

# EMPIRICAL RELATIONS AMONG AVERAGE MAXIMUM GROUND ACCELERATION, EARTHQUAKE MAGNITUDE AND EPICENTRAL DISTANCE

地震動最大加速度・マグニチュード・震央距離の関係について

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## 1. Introduction

The maximum ground acceleration of an earthquake motion is one of the most important factors for the practical aseismic design of structures. Most of the previous results concerning the maximum earthquake acceleration were obtained by assuming certain relations between the earthquake intensity scale and the acceleration values, or by generalizing a result determined from a small number of measured accelerations. However, strong-motion accelerograms accumulated in Japan in last twenty years can now be used to directly correlate the maximum acceleration with earthquake magnitude and epicentral distance.

## 2. Data Used

Acceleration values used were all recorded by strong-motion accelerographs (mostly SMAC-B2 Type) installed on the ground surface. A total of 660 horizontal maximum acceleration values

from 46 earthquakes recorded in Japan during the period from 1963 to 1970 were used for the analysis. Two horizontal component accelerations recorded at a station were considered as independent quantities. The smallest magnitude was 5.1 and the 1968 Tokachi-oki earthquake gave the largest magnitude of 7.9. Table 1 shows the numbers of earthquakes for different ranges of magnitude. The effect of focal depth was not included.

## 3. Least Square Fitting

The maximum acceleration values were divided into four groups according to the magnitude ranges as shown in the first two columns of Table 2 together with the number of data. Least square fitting was carried out by assuming the following relationship between the maximum horizontal acceleration  $a_{\max}$  (gal) and the epicentral distance  $\Delta$  (km)

$$\log_{10} a_{\max} = A - B \log_{10} \Delta. \quad (1)$$

The results are shown in the third and fourth columns of Table 2. Approximate ranges of epicentral distance for which the proposed formulas are applicable are shown in the last column of Table 2. The ranges were determined by considering the distributions of epicentral distances of the data used and the effect of focal depth. Fig. 1 shows the original data and the straight line determined by least square fitting for the case of  $6.5 \leq M \leq 7.4$ . The values of constants A and B are plotted in Fig. 2 against the approximate average magnitude.

Table 1 Number of Earthquakes for Different Magnitude Ranges

Magnitude Range	Number of Earthquakes
5.1-5.4	6
5.5-5.9	8
6.0-6.4	14
6.5-6.9	11
7.0-7.4	2
7.5-7.9	5

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Table 2 Results of Least Square Fitting

Magnitude Range	Number of Accel. Data	Constants in Eq. (1)		Range of $\Delta$ for Which Eq. (1) is Applicable (km)
		A	B	
5.1-5.4	60	2.824	0.868	30-200
5.5-6.4	238	3.172	0.993	30-400
6.5-7.4	220	3.891	1.184	50-1000
7.5-7.9	142	4.989	1.470	70-1000

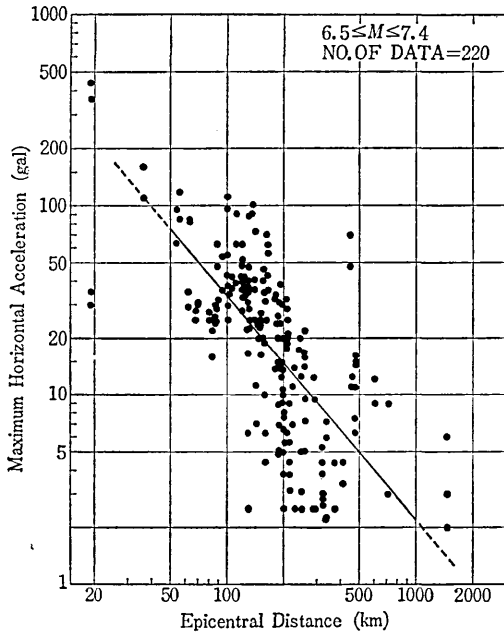


Fig. 1 Maximum Horizontal Acceleration Vs. Epicentral Distance for  $6.5 \leq M \leq 7.4$

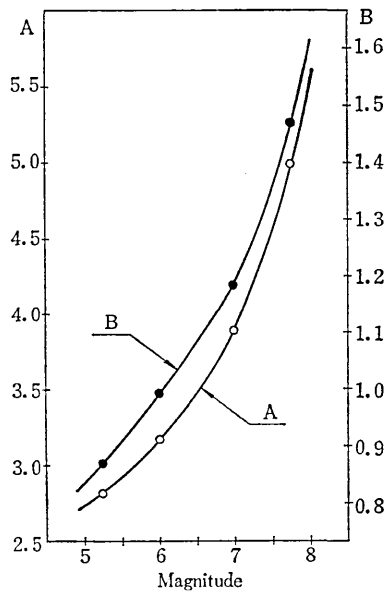


Fig. 2 Constants A and B in Eq. (1) Vs. Average Magnitude

4. Distribution of Maximum Ground Acceleration

The acceleration value determined by Eq. (1) for a given epicentral distance and a prescribed

range of magnitude (or, possibly, for an arbitrary value of magnitude by use of the relations shown in Fig. 2) shall be called the average maximum acceleration. As can be seen from Fig. 1, the

