EARTHQUAKE DAMAGE OF BUILDING STRUCTURES AND SITE EFFECTS

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SUMMARY

The relation between the ground condition and the damage of the area need to be announced, to hypothesize the earthquake damage of the area. Accordingly, it is an important to do the close survey with regard to the damage that inflicted by the earthquake that occurred in the past of the area. Hachinohe city suffered many damages in 2 large earthquakes of the 1968 Tokachi-Oki Earthquake and also the 1994 Sanriku-Haruka-Oki Earthquake. The author examined it about the common feature of the damage that Hachinohe city received by these 2 large earthquakes. The contents of the examination are the following 2 points. The 1st clarified about the relation between the predominant period of ground and the damage of the dwelling house. The 2nd clarified about the relation between the depth of surface layer and the damage of the dwelling house. From the study, it knew that the damage distribution place of the building where blushed by both earthquakes was almost same.

INTRODUCTION

The estimation of the earthquake damage needs to be carried out to examine the earthquake disaster prevention. The relation between the ground condition and the damage of the area need to be announced, to hypothesize the earthquake damage of the area. There are many unique things to the ground in each area. Even the situation of the earthquake damage has the characteristics by the area. Accordingly, it is an important to do the close survey with regard to the damage that inflicted by the earthquake that occurred in the past of the area.

Hachinohe city suffered many damages in 2 large earthquakes of the 1968 Tokachi-Oki Earthquake and also the 1994 Sanriku-Haruka-Oki Earthquake. The 1968 Tokachi-Oki Earthquake was the magnitude 7.9 in JMA scale and occurred 9:49 on May 16, 1968. The seismic intensity of Hachinohe was V in JMA scale. The 1994 Sanriku-Haruka-Oki Earthquake was the magnitude 7.5 in JMA scale and occurred 21:19 on December 28, 1994. The seismic intensity of Hachinohe was VI in JMA scale. The author examined it about the common feature of the damage that Hachinohe city received by these 2 large earthquakes.

The contents of the examination are the following 2 points. The 1st clarified about the relation between the predominant period of ground and the damage of the dwelling house. The 2nd clarified about the relation between the depth of surface layer and the damage of the dwelling house. Furthermore, as for in the damage of "the partial failure" the level, sundry contents coexist. Therefore, this damage was not done and not be watch so important in the damage survey, until now. This paper esteemed such "the partial failure" level.

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2. DAMAGE OF DWELLING HOUSES GROUND CHARACTERISTICS IN HACHINOHE CITY IN THE 1994 SANRIKU-HARUKA-OKI EARTQUAKE

2.1 Dwelling house damage distribution and topography

Damage concentrated on Hachinohe and Sannohe region in the 1994 Sanriku-Haruka-Oki Earthquake as the epicenter off the coast of Sannriku Off. In Hachinohe city, complete collapse numbers of the building structures and housings were 61. Half collapse numbers were 342. Partial failure numbers were 10,756. "A partial failure" does not reach to completely destroyed and partial destruction. However, it is the thing of the degree that needs repair. Furthermore, most of the damage of the failure is a part of wooden dwelling house.

The damage rate of partial failure is the ratios of all the ridge numbers and the ridge numbers of the partial failure in section inside of 340 m×240 m. Figure 1 shows the distribution of this damage rate inside Hachinohe all area is. Figure shows the classification of alluvium low ground and plateau.

The area where the damage of the partial failure is concentrating a part is the plateau. Especially the damages are resulting a lot on the edge of the plateau near alluvium low ground. The damage in alluvium low ground results a little to the area of the boundary with the plateau. But there is very little damage in the area which fragile alluvium deposit accumulates thickly. It is Ruike and Shimonaga area. Furthermore, the distribution of this partial failure damage rate almost corresponds with the situation of the distribution of complete collapse and half collapse building [Moro et al., 1996].

