



EARTHQUAKE DAMAGE OF BUILDING STRUCTURES AND SITE EFFECTS

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SUMMARY

The relation between the site condition and the damage of the region is necessary to expect the earthquake damage of the region. Therefore, it is important to do the close scrutiny for the damage received due to the earthquake that happened in the past of the region. The Hachinohe city received a lot of damages of the 1968 Tokachi-Oki Earthquake and he 1994 Far-Off-Sanriku Earthquake in the past about 30 years in two large earthquakes. The common feature of the damage that Hachinohe City had received in two large earthquakes was examined. The investigation examined the following two points. The first investigated the relation between the predominant period of the ground and the damage of the house. The second investigated the relation between the depth of the surface layer and the damage of the house. It was shown that the position where the damage building caused by both earthquakes was distributed was almost the same by this investigation.

INTRODUCTION

The estimate concerning earthquake damage is basic information to do the earthquake disaster prevention. The relationship between the site condition and the damage situation of the site are necessary to assume the earthquake damage of the site. It is known well that the difference of the site condition of the region greatly influences the difference of the damage situation. Therefore, it is important to do a strict comparative research for the damage received due to the earthquake that happened in the past of the region.

The Hachinohe city received a lot of damages of the 1968 Tokachi-Oki Earthquake and he 1994 Far-Off-Sanriku Earthquake in the past about 30 years in two large earthquakes. The 1968

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Tokachi-Oki Earthquake was generated at 9:49 May 16, 1968. The magnitude in the JMA scale was 7.9. The seismic intensity of Hachinohe was V in the JMA scale. The Far-Off-Sanriku Earthquake was generated at 21:19 December 28, 1994. The magnitude in the JMA scale was 7.5. The seismic intensity of Hachinohe was VI in the JMA scale. The common feature of the damage that Hachinohe City had received in these two large earthquakes was examined.

Contents of the examination were the following two points.

The first investigated the relation between the predominant period of the ground and the damage of the house. The second investigated the relation between the depth of the surface layer and the damage of the house.

It was shown that the position where the damage building caused by both earthquakes was distributed was almost the same by this investigation. In the investigation of the 1994 Far-Off-Sanriku Earthquake, the partial failure level to which it did not pay attention so much was used as house damage. The contents of damage at the partial failure level were considerably various. However, it was thought that it was a valuable information in not only the examination of the area distribution of damage but also the damage assumption in the future.

DAMAGE OF DWELLING HOUSES AND GROUND CHARACTERISTICS IN HACHINOHE CITY IN THE 1994 FAR-OFF-SANRIKU EARTHQUAKE

House damage distribution and geographical features

Damage concentrated on Hachinohe and a Sannohe region near the epicenter of the 1994 Far-Off-Sanriku Earthquake. The number of complete collapse of buildings was 61 in Hachinohe City. The number of partial collapse was 342. The number of partial failure was 10,756. Most in the damage building was a wooden dwelling house. The damage rate was requested according to the following procedures. The whole area of the city is divided into the mesh of 250 meters in length and 340 meters in width. The partial failure damage rate was a number in which the number of damage buildings in the mesh was divided by the number of all buildings in the mesh. Figure 1 showed the distribution of the partial failure damage rate of the whole area of Hachinohe City. Figure showed the classification of the low ground of the alluvial and the plateau. It was shown that the region of a high damage rate that is concentrated and distributed was a region in the plateau. Especially, it could be read that the region where a lot of damages exists is an edge of the plateau in the vicinity of the low ground of the alluvial. Damage in the low ground of the alluvial was distributed in the region in the vicinity of the plateau a little. However, damage was very small in the region where the alluvial layer accumulates thick. It was Ruike region and Shimonaga region. Moreover, the distribution of this partial failure damage rate almost corresponded to the distribution of the building of complete destruction. It was similar to the distribution of the building of partial destruction [Moro et al., 1996].

Dwelling house damage and surface layer

Partial failure damage rate and predominant period of ground

Figure 2 showed the relation to the predominant period obtained from the partial failure damage rate and the microtremor. The data of figure was a result of about 280 points of the measurement by 1995. The predominant period that became the maximum damage rate was a range of 0.4 seconds from 0.3. The damage rate was 70% or more. Damage rates of 0.2-0.5 seconds within the range exceed 50%. The

damage rate decreases while becoming a period that was longer than it. On the other hand, the damage rate has decreased from 0.2 seconds similarly for the small period.

