DEVELOPMENT OF AN AFTER EARTHQUAKE DISASTER SHELTER EVALUATION MODEL

Shen-Wen Chien[1], Liang-Chun Chen[2]*, Shin-Yi Chang[3], Ging-Hsiang Chiu[1],
and Ching-Lin Chu[3]

[1]*Department of Fire Science and Administration*
Central Police University
Taoyuan, Taiwan 333, R.O.C.
[2]*Graduate Institute of Building and Planning*
National Taiwan University
Taipei, Taiwan 106, R.O.C.
[3]*Office of the National Science &*
Technology Program for Hazards Mitigation
Taipei, Taiwan 106, R.O.C.

ABSTRACT

The research was carried out in two regions: the Chia-Yi area and Taipei City, investigating the needs of the local populations during earthquake evacuation. Based on real-life earthquake experience and hypothetical settings, with the use of questionnaires, this research probes into characteristics of evacuation behavior of the populace, and the research concentrates, as well, on parameters (age, income, education, rented or self-owned domicile), which influence the populace in selecting a short-term shelter, using estimate modules contained in Haz-Taiwan.

I. INTRODUCTION

In major earthquakes, the effective distribution and planning of shelters not only can ensure the personal safety of victims while escaping calamity, but also can ease economic pressure on the government in the follow-up recovery phase. In the past, most urban disaster prevention research focused on the governments' subjective evaluations of what the government could supply and how they could supply it and ignored related problems of demand and selection of shelters based on citizens' evacuation behavior in calamities. Based on the structure of Haz-Taiwan software, this research aims to gain a better understanding of these characteristics, to obtain the decisive parameters of evacuation behavior of residents in a model community, and to propose a shelter-selecting formula as a base for building up the Haz-Taiwan shelters supply and demand module software.

II. RESEARCH METHODS AND QUESTIONNAIRE STRUCTURE

This research focuses on the greater Chia-Yi area and Taipei City, investigating the needs of local populations during earthquake evacuation. Based on real-life earthquake experience and hypothetical settings, with the use of questionnaires, this research probes into characteristics of evacuation behavior of the

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*Correspondence addressee

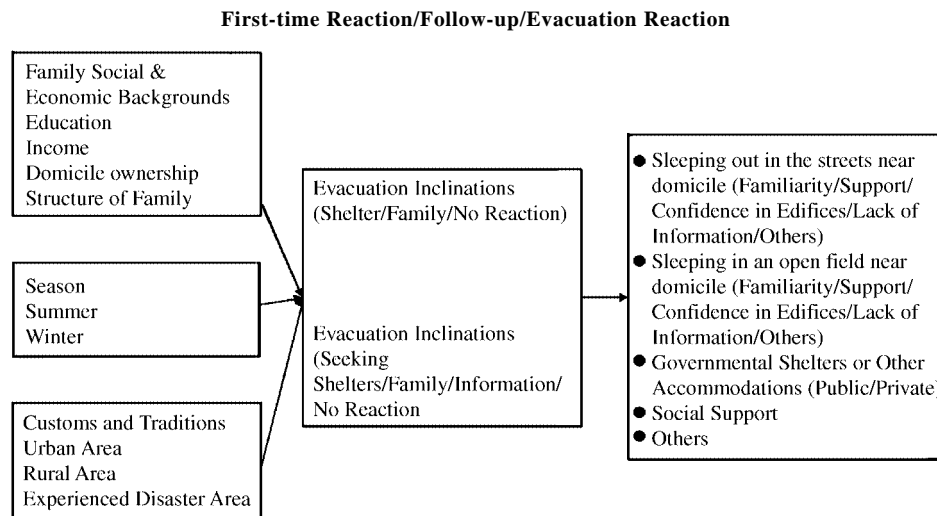**First-time Reaction/Follow-up/Evacuation Reaction**

Fig. 1 Questionnaire Structure

populations, in the 2 areas. This research concentrates on the parameters (age, income, education, rented or self-owned domicile), which influence the populace in selecting short-term shelters, using the estimate modules, contained in Haz-Taiwan. The structure of the questionnaire is shown in Fig. 1.

