

# STATE OF THE ART OF EARTHQUAKE HAZARD MITIGATION IN KUMAMOTO CITY

BY

Kenji Migita\*<sup>1</sup> and Ai'ichiro Tanaka\*<sup>2</sup>

## ABSTRACT

The authors investigated references concerning the above theme and made a study about seismic activity, earthquake damage, geology and characteristics of the ground in Kumamoto city locating in the central part of Kyushu. From a viewpoint of earthquake disaster, they referred to problems of ground conditions, fire risk in city area, life line reliability and area of large gradient slope. Finally, they investigated some problems to be settled in future and advanced the opinion that earthquake disaster prevention plan should be carried forward organically in related fields.

## SEISMICITY IN AND AROUND KUMAMOTO CITY

Earthquake which caused damages in Shikoku and Kyushu districts in the last two decades are listed in Table 1. The statement of the damages is shown in Table 2. Eurasian Plate and Philippine Sea Plate affect the crust of Kyushu district. Earthcrust has not been always inactive against general recognition of low seismicity in this district.

Hypocenters of felt earthquakes exist in northern and eastern part of Kumamoto city. At the suburbs of Kumamoto city, Yamaga, Kikuchi and Mifune, near local earthquakes had occurred frequently. The average depth of earthquakes in Kumamoto city is shallow and their intensities were reported as II or III ( J.M.A. scale )<sup>1),2)</sup>. The earthquakes of maximum amplitude of 20 - 30 microns were felt in this zone and amplitudes of earthquakes of intensity II were larger than 80 microns.

## BOUGUER ANOMALY AND UNDERGROUND STRUCTURE

They can find correlation between Hypocenters of earthquakes, tectonic lines and Bouguer anomaly. ( see Fig.1 ) Earthquake often occur around Aso volcano, Unzen volcano and northern Ariake Bay. Eruptive activities of Aso volcano are very active. However, their effects on seismicity in Kumamoto city are not confirmed yet.<sup>3)</sup>

## GEOLOGY IN AND AROUND KUMAMOTO CITY

The geology of this area is characterized roughly three categories, namely, Bed rocks, Aso volcanic rocks and river terrace deposits. From a view point of geological structure, Kumamoto plain has a kind of basin structure surrounded by Bed rocks. Aso volcanic rocks and Aso volcanic ash are deposited thickly in this basin. The fact that few latent faults locate in Kumamoto city and the suburbs is reported by Momikura.<sup>4)</sup> ( see Fig.2 )

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\*1 Professor, Department of Environmental Construction Engineering, Kumamoto University, Kurokami 2-39-1, Kumamoto, Japan 860

\*2 Assistant, Department of Architecture, Kumamoto University, Kurokami 2-39-1, Kumamoto, Japan 860

## GROUND CONDITIONS IN CITY AREA

The authors estimated SH wave velocity of surface layer from N-value by using the equation  $V_s = 76N^{0.39}$ . They investigated the horizontal distribution of SH wave velocity in 159 points. They regarded the layer whose N-value is greater than 30 as base layer of buildings. The standard point of following calculation is based on the boring data near Kumamoto Meteorological Observatory. The horizontal distribution of SH wave velocity ratio is shown in Fig.3. The larger  $V_0/V_s$  becomes, the softer the ground condition becomes. The seismic intensity distribution by questionnaire survey of northern district of Mountain Aso earthquake, January 23, 1975 is shown in Fig.3. 5) We can find relationship between ground conditions and seismic intensity distribution in detail by accumulation of these data.

## RISK ZONES IN CITY AREA

From a viewpoint of earthquake disaster, risk in southern part of Kumamoto plain seemed to be higher than the other part. Seismic risk zones in central part of Kumamoto city are shown in Fig.4. The area of large gradient slope has such risk as slippage or ground failure, having relation to the state of water content. Attention should be paid to earthquake disaster prevention in the above-mentioned areas.

## SOME PROBLEMS TO BE SETTLED IN FUTURE

### 1) Construction of earthquake observation network

Now strong motion accelerograms and network for engineering seismology are not yet established in this area. The authors think that construction of some observation points for earthquakes in ground of different conditions in Kumamoto city is very beneficial to clarify seismic risk in Kyushu.

### 2) Compilation of data about ground in Kumamoto city

Number of boring data about ground in this area is increasing. However, these data are scattered among many organisms. The authors hope to recompile them for seismic microzoning exactly. Microtremor measurement and velocity logging are to be executed in this area.

### 3) Survey for risk in existing building

In view of examples of building damages in recent years in Japan, Survey for risk in existing buildings is to be executed by proper organisms. The existing building of fire department is superaged. It should be rebuilt according to earthquake resistant design of higher level than usual structural design.

### 4) Insurement of roads for refuge

Most of back lanes are used as the roads on which pupils go to school daily. They face actual risk of wall collapse. Pre-checks of roads for refuge and functional disorder of main roads by earthquake are important.

### 5) Realization of earthquake resistant urban structure

There is a need for a realistic earthquake disaster prevention plan considering seismic activity and regional characteristics. Further examination of disaster prevention plan is required. The plan should be carried forward organically in related fields to realize earthquake resistant urban structure. It is desirable that the results of seismic microzoning would be reflected upon regional urban planning.

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Table 1 Earthquake caused damages in recent years

Earthquake	Time of commencement	Epicenter	Depth	Magnitude
Ebino Earthquake	1968.2.21,08h51m	32.0°N,130.7°E	0 Km	5.7
Hyuga-nada Earthquake	1968.4.01,09h42m	32.3°N,132.5°E	30 Km	7.5
Northern district of Mt.Aso Earthq.	1975.1.23,23h19m	33.0°N,131.1°E	11 Km	6.0
Central district of Oita Prefecture Earthquake	1975.4.21,02h35m	33.1°N,131.3°E	9 Km	6.4

Table 2 The statement of the damages by above earthquakes

Earthquake	De	I	Cl	H	Da	Nr	Pu	Ro	L	Br	Ri	Ba	Rw	Cm	P	W *
Ebino Earthquake	3	42	368	636	3239	1494	---	77	94	9	---	4	6	100	---	---
Hyuga-nada Earthquake **	---	57	2	38	7383	471	233	59	---	11	11	---	---	---	54	---
Northern district of Mt.Aso Earthq.	---	9	9	41	303	322	---	46	189	---	---	---	---	---	---	41
Central district of Oita Prefecture Earthquake	---	19	31	90	2260	111	---	47	141	2	---	---	4	---	---	35

\*De=Deaths, I=Injured, Cl=Collapsed, H=Half Collapsed, Da=Damaged, Nr=Non-Residential, Pu=Public Building, Ro=Road, L=Landslide, Br=Bridge, Ri=River, Ba=Bank, Rw=Railway, Cm=Communication System, P=Port, W=Water Service

\*\* Hyuga-nada Earthquake contains the damages in Shikoku district.

