

## 2.2.5. Seismicity

### (1) Earthquake Catalogue and Seismic Data

Two earthquake catalogues are used in the Study, namely:

- Moinfar, A.A., Mahdavian, A. and Maleky, E. (1994): Historical and instrumental data collection of Iran, Iranian Cultural Fairs Institute.
- IGTU (Institute of Geophysics, Tehran University) (1999)

In and around Tehran, IGTU (Institute of Geophysics, Tehran University) and BHRC (Building and Housing Research Center) have a seismic observation system. BHRC has some strong motion seismographs, but these observed the occurrence of only one earthquake in Manjil in 1990.

Moinfar et al.(1994) collected many worldwide references and compiled an earthquake catalogue for Iran. One of the major sources is Ambraseys and Melville (1982), who retrieved macro seismic data from a variety of documents and compiled them. This catalogue covers activity from the 7th Century through 1992 and includes almost 5,000 events. The data included in this catalogue consist of date, time, epicentre, focal depth, magnitude, etc. Iran has a long history, and there is much historic literature on earthquakes in ancient times. Instrumental records of earthquakes in Iran began around the beginning of this century. Ambraseys and Melville (1982) also includes instrument-recorded data up to 1979. Table 2.2.3 shows an example of the catalogue entries. It shows that, for some earthquakes, several organisations or researchers report different epicentres and magnitudes. Figure 2.2.6 shows the distribution of epicentres in the Tehran vicinity. In this figure, the average value of several epicentres and magnitudes, if any, are used. Surface wave magnitudes ( $M_s$ ) and body wave magnitudes ( $m_b$ ) are converted to the moment magnitude according to Utsu (1982). The epicentre of the earthquake in 1830 is modified after Berberian and Yeats (1999).

Table 2.2.4 shows a list of earthquakes which occurred near Tehran. Four earthquakes of with a magnitude above seven occurred in 855, 958, 1177 and 1830.

IGTU (Division of Seismology, Institute of Geophysics, Tehran University) has a seismic network around Tehran. Two stations are located within the City. One is the Tehran station (THE, 35.7367N, 51.3817E) and the other is the Shahrān station (SHR, 35.8061N, 51.2889E). Seismic observations were started in 1959 using an analogue recorder, which was replaced with a digital recorder in 1996. Over 1000 earthquakes occurred within a 100 km radius from the centre of Tehran between 1996 and 1999. Three-component time histories for those earthquakes are recorded in digital format. Data recorded at SHR are used in this Study. Table 2.2.5 shows the number of earthquakes by magnitude, while

Table 2.2.6 gives a list of catalogued earthquakes with magnitudes over four. An epicentre distribution map is shown in Figure 2.2.7. Most of the earthquakes had magnitudes less than 3.5. Micro-earthquake activity is observed in the following areas.

- Southeast Tehran
- South Tehran, near the North and South Ray faults
- Far eastward of Tehran, alongside the Mosha Fault

**Table 2.2.3 Example of Earthquake Catalogue**

No	Date			Time			Epicenter		Depth (km)	Magnitude		Epicentral Intensity	Reference	Area or Quality
	Year	Month	Day	Hour	Minute	Second	Latitude	Longitude		Ms	mb			
151	1485	8	15											
	1485	8	15	18	0		36.7	50.5		7.2		2	AMB	a
152	1493	1	10											
	1493	1	10	6	0		33	59.8		7.0		2	AMB	b
153	1495													
	1495						34.5	50		5.9			AMB	c
154	1497													
	1497						27.2	56.3		6.5		2	AMB	c
155	1498													
	1498						37.2	55.2		6.5		2	AMB	c
331	1990	11	6											
	1990	11	6	18	45	53	28.23	55.47	16	6.6	6.1		ISC	
	1990	11	6	18	45	52	28.25	55.46	11	6.7	6.2		NEIC	DARAB
	1990	11	6	18	45	54	28.3	55.48	25	6.8	6.3		BJI	
	1990	11	6	18	45	54	28.24	55.54	25	6.7	6.6		MOS	
	1990	11	6	18	45	58	28.29	55.47	32				CSEM	
	1990	11	6	18	45	59	28.06	55.25	15				HRVD	
332	1990	11	6											
	1990	11	6	19	30	20	28.2	55.37	18	5.7	5.3		ISC	
	1990	11	6	19	30	18	28.03	55.47	22	5.5	5.6		MOS	
	1990	11	6	19	30	20	28.4	55.29	19	5.3	5.7		BJI	
	1990	11	6	19	30	20	28.24	55.37	18	5.7	5.4		NEIC	DARAB
	1990	11	6	19	30	26	28.3	55.37	48				CSEM	