III. ANALYSIS OF INVESTIGATION RESULTS

These surveys were conducted within 6 months of the 921 Chi-Chi Earthquake. The numbers of usable questionnaires from Chia-Yi and from Taipei City were 353 and 180 respectively. The questionnaires focused on evacuation behavior of the populace under the following three conditions: ground-shaking, post-quake reaction, and collapse of buildings. Related sections applying to Haz-Taiwan (Sun and Wang, 1999) are discussed as below:

1. The Reactions of People during Ground Shaking

During an earthquake, the percentages of the population's evacuation behavior are as follows: staying in the original place and waiting for the ending of the earthquake (27%), running into living room or other open spaces in the house (18%), running toward a pillar or other more solid places (16%), hiding beside desks, beds or other more rigid objects (13%), or hiding under desks or beds (9%).

Distinguishing behavior patterns at the moment of an earthquake, three categories could emerge as follows: active evacuation behavior, passive evacuation behavior and collective evacuation behavior. As a result of this research, we found about 50% of the populace will actively evacuate.

2. The Reactions of People, Post-Quake

People's evacuation reactions include leaving for other places together with family (36%), going to turn off the gas and electricity (19%), running to open fields or streets (19%), staying in the original place and continuing to do the same thing as usual (11%), calling relatives (7%), listening to the radio or television (6%), and perceiving no earthquake or others (3%).

3. The Inclination to Go to a Sanctuary when Domicile has been Damaged during Earthquake

When domicile has been damaged during earthquake, the percentages going to various kinds of sanctuaries for temporary shelter are as follows: sleeping out or making tents in nearby open fields, parks or school playgrounds (35%), seeking support from relatives and friends (25%), and proceeding to various edifices such as community centers, schools, district offices, temples or churches for temporary shelter (20%), and others (4%).

4. Factors Influencing when People Select Shelters

Deducting the 25% of the evacuee population choosing to live with relatives or friends, 35% of the evacuee population chooses to sleep out or make tents in open fields, parks or school playgrounds. The results of this investigation provide the following explanations: being anxious about following earthquakes and convinced that staying in the house is unsafe (45%), being familiar with the surroundings (25%), and knowing the nearby residents and it

being easier to seek help (21%).

20% of the evacuee population chooses to settle down in edifices; among them, 84% would go to public shelters, and the rest 15% prefer private loci.

The rest, 16% of the evacuee population, choose to sleep out or put up tents in alleys or streets near domiciles. The following factors will help explain why a specific location is chosen: being familiar with the surroundings (48%), being anxious about aftershocks (33%), knowing the nearby residents (15%), concern about their property in the domiciles (2%) and others (2%).

Comparing the two behavior patterns, evacuation to the nearby streets and to the open fields, three main factors could be identified: being worried about following earthquakes and the unwillingness to stay in edifices, being familiar with nearby surroundings, and knowing the nearby residents. As to choosing evacuation behavior, the main difference is the familiarity of the surroundings. This is the reason why the residents will choose these areas during earthquake. Consequently, whether the residents know where the nearest park is, whether there is any large-scale open area that can provide shelters, and whether the residents are aware of the correct disaster response, all are confusing variables that will influence people in choosing the way to evacuate to large-scale open fields or to nearby streets. As a result, any quick conclusion concerning the evacuation behavior pattern of Taiwanese people should not be made. Further studies should be conducted to find out the potential reasons that can explain why these people choose to evacuate to nearby streets.

5. The Season's Influence on Populaces' Evacuation Behavior

In northern Taiwan the winter weather is wet and cold, it often rains and cold fronts pass through. Hence, the populaces' evacuation behaviors inclination may be affected by the weather. Therefore, this study focuses on the climate factor to further understand whether there is any difference due to weather condition.

According to our results, the percentages of the populaces' evacuation behaviors under conditions of bad weather and damaged domicile are as follows: making a temporary stay in community centers, schools, churches, temples or other buildings (38%), seeking help from relatives or friends (38%), choosing to stay in nearby parks, school play grounds, other open fields or making a tent (17%), living on alleys, streets or putting a tent near domicile (4%) or others (3%).

Comparing these two different evacuation behavior patterns under normal weather conditions and

under wet and freezing weather conditions, our statistics show that in normal conditions, the percentage proceeding to shelters is 20%, but in bad weather the percentage will increase to 38%. Furthermore the population sleeping out on streets or in open fields will decrease from 35% to 17% when the weather changes from good to bad. As for the population who seek help from relatives or friends for shelter, the percentage increases to 38% in bad weather.

