Comparison among Iran, Turkey and Kobe Earthquakes from the View Point of Ground Motion Characteristics and Damage

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Comparison among major earthquakes occurred in Turkey (1999), Kobe (1995) and Iran (Manjil, 1990 and Tabas, 1978) from the view point of Ground Motion Parameters (GMP) and building damages is investigated in this study. Peak Ground Acceleration (PGA), Velocity (PGV) and Displacement (PGD) as well as Spectral Intensity (SI), Power Spectral Intensity (PSI) and finally, Predominant Frequency (PF) are considered as GMP. Totally, 30 acceleration-time histories of the earthquakes having PGA more than 100 gal were dealt with. GMP of 4 records of each earthquake having big PGA are compared with each other and outline of damage in each earthquake is given.

***Key Words** : Damage, ground motion, peak ground acceleration, velocity and displacement*

1. Introduction

Earthquake damage investigation has been one of most effective ways to learn precious lessons from the past earthquakes and to advance the seismic design practice according to realities. Interpreting seismic damage principally means to what extent various factors involve in making the damage scenario. According to Corsanego[1)], damage is alternatively read as: (1) An indicator of seismic intensity; (2) A revealer of local site phenomena; (3) A measurer of seismic vulnerability and, (4) A lesson to learn.

Among the major earthquakes occurred around the world, four quakes making a big impression on the stricken countries have been chosen to investigate in this study. They are: the 1999 Kocaeli earthquake in Turkey, hereinafter referred to as "Turkey earthquake", the 1995 Hyogo-ken Nanbu earthquake in Japan, referred to as "Kobe earthquake", the 1990 Manjil-Rudbar and finally, the 1978 Tabas-e-Golshan earthquakes in Iran, referred to as "Manjil" and "Tabas" earthquakes, respectively in this paper. Some characteristics of these earthquakes are given in Table-1.

Table-1 Characteristics of 4 considered earthquakes

Eq.	Date	Local Time	Magnitude
Turkey	1999/8/17	03:01	$M_w = 7.4$
Kobe	1995/1/17	05:46	$M_J = 7.2$
Manjil	1990/6/20	00:30	$M_b = 7.3$
Tabas	1978/6/20	19:38	$M_s = 7.7$

Comparison among these earthquakes from ground motion characteristics and damage viewpoint is the aim of this paper. There are many ground motion parameters of which getting only peak ground acceleration seems to be not enough in interpreting seismic damage. Six ground motion parameters of the earthquakes records

are selected to compare with each other in this study.

2. Ground motion characteristics

(1) Acceleration-time history

This study deals only with horizontal records of the earthquakes having peak ground acceleration more than 100 gal. From 46 horizontal acceleration-time histories of the Turkey earthquake, 12 records were selected for this purpose. Similarly, from 14 of the Kobe earthquake, 4 records, from 36 of the Manjil earthquake, 10 records and finally, from 16 of the Tabas earthquake, 4 records were selected.

(2) Ground Motion Parameters (GMP)

Totally, 6 GMP were dealt with. Peak Ground Acceleration (PGA), gotten directly from acceleration-time history of each record, is the first one. Peak Ground Velocity (PGV) and Peak Ground Displacement (PGD), calculated by first and double integration of acceleration-time history, respectively, are the second and third ones. In this integration, software of K-Net homepage is used[2].

The other GMP are as follow:

4th GMP: Spectral Intensity (SI), defined by Housner as integral of velocity response spectrum or spectral velocity taken over the range of structural vibration periods from 0.1 to 2.5 seconds. SI value depends on damping ratio of structure taken 5 % in this study.

5th GMP: Power Spectral Intensity (PSI), defined as area limited to power spectrum graph and the abscissa axis, frequency.

The last and 6th GMP: Predominant Frequency (PF) of each record, correspondent with the maximum amount of Fourier amplitude spectrum. For obtaining real value of PF for each record, Fourier spectrum is smoothed by Parzen's spectral window[3].

(3) Comparative GMP values of the earthquakes

For doing comparison between 6 GMP values of 4 considered earthquakes, 4 records of each earthquake having big PGA were selected. These comparative values are shown in Figures 1 to 6.

