ADAK, ALASKA EARTHQUAKE —MAY 7, 1986

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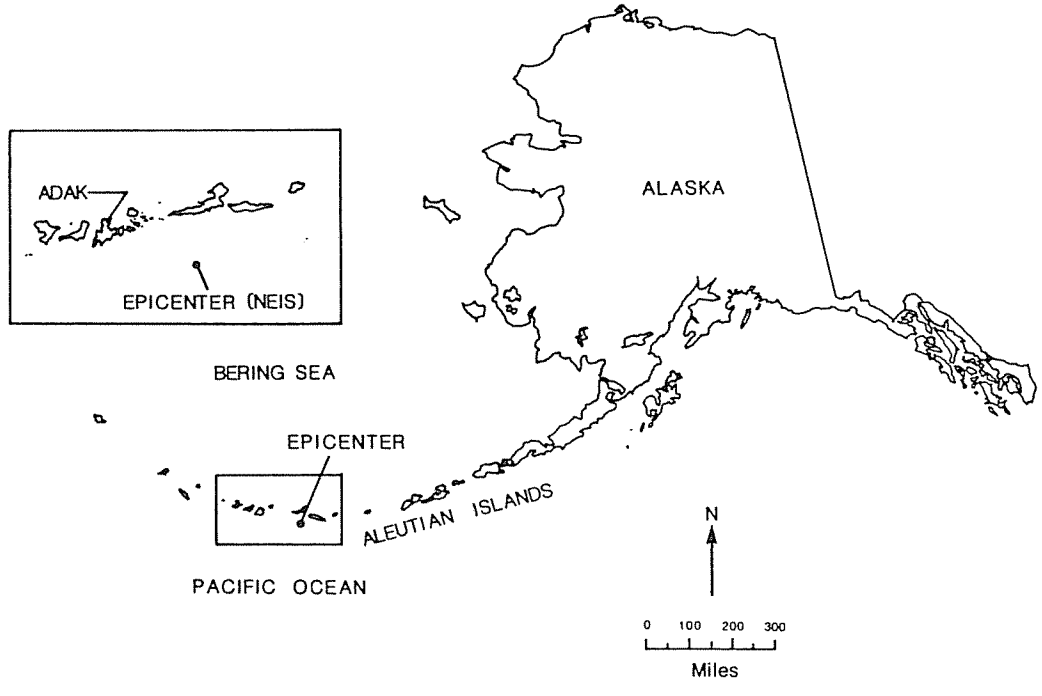

On Wednesday, May 7, 1986 at 1:47 p.m., Bering Daylight Time, a major earthquake (M_b=6.5, M_S=7.7) occurred southeast of the Andreanof Islands group in the Aleutian Islands chain. According to the U.S. Geological Survey's National Earthquake Information Service, the earthquake epicenter was located 51.4° north and 174.8° west, at a depth of 33 km, approximately 90 miles southeast of Adak, Alaska (Figure 1). The earthquake is the largest to occur in Alaska in the last 20 years. Three foreshocks of magnitudes 4.5, 6.0, and 5.0 occurred in the 3 hours prior to the main event. The two largest aftershocks to date are a magnitude 6.2 shock on May 8 and a 6.5 shock on May 17.

Mr. David Glick of the Geotechnical Engineering Branch and Mr. Neil Bass of the Pacific Northwest Branch, Western Division, Naval Facilities Engineering Command, were on Adak during the main shock and until May 9. On May 16, a second team comprised of Mr. Gary Ung of the Western Division Structural Branch and Mr. David McCormick and Ms. Nancy Horstman of EQE Incorporated traveled to Adak to study the earthquake further. They were able to verify information collected by the first team, study the performance of mechanical and electrical equipment, and identify additional damage that occurred during the aftershocks.

The island of Adak is about 25 miles wide and 35 miles long, with an irregular coastline that varies from broad beaches to sheer sea cliffs. The highest peak is Mount Moffet, with an elevation of 3,900 feet. The island is populated by 4000 to 5000 personnel living on the Navy base. Virtually no civilian or native community exists. The original portions of the base were constructed in the 1940s, with continued construction and expansion to the present time.

