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POST EARTHQUAKE CONSTRUCTION OF GEDİZ

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SUMMARY

The town of Gediz in Western Turkey was struck by an earthquake in March 1970. Since then the Turkish government has built a new town (New Gediz) about 8 kms from the original location. As the old town is still habitated the problem has arisen for the government to investigate and decide about the suitability for habitation of Gediz from the point of view of seismic risk. The present report is a culmination of such an investigation.

1. INTRODUCTION

1.1 Scope of the Problem

A devastating earthquake struck the town of Gediz and environs in March 1970. The damage due to this earthquake coupled with the fire caused by it destroyed some parts of the town. The government decided at that time to relocate the town. Peculiar topographical conditions of Gediz was one of the factors which caused panic in the inhabitants who in turn pressured the authorities to make the decision of relocation. The new town (called New Gediz) was constructed about 8 kilometers south of the old location and within two years it became a lively center of habitation. Today New Gediz has a population of about 12000.

The old town, on the other hand, did not disintegrate into a ghost town either and is occupied by about 7000 inhabitants today, approximately 70% of the population it had in 1970, before the earthquake. As the town offices have moved to New Gediz, the inhabitants of Old Gediz have again formed a pressure group to demand municipal facilities from the government.

This article is the summary of the investigation carried out by the Middle East Technical University Earthquake Engineering Research Institute to determine the suitability of Old Gediz for habitation with respect to seismic considerations, as requested by governmet authorities.

1.2 Pre-Earthquake Gediz

The town of Gediz had a population of 10651 according to the October 1970 census. In the province of Kütahya it was one of the four towns with population over 10000. For this reason it had a certain amount of social and commercial activity. This is influential to some extent to the number of public and civic buildings in the town in contrast to traditional dwellings.

The town is located in the valley of a river of the same name, (Figure 1). In the center of the town a peculiar basaltic formation underlying rubble dominates the scenery, (Figures 2 and 3). The river runs through this formation leaving a strip of narrow flat land on each side for suitable habitation. However, this land was densely populated before the earthquake. Although not as densely as this part; the 'castle' (as the basaltic formation is locally called) also provided habitable land to a considerable population.

The type of construction in Gediz prior to the earthquake may be classified in three categories.

- reinforced concrete frame
- wood frame
- stone or brick masonry

Almost all reinforced concrete buildings were non-residential. These were schools, banks, dormitories, hospitals, etc and totaled to no more than fifteen in Gediz.

By far the most common residential type of construction in Gediz is wood frame. A typical Gediz house of this type (Hımış) may be seen in Figure 4. The major deficiency of this type of construction during an earthquake is the danger of loose infill, improper diagonal bracing and poor masonry foundation. A more refined version of this type of construction may be seen in

Figure 5. The first two points of deficiency are generally taken care of in this type (Bağdadi) of construction.

Only 5-10% of buildings in Gediz were masonry [1]. But even such a small number of masonry structures influenced the number of casualties to a great extent.

2. EVENT OF MARCH 28, 1970

The Gediz earthquake occurred at 21 02 23.5 local time and had a magnitude of 7.3 on the Richter scale. The epicentral intensity was controversial and was given as VIII and IX on the Modified Mercalli scale by different experts. The epicentral coördinates were given as 39.21 N 29.51 E and the focal depth was calculated as 18 kms.

The epicenter lies about 20 kms NW of the town of Gediz. The earthquake was felt in an area of 350000 square kilometers and had an intensity of MM ≥ VII over an area of 1250 square kms.

According to Özsoy and Çelebi [1], although the material and workmanship of reinforced concrete structures were sub-standard they performed satisfactorily during the earthquake. Non of these collapsed completely.

The major causes of failure for wood frame structures were spilling of loose infill material, inadequate cross bracing and poor foundation. Sidesway of one such building due to inadequate cross bracing may be seen in Figure 6. On the whole, however, wood frame structures behaved exceptionally well during the earthquake.

Stone and brick masonry (unreinforced) structures behaved poorly and unpredictably. When they failed their failure was almost total and frequently catastrophic.

