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Survey on the Possibility of Post -Earthquake Quick Inspection of Damaged Building by Ordinary People using the European Macro-Seismic Scale 1998 (EMS-98)

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***Abstract*—**In recent years, the number of natural disasters in the world has occurred frequently. After a strong earthquake occurs, multiple disasters due to tsunami, strong aftershocks or heavy snow can possible to occur. To prevent a secondary disaster and to save a life, the quick inspection of the damaged building is necessary. This paper investigated on a possibility of post earthquake quick inspection of damaged building by ordinary people which used the European Macro- Seismic Scale 1998 (EMS-98).

***Keywords*—**Quick Assessment, EMS-98, Ordinary People, Post-Earthquake

I. Introduction

RECENTLY, various natural disasters have frequently occurred around Asia because of a change in environment, an economical rapid growth, etc. After a strong earthquake occurs, multiple disasters due to strong aftershocks, heavy rain, landslide or heavy snow can possible to occur [1].

The damaged building can cause further injuries and death to residents. To prevent a secondary disaster, to save a life, to restore a mental balance, and to protect properties from aftershocks, a quick inspection of the damaged building is needed. However, for evaluating structural safety a lot of specialists are needed, it takes time and a lot of money. But, foreign aid and rescue team only pay attention to the famous earthquake and specialists are insufficient in developing country [2], [3].

On the afternoon of May 12, 2008, an earthquake measuring 7.9 on the Richter scale hit Sichuan Province, a mountainous region in Western China. The earthquake killed more than 69,107 and 373,577 were injured, with another 18,230 people are still missing. Over 15 million people live in the affected area, including almost 4 million in the city of Chengdu, homes, schools and apartments in Sichuan Province were poorly designed, with a severe shortage of the steel reinforcement.

As of May 21th, 162 aftershocks had been monitored in Bureau.

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Among them, 26 aftershocks measured higher than 5.0 on the Richter scale, more than 490,000 buildings were collapsed and a lot of buildings were cracked and needed to reinforce immediately. But foreign rescue teams were not allowed into Sichuan until May 16. However, the specialists from Tongchi University had done the rapid evaluation safety in the damaged area.

In addition, according to our survey in Dujiangyang City, Chengdu province for 7 days, there were strong evidences that after the terrible event calm down, residents returned to their house for taking properties, they went back inside and living in the damaged building which had been unchecked the safety. Those actions can bring a tragedy to people's life as another disaster [4].

The rapid safety evaluation and the quick reinforcement of buildings help prevent loss of life and property from the secondary disaster. For classifying the visual damage of buildings the European Macro-seismic Scale 1998 (EMS-98) were used [5], [6], [7], [8], [9], [10].

Based on the different circumstances and politics that exists in developing countries, this paper provides a new idea on a quick assessment of damaged building for ordinary people by using European Macro-seismic Scale 1998 (EMS-98), we have done a survey to measure the possibility on quick assessment of damaged building by ordinary people.

II. Contents and Method of Survey

For evaluating the level of damage from earthquake on building by ordinary people, the European Macro-seismic Scale 1998 (EMS-98) and 52 photographs of damage building which taken from Sumatra earthquake and several Japan earthquakes were used, and 44 people from 9 countries were checked the damage of building from the photographs. The participants were checked damage on building and determined the damage level by comparing the damage which seen from the photographs and illustration from the EMS-98.

A. European Macro-seismic Scale 1998 (EMS-98)

The European Macro-seismic Scale 1998 is a basic scale for assigning seismic intensity in European countries. Most recently updated in 1998, the scale is referred to as EMS-98.

The EMS-98 is the first intensity scale designed to encourage co-operation between engineers and seismologists, rather than

being for use by seismologists alone, it comes with a detailed manual, which includes guidelines, illustrations, and application examples. The term macro-seismic intensity is used entirely in the meaning of a classification of the severity of ground shaking on the basis of observed effects in a limited area.

