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A COMPARATIVE STUDY OF AN ASSESSMENT OF EARTHQUAKE RISKS

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SUMMARY

This paper describes the earthquake risks in Shanghai in comparison with those in Tokyo , and also the earthquake disaster risk of residential areas in Shanghai. In this study those of histrical earthquakes,subsoil conditions and structural characteristics of residential houses and buildings were studied. Consequently,the earthquake risk in Shanghai are lower than those in Tokyo,for example,anticipated earthquake accelerations are estimated as 35 gals in Shanghai and 120 gals in Tokyo for the return period of fifty years. The failure probability of the residential houses and buildings was evaluated as almost zero to 96.6% depending on the structural characteristic and ground conditions for the return period of 1950 years in Shanghai.

INTRODUCTION

On the viewpoint of statistics as of 1985 , Shanghai is populated as 12,170,000 in the area of 60,000 km^2,i.e.the average density of population is about 20,000 persons in one square kilometer [Ref.1]. The density is greater than at of 14,000 persons in one square kilometer in Tokyo of which the population exceeds ten million, as shown in Fig.1.

As for the histrical earthquake in Shanghai, eightyseven earthquakes were recorded in the period from 419 to 1984, including once with magnitude of 5 on Richter scale and five with magnitude between 4 and 4.75

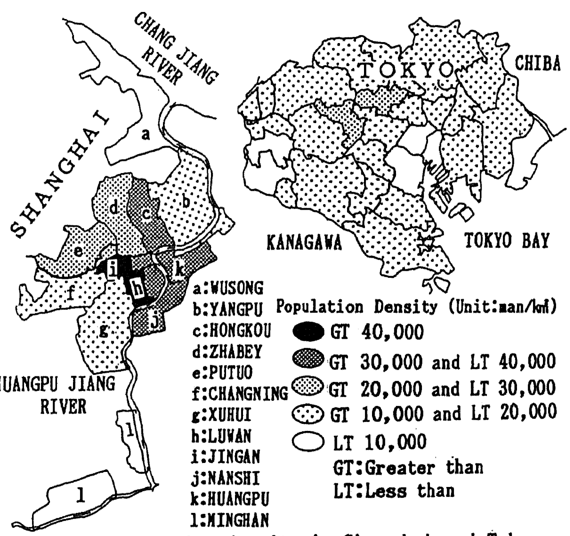

Fig.1 Population density in Shanghai and Tokyo

[Ref.2]. Almost all of the district of Shanghai is covered with diluvial strata.

In this analysis the structural characteristics of three types of residential houses and buildings are assumed. Probabilistic earthquake accelerations are evaluated from statistics of the earthquake magnitude and epicentral distances. The probability of the occurrence of the earthquake is evaluated by using truncated Gutenberg-Richter formula.

PROBABILISTIC EARTHQUAKE ACCELERATIONS

The earthquakes with 4 or more of magnitude in Richter scale within the area limitted in a circle of the radius of 400km at center of the origin located in Shanghai as shown in Fig.2. The area of the circle divided into four areal sources [Ref.3] as follows,were selected from Earthquake Catalogue.[Refs.4,5]

Areal source A; active seismic zone including Southern Yellow sea,

Areal source B; possible large-scale earthquake zone including Tanglu fault and Maoshan fault,

Areal source C; inactive seismic zone,

Areal source D; inland type earthquake zone including the estuary of Chang Jiang river.

The frequency of the occurrence can be estimated from trancated Gutenberg-Richter formula given in Eq.1.

