14. *Human Susceptibility to Shock Vibrations of the Ground.*

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Earth-vibrations caused by the dropping of a heavy mass or by hammerring shocks are used for the seismic method of examining underground geology. But these vibrations frequently incur complaints from townspeople owing to noises and unpleasant shocks. It thus becomes necessary not only to study the vibrations from seismometry but also to lessen the disturbance. The writer measured such vibrations and investigated human susceptibility or the lower limit of feeling earthquake motions.

The human susceptibility was studied, on the other hand, from medical or physiological points. Recently M. Oshima published a paper "Vibration and Human Being"[1]. He drew a graph of the relation between the susceptibility and the amplitude and frequency of harmonic vibrations which is reproduced in Fig. 1.

Firstly, the relation obtained by K. Suyehiro[2] was added in the graph as white circles, the values of which he got from a seismologist point of view. The values may fit the line drawn by Oshima as shown in Fig. 1.

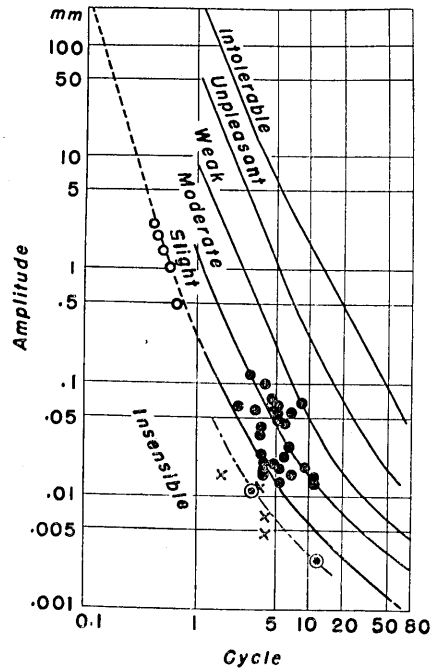

Fig. 1. Human Susceptibility to vibrations. (cross = insensible)

The writer, as mentioned above, had several occasions to measure

1) M. OSHIMA, *Tekkō-Rōdō-Eisei* **2** (1953), Nos. 1, 2 and 3-4.
2) K. SUYEHIRO, *Proc. Imp. Acad. Japan* **5** (1929), 411.

the ground vibrations caused by heavy failling mass, and some of the results were reported before[3]. The writer compares here his results with Oshima's, after describing his observed results briefly.

The acceleration of ground motions caused by fallen mass decreases rapidly with the distance from the source of the shock (Fig. 2). The shock was not felt at a greater distance than about 200 m. The vertical component was larger than the horizontal component within 200 m from the source both in amplitude and acceleration (Fig. 3), while at a distance beyond 200 m, the relation becomes contrary.

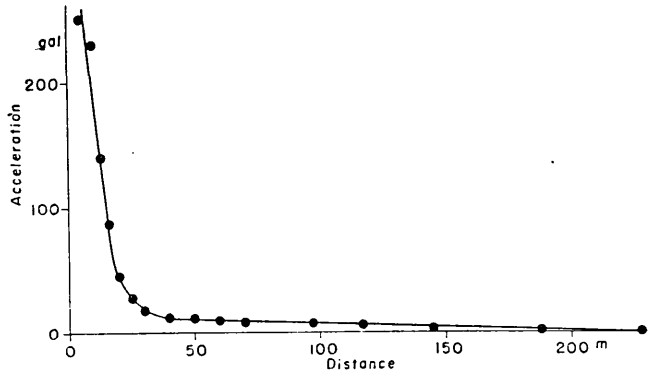

Fig. 2.

The writer considers that vertical motions of the ground and rattling of window-panes and doors caused by the shock aggravate the human feeling against the vibrations.

The values obtained by the writer plotted in Fig. 1 by black dots and crosses will show that the susceptibility to shocks is lower than to harmonic motions.

The human susceptibility to earthquake motions had been studied by seismologists. M. Ishimoto[4] found a relation between the acceleration of earthquake motions and the seismic intensity scale adopted in Japan. His studies were concerned especially with earthquakes at Tōkyō, and the result is shown below:

Ishimoto's Scale

Intensity scale	0	I	II	III	IV	.....
Acceleration (gal)	0–0.5	0.5–2	2–8	8–32	32–128	.....