Partial failure damage rate and depth of surface weak stratum

Figure 3 showed the relation between the partial failure damage rate and the depth of the surface weak stratum (H: meter). Here, the depth of the surface weak stratum was requested from the distribution of N-value obtained from the ground boring exploration. In the depth of the weak stratum, the N-ary was depth to the point of about 40. As for figure, it was understood that the damage rate was growing by the depth of 10-15 meters of the weak stratum in the surface layer.

Dwelling house damage and surface course ground characteristics of residential areas

To examine the relation between the house damage and the dynamic characteristic of ground in detail, a detailed microtremor was measured in the residential areas of ten. The region in ten dwellings is Chouja C Fukiage, Asahigaoka, Misakidai, Hachinohe Newtown new Minato, Same, and is Uchimaru, Shimonaga, and Ruike. The relation between the damage distribution of the house and the predominant period was examined in these regions.

Shinminato and Same region were regions with little damage due to this earthquake. And, there was little damage in this region even at time in past 1968 Tokachi-Oki Earthquake. The predominant period of ground in these regions was smaller than that of 0.2 seconds.

Uchimaru, Chouja, and Fukiage were located in the Hachinohe plateau in an old built-up area. Asahigaoka, Misakidai, and Hachinohe Newtown were located in the housing complex it, and the plateau developed after 1968 Tokachi-Oki Earthquake. These regions were regions where a lot of damages were caused. The predominant period of the ground in these regions was about 0.3 seconds from about 0.5 seconds.

Shimoosa and Ruike were the residential area regions where a soft alluvial layer was deep. The depth also has the place where it reaches almost as many as 40 meters, too. These regions were minimum regional of the damage rate. The predominant period in these regions was about one second. The predominant period reached considerably long according to the place at about 1.8 seconds.

Figure 4 was assumed to be an example, and the distribution of damage in the region and the relation of the ground property were shown. The value at the predominant period and the position of the ground bore and the house damage were indicated in Figure 4. Figure 4(a) was a region in Shinminato. Figure 4 (b) was a region in Asahigaoka. Figure 4 (c) was a region in Shimonaga.

Topographic feature of region and N-value distribution of columnar section of soil.

Figure 5 was a columnar section of a typical soil in Shinminato, Asahigaoka, and the Shimoosa region. Figure 4 showed the position where these columnar sections were gathered.

When the columnar section of Shinminato in Figure 5 was seen, it was shown that the depth of the weak stratum was several meters or less. A stratum that is deeper than it is a solid rock. There was even a place where the rock had the outcrop like the position's being shown in Figure 4(a) for this region. Geographical features was a low ground in the coast. The position where it showed with the dotted line during the figure is a cliff. The cliff top was Tatehana. There was a Hachinohe meteorological observatory.

Asahigaoka in Figure 4(b) was in the plateau. In this region, the stiff stratum where N-value exceeded 50 exists from the depth of 10-20 meters. The distribution map of the N-value of Shimonaga located at the

center of Figure 4(c) was the one of the thought point that the alluvial layer was the thickest in the low price ground in Mabechi River. Here, the weak stratum whose N-value was 5-10 was consecutive even in the depth of 40 meters. Figure showed that the depth of the alluvial layer thins in the vicinity of the Negishi elementary school of the boundary with the Gonohe plateau.

Damage distribution and predominant period of ground.

It has been understood that there was little house damage from Figure 4 on the site of the predominant period of 0.2 seconds or less. And, it could be read to cause damage in the region of 0.3 seconds or more at the predominant period. All regions were predominant periods of 0.3-0.4 seconds in Asahigaoka. Damage was caused in the entire region Asahigaoka. In Shimonaga, Ishidou and Negishi region ,predominant periods were 0.8-1.8 seconds and long periods. Damage was hardly caused in these regions. However, the predominant period near the Negishi elementary school was about 0.4 seconds. A lot of damage was caused on this site.

From the above-mentioned thing, it could be said that there are relations in a flat situation of the occurrence of damage and the distribution situation at the ground predominant period. The ground predominant period could be said to the relation that damage would occur easily on sites of 0.3-0.4 seconds. And, damage decreases by coming off from the value at this predominant period.

