A FIELD SURVEY ON HUMAN RESPONSE DURING AND AFTER AN EARTHQUAKE

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SYNOPSIS

From the viewpoint that the human behaviors during an earthquake have a significant influence upon increasing and reducing earthquake disasters which might be suffered, a field survey on human responses during and immediately after an earthquake, and on succeeded daily lives was conducted at the 1978 Miyagi-ken-oki earthquake. By means of questionnaire and interview, it was clarified that some of the human behaviors are strongly correlated with seismic intensity, and some are controlled by the situated circumstances of family constituents, a housing plan, and existence of fire sources in use. A schematic model for explaining total process of human behaviors during shaking was tentatively proposed.

INTRODUCTION

Rapid urbanization and increasingly complicated lives of citizens supported with various kinds of information and flow of commodities make earthquake disasters in large cities more complex than ever before. In this new situation so-called secondary disasters such as fires, trafic confusion and sometimes panic fear, coupled with primary disaster of physical damage to dwelling houses and man-made structures, are supposed to not only deprive the inhabitants of daily services and necessities, but also endanger a great number of human lives. This urges us to a more comprehensive study on how to reduce the secondary disasters due to an earthquake. Since it is expected that appropriate behaviors by human beings play a very important and sometimes dominant role in reducing these disasters, clarification of human behaviors under the circumstances of a large earthquake is indispensable as the first step to find out the better way of mitigating earthquake disasters. However, the data obtained up until now in Japan is far from being sufficient.

From these points of view, after several times of preliminary tests, a detailed field survey on human responses during and after an earthquake was carried out on the 1978 Miyagi-ken-oki earthquake (M=7.4, 6.12, 17h14m) by means of both questionnaire and interview methods. This report introduces an outline of this field survey to quantify human behaviors and to examine the factors governing those responses.

SURVEY BY QUESTIONNAIRE METHOD

Method. The survey was conducted late in June and July at five cities of Sendai, Ishinomaki, Ofunato, Fukushima and Shinjo (Fig.1) where intensities were reported as I_{JMA}=V(I_{MM}=VII-VIII) by the Japan Meteorological Agency (Table 1). A questionnaire sheet contains 21 questions about responses of persons, surroundings and structures. A seismic intensity was calculated from replies to them, so as to be an index of the strength of ground shaking. By the way this method of intensity measurement was originally developed in order to make seismic microzoning maps, and 25,000 sheets have been

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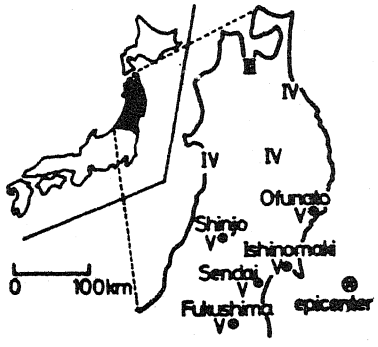

Fig.1 Surveyed cities and JMA intensities reported by the Japan Meteorological Agency in Roman numerals.

Table 1 Collection of questionnaire sheets

City	Distrib-uted	Collected (%)	I-mean
Sendai	1550	1360(89)	5.2
Ishinomaki	700	610(87)	5.2
Ofunato	550	434(78)	4.8
Fukushima	1000	708(71)	4.8
Shinjo	500	474(95)	4.1
All Data	4300	3586(83)	

Table 2 Earthquakes for which intensity surveys were conducted.

Earthquake	Date	Time	Magni-tude	Surveyed Area (I-JMA)	No. of cases
Yamanashi-ken-tobu	1972. 1.27	23h41m	4.8	Kawasaki(III)	1821
Hachijo-jima-oki	1972. 2.29	18h23m	7.2	Kawasaki(IV)	2219
Hachijo-jima-toho-oki	1972.12. 4	19h16m	7.3	Kawasaki(IV)	2523
Nemuro-hanto-oki	1973. 6.17	12h55m	7.4	Eastern Hokkaido (IV-V)	4059
After shock (a)	1973. 6.17	22h33m	5.7		1169
After shock (b)	1973. 6.24	11h43m	7.1		1239
Oita-ken-chubu	1975. 4.21	2h35m	6.4 7.4	Kyushu District (I-VI)	8420
Miyagi-ken-oki	1978. 6.12	17h14m	7.4		3586
All Data					25036

obtained for the recent 8 earthquakes (Table 2)(Ohta et al. (1979)). The measured intensity I, equalized to the JMA intensity when rounded off, has two significant digits and was proved to be more precise and sensitive. As for human behaviors, detailed responses during an earthquake and immediately after the quake, namely for the first one minute and for about 10 minutes, as well as influence on succeeded daily lives were asked by 18 questions prepared.

