

On the December 26, 2003, southeastern Iran earthquake in Bam region

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Abstract

In this paper, the December 26, 2003, earthquake in the historical city of Bam is studied. The seismological aspects are considered and the earthquake source is introduced. The strong ground motion is studied and its spectra are compared to the design spectra of UBC-97 and the Iranian seismic code, as well as previous earthquakes in Iran. Finally, the structural behavior of buildings and lifeline systems in this region is studied and damages are outlined.

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1. Introduction

On Friday, December 26, 2003 at 1:56:56 GMT (5:26:56 local time), a powerful earthquake struck the southeastern region of Iran. The magnitude of this earthquake is reported to be 6.6 by USGS¹, killing more than 40,000 and injuring more than 25,000 people in Bam Township (Fig. 1).

Preliminary studies show that the S- and P-waves arrived at the surface with about 1 s difference. Hence, the focal depth of this earthquake is estimated to be about 7 km. The epicenter of this earthquake is located at N29.2 E58.4 coordinates as reported by the Institute of Geophysics of Tehran University.

The construction quality in Iran is generally poor, particularly in small towns and villages. The buildings in these regions are highly vulnerable even to moderate earthquakes and most of them completely collapse when subjected to these excitations [5].

With an area of 186,422 km², Kerman province is one of the largest provinces of Iran located in southeast of the country. The population of Bam was approximately 100,000 at the time of the earthquake in 2003 [3].

The city of Bam is well known for its historical castle of Arg-e-Bam, the biggest mud-brick complex in the world, which is about 2000 years old. This historical monument is located on an igneous hill besides the Silk Road and has an area of some 240,000 m². This castle was severely damaged in the 12/26/2003 Bam earthquake as shown in Fig. 2.

2. Seismological aspects

Iran is located on the Alpine–Himalayan earthquake belt and is very often subjected to relatively strong

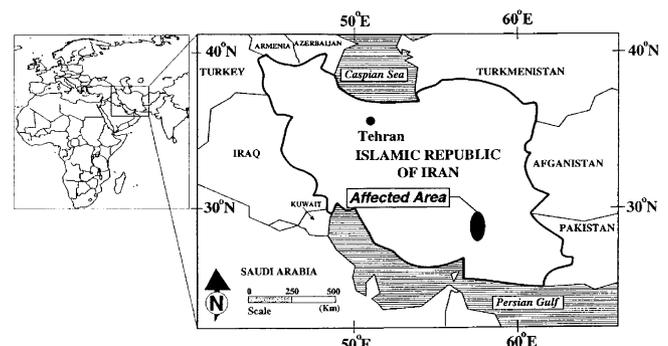


Fig. 1. Map of Iran and affected area (adapted from [1]).

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¹ United States Geological Survey.

(a)



(b)



Fig. 2. Bam Castle at its undamaged state (top) and after earthquake (bottom).

earthquakes. The country is located at the intersection of three tectonic plates, namely Arabian, Eurasian, and Indian plates, which experience relative motions and cause earthquakes (Fig. 3).

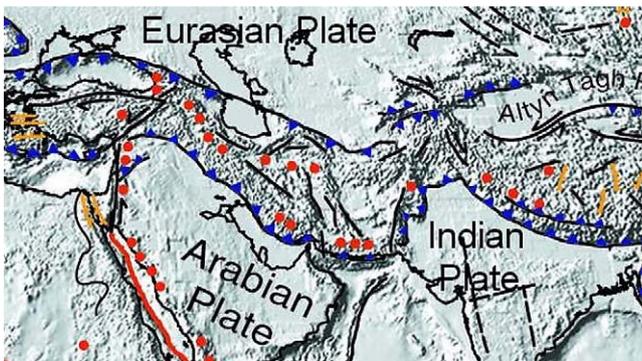


Fig. 3. Plate tectonic map of Iran region.

This earthquake occurred as the result of the stresses generated by the motion of the Arabian plate northward against the Eurasian plate at a rate of approximately 3 cm/year (about 1 in. per year). Deformation of the Earth's crust in response to the plate motion takes place in a broad zone that spans the entire width of Iran and extends into Turkmenistan. Earthquakes occur as the result of both reverse faulting and strike-slip faulting within the zone of deformation [4].

Preliminary analysis of the pattern of seismic-wave radiation from the December 26 earthquake is consistent with the characteristics of an earthquake being caused by right-lateral strike-slip motion on a north-south oriented fault. The earthquake occurred in a region within which major north-south, right-lateral, strike-slip faults had been previously mapped, and the epicenter lies near the north-south oriented Bam fault (Fig. 4) [4]. Field investigations show that the earthquake has occurred on this fault. The intensity of this event is reported to be IX in Bam and Baravat as shown in Fig. 4.

The Bam earthquake-prone area is located in SE Iran, which is an active seismic zone. The city of Bam itself had no reported great historical earthquakes before the event of 12/26/2003. Furthermore, there were many historical adobe masonry buildings in this region since about 2000 years ago. It seemed that these buildings did not experience strong earthquakes in their life, and hence, the Bam fault was identified as an inactive one. For these reasons, the location was not categorized as a region with high seismic activity and highest earthquake risk in the Iranian Seismic Design Code [6]. Towards the northwest of Bam, four major earthquakes with magnitudes greater than 5.6 have stricken cities and villages between 1981 and 1998. The recent earthquake is 100 km south of the destructive earthquakes of June 11, 1981 (magnitude 6.6, approximately 3000 deaths) and July 28, 1981 (magnitude 7.3, approximately 1500 deaths). These earthquakes were

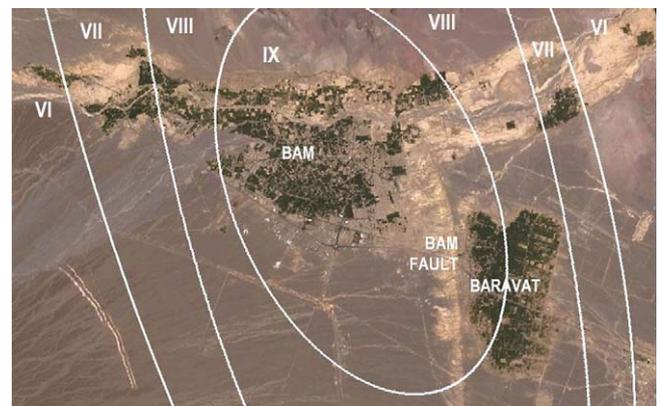


Fig. 4. Modified Mercalli intensities.

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