HOUSE DAMAGE OF HACHINOHE CITY BY 1968 TOKACHI-OKI EARTHQUAKE AND CHARACTISTIC OF GROUND

The investigation of the damage of the timbered house in 1968 Tokachi-Oki Earthquake was a little. It was the least part in the damage report of architectural institute of Japan. The dwelling house's complete destruction was 144 houses according to the survey of Hachinohe City. Partial destruction was 379 houses. And, the partial failure was 22,700 houses.

When the area distribution of damage was presumed based on this little data of Hachinohe City, damages were caused in the Uchimaru region that was the urban area and on ground in alluvial layer where shallow water riverbank is thin. And, it was distributed in the Gonohe plateau in Mabechi River paralleled in low ground. Damage was hardly caused in Ruike and Shimonaga in a thick weak stratum that had piled up.

Figure 6 was the damage distribution charts of the Hachinohe built-up areas in. This figure was the one that Hotta and others investigated [Nishimura et al., 1969].

The microtremor measurement point and the predominant period were written when Moro measured it and it added in figure. When damage from this figure to the building was distributed on the plateau and the edge of the plateau and the low ground, it was possible to read. The distribution of this damage came in succession almost in the damage distribution about the 1994 Far-Off-Sanriku Earthquake. Therefore, the relation to the ground predominant period is also similar.

Figure 7 is the quotations from the Tanaka and other's report of the surveys of the 1968 Tokachi-Oki Earthquake [Tanaka et al., 1968]. The complete destruction rate of the village in the alluvial layer plains in the Asamizu river shore was shown in figure. Moreover, the value at the predominant period that had been obtained from the microtremor measurement was recorded. It was able to be read that the predominant period of the site where damage was large was a value of about 0.4 seconds. When Figure 1 and Figure 6 are seen, it seems that the damage generation place of the Asamizu river measuring up was considerably corresponding by the 1994 Far-Off-Sanriku Earthquake and 1968 Tokachi-Oki Earthquake .

When Figure 1 and Figure 6 are seen, it seems that the damage generation place of the Asamizu river measuring up is considerably corresponding by the 1994 Far-Off-Sanriku Earthquake and 1968 Tokachi-Oki Earthquake . The area distribution of the house damage of 1968 Tokachi-Oki Earthquake was presumed to come in succession the area distribution of the house damage of the 1994 Far-Off-Sanriku Earthquake from these things.

CONCLUSION

The result of this research can conclude as follows:

- (1)The region of the house damage due to both earthquakes was roughly the same region. Accordingly, The dwelling house damage by both earthquakes happened in an area of the same surface layer characteristic for the most part.
- (2)Damage concentrated on the plateau and the vicinity.
- (3)The predominant periods in the damage area of the dwelling house were about 0.3 ~ 0.4 second.
- (4)The depth of the weak stratum on the surface of the damage region was from 10 to about 15 meter.

In 1968 Tokachi-Oki Earthquake, the duration of the principal shock continued in the vicinity for one minute. The long period component was considerably superior. On the other hand, the duration of the principal shock was about five seconds in the 1994 Far-Off-Sanriku Earthquake. The short period component was considerably superior.

The source area of building damage was considerably corresponding though it was a difference of this characteristic of two earthquakes. Osaki searched for Great Kanto Earthquake about damage in the timbered house and the relation to the surface weak stratum [Osaki 1962]. And, the damage rate of a wooden dwelling was assumed to have grown rapidly by the alluvial layer thick. The result of this theory doesn't correspond to the conclusion of this Osaki.

