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TABAS-E-GOLSHAN (IRAN) CATASTROPHIC EARTHQUAKE OF 16 SEPTEMBER 1978; A PRELIMINARY FIELD REPORT

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INTRODUCTION

The Tabas-e-Golshan catastrophic earthquake of 16 September 1978 of magnitude Ms=7.7, the largest shock which has ever been recorded in Iran, occurred in Khorassan Province east central Iran (Fig. 1). The main shock took place in the evening, when most people were in their houses, at 19.38.18 local time (15.35.58 GMT), without any felt foreshock. The preliminary instrumental epicentre is recorded at 33.145 N and 57.340 E with a focal depth estimated at 42 km by the National Earthquake Information Service of the USGS. The earthquake was preceded by a strong roaring noise described as like the firing noise of fifty cannons by many survivors in Tabas and in the adjoining villages By timing peoples' actions in a reconstruction of the event in the epicentral region, the time lapse between the roaring noise and first arrival of the tremor was estimated at 4 - 4.5 seconds. Some of the survivors heard the roaring noise while lying on the ground and they described it as coming from the interior of the Earth. As the warning given by this noise was short, few people reacted fast enough to save their lives by running outdoors.

Although the earthquake occurred in a rather isolated and thinly populated area, it destroyed or severely damaged about ninety villages, slightly damaged another fifty villages in the region and completely demolished the ever-green oasis town of Tabas where 85 % of the inhabitants were killed (11,000 out of 13,000). Total fatalities were over 20,000 (see Table 1). The lunar eclipse two hours after the main shock, together with the breakdown of the Tabas Power Station during earthquake, made it impossible for survivors to start the immediate rescue operation of their families and neighbours. The earthquake which was strongly felt over an area of 1,130,000 km^2, destroyed over 15,000 housing units and thirty qanats (underground water canals) in the epicentral region.

The earthquake was associated with 85 km of surface rupture of thrusting along an existing but unrecognized late-Quaternary fault.[1] The maximum damage zone and highest intensity was experienced along this fault and affected areas roughly 30 km away from it.

BACKGROUND

Iran is situated in a highly seismic part of the world, and has been frequently struck by catastrophic earthquake during recorded history. These earthquakes have resulted in great loss of life, and, in rendering large numbers of people homeless and disrupting the agricultural and individual basis of their lives, have been wasteful of national resources. Probability of earthquake occurrence and high magnitude of resultant damage and destruction is high and should be taken very seriously. Since the beginning of this century at least 72,222 people have lost their lives during earthquakes in Iran [2,3] (Fig. 2 and Table 2).

Tabas-e-Golshan, the largest settlement in the area which was demolished by the earthquake, was an ancient and historic oasis located between Iran's vast desert of Great Kavir and the Dasht-e-Lut, 550 km southeast of Tehran. No historical (pre-1900) earthquake is known from Tabas-e-Golshan and the region was not recognized as a high-risk disaster area.[1] This may be due to its remote situation isolated from the rest of the country by deserts, to the lack of adequate historical seismic information, or to the long recurrence period of major seismic events in this part of the country.

Tabas-e-Golshan town, known as the "Khorassan Gate" by the Arab invaders in the 7th Century, was the first town in the Khorassan Province of Iran which was conquered by Abdolah ebn-e Badil ebn-e Vargha, the commander of the Islamic Arab army, in the time of Khalife Osman ebn-e Afan (23-35 A.H.) in the year of 29 A.H. (650 A.D.).[4] Nasser Khosrow 394-481

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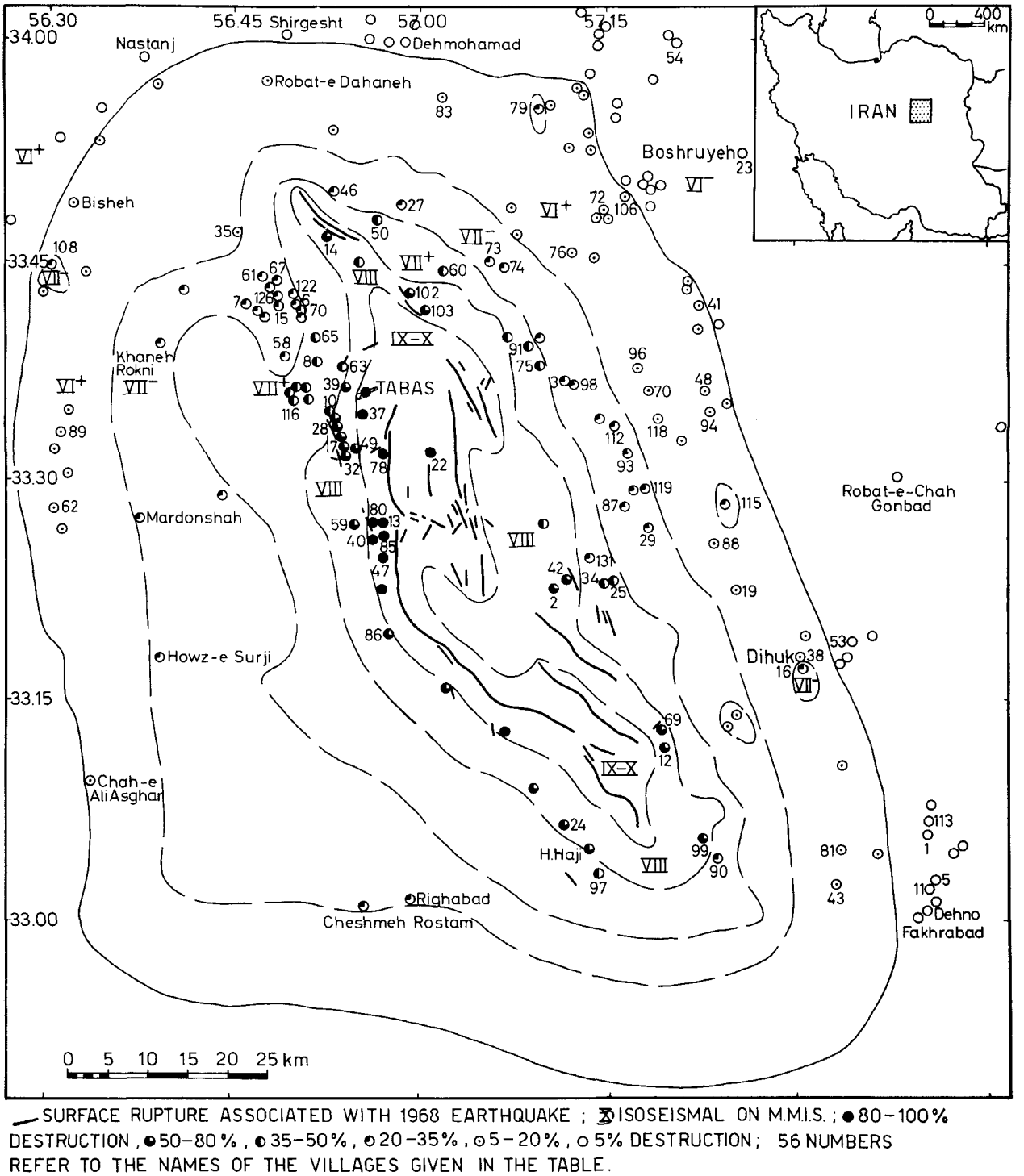