Source: Moïfar et.al. (1994)

**Table 2.2.4 List of Earthquakes near Tehran**

year	month	day	Mw	Latitude (degree)	Longitude (degree)	Epicentral distance (km)	Assumed PGA (gal)
743			7.1	35.30	52.20	81	49
855			7.0	35.60	51.50	12	412
856	12	22	7.9	36.20	54.30	263	17
864	1		5.4	35.70	51.00	41	34
958	2	23	7.7	36.00	51.10	46	161
1119	12	10	6.4	35.70	49.90	140	13
1177	5		7.1	35.70	50.70	68	63
1301			6.6	36.10	53.20	164	12
1485	8	15	7.1	36.70	50.50	140	23
1608	4	20	7.6	36.40	50.50	116	44
1665			6.4	35.70	52.10	59	44
1687			6.4	36.30	52.60	123	15
1809			6.4	36.30	52.50	116	17
1825			6.6	36.10	52.60	113	21
1830	3	27	7.0	35.80	51.70	25	208
1868	8	1	6.3	34.90	52.50	130	13
1930	10	2	5.4	35.78	52.02	52	24
1957	7	2	6.7	36.20	52.60	118	21
1962	9	1	7.1	35.54	49.39	187	15
1983	3	26	5.3	36.12	52.21	83	10
1990	6	20	7.4	36.96	49.39	232	14
1994	11	21	4.5	35.90	51.88	45	14

Source: List from Moinfar et al. (1994)

Location of 1830 earthquake is quoted from Berberian et al.(1999)

Magnitudes and PGA were calculated by Study Team

**Table 2.2.5 Number of Earthquakes (100 km from Tehran, from 1996 to 1999)**

Magnitude mb	Number of earthquake
0<mb≤1	29
1<mb≤2	670
2<mb≤3	350
3<mb≤4	44
4<mb≤5	5

Source: IGTU (1999)

**Table 2.2.6 List of Earthquakes (mb>4, 100 km from Tehran, from 1996 to 1999)**

Date	Time	Latitude	Longitude	Depth (km)	mb
1997/6/7	29:47.3	36.17	50.48	7.9	4.2
1997/11/5	42:55.2	35.01	51.55	23.3	4.6
1998/1/9	06:08.5	36.47	52.24	6.5	4.7
1998/12/3	13:27.5	36.17	50.97	17.9	4.5
1999/3/26	06:48.5	36.37	50.26	9.1	4.5

Source: IGTU (1999)

## (2) Earthquake Damage in Tehran

Fortunately, Tehran has not suffered severe damage due to an earthquake in over 150 years. Based on the historical earthquake catalogue, earthquakes that could likely affect Tehran can be speculated as follows:

Due to the spatial extent of the Greater Tehran area, a sample site was selected for PGA computations. This point was the Ferdowsi Square, a highly populated area near the City Centre, with a latitude of 35.70N and a longitude of 51.45E. PGA was calculated using Campbell et al. (1997) for a dip-slip type earthquake and alluvial ground conditions. Details are explained in Chapter 3, section 3.3.1.

The largest Peak Ground Acceleration (PGA) was 412 gal, observed in the earthquake of 855. The second largest PGA observation occurred in 1830, and the third largest in 958. According to Berberian (1999), the events in the years 958, 1830 and 1665 occurred in a segment of the Mosha Fault. It has also been said that the event in 855 may have occurred at the South Ray Fault. As for the North Tehran Fault, it is not clear, but the events in 958 and 1177 are correlated with this fault according to Berberian et al. (1983).

The following excerpts Ambraseys and Melville (1982) describe the damage caused by these historical earthquakes:

### **Year 855 :**

A major earthquake in Ray destroyed many houses and caused a large number of casualties in the district. The shock was strongly felt, perhaps with some damages in Qum and Kashan. Aftershocks continued for more than a month.