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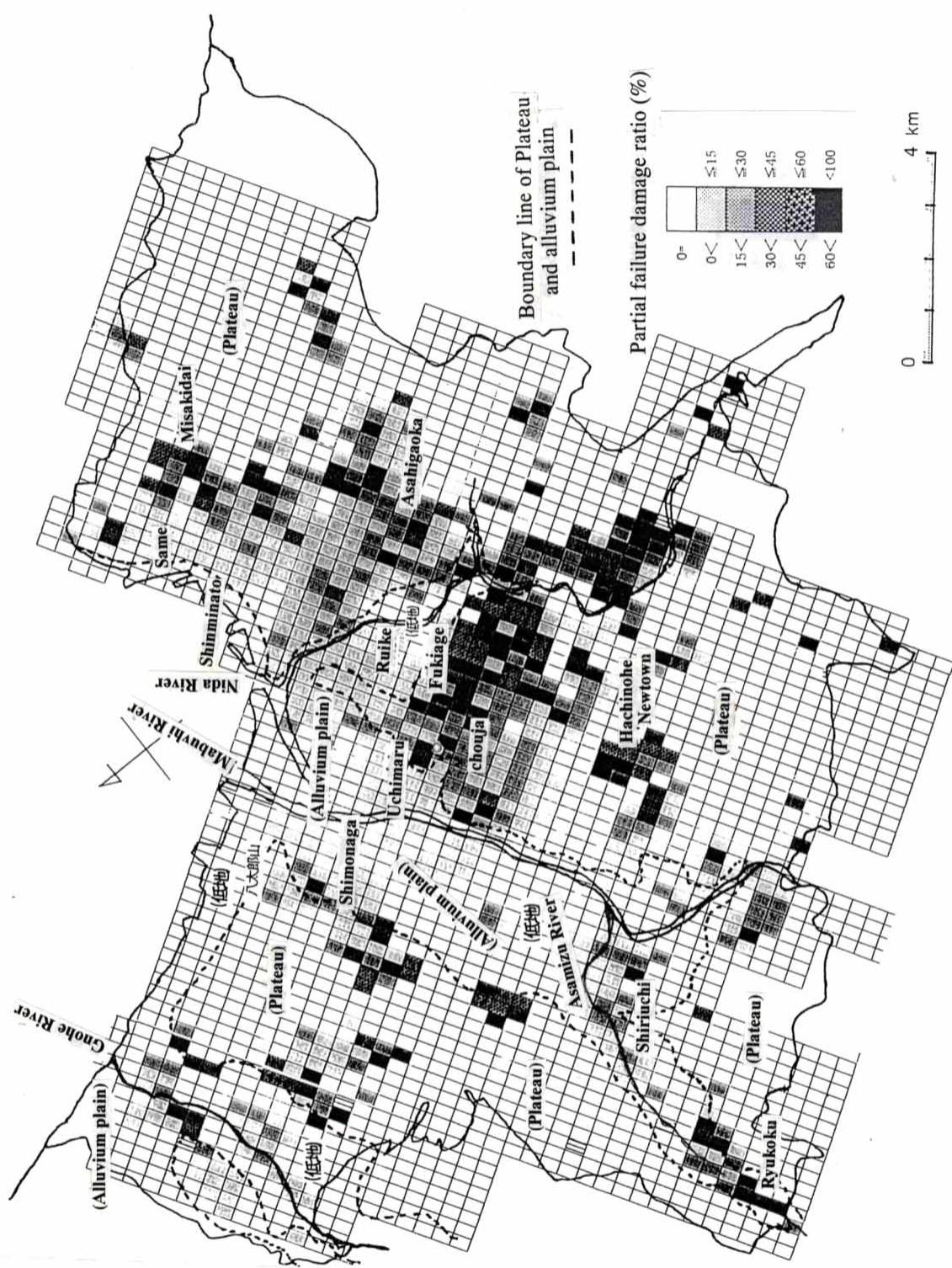