Fig. 1. Isoseismal map and damage distribution in the epicentral region of Tabas-e-Golshan earthquake of 16 September 1978.

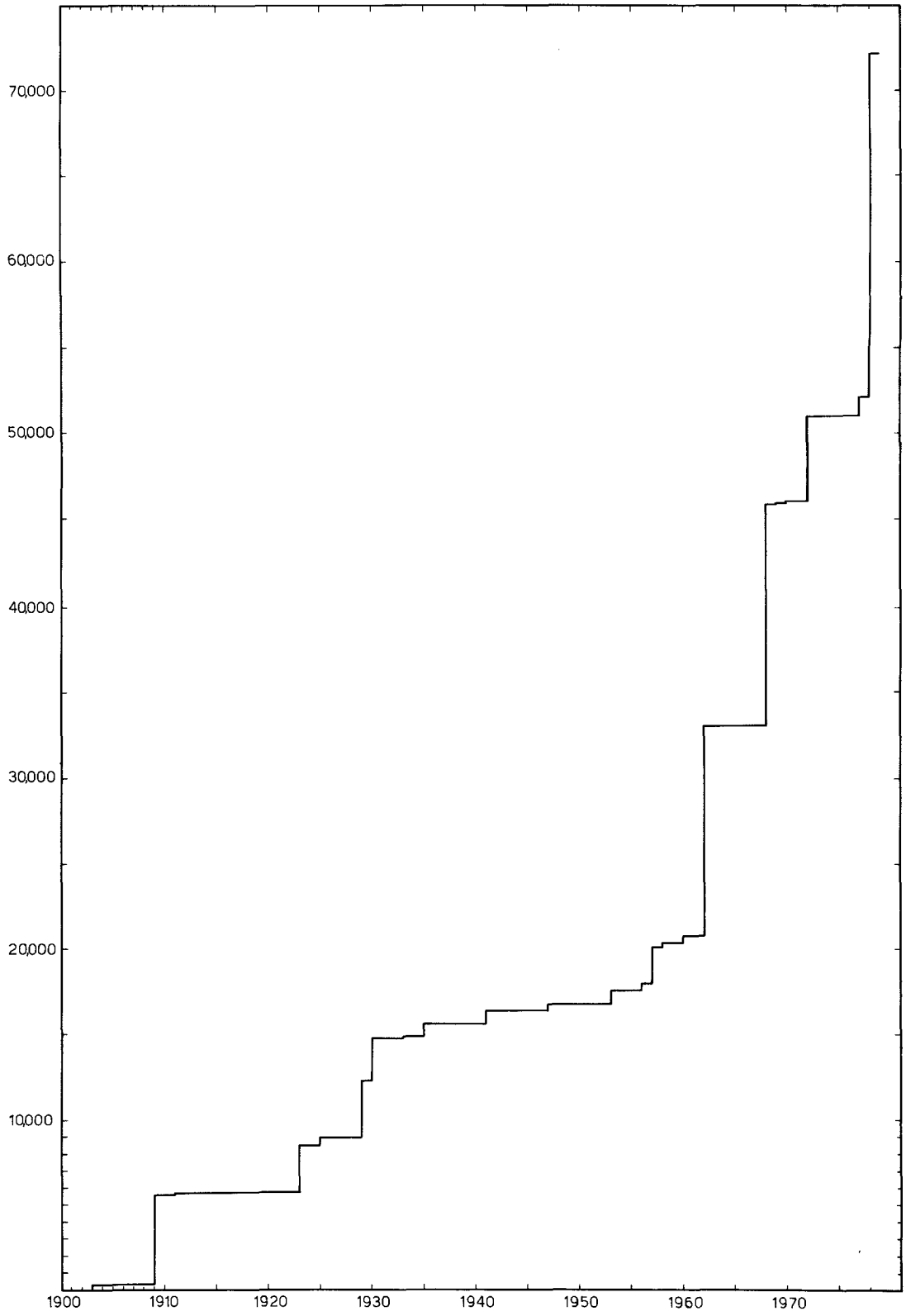

Fig. 2. Total number of deaths during Iranian earthquakes from 1903 to 1978 (also see Table 2).

