



## AN INVESTIGATION OF THE RECENT EARTHQUAKE DISASTERS FROM A VIEW POINT OF URBAN ENGINEERING (2)

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### ABSTRACT

Recently, many earthquakes that attacked modernized cities have been occurred. In those cities, the large disasters for human beings and for the environment including buildings, transportation's systems and others have been happened by the earthquakes. There have been some examples for these disasters at Tangshan, Mexico City, Erzincan and Northridge in the last quarter of the 20th Century. In this paper, mention about the characteristic points concerning Erzincan, Northridge and Kobe. Some proposals would be issued for the future protection against the calamities mainly on the point of the urban engineering that is the one component of the social science.

### KEYWORDS

Earthquake disaster, Modernized City, Ground collapse, Impact force, Foundation structure

### 1. PREFACE

The first half five years should be passed after the declaration for international protection against calamities through ten years. Since this international event opened splendidly with getting resolutions in the world wide at United Nations, the nature has been giving strong punches to the earth, as if it took a defiant attitude for the declaration, so that others may see.

Earthquakes, storms and volcanic eruptions have occurred one after another, and they gave much human and many material disasters. In this paper, I try to consider the disasters in the modernized cities as the focus with referring the disasters occurred by the recent earthquakes (Table 1) in the last ten years of the 20th century (1985~1995) from the wide social and scientific view points.

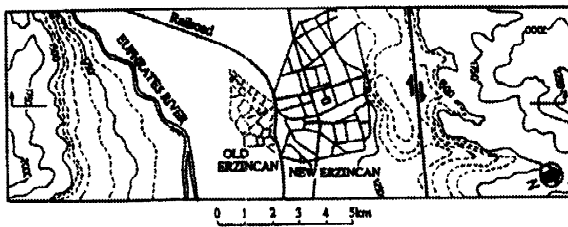


Fig.1(a) The old and the new areas at Erzincan (Bozazigi University reports)

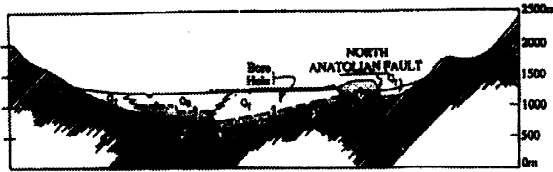


Fig.1(b) The section for the soils at Erzincan (Bozazigi University reports)

## 2. ERZINCAN EARTHQUAKE IN TURKEY

Erzincan city located at a east district in Turkey, was shaken with the big earthquake(M=6.8) that was caused by the new Anatorian fault on March in 1992. More than 500 persons were died and the 16,200 houses were destroyed. This city had a population of about 130,000, and lies on the plateau from 1200 meters above sea level that spreads for 30 km in the east and west and for 15km in the north and south.

The heights of the mountains around this city are about 3000m, and the origin of the famous river Euphrates is located. The site was heaped up in the alluvial periods and the depth of the site are more over 250m. Generally, it is the case that these sites are composed with sea layers. However, the site is composed of the soil of weathered igneous rock, mainly sand without sea layers.

Erzincan city was attacked with deadly crushing blow in 1939(about 50 years before) by the big earthquake and this city has the miserable experience that the center of the city was transferred in the north direction to rebuild the city.

The actual state of this circumstance is showed in Fig. 1(a) and Fig. 1(b). It means that the new city was transferred more near to the active fault. The authorities of the city had performed the strict control that it was not possible to construct the buildings more than two floors at the transportation of the city. They had been tidying up the pretty row of houses and people had been enjoying with quiet lives for about half century after that time.

However, modernized waves came to an area remote from population in the world with the world wide expanse of the modern technological development, and the reconstruction from old houses(such as adobe brick or brick structures) to new houses(such as RC structures) has been performed. At the same time, the city ward drifting of population had been spread to this city, that was the tendency in the world. The administrative authorities leaned to approve for construction the buildings less than 6 floors with the pressure by the opinion of the citizen that relaxed the restriction for the control of the building height and it was said that authorities would perform to tighten control for the seismic code as a substitute for this approval. Even though they changed the seismic code, it was the fact that details for the RC construction could not used efficiently, because people could not adapt themselves to construct RC buildings. The middle and low high RC buildings were destroyed by that earthquake and real facilities of the city were stopped for a long time. The city dropped into a state of emergency.