2.2 Dwelling house damage and surface layer

2.2.1 Partial failure damage rate and predominant period of ground

Figure 2 shows the relation with the partial failure damage rate and the predominant period that was obtained from microtremors. The data in the figure is the result of about 280 points that I measured by 1995. When it sees Figure 2 the damage rate is a biggest peak with in 0.4 seconds from 0.3. The value is with nearly 70%. From 0.2 seconds in the range in 0.5 seconds the damage rate exceeds 50%. As it consists to a longer period than it the damage rate decreases. On the other hand, the damage rate has decreased even 0.2 or fewer seconds.

2.2.2 partial failure damage rate and depth of surface weak stratum

Figure 3 shows relation between a part of failure damage rate and the depth (H: meter) of surface weak stratum. Here the depth of surface weak stratum obtained it even from the N-value distribution of the ground boring log. The depth of the weak stratum of the surface layer made such depth that that the N-value reaches over about almost 40. The figure shows that the damage rate is big in the place of about 10～15 depth meters of the weak stratum of the surface layer. The damage rate is small in the range other than it.

2.3 Dwelling house damage and surface course ground characteristics of residential areas

We did the microtremors measuring of many points in 10 residential areas where it shows to Figure 1, in order to examine the relation between the dwelling house damage of the area and the dynamic characteristics of ground in detail. The 10 residence areas are Shinminato, Same, Uchimaru, Chouja, Fukiage, Asahigaoka, Misakidai, Hachinohe Newtown, Shimonaga and Ruike. I examined the correspondence of the damage distribution of the dwelling house and the predominant period about these areas.

Shinminato and Same area are the area without damage almost with the earthquake in this time. And, this area is the area without damage almost even when it puts it to the 1968 Tokachi-Oki Earthquake in the past. The predominant period of the ground is the areas of 0.2 or fewer seconds.

Uchimaru, Chouja and Fukiage area are on Hachinohe plateau in old built-up area. Asahigaoka, Misakidai and Hachinohe Newtown are the residence housing that was developed after the 1968 Tokachi-Oki Earth and be on a plateau. These areas

are the area which many damages resulted. The predominant period of the ground is about 0.3～0.5 seconds.
Shimonaga and Ruike area are the residential area on the such alluvium ground that the soft alluvium deposit accumulates nearly 40 meters in a deep place. These areas are the least area of the damage rate. The predominant period of the ground is over almost 1 second of area. By the place, it is about 1.8 seconds.
This paper studies Sinminato, Asahigaoka and Shimonaga area of Figure 4 about the local distribution of the damage and the ground characteristics as an example. Figure 4 (a) shows the positions that measured microtremors, the value of predominant period and the positions of the dwelling house damage of Shinminato. Figure 4 (b) shows of Asahigaoka area. Figure 4 (c) shows of Shimonaga area.

2.3.1 Characteristic of the topography of area and N-value distribution of soil columnar section

Figure 5 shows the representative N-value distribution chart of each area. Furthermore, showing the picking position of this each ground boring log in Figure 4 it exists.
As shown in Figure 5 in Shinminato area, the depth of weak stratum that the N-value is 10 or less is several meters. Than it the deeper bed is a hard bed such that the N-value exceeds 50. It is the area which that this area depends on the place becomes a rock right away. As for this area, there is the place where the rock does the outcrop as shown in Figure 4 (a). The topography is beach low ground. The position where it showed with the dotted line during the figure is a cliff. The cliff top is Tatehana. There is Hachinohe weather station.

Asahigaoka is on a plateau. Even the N-value distribution of the area ground is not decided uniformly. The N-value exceeds 50 or a sufficient N-value exists from the depth of 10～20 meters as the support ground.
The N-value distribution chart of Shimonaga is the thing of the point that is thought that alluvium deposit is thickest in Mabuchi river low ground. As for the characteristic of the distribution, a fragile layer weak stratum that the N-value is about 5～10 has reached to the depth of about 40 meters it is case. The figure is showing that as it accesses in the Negishi elementary school neighborhoods of the borders with Gonohe plateaus the depth of the alluvium deposit becomes thin.