B. Type of Photographs

52 photographs of damage building from the Sumatra earthquake and the Japan earthquake were used in this survey. In that, 27 photographs are masonry and 25 photographs are reinforced concrete buildings, respectively. Because a limit of number of photos that used in this survey, some of unclear damage level photos were used.

In addition, for improving the method, some photos of the same building which were taken in different distance and direction are used. Table II shows the number and damage level of photographs. The Photographs which used in this survey are shown in Fig. 1 to2 respectively.

TABLE I
NUMBER OF PHOTOGRAPH AND DAMAGE LEVEL

Damage Level	Structure Type	
	Masonry	RC
Level 1	7	1
Level 2	5	7
Level 3	3	5(4*)
Level 4	6	4
Level 5	6	8
Total	27	25

(*) same building photos which were taken different approach

III. Survey and Questionaire Contents

A questionnaire survey was conducted for 3 days from 12th April to 14th April 2007. 44 people with 9 nationalities were surveyed. In that, 19 are male, 25 are female, 35 are foreign students and 9 are Japanese. They were divided into 2 groups, group 1 was the group that has no knowledge about structure which has 34 people and the other group have, which have 10 people in the group.

They were 2 parts in the questionnaire form, first part was the questionnaire about general information and second part was a table for writing an answer after check the safety on buildings from the damage photos. The questionnaire contents are shown in Table II.

TABLE II
QUESTIONNAIRE CONTENT

Item	Questionnaire
1	What is your country name and sex?
2	What is your major?
3	Are you undergraduate student? Researcher? Master? Doctoral? Civilian? Other?
4	Please select your age group
5	Does earthquake occur often in your country or not?
6	How often do you have experience earthquakes?
7	Please select earthquake level have you ever experienced
8	How much do you pay for buying house in percentage?
9	How much do you pay for reinforcing your house in percentage?
10	Does the check easy or difficult?
11	What do you think about the structural safety which check by seeing the damage building photographs and checking the safety by your self
12	If an earthquake occurs in the future can you check the safety of your house by using the checking?
13	How's confidence on the structural safety checking in this time?
14	If you have any comments, suggestions about this survey, please don't hesitate.

IV. Survey And Analysis Result

A. General Information Survey Result

In the first part of survey, the questionnaire content is ask about the participant's personal information such as gender, age, major, earthquake experiences, etc. The survey results are as follows.

By Country, China represents the maximum number of 22 people, followed by Japan (9), Koreans (4), Indonesia (3), Laos (1), Papuanewguinea (1), Malaysia (1), Thai (1), Taiwan (1) and Vietnam (1).

By Major, 23% of participants are belong to Architecture and engineering, followed by Medicine (11%), Economic (11%), Science (9%), Literature and Education (7%), Law (5%), Gardening, and Other (2%).

By school year, Doctoral Students were the biggest group with 30%, followed by Master (29%), Undergraduate (25%), Public (11%) and other (5%).

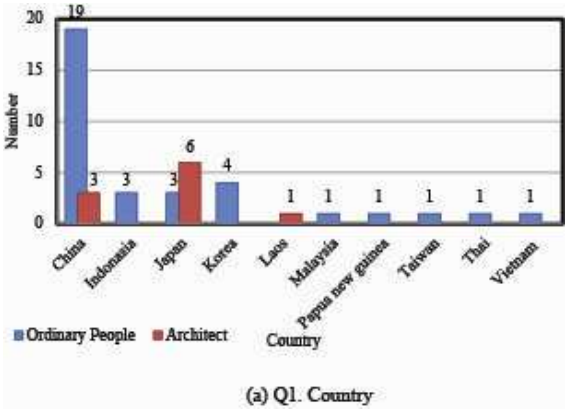
By age, 31% of participants were in the age range of 20-24 and 25-29 years old, followed by 30-34 (30%), 55-59 (5%), 50-54 (2%), and 40-44 (2%).

To the question No.5: "Does earthquake occur often in your country or not "66% replied "No" and 34% replied "Yes".

