DAMAGE CHARACTERISTICS OF WOODEN HOUSES IN NEAR FAULT CAUSED BY KOBE EARTHQUAKE AND RELATED GROUND MOTIONS

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SUMMARY

This paper describes the structural damages of Japanese wooden houses and water supply pipe lines in the near fault region caused by Kobe Earthquake of 1995. The damages of wooden house are shown to depend upon mainly three factors of geotechnical condition, distance from the fault, and house ages since construction. The most severe damages were found in soft soil ground for structures. The ground motion was very severe especially in the near fault region within 6-7km from fault and the motions were two to three times higher level than those expected by the existing seismic codes.

DAMAGE OF WOODEN STRUCTURES

To study damage analysis for earthquake disaster mitigation study for Shiga-Prefecture, number of damages of building structures were collected from local city governments.

Among various structures, Japanese wooden type structures are selected here as a typical index to show the effect of the ground motions to independent structure. The term "collapse" is used if the level of the damage is identified as "useless to live in" and/or "so severe and the cost of repair is the same as to build new one. "

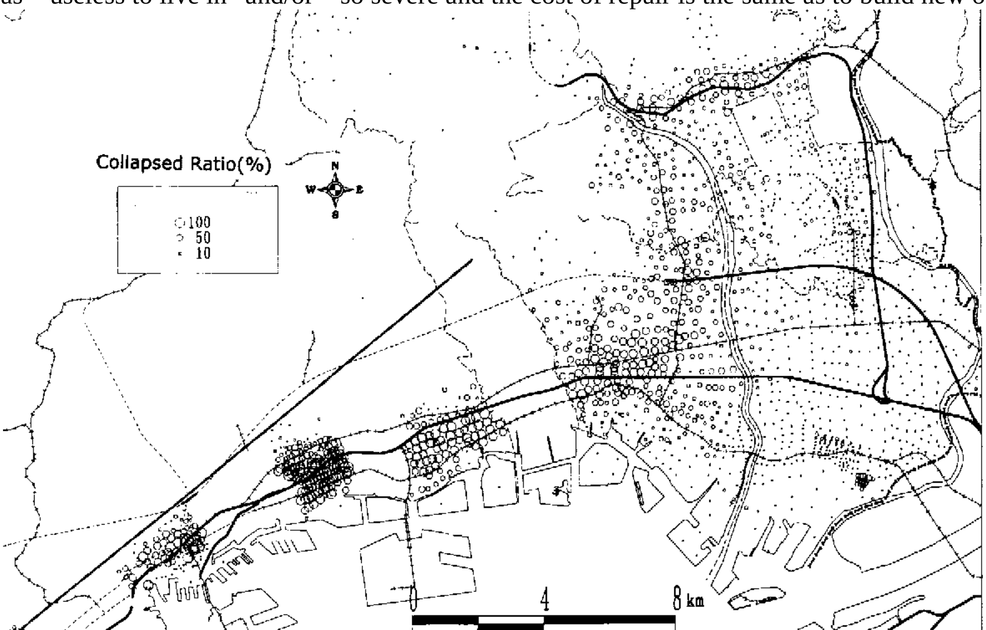

Fig.1 Distribution of Collapsed Ratio

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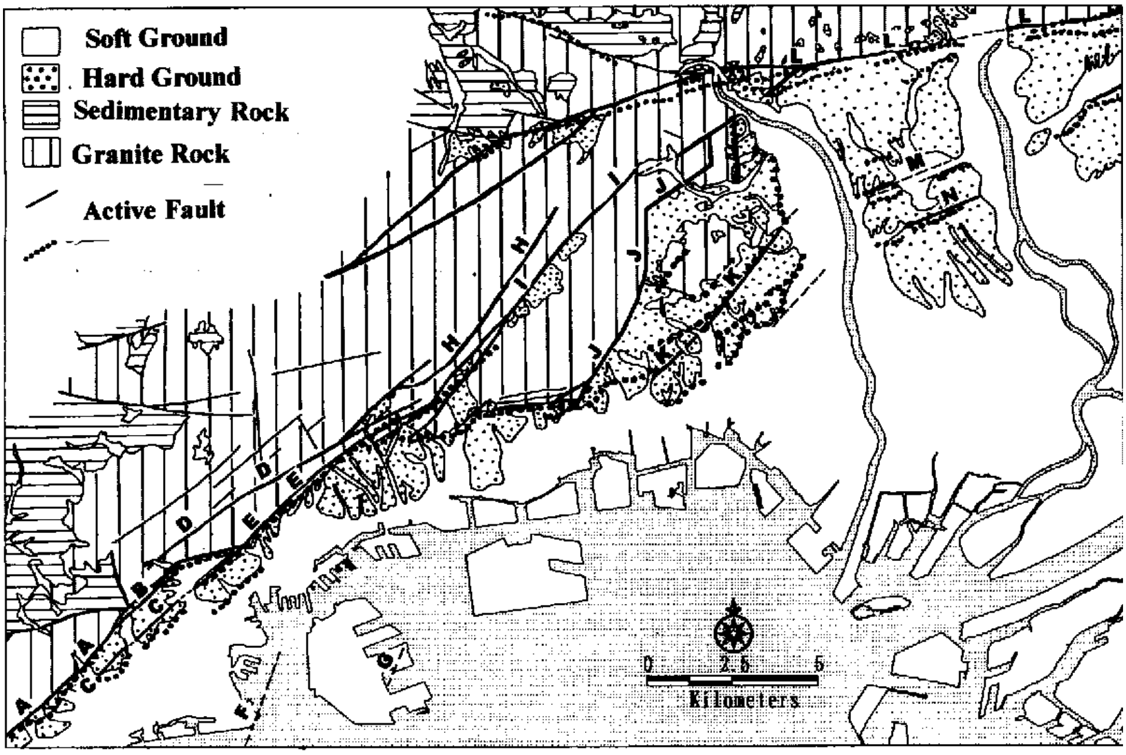

Fig.2 Geological condition