Table 1. Damage and casualties caused by the Tabas-e-Golshan (Iran) earthquake of 16 September 1978.

No	Village	People Dead	% Dead	% Houses Des	Dam	Fis	Tent	Remarks
1	Abasabad (Seyedabad)	–	–	–	–	+		
2	Abbassabad	2	10	50	+	+		Qanat collapsed
3	Abru	–	–	25	+	+		
4	Ahjui	–	–	–	–	+		
5	Ahamadabad	–	–	–	–	+		
6	Ahmadieh	–	–	35	+	+		
7	Akbarabad	–	–	30	+	+		Qanat collapsed
8	Aliabad (NW Jamaz)	–	–	25	+	+		
9	Aliabad (S. Raqeh)	–	–	–		+	9	
10	Allahabad	16	5.3	75	+	+		
11	Arababad	–	–	–	–	+		
12	Baghamza	15	15	80	+	+		Landslide, rockfall; spring water in limestone mt. increased but decreased in the palm trees field.
13	Baghestan-e-Korit	300	60	100	+		10	
14	Baharesian (Old site)	–	–	75	+	+		Destroyed in 1939.06.10 earthquake, location changed
15	Baharesian (New)	–	–	25	+	+		
16	Bazg	45	11	50	+	+	120	
17	Beheshtabad	?	?	65	+	+		Qanat collapsed
18	Bidak	–	–	–	–	+	2	Qanat collapsed
19	Bidkuh	–	–	–	–	+		Qanat water flow decreased
20	Bisheh	–	–	–	–	+		
21	Bonabad	–	–	–	–	+		Qanat water dried
22	Boraf	?	?	90	+	+		
23	Boshruyeh Town	–	–	1	+	+		
24	Chah-e-Sadegh	–	–		+	+		Lurching cracks, mud-salt volcanoes.
25	Chiruk	17	3.2	70	+	+		Landslide, rockfall; water flow decreased in highland spring and increased in the lowland one
26	Dahaneh	–	–	–	–	+		5 Killed in Tabas.
27	Dareh Bid			30	+	+		
28	Dasht-e-Gharan	300	30	75	+	+		
29	Dashtu	?		25	+	+		
30	Deh-Mohamad	–	–	–	–	+		
31	Dehno (Raqeh)	–	–	–	–	+	4	
32	Dehno Fatemeh Barat	33	23	75	+	+	27	Ground roaring noise heard prior to the main shock; abnormal animal behaviour
33	Dehno (Zenoghan)	–	–	–	+	+		
34	Dehshib	2	11	35	+	+		2 Killed in Tabas
35	Dehshur	–	–	–	+	+	4	
36	Delbaran	–	–	–		+		Qanat water dried
37	Diheshk (Dehestak)	2000	52	100	+			
38	Dihuk	15	1.2	25	+	+	150	
39	Dowlatabad	?	?	60	+	+		
40	Ebrahimabad	100	20	100	+			100 Injured
41	Ereshk	–	–	1	+	+		
42	Esfahk	102	17	70	+	+		4 Guests killed; abnormal animal behaviour
43	Esfandiar	–	–		+	+		
44	Esmailabad	–	–	–	–	+		
45	Espasko	–	–	–	–	+		Destroyed in 1939.06.10 earthquake[1]
46	Ezmaighan	–	–	–	20	+	5	Spring water flow increased
47	Fahalanj	2500	71	100	+			
48	Fathabad	–	–	–	+	+		
49	Firuzabad	–	–	80	+	+		
50	Gasht	–	–	–	20	+		
51	Gazu	?	?	20	+	+		
52	Gazvar	–	–	–	–	+		
53	Ghanbarabad	–	–	–	–	+		
54	Ghaniabad	–	–	–	–	+		
55	Hajabad	–	–	3	+	+	9	
56	Halvan	–	–	–	+	+	10	Qanat collapsed
57	Hassanabad	?	?	30	+	+		
58	Havas	–	–	30	+	+		
59	Hematabad	?	?	60	+	+		
60	Hermok	–	–	20	+	+	5	Qanat collapsed
61	Hosseinabad	–	–	25	+	+		
62	Howz-e-Nuri	–	–	+	+	+		

Table 1 (cont)