A disadvantage of wood structures was observed during the fire which followed the earthquake. Due to the narrowness of the streets near the quay and blockage by debris made it impossible for rescue teams to reach the affected area increasing the number of casualties considerably.

Total number of casualties due to the earthquake (including fire casualties) totaled 1086 of which 360 were from Gediz. The relative destructiveness of the Gediz earthquake to those recently occurred in Turkey may be seen in Table 1, (from [2]).

3. SEISMIC RISK CONSIDERATIONS

3.1 Methodology

Seismic risk of Gediz and its environs were considered using the method developed by Cornell and Mertz [3] revised by Shah et al [4] and Gürpınar and Gülkan [5]. First of all, seismic sources are selected based on seismicity and tectonics of the considered area. All the past epicenters are then associated with one of these sources. Frequency-magnitude relationships are established for each source and maximum magnitudes that may be generated by these sources are estimated. Iso-acceleration contours for given exceedance probabilities and time periods are drawn for the considered region.

Characteristics of seismic sources may be seen in Table 2.

3.2 Regional Comparison of Seismic Risk

Iso-acceleration contours for 20% probability of exceedance and 50 year time period may be seen in Figure 7. Peak ground acceleration values for some towns in the region are as follows: Gediz, 850; Emet, 780; Simav,770; Uşak, 690; and Kütahya, 640; all in gals.

It should be pointed out that New Gediz which is only 8 kms south of the old town is still within the 800 gal contour. Although Gediz has the largest peak ground acceleration value for given probability of exceedance and time period, the difference between Gediz and other towns (such as Emet and Simav) is not appreciable enough to decide against habitation in Gediz. The risk curves for 1, 20 and 50 year periods may be seen in Figure 8.

4. MICROZONING CONSIDERATIONS

Microzoning of Gediz is considered from the following points of view:
-proper land usage (industrial, residential, green area, etc)
-spacing and height restriction of buildings in each zone
-proper seismic coefficient for each zone

In doing this, three major factors were considered as hazard potentials.
-soil amplification of earthquake ground motion
landslide potential
-fire potential

Fifteen bore holes were drilled and a resistivity study was carried out to determine the influence of the first two points on microzoning. Unfortunately, microzoning of Gediz has not been completed at the time of the writing of this article.

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Western Turkey					Eastern Turkey				
Earthquake	I_o	N	M	r	Earthquake	I_o	N	M	r
Adapazarı 27.7.67	IX	89	5569	16	Varto 19.8.66	IX	2394	20007	120
Amasra 1.9.68	VIII	29	2072	14	Pülümür 26.7.67	VIII	97	1282	76
Alaşehir 28.3.69	VIII	41	1700	11	Bingöl 22.5.71	VIII	870	5356	162
Gediz 28.3.70	IX	1086	9452	114	Lice 6.9.75	VIII	2385	8165	292
Burdur 12.5.71	VIII	57	1487	18	Çaldıran 24.11.76	IX	3840	9232	415
Total	8.4 Ave.	1302	22280	38 Ave.		8.4 Ave.	9586	44042	213 Ave.

N: number of loss of life
M: number of heavily damaged structures
r: number of loss of life per 1000 destroyed structures

Table 1. A Comparison of Recent Turkish Earthquakes

Source	Length (km)	Average Focal Depth (km)	Distance to Gediz (km)	a	b
1	105	33.8	34.8	3.8990	-0.5541
2	110	27.3	30.2	3.5428	-0.5073
3	105	27.3	33.9	4.6003	-0.7332
4	150	39.0	55.9	4.7865	-0.6454