2.3.2 Damage distribution and predominant period of ground

From figure 4, it knows that almost there is not dwelling house damage in the sites of 0.2 or fewer seconds of the predominant period. And it knows those damage results to the area of over 0.3 seconds of predominant periods.
In Asahigaoka area, all the areas are the predominant period of about 0.3～0.4 seconds. Also, even damage is resulting to all the areas. In Shimonaga, Ishidou and Negishi area, the predominant period is 0.8～1.8 seconds and long period. Damage hardly result to this area. But the predominant period is about 0.4 seconds in the area of the Negishi elementary school neighborhood. This neighborhood is able to read it that there are many damages.

From over, it knows that the distribution situation of damage is closely related to the distribution situation of the predominant period. As for the relation, damage has occurred a lot in the area in 0.4 seconds from 0.3 seconds of the predominant period it is case. And, the damage decreases, as it comes off from the value of this predominant period.

3. DWELLING HOUSE DAMAGE AND GROUND CHARACTERISTICS OF IN HACHINOHE CITY BY THE 1968 TOKACHI-OKI EARTHQUAKE

There are few surveys regarding the damage of the wooden dwelling houses in the 1968 Tokachi-Oki Earthquake. It is the least part in many survey reports. Especially there is few that data regarding the distribution of damage. According to, the survey of Hachinohe city as for complete collapse, there were 144 ridges. As for half collapse, there were 379 ridges. And, as for the partial failure, there were 22,700 ridges. I estimated the area distribution of the architecture damage that Hachinohe city received on the basis of few data for investigation. Then, the damage distributes in Uchimaru area of the built-up area, the alluvium low ground of Asamizu riverside and the Gonohe plateau going along Mabuchi river low ground. There is not almost damage in Ruike or Shimonaga such a flimsy ground distribution area.

Figure 6 is the damage distribution charts of the Hachinohe built-up areas in. This figure is the one that Hotta and others investigated [Nishimura et al., 1969]. Writing the ground predominant period of the point that I measured in figure I added it. From this figure, it is able to read it that the dwelling houses of the complete collapse damage and half collapse damage are distributing to the plateau and the connection. The distribution of this damage agrees approximately with the damage distribution of the Sanriku-Hakuka-Oki Earthquake. Accordingly, even the relation with the ground predominant period is conceivable as the same.

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 figure is showing the completely destroyed rate of the villages that are in the alluvium plain of an Asamizu riverside and the predominant period that was obtained from microtremors observation. It is able to read it that the predominant period of the damage area ground is around 0.4 seconds. As know and see Figure 1 and also Figure 6, the damage area of this Asamizu riverside overlaps with the area which damage occurred a lot with the 1994 Sanriku-Haruka-Oki Earthquake

From over, the area distribution of the dwelling house damage of the 1968 Tokachi-Oki Earthquake is able to estimate as the one that agrees fairly with the area distribution of the dwelling house damage in the 1994 Sanriku-Haruka-oki Earthquake.

4. CONCLUSIONS

The results of this study are concluded as follows:
(1) The Area of the dwelling house damages by both earthquakes are the same areas for the most part. Accordingly, The dwelling house damage by both earthquakes happened in an area of the same surface layer characteristic for the most part.
(2) The damages concentrated on the plateau and it's near field.
(3) The predominant periods in the damage area of the dwelling house were about 0.3～0.4 second.
(4) The depth of surface week stratum in the damaged area were about 10～15 m

In the 1968 Tokachi-Oki Earthquake as for the continuation time of the principal shock, a long period component excels fairly near, 1 minute. To it, in the 1994 Sanriku-Haruka-Oki Earthquake the continuation time of the principal shock was the earthquake that short period component excelled with about 5 seconds. Without being related to those differences, the occurrence area of the building damage where resulted by the earthquake of both is same almost. Osaki examined it about the relation between the wooden damage and surface course ground in Great Kanto Earthquake [Osaki 1962]. And, his paper was concluding that the damage of a wooden dwelling house occurs a lot, as the alluvium deposit is thick. The conclusion of this paper contradicts with this Osaki's conclusion.