The collapse ratio[=Nc/Nt] (Nc;number of the collapsed house, Nt; total number of houses in a town block) of wooden house is shown in Fig.1. Fig.2 shows geological condition in the area. The most severe damage is found in the lowland alluvial deposit area in front of Rokko mountain, where the area is termed "damaged belt zone." The damages are analyzed and the collapsed ratios are computed for different ground types of rock, hard ground, soft ground, and liquefied ground and are shown in Figs.3. The liquefied area resulted in smaller ground motion and the collapsed ratio is less than soft ground and is almost the same as hard ground

In the preliminary analysis, the damage ratio is found strong correlation with the constructed year. The damage ratio increases continuously with the elapsed years form the construction. If the houses become older, the damage rate increases. The wooden houses are grouped into four groups as

very old house; house age more than 30years after construction (before 1965)

old house; house age 20-30 years (from 1966 to 1975)

used house; house age 10-20 years (from 1976 to 1985)

new house; house age 0-10 years (from 1986 to 1995).

Fig.4 shows that the collapsed ratio increases with house age under the same geotechnical ground condition of soft soil ground.

.It is clearly shown that damage ratio depends upon these important three factors as 1 distance from the fault, 2.ground type, and house age since construction.

If the house was built on soft ground and is located within 6-7km from the earthquake fault, the expected damage ratio varies from very high of 80-90% for very old house to medium high of 30% for new house. If the distance from the fault becomes more than 6km, the damage ratio decreases with distance and becomes minimum level at 10km.

