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EATHQUAKE DAMAGE OF BUILDING STRUCTURES BY THE 1994 FAR-OFF-SANRIKU EATHQUAKE AND SITE EFFECTS

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ABSTRUCT

The 1994 Far-Off-Sanriku Eathquake with the magnitude 7.5 in JMA scale occurred 21:19 on December 28, 1994. It gave great damage to Hachinohe region. The largest after shock with magnitude 6.7 occurred on January 7, 1995, gave great damage to same region. Damage by the Eathquake extended over various domains in the regional society and appeared on many publics and private structure. The damages concentrated on plateau and it's near field. The damage distribution by the main shock and after shock did not overlap at all. The damage of the building and housing occurred on the site whose predominant periods of the surface layer coincide with the predominant periods of the ground motion at the base layer.

KEYWORDS

the 1994 Far-Off-Sanriku earthquake; the after shock; the damage distribution; the predominant period of the subsurface layer; the microtremors; the predominant period of the ground motion; the amplification of the ground motion

INTRODUCTION

The 1994 Far-Off-Sanriku Eathquake with the magnitude 7.5 in JMA scale occurred 21:19 on December 28, 1994. It gave great damage to Hachinohe region in north east part of Honshu, 200*km* apart west from the epicenter. The ground motion estimated as VI in JMA scale. The largest after shock with magnitude 6.7 occurred on January 7, 1995, gave great damage to Hachinohe region. The ground motion estimated as V. Damage by the Eathquake extended over various domains in the regional society and appeared on many structures. In Hachinohe city, complete collapse numbers of the building structures and housings were 66 at the main shock and 16 at the after shock. Half collapse numbers were 354 at the main shock and 48 at after shock. The main shock and the largest after shock were very similar in the acceleration level and the duration of earthquake(Takita *et al*,1995).However these Earthquakes differed with the distribution of the damaged area in Hachinohe. The central area and the western areas were damaged during the main shock. The eastern area was damaged during the largest after shock. The purpose of this study is to invest the site effects on basis of the relationship between the building damage distribution and the following factors:

1)topographic feature, plateau and alluvial plain
2)distribution of predominant period basis of the microtremors at 188 sites
3)thickness of surface layer
4)frequency characteristic of the earthquake motion observed at the depth of 20*m* (base layer, Vs=700*m/sec*) at Hachinohe Institute of Technology.

TOPOGRAPHY IN HACHINOHE CITY AND PREDOMINANT PERIODS

Fig.1 shows topographic feature and the distribution of the predominant period in Hachinohe city. Alluvial plain is shown by dark area. Other area is plateau. In this region there are alluvial plains alongside the three rivers (Nida River,Mabechi River and Gonohe River) and Pacific Ocean. The number in the figure indicates the location of 188 points and the predominant period. The values of the predominant periods are shown by the legend in the figure. These were obtained from Fourier spectra of the microtremors.

Predominant periods of alluvial plain are from 0.5*sec* to 1.2*sec*. These is from 0.5*sec* to 1.0*sec* in alluvial plain alongside Nida River, from 0.5*sec* to 1.2*sec* alongside Mabechi River, from 0.9*sec* to 1.2*sec* alongside Gonohe River and from 0.3*sec* to 1.1*sec* alongside the see coast.

Predominant periods of plateau are from 0.14*sec* to 0.5*sec*. These is from 0.14*sec* to 0.42*sec* in the east side of Nida River and from 0.3*sec* to 0.5*sec* in the west side. But there are a few points over 0.9*sec*. The distribution of the predominant periods in the east side this river shows a tendency to be shorter than in the west side.

DISTRIBUTION OF DAMAGED BUILDINGS AND PREDOMINANT PERIODS

Fig.1 shows the damage distribution of the complete collapse buildings and the half collapse at the main shock and the after shock. In Hachinohe city, complete collapse numbers of the building structures and housings were 66 at the main shock and 16 at the after shock. Half collapse numbers were 354 at main shock and 48 at after shock. In this figure it can be observed that the damage distributions concentrate on the plateau and it's hedge. The damage distribution of the main shock is localized on the western area of Nida River and the predominant periods of this damage area are above about 0.3*sec* and under about 0.4*sec*. The damage distribution of the largest after shock is localized on the eastern and the predominant periods of this damage area are above about 0.1*sec* and under about 0. *sec*.

