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STUDY OF CASUALTIES DUE TO THE HYOGO-KEN NANBU EARTHQUAKE BASED ON A SURVEY OF WOODEN DETACHED HOUSES

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SUMMARY

A survey of households with persons seriously injured during the Hyogo-ken Nanbu Earthquake was performed in this study. People who sustained serious injuries during the earthquake and are still living in the same area (Higashinada-ku in Kobe City, Nishinomiya City and Ashiya City) acted as subjects. The investigation consisted of a questionnaire and interview survey of the serious injured person and his /her family. Answers from 56 families and 197 inhabitants were obtained. Among these, our data confirmed 9 deaths, 31 serious injuries, 13 moderate injuries and 15 slight injuries, while 120 people were not injured.

INTRODUCTION

In our previous studies, we built a database of structural damage and human casualties caused by the Great Hanshin-Awaji Earthquake in an attempt to gather data for developing techniques to assess human casualties using dummies. We have also investigated the relationship between human casualties and structural damage and the factors related to earthquake-related deaths and severe injuries. The results have shown that the main cause of the death was suffocation due to chest compression, while that of the severe injuries was bone fracture of the abdomen/lumbar region or the legs. Hence, it was confirmed that the site and cause of injury differed between the deaths and severe injuries.

The objective of the present study was to clarify the differences in onset factors between the deaths and severe injuries caused by earthquakes in terms of the physical state of the victims and their actions at the time of the earthquake. A questionnaire-interview survey was conducted, and we gathered data for people who received moderate, mild or no injuries.

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STUDY METHODS

Subjects were people who were living in the southern part of Hyogo (Higashinada-ku in Kobe City, Nishinomiya City or Ashiya City) at the time of the earthquake and who continue to live in the same area. Potential subjects were extracted from the database combining the results of the building damage survey conducted by the Building Research Institute of the Ministry of Construction[1], and the data for people with severe injuries compiled by the Early Emergency Care Survey Group [2].
As shown in Table 1, based on the above-mentioned database, 270 people from Higashinada-ku, 331 from Nishinomiya City, and 131 from Ashiya City suffered severe injuries due to the earthquake. Of these, those living in wooden buildings were extracted: 132 people from Higashinada-ku, 204 people from Nishinomiya City and 96 people from Ashiya City. In addition, the current addresses of these people were confirmed using the Zenrin Residential Map 2000[3] and showed that 65 people lived in Higashinada-ku, 93 people in Nishinomiya City and 43 people in Ashiya City. Telephone numbers were known for 46 people from Higashinada-ku, 66 people from Nishinomiya City and 30 people from Ashiya City.

Table 1 Number of Subjects

District	Severe injury	Wooden building	Known address	Known phone No.
Higashinada	270	132	65	46
Nishinomiya	331	204	93	66
Ashiya	131	96	43	30
Total	732	432	201	142

To people who consented to participate in the present study over the telephone, questionnaire sheets were mailed, and study collaborators physically visited each household to collect the sheets and to conduct interviews. In the present study, not only the people who were severely injured by the earthquake, but also other members of their families were enrolled. In other words, the survey consisted of two parts, one for the entire household and the other for individual family members. During the initial telephone conversation, the number of family members was noted, and a questionnaire sheet was sent to each family member.

The questionnaire survey consisted of two parts:
1) Household questions
Building structure, year of construction, rough floor plan, degree of structural damage (Damage grade; DG), pattern of structural damage[4], earthquake preparedness, etc.
2) Individual questions
Age, gender, body position at the time of earthquake, sleeping arrangement, actions taken immediately after the earthquake, furniture arrangement, injury site, injury severity, injury-causing object, and rescue methods.

RESULTS AND DISCUSSION

Response summary

A response was obtained from a total of 57 households, but one family did not live in a wooden building at the time of the earthquake, and thus the data obtained from 56 households were analyzed. Of these, 19 households were from Higashinada-ku, 25 from Nishinomiya City and 12 from Ashiya City. Of the 56 households, a total of 197 people, including the people with severe injuries, were enrolled. Table 2 shows the degree of injury for the 197 people. The time of construction was "before 1949" for 25 households, "from 1950 to 1981" for 20 households, "after 1982" for 9 households, and "unknown" for 2 households. Hence, most buildings were relatively old. There were 4 one-story buildings, 47 two-story buildings and 5

three-story buildings. While 51 buildings were residential homes, 5 were commercial/residential complexes. The severity of structural damage was as follows: "destroyed" for 7 households, "total collapse" for 36 households, "partial collapse" for 8 households, "partial damage" for 4 households, and "no damage" for one household. Therefore, the severity of structural damage was very high.