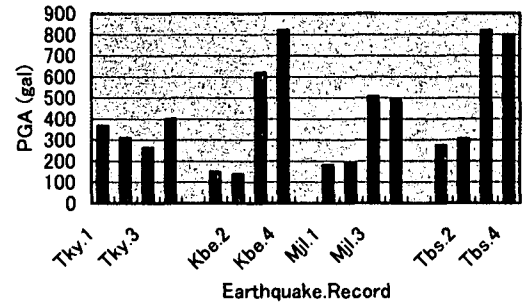

Figure-1 PGA in 4 Earthquakes

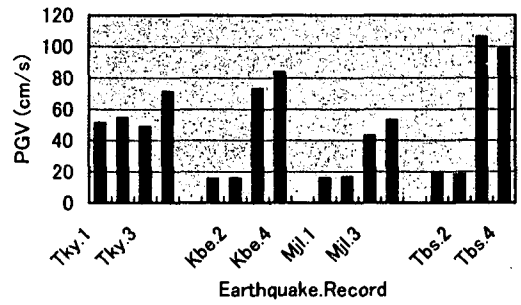

Figure-2 PGV in 4 Earthquakes

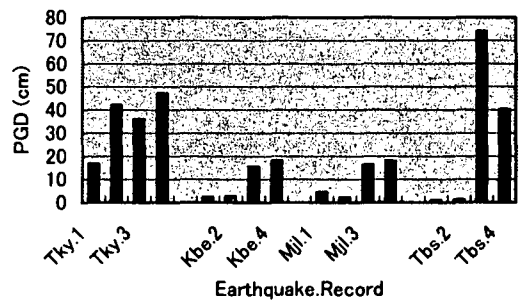

Figure-3 PGD in 4 Earthquakes

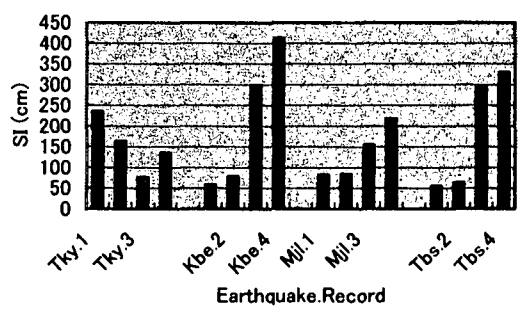

Figure-4 SI in 4 Earthquakes

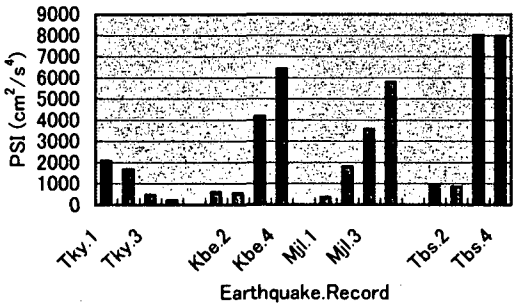

Figure-5 PSI in 4 Earthquakes

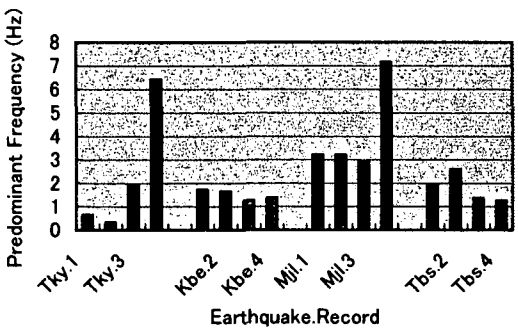

Figure-6 Predominant Frequency in 4 Earthquakes

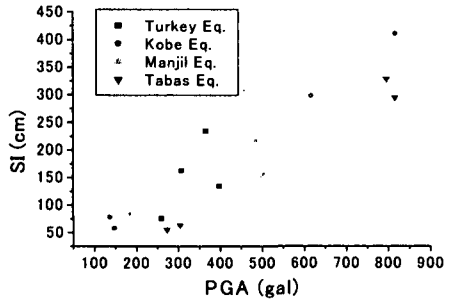

Figure-7 Correlation between PGA and SI in 4 Earthquakes

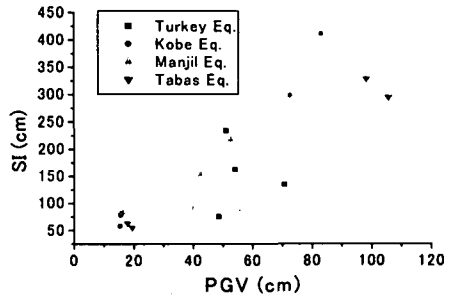

Figure-8 Correlation between PGV and SI in 4 Earthquakes

Figures 7 and 8 show correlation between SI, PGA and PGV in 4 earthquakes. It is seen good compatibility between SI, PGA and PGV. Nevertheless, considering all records of the earthquakes, compatibility of SI and PGV is not as good as of SI and PGA.

3. Outline of damage in each earthquake

(1) Turkey earthquake

According to the damage reports[4-6], this earthquake hit the western part of Turkey, about 8 provinces, causing tremendous casualties, huge building losses and severe socio-economic disruption. From the building damage viewpoint, most of them seem to be caused by the characteristic structures of Turkish buildings. A majority of the residential buildings collapsed in first story due to the poor structure, so-called soft-first story.

(2) Kobe earthquake

For the buildings in Kobe city, more than half the number of buildings suffered collapse and severe damage. The ratio of such buildings is 70% for the reinforced concrete structures, 60% for the steel and reinforced concrete structures and 55% for the steel structures. For the reinforced concrete structures, the major damages were collapse of story and yielding of column while for the steel structures the other damages (rupture of brace, fracture of welding and clash of column foot) were remarkable. Also, about a half of the collapsed and severely damaged buildings had piloti[7, 8].

(3) Manjil earthquake