Table 1.The main recent earthquake disasters in the world from 1985 to 1995

Date	Epicenter Zone	M	Casualties	
			Dead	Injured
1985	9 Michoacan(Mexico)	8.1	>9500	
1986	11 Taiwan(Taipei)	7.5	15	
1987	3 Columbia-Ecuador Border	7.0	1000	4000
	12 Chiba,Japan	6.7	2	138
1988	12 Turkey-USSR Boder(Armenia Spitak)	7.0	25000	
1989	1 Tajik USSR	5.3	274	
	10 California (San Francisco)	7.1	62	
	10 Algeria	5.9	>50	
	12 S.E.Australia (Newcastle)	5.4	12	
1990	5 Romania	7.1	14	
	6 West Iran	7.7	4-50000	
	7 Luzon (Philipine Island)	7.8	>1621	
1992	3 Turkey(Erzincan)	6.8	677	
1993	1 Kusiaooki.Japan	7.8	2	967
	7 Hokkaido W.S.Oki	7.8	243	235
	8 Guam	8.1	0	84
	11 South India	6.3	9748	30000
1994	1 Northridge(L.A.) (California)	6.8	50	7300
1995	10 Hokkaido East Oki	7.9	11	342
	1 Southern Hyogoken	7.2	6308	70000

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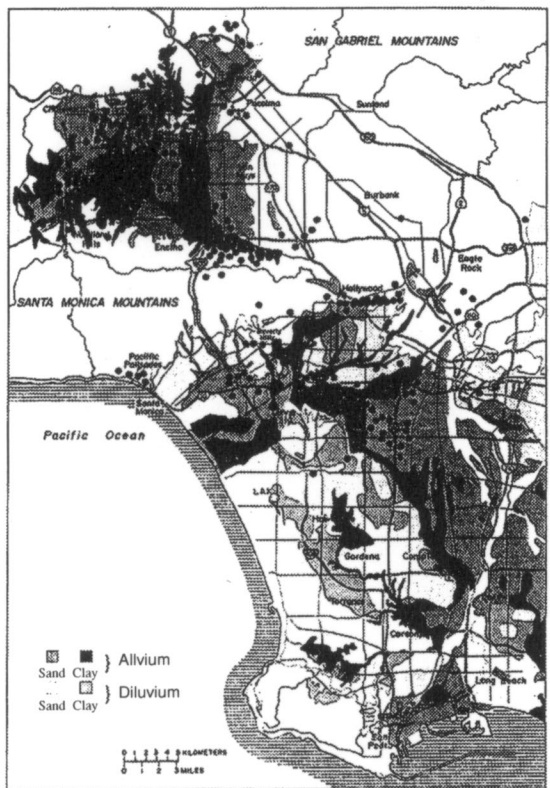


Fig. 2 surface soil and damage situation  
(Technical report by Oobayashi gumi)

The big earthquake ( $M=6.8$ ) occurred at Northridge located in the north of Los Angeles at the coast of the Pacific Ocean in USA on 17th, January in 1994. The serious disasters for all of life lines were broken out, though only about 50 people were died. The characteristics of that earthquake from the social and scientific view points are showed as followings.

#### 1) Scale and Direction of the Earthquake

It is the fact from putting together the information from people, who had been living near the epicenter of the earthquake, that people felt big shock from the earth and went out from houses by their fear. There are records getting from a strong motion seismograph to verify this fact. We can see the maximum acceleration gotten at Tarzana observatory point aparted from 6 km epicenter in the south. It shows 1.82G in the horizontal direction and 1.18G in the vertical direction in Fig. 4. Many people were force to live in tents for a long time in order to avoid the after-shock.