63	Jamz	22		35	+	+		18 Killed in Tabas; lurching cracks
64	Jafari	44		70	+	+		Killed in Tabas
65	Javadieh	2	3.3	45	+	+	6	2 Killed in Shirabad
66	Jili	–	–	–	+	+	4	
67	Jokhah (Chahar Deh)	9	1.5	28	+	+	100	
68	Joriz	?	?	55	+	+		
69	Kalateh	8	14	80	+	+		Rockfall, landslide
70	Kamnai	–	–	+	+	+		
71	Kardabad	–	–	30	+	+		3 Injured
72	Khanik	1	1	25	+	+	24	1 Injured
73	Khorovan Olia			30	+	+		Sheep and cows killed
74	Khorovan Sofla	2	4	30	+	+		Sheep and cows killed; 2 shepherds killed by rockfalls in mountains
75	Kharv	2	1.8	35	+	+		3 Injured; Landslides
76	Khodaafarid	–	–	–	+	+	10	
77	Khoramabad	–	–	–	+	+		
78	Khosrowabad	500	50	100	+			Qanat water dried
79	Korond	7	1.4	40	+	+		1 Injured; Qanat and spring water flow decreased for the first 5 days and increased later on
80	Korit	2000	60	100	+		60	500 Badly injured
81	Marghub	–	–	1	+	+		Spring water flow increased
82	Mazrae Akbarabad	–	–	–	–	+		Qanat collapsed
83	Malvand	–	–	–	–	+		
84	Mehdiabad			20	+	+		
85	Mir Omaru	80	53	100	+	+		
86	Moazamabad	–	–	50	+	+		Inhabitants left to Fahalanj in 1977
87	Mowdar	2		35	+	+		Landslide and lurching
88	Mohamadabad	–	–	–	–	+		
89	Mohamadieh	–	–	–	+	+		
90	Neysan	–	–	–	+	+		Spring water flow increased
91	Niaz	–	–	55	+	+		Inhabitants were in the fields during earthquake; rockfall blocked the road
92	Niknam	–	–	–		+		
93	Niuj	?		25	+	+		
94	Onj-e-Bala	–	–	–		+		Qanat dried for a few hours
95	Onj-e-Pain	–	–	–		+		Spring water increased
96	Palangabad	–	–	–	20	+		Sheep were killed
97	Parvardeh	–	–	25	+	+		Lurching and mud-clay volcanoes blocked the road
98	Pedanaki	?		20	+	+		
99	Peykuh	36	12	55	+	+		Qanat water increased; 15 injured
100	Peyassan	–	–	–		+		
101	Pirhajat	–	–	–	+	+	4	
102	Posha-e-Bozorg	5	12	75	+	+	8	1 Killed in Tabas and 4 people from Tabas killed here; lurching cracks; Qanat collapsed; damaged in 1974.06.17 and 1974.06.24 earthquakes[1]
103	Posha-e-Kuchek	–	–	75	+	+		Qanat collapsed; lurching cracks; mud flow in dry river bed; damaged in 1974.06.17 and 1974.06.24 earthquakes[1]
104	Qanbarabad	–	–		+	+	9	
105	Qavamieh	–	–		+	+		
106	Raqeh	8	0.6	25	+	+	225	1 Killed in Korond; 5 injured; Qanat water flow decreased
107	Razavieh	–	–	–		+		
108	Robat-e-Gur	?		50	+	+		
109	Saadatabad	?	?	50	+	+		
110	Sar Tanureh	–	–	–	–	+		
111	Sekandarabad							Ancient ruined village near Esfahk
112	Senjetu	?		25	+	+		
113	Seyedabad	–	–	–	–	+		
114	Shadu	–	–	20	+	+		
115	Shahzedhali	2	3.3	25	+	+	7	
116	Shirabad	2		30	+	+		2 Guests killed
117	Soleymanabad			20	+	+		
118	Sonj	–	–	25	+	+		
119	Sorond	3	2.4	35	+	+		
120	Tabas-e-Golshan	11000	85	100	+			
121	Taghiabad	?		35	+	+		
122	Tajabad (W Tabas)	–	–	25	+	+		

Table 1 (cont)

123	Tajabad (SE Korond)	–	–	–	+	+		
124	Tajarg	–	–	–	+	+		
125	Targhinan	2	0.6	35	+	+	20	
126	Tashkanan	27	14	35	+	+		1 House collapsed in 1939 earthquake[1]
127	Tukhanik	–	–	–	–	+		
128	Yegin	1	0.8		+	+	24	
129	Zahruj	–	–	–	+	+		
130	Zenoghan	–	–	–	+	+		
131	Zerk	4	10	40	+	+		

Total casualty at least 19,214
More than 15,000 housing units destroyed
More than 20 Qanats collapsed

Abbreviations used in this table: –: no casualty or no destruction and damage; Dam: damaged; Des: destroyed; Fis: fissured; Tent: tents supplied. List is not complete

