GEOLOGY

The North Palm Springs earthquake of July 8, 1986 occurred within the San Andreas fault zone in the northern part of the Coachella Valley. The Coachella Valley is the geographic name applied to the northern part of the Salton Trough—a structural depression created at the head of the Gulf of California during extensional rifting and transform faulting associated with the late Miocene to Holocene evolution of the Gulf. Since the advent of the San Andreas fault 4 or 5 million years ago the Salton Trough has been filling up with sediment derived from the Colorado River and from escarpments which flank the margins of the depression.

The San Andreas fault in the Coachella Valley is viewed by most workers as the northwesternmost of a series of right-stepping transform faults which extend from the mouth of the Gulf of California onshore into the Salton Trough (Johnson and Hill, 1982, fig. 6). From the southern Coachella Valley, where the modern neotectonic trace of the San Andreas interacts with the Brawley seismic zone near the Salton Sea (Johnson and Hill, 1982, fig. 6; Sharp, 1982, fig. 4), the fault extends northward to the Indio Hills where it splits into two strands (Allen, 1957; Clark, 1984).

The northern strand (the Mission Creek fault) continues northward through the northern Coachella Valley toward the southeastern San Bernardino Mountains, while a southern strand (the Banning fault) trends more westerly toward the San Gorgonio Pass region.

The Garnet Hill fault, a little-understood structure which occurs a few kilometers southwest of and parallel to the Banning fault, may represent a third neotectonic trace of the San Andreas zone.

Throughout most of Pliocene and Pleistocene time, the principal strand of the San Andreas fault was the Mission Creek trace which carried slip through the southeastern San Bernardino Mountains and onto the Mojave Desert segment of the fault. However, in late Quaternary time an evolving left step in the San Andreas zone at the latitude of the left-lateral Pinto Mountain fault created structural complications which impeded throughgoing slip on the Mission Creek strand and led to a structural knot in the San Andreas fault (Matti and others,
1985). This structural knot has guided the late Quaternary evolution of fault complexes in the northern Coachella Valley and the southeastern San Bernardino Mountains by creating multiple strands of the San Andreas fault and by initiating late Quaternary slip on the Banning fault and an associated zone of compressional thrust and reverse faults in San Gorgonio Pass.

During latest Pleistocene and Holocene time, slip on the San Andreas fault apparently has passed around rather than through the southeastern San Bernardino Mountains by stepping left from the Mission Creek fault onto the Banning fault, or perhaps even onto the Garnet Hill fault (Matti and others, 1985). This stepping process is suggested by contrasts in tectonic geomorphology between the Mission Creek and Banning faults. Southeast of Desert Hot Springs, the Mission Creek fault is characterized by youthful tectonic landforms and faulted Holocene alluvial deposits (Clark, 1984; Keller and others, 1992); however, between Desert Hot Springs and the southeastern San Bernardino Mountains the Mission Creek fault does not have well-developed tectonic geomorphology and may not break the latest Quaternary alluvial deposits.

By contrast, in the region where evidence for youthful activity on the Mission Creek fault is equivocal, the Banning fault has well-developed tectonic geomorphology and Holocene deposits are broken by the fault. Hypocentral positions for the July 8 earthquake and its aftershock sequence are located in the region where slip may be stepping left between the Mission Creek and Banning faults, and the fault-place solutions and source parameters for these earthquakes may shed light on the physical mechanics of such a step.

ENGINEERING SEISMOLOGY
FOCAL MECHANISMS AND LOCATION

The North Palm Springs earthquake occurred at 2:21 a.m., POT, July 8, 1986 at an epicenter of 33°59.9'N 116°36.4'W with a preliminary local magnitude of 5.9. Preliminary analysis of this earthquake and its aftershocks suggests that the event occurred because of slip on the Banning fault with slip confined between depths of 7 km and 15 km. The rupture plane of the mainshock appears to strike N60°W and to dip 40°-60° to the north. The slip on this plane during the mainshock was pure right-lateral strike-slip. Some of the aftershocks show a component of oblique reverse faulting in addition to right-lateral strike-slip motion on the same north-dipping plane.

The mainshock is located in the middle of the hypocentral distribution at 11 km depth.

See accompanying map. (Fig. 1).

The results are preliminary and will be updated when the aftershocks are processed.

TRACE FRACTURES ON THE BANNING FAULT

Surface fractures formed along the trace of the Banning strand of the San Andreas fault near San Gorgonio Pass in association with the M 5.9 North Palm Springs earthquake of 8 July 1986.

See accompanying map. (Fig. 2).

The term fractures rather than ruptures or surface faulting is used here to emphasize the incipientity of the right-lateral displacement on the breaks along this fault trace.

