研 究 速 報

UDC 624.042.7
550.344.094.72

EMPIRICAL PROBABILITY DISTRIBUTION OF EARTHQUAKE ACCELERATION MAGNIFICATION FACTOR

地震動加速度応答倍率の経験的分布について

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1. Introduction

This paper describes the characteristics of the empirical distribution of the acceleration magnification factor and presents spectra of the acceleration magnification factor, for the typical alluvial soil in Japan, with specified probabilities of being exceeded. Here, the acceleration magnification factor is defined as the ratio of the absolute maximum response acceleration of a one-degree-of-freedom system to the maximum ground acceleration.

A number of factors influence the spectrum of the acceleration magnification factor to varying degrees. In this investigation it was assumed that the ground condition and the analyzed record length are the two most important factors.

Regarding the ground condition, only those records obtained on the typical alluvial soil in Japan were used for analysis. Records on extremely hard or soft ground were discarded. Also excluded are the records which give a single dominant peak in the acceleration response spectrum at period shorter than 0.2 seconds. The number of records thus selected was forty two.

Table 1 Modification Factors to Take Account of the Effect of Analyzed Record Length. (Multiplication of factors to the spectrum obtained from records with shorter durations gives the spectrum of equivalent duration of 25 to 30 seconds)

		Analyzed Record Length (sec)			
		5	10	15	20
Ranges of Undamped Natural Period of One-Degree-of-Freedom System (sec)	$.1<T\leq.5$	1.6	1.1	1.0	1.0
	$.5<T\leq1$	2.2	1.3	1.1	1.1
	$1<T\leq4$	2.8	1.7	1.4	1.2

The effect of analyzed record length cannot be ignored especially at longer periods. The effect was incorporated by using the modification factors shown in Table 1. The values in Table 1 were obtained from the analyses of actual strong-motion earthquake records. Twelve horizontal components of the 1968 Tokachi-oki earthquake and its aftershock recorded at three stations—Muroran, Miyako, and Aomori—were analyzed. Average acceleration response spectra were constructed for durations of 5, 10, 15, 20, 25, and 30 seconds, from which the modification factors were determined empirically.

2. Distribution of Acceleration Magnification Factor

The distributions of acceleration magnification factor, β, were investigated at 17 discrete natural periods between 0.1 and 4.0 seconds. The periods analyzed were

T=0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.5, 2.0, 3.0, 4.0 seconds.

All the following discussions are for the case of 5% damping.

In order to obtain information about the shape of the distribution at a certain natural period, the range between $\beta_{\min}$ and $\beta_{\max}$ were divided into seven equal intervals and the numbers of data in each interval were counted. Some of the results thus obtained are shown in Fig. 1 by bar charts. Though the shape of distribution differs for different natural periods, strong non-symmetricity is found at all periods. The distributions are skewed to the larger value of acceleration magnification

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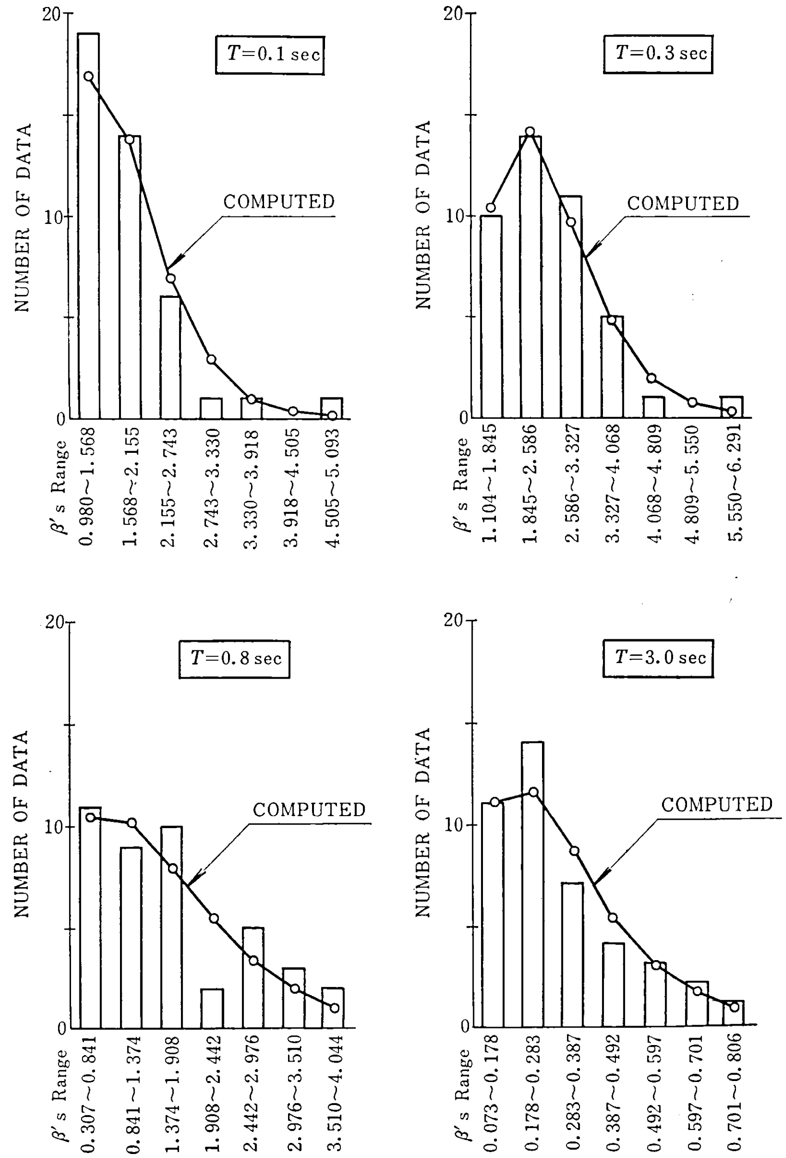