Table 2. Casualty figures during the major Iranian earthquakes from 1903 to 1978

Date	Casualty	Region	Date	Casualty	Region
1903.09.25	300	Turshiz	1957.12.31	3	Deh Kohneh
1909.01.23	5500	Silakhor	1958.08.16	191	Firuzabad
1911.04.18	60	Ravar	1958.09.21	16	Karksar
1913.03.24	11	Reyhan	1960.04.24	400	Lar
1923.05.25	2219	Kaj Derakht	1961.06.11	60	Deh Kuyeh
1923.09.17	157	Qaleh Jaq	1961.10.14	2	Aliabad Magh
1923.09.22	260	Qaleh Asgar	1962.04.01	3	Mussavieh
1923.11.14	1	Abassabad	1962.09.01	12225	Buyin Zahra
1925.12.10	2	Shirvan	1962.10.05	6	Ahmadabad
1925.12.14	500	Bajestan	1963.03.31	4	Dahaneh Ojaq
1925.12.18	2	Ahram	1963.07.29	5	Gahkom
1928.03.08	4	Nehbandan	1964.12.22	2	Fatuiyeh
1928.08.21	10	Neishabur	1965.02.10	5	Alikhalaj
1929.05.01	3257	Baghan-Germab	1968.04.29	37	Bedavli
1929.07.13	5	Faruj	1968.08.31	12000	Dasht-e-Bayaz
1929.07.15	9	Londeh	1968.09.01	730	Ferdows
1930.05.06	23	Salmas	1968.09.14	2	Tang-e-Ruin
1930.05.06	2514	Salmas	1968.09.14	1	Mobarakabad
1930.05.08	4	Shekaryzi	1969.01.03	50	Dahaneh Ojaq
1930.10.02	3	Ah-Mobarakabad	1969.04.02	2	Mirza Rashin
1933.11.28	7	Behabad	1970.03.14	4	Badalan
1935.03.05	60	Alborz	1970.07.30	200	Qarnaveh
1935.04.11	700	Alborz	1971.02.14	1	Hunestan
1936.06.30	12	Abiz	1971.04.12	2	Tazarj
1941.02.16	680	Mohamadabad	1971.08.09	1	Babol Kenar
1941.04.13	6	Dowatabad	1972.04.10	5000	Qir
1944.04.05	20	Gorgan	1973.11.11	1	Qeshlaq
1945.05.11	8	Garmsar	1975.03.07	7	Sarkhun
1945.09.27	2	Hariman	1975.09.21	2	Sarpir
1946.02.10	3	Giv	1976.11.07	6	Vondik
1947.09.23	400	Dustabad	1977.03.21	152	Khurgu
1950.01.22	30	Dehno, Assalu	1977.03.22	2	Abpish
1953.01.15	11	Goder	1977.04.06	348	Naghan
1953.02.12	930	Torud	1977.05.26	3	Mokhor
1954.08.20	1	Tonbak	1977.12.19	551	Bob-Tangol
1955.11.24	1	Musha	1978.09.16	20000	Tabas-e-Golshan
1956.10.31	270	Gowdeh	1978.12.15	100	Izeh
1957.04.23	16	Kachu Mesqal			
1957.07.02	970	Sangechal			
1957.09.05	1	Jahrom	Total	72222	People killed in Iran from 1903 to 1978
1957.12.13	1130	Farsinaj			

A.H.) visited Tabas in the 11th Century and described it as "a town resembling a village with little water and little agricultural acitivity; with a rigid mountain on its east named "Shotori".[5] According to Estakhri (in Mujamolboldan of Yaghut), [4] 'Tabas is a small town, smaller than Qaen, and the buildings are made of sun-dried mud bricks with mud mortar".[4] The Minaret of Manasser school (Menar-e-Madresse), Arg of Tabas and two other Minarets and the mosque were monuments built in the time of the Seljuk dynastyyin Tabas between 11th and 13th Centuries.[4] These buildings which were undamaged until the recent catastrophic earthquake, show that there have been no destructive earthquakes in Tabas since, at least, the 11th Century.

ABNORMAL ANIMAL BEHAVIOUR

Many villagers in the central part of the epicentral region, noticed that the cows became restless around 13.00 local time of the earthquake day and were mooing continuously until evening. Local people at first thought the cows were thirsty so led them to the water canal but the cows refused to drink. The villagers then thought that the cows became mad due to the midday sunshine. Strange animal behaviour was also noticed amongst the sheep. Usually each evening sheep come back from the field and go to their sheep-fold. The Dehno villagers noticed that the sheep refused to enter their sheep-fold, again the villagers thought they might be thirsty, therefore, they led the sheep to the water canal. but like the cows they refused to drink and suddenly they were thrown on the ground by the mainshock.

In the whole region, almost no abnormal behaviour was noticed amongst other animals especially dogs and donkeys. The only case of abnormal dog behaviour was reported by butcher in Espahk village; he was working in his shop and the dog was resting inside. Suddenly the dog started barking and jumped out of the butchery. The butcher followed the dog to find out the cause of its restlessness. After a few seconds the shop collapsed completely due to the earthquake.

DAMAGE TO HOUSES

Although the earthquake took place in a sparsely populated and remote area, it destroyed or severely damaged ninety villages together with Tabas town, slightly damaged another fifty villages and demolished more than 15,000 housing units (Table 1 and Fig. 1). Had the earthquake happened in a populated area such as Tehran, the casualty figures and destruction would have been infinitely greater.

The settlements in the Tabas region, like the other parts of the country, conform to a uniform traditional building style with small variations. The style in the epicentral area, including Tabas town consists of sun-dried brick with wooden beams or domed heavy roofs, mud-wall constructions and masonry buildings with mud mortar. Only some schools and some governmental buildings in the town or large villages were brick masonry with steel-beam jack-arch roofs. The walls are usually made of *in situ* cast sun dried clay bricks or a mixture of stone and mud. In Tabas great care was taken by the officials to preserve the original adobe structures of the old and traditional style by enforced building codes. For this reason the steel-beam jack-arch roofs were built on top of the sun dried mud brick walls (Fig. 3.). These walls, unable to sustain the lateral forces of the earthquake, were completely destroyed. All the adobe houses in the earthquake region were completely destroyed or damaged beyond repair. However, the proper brick masonry buildings suffered far less damge.

1. *Adobe and masonry constructions*

The adobe brick constructions with domed or wooden beam roofs together with the stone masonry houses with clay mortar, comprise 98 % of the houses in the area (Fig. 4). The walls are of adobe brick and clay mortar, and the roofs of wooden beams or domed, covered by clay and straw and tamped earth. New layers are added annually to the roof as a protection against rain and snow percolation. The houses are very simple in plan and do not rise higher than the ground floor. They cluster together to form settlements (Fig. 5). Occasionally the settlements show the more orderly arrangements of a village with narrow streets and joined houses. In masonry houses, usually rounded stones of different sizes are used with clay mortar. Most of these constructions are now completely destroyed, or are seriously damaged and unsafe as dwellings (Figs 3, 4 and 5). In Tabas, the kiln bricks were used for facing the external walls of adobe houses without any adequate connection between them. It was observed that cracks usually started from the corners or openings in houses and progressed into the walls, causing the collapse of the heavy roofs.

