

## Learning from Earthquakes

# Summary Report on the Bojnoord (Northeast Iran) Earthquake of February 4, 1997

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A strong earthquake of magnitude 6.1 on the Richter scale shook a large area in the Khorasan province in northeast Iran on the afternoon of February 4, 1997. This earthquake was preceded by a fore-shock that helped reduce the number of casualties caused by the main excitation. The epicenter of the earthquake was identified to be 25 kilometers northeast of Bojnoord, a city of about 100,000 in the northeast part of Khorasan province. The peak ground acceleration (PGA) close to the epicenter was estimated to be about 0.3g. There were several hundred aftershocks; the strongest measured magnitude 5.7 on the Richter scale.

Due to this earthquake, 88 people died and more than 173 villages experienced considerable damage. From the observed damage extent, an intensity of VIII on the Modified Mercalli scale was assigned to affected areas in the close vicinity of the epicenter (10 kilometer radius).

The following is a summarized version of the IIEES reconnaissance report on the engineering aspects of the earthquake.

### Geological

Bojnoord's earthquake epicenter was located at latitude and longitude of 37.39 and 57.35 degrees respectively. It occurred in the northeastern part of Iran within the Kopeh-Dagh mountain ranges, which have a general east-west direction. These ranges are bound by the Main Kopeh-Dagh fault at its northeast end. The mechanism of this fault is a combination of right lateral strike-slip accompanied by a small component of wide angle reverse movement. Morphological observations are one of the indications of the active status of this fault, and the 1948 earthquake of Eshghabad is strong evidence for this claim. According to the displacements observed along the quaternary faults, ground ruptures along the large historical earthquakes and the occurrence patterns, it can be deduced that many of the geological structures in this area are still active. These structures have formed conjugate faults with general northwest-southeast and northeast-southwest directions.

### Geotechnical

Most of the slope instabilities and landslides occurred along steep slopes, road banks, and unprotected river banks within a radius of about ten kilometers from the earthquake source. Liquefaction was not a big problem in this earthquake because the extent of liquefiable soil layers in this area is negligible.

### Building and Lifeline Damage

Most damage occurred in village adobe houses built on steep slopes

of the mountains in the affected area. These houses are inherently heavy and very weak against earthquake forces. In a village within a ten-kilometer radius of the earthquake source, where one hundred percent of the adobe houses had completely collapsed, the town's only two-story reinforced concrete building survived the earthquake with about 30 percent induced damage.

Bojnoord, about 30 kilometers from the epicenter, was the only city within range of the strong ground shaking. The reported PGA recorded in the city was about 0.2g. None of the houses or government buildings in this city collapsed in the course of this earthquake, but many of them experienced shear cracks and some minor connection failures.

The damage and destruction to one-story village houses indicate the presence of higher frequency components in the frequency content of this earthquake. This observation is also explainable with the stiff and rock-like nature of the area's soil. Preliminary investigations of the main earthquake record and some of its aftershocks show that the ground motions in the area have strong components in the 0.2 to 0.3 second range.

Except for the province's petrochemical facility, located about 15 kilometers from the earthquake epicenter, no other lifeline facility was in the general area affected by the earthquake. Although no significant damage occurred in this facility during the earthquake, the operation was halted for several days after the main shock.

There were a few steel and concrete bridges within the 30 to 40 kilometer radius of the epicenter, but none of them experienced any observable damage