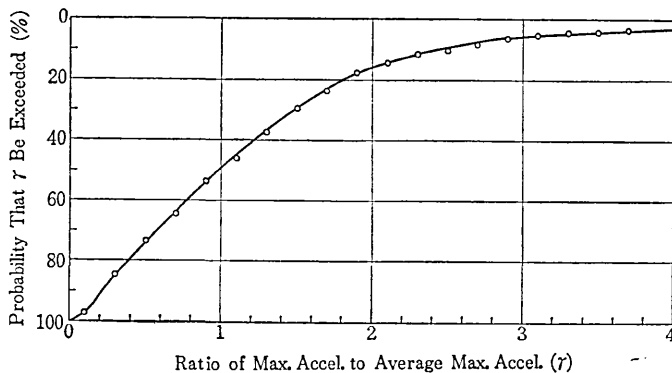


Fig. 3 Distribution of Maximum Ground Acceleration

actual measured values are greatly deviated from the least square fitted line. Hence, the values of the ratios

$$\gamma = \frac{\text{measured max. acceleration}}{\text{average max. acceleration}}$$

were calculated and their distribution was obtained. Here, the denominators were computed by using the constants A and B in Table 2 for each of the ranges indicated. The result is shown in Fig. 3.

The following example illustrates the meaning of the distribution given in Fig. 3. Let us find

the maximum ground acceleration of an earthquake of  $M=7$  at an epicentral distance of 50 km for which the probability of being exceeded is 10%. For  $M=7$  and  $\Delta=50$  km, from Eq. (1) together with the values of constants A and B in Table 2 the average maximum acceleration can be computed as 76 gal. Since, from Fig. 3, the value of  $\gamma$  for the 10% probability of being exceeded is approximately 2.4, the desired maximum acceleration is  $76 \times 2.4 = 182$  gal.

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### 鉄ウイスキーの製造と性質に関する研究 (和文)

—Studies on the Production of Iron Whisker and its Properties—

鉄ウイスキーは微小繊維状単結晶で、完全結晶構造に近く理論強度に近い強さをもち、しかも酸化しにくく、高温強度も大きく、電磁氣的性質もすぐれ、各種の特性を有することはすでに知られている。

基礎で、この報告では、原料  $\text{FeCl}_2 \cdot n\text{H}_2\text{O}$  から鉄ウイスキーを製造する基礎的研究、すなわち、鉄ウイスキーの成長に必要な条件 (温度、 $\text{FeCl}_2$  の蒸気圧、添加物の種類、および量、ガス流量) を調査し、あわせて鉄ウイスキーの成長方向と形状について述べ、それぞれについて考察を加えた。

次にこの机上実験結果にもとずきスケールアップ時の製造条件と、製造装置の開発を試みた結果について述べた。まず従来の方法にガス・カーテン装置を設置した。ガス・シール法を採用し半連続製造装置を試作し反応装置内のウイスキー生長に必要な条件、すなわち炉内ガス濃度分布、流速について調査し、ガス・カーテンシール法と蝶番扉の組合せシールにより十分基礎実験結果を再現出来ることが明かとなり、つづいて連続育成装置を試作した。その結果、多重蝶番扉とガス・カーテン装置の組合せ雰囲気ガスシール法をもちいることにより、ハロゲン化物の水素還元によるウイスキーの連続製造が可能になった。この連続装置を用いてウイスキーを連続製造し、基礎実験時の生成量と比較一検討をくわえ、溶融  $\text{FeCl}_2$  法による製造条件をもあわせて検討した。

また、連続製造時のウイスキーの育成条件と成長軸方位および断面形状と成長軸方位についても調査した。

以上のようにして製造せるウイスキーの機械的性質について研究し、特に  $-190^\circ\text{C} \sim +230^\circ\text{C}$  の範囲における引張応力と歪みとの関係について研究調査した。その結果、すべり帯と応力-歪み曲線上にあらわれるセレーションとが対応することを明らかにし、セレーションは温度依存性が強く、太さの効果のあることを確認した。

なお低温においても同様の実験を試みその結果を述べている。特に化工軟化領域から化工硬化への移動の問題にふれ考察を加えた。

最後に電子顕微鏡により透過観察をおこないラセン転位の追跡を試み、それらの結果について考察および検討を加えた。

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