The main earthquake resulted in moderate to strong shaking at Adak. Physical effects included the following: cracking of masonry and concrete structural members, local power disruptions, cracked windows, overturned file cabinets, and displaced and overturned items on tables. Rock falls were observed at two quarry sites, and evidence of snow avalanches was observed along steep mountain ridges. Combined observations of occurrences during the earthquake suggest an intensity range of V to VII on the Modified Mercalli Intensity scale. No significant earthquake-related injuries were reported.

A tsunami warning was issued within 5 minutes after the earthquake. Personnel on Adak were evacuated to higher elevations for approximately 1 hour. Observed water levels receded approximately 1.5 to 2 feet in Sweeper Cove (Adak) and wave height estimates ranged from 0.5 to 1.5 feet. No significant wave heights were generated elsewhere in the Pacific.

Seismicity

The Alaska-Aleutian Islands lie in one of the most active seismic zones in the world. The island arc marks a subduction zone where the Pacific Plate is sliding beneath the North American Plate. The most recent major earthquake in the area was the magnitude 8.2 event in 1957, which had an epicenter 100 miles southeast of Adak. Some structural damage was sustained on the island as a result of the shaking and of the ensuing tsunami, which also caused damage as far away as Hawaii.

The island of Adak frequently experiences minor to moderate ground shaking. A local array of seismometers used to study these small earthquakes recorded many aftershocks within their recording range, but saturated on the main shock and the larger aftershocks.

The Naval Civil Engineering Laboratory in Port Hueneme, California maintains three Kinemetrics strong motion instruments on the island. These instruments are located in or near the AIMD Hangar, which is situated on hydraulic fill. Two of the instruments - an SMA-1 located on the foundation slab, and an FBA-3 located on the bottom chord of a steel roof truss (approximately 45 feet above grade) - recorded the main earthquake. A third instrument, located in the free field, did not operate because of dead batteries.

Horizontal peak ground accelerations between 0.20g and 0.25g were scaled from the time histories, and horizontal accelerations in excess of 0.60g were experienced at the bottom chord of the roof truss. Peak ground accelerations greater than 0.10g had a bracketed duration of 25 to 30 seconds. The time histories will be used to derive spectra, which will be available at a later date.

Geotechnical

Soil profiles at Adak consist of loose sand or sand and muskeg (thin layer of grass and moss) to a depth of 6 to 8 feet, with firm sand below. The firm sand extends to depths of up to 60 feet and is underlain by basaltic rock. The lower elevation area, occupied by the Naval Air Station, is a reclaimed marsh covered with 20 to 50 feet of hydraulic fill. Rock underlies the ground surface at higher elevations of the island, where several of the facilities are located.

Most effects of the earthquake were observed in the lower-lying areas of the island. Lurch cracks were noted adjacent to many structures and in backfill soils. Differential settlements of up to 4 inches were experienced by the small concrete structures containing the sewage lift stations. Substantial cracks developed in the foundation slabs, but the concrete walls experienced little damage. Pumps at the stations had no significant operational problems.

Differential lateral and vertical movements at construction joints in floor slabs were noted in several buildings. Minor movements had also occurred prior to the earthquake. Differential settlement between shallow column footings and adjacent concrete slabs was observed in one structure. A number of houses experienced differential foundation settlements of several inches, resulting in sloped floors, cracked partitions and foundation walls, and beams lifting off foundations. It was reported that some of these houses were located over old river beds. Similar damage to houses was reported after the 1957 earthquake.

Sand boils were noted in one localized area where an antenna array is located. Inspection of the area revealed that one antenna foundation had settled approximately 3 feet and that other antennas were out of plumb. Numerous deadman anchor blocks for antenna guy wires had also settled, displaced laterally, or rotated. The common construction practice at this site was to overexcavate existing soils and backfill with compacted sandy soils. Soil liquefaction was limited to localized areas of backfilled soil, confined within the cohesive natural deposits, where water tends to accumulate.

