Preparedness for the coming Tokyo Metropolitan M7 earthquake

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Abstract

According to the past seismic statistics, Tokyo Metropolis and its surrounding area, so-called as Kanto basin, may have an M7 earthquake very soon. As the under-ground geologic condition is not so good both in the surface layers and even in the deeper sediment structure, earthquake ground motion must be largely amplified with individual predominant periods. The author is afraid that tall buildings already con-structed without considering site condition may suffer not a few damages. It does not mean structural collapses but brings unexpected social problems to continue daily lives. The author would like to recommend responsible government authorities to pre-pare reasonable countermeasures for assisting ordinally residential citizens.

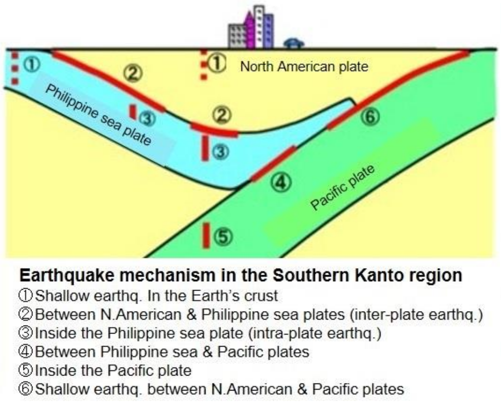
Key-words: M7 earthquake, Tokyo Metropolis, long-period ground motion, tall buildings, fire induced by an earthquake

Introduction

Tokyo Metropolitan area is located to the subducting Kanto basin with very dense population. Moreover the seismicity looks very high, and seismologists say that M7 earthquakes may happen anytime, even today or tomorrow. In such case, what will be the most serious problem among big fire, tsunami and other water diseases, building collapses, damage of infra-structure, and so on? Most of all, big fires induced by collapsed wooden houses will appear in wide area, and they will disturb current evacuation activities. In the past, we have learned such example by the 1923 Kanto M8 earthquake. But at that time, almost a hundred years ago, there were no tall buildings, no huge oil strages, no high-ways, and no super-express trains. Therefore we need to get additional information through recent experienses. In this paper, the author would like to pay attention to the 2005 Fukuoka-oki M7 earthquake, that brought a serious damage to tall residensial buildings in a quite limited area. He is really afraid that the similar damage will appear more widely in the future Tokyo Metropolitan M7 earthquake.

Seismicity

At this moment, nobody can make accurate prediction of future earthquakes, and this is the agreement in the seismological academic society. But we need to prepare possible counter-measures following to some probable condition. According to recent seismological studies done by committees in the national government [3, 4] and Tokyo Metropolitan Office [2], the evaluation of future earthquake occurrence seems to be made following to different magnitude size, such as M9, M8 and M7. It looks quite reasonable because the return period of each magnitude size is clearly different. They say, the return period of M9 earthquakes is from 2000 to 3000 years, and that of M8 earthquakes is from 200 to 400 years. Unlike such huge earthquakes, M7 earthquakes are considered to happen possibly anytime. Therefore the recommendation says that we must pay the most attention to M7 earthquake. Among a geat deal of information, the author would like to pay attention to the following two items, showing the mechanism as Fig.1 and the history as Fig.2.