The high ratio of death to injuries emphasizes that the traditional adobe houses of the devastated region, with their weak walls and heavy earthen roofs, offer little resistance to shocks. Even an earthquake of much lower magnitude could cause the same disaster. Since the villagers cannot afford to use better or expensive building materials to build their houses, the traditional adobe constructions should be redesigned and/or walls should be strengthened to sustain roofs in the event of an earthquake. This should be done in a simple and cheap way that the villagers can both afford and follow construction regulations. As in previous earthquakes in Iran, the traditional dome shaped water reservoirs in Tabas region (a simple dome built directly on the ground without walls), stood up without damage (Fig. 6) and the dome vault houses showed a better resistance to earthquakes than barrel vaults (Fig. 5). These observations should be considered during redesigning of the adobe structures in Iran.

2. *Brick masonry buildings with steel-beam jack-arch roofs*

Most of the schools and some governmental buildings in the area were built of brick masonry. Usually a steel concrete

Fig. 3. Steel-beam jack-arch roof constructed on the adobe walls in Tabas is completely collapsed during the earthquake.

Fig. 4. Complete destruction of the adobe houses in Korit village south of Tabas (No. 80 in Fig 1 and Table 1).

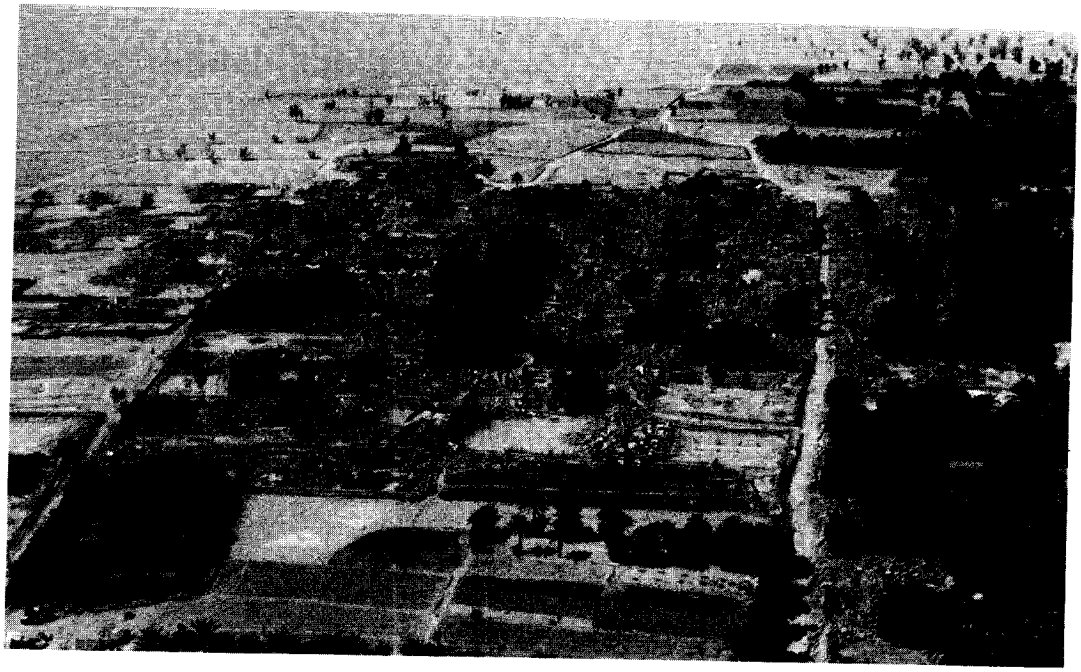

Fig. 5. Aerial view of Fahalanj village (No. 47 in Fig. 1 and Table 1) with complete destruction of adobe houses. Note a few dome vault houses which stood up during the earthquake.

frame or ring supported the steel-beam jack-arch type roof. In this case there was no anchor between the roof and the reinforced concrete rings. In some cases other reinforced concrete tie-beams were used at the foundations, under the walls. The buildings were usually single storey and relatively good cement mortar was used. This type of composite structure performed very poorly in the badly shocked areas (Figs 7 and 8). The failure mechanism suggests that collapse started at the shallow roots of the supporting columns and at the corners of the buildings. This is followed by loosening and tearing up the steel concrete frame and finally the collapse of the steel-beam jack-arch roofs (Figs 7 and 9). These structures suffered minor damage outside the badly shaken area.

3. *Elevated steel water tanks and concrete water canals*

The elevated steel water tanks which were not full during the earthquake, survived and suffered little damage. Usually the bracing rods in the upper panel were cut or the tank slightly tilted. A 5 km concrete water canal constructed on the clay beds east of Fahalanj village (No. 47 in Fig. 1) broke and was displaced at 60 points (Fig. 10).

DAMAGE DISTRIBUTION

There was a clear correlation between the surface rupture associated with the earthquake and the areas of earthquake damage. Destruction and damage decreased at distances from the fault (Fig. 1). The intensity values assigned to the damage area ranged from VI to X on the Modified Mercally Intensity Scale. The highest intensity of IX-X (80-100 % destruction with 50-85 % casualty of the inhabitants) covered an area of about 800 km^2 and was experienced approximately for 80 km along the ground rupture and roughly about 3 km on either sides of it (Table 3 and Fig. 1). The very damaging intensity of VIII (50-80 % destruction with 10-30 % casualty of the inhabitants) covered an area of 1000 km^2 and was generated for 100 km along the earthquake fault and roughly 10 km from it. The damaging intensity of VII (20 - 50 % destruction) covered 3600 km^2 and extended for 110 km along and about 60 km across the fault. The approximate limit of the building destruction and severe damage stopped about 45 km away from the ground rupture (see Table 3 and Fig. 1).