Ground fractures caused by spreading, lunging, gravitational collapse of unsupported free faces and slopes, and shattering of ridge crests and hill tops during the strong shaking of this event were widespread phenomena near some parts of the Banning fault, as well as near the traces of the Garnet Hill fault in Whitewater Canyon and the Mission Creek strand of the San Andreas in northern Coachella Valley. Fractures considered to be tectonic in origin, however, are spatially associated only with the Banning trace, previously identified geologically and geomorphically in detail by Allen (1957), Proctor (1968), Clark (1984), and Matti and others (1985).

Fringing along the Banning fault is incipient and the component of the right-lateral slip attributable to it is infinitesimal. Barring the complication of distributed slip not expressed on fractures in the poorly consolidated alluvial materials cut by the fault, tectonic displacement for this event is near the limit of resolution for non-geodetic field methods for determining tectonic offset. A single man-made feature, a curb at the edge of State Highway 62, gives some clue to the absence of significant right lateral offset on the fault as well as the probable absence of distributed slip.

However, definitive data on the role of distributed movement may depend on remeasurement of an alignment array monitored by Caltech at Devers Hill, near the east end of the trace-fracturing.
STRONG-MOTION DATA

Strong-motion data—USGS

The July 6, 1986, North Palm Springs earthquake triggered accelerographs at more than 35 stations operated by the U.S. Geological Survey (USGS) in southern California. This note describes the records from six stations located within 50 km of the epicenter.

See accompanying map. (Fig. 3.)

Instrumentation at each site consists of a single Kinematics SIVIA-1 accelerograph that records three channels of data on 70 mm photographic film with two pulse per second signals and WWVB time encoding. The equipment is triggered by vertical accelerations exceeding 0.01 g in a nominal frequency range of 1 to 10 Hz. Instruments at each station are installed on the concrete floor slab of one-story, small, light-weight buildings.

The stations ranged between 5 and 44 km from the earthquake epicenter; the peak horizontal ground accelerations were between 0.13 and 0.70 g.

See accompanying table. (Fig. 4.)

Corresponding peak vertical ground accelerations ranged from 0.06 to 0.78 g, exceeding the horizontal maxima at North Palm Springs, Morongo Valley and Cabazon.

See accompanying figure. (Fig. 5.)

The duration of strong shaking, i.e., acceleration pulses greater than 0.10 g, lasts three to six seconds at the four nearest sites. There is a contrast in prominent frequencies at Morongo Valley where relatively long-period horizontal motion was recorded on both north-south and east-west components compared to the high frequencies observed on the vertical component. Similar ground motion characteristics have not been observed in numerous minor records obtained at this site during previous earthquakes.

Acknowledgments: The USGS thanks the numerous property owners who have provided space for the long-term operation of the instrumentation, and other agencies that have cooperated in the recording program, including

Fig. 3. Six USGS and four CSMIP strong-motion stations.

<table>
<thead>
<tr>
<th>STATION</th>
<th>Location</th>
<th>Coordinates</th>
<th>Distance (km)</th>
<th>Component Direction</th>
<th>Acceleration (g)</th>
<th>Duration (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whitewater</td>
<td>33.99°N</td>
<td>116.66°W</td>
<td>5</td>
<td>270°</td>
<td>.66</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Up</td>
<td>.44</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>180°</td>
<td>.50</td>
<td></td>
</tr>
<tr>
<td>Trout Farm</td>
<td>33.92°N</td>
<td>116.54°W</td>
<td>9</td>
<td>300°</td>
<td>.68</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Up</td>
<td>.78</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>210°</td>
<td>.70</td>
<td></td>
</tr>
<tr>
<td>North Palm</td>
<td>34.05°N</td>
<td>116.58°W</td>
<td>11</td>
<td>135°</td>
<td>.22</td>
<td>4.7</td>
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<tr>
<td>Springs</td>
<td></td>
<td></td>
<td></td>
<td>Up</td>
<td>.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>405°</td>
<td>.23</td>
<td></td>
</tr>
<tr>
<td>Morongo</td>
<td>33.92°N</td>
<td>116.70°W</td>
<td>16</td>
<td>270°</td>
<td>.21</td>
<td>3.3</td>
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<tr>
<td>Valley</td>
<td></td>
<td></td>
<td></td>
<td>Up</td>
<td>.38</td>
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<td></td>
<td></td>
<td></td>
<td>180°</td>
<td>.22</td>
<td></td>
</tr>
<tr>
<td>Cabazon</td>
<td>33.75°N</td>
<td>116.21°W</td>
<td>44</td>
<td>315°</td>
<td>.13</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Up</td>
<td>.06</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>225°</td>
<td>.06</td>
<td></td>
</tr>
</tbody>
</table>

Duration is the time between first and last peaks of acceleration greater than 0.10 g.

Fig. 4. Strong-motion data—USGS

Fig. 5. Strong-motion records from USGS stations.
the Metropolitan Water District of Southern California, the Army Corps of Engineers, the Veterans Administration, and Caltrans. The instrumentation network was maintained by John Nielson and Frank Risavich with assistance from Dennis Johnson and Marion Salzman in record collection and processing.