3) F. KISHINOUYE, *Bull. Earthq. Res. Inst.*, **30** (1952), 59.

4) M. ISHIMOTO, *Bull. Earthq. Res. Inst.*, **10** (1932), 614.

Similar relations were published by W. Inouye[5], whose study was carried out at Tukuba on the bed of granite of Mt. Tukuba about 60 km N of Tōkyō.

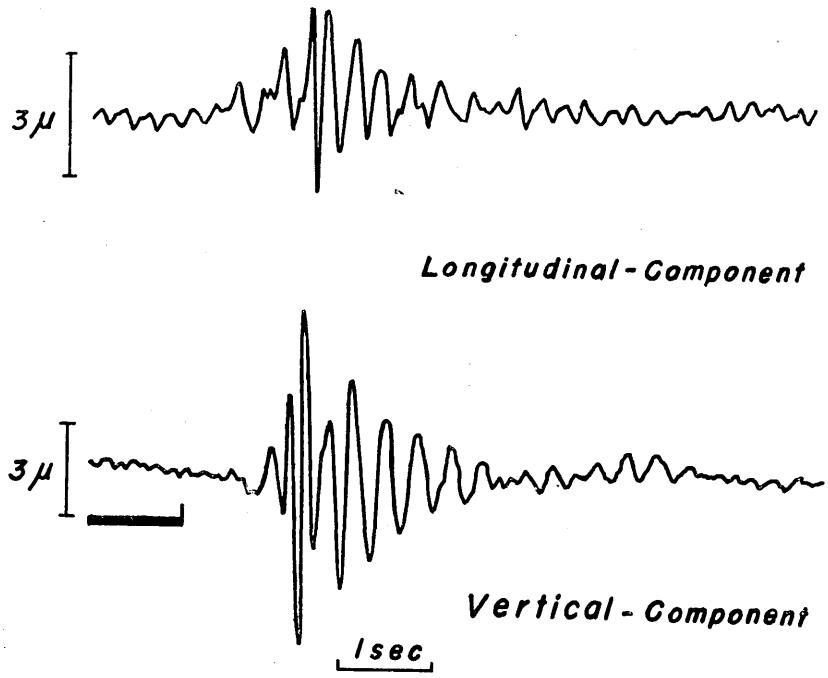

Fig. 3. Earth-vibration by falling of a mass recorded at 130 m distance.

Inouye's Scale

Intensity scale	0	I	II	III	.....
Acceleration (gal)	0–1.7	1.7–6.9	6.9–35	35–	.....

Both investigations failed to determine the relation to earthquakes of high grades because such strong earthquakes did not occur during their observations.

The lower limit of human susceptibility obtained by the two investigators may be moderately different from each other. It will be due to the difference in the periods of earthquake motions at the two places. Ishimoto's observations were carried out at Hongō, Tōkyō, on loam, and Inouye's on granite. The periods at the two places were

5) W. INOUYE, *Bull. Earthq. Res. Inst.*, **11** (1933), 69.

obtained as 0.3 sec (3.3 c/s) and 0.08 sec (12.5 c/s) respectively. The writer must mention here that their results were given in terms of acceleration of motions. So the relation between period and amplitude was reduced by the formula $\alpha=4\pi^2 a/T^2$, where α denotes acceleration of earthquake motion, a amplitude, T period of earthquake motion. The above two data are plotted in Fig. 1 with dots in circle.

After plotting these dots, it occurred to the writer that the variation of the human susceptibility to vibration has to be taken into consideration regarding the intensity distribution of earthquakes and seismic intensity scale. In other words, even if the grade in intensity is equal at two places, the acceleration of earthquake motions will be greater at hard ground than at soft ground.

Consequently, the observation of the proper period of the ground will be important in studying earthquake intensity and earthquake-proof construction.

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14. 衝撃による地動に対する人体感覚

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重い物体が落ちた時に起る地動を測定した結果を，医学又は生理学的の方から研究された正弦振動に対する人体感覚と比較し，更に地盤の異なる所で求められた震度階と地動加速度の関係とも比べた．

その結果，衝撃性地動は正弦振動よりも人体には強しく感ずることと，震度階も土地の固有振動周期によつて加速度との関係は変はることを求め得た．