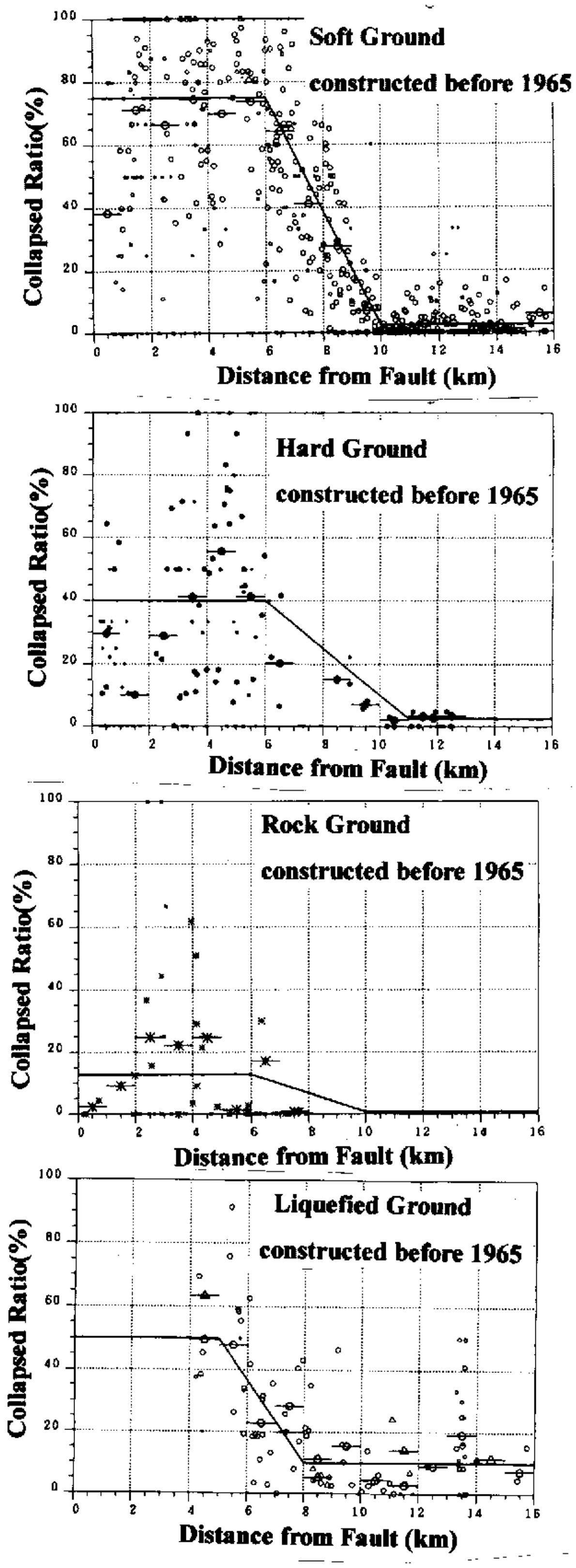

Fig.3 Damage Ratio vs. Fault Distance

(Ground Condition)