Behaviors. Among 21 questions prepared for measuring seismic intensity, there are several questions concerned with human behaviors and psychological conditions during an earthquake (Ohta and Omote (1977)). Their frequency distributions are presented in relation with seismic intensity, and those obtained using the whole data by the previous surveys listed in Table 2 are referred for comparison (Fig.2). The emotional response of fright and difficulty in moving are gradually intensified in accordance with the intensity increasing from II to VI in I_{JMA}(IV to X in I_{MM}). As for fright, difficulty in moving and general behavior, the results by the Miyagi-ken-oki earthquake agree quite well with those obtained using the whole data, however, the people who were unable to put out a fire are far less in case of the Miyagi-ken-oki earthquake. This may be due to the kinds and locations of fire

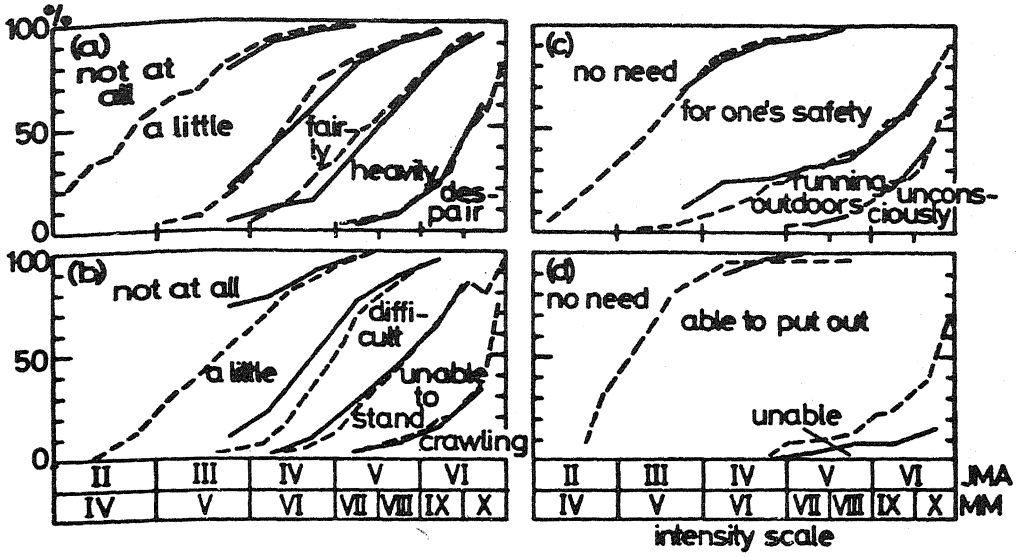

Fig.2 Changes of human responses in relation with seismic intensities.
—— the Miyagi-ken-oki earthquake ---the whole data (a)fright (b)difficulty in moving (c)general behavior (d)extinction of a fire

sources in relation with respondents' positions. The intensity at which each item category exceeds 50% can be regarded as a threshold, that is, a very important index.

Assuming that one's behavior during shaking is often a sequence of several actions, one of the questions in a questionnaire sheet offered 36 actions as alternatives and permitted multiple answers. Grouping similar actions for simplicity, and selecting 2973 cases who were indoors at the time of earthquake occurrence, typical actions are shown in relation with seismic intensity and presence of fires in use and/or people who need protection (Fig.3). Actions such as "holding on", "injured" and "supporting furniture" increase in number when intensity gets higher, and this seems very reasonable because the former two situations represent obstacle in moving and the latter is often motivated by heavily shaking furniture. As for the rest of the actions, however, no systematic change in this intensity range is recognized. Fires in use drive most people to an action of "putting out a fire" and existence of children, the aged or the handicaped people often results in protecting behaviors. In either of the two cases, protection or extinction of a fire acquires a kind of priority over the rest of actions and a fire seems to be more dominant in motivating human behavior than the people who require protection. It is interesting that other behaviors such as going outdoors, going under tables and supporting furniture are not affected by these surrounding conditions.