### Strong-motion data — CSMIP

Strong motion records were recovered at over thirty stations of the California Strong Motion Instrumentation Program (CSMIP) following the North Palm Springs earthquake of 8 July 1986. In total, records were recovered from 21 free-field stations, 8 buildings, 2 earth dams and one power plant. These records are shown in the CSMIP data report OSMS 86-05.

See accompanying abbreviated table. (Fig. 6).

Particularly noteworthy features of the strong motion data from the main shock include:

- **Hemet Array.** The Hemet strong motion array is a northeast-southwest alignment of 8 stations which transects the San Jacinto Fault south of San Bernardino.
  - Although the array was installed in 1975, this earthquake is the first which triggered all stations of the array. The array station closest to the epicenter (28 km) recorded a peak acceleration of 15% g. The most distant station, at 66 km, recorded 5% g. Interestingly, an intermediate station, at 34 km, recorded a peak acceleration of 26% g. There are also clear variations in the frequency content at the different stations.
  - Palm Springs Desert Hospital. One of the few hospitals instrumented by SMIP is located in the town of Palm Springs, approximately 19 km south of the epicenter. The building is a 4-story steel-frame structure. Peak acceleration at the ground floor was approximately 21% g.

---

<table>
<thead>
<tr>
<th>Station No.</th>
<th>Name</th>
<th>N.Lat</th>
<th>W.Long</th>
<th>Epicentral Dist(km)</th>
<th>Az*</th>
<th>Maximum Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>12149</td>
<td>Desert Hot Springs — Fire Station</td>
<td>33.952</td>
<td>116.599</td>
<td>19</td>
<td>150</td>
<td>0.89g V 0.35g H</td>
</tr>
<tr>
<td>12299</td>
<td>Palm Springs — Desert Hospital</td>
<td>33.838</td>
<td>116.561</td>
<td>19</td>
<td>161</td>
<td>0.13g H 0.15g V 0.52g H</td>
</tr>
<tr>
<td>12025</td>
<td>Palm Springs — Airport</td>
<td>33.829</td>
<td>116.501</td>
<td>21</td>
<td>152</td>
<td>0.21g H 0.17g V 0.52g H</td>
</tr>
<tr>
<td>12284</td>
<td>Palm Desert — Kleit Building</td>
<td>33.762</td>
<td>116.407</td>
<td>32</td>
<td>145</td>
<td>0.13g H 0.09g V 0.20g H</td>
</tr>
</tbody>
</table>

--- Hemet Array Stations (Northeast to Southwest) ---

- 12206 Silent Valley — Poppet Flat | 33.851 | 116.852 | 28 | 234 | 0.15g H 0.10g V |
- 12204 San Jacinto — Soboba | 33.797 | 116.880 | 34 | 229 | 0.26g H 0.21g V |
- 12202 San Jacinto — Valley Cemetery | 33.769 | 116.960 | 42 | 231 | 0.07g H 0.06g V |
- 12231 Hemet — Stetson Ave Fire Station | 33.729 | 116.979 | 46 | 229 | 0.15g H 0.09g V |
- 13201 Winchester — Page Bros. Ranch | 33.718 | 117.022 | 49 | 231 | 0.11g H 0.08g V |
- 13200 Winchester — Hidden Valley Farms | 33.681 | 117.056 | 54 | 230 | 0.09g H 0.04g V |
- 13199 Winchester — Bergman Ranch | 33.640 | 117.094 | 60 | 229 | 0.10g H 0.06g V |
- 13198 Hurriceta Hot Springs | 33.599 | 117.132 | 65 | 228 | 0.05g H 0.04g V |

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Fig. 6. Strong-motion data — CSMIP

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**SENSOR LAYOUT**

Palm Springs — Desert Hospital (CSMIP Station No. 12299)

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**South/North Section**

Roof
4th Floor
3rd Floor
2nd Floor
1st Floor
Basement

**Structure Reference Orientation:** N = 0°

**Basement Plan**

---

**Roof Plan**

**3rd Floor Plan**

**2nd Floor Plan**

---

Fig. 7. Palm Springs — Desert Hospital — Sensor layout — CSMIP
20 \% g; the peak acceleration at the roof was 60 \% g. Despite these acceleration levels, little damage was reported.

See accompanying sensor layout and record. (Fig. 7). (Fig. 8).

Desert Hot Springs Fire Station. A triaxial instrument in this light 1-story structure located approximately 10 km from the epicenter recorded a peak acceleration near 60 \% g on the vertical component and 35 \% g on a horizontal component. Little damage was observable.

**Strong-motion data—USC**

Of the 81 stations in the USC, Los Angeles strong motion accelerograph network (Anderson et al, 1981), 18 were triggered. The motions were small; eight stations stopped recording, to be triggered again by the arrival of surface waves, a few seconds later. In other instances only the surface wave portion of ground motion was recorded.