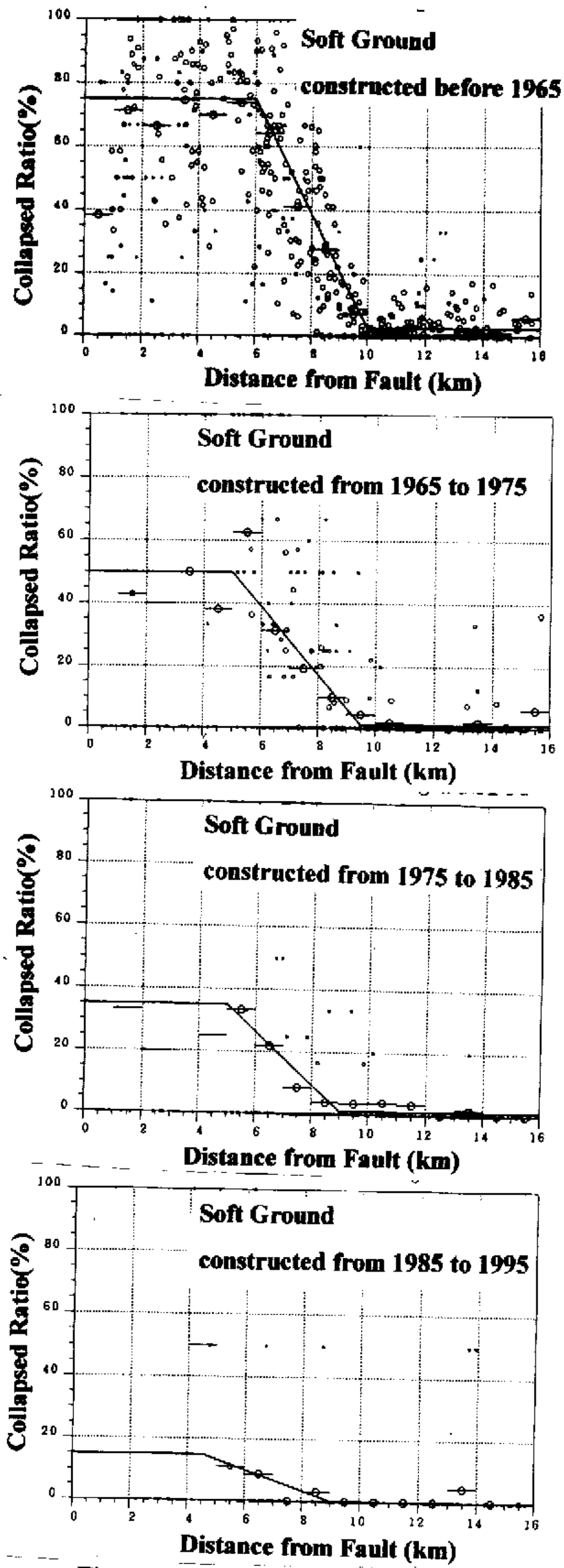

Fig.4 Damage Ratio vs. Fault Distance

(Construction year)

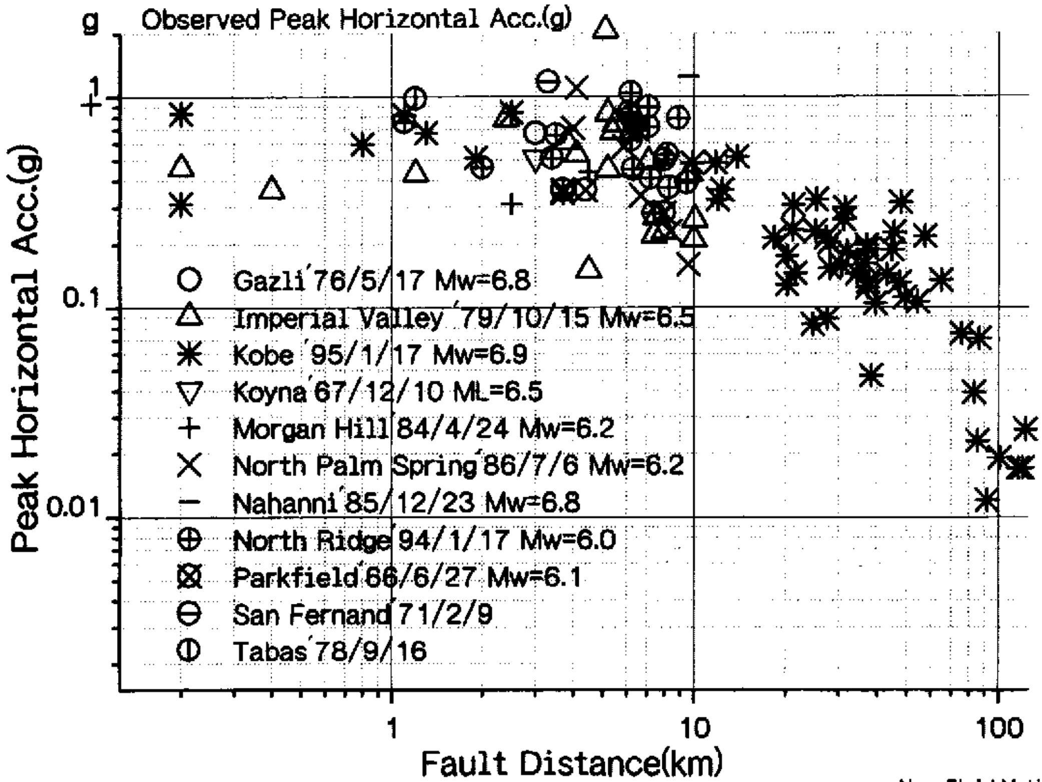

Fig. 5 Maximum Horizontal Acceleration vs. Distance(log scale) Near Field Motion Graph-3 Geo-Research Inst.,Osaka