This earthquake would be called as the earthquake on directly under the city that seismic center would be located at a shallow point in the site. The site is composed of alluvium in the Quaternary period and unstable. By these reason, the response on the surface of the site would be amplified considerably in both horizontal and vertical direction. Especially, vertical impact motions would be large. Unprecedented disasters would be occurred by those motions. It would be considered that no people could image such big motions of the site from their experiences.

#### 2) Re-collapse of highways and elevated roads.

The big disasters occurred at the elevated roads with the San Fernard earthquake 23 years ago. However, sufficient investigation for these structures was performed from view point of the seismic design and it is considered that the strong seismic faculties were added. It was heard that much important treatment for the seismic capabilities, that means dynamic analysis and strengthening the joints' parts as the result by the earthquake, was performed after Roma Prieta earthquake occurred five years ago. It is natural to have the questions why the structures destroyed again. It would be considered that the old structures could not resist for the increase of the traffic vehicles in the modern generation. I am anxious about same situation for the network of the highway in the big cities in Japan.

#### 3) Damage of life line

In this point, I intend to describe the facilities in the city except roads, though disasters of roads would be included in the wide meaning. The fire of mobile houses was the impressive report by the television to me. The housing developments have been made in a particular blocks of the cities. These houses could be moved by cars in any areas. It would be unique custom to USA or Europe.

The equipment for electric power, gas, and water to enjoy with the house-developments would be set perfectly in the public and welfare state, USA. The pipe equipment buried in the shallow parts would be damaged seriously by big shake at the surface of soil. Especially, cutting the gas pipes caused fires directly. These life lines in other parts of the city would be damaged at the points on the way to supply by site shaking and destruction of the buildings.

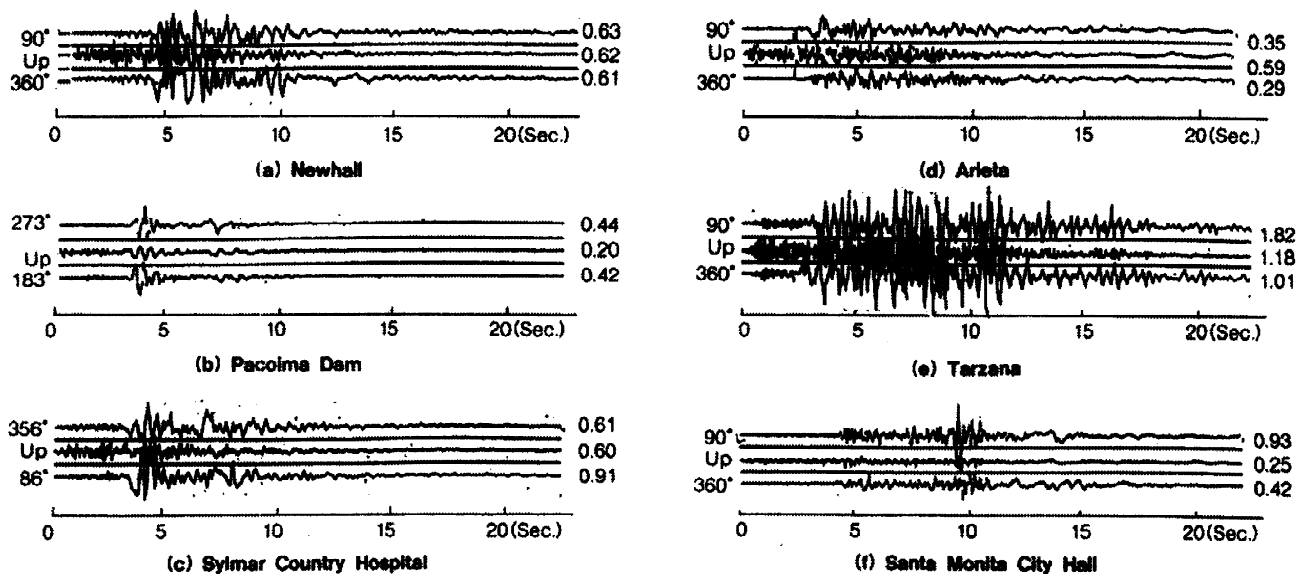


Fig. 3 Time history of waves for acceleration in free field(A.I.J)