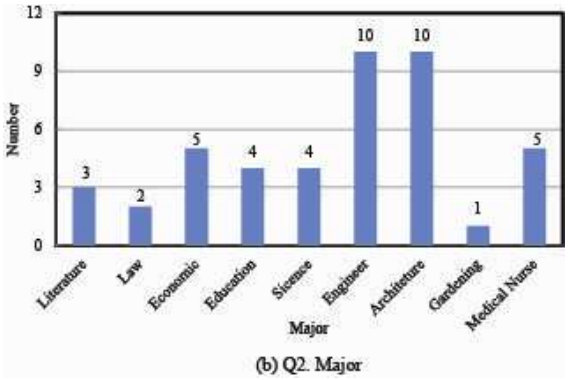
To the question No.6: "How often do you have experience on earthquakes?" 63% answered "sometimes", 18% "Rarely", 14% "Frequency", and 5% "Never".

To the question No.7: "Please select earthquake level have you ever experienced", 61% selected "few scary level", 34%" feel shaking extent level", and 5% " feel building shaking level".

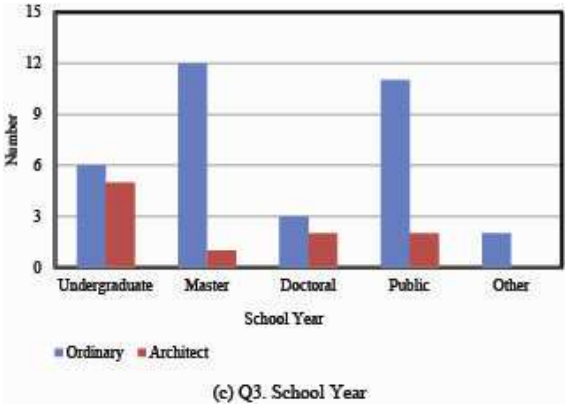
To the question No.9: "How much do you pay for reinforcing house by percentage?"40% answered 10% and 21% answered 5% respectively. Fig.3 (a) to (f) shows general information survey result.



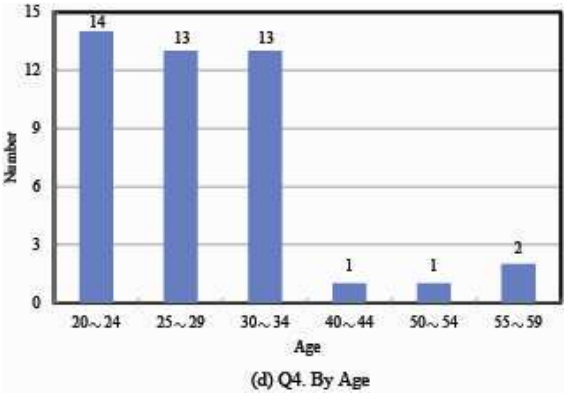
(a) Q1. Country



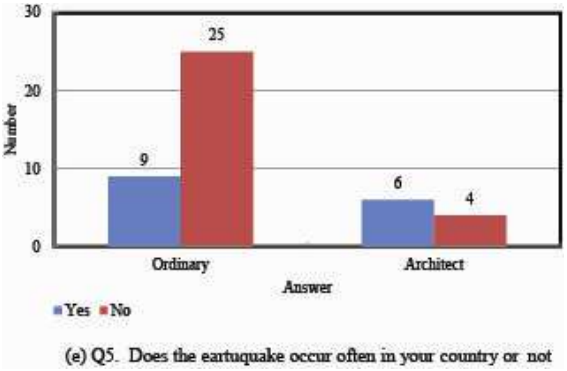
(b) Q2. Major



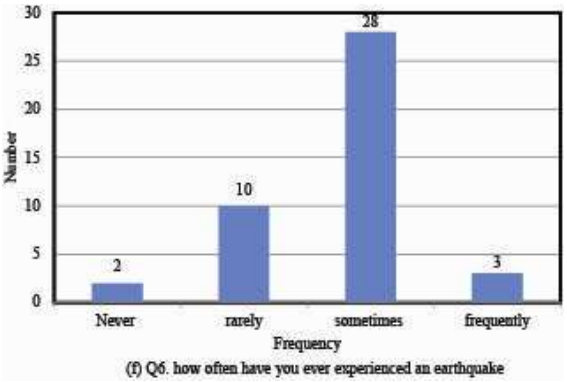
(c) Q3. School Year



(d) Q4. By Age



(e) Q5. Does the eartuquake occur often in your country or not



(f) Q6. how often have you ever experienced an earthquake

Fig. 3 General information result (a)-(f)