Fig. 1: Distribution of partial failure damage ratio

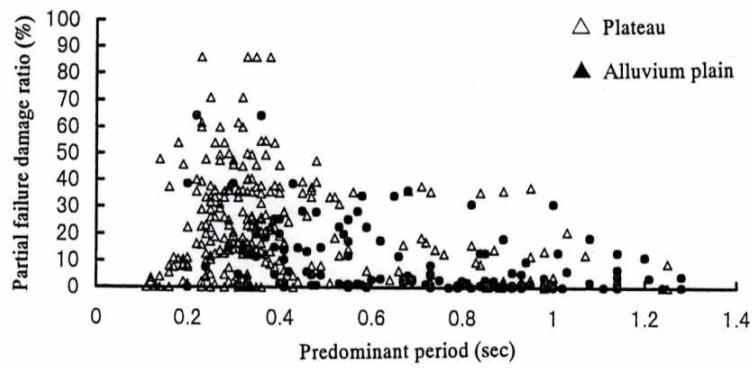


Fig. 2 : Predominant period partial failure damage ratio

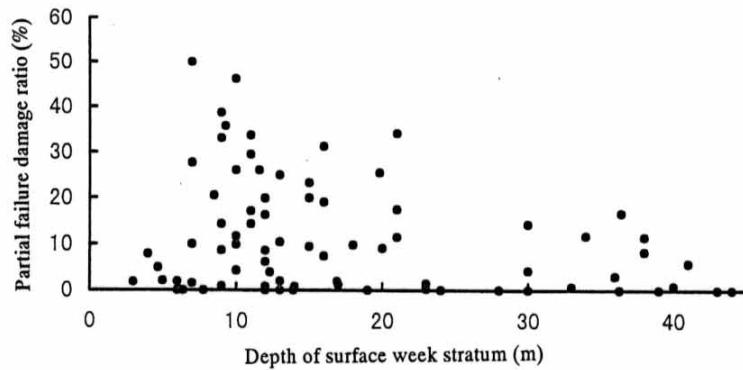