However, it was said that recovery to maintain those equipment would be performed quickly, as the system to get detail information worked efficiently after earthquake occurred. This system was called as CUBE system. The information for damages in every area could be reported at each time with the control facility (company). This system was developed by soil laboratory in the California Institute of Technology and sixteen companies are admitted. It was reported there were a little problem, as damages about structures for other power plants were small. The damages of equipment for telephone system were also small. It could be considered that many important treatment, that was gotten from the experience about correspondence for protection against calamities, made good results, as system of these information and communication are mostly reliable for people. People are not anxious about the correspondence for the protection against calamities about the high information system now and it is more valuable. It is necessary for us to arrange the policy for these problems in the future quickly in Japan with considering those lessons.

#### 4. EARTHQUAKE AT THE SOUTHERN HYOGO PREFECTURE IN JAPAN

The big earthquake(M=7.2), that occurred at shallow site, attacked Kobe city on 17th January 1995, when just one year passed from attack with big disasters by the earthquake at Northridge. More than 6300 people were died and big disasters were occurred at the modern ten cities around Kobe. I mention the characteristic matter about it as following.

1) All of equipment and structures was damaged. This fact implies the very important social and structural meanings. It would be showed that there were problems for design against seismic capabilities in all structures. However, we must remark the difference from buildings that now are remaining stable and damaged buildings. Basically, I take a serious view of the size in motion caused by the propagation and amplification in the site, as the calamities would be occurred by combination the causes from characteristics of site, structural design, detail connection of structures and construction technology, of course.