a,b: regression constants of frequency-magnitude relationships

Table 2. Seismic Source Characteristics

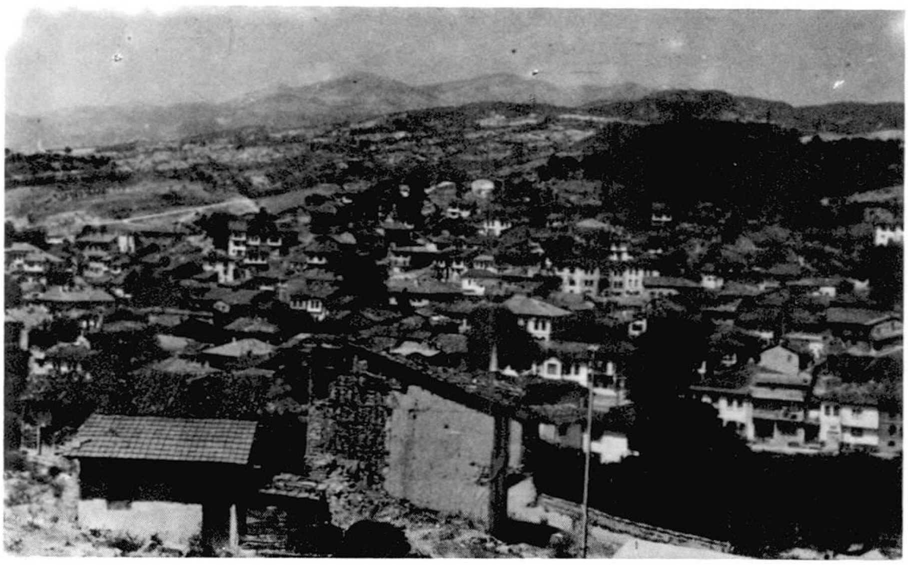

Figure 1. General View of Gediz

Figure 2. Gediz-Peculiar Topographical Feature

Figure 3. Ruins of a Mosque on Basaltic Formation

Figure 4. Typical Wood Frame Structure (Hımış)

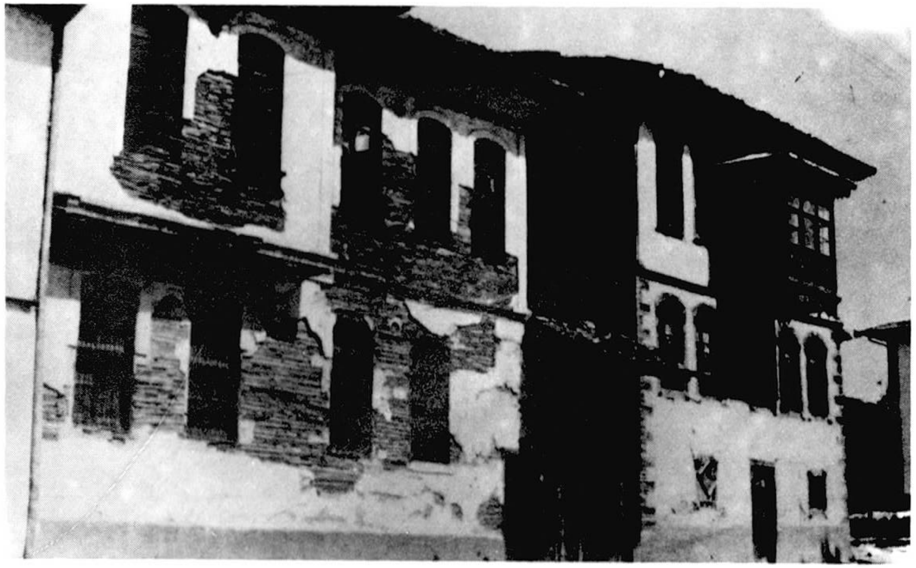

Figure 5. Typical Wood Frame Structure (Bağdadi)