In the Manjil earthquake, destruction extended to a radius of 100 km from the epicenter. Contrary to the past major Iranian earthquakes almost all of which had occurred in remote and sparsely populated rural areas, this earthquake struck a densely populated region. Among the earthquake-stricken towns, Manjil seems to have suffered the most losses as almost 90% of its mostly single-story buildings (having high natural frequency) were devastated. The severity and the manner of destruction of brick masonry buildings in the towns of Manjil and Rudbar indicate that the power of the earthquake was concentrated in the high frequency range spectra (See Figure-6). Only a few

Table-2 Outline of damage in 4 earthquakes

Eq.	Casualties	Injured	Collapsed Buildings	Loss (10^6 US$)
Turkey	15,851	43,953	77,297	16,000
Kobe	6,310	28,500	100,000	100,000
Manjil	37,000	60,000	100,000	7
Tabas	20,000	Thousands	15,000	?

buildings with concrete ring beams and steel or concrete framed structures existed in Manjil and Rudbar. There are also a large number of steel-framed buildings lacking any kind of recognized lateral resistant systems which have survived the destruction, merely due to the infills, although the infills themselves had cracked and collapsed in some parts[9].

(4) Tabas earthquake

The catastrophic Tabas earthquake occurred in a desert region of east central Iran where no major historical (pre-1900) earthquakes are known since the 7th century. This earthquake completely demolished the oasis town of Tabas where 85% of the inhabitants (11,000 out of 13,000) were killed[10, 11].

Outline of damage in 4 considered earthquakes are given in Table-2.

Conclusions

In the present study, some ground motion characteristics and damage in 4 major earthquakes were compared. Most ground motion parameters rather than one of them say PGA can describe the earthquake damage. It seems that for doing real comparison among different earthquakes and their damage, same condition e.g. same buildings is necessary. However, determining structural response can be an approach in this regard.

Acknowledgements

General Directorate of Disaster Affairs of Turkey, Japanese Meteorological Agency (JMA), Building and Housing Research Center (BHRC) and International Institute of Earthquake Engineering and Seismology (IIEES) of Iran are sincerely acknowledged for preparing earthquakes ground motion records and related assistance.

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