Lateral spreading cracks and differential ground settlement of 3 to 8 inches were observed along a small wharf. A side slope for the approach road to a bridge experienced slumping. As a result, the road is being relocated further from the slope. Underground pipeline breakage occurred where obstructions (rocks, blocking, etc.) existed beneath the pipes that settled.

Structures

Existing structures on Adak consist of pre-1950 timber frame, 1950-60 reinforced masonry, 1960-80 precast reinforced concrete, and 1970-80 reinforced masonry. Virtually all structures are three stories or less and, except perhaps for the oldest structures, were designed according to the applicable Uniform Building Code (Zone 4). Wind loads associated with wind speeds of 125 miles per hour were typically considered. Many of the structures have been modified to some extent and some experienced various degrees of damage during the 1957 earthquake.

The timber frame structures experienced large deformations during the main shock, but apparently sustained no significant structural damage. Partitions, suspended ceilings, and contents within these buildings were damaged.

Most masonry structures are limited to two stories and have metal deck roofs. A number of the older masonry structures experienced some cracking of their bearing walls. Most cracking was hairline (up to 1/8 inch) in nature, but some cracks were as wide as 1/4 inch. The large AIMD hangar has a two-story shop area consisting of a steel-framed roof and non-bearing, reinforced masonry walls. The walls have a large number of vertical and diagonal cracks, some of which

existed prior to the earthquake. The stairwell area, which included concrete encased steel beams and columns with masonry infill, sustained a proportionately large amount of cracking. Within the building there was also damage to pipe supports and couplings (described in next section). A rod-supported monorail crane vibrated during use after the earthquake and required realignment. A tall cast-in-place concrete wall that separates the shop area from the hangar area experienced substantial working at the horizontal pour-joints at several elevations.

The precast concrete structures on the base performed well, although some working was observed at connectors. At the Navy Exchange, permanent vertical offset, loose bolts, and bent connectors were noted between adjacent precast roof panels of the gas station. Spalling was observed around angles embedded in roof slabs and welded to embedded steel plates in precast concrete beams.

Waterfront structures, including two large piers, performed well. One concrete pier experienced spalling and cracking near an expansion joint as a result of 1 to 2 inches of relative movement of the pier and its approach structure.

Wood-frame family housing units built between 1960-80 sustained minor interior wall cracking as well as differential settlement up to 5 inches. The houses were determined safe for occupancy, but are scheduled to be phased out in the next few years. New prefabricated housing in the construction phase sustained no significant damage; the units were simply resting on cast-in-place grade beams or elevated wood blocks.

Industrial Facilities

On the island of Adak there are diesel generator power plants, steam plants, electrical substations, and a large number of facilities with computer equipment and emergency power facilities. The equipment in these facilities is generally well anchored. Pipes are generally rod-hung with no seismic bracing. The industrial facilities experienced little damage.

Base power remained on during and after the earthquake, but was shut off by Public Works personnel as a precautionary measure during the evacuation to higher ground. Local power losses did occur, and emergency power systems operated well. Thirty-three emergency diesels exist on the island and all were operating properly after the earthquake. Two uninterruptible power supply (UPS) systems performed properly after the earthquake, when power was dropped for reasons not related to the earthquake.

The outboard bearing support (pillow block) for a large, 3000 kW diesel generator at Power Plant 3, which was operating at the time of the main shock, burned its bearing approximately 1 week after the earthquake. The damage was apparently caused by misalignment resulting from the main earthquake or the aftershocks. Two other diesels operating during the earthquake were undamaged.

In the AIMD hangar, a Victaulic coupling failed on a 3-1/2 inch diameter, threaded sprinkler pipe. The office area below was flooded. In addition, a diagonal rod brace 6 inches above the coupling pulled loose from its connection at a steel beam. A T-joint between 1/2-inch and 2-inch diameter welded-copper hot water pipes failed. The pipe is rod-hung and is not braced.

Relay trips occurred at several locations on the island. Two relays (snap action diaphragm switches) on the boilers at Steam Plant 3 tripped and had to be manually reset. A relay/motor controller tripped on a boiler-fan motor at the same plant. One relay in a medium-voltage switchgear tripped at an electrical substation. Once the relays were reset, all the equipment operated properly.