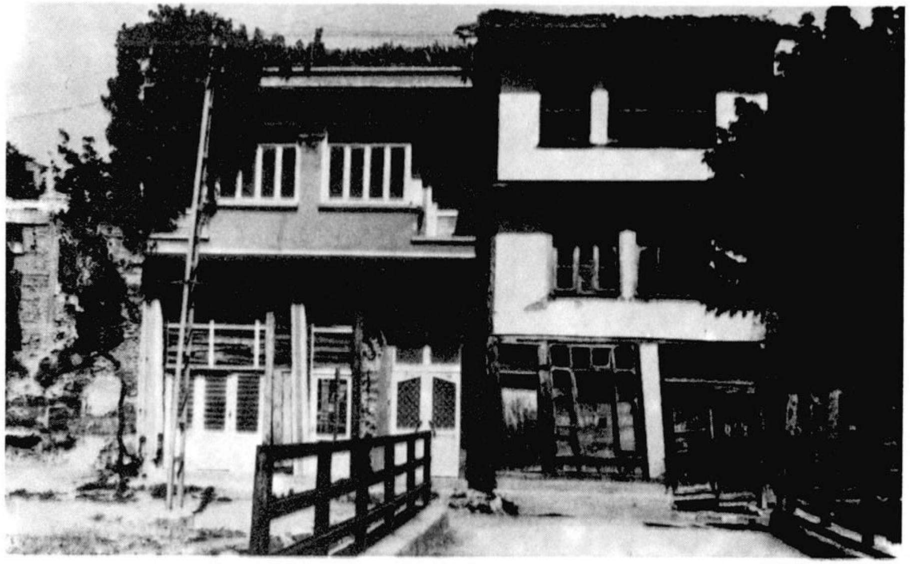

Figure 6. Sidesway Caused by Inadequate Cross Bracing

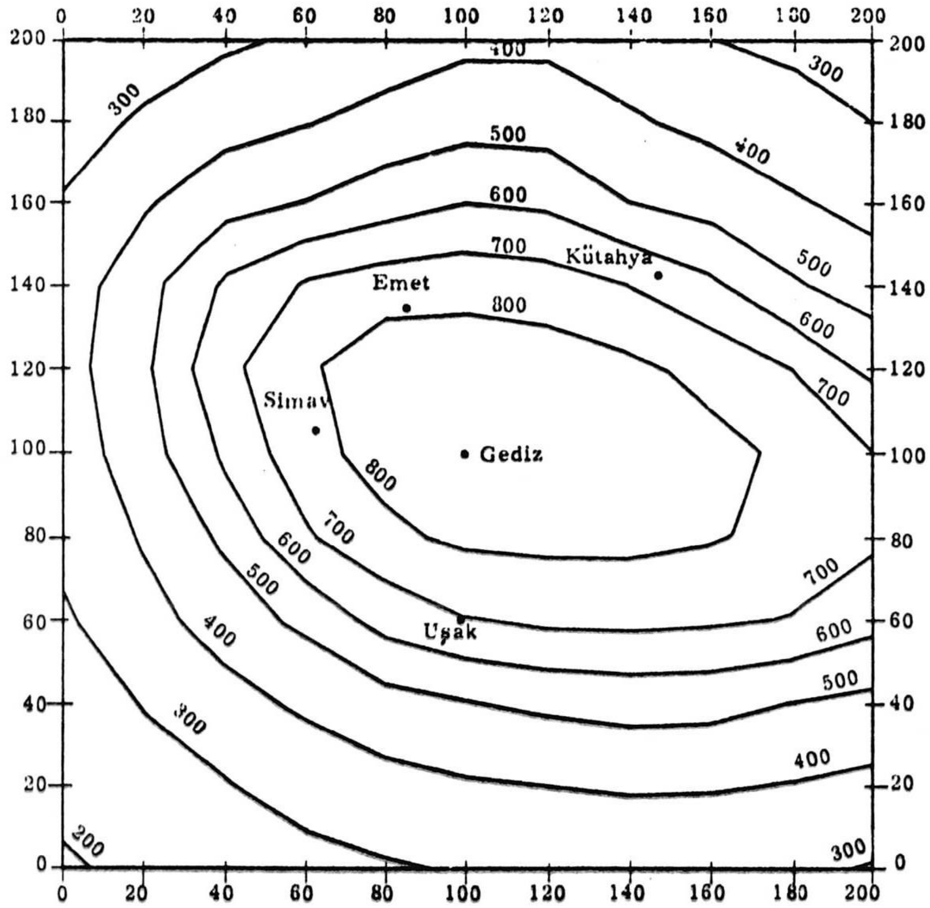