The shock was strongly felt over an area of 1,130,000 km^2. It was strongly felt in Tehran capital city, where window panes started trembling and caused panic amongst people. Damage to buildings was caused mostly by earthquake shaking and in a few cases by landslides triggered by the earthquakes. The damage zone was more extensive in the alluvial plain (Tabas playa) than in the mountains east of Tabas, where the villages were built on bedrock.

DISPLACEMENT OF HEAVY OBJECTS

Heavy objects like the Tabas power generator (of more than 50 tons weight) and the diesel reservoir-tank of the Tabas Power Station (containing 50,000 litres of diesel at the time of earthquake) were shifted eastwards about 80 cm and 17 cm respectively during the earthquake (Fig. 11). The latter stopped, after 17 cm displacement, by hitting a wall. A less heavy generator in Tabas Power Station did not break its bolts and

Fig. 6. Traditional domed water reservoir in Tabas is one of the few constructions which did not collapse during the earthquake.

Fig. 7. Steel concrete frame school with arch-type roof at Tabas. Collapse started at the shallow roots of the columns.

Fig. 8. Failure at steel concrete frame school with arch type roof at Fahalanj (no. 47 in Fig. 1 and Table 1). Note the steel-beams of the collapse roof which were constructed on the sun dried clay bricks.

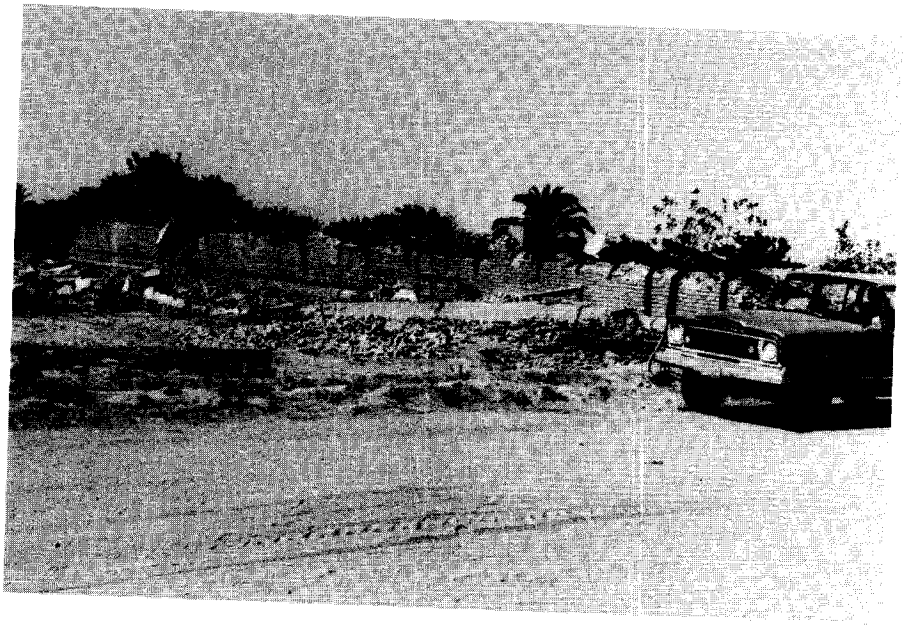

Fig. 9. Complete collapse of the steel-beam jack-arch roof of the brick masonry school at Korit (No. 80 in Fig 1 and Table 1). Note the broken steel concrete ring on the foot of the wall.

