February 28, 2008, Seoul City University, Korea

Damages, Human Behaviour and Recovery of Urban Residents in the 2005 West off Fukuoka Earthquake

H. Murakami [1*]

[1] Division of Environmental Science and Engineering, Yamaguchi University, Ube, Japan

Abstract

The 2005 west off Fukuoka earthquake with Mjma 7.0 occurred in the vicinity of Fukuoka city with 1.4 million populations, which had been regarded as rather seismically inactive in Japan. The strong motion records by K-net indicated PGV of 64 cm/s in Fukuoka city and some condominium buildings sustained extensive non-structural damages. In this study, we conducted a questionnaire survey for residents of 8 condominium buildings located in the downtown area of Fukuoka city after the earthquake. The results indicate that damaged non-structural walls and distorted doors disrupted evacuation route for many occupants, and furniture and content damage on upper floors became severer resulting in higher rates of human casualty. Earthquake preparedness for indoor safety was raised after the earthquake, though further safety measures can be advised. In the phase of post-earthquake emergency and restoration period, residents' management organizations play important roles, so that neighborhood activities to promote communication networks are important in urban environment with aging population.

Keyword: *human behavior, casualty, architectural damage, condominium residents, questionnaire survey, recovery process, casualty, Fukuoka city, earthquake safety*

1 Introduction

The 2005 west off Fukuoka earthquake occurred on March 20, Sunday at 10h53m in the morning. The JMA magnitude was 7.0 and the epicenter was located at 33 deg. 44.35 min N in Longitude and 130 deg. 10.58 min. E in Latitude, which is near Genkai Island in Fukuoka city. Maximum JMA seismic intensity of 6 minus was reported for Central and East wards of

[*] *Corresponding author address:* H. Murakami, Division of Environmental Science and Engineering. Yamaguchi University, Tokiwadai 2-1-16, Ube, 755-8611, Japan, hitomim@yamaguchi-u.ac.jp

Fukuoka city, Maebaru city, and Miyaki town in Saga Prefecture. The maximum PGV observed was 64.4 cm/s at FKOS01 station in the Central Ward of Fukuoka city, and the maximum PGA observed was 361.8 gal (cm/s^2) at FKOS04 station in Jonan Ward of Fukuoka city.

Human casualty in this earthquake was 1 human loss by collapse of concrete block wall, 75 serious injury, and 994 light injuries as reported by Fukuoka prefectural government. In Fukuoka city with 1.4 million populations, damages in Central ward were serious for mid-rise condominium or apartment buildings. Many condominiums suffered non-structural damages with infill walls cracked, and disabled opening of the doors and evacuation routes. The authors made a questionnaire survey to the residents of several condominium buildings to elucidate relations of indoor architectural damage, occupants' behavior, evacuation, and risk of casualty. We also made a hearing survey for the relief and recovery process of damaged condominiums. This paper summarizes the results of the survey and discusses what we should learn from the experiences of this earthquake. Detailed survey result is reported in Murakami, et al. (2005) [1].

2 Damage to Condominiums and Occupant Behavior

2.1 Survey Method

In the Central ward of Fukuoka city, where active Kego fault runs underground, serious damages to mid-rise condominium and apartment buildings were observed. According to the damage report by Fukuoka city (as of May 6, 2005), heavily damaged 3 buildings, partially damaged 19 buildings were counted for RC or steel condominium or apartment buildings. We made questionnaire survey for the 8 condominium buildings with 364 households (Table 1) to ask architectural and indoor damage and human behavior of the occupants. Figure 1 shows location of Kego active fault in Fukuoka city. The questionnaire asks indoor architectural damage conditions, human response during and after the earthquake, location of family members and casualty, evacuation behavior, preparedness before and after