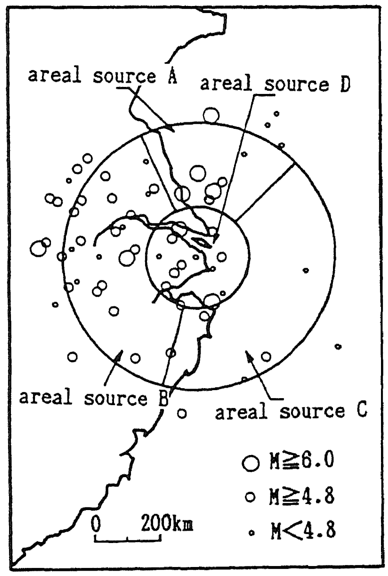

Fig.2 Distribution of earthquake

$$\log N(m) = a - b \cdot m \qquad m \leqq m_u$$
$$N(m) = 0 \qquad m > m_u \qquad (1)$$

where N(m) represents the frequency of the cumulative occurrence of the earthquake depending on time , m represents magnitude on Richter scale,and a and b are arbitrary constants derived from the least square method.

And the cumulative density function, $F_M(m)$ can be defined as follows,

$$F_M(m) = \frac{1 - \exp\{-\beta \cdot (m - m_0)\}}{1 - \exp\{-\beta \cdot (m_u - m_0)\}} \qquad (2)$$

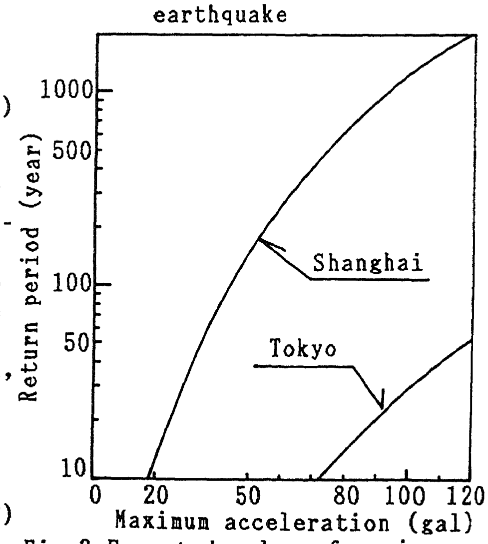

Fig.3 Expected value of maximum acceleration in Shanghai and Tokyo

where

$\beta = 2.3025$ b,

m_0;the lower limit of earthquake magnitude in the caluculation process,

m_u;the ultimate muximum value of earthquake magnitude.

On the other hand an attenuation formula of the soft ground acceleration is provided by the formula in the references 6 and 7 listed in this paper.

Assuming Poisson process and statistically independent characteristics between time and space,the probability of the occurrence of the ground acceleration for one year is given as follows,

$$P(Y>y,1) = 1 - \exp\{-\lambda(y)\} \quad \text{or} \quad = \{1 - 1/R(Y>y,1)\}^T \qquad (3)$$

where

Y;ground acceleration in lognormal distribution , cm/sec^2,

y;expected ground acceleration, cm/sec^2,

$\lambda(y)$;average frequency of the occurrence of the ground acceleration for one year,

R(Y>y,1);return period , year.

When given 0.05 of the probability, P(Y>y,1) and 100 years of the durable period of the houses and buildings , the return period ,R(Y>y,1) is evaluated as 1950 years,and the expected ground acceleration is evaluated as 118 gals,respectively,as shown in Fig.3. In addition to the acceleration , once again by employing the references 6 and 7 , probabilistic acceleration response spectra in 0.05 of damping constant corresponding to the ground conditions are given for example,as shown as chain lines in Fig.4. The ground conditions are classified into five categories , as shown in Fig.5 [Refs.8,9].