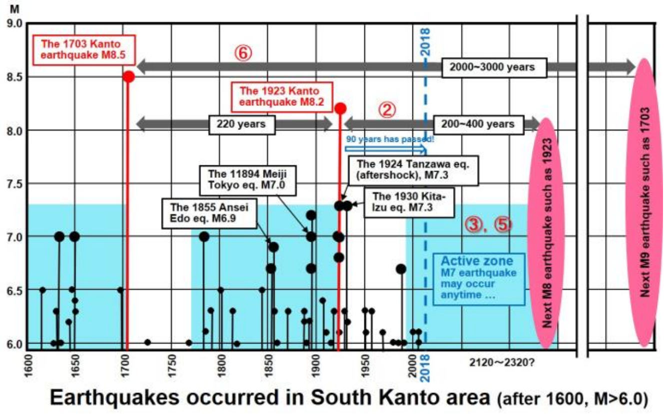
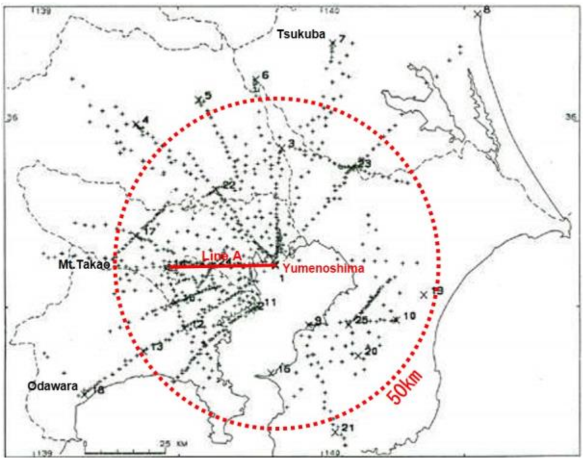


Fig.1 Possible earthquake mechanism [3]

Fig.2 Historical map of earthquakes [3]

Site Geological Condition

In the recent few decades, we have made numbers of field surveys to make clear the deep basin structures in Kanto reasion, using dynamite explosions, seismic reflection surveys, and micro-tremor array measurements. As results, the total thickness of quaternary and tertiary sediments over the seismic bedrock is about 2 to 3 kilometers, and such deep structure may excite 6 to 10 seconds in period. In the quaternary sediments within a few hundred meters in thickness, predominant period around 2 seconds, so-called the rather long period, appears very often in wide area of Kanto basin. Therefore we must be very careful to make sure site condition before planning tall buildings. (see figures Fig.3 through Fig.7)



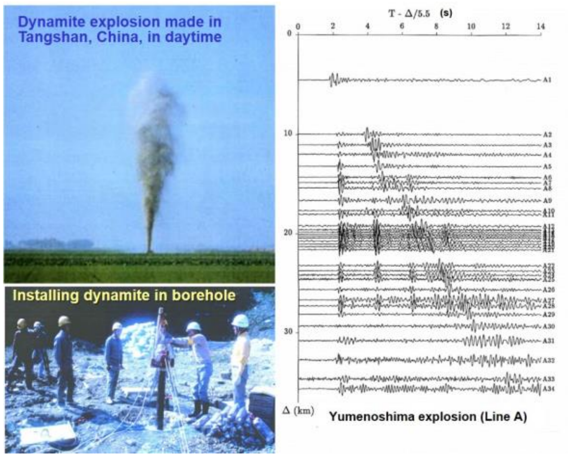


Fig.3 Area of the explosion experiments [1]

Fig.4 Explosion site and Observed data [1]

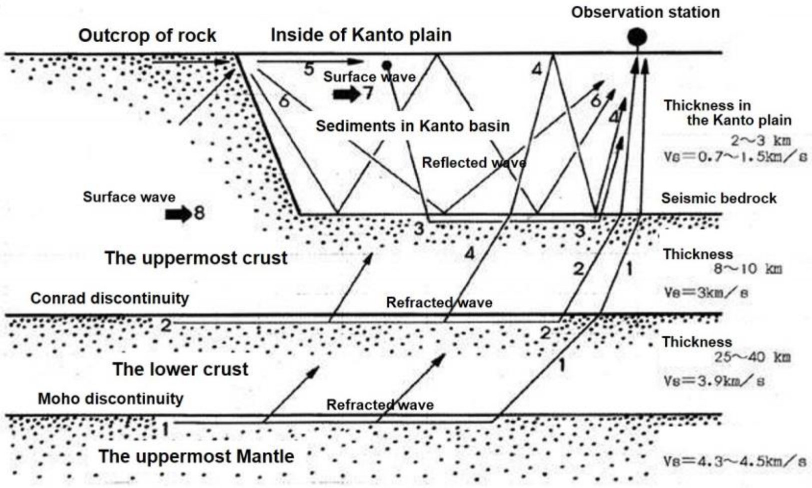
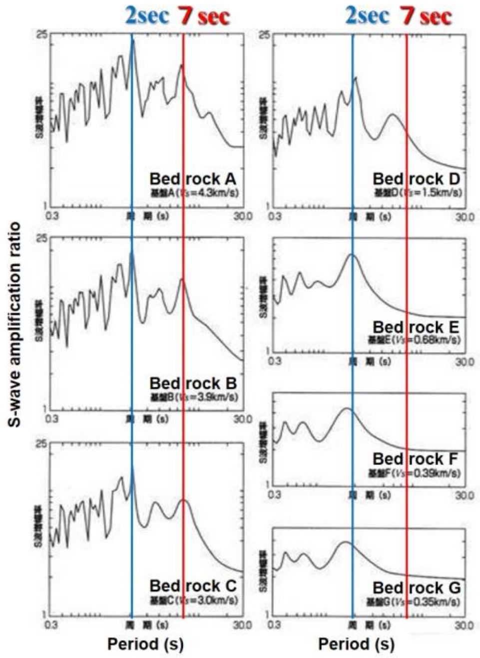