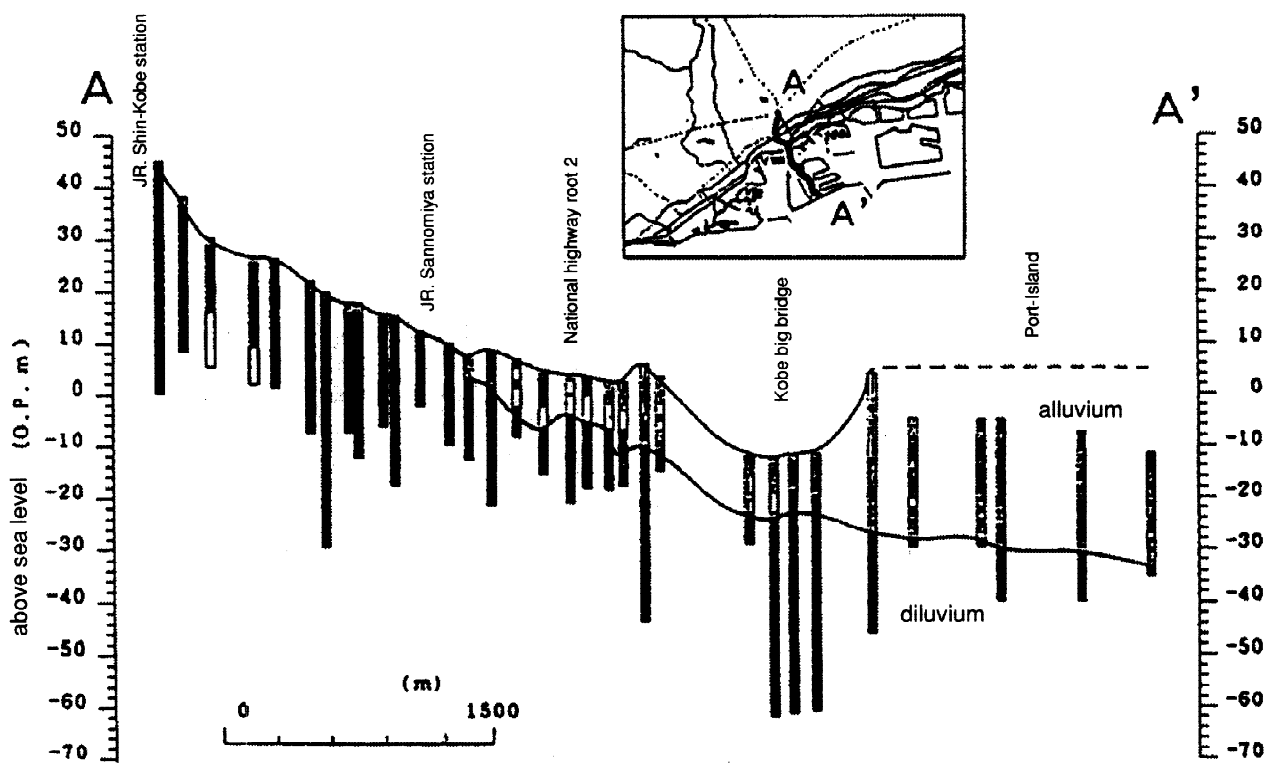


Fig. 4 South-northern section at Port-Island(A.I.J)

2) I mention the characteristic damages at this earthquake.

(1) More than 6,300 people were died and about 200,000 houses were destroyed. The rank of the disasters in this earthquake were next second to the disaster by The Kanto earthquake in 1923.

(2) Though it was not strong wind, fire continued for 2 days. About 7,000 houses were burnt down. Especially, people were surprised with blazing up of RC buildings. It was the fact that RC buildings could not stopped fires.

(3) As railways between Kobe and Osaka were stopped for a long time, a lot of bus transportation were performed in place of railways. The connection between cities beside the Osaka bay were made by ship transportation and full extra and increased ships for transportation were performed. The railway transportation systems such as the JR. line, the Hankyu line and the Hanshin line were literally cut to pieces. It became dull to do refuge and relief and it made people anxious.

(4) Man-made island that were made as expansion for the area and for growth of the modern city was isolated for a little time with cutting the new transportation system by ground subsides at the Port Island and Rokko Island. These two islands were damaged by the liquidity of soil that were filled up. In this district, the third man-made island, called Harbor Island, were constructed. There were not remarkable disasters except the harbor area on the seashore. New cities at the western Kobe area were gotten off big disasters.

(5) The damages at the harbor facilities were quite serious and it caused the economical blow, because facilities at three described harbors and at old Kobe harbor were stopped perfectly.

(6) It was the most serious impact for the people that destruction for the elevated highways, bridges, and piers of bridges was occurred.

## 5. CONCLUSION

I recommend the countermeasure for protection by analysis main causes made calamities in Kobe that was modern city. The same problems would be applied to other cities such as Erzincan and Northridge.

1) Kobe has been developing at the area that were grown for a southern direction on the seashore. Those areas are made by soft soil and were attacked by the big earthquake at this time. I can't still understand the active fault that was explained at the latter half of this century, as I described that the action from the active faults caused earthquake.

2) Inhabitant areas have been developing at the northern foot of a mountain and northern-western hills by the concentration of population with increased people rapidly and man-made islands also were made. By this development, there were the change for the circumstances and destruction of the nature.

3) Influence by the vertical vibration, that we could see the same phenomena in the Northridge one year before, was appeared. It is not possible to analyze the behaviors in the structures by the general dynamic analysis, because impact forces destroyed the structures. It was proven that impact forces caused the big damages, as people say about it from the Mexico earthquake.

4) Structural materials such as steels and reinforced concrete were exposed weak under described big vertical cyclic and high-speed forces.

5) It would be considered that there are not sufficient resistant capabilities for the change of soil moving, as structures of foundation for the low buildings at more soft soil compared to other site.

6) It would take a long time to repair the life lines, because they had been weaken not to resist against move of soil by passing many years and damages of them were spread to large areas.

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