B. Structural Assessment Result

To compare and check the answer from participants the authors asked Prof. Toru Takahashi and Assoc. Prof Koichi Ohami from structural laboratory, Chiba University to classify damage level of buildings, the answer assumed to correct answer. The authors compared the correct answer with 2 groups in three ways. The structural assessment results are as follows:

1. Mode Value

The authors compared the mode value of group 1 and group 2, the results are as follows.

First, the result of ordinary people group (group1) was different 12 in 27 photographs, in that 8 were similar, 15 photos

were same answer with the correct answer, and 3 photos were not match at all for masonry structure. However, 11 were different in 25 photos for reinforced concrete structure, in that 8 photos were similar answer, 14 photos were same answer with the correct answer, and only 2 photos which not match at all. The ratio of same answer was 55.6% and 56.0%, respectively.

Second, the result of architecture group (group2) was different 9 photographs, in that 7 photos were similar answer, 18 were same answer with the correct answer, and 3 photos weren't match at all for masonry structure. For RC structure, 10 photos were different, in that 7 photos were similar answer, 15 photos were same answer with the correct answer, and 3 photos weren't match at all. The ratio of same answer was 66.7% and 60%, respectively. The mode value result shows in Table III.

TABLE III
MODE VALUE OF CORRECT ANSWER

Answer	Masonry		RC	
	Group1	Group2	Group1	Group2
Same Answer	15	18	14	15
Similar Answer	9	7	8	7
Not Match at All	3	2	3	3
Total	27	27	25	25

Unit: Photograph

2. Accuracy Rate

The authors compared accuracy rate survey results of 2 groups. The results are as follows.

First, the accuracy rate of group 1 is lower than group 2 for both structures, the difference of two groups was 8% for masonry and 5.8% for RC structure. The value is shown in Table IV.

TABLE IV
ACCURACY RATE BY STRUCTURE TYPE

Structure	Group1	Group 2
Masonry	37.7%	45.7 %
RC	37.8 %	43.6 %

Second, the difference of the answer by countries isn't big, except the answer from Taipei and Lao student, 60% for RC structure, 33.3% and 59.3 for masonry structure respectively. The accuracy rate value is indicated within 30% to 60%. The result by country of ordinary people group and architect group is shown in Table V and Table VI respectively.

TABLE V
ACCURACY RATE BY COUNTRY OF ORDINARY PEOPLE

Country	Structure Type	
	Masonry	Reinforced Concrete
China	34.5	38.5
Japan	35.8	41.3
Papuguinia	51.8	28.0
Korea	47.2	37.0
Indonesia	42.0	44.0
Taipei	33.3	60.0
Thai	44.4	32.0
Malaysia	44.4	44.0
Vietnam	29.7	32.0

TABLE VI
ACCURACY RATE BY COUNTRY OF ARCHITECT PEOPLE

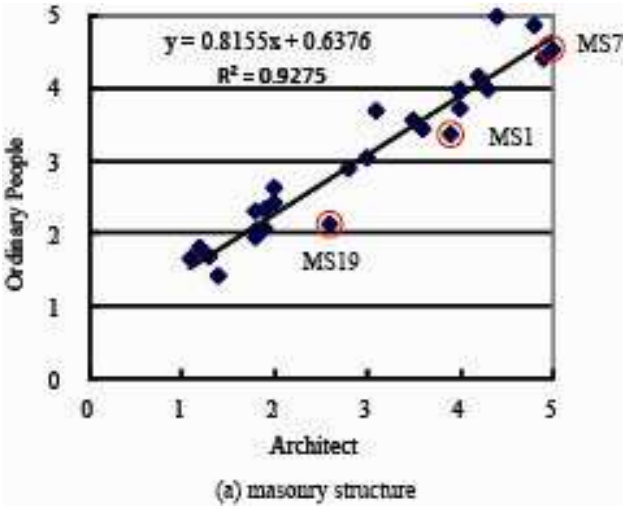
Country	Structure Type	
	Masonry	Reinforced Concrete
China	45.7	41.3
Japan	43.0	49.3
Lao	59.3	60.0

3. Average and Standard Deviation of Damage Level

The average and standard deviation of damaged level are as follows.

