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THE CASUALTY OF THE 1946 NANKAI EARTHQUAKE AND ITS EFFECT UPON HUMAN BEHAVIOR

Michio MIYANO¹ and Toshio MOCHIZUKI²

¹Department of Housing & Design, Osaka City University,
Sumiyoshi-ku, Osaka, Japan

²Center for Urban Studies, Tokyo Metropolitan University,
Meguro-ku, Tokyo, Japan

SUMMARY

Through new tracing investigations, this study seeks to clarify the scope of the 1946 Nankai Earthquake (M8.1) in terms of human casualties and to focus upon the behavior of those who suffered through the earthquake and its tsunami. In areas struck by the tsunami caused by the Nankai Earthquake, a large percentage of children and elderly people suffered death. Females suffered higher casualty rates than males. In terms of behavioral responses to the earthquake, women demonstrated more active behavior in the protection of children and the elderly than did men.

INTRODUCTION

The Nankai Earthquake which occurred at 4:19 a.m. on December 21, 1946 off the coast of Kii Peninsula, Japan, recorded a magnitude of 8.1 and caused extensive damages over the wide area including Kochi, Tokushima and Wakayama Prefectures. In spite of the material gravity of consequences, we do not have enough facts concerning the earthquake compared with other major seismological events which took place in and around Japan, perhaps because the country was still suffering from the outcome of the Second World War at that time. On the other hand, now that more than 40 years have passed since the earthquake, it is becoming increasingly difficult to interview those who happened to experience the calamity. We do know, however, that the earthquake is characteristic in that it was accompanied by severe damages due to tsunami. We also know that the risks of tsunami, in terms of casualties and otherwise, are quite significant today, as the recent earthquake which occurred in 1983 in the central region facing the Sea of Japan.

Thus, we believed that meaningful facts could be obtained if efforts were made to survey the actual impact of Nankai Earthquake even at our time, and this led us to undertake a survey of casualties and damages caused by the Nankai tsunami for several regions in Kochi, Tokushima and Wakayama Prefectures which are known to have sustained particularly severe consequences. In this paper, we shall consider especially the aspect of human casualties of the Nankai Earthquake in terms of those attributes such as age, sex and other factors concerning the victims and the circumstances of casualties as well as behaviors at the time of the calamity.

METHODOLOGY

Some communities in Kochi, Tokushima and Wakayama Prefectures shown in Table 1, were sustained especially heavy casualties and that they were the direct consequence of tsunami. Because of this, we selected these five communities - the central part of Susaki City in Kochi Prefecture, Township of Mugi and Asakawa Community of Kainan Town in Tokushima and the central part of Tanabe City (including Shinjo) and Susami Town in Wakayama as these are called at this time - as the targeted area of our survey (Fig. 1).

As to the actual information gathering, we first contacted the representatives of senior citizens' associations in each community and asked them to notify the members the time and place where the survey was to be made. Then, on the notified day, we asked the member citizens to come to the meeting place, and to fill out the questionnaire following our explanation. For those who were unable to come, we requested the association representatives to circulate the questionnaire forms which were to be mailed back later on. The survey was conducted on Sept. 1, 1986 at Susaki, on Sept. 4-5, 1986 at Mugi, on Sept. 6, 1986 at Asakawa, on Oct. 12, 1987 at Tanabe and on Oct. 13 and on Nov. 5, 1987 at Susami.

Table 1 Outlines of Damage due to Nankai Earthquake

Regions	Damage of Houses				Casualty	
	Total Collapse	Half Collapse	Washed away	Flooded	Dead	Injured
Susaki	80	186	45	1089	57	90
Mugi	154	199	121	990	52	40
Asakawa	187	169	158	100	66	37
Tanabe	57	19	38	493	45	22
Shinjo	50	35	79	391	26	30
Susami	12	—	27	190	17	93
Total	540	608	468	3262	263	312

The questionnaire consists of 30 questions. Of these, questions 1-7 pertained to types and characteristics of houses which were occupied by the respondents at the time of the tsunami. Question 8-10 were to determine material damages on the housing caused by the earthquake; question 11 related to the attributes of respondents and their household members at the time of the calamity as well as to the casualties resulting from the earthquake, while questions 12-30 were to know the respondents' behavior following the earthquake.

