37. *On the Damage to Buildings by the Imaichi Earthquake of Dec. 26, 1949.*

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1. Introduction.

Two destructive earthquakes occurred successively near Imaichi-town (Tochigi prefecture) at 8 h 18 m and 8 h 26 m on Dec. 26, 1949, and caused damage as shown in Fig. 1 and Table. I.

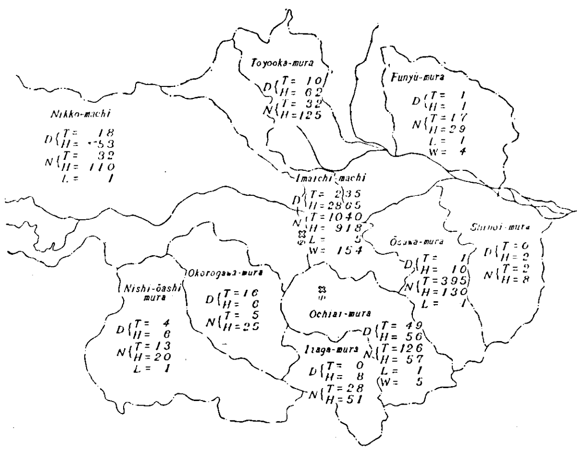

Fig. 1. Distributions of the damage to buildings and humans. Symbles *D* and *N*, represent dwelling houses and not-dwelling houses. Symbles *T*, *H*, *L* and *W* represent number of houses totally destroyed, half destroyed, lives lost and persons wounded. Mark × indicates the epicenter.

Table I. Damage of the Imaichi Earthquake

No. of Dwelling-houses		No. of Build. not for dwelling		No. of Lives loss	No. of Persons wounded
Totally destroyed	Half destroyed	Totally destroyed	Half destroyed		
334	3069	1690	1484	10	163

The buildings not for dwelling in the seismic region are mostly soft-stone granaries or wooden buildings covered with soft-stone.

Generally speaking, relatively flexible buildings as wooden dwellings received slight damage, but, the damage done to rather rigid structures like soft-stone granaries or wooden buildings covered with soft-stone was somewhat large.

Similar phenomena concerning the damage done to buildings were to be seen in the Tokyo Earthquake of Apr. 26, 1922.[1)]

The phenomena just mentioned are likely to be explained by the facts that the scale of the earthquake was small, and the afflicted area being very near to the origin, the period as well as the duration of shocks were short.

2. Results of the investigations regarding the wooden buildings covered with soft stone.

As there are a great number of wooden granaries covered with soft-stone in the afflicted area which suffered comparatively large damage, we carried out mainly statistical investigations in connection with the damage done to those buildings. The method of the investigations employed was as follows: first, the height of each damaged building was divided into three to examine which part of it had suffered most: next, we collected the same kind of destruction at every block of village, and investigated the relation between the most damaged part of the building and the nature of ground. The results arranged are shown in Fig. 2 as well as Table II.

Table II. Damage to wooden granaries covered with soft stone.

Ground condition	Part most damaged			
	Evenly	Upper	Middle	Lower
Up (Hard) lands	2%	87%	4%	7%
Plain (Soft) lands	11%	27%	20%	42%

From these results, it will be seen that, on plain lands, the rate of the buildings which suffered most damage at the upper part is high, while on uplands most buildings were damaged at their lowest part.

If we consider the problem of forced oscillation of structure according to the general idea, the part subjected to the maximum stress must be placed higher as the period of the earthquake shocks becomes shorter. Then, the

1) *Rep. Earthq. Inv. Comm.*, No. 99 (1925), 44.