Plots of instrument and baseline corrected data were included in a preliminary announcement. In a few weeks you may request the digitized data which will be available on our standard magnetic tape format. We will be grateful if you can make copies of this material and distribute these to your colleagues.

**Strong-motion data—Kinematics**

At the Kinematics plant in Pasadena, 80 miles away from the epicenter, a new SSA-1 recorded the main shock. The record was retrieved at 0645 AM on the morning of July 8, and by 0650 AM it was graphically examined on an IBM PC for further processing. The SSA-1 accelerograph station was set to trigger on any channel at 0.002g. It triggered on the vertical motion.

Each time-series and its corresponding Fourier spectrum were plotted and studied before starting standard processing. The SWS-1 workstation and IBM PC/XT were used for the standard data processing, and copies are enclosed. (Peak acceleration of about 0.01 g -- Ed.)

This is the first earthquake record from the SSA-1, Kinematics' Solid State Accelerograph.

**STRUCTURAL ENGINEERING**

**PERFORMANCE OF PUBLIC SCHOOLS AND HOSPITAL BUILDINGS**

No structural damage occurred to any public school building constructed under the provisions of the Fire Act, or to any hospital building constructed under the Hospital Act, during the North Palm Springs earthquake on July 8, 1986. There was some non-structural damage which is described in the following paragraphs.

**Desert Hospital, East Tower, Palm Springs**

In the East Tower of the Desert Hospital, which contains instrumentation by the Strong Motion Instrumentation Program of the California Division of Mines and Geology, the elevator
counterweights became disengaged from their guides in two of the three elevators. No other heavy equipment was displaced. Due to the early morning hour of the earthquake, the elevator cab was probably at the ground floor and the counterweights were at the upper floor. Only those counterweight brackets at the roof were bent, which allowed the counterweights to become displaced. All brackets were strengthened after the earthquake. The plaster was cracked along the second floor beams in the elevator shaft. The beams were examined by the hospital’s consulting structural engineer and no damage or evidence of yielding could be detected; thus no explanation can be given for the pattern change in the record at the time. It is interesting to note that the building experienced 62% g peak acceleration at the roof in each direction, 30% in the longitudinal and 24% in the transverse on the second floor and 16% longitudinal and 19% transverse at the basement.

There was minor damage to the dry wall on the 2nd, 3rd and 4th floors and to the plaster in the stair well which was repaired.

The emergency generators operated as intended.

This building was not constructed under the provisions of the Hospital Act. The elevators were upgraded in 1983 under the elevator rehabilitation program.

Desert Hospital, Sinatra Tower, Palm Springs

This tower, constructed under the provisions of the Hospital Act, had no structural damage. The architectural coverings and some ceiling and wall finish at the seismic separation joint between the main tower and the west elevator tower were damaged, due to the relative movement between the towers.

McCallum Theater, Palm Springs

This building, under construction under the provisions of the Field Act, had no structural damage. It is interesting to note that the approximately 40-foot high pilastered reinforced concrete block walls, currently standing without bracing while under construction, were not damaged. These walls and pilasters were filled full height with low lift grout. Apparently the period of vibration of these high walls was so long that the earthquake ground motion was ineffective.

Idylwild

This elementary school, located some 18 miles southwest of the epicenter in the Hemet Unified School District and in the San Jacinto Mountains, did not experience any structural damage; however, it did have some non-structural damage. The drywall showed minor cracks in the taped joints in the toilet rooms and in the plaster in the kitchen. An unanchored heater moved an inch and another unanchored heater did not move.

The T-bar ceiling along the edge of the two classrooms dropped down enough to allow the tile to fall to the floor and a couple of T-bars fell. This building was constructed in 1964 before regulations on ceilings were adopted. The lenses on several light fixtures opened but did not fall. Book shelves were pulled away from the wall and books fell to the floor.

Acknowledgments: Appreciation is expressed to Clifford Chaffin, Jack Bruce and Neal Sinkeldam of the Structural Safety Section, Office of the State Architect, to Tony Shakal at COMG’s Strong Motion Instrumentation Program, to Fred Spahn at the Desert Hospital and to Kar-Ban Leung and Richard J. Phillips, Structural Engineers, for information presented here.

BUILDING DAMAGE

Introduction

The strongly shaken area of the July 8, 1986 North Palm Springs earthquake is relatively sparsely populated, with the exception of the communities surrounding Palm Springs, and few structures were seriously damaged by the earthquake motion. Riverside County has assessed the total damage at 4 homes and 16 businesses destroyed, 102 homes and 117 businesses damaged, with residential damage totaling $737,000 and business damage $1,164 million (Riverside County Fire Department, Emergency Services Div., 15 July).

Structures in the area are generally low-profile wood-frame buildings, almost all one or two stories. A few, such as hotels and hospitals, are three to five stories. Generally, all buildings have apparently been designed according to applicable codes (i.e., UBC), with the exception of some rural structures. Several single story commercial buildings, such as department stores and the airport terminal, have rather extensive open fronts. Mobile home parks are located throughout the area.