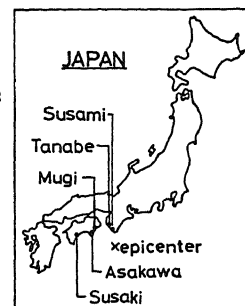


Fig. 1 Investigated Areas

RESULT OF THE SURVEY AND ANALYSIS

Private attributes of the respondents Table 2 shows the number of the questionnaire forms, returned either on the day of the survey or later by mail, for each community concerned.

Table 2 Number of Questionnaire Forms Returned

Regions	On the Day of the Survey	Later by Mail	Total
Susaki	12	68	80
Mugi	72	7	79
Asakawa	44	0	44
Tanabe	29	2	31
Susami	41	8	49
Total	198	85	283

* Tanabe includes Shinjo

Fig. 2 shows the respondents' private or personal attributes at the time of the earthquake. 36.5% were male and 63.5% were female. Because we decided to use members of Senior Citizens' Association as the vehicle of the survey, 98.2% of the respondents were 60 years of age at the time of the survey, and this is one of the reasons why women's percentage was relatively high. Nearly 30% answered that their household had consisted of 7 or more members back in 1946, and this large size of families could be explained partially by the fact that many demobilized people were temporarily staying at their relatives' homes in the period immediately after the end of the Second World War. Nearly 60% of the respondents said that they

Sex	Male	Female
	36.5%	63.5%

Age	0-19	20-29	30-39 Years	40-49	50-
	1.8	26.2	52.0	19.4	0.7

Houshold	1-3	4-6 Persons	7-
	23.6	47.4	29.0

Fig. 2 Respondents' Personal Attributes at the Time of the EQ.

had been living in the communities in question even since 1910', and this shows that most of them were born and grew up in these communities.

Housing and Damages to the Dwellings
With regard to the respondents' homes, practically all had lived in homes made of wood. 232 lived in single-family units while 6 were living in tenement houses and 1 in an apartment. 33 said their homes were also serving as stores, while 3 did not fit in any of these categories. As to the ownership, 233 owned their houses and 37 were tenants(including those who lived in civil-servant dwelling units). 138 (50.2%) of these houses had one floor only(the ratio is to the total meaningful responses rather than to total number of respondents since some of them did not always supply answers to every specific questions). 137(49.8%) houses had two floors.

Fig. 3 shows the varying degree of damages to the respondents' houses. 13 said their houses collapsed by the earthquake, while 95(34.5%) said that the tsunami submerged the floor. Moreover, large number of houses were simply washed away, and this means that 66.2% of houses were damaged or lost due to the tidal wave. The earthquake also caused a fire at Susaki and destroyed 9 homes, and one of the respondents was actually hit by the fire. Otherwise, no major fire was reported in any of the communities.

Casualties On this item of our survey, we obtained 283 replies and because these covered respondents' family members as well, we were able to gather casualty data on the total 1206 persons.

Table 3 shows the correlation between the age and the number of casualties. The death rate was 3.9% of those aged 0-4, 1.6% for those between 5 and 69, and 8.3% for those aged 70 years or more. This shows that the casualties were high among the very young and the old. On the other hand,

Table 3 Correlation between the Age and the Number of Casualties

Age	Dead	Serious	Slight	Not Inj.	Others	N.A.	Total
0 - 4	7	0	0	166	0	8	181
5 - 9	2	1	0	124	0	3	130
10 - 19	3	0	3	176	0	7	189
20 - 29	1	0	8	144	0	11	164
30 - 39	3	1	6	189	0	17	216
40 - 49	3	2	2	110	0	12	129
50 - 59	0	0	0	64	0	0	64
60 - 69	0	0	2	64	1	1	68
70 - 79	3	0	0	29	1	2	35
80 -	1	0	0	10	0	2	13
Total	23	4	21	1076	2	63	1189

