tr>
<tr>
<td>- solives bois: 1-2-3-4-5</td>
<td>- couverture toiture: 1-2-3-4-5</td>
</tr>
<tr>
<td></td>
<td>- couverture amante ciment: 1-2-3-4-5</td>
</tr>
<tr>
<td></td>
<td>- couverture métallique: 1-2-3-4-5</td>
</tr>
</tbody>
</table>

**Note:** entourer la mention utile, dans le cas de un ou plusieurs numéros, peuvent être réutilisés.
ELEMENTS SECONDAIRES

Escalliers
- béton: 1-2-3-4-5
- métal: 1-2-3-4-5
- bois : 1-2-3-4-5
- maçonnerie : 1-2-3-4-5
- béton préfabriqué : 1-2-3-4-5
- bardages : 1-2-3-4-5
- autres : 1-2-3-4-5

Autres éléments intérieurs
- plafonds : 1-2-3-4-5
- cloisons : 1-2-3-4-5
- éléments vitrés: : 1-2-3-4-5

Eléments extérieurs
- balcons : 1-2-3-4-5
- garde-corps : 1-2-3-4-5
- auvents : 1-2-3-4-5
- acrotères-corniches : 1-2-3-4-5
- cheminées : 1-2-3-4-5
- autres : 1-2-3-4-5

INFLUENCE DES CONSTRUCTIONS ADJACENTES (X)

La construction menace une autre construction : OUI-NON
La construction est menacée par une autre construction : OUI-NON
La construction peut être un soutien pour une autre construction : OUI-NON
La construction peut être soutenue par une autre construction : OUI-NON

VICTIMES

Oui - Non - Peut-être - si oui combien ?

COMMENTAIRES SUR LA NATURE ET LA CAUSE PROBABLE DES DOMMAGES

- symétrie en plan : bon - moyen - mauvais
- régularité en élévation : bon - moyen - mauvais
- redondance des files : bon - moyen - mauvais

AUTRES COMMENTAIRES:

EVALUATION FINALE (X)

Niveau général des dommages
1 - 2 - 3 - 4 - 5

Couleur à utiliser
VERT ORANGE ROUGE

MESURES IMMEDIATES A PRENDRE:
1. - **PAS DE DOMMAGE** :

À l'exception des meubles renversés et des glaces cassées.

2. - **DOMMAGES LÉGERS** :

   - Fissures dans cloisons intérieures
   - Fissures dans plafonds
   - Dommages pour canalisations d'eau - électricité - lustre

   En résumé, dommages non structuraux isolés.

   **Remarques** : Prendre le cas le plus défavorable et faire commentaire si nécessaire.

3. - **DOMMAGES MODERES** :

Dommage important pour les parties non structurales et dommage faible pour les parties structurales.

* **Parties non Structurales** :

   Toutes les parties d'architecture et ce qui ne fait pas partie du système structural.

* **Parties Structurales** :

   Système porteur (voiles, ossatures avec remplissage ou la combinaison des deux).

   **Remarque** : Dans le cas de rupture des vide-sanitaires, et si le bâtiment est descendu en penché, même si la superstructure n'a rien, classer ce type de dommage dans la catégorie 4.
4. **DOMMAGES IMPORTANTS** :

- Dommages non structuraux très importants et dommages structuraux considérables.

- Fissures en X dans les voiles de contreventement, éclatement des noeuds poutres - poteaux.

**Remarques** : Soyez sûrs de bien choisir entre les niveaux 3 et 4. N'hésitez pas à demander l'avis d'autres ingénieurs.

5. **BÂTIMENTS À CONDAMNER OU EFFONDRES** :

**Par exemple** :
- Un étage a disparu,
- Un bâtiment a basculé,
- Trop de noeuds poutres-poteaux éclatés.

En général, les bâtiments à condamner sont ceux qui ont subi trop de déformations, ou dont la réparation coûterait aussi cher que le prix initial du bâtiment.

**En conclusion** :

* Couleur Verte : .................. Niveaux 1 et 2
* Couleur Orange : .................. Niveaux 3 et 4
* Couleur Rouge : .................. Niveau 5