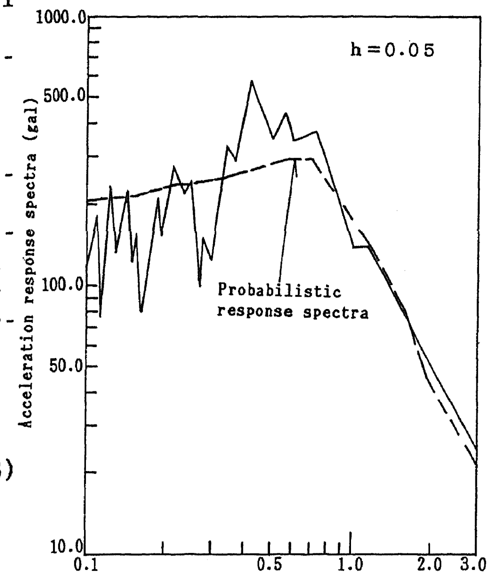

Fig.4 Acceleration response spectra of Type A

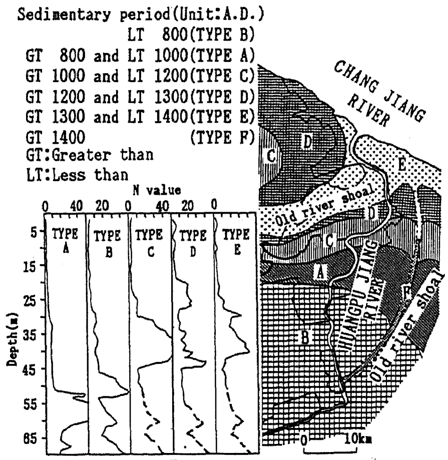

Fig.5 Soil profile in Shanghai

The transfer function corresponding to the ground conditions give five sets of acceleration response spectra , for example as shown as solid lines in Fig.4, after processing the input acceleration , at the bottom of the soil profiles,seventy meters deep from the surface of the ground , through transformation of the probabilistic acceleration spectra at the surface.

CHARACTERISTICS OF HOUSES AND BUILDINGS

The residential houses and buildings are classified into three categories as follows ,

Two story tenement house;two story old buildings are divided into tenements , of which the beam and column are composed by timber , and the wall and the roof are covered with bricks and tiles , respectively , as shown in Fig.6.

Three story tenement house;three story reformed buildings are divided into tenements , of which the structural conponents are same as two story tenement houses , shown in Fig.7.

New town apartment house;multi story masonry buildings are mostly composed of bricks but rarely reinforced elements , which have been constructed since 1951 , as a typical example of a six story apartment building as shown in Fig.8.

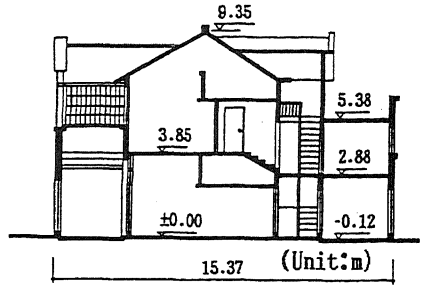

Fig.6 Cross sectional view of two story tenement house

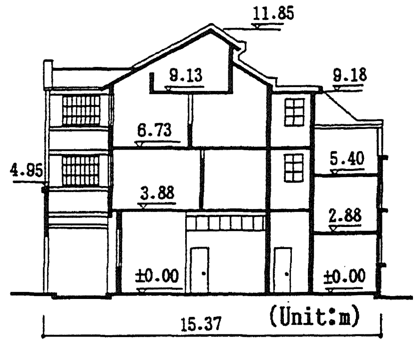

Fig.7 Cross sectional view of three story tenement house

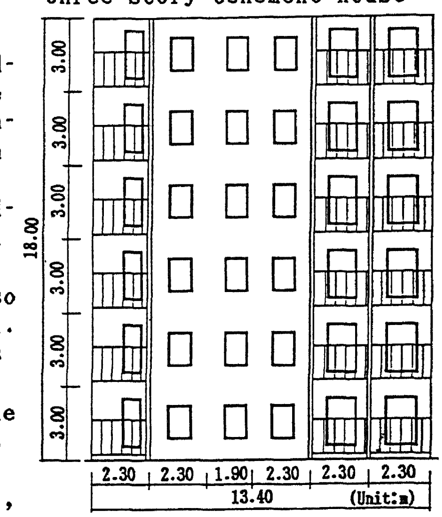

Fig.8 Front view of new town apartment house

PROBABILITY OF FAILURE OF HOUSES AND BUILDINGS

The failure of the houses and buildings is defined as the critical tilt angle of the column or wall for the brick construction in 1/400 and timber construction in 1/60 [Ref.10].