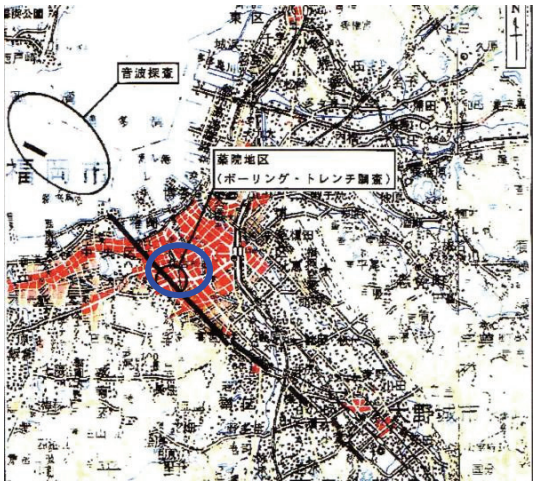

Fig. 1 Map of Fukuoka city with Kego Fault (L=22km) in black line
http://bousai.city.fukuoka.jp/kegodansou.htm

the earthquake. The questionnaires were distributed in late May, 2005 and were collected up to August, 2005 via each condominium management organization. Total number of family members and occupants listed in the questionnaire is 339 persons.

Table 1 List of the condominiums for the survey in Fukuoka city

id	address	Intensity *	year built	year of age	no of floors	structure	damage	no of units	no collecte
7	Imaizumi 2	5.8	1981	23	11	SRC	D2	66	19
9	Yakuin 2	4.9	1979	25	11	SRC	D0	51	30
8	Kego 2	4.9	1963	42	8	RC	D2	45	24
3	Daimyo 1	5.7	1975	30	6	S	D1	26	20
2	Daimyo 1	5.7	1987	17	10	SRC	D0	44	18
4	Daimyo 1	5.7	1998	6	15	SRC	D2	38	26
1	Akasaka 1	5.1	1985	19	10	SRC	D0	46	29
5	Imaizumi 2	5.8	1999	5	14	SRC	D3	48	30
* estimated by intensity questionnaire survey (Narahashi, 2005)							sum	364	196

2.2 Architectural and Indoor Damage

Figure 2 shows damage distribution of distorted doors and non-structural walls. As for architectural damage, difficulty or unable to open the doors is 9%. As for the wall damage, 18% answer fallen and displaced walls. Some occupants had to evacuate thru balcony partition to their neighboring dwelling units.

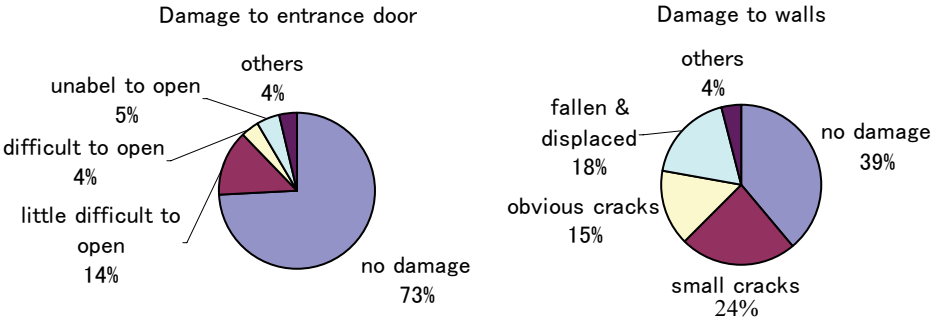

Fig. 2 Damage frequency of entrance doors (left) and walls of residential units (right) (N=196 cases).

As for the interior contents damage, Fig. 3 indicates rates of falling furniture along floor levels. Rates of falling in 10-14th floors are 2 to 4 times higher than those in 1-3rd floors as reasonably explained by higher floor response in upper floors. Falling rates are highest for bookshelf and TV, and are medium for wardrobe and cupboard. Damages are severest for living rooms and kitchens followed by

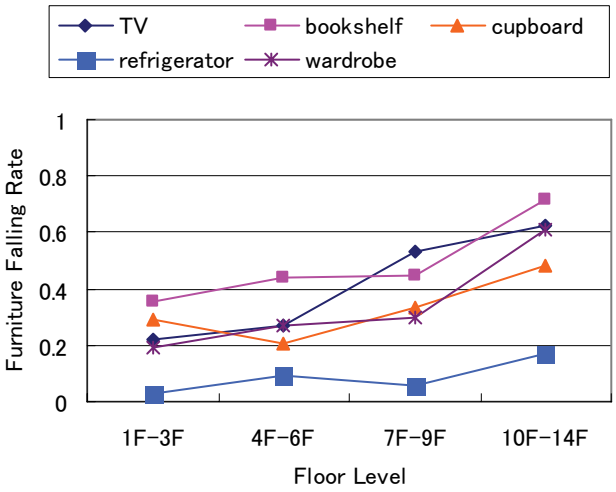

Fig. 3 Furniture falling rates vs. floor levels (N=196 cases).

bedrooms.