As for the average of masonry structure, the ordinary people group's result was slightly higher than the architect group and show opposite result for reinforced concrete structure. The masonry structure of the difference between 2 groups is a little higher than RC structure, but the difference was very small. On the other hand, the correlation coefficient of 2 groups shows a strong correlation.

As for the standard deviation, the value shows from 0.5 to 1, the variation of masonry structure is higher than RC structure and isn't much difference between 2 groups. Meanwhile, there is no correlation in their standard deviation between 2 groups. The change is also small and the reliability is obtained to the same degree. The Average and standard deviation of accuracy rate results are shows in Fig.4 (a) to (b) and Fig.5 (a) to (b) respectively.



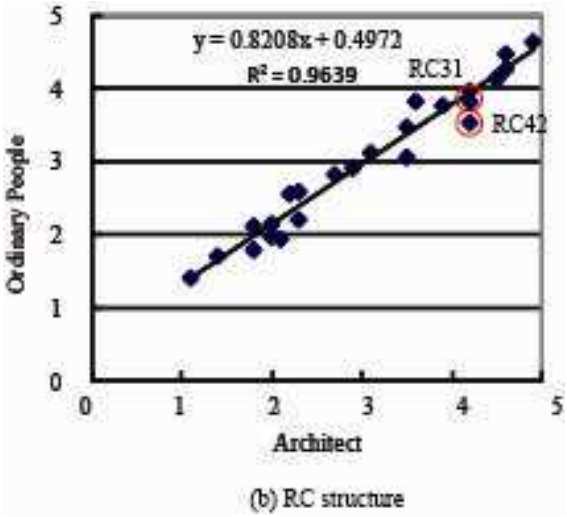
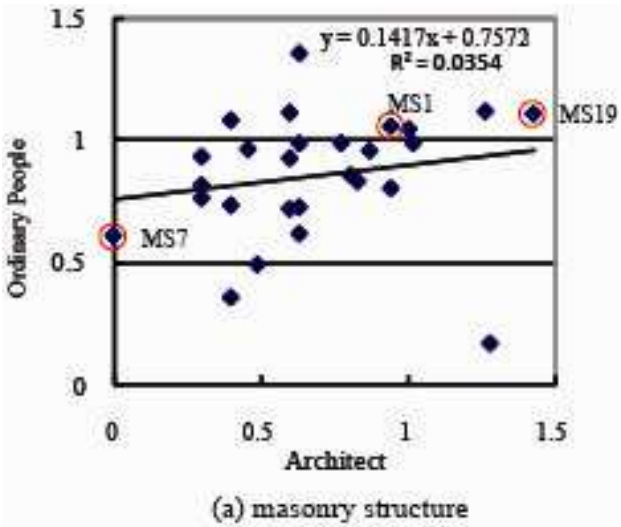


Fig. 4 Average of accuracy rate (a)-(b)



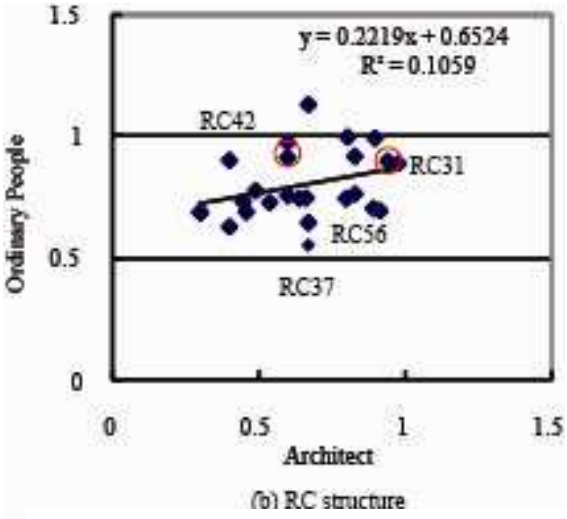


Fig. 5 Standard deviation of accuracy rate (a)-(b)