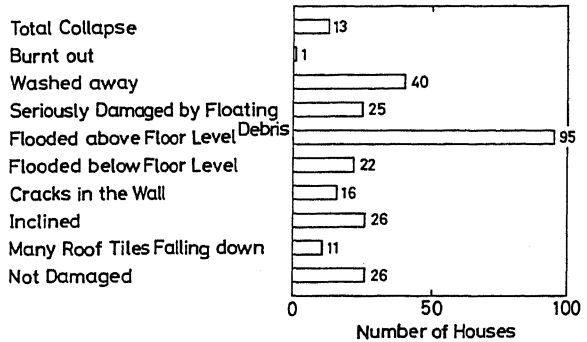


Fig. 3 Damages to the Dwellings
Table 4 Number of Casualties

	Dead	Serious	Slight	Not Inj.	Others	N.A.	Total
Male	9	2	8	515	1	34	569
Female	14	2	13	568	1	34	632
Unknown	0	0	0	2	0	3	5
Total	23	4	21	1085	2	71	1206

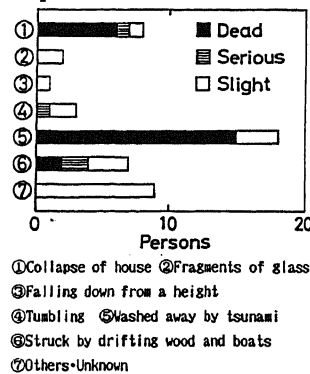


Fig. 4 Number of Dead and Injured Persons from each Cause

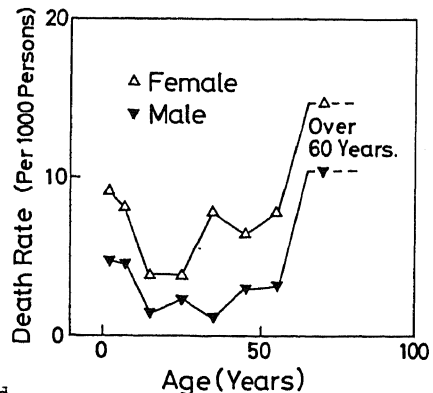


Fig. 5 Change of Death Rate with Age

injuries were most frequent for those between 16 and 69. These data are characteristic of casualties caused by tsunami as survival and safety depend on the speed of evacuation. According to the Reference 1, the victims of tsunami at Susaki were all women, children and the old. A number of women perished with their children. In fact, among those 36 confirmed victims, 26 were women, while the rest 9 were either at least 60 years old or 15 years or less. Thus, there were no death for males between 16-60 years old. Moreover, according to the Reference 2, 53 died or disappeared in Mugi, and of these, 21 were men and 32 were women. The list of victims in the Reference 3 shows that of those 85 deaths in Asakawa, 28 were men and 57 were women. Table 4 shows the number of casualties for both sexes, and we can see that the mortality and casualty ratio for men were 1.6% and 3.3%, while those for women were 2.2% and 4.6%, respectively. Clearly, women are more vulnerable.

In Fig.4, we showed the breakdown of casualties according their causes known as the result of our survey. We notice that a large number of people were killed while trying to escape from tsunami either as they were drowned, or hit by woods or boats and so on. Six were injured when their houses collapsed, of which 2 due to the tidal wave and not the earthquake itself. Injuries were most frequent on lower limbs. The main reason for this is thought to be that the earthquake occurred before dawn at 4:19 a.m. and immediately cut off power supply, so people had to move in the dark frantically seeking the escape. As to the types of injuries, most of minor injuries were scars and incisions, while more serious ones came from contusion, sprain, dislocation and fractures. Drowning, as mentioned earlier, was the most prevailing cause of the death.

On the other hand, data by the official announcements also show the tendency that children and elderly people were killed at a higher rate (Fig. 5). And, a characteristic of this figure is that those in their 30's women suffered death at a rather high rate because of helping their children.

BEHAVIOR DURING AND AFTER THE EARTHQUAKE

Fig. 6 shows the result obtained from multiple responses on the behavior during the earthquake. Since there were 283 respondents, this means that they took more than one but less than two actions on the average. What is meant by "shaking" here is perhaps a little ambiguous, but if we add ① and ② of the answers, then we can say that 52 of males (30.2%) and 96 of women (36.6%) were more or less unable to move. As to the positive behaviors, male shows higher degree of activity for almost all of the items, while ⑧ --- attempts to protect children and the aged --- shows women were more active. Thus tells us that women were taking care of the young and the old in the household and they did the same when the earthquake took place quite naturally.