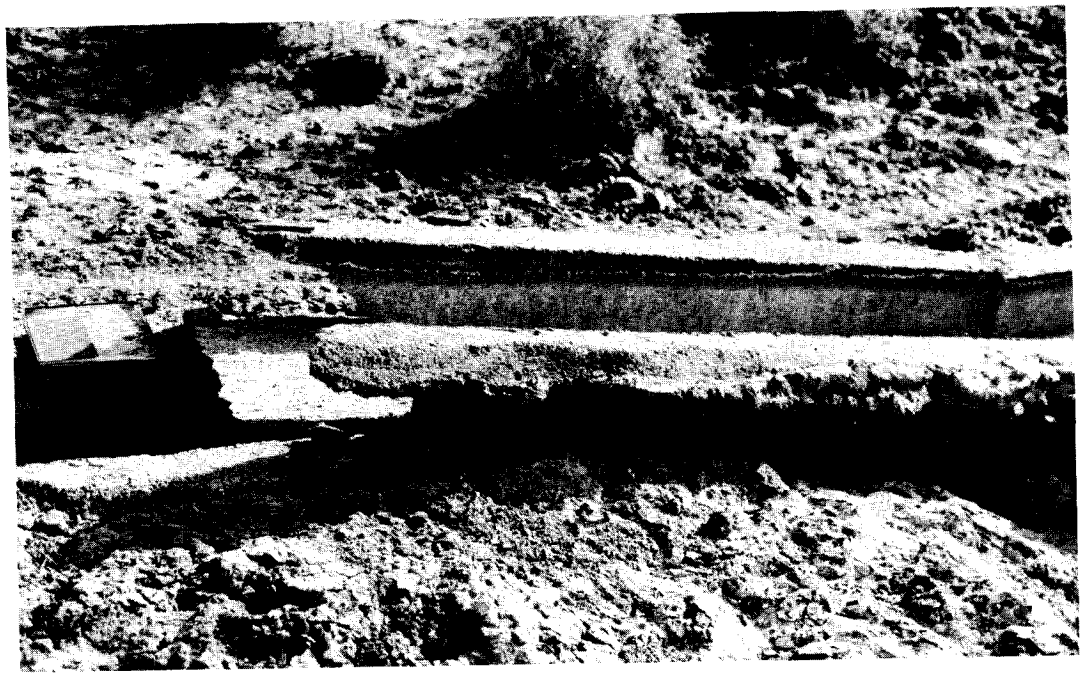

Fig. 10. Displacement of the concrete water canal supplying the Fahalanj region, east of Fahalanj (No. 47 in Fig. 1 and Table 1).

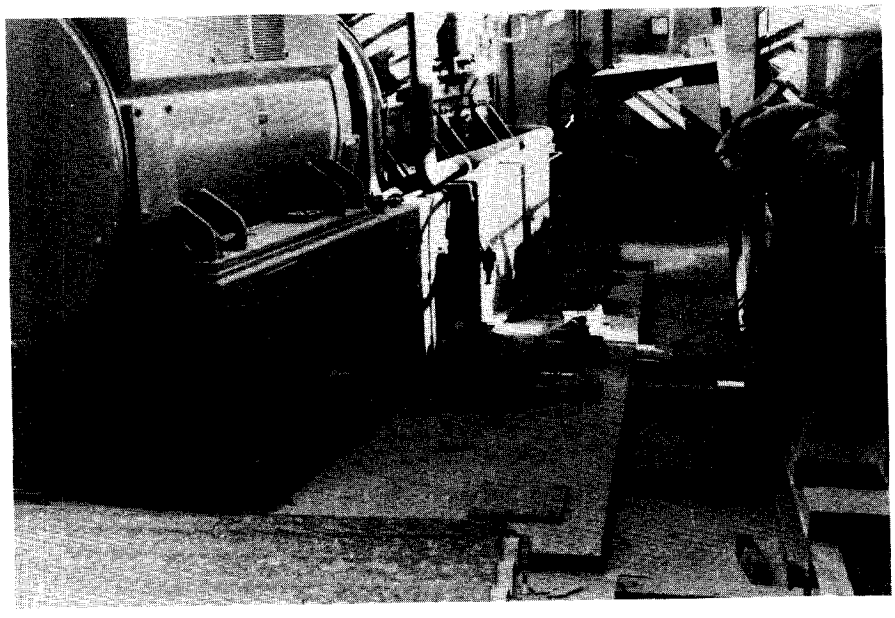

Fig. 11. Eastward shifting of Tabas power generator during the earthquake.

Table 3. Percentage of damage and casualties caused by the Tabas-e-Golshan (Iran) earthquake of 16 September 1978 in different zones

No.	Intensity on M.M.I.S.	% Houses destroyed	% People killed	% Mean casualty	Area (km^2)
1	IX-X	80-100	50-85	64	797
2	VIII	50-80	10-30	17	1055
3	VII+	35-50	1-11	6	1493
4	VII –	20-35	– 14	2	2483
5	VI +	5-20	–	–	4392
6	VI –	1- 5	–	–	8428
7	V	Strongly felt	–	–	1,130,000

did not move during the earthquake. This earthquake is of major engineering significance since it provided evidence of the ground motion characteristics of a large event. The response of simple heavy objects to ground motion during the earthquake becomes the controlling event for the design of structures with high safety requirements in Iran, e.g. nuclear power plants.

RESCUE OPERATION

Since the earthquake took place in the evening, most residents in the devastated area were at home dining or resting. The earthquake was not preceded by any pre-monitoring foreshock to give an early warning or enough time for people to run outdoors and save their lives. The warning given by the roaring noise about 4 seconds before the earthquake was very short and few people reacted fast enough to save their lives by running outdoors. Unfortunately the breakdown of the Tabas Power Station during earthquake together with the lunar eclipse two hours after the main shock, made it impossible for survivors to start the immediate rescue operation of their families and neighbours. The rescue operation started in the morning of the next day, roughly 12 hours after the disaster struck. Army aircrafts set up a relief shuttle from Tehran on 17 September and air force helicopters assisted survivors in different villages by supplying tents and food.

CONCLUDING REMARKS

The Tabas-e-Golshan catastrophic earthquake is a case of earthquake damage inflicted to a town in Iran and emphasizes once more the importance of enforcing building codes in a seismic country like Iran. Unfortunately building code requirements for aseismic design are not yet officially established and enforced in Iran. During the last 78 years earthquakes caused a total death-toll of over 72,000 in the country. The large number of casualties in the Iranian earthquakes is mainly due to the immediate, total destruction of adobe and other improperly built houses and lack of reinforcement of aseismic building codes or any proper building control; to delay in emergency action and lack of plans for a proper and immediate rescue operation after an earthquake, and to underestimating the geological hazards. The recent earthquake introduced invaluable input to the regional seismotectonic interpretation since the seismic fault of Tabas was not recognized prior to the catastrophic shock.[1] The seismotectonic situation of Tabas is very similar to many other important and large Iranian cities like Tehran, which are built next to seismic faults without using proper regulations to control constructions in a seismic region. Constructing the earthquake resistant houses enforced by the government is the only way to minimize the earthquake hazard and to stop the rapid increase in the casualty numbers due to Iranian earthquakes.

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