PREDOMINANT PERIODS AND THIKUKNESS OF SUBSURFACE LAYERS

Fig.2 shows the relationship between the predominant periods basis of the microtremors and the thickness(He*m*) of subsurface layers. The thicknesses of subsurface layers were obtained from the depth where N-value of the soil boring log became about 50. This figure shows that the thickness of the subsurface layers at the site suffered the great damages are from about 15*m* to about 30*m* at the main shock and from about 5*m* to 15*m* at the after shock.

DISTRIBUTION OF DAMAGED BUILDINGS AND GROUND MOTION

Fig.3 shows the acceleration response spectra of the ground motion recorded in the base rock(Vs=700 m/*sec*) of the 20m ground under the surface in Hachinohe Institute of Technology at the main shock of the

1994 Far-Off-Sanriku Earthquake. Fig.4 shows at the largest after shock. From Fig.3, it is clear that the predominant period of the horizontal ground motion is from about 0.3*sec* to about 0.35*sec*. From Fig.4, it is clear that the predominant period is from about 0.1*sec* to about 0.25*sec*. If this predominant period should be observed commonly in the characteristic of the input motion from the base rock, the ground motions on the subsurface layers with the similar predominant period were amplified stronger. Fig.1 shows that the predominant period of the subsurface layer of the site suffered the damage agree approximately with the predominant period of the ground motion at the main shock and the after shock. This amplified ground motion of the subsurface layers is seemed to be one of the most important cause of the damage.

RESULTS

The results of this study will be concluded as follows. (1) The damages concentrated on plateau and it's hedge. (2) The damage distribution by the main shock and the after shock did not overlap at all. (3) The predominant periods in the damaged area by the main shock were from about 0.3 *sec* to about 0.4 *sec*. These by the after shock was from about 0.15*sec* to about 0.3*sec*. (4) The depth of the subsurface layers at the site suffered the great damages is from about 15*m* to about 30*m* at the main shock and from about 5*m* to 15*m* at the after shock. (5) The acceleration records at the main-shock clearly show predominant periods in the 0.3*sec* to 0.4*sec* range. Those at the after shock clearly show predominant periods in the 0.1*sec* to 0.3*sec* range.

The damage of the building structure and housing occurred on the site whose predominant periods of the surface layer coincide with the predominant periods of the ground motion at the base layer.

REFERENCE

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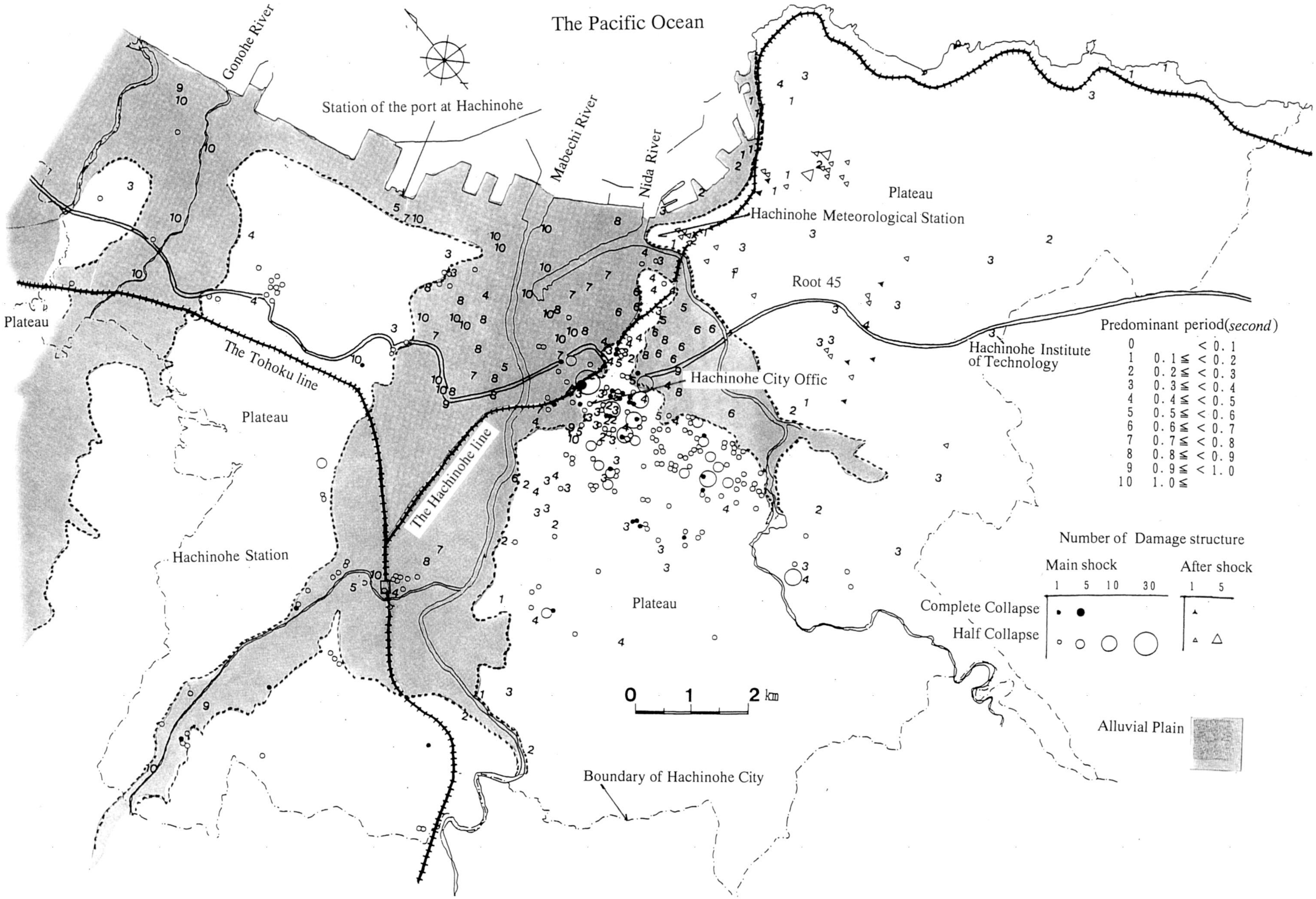