5.REFERENCES

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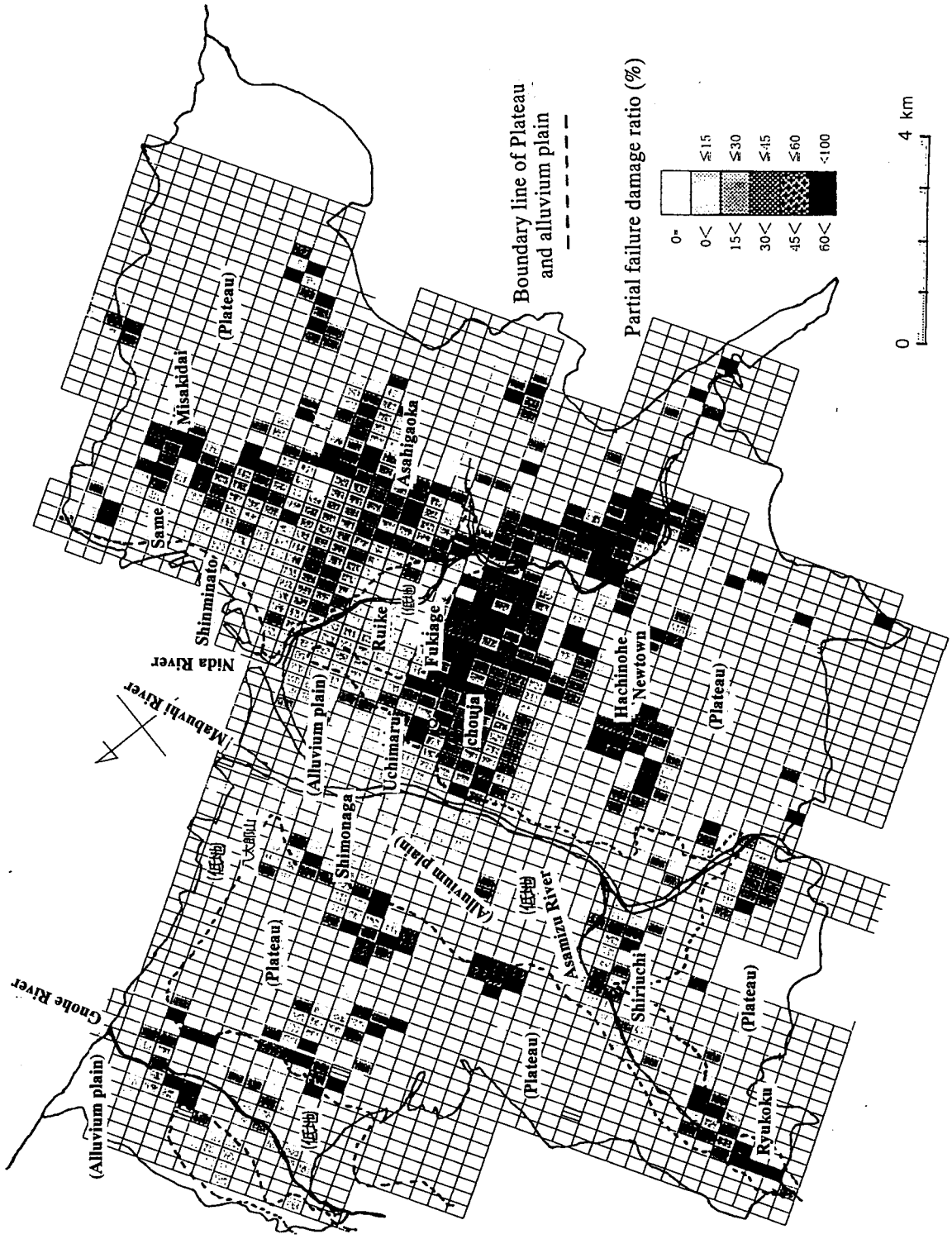