Table 2 Severity of human injury

District	Death	Severe	Moderate	Slight	Unknown	No Injury	Total
Higashinada	3	11	5	5	1	36	61
Nishinomiya	4	11	5	8	6	60	94
Ashiya	2	9	3	2	2	24	42
Total	9	31	13	15	9	120	197

Relationship of severity of human injury to various factors

Of the 197 people, although 58% of the people who were on the first floor of buildings at the time of the earthquake were injured to some degree, 77% of the people on the second floor of buildings were not injured at all. The incidence of severe injury, including death, for those on the first floor was three to four times higher, thus agreeing with the results of previous studies [5].

Table 3 shows the relationship of the severity of injury, including death, to the site of injury and physical state at the time of the earthquake. While there was hardly any difference in the presence or absence of injury with respect to the physical state at the time of the earthquake, every person who died was sleeping (or more accurately, they were in bed). Furthermore, with regard to the relationship between the severity and site of injury, people who died received injuries to the chest and legs, and among people with severe injuries, the common sites of injury were the lumbar region and legs. Hence, these findings mostly agreed with the results of past studies, thus suggesting that the subjects in the present study were fairly representative of the entire population of people with lethal and severe injuries in the southern part of Hyogo. Furthermore, the results of the present study showed that, among people who suffered injuries that were moderate or less, the common sites of injury were the thoracic and lumbar regions. Furthermore, among people with moderate injuries, the incidence of leg injury was high, while among people with mild injuries, the incidence of head injury was high.

Table 3 Detail of casualty

	Body position at time of earthquake			Injury site									Total
	Sleep-ing	Sitt-ing	Stand-ing	Head	Neck	Chest	Lumb er	Back	Arm	Leg	Syste mic	U.K	
Death	9	-	-	-	-	4	-	-	-	2	1	2	9
Severe	29	2	-	1	1	6	11	3	1	8	-	-	31
Mod.	10	1	2	1	-	4	3	-	-	5	-	-	13
Sligh.	15	-	-	6	-	3	3	1	-	1	-	1	15
U.K	7	1	1	-	-	3	2	-	1	3	-	-	9
No	110	5	5	-	-	-	-	-	-	-	-	120	120
Total	180	9	8	8	1	20	19	4	2	19	1	123	197