Fig.5 Estimated underground deep structure using explosions and natural earthquakes [1]

Depth	Layer No.	Density(g/cm³)	Vp (km/s)	Vs (km/s)	Q value	Thickness (km)	Materials
GL	1	1.60	1.35	0.11	10	0.009	Top soil
	2	1.70	1.35	0.15	10	0.038	Silt
	3	1.70	1.35	0.20	10	0.027	Silt and Sand
-74m	4	1.70	1.65	0.35	20	0.008	Bedrock G (Gravel)
-82m	5	1.80	1.80	0.39	30	0.068	Bedrock F (Silt and Sand)
-150m	6	1.90	1.80	0.68	50	0.750	Bedrock E (Kazusa Group)
-900m	7	2.20	2.80	1.50	100	1.600	Bedrock D (Miura Group)
-2.5km	8	2.50	5.50	3.00	200	8.000	Bedrock C (Uppermost Crust)
-10.5km	9	2.88	6.70	3.90	500	25.000	Bedrock B (Conrad Interface)
-35.5km	10	3.28	7.50	4.30	1000		Bedrock A (Moho Interface)

Fig.6 Probable model of underground deep structure estimated in Ukishima, Kawasaki city, located along the Tokyo bay area (the upper figure) [1]

Fig.7 Calculated S-wave amplification ratios where verious bedrocks were assumed with the deep structure model in Fig.6 (the right figure) [1]



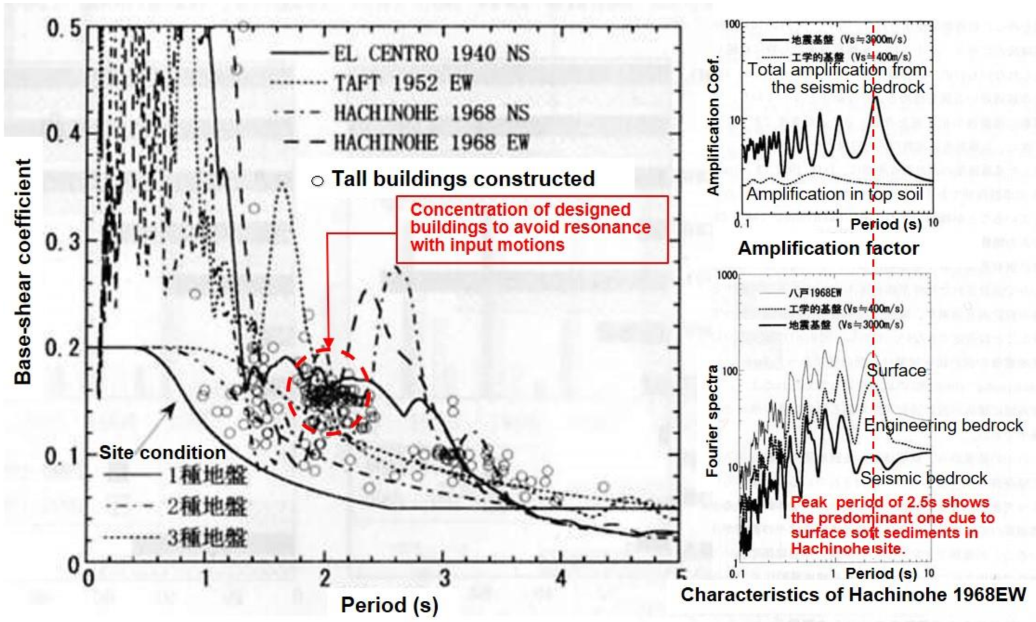


Fig.8 Procedure of practical structural desigh of buildings using observed strong motions [1]