According to Fig. 7, 41.3% of males and 73.9% of females started to take refuge after the shaking had stopped. An interesting fact is that 22.4% of males

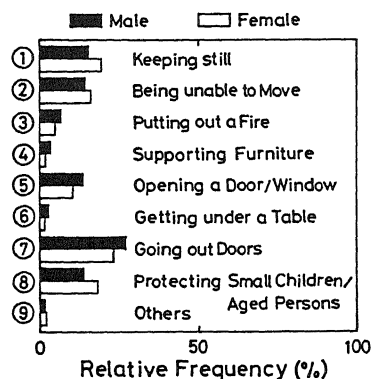


Fig. 6 Human Behavior during Shaking

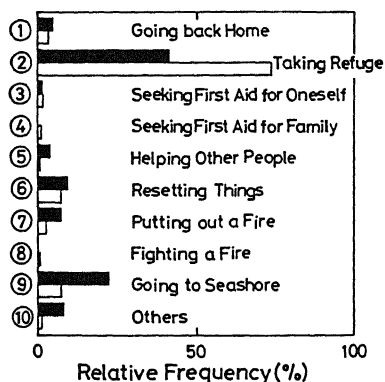
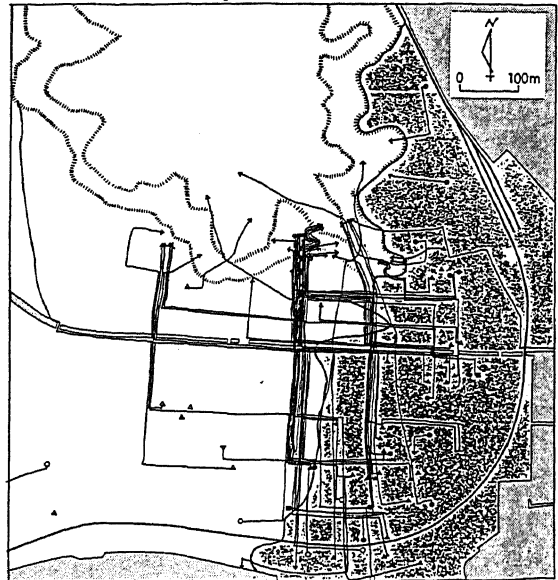


Fig. 7 Human Behavior after Shaking

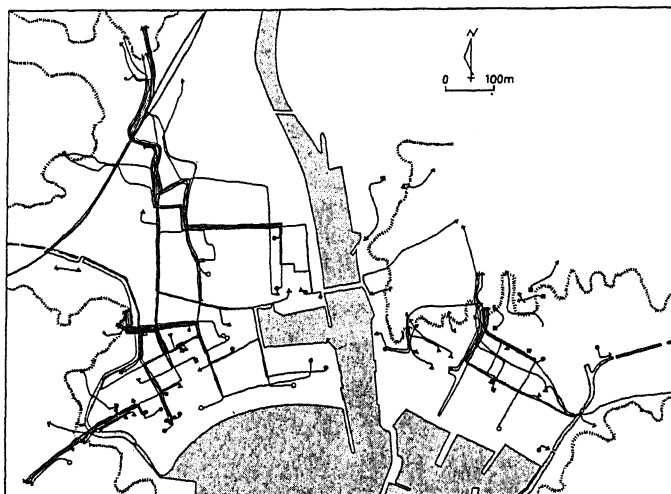
say they went to the shore to take a look at the sea. Our survey could not find out if this behavior had any consequence in terms of the number of victims, but we should know at least that such a behavior, while natural for those whose life is inseparable from the sea, could lead to a grave danger at a major earthquake followed by tsunami. When the earthquake happened, 17 were not at home, including one who was fishing on the sea, of whom 13 returned home immediately after the seism.

Fig. 8-1 shows the courses of evacuation at the hardest-hit area of Susaki, together with the zone submerged by tsunami indicated in the Reference 1. From this figure, it can be seen that almost everybody headed toward the hills located to the north of the town, and more specifically to the shrine or the temple. The town faces the open sea to the south while the north side is hilly. In consequence, the people were conscious that tsunami must come from the south, and this explains their behavior. Unfortunately, however, the Nankai tsunami swept first the port extending from the east to the north side of the town, and the returning tide then hit the town from the north. In consequence, and particularly around the railway station, a number of people who were trying to move north saw their way of escape cut off by the tide, and perished.