U.K.:Unknown

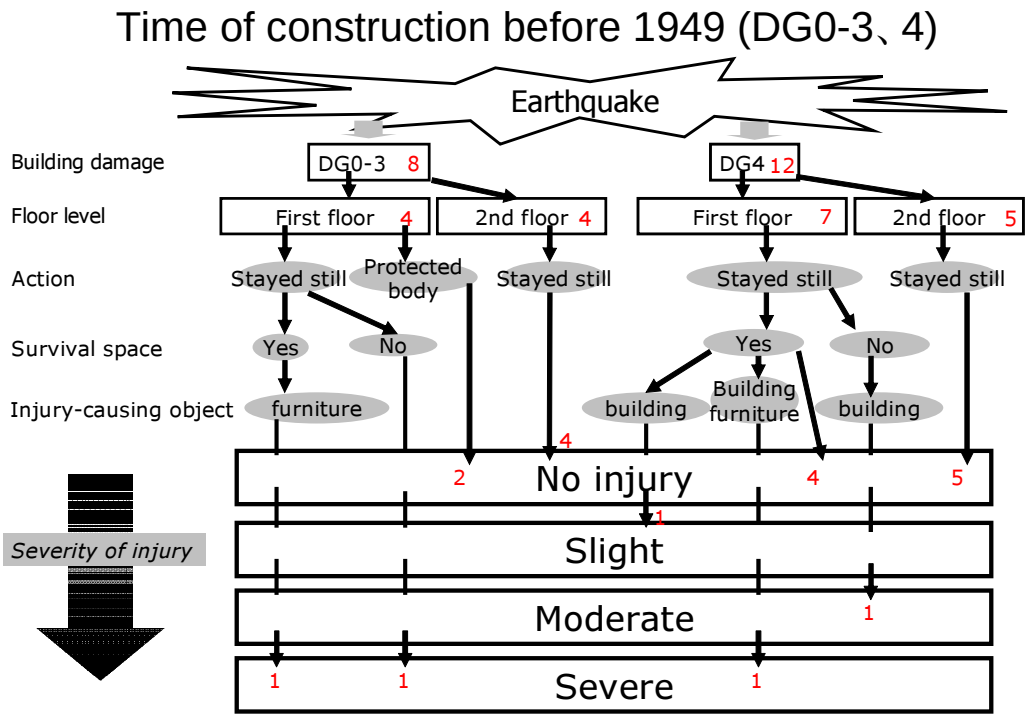

Figure 1(1) Flow Chart of Casualty (1)

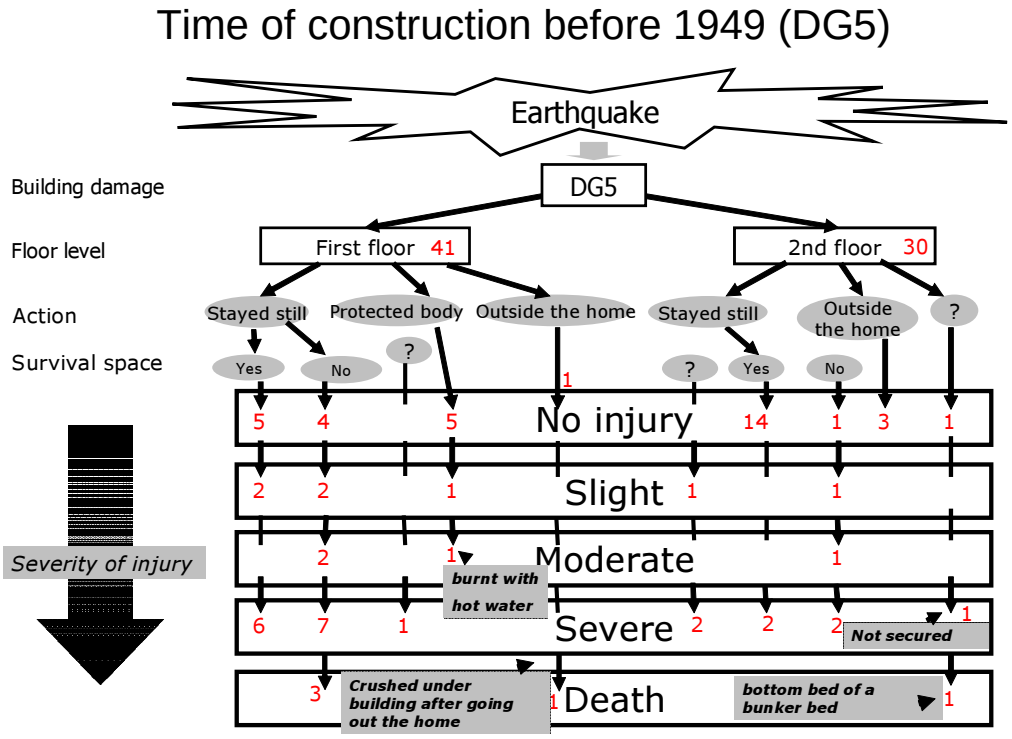

Figure 1(2) Flow Chart of Casualty (2)