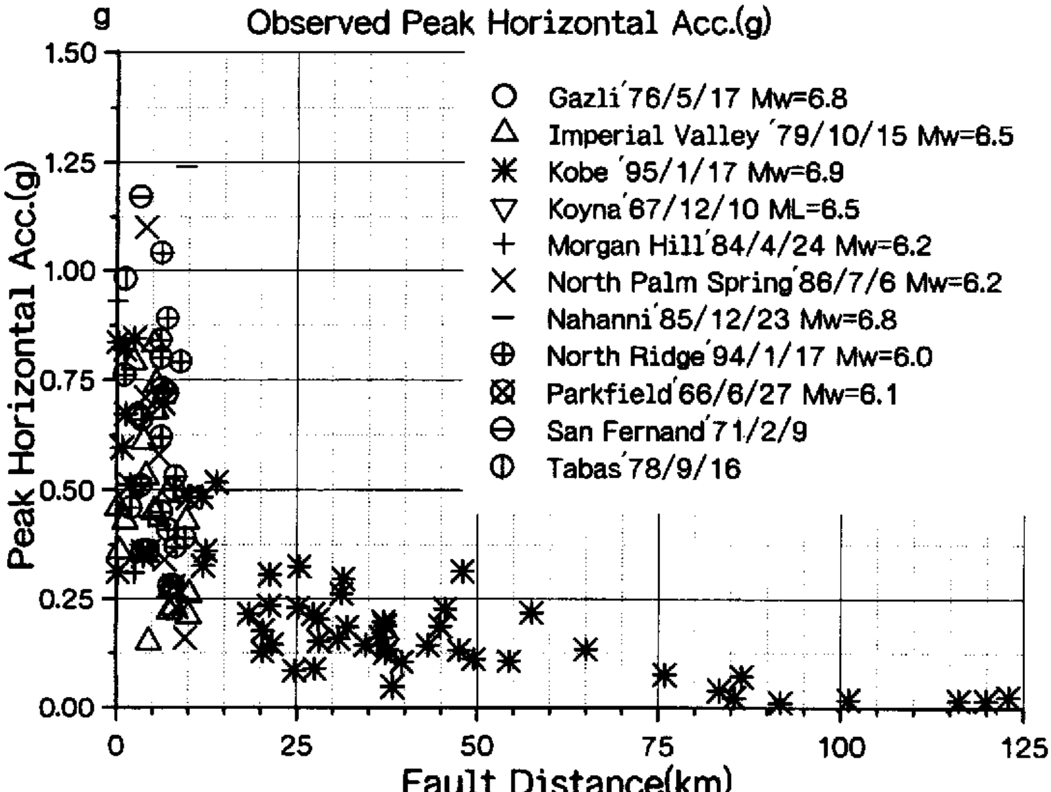

Fig.6 Maximum Horizontal Acceleration vs. Distance(normal scale) Near Field Motion Graph-3 Geo-Research Inst.,Osaka