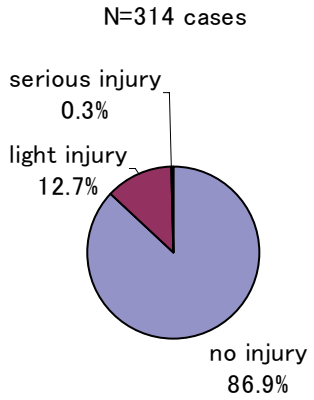

Fig. 4 Injury distribution of family members.

2.3 Human Behavior and Casualty Risk

Effective responses for family member of 339 cases are examined here regarding casualty risk. Males are 39% and females are 61%. Sixty two % of people were at home, 20% were indoors except for one's home, 10% were outdoors at the time of the earthquake occurrence. Injury rate of those people reach as high as 13.1% (Fig. 4). Causes of injury are falling furniture, broken glass, one's falling and falling objects. Out of the injury cases, 26.8% were treated as out-patient o

r were hospitalized. Rate of injury cases who were treated by medical facilities can be estimated as 3.5%. This rate is much higher than 0.2% in Chuo Ward derived from municipal casualty statistics.

Fire usage rate of 2% was small. Though, half cases turned off the devise, in the left cases, automatic shut off device were activated. The rate of responses who think there was a risk of fire occurring from their own home reaches 13%, warning danger of human loss by combination of fire occurrences and disabled evacuation routes.

Figure 5 depicts degree of community involvement affects behavior of knocking doors of neighbors in earthquake emergency. Positive participation in community and owners organizations is important to improve mutual communication and accordingly cooperation in case of emergency.

2.4 Earthquake Preparedness

As for the earthquake preparedness at home, 2% of respondents answered that they had taken measures to prevent falling furniture before the earthquake, which seem to be much lower than other survey results in Tokyo metropolitan area and other regions, reflecting Fukuoka citizens' belief that Fukuoka could be free from any damaging earthquakes. Fifty two % of respondents answered that they took some measures after the earthquake for indoor safety to prevent falling furniture and objects. It is important to disseminate earthquake safety

measures to raise awareness and preparedness of people, because potential hazard by future occurrence of Kego fault earthquake is significantly high.