The above data show that evacuation patterns are not stable constants; instead, they vary with the outside environment. In planning a public shelter field in a certain area, a space with the capacity to contain 17% to 35% of the evacuee population, can then be predicted as sufficient for disaster evacuation in all seasons.

IV. SUGGESTIONS TO AMEND THE SHELTER MODULE STATISTICS

In the Haz-US shelter module software, estimating the demand for shelters requires, in advance, the percentage of people proceeding to shelters in different circumstances (population structure, income structure and domicile structure). Based on our investigation, the following factors influence the percentages of people going to shelters: structure of family, amount of income and ownership or non-ownership of pre-quake domicile. These figures can be consolidated into tables to estimate the demand for shelters.

1. Relation between Family Structure and Evacuation Behavior Patterns

The different sample structures of evacuation behaviors are shown in Table 1. Based on models of evacuation shelters and given family structures to estimate the volume of shelters, we acquire the percentages of people's evacuation behaviors at different ages. We find that the samples focus on family structure, not different ages; therefore, we could not divide these samples categories by age. Why? Because most families contain members in all age categories, we could not divide them into separate age categories, related to behavior categories. In order to acquire all ages for our samples, we must investigate in shelters immediately after an earthquake to acquire these data. Finally, inferring, based on the present research, we need to consolidate the investigation results.

Investigation samples can be divided into students, senior citizens living in solitude, and non-local population. Under the assumption that the family is the evacuation behavior unit for students; senior citizens living in solitude are weak minorities;

Table 1 Choosing temporary shelters because of damage to domicile during earthquake

Item \ Sample	Children under 7 years old	Junior & Senior High School Students	Senior citizens living in solitude	Non-local population	Percentage
Putting tents on streets near the domiciles	20.8%	14.3%	24.5%	12.8%	16.6%
Putting tents in the school playgrounds, parks or farmlands near the domicile	31.3%	42.9%	15.1%	20.5%	34.4%
Going to a government shelter	22.9%	20.2%	26.4%	12.8%	20.7%
Seeking support from relatives and friends	18.8%	20.7%	22.6%	48.7%	23.9%
Others	6.3%	2.0%	11.3%	5.1%	4.4%
Subtotal	100%	100%	100%	100%	100%

Table 2 Revised suggested parameter values of age structure for proceeding to temporary shelters

Subject	Age	HazUs Default Value	Haz-Taiwan Suggestion Value
AM1	Population under the age of 16	0.4	0.22
AM2	Population between the age of 16 and 65	0.4	0.18
AM3	Population above the age 0f 65	0.4	0.24

non-local populations living in solitude will return to hometowns after disasters. These three populations are expected to possess comparatively different evacuation behavior patterns, and therefore can be referred to as indexes in predicting the percentage of demand for short-term shelters. Transforming and analyzing the investigation data can result in the following:

(1) The ratio of population under the age of 16 which goes to shelters is 0.22.
(2) The ratio of population between the age of 16 and 65 which goes to shelters is 0.18.
(3) The ratio of population above the age of 65 which goes to shelters is 0.24.

The calculation above is based on the structure ratio of evacuee population. Revised statistics determined are shown as Table 2.

2. Relation between Income and Evacuation Behavior Patterns

The evacuation behaviors of different income groups are shown as Table 3. Please note that in the questionnaire the classifying standard is family monthly income, whereas in the Haz-US module the classifying standard is family annual income. Based on different income levels of people proceeding to shelters, we could cite Table 3 directly to deduce the percentage of evacuee populace with different incomes going to public shelters shown as in Table 4.

3. Relation between Homeownership and Evacuation Behavior Patterns

Different living conditions linked with different evacuation behaviors are shown as Table 5. As a base for estimating demand for shelters, homeownership can be divided into 4 general types: self-owned domicile, rented domicile, dormitory, and domicile borrowed from relatives or friends. (Those who choose the "other" option are queried for more detail.) By weighted grade calculation, the amended suggested values are determined as shown in Table 6.