In the same way, concerning behaviors immediately after the quake, a question presented 13 actions as alternatives, permitting multiple answers. Fig.4 indicates the frequency of each action for the cases who were indoors,

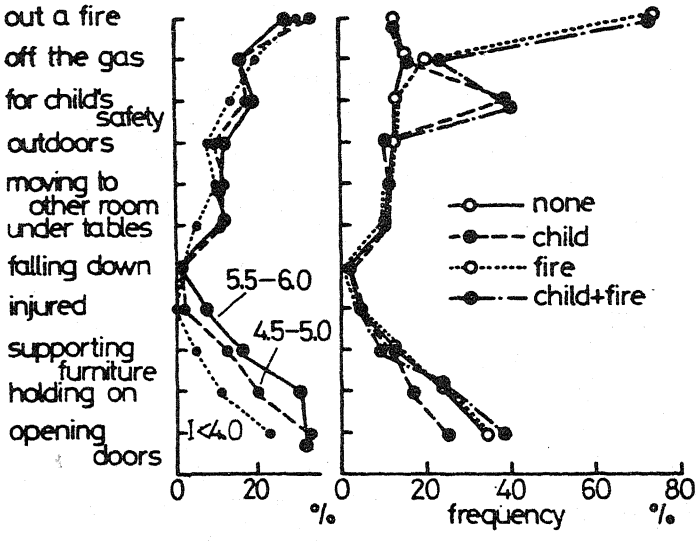

Fig.3 Actions during the Miyagi-ken-oki earthquake in relation with seismic intensities and presence of fires and children.

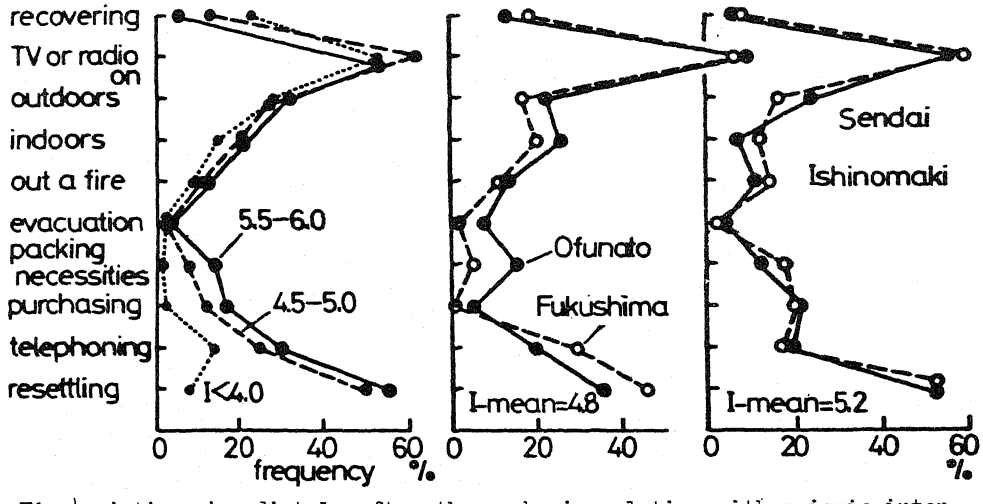

Fig.4 Actions immediately after the quake in relation with seismic intensities and localities.

in relation with seismic intensity. An action of "putting TV or radio on" amounts to 50% or more at any intensity and at any locality, so that we can know how inhabitants depend on this kind of mass communication in order to acquire information on such occasions of urgency. "Packing necessities", "purchasing" food or urgently needed commodities, "telephoning" and "resettling" scattered and overturned materials increase in number quite rapidly in accordance with intensity. Since mean intensities in Fukushima and Ofunato cities happen to be the same (4.8) and those in Sendai and Ishinomaki

are equal (5.2)(Table 1), the average behaviors were compared in each group to examine local effects on them. The former two cities show larger difference than the latters. That is, in Ofunato more people packed valuables and necessities to make evacuation and accordingly less people resettled than in Fukushima. This can be attributed to geographical circumstance in Ofunato, which often suffers tsunami hazards.

Behaviors during shaking are usually affected by surrounding situation just nearby, since an indoor space is limited and information from outside is interrupted. On the other hand, behaviors after the quake seem to reflect the features of damage in and around the environs.

SURVEY BY INTERVIEW METHOD

Method. While a questionnaire method aims at finding general features of behaviors by statistical data processing, an interview method was introduced to elucidate details about time-dependent changes of behavioral patterns under drastically changing environments. A group of housewives living in apartments of the identical housing plan (Fig.5) was chosen in Sendai city so as to reduce number of spacial factors which may affect and complicate human behaviors. The survey was conducted for 118 cases in 4 days at the end of June.