Fig. 1: Distribution of partial failure damage ratio

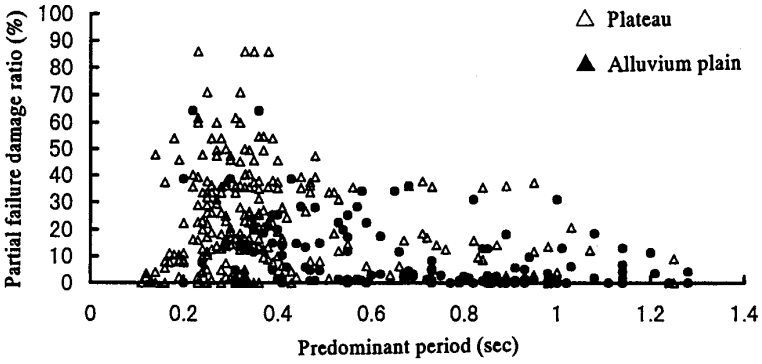


Fig. 2 : Predominant period partial failure damage ratio

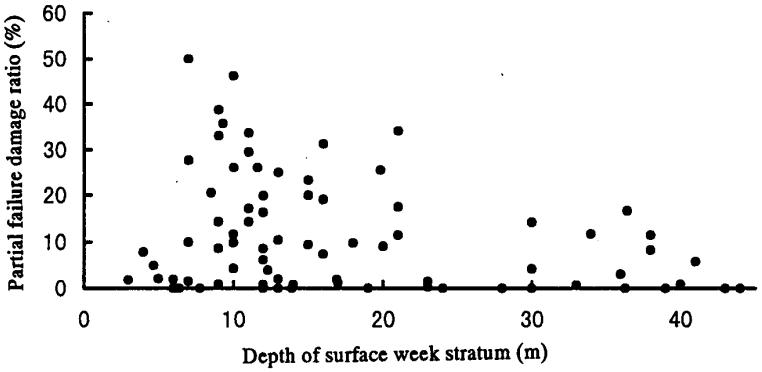
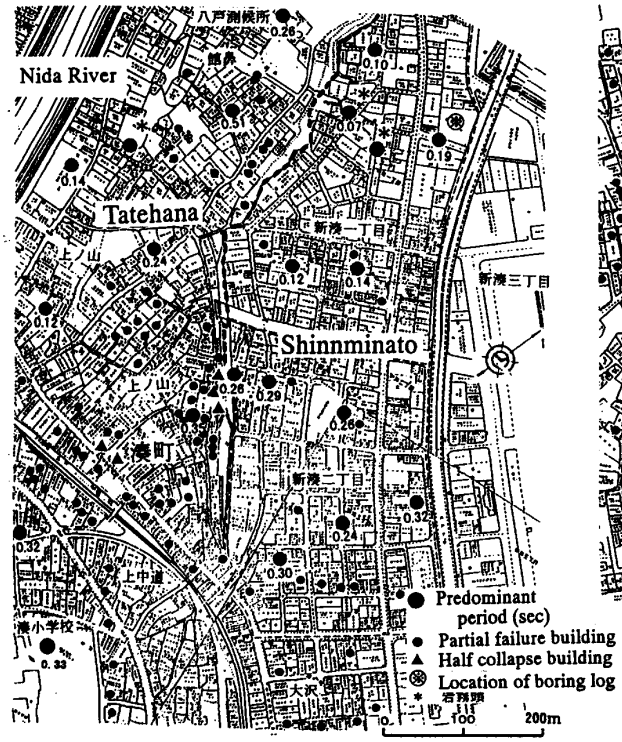