V. Conclusion

(1) The possibility of the quick assessment of damaged building for ordinary people has been investigated. It was found that:
(2) The ratio of mode value of the same answer result of Architecture group is a bigger than Ordinary people group. The difference of 2 groups about 11.1% for masonry structure and 4% for RC structure, respectively.
(3) The average accuracy rate of masonry structure shows 38% for ordinary people group and 46% for architecture, group respectively. In addition, the average accuracy rate of reinforced structure shows 38% for group1 and 44% for group2, respectively.
(4) The difference of average accuracy rate between ordinary people group and architecture group was not large. It was 8% for masonry, and 6% for reinforced concrete structure.
(5) The difference of average accuracy rate by countries wasn't that big. The value indicated within 30% to 60%, except the answer from Taipei and Lao student, 60% for RC structure and 60% for both structures.
(6) The difference between male and female isn't large about 3%.It is clearly that using the clear photographs will lead them to a correct decision.

VI. Difference Factors

Difference factors are as follow:

First, the EMS-98 which used in the survey doesn't cover inclined building. Therefore, they could not select the correct answer, Fig.6 (a) and (c).

Second, it is very difficult for ordinary people who don't have knowledge in a field of structure to determine the damaged level correctly when a top part of structure isn't collapse but the first floor collapsed, Fig.6 (b).

Third, the building partially destroyed but the remaining part was perfect state, therefore they could not determine the level correctly Fig.6 (d).

Fourth, they could not determine correctly the kind of building which the main part of building collapsed and lose one's structural support, especially ordinary people. (Fig.6)

Firth, they could not determine correctly the buildings which suffer great damage but building frame still remaining.

Sixth, unclear and difficult to see the damage photographs were used, etc.

Seventh, Different structure types of photographs (2 photos) were mixed in the photographs.

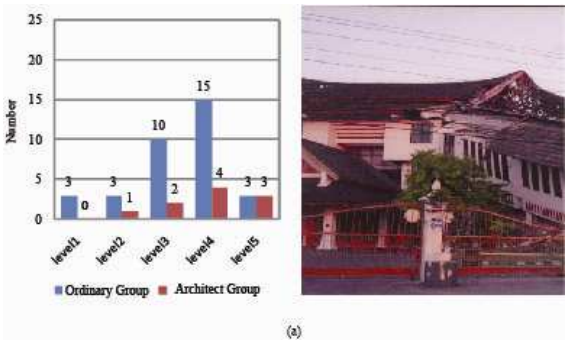
Eighth, the photograph which takes with different angles and distances can give a different decision even it was the same building photo, and it was confirmed in this survey.

In this research, the authors provided a new way of quick assessment of damaged building for ordinary people by using the EMS-98. The accuracy rate of structural check by individual was about 30% to 50%, but the mode value was shown in high value about 78%. The importance and necessity of a quick safety check was reconfirmed in our survey in Dujiangyang City on 2008, but the actual situation in each country is not supported. The most important thing about this study is providing the way for ordinary people to help them check the safety by themselves when needed. However, the checking need to improve and to use this checking the proposal education and training several times per year is needed. To increase the likelihood of the result in the future, few photographs of the same building which take with different angles and distances are needed.

The difference between ordinary people group and architecture group is determining the loss of structural support of damaged building and classifying an inclined building.

If we used mode value or check the structural safety by large number, give training and education, we can expect it in the near future.

This study is a first step for checking possibilities, and the possibility was confirmed and it is highly likely that it's possible for ordinary people to check the safety. Fig.6 (a) to (d) shows an example of damage classification by ordinary people group and architecture group.