### **Year 958 :**

There was a catastrophic earthquake in the northern part of central Persia. It destroyed all villages in the districts of Ray and Taliqan, both in the plains and in the mountains, and much of the city of Ray was totally ruined, heavy casualties being reported in both districts. In Taliqan, there were only 30 survivors and in the district of Ray, 150 villages were destroyed, one village in the mountains being overwhelmed by landslides. A mountain near Ray was fissured and water spouted out of the ground. In the mountains of Ruyan to the north of Ray, large-scale landslides blocked the course of a river whose waters receded to form a lake. Damage extended to the northwest into Dailam and south to Qum and Kashan. The shock was possibly felt in Isfahan and as far west as in Baghdad. Damaging aftershocks continued for forty days and were felt throughout north-central Persia. It is possible that the earthquake was connected with an abnormal drop in the level of the Caspian Sea, which, however, seems to have occurred before the event.

**Year 1177 :**

An earthquake destroyed many towns of Persian Iraq, along the southern slopes of the Alburz up to the region beyond Ray. The cities particularly devastated were Qazvin and Ray, where many people were killed. Internal evidence indicates that the Ray area, eastern Buyin Zahra and the Karaj settlements were worst affected.

**Year 1665 :**

There was a destructive earthquake in Damavand and its dependencies. The earthquake destroyed many houses and buildings in Damavand. An inscription in the Masjid-i jami refers to the earthquake damage and records the restoration work done in 1670.

**Year 1830 :**

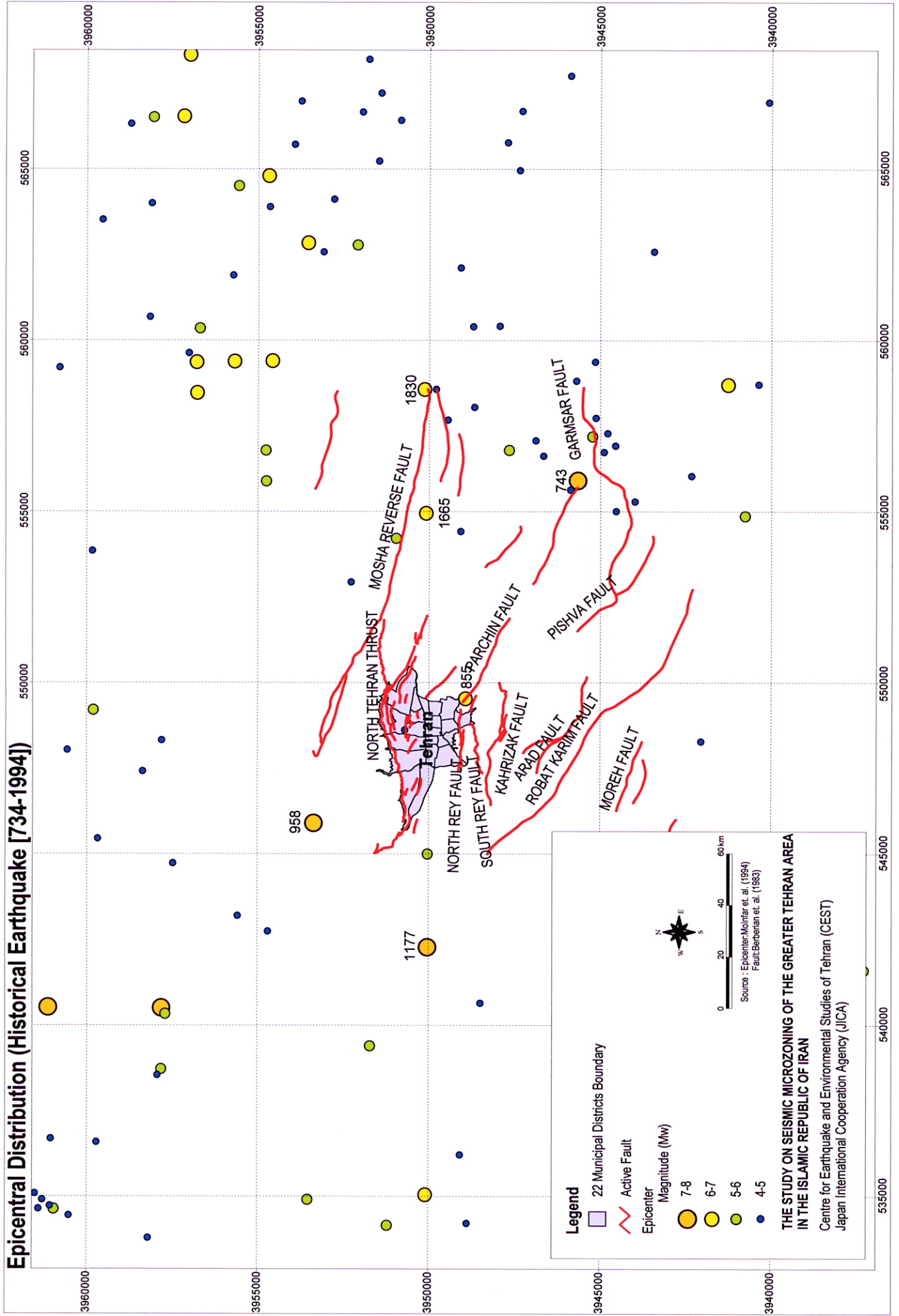
On the morning of 2 Shawwal 1245, a major earthquake in the southern Mazandaran almost totally destroyed the districts of Shamiranat and Damavand, east of Tehran. About 70 villages, lying eastwards of the Jai-rud, along the routes via Damavand to Simnan and Damghan, were ruined and more than 500 people were killed in Damavand alone. Damage extended to Jaj-rud, where the Caravanserai was shattered and in Tehran, many old houses collapsed killing about 30 people. Not a single house in the capital escaped from the damage and part of the palace, together with many adjoining houses and part of the bazaar were thrown down. The Arg, the Great Audience Hall, a number of mansions, as well as the old British Embassy building were badly damaged and garden walls were levelled off on the ground. The loss of property in Tehran was estimated at half a million tomans. The shock caused some damage to a number of public buildings in Amul, Sari and Damghan and triggered rock-falls that blocked the passes on the Harhaz and Talar-rud roads to the north. The earthquake was felt as far as Baku and was followed by violent aftershocks that caused additional damage in the Shamiranat region and great panic in Tehran, where a large proportion of the population camped in tents. The royal court also encamped in the open courts of the Arg. The aftershock of 6 April destroyed the old caravanserai totally at Jajrud.