The stiffness of the houses and buildings at the critical tilt angle is assumed as one fourth of the initial stiffness , and the equivalent damping constant is also assumed as five percents of the critical. The linear earthquake response analysis were carried out in this assumption.

Consequently , as shown in Table.1 the probability of the failure is evaluated as follows ,

0.844 ~ 0.966 in two story tenement ,
almost zero ~ 0.0516 in three story tenement ,
0.0307 ~ 0.268 in new town apartment.

As shown in Fig.9 the distribution of the probability of the failure in Shanghai indicates forty percents or less of the probability.

Table-1 Failure probability of the houses and buildings

Type of Ground	Failure Probability		
	two story tenement house	three story tenement house	new town apartment house
A	0.911	3.70×10^{-5}	0.0307
B	0.966	6.88×10^{-7}	0.023
C	0.961	1.90×10^{-5}	0.0049
D	0.844	0.0207	0.0505
E	0.853	0.0516	0.268

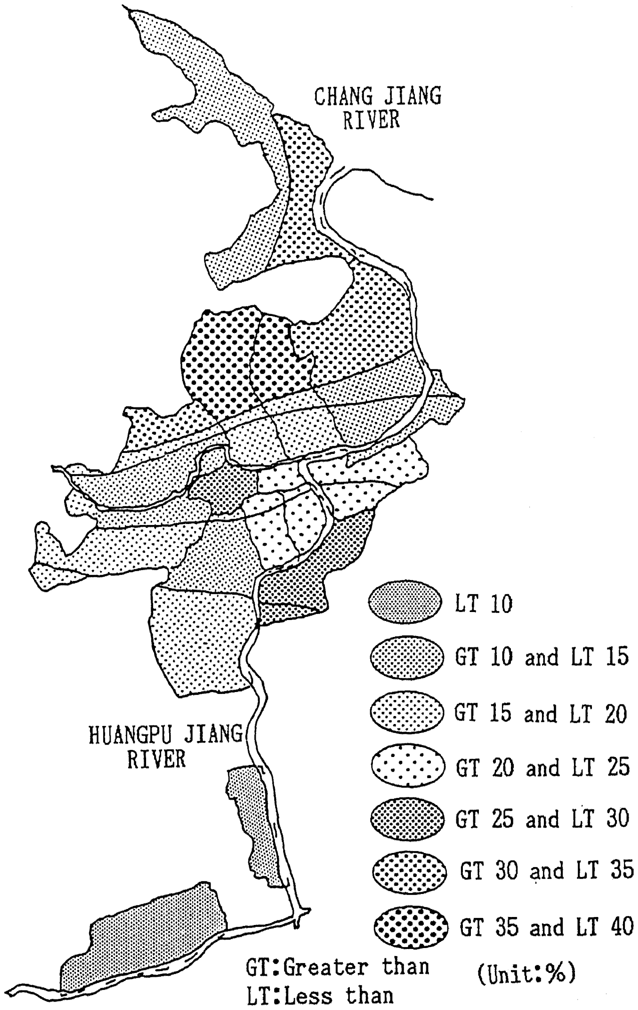

Fig.9 Earthquake risks in regard to residential houses and buildings in Shanghai

CONCLUSIONS

In this study an effective evaluation method for the probability of the failure of residential houses and buildings by employing the case study is proposed in taking acount of a trend of the occurrence of the earthquake , the subground conditions and the structural characteristics.

There are several assumptions , for example , Poisson process in the occurrence of the earthquake , the critical tilt angle to define the failure of the residential houses and buildings , and the linearized stiffness of the constructions. Therefore a satisfactory answer should be given to the questions in the future research.

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Note , all references are written in English except,4,5,6,7,8 and 10.