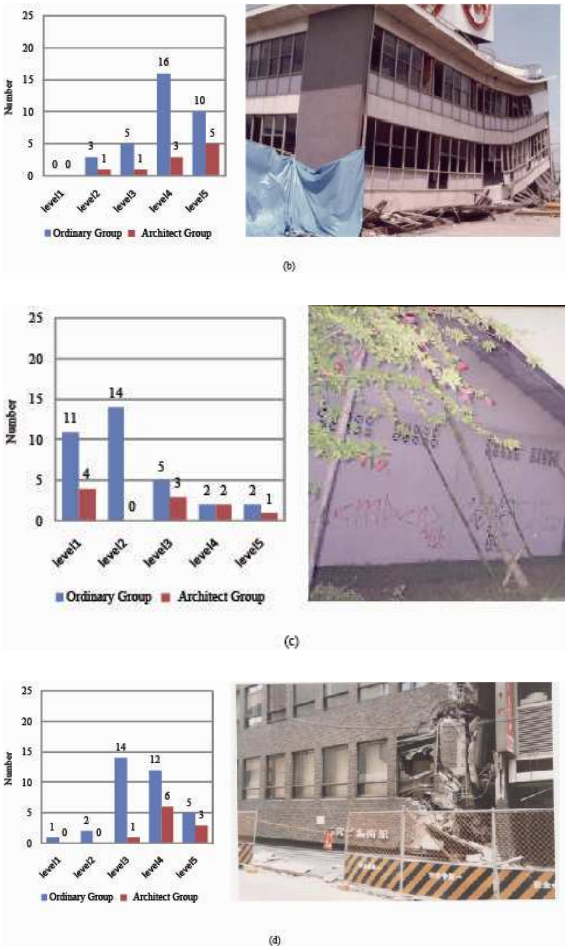


Fig. 6 Example of damage classification

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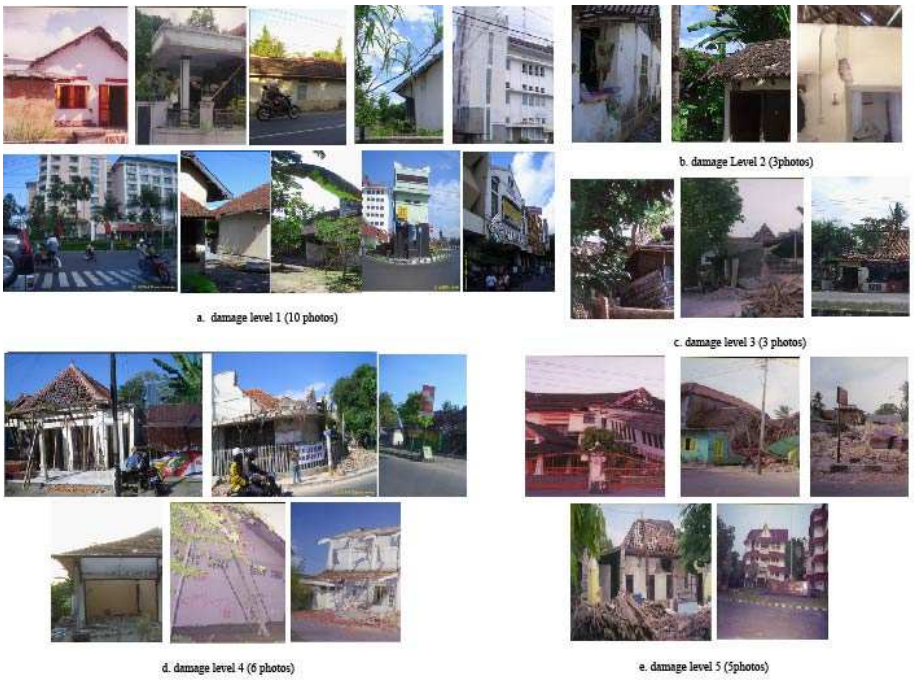

Fig. 1 Damaged photographs of masonry structure

Fig. 2 Damaged photographs of frame structure

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