V. CONCLUSION

The result of this research can help revise the

Table 3 Choosing temporary shelters because of damage to domicile during earthquake

Income Item \ Family Monthly Income	Below NT$ 32,000	NT$32,000 ~ NT$79,000	NT$80,000 ~ NT$159,000	NT$160,000 ~ NT$290,000	Above NT$ 290,000	Percentage
Putting tents on streets near the domiciles	22.1%	12.4%	14.7%	–	–	16.4%
Putting tents in school playgrounds, parks or farmlands near the domicile	28.7%	40.0%	26.5%	25.0%	50.0%	33.7%
Going to a government shelter	16.9%	22.1%	26.5%	25.0%	25.0%	20.4%
Seeking support from relatives and friends	25.7%	23.4%	26.5%	50.0%	25.0%	25.1%
Others	6.6%	2.1%	5.9%	–	–	4.3%
Subtotal	100%	100%	100%	100%	100%	100%

Table 4 Revised suggested parameter values of income for proceeding to temporary shelters

Subject	Income	Haz-US Fault Values	Haz-Taiwan Suggestion Values
IM1	Family annual income < NT$400,000	0.62	0.17
IM2	NT$400,000 ≤ Family annual income<NT$1,000,000	0.42	0.22
IM3	NT$1,000,00 ≤ Family annual income<NT$2,000,000	0.29	0.27
IM4	NT$2,000,000 ≤ Family annual income<NT$3,500,000	0.22	0.25
IM5	NT$3,500,000 ≤ Family annual income	0.13	0.25

Table 5 Choosing temporary shelters because of damage to domicile during earthquake

Item \ Ownership of Domicile	Self-owned domicile	Rented-domicile	Dormitory	Others	Percentage
Putting tents on streets near the domiciles	13.1%	18.2%	11.1%	64.3%	16.7%
Putting tents in school playgrounds, parks or farmlands near the domicile	37.4%	30.3%	33.3%	14.3%	34.2%
Going to a government shelter	21.5%	20.2%	11.1%	7.1%	20.2%
Seeking support from relatives and friends	24.3%	25.3%	44.4%	7.1%	24.4%
Others	3.7%	6.1%	–	7.1%	4.5%
Subtotal	100%	100%	100%	100%	100%

parameters or numbers fed into the evacuation module of HAZ-Taiwan, so that we can come to a more precise prediction as to the numbers of people engaging in different evacuation behaviors with the use of the HAZ-Taiwan software. Furthermore, through the evacuation behavior research in greater

Table 6 Revised suggested parameter values of domicile ownership for proceeding to temporary shelters

Subject	Ownership of domicile	Haz-US Fault Values	Haz-Taiwan Suggested Values
OM1	Self-owned domicile	0.4	0.22
OM2	Others-owned domicile	0.4	0.16

Chia-Yi and Taipei City, we have added to our knowledge of Taiwanese's evacuation behaviors. Finally, we have shown the effectiveness of the parameters used to evaluate the need for constructing evacuation shelters that are required.

In the present HAZ-Taiwan software, the inferences and the calculation procedures of most modules depend on the original design of Haz-US. However, after two years of module research, investigation and parameter amendment, researchers realize that some of the inference procedures or the influential parameters are not ideal predictive variables, nor do they fit the real pattern for this Island. For instance, among those variables, the percentage of people who proceed to shelters does not include higher incomes, which reveals that income is not an ideal and effective predictive variable. In addition, a large number of research units have gone deep into the disaster zone to collect information after the 921 Chi-Chi Earthquakes in the year of 1999. Utilizing these accumulated research results to guide or to amend to a more suitable calculation module of casualties and demands for shelters for Taiwan is a promising topic for further research.

REFERENCE

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地震災害短期避難所需求性及居民避難行為之研究

簡賢文[1]　陳亮全[2]　張歆儀[3]　邱景祥[1]　朱慶琳[3]

[1] 中央警察大學消防科學研究所
[2] 國立台灣大學建築與城鄉研究所
[3] 防災國家型科技計畫辦公室

摘　要

本研究分別針對嘉義縣市及台北市進行居民於地震災害時避難需求態樣調查，根據實際震災經驗及假設情境方式，透過問卷調查探討民眾在地震時之避難行為特性。本研究並探討 Haz-Taiwan 短期避難所需求推估模組所使用的參數（年齡、收入、住屋自有或非自有），對民眾選擇短期避難所的影響。

關鍵詞：短期避難所，避難傾向，避難行為，地震災害。