Fig.1 Map of the predominant periods, the topography and the distribution of the damaged buildings in Hachinohe city

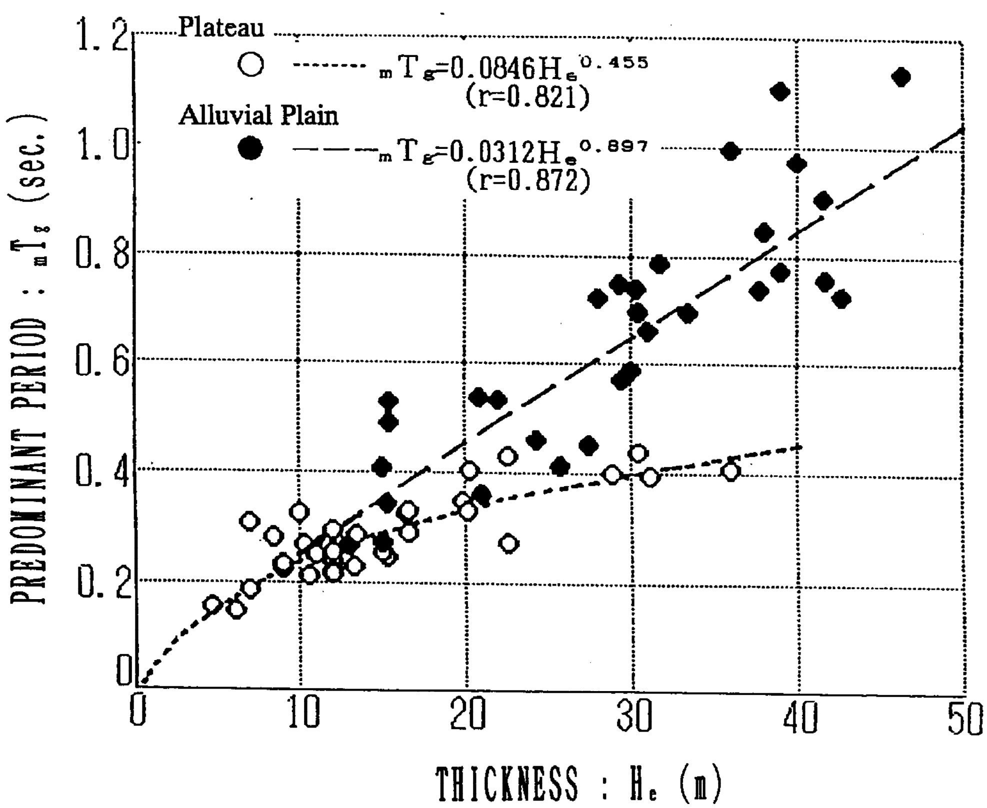

Fig.2 Relation between the predominant periods and the thickness of subsurface layers