Figure 7. Iso-Acceleration Contours for P(A > a) = 0.20
50 Years

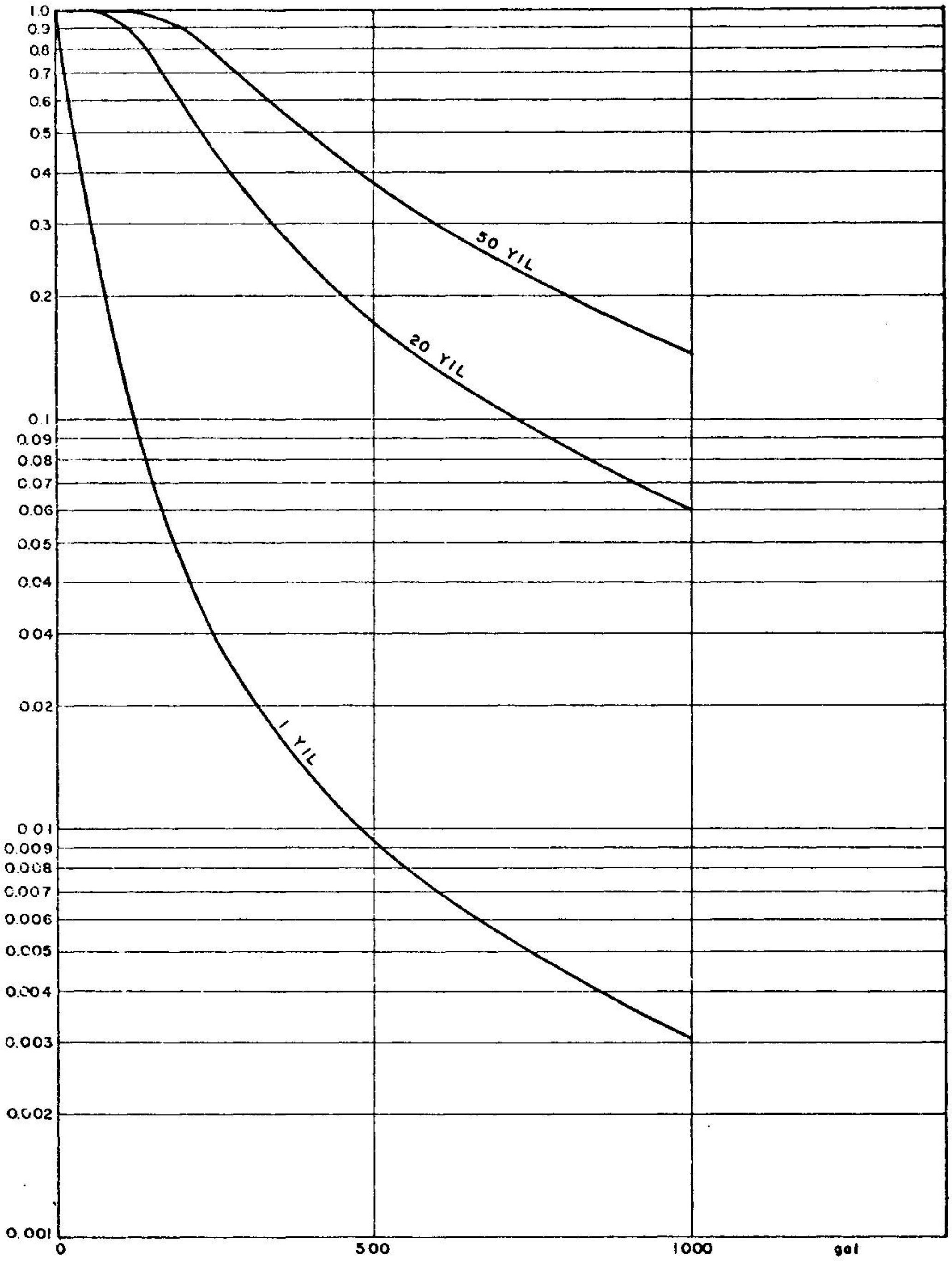

Figure 8. Seismic Risk Curves for Gediz- 1,20,50 Years