Building damage was generally limited to:

(i) window glass breakage in stores (e.g., Robinsons-Palm Springs Dept. Store, a building with an extensive open front)

(ii) suspended ceiling panels, and

(iii) contents, such as furniture and shelf items, which were liberally but sporadically strewn about, and generally replaced by the next day.

Perhaps the most extensive damage to an engineered building occurred at the Desert Spa Hotel in central Palm Springs, which was closed for renovation at the time. This is a five story H-shaped building (age perhaps ten or twenty years; structure indeterminate) which experienced substantial glass breakage in the upper floors and cracking in the stucco on the end walls at the floor levels. Across the street, the newly completed Maxims de Paris Hotel sustained a few hairline cracks at similar floor level joints, but no glass breakage. Most other buildings, for example the open-fronted Palm Springs Airport Terminal building, showed no evidence of damage, or even movement at joints.

Mobile Home Parks

Mobile homes closer to the epicentral area sustained heavier damage, typically due to their being supported by light-weight narrow-based tripods, which tipped over when subjected to strong ground motions. This damage is typical and has been observed in many previous earthquakes. Western Village MHP, located 2 miles S of Hwy 111 at a point 5.2 miles S of I-10, had 10 mobile homes out of a total of approximately 110 fall in such a manner. Carefree Mobile Village Park (N of I-10 on Indian Ave, at
Dillon Rd.) was on the edge of the epicentral area, and 1 mobile home fell off its tripods, and several displaced several inches to a foot or more, out of a total of approximately 40 homes. In the same park, two steel water tanks (about 8' diam. by 15' high supported on a concrete platform approximately 5' off the ground and presumably full), were displaced about 4 inches. Station 36 of the Riverside County Fire Dept. (a prefabricated light metal building) next door was undamaged, although contents were disturbed.

Epicentral Area

There are relatively few structures in the epicentral area (defined here as N of I-10 to the county line, and east of Whitewater Canyon to Indian Ave.). Besides the Carefree MHP and Station 36 (discussed above), there are several dozen homes and small business buildings, typically wood frame or reinforced concrete block, which had no apparent damage. Several wood-framed buildings at the Whitewater Trout Farm, where 0.61 g was recorded, had no damage.

About 3/4 mile south of the trout farm on Whitewater Canyon Rd. (i.e., in line with the WNW trending apparent surface faulting), the MacKenzie adobe house sustained major damage.

See accompanying photo. (Fig. 9).

This was a one story L-shaped building, built in several stages but basically dating from about 1946. The walls were 12” unreinforced stabilized adobe of local manufacture and good quality, with a 4”x12” reinforced concrete bond beam at the eave line. The pitched tile roof was carried on 3”x6” rafters 3” on center nailed to a 3”x6” plate bolted to the bond beam. Damage, consisting of major diagonal cracking, was prevalent throughout the south portion of the building, with the eastern wall at the SE corner having fallen away from the building. The chimney, on the east side and also of adobe, collapsed completely. The NW portion of the building was an almost completed wood-framed addition which had no apparent damage.

Conclusion

This was a modest earthquake in a sparsely populated area, resulting in minor damage to buildings. In a major California population center, this would still have resulted in only moderate damage, primarily to substandard buildings, and would not have been a major disaster. The low level of damage in this earthquake is due to generally good seismic building practice.

LIFELINE ENGINEERING

ELECTRIC POWER

The North Palm Springs earthquake of July 8, 1986, was centered near a high voltage transmission substation and wind energy generating facilities. Some of the distribution system was also in the area of strong shaking.

Of particular interest is the Southern California Edison Devers Substation near the intersection of I-10 and Hwy 62. Ground motion records taken on the substation site indicate 0.97 g N, 0.72 g E, and 0.48 g vertical. It is clear that the substation design basis ground acceleration of 0.50 g was exceeded during the earthquake. The Devers Substation includes a 115, a 220, and a 500 kV switchyard, with equipment installations ranging in vintage from the early 1960's to the 1980's. The 500 kV switchyard of the substation was constructed using specifications developed after the 1971 San Fernando earthquake that required the use of spectra anchored at .5 g. Because of the size of the substation, its diversity of equipment, and the high level of recorded ground motion, the Devers Substation presents a unique and important source of data for the seismic performance of high voltage switchyard equipment.

Seismic damage in the substation was concentrated in ceramic columns in transformer lightning arrestors, bus taps, disconnect switches, and circuit breakers. The greater portion of the damage occurred in the new 500 kV switchyard.

See accompanying photos. (Fig. 10). (Fig. 11). (Fig. 12). (Fig. 13).
Fig. 11. Air blast circuit breakers in the 500 kV yard.

Fig. 12. Devers Substation damage to ceramic columns of equipment in the 500 kV yard.