Probable Damage

Before the 1995 Kobe earthquake, individual site condition was not taken into account so much in the constructing process of building structures. They often used well-known observed motions during the 1940 El Centro earthquake, the 1952 Kern County earthquake in California, and the 1968 Tokachi-oki earthquake.(see Fig.8) It may be true that they surely made seismic response analyses using strong motions, but it did not mean the evaluation of site condition. Because the charasteristics of observed strong motions in the process had no relation with the practical site geological condition. Nowadays such tall buildings for residenses, offices, hotels and schools still remains without suffering any earthquake damage. It is merely because there was no big earth-quakes since the 1923 Kanto earthquake in this area.

Recently we have had many M7 earthquakes, the 1978 Sendai, the 1995 Kobe, the 2005 Fukuoka and the 2016 Kumamoto, for example. In such earthquakes, we have noticed very often to the similar types of damage in tall buildings, something like cracks and shear-failures of non-structural walls or clash of entrance doors. Two buildings often clash with each other, and the stronger one

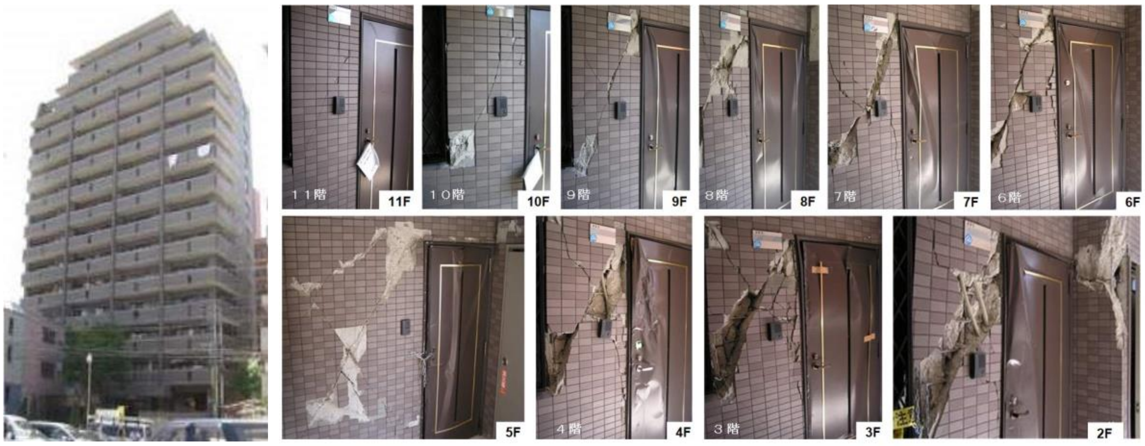


Fig.9 Damege of a 14 storyed residential building during the 2005 Fukuoka-oki earthquake [1]

Fig.10 Similar damage had been noticed in the 1978 Miyagiken-oki earthquake in Sendai [1]

harms the weaker one. They may not be so hard and serious from the engineering point of view. But for residential citizens, they will have very serious problem that who should be blamed and who should pay for repairing the damage of buildings. (see Figs.9 and 10)

Concluding Remarks

Through the experience during the 2005 Fukuoka-oki earthquake, it will be made very clear that the worry of residential citizens is quite different from that of seismologists and technical engineers. In deed they do not have enough knowledge to evaluate the strength and characteristics of the earthquake motion and hardness of the damaged building structure. Maybe they (ordinary citizens) need an interpreter or an adviser to understand what happened by the sudden earthquake. Then they can face disasters, what to do next. The author would like to hope a new system to connect the both, technical specialists in natural disaster research field and ordinary citizens with cooperative supports from the national and the local governments.

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