Fig. 3 : Depth of surface week stratum and partial failure damage ratio



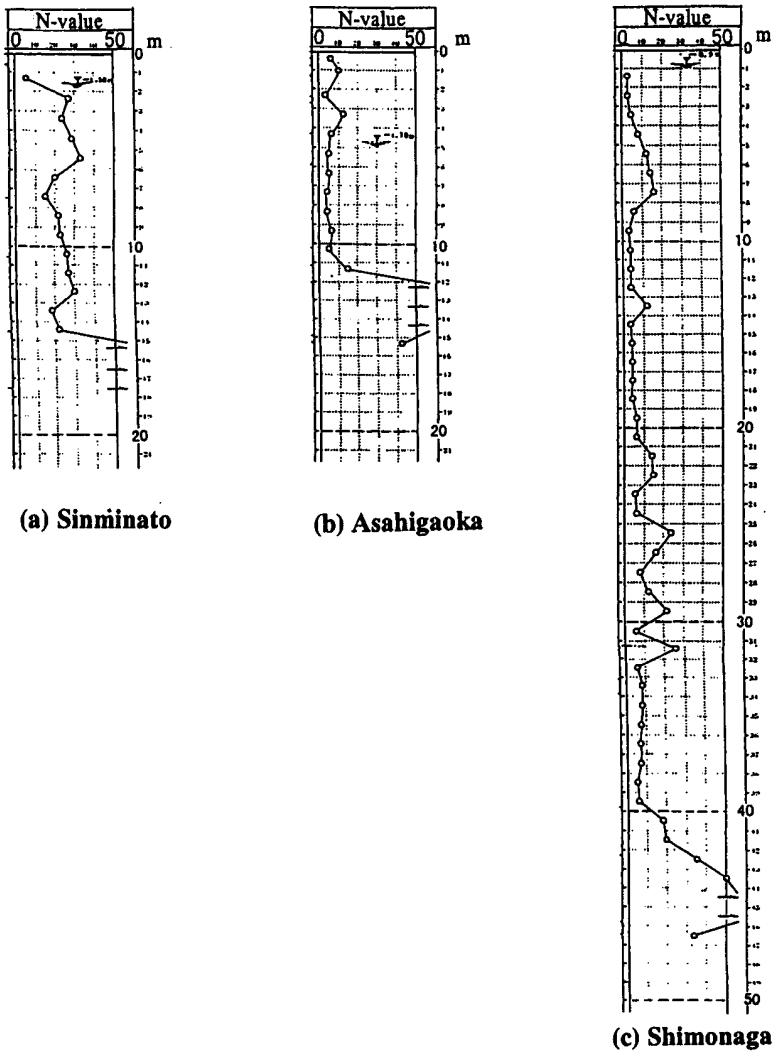
(a) Shinnminato and Tatehana area

(b) Asahigaoka area

Fig. 4: Distribution and damage building and predominant period

(c) Shimonaga and Kawaragi area

Fig. 4: Distribution and damage building and predominant period



(a) Sinminato

(b) Asahigaoka

(c) Shimonaga

Fig. 5: Boring logs of three areas