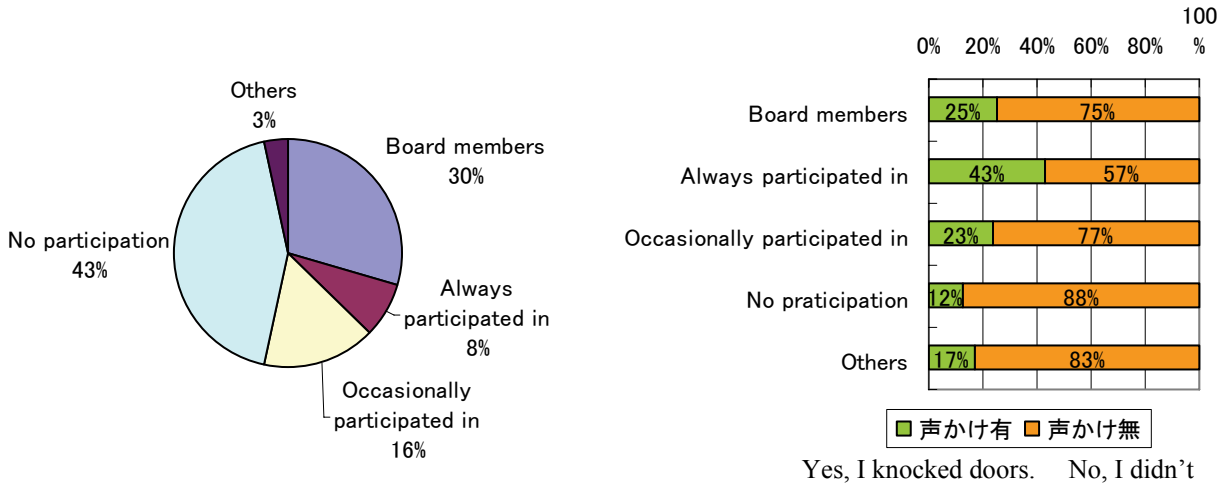

Fig. 5 The residents' participation in community activities (left) and their behaviour of knocking doors of neighbours in an earthquake emergency (right).

3 Recovery and restoration of condominiums

Figure 6 indicates respondents' interests to ask earthquake safety and structural conditions of the condominium building when they made decisions to purchase or to rent the dwelling unit. Majority of 73% say they didn't make any inquiry, and 21% say they asked few questions. It is important for lay people to ask for due explanation of earthquake safety, ground conditions, structural safety levels and expected level of damages in case of a major earthquake.

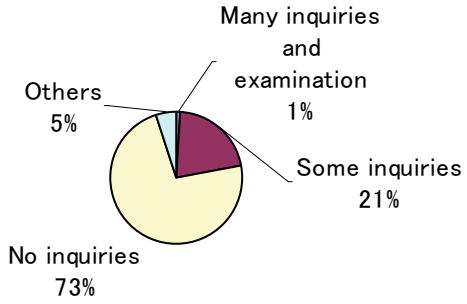

Fig. 6 The residents' interest to ask earthquake safety of the condominiums before they made decisions in purchasing or renting the condominiums.

After the Aneha cases of farcified seismic design data exposed in November 2005, public enormously raised concern and disbelief in the seismic safety of existing condominium buildings. It is crucial to improve the mechanism to provide incentives to supply safer buildings and to support better communication among potential customers (citizens), structural engineers and architects in regard of structural safety and seismic design principle.

The partially damaged condominium had great difficulty in making decisions how to repair or to retrofit the building collectively owned. Owners and residents management organizations

play crucial role in case of emergency and post-earthquake recovery phase. The residents of a condominium had to find places for temporal relocation during extensive repair and retrofit work taking almost one year. In case of another condominium partially damaged and fortunately insured against earthquakes, the owners' management organization made rapid decision to repair and retrofit the structural frames and walls, while the residents continued to stay there. With aging occupants of urban condominiums, daily communication and kind and familiar relationship among residents are important, even if many residents seek privacy and have less attention in their neighbors than in case of independent houses.

4 Concluding Remarks

Based on the questionnaire results for 8 condominium residents who experienced the 2005 west off Fukuoka earthquake, severe architectural damage, contents damage and high rate of occupants' casualty were elucidated. Non-structural damage made great hazard in occupants' evacuation route, so that seismic designs have to take much care to prevent such damages. The residents' active participation in community organization and events are important for mutual assistance in emergency and recovery phase after the earthquake.

In Fukuoka city, ratio of apartments among dwelling stock reaches 70.8% in the 2003 national census of housing and is the highest among metropolitan cities in Japan. National earthquake committee estimates probability of M7.2 earthquake occurrence in south-eastern part of Kego fault as 0.3%-6% in 30 years. Fukuoka prefectural government reported that such an earthquake would cause 1000 human loss in Fukuoka city and vicinity. Earthquake preparedness actions for urban residents are getting more important for mitigating casualty, and property losses.

Acknowledgement

Authors wish to express sincere gratitude to the residents of the condominiums answering the questionnaire survey. Fukuoka Condominium Management Organization kindly provided contact information for the survey.

References

[1] Murakami, H., "Factor Analysis of Human Casualty and Indoor Contents Damage of Condominium Buildings due to the West off Fukuoka Earthquake," Investigation Research Report of the Strong Ground Motion and Structural Damage in the West off Fukuoka Earthquake, Kyushu University, (2006), pp. 218-229 (in Japanese).