Fig. 3 : Depth of surface week stratum and partial failure damage ratio

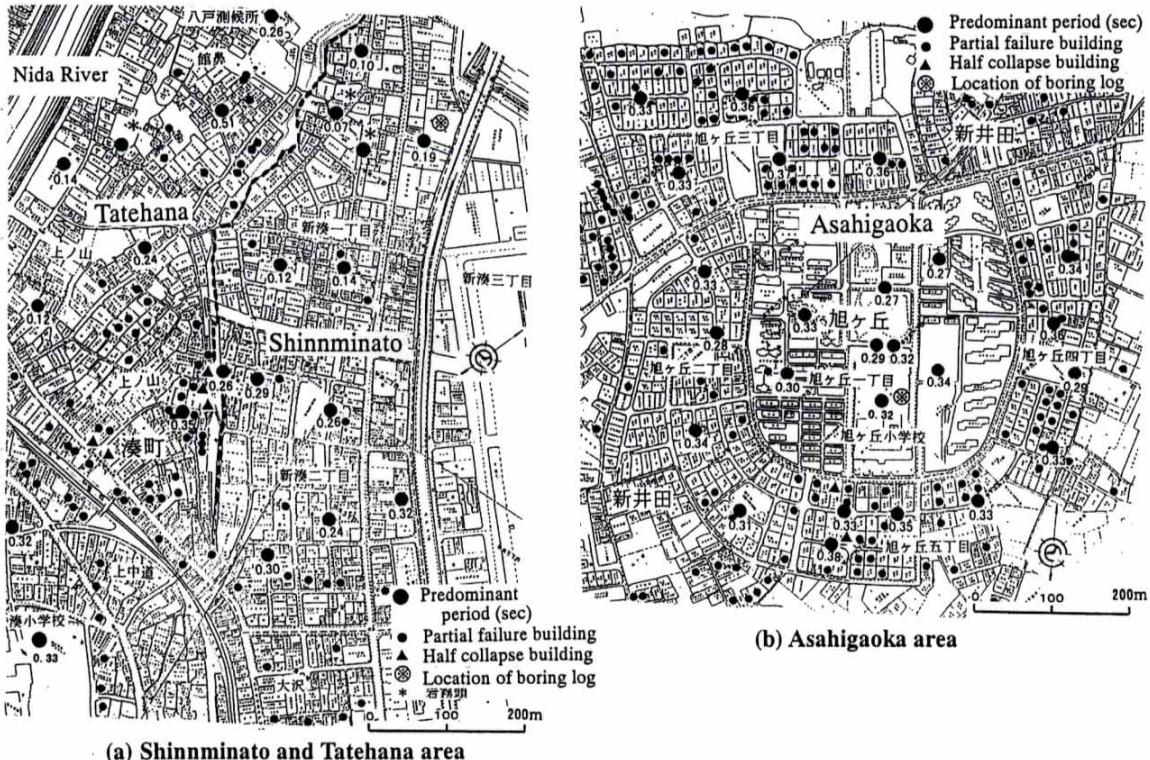
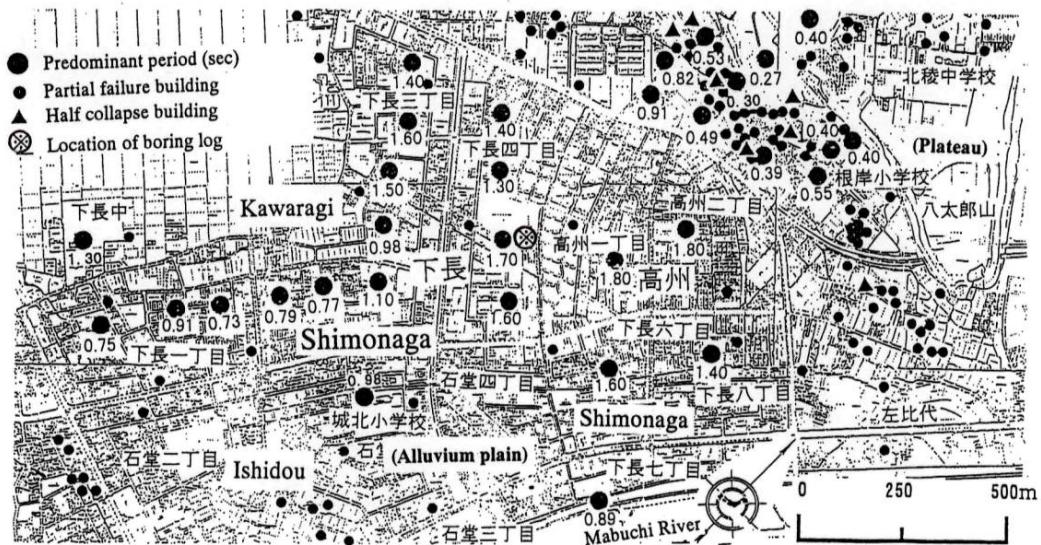
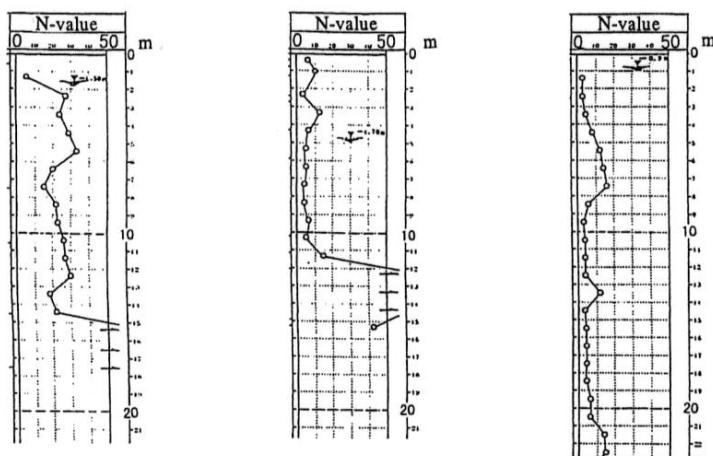