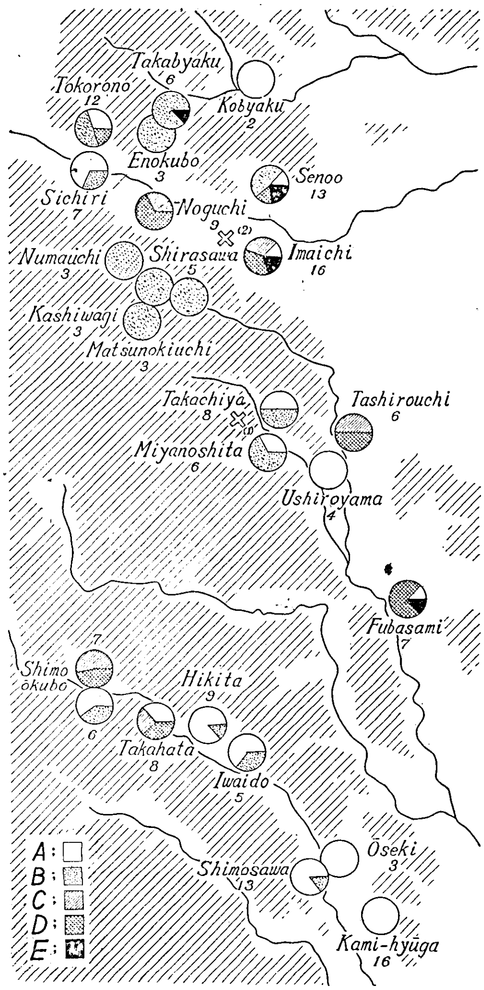

Fig. 2. Distribution of the damage to wooden granaries covered with soft stone. The spaces indicated by symbol *A*, *B*, *C*, *D* and *E* represent the rate of the buildings undamaged, damaged at the upper part, middle part, lower part and evenly, respectively. The figure written under the name of each block of village represents the number of buildings which had been investigated. Hatched zone is upland. Mark × indicates the epicenter.

general conception that the period of earthquake shock on plain lands is rather large compared with that of the uplands, is quite opposed to the above-mentioned phenomena.

However, it will be cleared up considerably by the results of our theoretical study based upon the idea that at the time of earthquake the vibration energy of buildings dissipates to the ground again as the elastic wave that starts from the foundation.[1]

Namely, according to our theoretical studies, the dissipation of vibration energy of structures into the ground as well as the height of the part subjected to the maximum stress tend to increase with the decrease in the rigidity of the ground, supposing that the period and the amplitude are constant.

This theoretical results coincide fairly well with the destructive phenomena of buildings in the earthquake studied here. These features had been already pointed out in the study of the damage done to ferro-concrete buildings in the Kwantô earthquake.[2]

3. Conclusion.

Investigating statistically into the damage done to wooden granaries covered with soft stone, we came to the conclusion that, on soft ground, the most damaged part of these buildings was the upper part, while on hard ground, it was the lower part.

On the other hand, the soft-stone granaries situated on the soft level lands were scarecely damaged, but, on the hard up-lands, the damage done to similar buildings were considerably large.

It is more natural to consider that these phenomena occurred by the nature of dissipation of vibration energy of buildings into the ground rather than by the difference of periods of earthquake shocks. In conclusion, we wish to express our hearty thanks to Mr. M. Suzuki who worked together in this investigation.

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37. 昭和24年12月26日今市地震の建物被害について

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今回の地震被害は，比較的に柔構造の木造住家等に小さく，比較的に剛構造の石造及び貼石木構造の藏等に大きい傾向を明かに示していた．この現象は，地震の規模が小さく，激震地域が震源に近いために，地震動の周期が短く，震動繼續時間も短かかつたために起つたと考えてよかろう．

被害数の多かつた貼石木構造の藏について最大被害個所と地盤との関係をしらべたところ，軟い地盤上では上部で最大の被害を受けたものが比較的に多く，反対に硬い地盤上では下部のものが多いことがわかつた．この事実は，地盤による地震動の周期の差違では説明が困難で，地震時に建物の震動勢力が地下に逸散する性質に関する数理的研究結果と定性的にはよく合う．

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1) K. SEZAWA and K. KANAI, *Bull. Earthq. Res. Inst.*, 14 (1936), 164.
2) K. KANAI, *Bull. Earthq. Res. Inst.*, 27 (1949), 97.