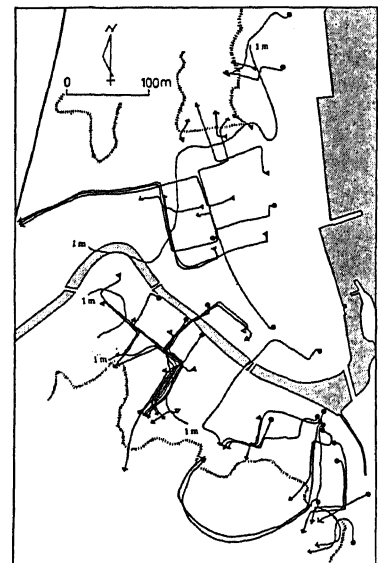
Fig. 8-2 and 8-3 shows courses of escape for Mugi and Asakawa, respectively. In Fig. 8-2, we also showed, using the data contained in the Reference 4, the areas where water reached 1m above the ground level. Both figures show that the people of Mugi and Asakawa also tended to seek refuge at surrounding hills, and that their courses of movement were heading either the shrine or the temple, just as the case of Susaki. Historically, all of



1. Susaki



2. Mugi



3. Asakawa

Fig. 8 The Courses of Evacuation

these three communities we surveyed had met several tsunamis caused by major earthquakes and for this reason, the temples and shrines located of higher places had long been known to be the safe places. Many people in fact had these places in mind as the site to take refuge in case of tsunami. Moreover, as Fig. 9 shows, people started to do so fairly promptly after the earthquake. According to the data, more than 70% started to leave their house within 15 minutes following the earthquake, while according to Fig. 10, 65% of people said the tidal wave did not arrived yet when they started to escape. We see also that some places were so congested by refugees as to cause confusions(Ref. 1).

Immediately after the EQ.
 Within 15 Minutes
 Within 30 Minutes
 Within 1 Hour
 Not Taking Refuge

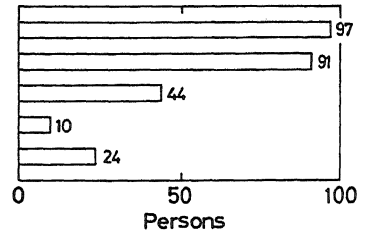


Fig. 9 Time When Respondents Started to Escape

Tidal Wave did not Arrive
 Water Level up to the Ankles
 Water Level up to the Knees
 Water Level up to the Waist
 Water Level up to the Breast
 Beyond One's Height

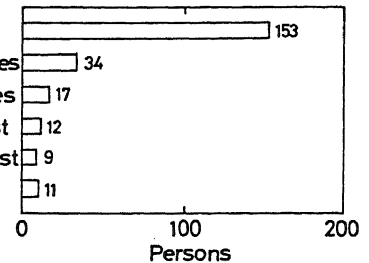


Fig. 10 State of Flood at the Time of Taking Refuge

On the other hand, however, the Reference 1 states that in Susaki, the first of the tidal waves hit the town 10~15 minutes after the earthquake and that the tides returned 6-7 times with the frequency of 20 minutes or so. This description leads us to assume that quite a few people were endangered while they were on their way to the places of escape.

CONCLUSION

From the survey, we now know that small children, the old and women were the main victims of Nankai Earthquake. It should be remembered that this trend is not the characteristic of those earthquakes accompanied by tidal waves, but it is common to all other major earthquakes such as Mikawa Earthquake(which is remarkable in that the mortality ratio was extremely high in terms of the number of buildings collapsed) and Fukui Earthquake(which registered VII J.M.A. intensity). It can therefore be presumed that under these almost boundary conditions, slight difference in the survival capacity due to physical force and other factors become decisively important.

In closing, we would like to express our sincere thanks to Dr. Shunkichi Kosaka and Dr. Keishi Shiono of Tokyo Metropolitan University for their valuable advice. Our deep thanks are also due to the public bodies of the local communities, members of the senior citizens' association were indispensable for our survey.

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