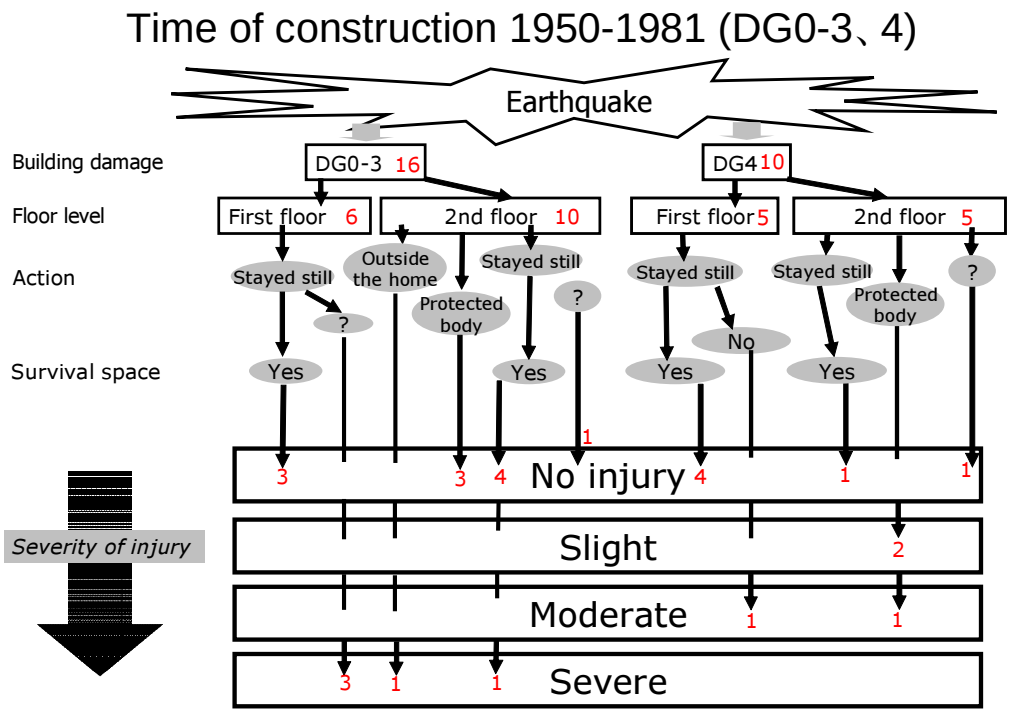

Figure 1(3) Flow Chart of Casualty (3)

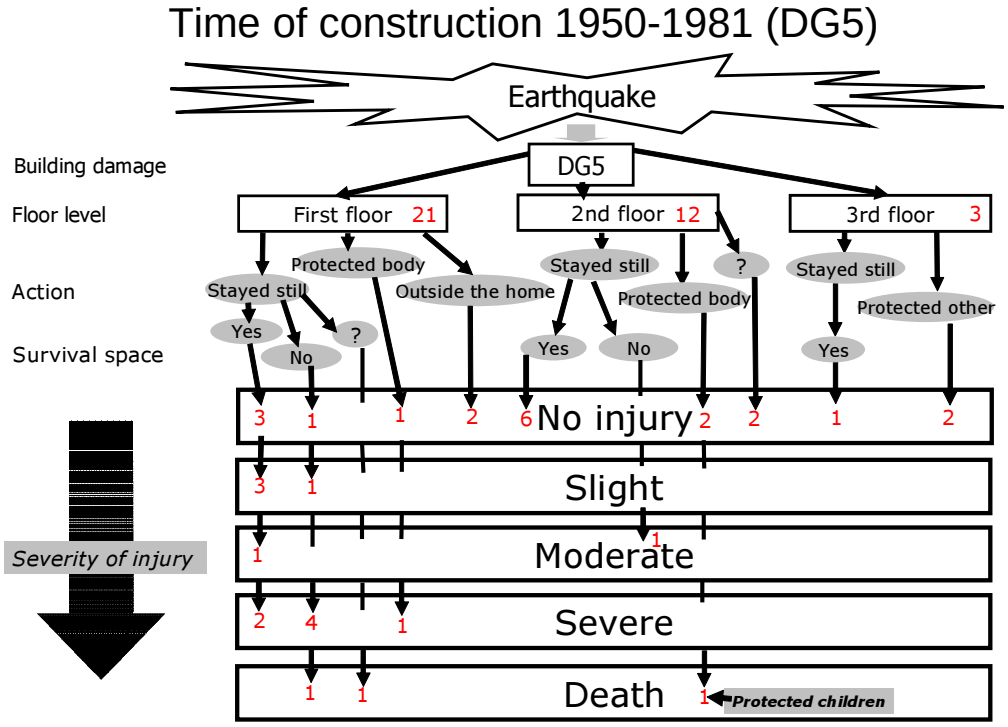

Figure 1(4) Flow Chart of Casualty (4)