As have been mentioned, Tehran has not suffered severe damage in over 150 years, but there occurred many devastating earthquakes in recent years in other regions of Iran. In 1997, three disastrous earthquakes occurred. On 4 February, a magnitude 6.1 earthquake rocked Northern Khorasan and East Mazandaran in northeast Iran. In total, 91 people died and 5,500 houses collapsed. On 28 February, an earthquake of magnitude 5.5 hit Ardebil and Meshkin-shahr in northwest Iran. A total of 800 people died and 8,500 houses, 100 % of houses in the area, collapsed. On 10 May, a large earthquake of magnitude 7.3 hit Birijand and Qaen in the southern part of the Khorasan Province in eastern Iran. The overall damage was 1,568 dead and 13,605 houses completely destroyed.

On 21 June 1990, a magnitude 7.3, large earthquake hit the Manjil region. The damage was devastating, 37,000 people died and 100,000 houses collapsed. After the disastrous earthquake, many academic investigations were carried out and many reports were written. However, there are only a few quantitative studies on vulnerability functions of different types of structures. It is necessary to continue research of this type with relevant organisations in Iran.

Figure 2.2.6

**Epicentral Distribution (Historical Earthquake [734-1994])**



**THE STUDY ON SEISMIC MICROZONING OF THE GREATER TEHRAN AREA IN THE ISLAMIC REPUBLIC OF IRAN**  
 Centre for Earthquake and Environmental Studies of Tehran (CEST)  
 Japan International Cooperation Agency (JICA)

Figure 2.2.7

**Epicentral Distribution (1996-1999)**

**Within 100km from Center of Tehran**