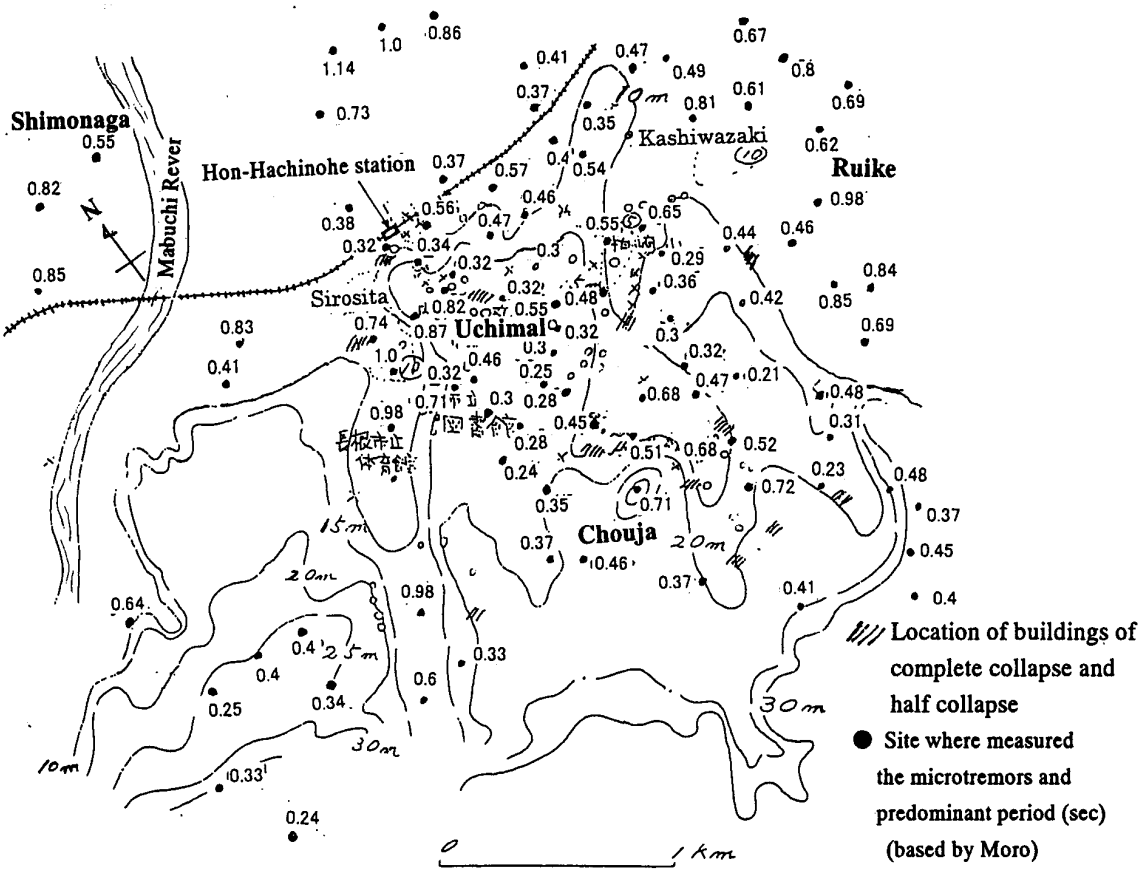


Fig. 6: Locations of damage buildings by the 1968 Tokachi-Oki Earthquake and predominant periods on Hachinohe plateau in old built-up area

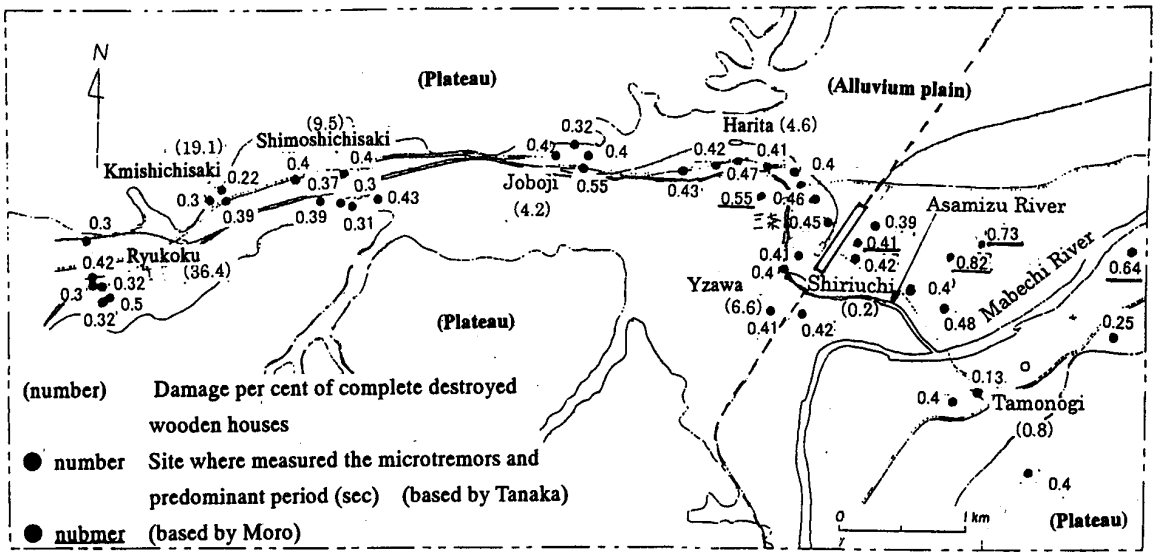


Fig. 7: Damage per cent of tottally destroyed wooden houses by the 1968 Tokachi-Oki Earthquake and predominant periods on the alluvial plain along the river Asamizu , west of Hachinohe city