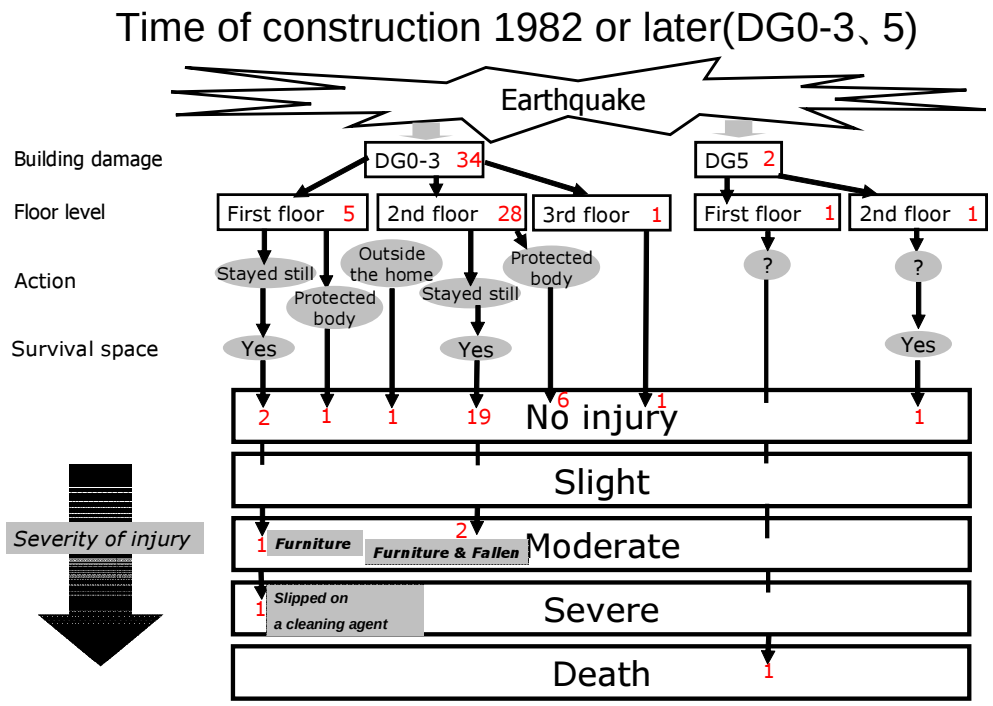

Figure 1(5) Flow Chart of Casualty (5)

Relationship of human casualties to structural damage and victim attributes

As shown in Figures 1(1) and 1(2), a total of 91 people were injured in buildings that were built before 1949, and among these, the breakdown of the severity of structural damage was as follows: DG0-3 (partial collapse or less) for 8 people, DG4 (total collapse) for 12 people, and DG5 (destroyed) for 71 people. As previously reported [4], DG stands for damage grade, and the severity of structural damage was assessed in six grades, from 0 to 5. Among the 91 patients, severity and presence of injury could be summarized as follows:

Firstly, 71 people were in DG5 buildings, and 5 of these died. None of the people in buildings that sustained less damage (DG4 or less) died. Of the 71 people, 41 were on the first floor, and 4 died, which is a mortality rate of 9.8%. In addition, 30 people were on the second floor, and only 1 died (mortality rate of 3.3%). In other words, the mortality rate was about three times higher for people on the first floor of buildings.

Furthermore, the incidence of injury, including death, was compared between the first and second floors with respect to the severity of structural damage. The incidence of injury, including death, was 50% (2/4 people) for the first floor of the DG0-3 buildings, 0% for the second floor of the DG0-3 buildings, 42.9% for the first floor of the DG4 buildings, and 36.7% for the second floor of the DG4 buildings. Except for DG5 buildings, no one died on the second floor, and the incidence of injury for the first floor of DG5 buildings was about twice that for the second floor of the DG5 buildings. As a whole, the incidence of injury, including death, for the first and second floors of buildings built before 1949 was 59.6% and 28.2%, respectively.

As shown in Figures 1(3) and 1(4), for the 62 people who were injured in buildings that were built between 1950 and 1981, the breakdown of the severity of structural damage was as follows: DG0-3 (partial collapse or less) for 16 people, DG4 (total collapse) for 10 people, and DG5 (destroyed) for 36

people. Three people died, and they all lived in DG5 buildings. The mortality rate for people on the first and second floor of the DG5 buildings was 9.5% and 6.7% respectively. Furthermore, the incidence of injury, including death, was 50.0% for the first floor and 20.0% for the second floor of the DG0-3 buildings; 20.0% and 60.0%, respectively, for the DG4 buildings; and 56.3% and 23.3%, respectively for the DG5 buildings.