Every respondent was asked to fulfill the questionnaire sheet for seismic intensity determination (Ohta et al.(1979)) and the mean intensity obtained in this way is 5.6. This value agrees quite well with the one calculated using 271 questionnaire sheets collected from the surrounding area. The apartment housings were five storied RC construction and suffered no structural damage. The ratio of overturned furniture is highest for cupboards (61%) followed by bookcases (45%), dressers (42%) and shoe cases (37%). The changes of indoor circumstances from pre- to post-earthquake is visualized as shown in Fig.6 by an array of furniture occupancy ratios on the housing plan. This ratio here indicates the degree that each unit surface of room floor is occupied by any furniture standing or overturned. Reduction of free-to-walk space and obstruction in the passage to the outside are conspicuous in the post-event situation, and this proves how over-

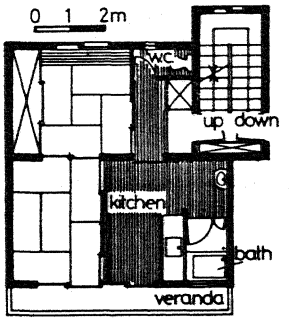

Fig.5 Plan of an apartment.

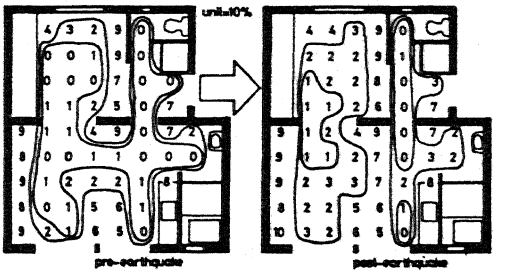

Fig.6 Comparison of furniture occupance ratios between pre- and post-earthquake.

turned furniture prevents the residents from free movement.

Classifying all the cases into 4 groups according to the presence of fires in use and/or children, as (no fire + no child), (fire), (child) and (fire + child), they are 30, 15, 59 and 14 cases respectively. The children being at home are very young and actually half of them are under 3 years old.

Behaviors. Here comes to the question how the residents behaved in such surroundings restrained by the identical housing plan. Fig.7 shows trajectories along which each housewife moved during shaking. Their movements range so widely from staying at the same position all the time to running continuously to outside, that they look rather random and out of order. Still, a definite flow from indoor space to a front door and further to a staircase can be noticed. Those who got injured amount to 26 out of 118 cases, most of which were due to scattered pieces of broken glassware, upset objects and overturned furniture. This ratio of injuries (22%) is much higher than the result for the same intensity by the questionnaire survey (Fig.3).

In Fig.8, frequencies of typical actions are shown in relation with presence of fires and children. In cases with fires around, extinction of a fire exceeds the other actions and most of the cases with children protected them. Attention to children being almost comparable to fires, people who tried to protect children were larger in percentage in the interview than in the questionnaire survey. It is interesting that active behavior of supporting furniture exceeds defending oneself in number, when there were neither children nor fires. Number of unit actions each respondent performed was counted and totally moved distance was measured in order to quantify human behaviors during shaking (Fig.9). Both number of actions and moved distance increase in the order from (none), (child), (fire) to (child + fire).

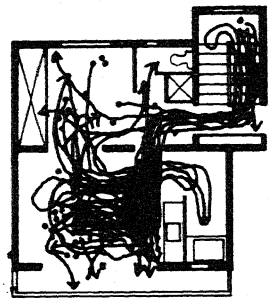

Fig.7 Trajectories along which housewives moved during shaking. A solid circle is one's position just prior to the quake

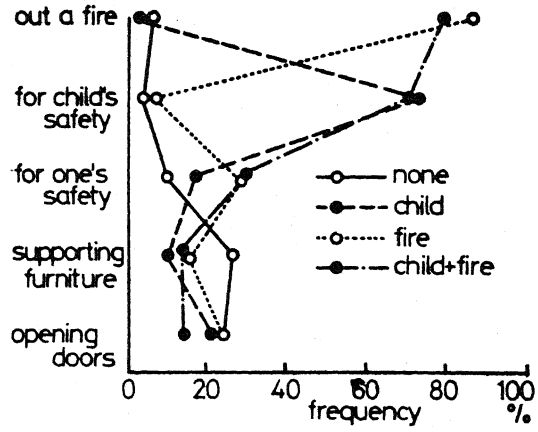

Fig.8 Change of behavioral frequencies in relation with children and fires.