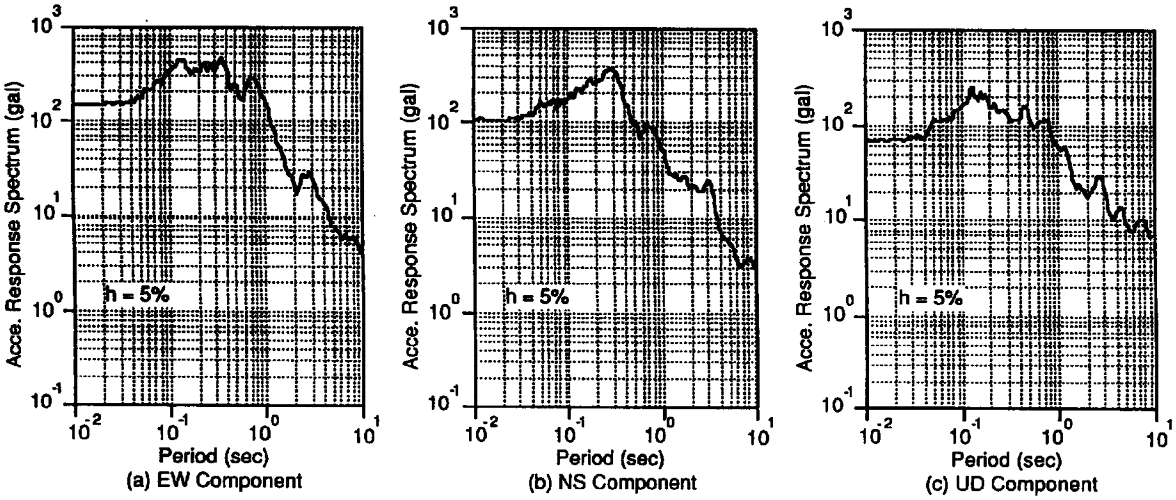

Fig.3 Acceleration response spectra of the ground motion recorded in the 20*m* ground under the surface in Hachinohe Institute of Technology at the main shock of the 1994 Far-Off-Sanriku Earthquake

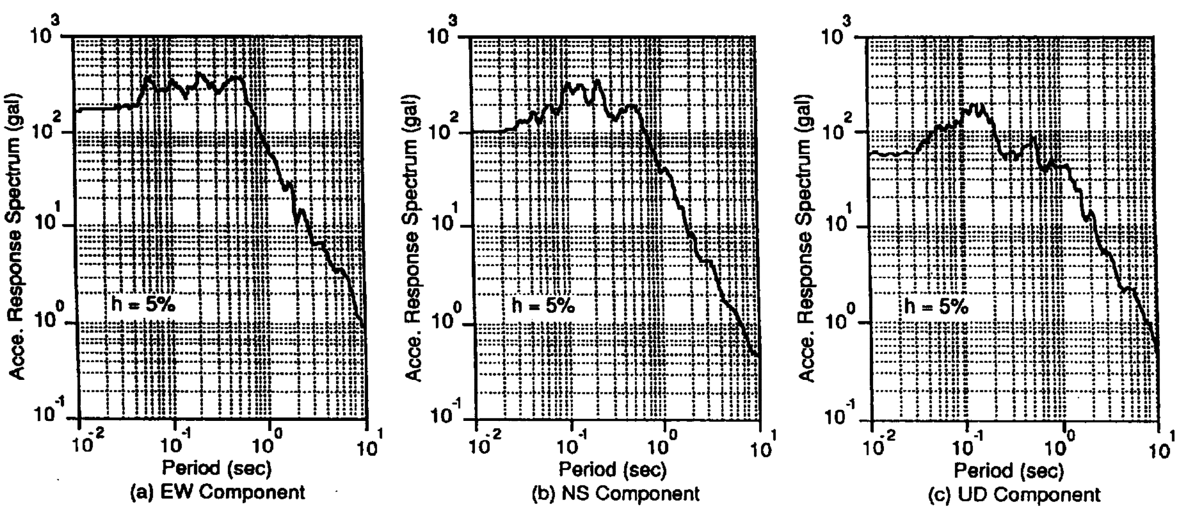

Fig.4 Acceleration response spectra of the ground motion recorded in the 20*m* ground under the surface in Hachinohe Institute of Technology at the largest after shock, occurred on January 7,1995, of the 1994 Far-Off-Sanriku Earthquake