Fig. 13. Air blast circuit breakers in the 220 kV yard.
The 500 kV switchyard was heavily damaged with about 75% of the ceramic members destroyed. The most severe damage was to six air-blast circuit breakers that lost the ceramic columns which support the interrupter heads. In addition, numerous air disconnect switches, current transformers, potential transformers, surge arresters, and post insulators supporting flexible busses had ceramic members fail. Several failures could be attributed to interaction between equipment with inadequate slack, particularly with suspended line traps. The 500/200 kV transformers and 500 kV line reactors broke clear so that the transformers could lift off of their pads and rock. Bushings were leaking oil but the units were serviceable. A spare transformer, which was bolted to its pad, had the four inch bolts shear, allowing the transformer to slide. Three SF6 circuit breakers did not fail.

In the 220 kV switchyard two SF6 circuit breakers, base supported capacitive voltage transformers, two air disconnect switches, and surge arresters on the 220/115 kV transformers had ceramic members fail. In a couple of cases, the metal base holding the ceramic failed.

Within the substation control buildings, relay panels and control boards were unaffected by the earthquake. However, sudden pressure relays were tripped on some transformers, station batteries walked along the length of the rack and moved off the end so that they were supported by the nearby wall. They remained operational. A few "T" bar supported ceiling panels fell and several storage cabinets fell.

Damage to the distribution system was limited to several poles tilting, several wooden cross arm failures, and several hanging but operational lines due to damaged insulators or broken anchor wires. Within Palm Springs about 75% of the distribution system is under ground. There were no failures. There were a few cases of relay trips indicating that lines had touched but there was no burn down. Due to the loss of power at the substation, lines were quickly de-energized.

The epicentral area also includes extensive installations of wind generators of various designs. Close to 4000 wind-generators are located on "wind farms" in the area north of Palm Springs. Brief investigations of wind generators in the vicinity of the epicenter indicated that wind generator damage was not widespread. There were several examples of structural damage to wind generator support columns.

See accompanying photos. (Fig. 14). (Fig. 15).

Damage also occurred to ceramic members at step-up transformers at several locations. In a few cases the damage was sufficient to render the units inoperable.

COMMUNICATIONS

There is no known damage to...
communications equipment (causing disruption) in the epicentral region of the July 8, 1986 North Palm Springs earthquake.

The main microwave tower at Whitewater had the first three tiers severely torsionally deformed. Communications with the tower were not interrupted. The emergency diesel engine at the site fell off its isolation system and broke the fuel connection to the tank. One of two buried fiberglass fuel storage tanks was punctured when a concrete block, used in fill next to the tank, punched a 2" x 2" hole. One set of emergency batteries in the control house broke the end wooden restraints. One case of a cell had a small crack that allowed a little electrolyte to leak before it sealed itself. The site did not lose power, and remained in operation.

The internal telephone network at the Southern California Edison maintenance yard failed about an hour after the quake. There was no indication of failure and there is no explanation as to what caused the disruption or how it was fixed.

Telephone buildings and equipment (General Telephone) in the epicentral region suffered no damage. According to Mr. Ernie Moreno, Division Operations Manager for that region, all General Telephone buildings, equipment and equipment supports were upgraded for seismic resistance after the 1971 San Fernando earthquake, and these modifications prevented damage during this earthquake.

The only significant impact to the telephone system after the earthquake was a dramatic increase in traffic. Whereas the Palm Springs telephone exchange normally handles 600 calls between 2:00 and 3:00 a.m., it handled 30,000 calls between 2:22 a.m., the time of the main shock, and 3:00 a.m. There were no restrictions on incoming calls, but outgoing callers sometimes got an "all trunks busy" signal.

The 911 emergency phone system stopped working immediately after the earthquake for approximately one hour and twenty minutes. The equipment that operates the system is located in Los Angeles and experienced no shaking. The cause of the failure is not clear. Fortunately, there were no significant emergencies.

All public service sector communications such as Police, Fire and other agencies in Palm Springs, are coordinated at an Emergency Coordinations Center located at the City Hall. A redundant center located 6 miles east of Palm Springs can also be used during emergency conditions.

No damage occurred to either buildings or equipment. All public service sector communication systems, with the exception of the 911 system (above), were fully functional after the earthquake.

Communications with outside agencies and private organizations relied on telephone communications. Extensive use was made of amateur radio operators where telephone service did not meet communication demands, or the lack of common radio frequencies prevented wireless communications.

The Emergency Service Coordinator for Palm Springs, Mr. Jim Runge, sees a need for 4 very-high-frequency radio channels for administrative, logistical, operations, and field command communications functions.

No significant effects are known to radio, television or other facilities or operations.

WATER SUPPLY AND SEWERAGE

The communities of Palm Springs, Desert Hot Springs, Banning, Beaumont, and Hemet have extensive water supply and wastewater collection facilities, and even though these communities are located near the earthquake of July 8, 1986, the water and sewage facilities performed satisfactorily and there was no significant damage. Water and sewer agencies in the area reported their emergency response system operated satisfactorily.