Figure 1(5) summarizes the data for 36 people who were injured in relatively new buildings that were built after 1981. For 34 people, the severity of structural damage was DG0-3, and for 2 people, it was DG5. One person who lived in a DG5 building died. The mortality rate for the first-floor and the second-floor of DG5 buildings was 100% and 0%, respectively. The incidence of injury, including death, was 40.0 and 6.9% for the first floor and second/third floor of the DG0-3 buildings, respectively, and 100% and 0% for the first floor and second/third floor of the DG5 buildings. Among the buildings built in this period, the incidence of injury, including death, was 50.0 and 6.7% for the first and second floors, respectively.

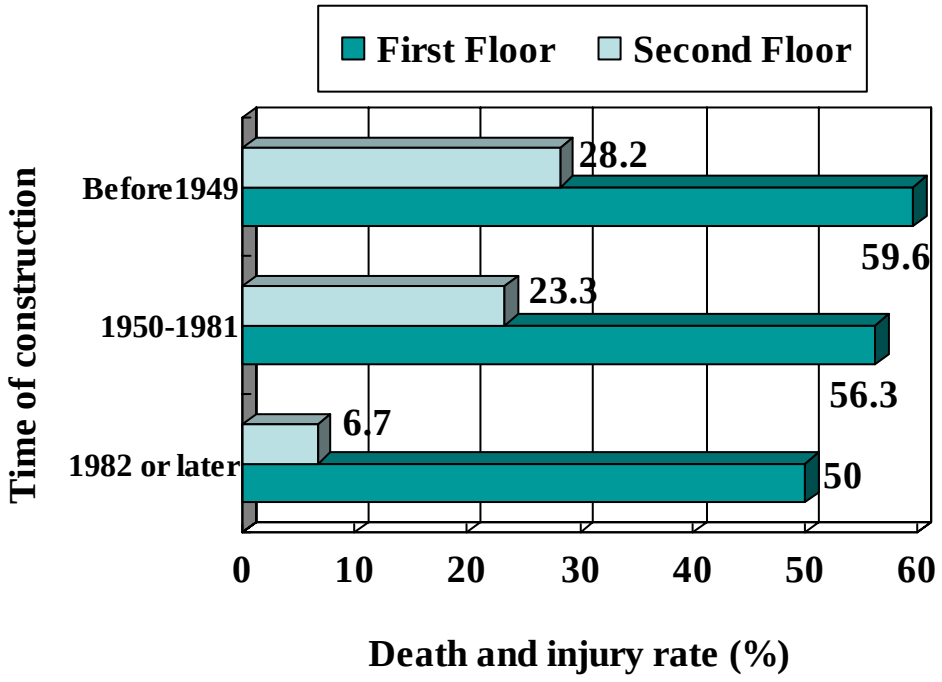

Figure 2 Comparison of risk for death and injury between the first and second floors of wooden buildings

The above findings clarified the following points. Firstly, regardless of building age, people died when their homes were destroyed (DG5) and living space was eliminated, but no one died when the severity of structural damage was DG4 or less. In addition, the mortality rate for the first and second floors of DG5 buildings was 11.1% and 4.3%, respectively, and thus the mortality rate for the first floor of the DG5 buildings was about three times higher than that for the second floor. The incidence of injury, including death, for the first and second floors of the DG5 buildings was 65.1 and 28.3%, respectively, and that of the DG4 buildings was 40.7% and 13.2%, respectively.

Figure 2 compares the incidence of injury, including death, between the first and second floors of buildings that were built in different periods. The results show that the incidence of injury, including death, tended to be lower for newly constructed homes.

CONCLUSIONS

A study was conducted on households with family members who suffered severe injuries in areas that heavily damaged by the Great Hanshin-Awaji Earthquake, and the results of analyses on deaths, injuries and victim attributes clarified the following:

1) People died when the severity of structural damage was marked (DG5), destroying first-story or second-story homes. The relationship between severity and site of injury agreed with the results of past studies [6].

2) The mortality rate for people on the first floor of the DG5 buildings was 11.2%, which was about three times higher than that for people on the second floor. Furthermore, the incidence of moderate or less injury for the first floor was 65.1%, which was about twice that for the second floor at 28.3%.

3) When including buildings that sustained damage of DG3 or less, the incidence of injury, including death, for the first floor was 57.8% and that for the second floor was 20.2%. These numbers were lower with newer buildings (Figure 2).

4) Every person who died was sleeping (or in bed). With regard to the relationship between mortality rate and actions taken during the earthquake, the incidence of injury, including death, for people who stayed still (could not move or remained motionless) was 43.6%, while that for people who took active measures was 23.7%.

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