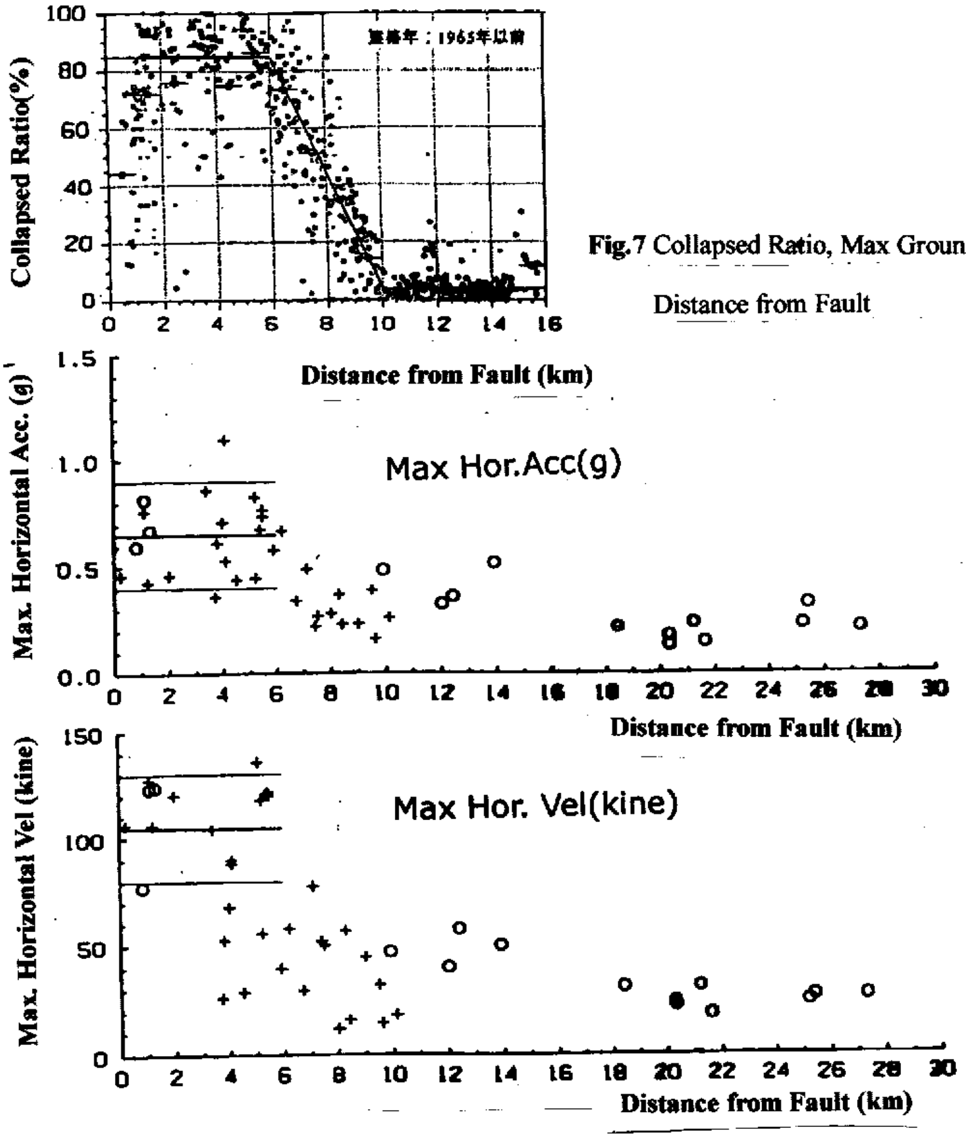

Fig.7 Collapsed Ratio, Max Ground Motions vs. Distance from Fault

NEARFIELD GROUND MOTIONS

The maximum ground motion in the near faults on rock site was recorded 305gals and 55kines at Kobe University which locates within one kilometer from the fault. The recorded motions on hard ground was 818gals and 91kines at JMA, Kobe observatory and 635gals and 138kines on soft ground at Takatori JR station.The attenuation of the maximum horizontal ground motions from the fault in the past from the world were shown in Fig.5 in log-log scales. It might be said there is a tendency for the acceleration to reach a some maximum limit near the fault and become rather constant. However, Fig.6 shows the same relationship in normal scales. The acceleration increases rather abruptly and shows several times larger values than those of outside of the near fault region. This very strong ground motion is the one of the special characteristics of the near fault ground motion. Fig.7 compares these recorded maximum ground motions with the collapsed ratio against fault distance. It is clearly shown that these damages are due to very strong ground motion in the near field region.

CONCLUSIONS

Based upon case study of damage of wooden, several lessons learnt are 1 Within the near earthquake fault region, the ground motions become very strong and the seismic design should be considered based upon the strong ground motions caused by the specified active fault. 2 Characteristics of structural damages differs according to geotechnical conditions as well as structural types. Damages of independent structures depend mainly upon the ground motion intensity itself, on the other hand