Fig. 1　Examples of distributions of acceleration magnification factors at given natural periods

Table 2　Values of β_{min}, $\bar{x}$, $\beta_{0.5}$, and σ_x for Seventeen Natural Periods Analyzed

Undamped Natural Period (sec)	β_{min}	$\bar{x}$	$\beta_{0.5}$	σ_x	Undamped Natural Period (sec)	β_{min}	$\bar{x}$	$\beta_{0.5}$	σ_x
0.1	0.980	0.846	1.696	0.367	0.7	0.309	1.106	1.532	0.472
0.15	1.312	0.813	1.974	0.363	0.8	0.307	1.023	1.353	0.468
0.2	1.452	0.978	2.409	0.374	0.9	0.274	0.972	1.219	0.476
0.25	1.267	1.073	2.418	0.343	1.0	0.253	0.936	1.128	0.467
0.3	1.104	1.129	2.378	0.398	1.5	0.163	0.708	0.664	0.370
0.35	0.796	1.208	2.254	0.449	2.0	0.093	0.578	0.427	0.252
0.4	0.609	1.177	1.995	0.398	3.0	0.073	0.437	0.263	0.186
0.5	0.451	1.192	1.872	0.424	4.0	0.063	0.366	0.197	0.160
0.6	0.302	1.217	1.783	0.450					

factor.

Several trial calculations were made to find the most appropriate functional relation to represent observed distributions. It was found that, when a new variable is defined as

$$x=\sqrt{\beta-\beta_{\min}},$$

its distribution is approximately normal. Table 2 summarizes $\beta_{\min}$, $\bar{x}$ (mean value of x), $\beta_{0.5}$ (value of β corresponding to $\bar{x}$), and σ_x (standard deviation of x) for 17 values of natural periods. Here, $\beta_{0.5}$ is the value of acceleration magnification factor with 50% probability of being exceeded. Several computed frequency distributions by assuming that x obeys the normal distribution are shown in Fig. 1 by line diagrams. It can be seen that agreement is generally reasonable.

3. Acceleration Magnification Factor Spectrum with Specified Probability of Being Exceeded

By using the values of $\bar{x}$ and σ_x, acceleration magnification factor spectra were constructed with specified values of probabilities of being exceeded. The results are shown in Fig. 2. The spectra of the ratios of each spectrum in Fig. 2 to the spectrum of 50% probability of being exceeded are shown in Fig. 3. It can be seen that the scatter of acceleration magnification factors at periods longer that say 1 second is larger than those at periods shorter than 0.5 seconds.

(Manuscript received July 25, 1972)

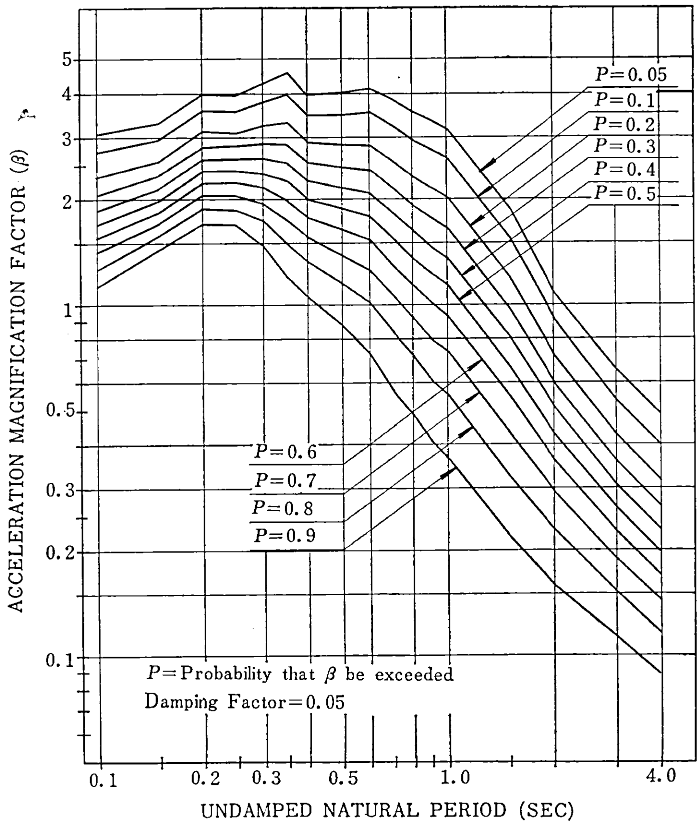

Fig. 2 Acceleration magnification factor spectra with specified probabilities of being exceeded

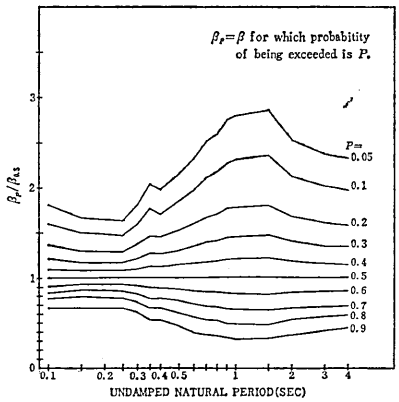

Fig. 3 Values of $\beta_P/\beta_{0.5}$ at different periods