Minor damage occurred to the water distribution system near Desert Hot Springs, where leaks in the distribution mains occurred in the area of ground deformation. The water mains of "invasion pipe" were installed shortly after World War II. "Invasion pipe" is a thin-walled steel pipe with minimum coating and lining, used during World War II by the military. Distribution mains of other materials performed satisfactorily in the area.

A minor disruption occurred on the Colorado River Aqueduct where a crack appeared in a cast-iron Tee of a blow-off assembly, located on a sag pipe (inverted siphon) crossing a wash. The blow-off assembly was repaired and put back in service in a few hours. Inspection of other sag pipes in the area revealed no further damage.

All water and sewer agencies reported they have extensive water production wells, booster pumping stations, tanks, and fresh water treatment plants, in addition to wastewater collection systems and wastewater treatment plants, which operated without difficulty after the earthquake.

POSTEARTHQUAKE FIRE AND FIRE-RELATED ASPECTS

Introduction

This section reports on the fire-related aspects of the 8 July 1986 North Palm Springs earthquake, which was felt over a wide area of Southern California. The strongly shaken area, however, is relatively sparsely populated, with the exception of the communities surrounding Palm Springs. The shaking resulted in several fires and other incidents and numerous calls to the local fire departments. These incidents, while all handled by local fire service resources, suggest the nature and scale of demands the fire service will be called upon to respond to in a great earthquake in a populated area.

Affected region

The earthquake epicenter was located in the northwesternmost portion of the Coachella Valley, approximately 10 km west of Desert Hot Springs. The immediate epicentral area (North Palm Springs/Whitewater) contains numerous windmills, the Devers substation of Southern California Edison Co., intermittent semi-rural housing, a trailer park, and a few stores, etc. This area is served by Riverside County F. D. station 36, whose personnel estimate the population served to be approximately 600 at this time of the year.
From this point the valley extends southeastwards towards the Salton Sea and contains, along Interstate 10 and Hwy 111, the Riverside County communities of Palm Springs, Cathedral City, Palm Desert, Thousand Palms, Indio, etc., with an estimated population of about 100,000. Of these communities, the largest is Palm Springs, located approximately 20 km south of the epicenter. Westwards from the epicentral area along I-10 is the town of Banning, on the other side of the San Gorgonio Pass. About 25 km to the southwest, on Hwy 243 in the San Jacinto Mountains, are the communities of Pine Cove and Idyllwild. North of the epicentral area, there is little development until the San Bernardino County communities of Morongo Valley and Yucca Valley on Hwy 62.

Within the Beaumont, Banning, Idyllwild, Indio, and Desert Hot Springs quadrilateral of Riverside County, there are a total of approximately 26 Riverside County F. D. (contracted from Calif. Div. Forestry) fire stations, as well as the separate fire stations of Palm Springs and the Idyllwild FPD.

In summary, probably no more than a thousand people (and associated buildings and infrastructure) were subjected to MMI VI or greater in this earthquake, while a population of perhaps 70,000 were subjected to MMI V or greater.

Fire-related incidents

Riverside County F. D. (RCFD) set up an Incident Command Post at Station 55 (Indian Wells), with BC M. McConnell as IC. For the entire affected region, for the period from the earthquake (0221 PDT) until noon (approximately ten hours), there were a total of 79 incidents, 46 of which were investigations by fire units of gas leaks or odors. Five structure-related fires occurred, and three vegetation fires.

Cathedral City

The only structural fire of any significance occurred in Cathedral City, which is served by Station 34 of the Riverside County Fire Dept. An officer and a firefighter were on duty and asleep at the time of the earthquake. Following the earthquake, they were able to raise the doors and pulled their 1250 gpm engine and 750 gpm reserve engine outside, per standing procedure. The reserve engine transmission broke down almost immediately, and was thereafter not available. After a radio report of the earthquake to Battalion headquarters in Indio, the officer and firefighter proceeded in the engine to the police station, where they traded portable radios ("handie-talkies") with the sergeant on duty, in order to permit police/fire communications in the event of a central dispatch failure. This was not a standing procedure and was decided on the spur of the moment, based on a perceived potential for loss of police/fire communications.

There being no calls for assistance, E34 proceeded to check an industrial complex for possible hazardous material release. This was done and, finding no problems, E34 next patrolled the residential districts, looking for downed wires or structural damage as well as to provide visible assurance to the numerous citizens roused by the earthquake and standing outside. While performing this damage reconnaissance, E34 was dispatched at 0348 (87 minutes after the earthquake) to a structural fire at a glass and mirror store and warehouse (approx. size 10,000 sq. ft.) on E. Palm Canyon St., which had been reported by telephone by a passing motorist. This fire was apparently due to short circuit/arcing of an external floodlight, which ignited vegetation next to the woodsided building. The fire progressed up the siding and into the walls and attic through the overhanging eave. E34 arrived within two to three minutes and made an aggressive interior attack, having ample water supply from a hydrant across the street (gravity fed from hillside tanks). E35 (Thousand Palms) and E50 (Rancho Mirage) were on scene by 0355. The fire was quickly knocked down and E34 stood by for several hours.