Fig. 4: Distribution and damage building and predominant period



(c) Shimonaga and Kawaragi area

Fig. 4: Distribution and damage building and predominant period



(a) Sinninato

(b) Asahigaoka

(c) Shimonaga

Fig. 5: Boring logs of three areas

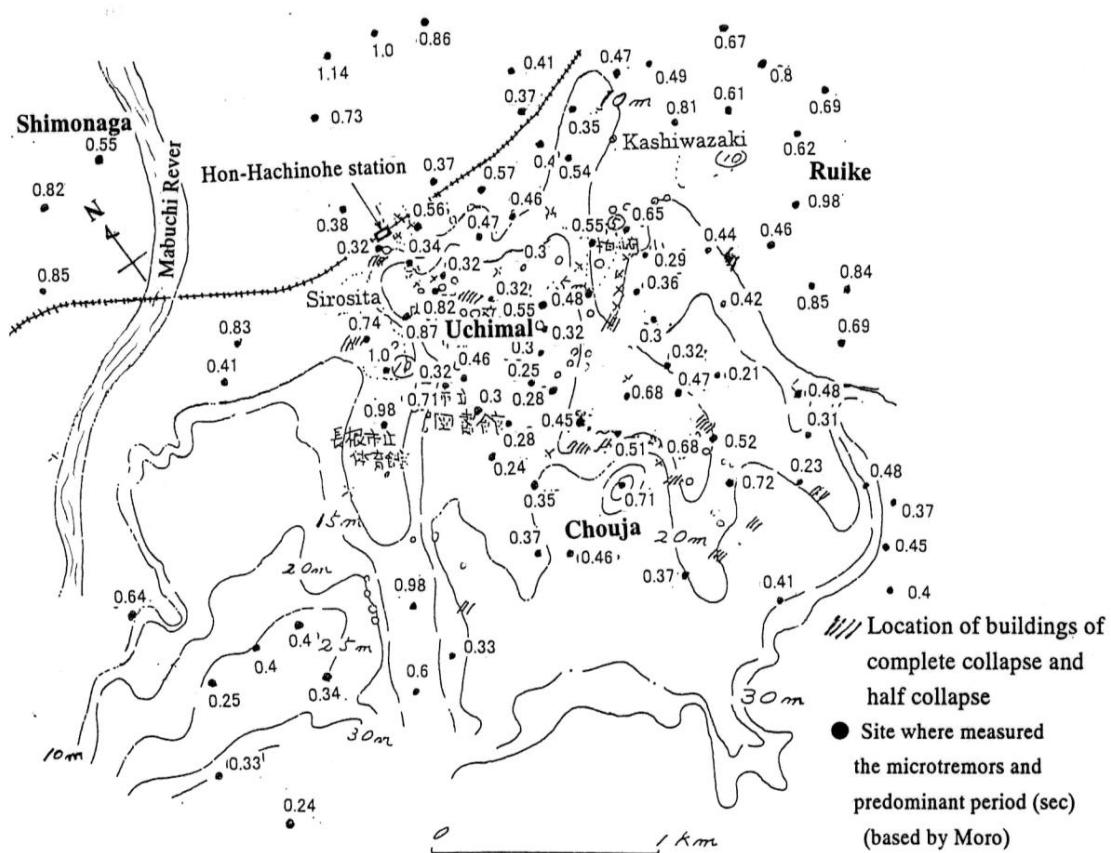


Fig. 6: Locations of damage buildings by the 1968 Tokachi-Oki Earthquake and predominant periods on Hachinohe plateau in old built-up area

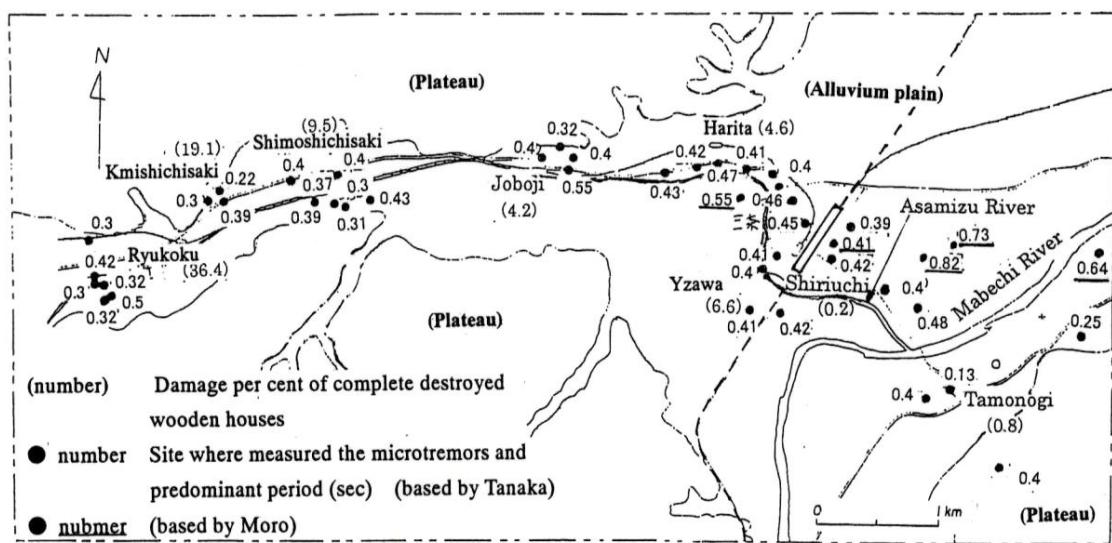


Fig. 7: Damage per cent of totally destroyed wooden houses by the 1968 Tokachi-Oki Earthquake and predominant periods on the alluvial plain along the river Asamizu , west of Hachinohe city