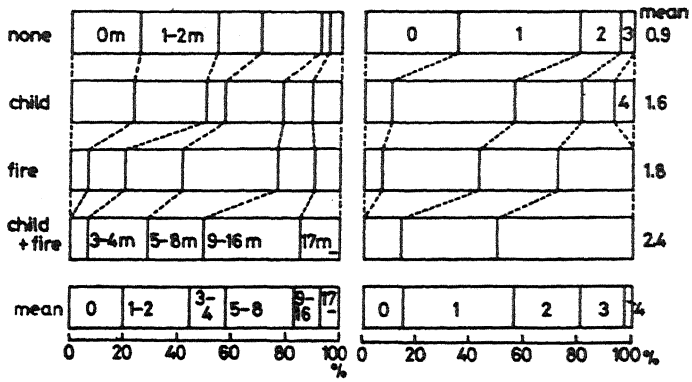

Fig.9 Relation of totally moved distance (left) and of number of performed actions (right) during shaking with children and fires.

CONCLUDING REMARKS

The results obtained are as follows.

(1) Using the questions originally prepared for measuring seismic intensity, it was found that responses such as fright, difficulty in moving, general behavior and extinction of a fire are all sensitive to seismic intensity. As for the former three behaviors, the result by the Miyagi-ken-oki earthquake agrees quite well with that obtained by the whole data of preceding survey. Those who were unable to put out a fire are less in the Miyagi-ken-oki earthquake than in the other earthquakes.

(2) Behaviors during the Miyagi-ken-oki earthquake were surveyed in detail. According to the data by the questionnaire method, actions such as "injured" and "holding on" which represent obstacles in moving and "supporting furniture" increase in relation with seismic intensity, while extinction of fires is affected by the presence of fires and protection by existence of children, the aged and the hadicaped people. As for the rest of actions, neither intensity nor surrounding conditions influenced them. The same effects by children and fires were also found in interviewed cases. By the way, one can be free from a fire at the very moment it is put out, while one must continue to protect children at least as long as shakings last. This difference should be considered when examining the effects of children and fires.

(3) Behaviors immediately after the quake, especially resettling, telephoning and purchasing were activated in accordance with increasing seismic intensity. Comparing behaviors in Fukushima and Ofunato in which mean intensities are equal, packing necessities and evacuation are more frequent in Ofunato than in Fukushima. Behaviors after the quake seem to be affected by the geographical conditions and characteristics of damage in and around the environs.

Considering and unifying the results indicated above, a flow of human

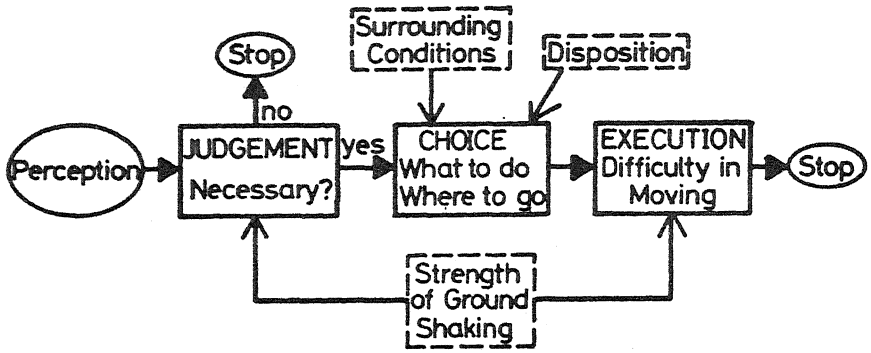

Fig.10 Schematic picture to clarify the flow of human response during shaking and affecting factors.

response during an earthquake and factors affecting it are schematized (Fig. 10). Total process from perception of shakings to the end of behavior with some results, can tentatively be devided into three main steps of JUDGEMENT, CHOICE and EXECUTION. In the first step, one must judge whether or not it is necessary to move or do something special. Most people feeling it necessary if $I_{JMA} \geq IV$ ($I_{MM} \geq VI$) (Fig.2), here comes to the second step of choice among alternatives concerning where to go and what to do. Surrounding conditions such as presence of children, the aged people and fires affect this choice as motivation (Murray (1964)), as well as individual knowledge and disposition. Then, execution follows and strength of ground shaking disturbs it increasing difficulty in moving. In other words, strength of ground shaking dominantly influence how actions are performed.

This behavioral model is still qualitative and tentative at this moment so that it should be examined quantatively by additional data including higher intensities. Seismic intensity itself, used as an index of strength of ground shaking, should be refined in relation with physical parameters. We hope the results obtained here can make any use in reexamining counter measures to mitigate earthquake disasters from the side of the residents.

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