Other than this fire, E34 had very few incidents. This is partially attributed to the seasonal nature of the population of Cathedral City, with a substantial portion leaving in the spring and returning in the fall. During their summer absence, the residence utilities (gas and electric) are turned off, so that there were fewer than normal opportunities for gas- or electric-origin fires in this earthquake. It is anticipated that this autumn may experience a higher than average number of structural fires, as these residents return and turn on earthquake-damaged appliances.

Cathedral City's water supply is divided, with the southern side supplied by gravity feed from hill tanks, and the northern side supplied by pumps. Following the earthquake, the southern side had power for the first two hours after the earthquake, while the northern side was without power for the first seven hours. Thus, if the fire had occurred on the northern side (note however that it was electrical in origin), E34 would have found no water at the hydrants, and would have had to call for a tanker from neighboring Palm Springs, with an associated delay.

Palm Springs

The Palm Springs F. D. has a total of 66 personnel (56 of whom are in fire suppression) five stations, and 21 fire trucks. While Palm Springs is the largest community in the vicinity of the earthquake, and had the largest number of incidents, most of these were gas investigations and none was a serious fire. The two structural fires were a pole transformer fire and a fire in a swimming pool pump "pit", both electrical in origin. A personnel recall was initiated at 0430, and 45 personnel (who carry "beepers" at all times) had responded within 30 minutes.

Communications were a problem and on-duty personnel were nearly overwhelmed:

"Immediately after the quake the 911 phone line went dead. Phone calls began coming in on the old emergency and business lines. The telephone company was contacted and dispatched, both police and fire, began taking information and advising informants there would be a delay in the Fire Department response. In most cases this delay averaged about fifteen to twenty minutes. At about 0435 two additional dispatchers arrived to assist. The phone company also repaired the 911 phone line at this time."

In a follow-up critique, the department felt that calls for aid could be reduced by a public information message on gas leaks, to prevent jamming emergency phone lines.
Pine Cove/Idyllwild

Station 23 at 0240 received a report of a ruptured propane tank at Buckhorn Campground, and arrived there about 3 minutes later finding an 8000 gal propane tank with a hissing leak between the tank and shut-off valve on the main supply line (i.e., it could not be valved off). E23 moved the approximately 100 people present up-slope and laid line in case of ignition. The gas supplier arrived about an hour later and at first tried a pump transfer but then succeeded in stopping the leak by tightening the piping. The amount lost was not measurable by the tank gage. E23 returned to quarters at 0930.

At 0654 QA23 and other units responded to a report of a propane flash fire at a house on Hwy 243. They determined that the earthquake had loosened a connection to a water heater enough to permit minor leakage of propane and the subsequent accumulation of a flammable mixture. This mixture ignited but no spread occurred. On their arrival they found no fire, shut the system down and notified the supplier. Other calls included two collapsing fireplaces, and another propane leak.

Morongo Valley

Rockslides partially blocked Hwy 62 and necessitated E32 of San Bernardino County F. D. closing the highway.

Concluding remarks

The earthquake of 8 July, while felt over a wide area of southern California, in reality subjected only a small population to strong ground motion. This small exposure, combined with a relatively small industrial base and widespread power outages, resulted in few fire-related incidents. The in-place fire service was able to respond to these incidents without need for mutual aid. Nevertheless, we see in this earthquake the same pattern of previous earthquakes: disrupted communications and power supply, numerous gas investigations and medical aid calls, loss of water supply, and earthquake-caused ignitions.

This insert on the North Palm Springs earthquake of July 8, 1986, has been put together from contributions from a number of scientists, engineers and other professionals with first-hand information. Some of the contributions have been edited and spliced, but slight conflicts still occur where the subject matter spills over into more than one chapter heading. EERI members participating are Luis Escalante, Coleman W. Jenkins, Le Val Lund, Richard P. Maley, John F. Mehan, Ronald L. Pecelis, Charles Scawthorn, Anshell J. Schiff, Anthony F. Shakal, Mihailo Trifunac, A. Gerald Brady (Managing Editor), and Roger Scholl (Technical Director).

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REFERENCES


Clark, M. M., 1984, Map showing recently active breaks along the San Andreas fault and associated faults between Salton Sea and Whitewater River-Mission Creek, California: U.S. Geological Survey Miscellaneous Investigations Map I-1483, scale 1:24,000.


Please note the photos and brief preliminary descriptions in the August 1986 Newsletter, concerning the Whitewater Overcrossing bridge and early newspaper reports.