An analysis of residents' responses to the 2006 Central Java Earthquake

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ABSTRACT: Through analysis of questionnaires and one-on-one interviews, this study assesses the physical and sociobehavioral states of people affected by the earthquake measuring Mw 6.3 that struck the Indonesian island of Java near Yogyakarta on 27 May 2006 at 5:53 AM local time, leaving tremendous damage in the lives of the residents. Data collection for the study was carried out in October and November 2006 as an integrated continuation of a previous session conducted in June. The present survey found (1) that although traditional wooden houses performed seismically better than brick houses, residents continue to prefer using brick masonry to rebuild their homes because of their persistent good image of it, (2) that traditional living practices and community values such as *gotong royong* play quite important roles in the reconstruction process, and (3) that access to information regarding disaster prevention and mitigation had been lacking in the community prior to the earthquake. The overview of results provided in this report will prove useful in developing relief programs and precautionary measures for future disasters.

1 INTRODUCTION

An earthquake measuring Mw 6.3 (USGS and ERI) struck the Indonesian island of Java with an epicenter of about 20 km south of Yogyakarta on Saturday, 27 May 2006, at 5:53 AM local time. Even though the shaking lasted for only 57 seconds with a major aftershock occurring at 10:15 AM, it killed over 5,000 people, injured thousands, and displaced up to 200,000 from their homes.

The earthquake left tremendous damage in the lives of the residents both physically and psychologically. Thus the aim of our survey was to interview survivors on the effects of the earthquake as well as factors that were or were not helping them to go on with their lives under hard conditions.

Interviews focused on three main aspects: (1) physical (effect of house structure type on seismic performance, rates of entrapment and injury, and residents' preferences for future dwellings), (2) behavioral and cultural (impact of traditional living practices on the recovery process), and (3) informational (types of information residents most needed as well as when, how, and where they obtained them).

2 SURVEY METHOD

To compare how degree of building damage affected resident condition, the survey was conducted on October and November 2006 in 12 different sub-villages listed in table 1. Respondents were selected based on types of previous homes and current living conditions.

The survey was divided into two phases. For the first phase, six sub-villages were chosen from heavily damaged areas where the majority of houses had been brick masonry with/without reinforcement. Most respondents had lived in buildings that collapsed during or immediately after the earthquake. For the second phase, six other sub-villages were chosen based on type of community and predominant house structure. Most of these respondents still lived in their original homes. For both phases, the survey was conducted using identical methods of visual observation, questionnaires, and interviews carried out with the help of six volunteer students from Gadjah Mada University.

Table 1. Target sub-villages: Seismic intensity, house structure types, and area characteristics

No.	Kabupaten (District)	Kecamatan (Sub-district)	Desa (Village)	Dusun (Sub-village)	MSK* Intensity scale	House Structure				Characteristics **
						Brick-URM	Brick - CM	Wood-brick walls	Wood-wood walls	
1	Bantul	Imogiri	Imogiri	Payaman Utara	6.91	-	-	5	11	A
2	Yogyakarta	Kotagede	Kotagede	Purbayan	6.99	-	1	14	1	B
3	Bantul	Pleret	Wonokromo	Ketonggo	7	7	9	-	-	C
4	Klaten	Wedi	Kaligayam	Mindi	7.31	1	1	3	11	A
5	Klaten	Gantiwarno	Karangturi	Bungasan	7.33	-	2	5	9	A
6	Bantul	Imogiri	Wukirsari	Manggung	7.4	10	6	-	-	C
7	Bantul	Bantul	Palbapang	Peni	7.9	10	6	-	-	C
8	Bantul	Pleret	Segoroyoso	Jembangan	8.11	2	4	7	3	D
9	Klaten	Gantiwarno	Mlese	Mlese	8.2	10	6	-	-	C
10	Bantul	Pleret	Bawuran	Tegalrejo 2	8.54	3	6	6		D
11	Bantul	Sewon	Timbulharjo	Bibis	8.8	10	4	1	1	C
12	Bantul	Pleret	Bawuran	Tegalrejo	9.1	8	4	4	-	C

* Estimation of MSK seismic intensity scale by Prof. Murakami of Yamaguchi University (Murakami 2007)

** Area characteristics (type of community/degree of damage)

A: Rural village area with mostly little-damaged wooden houses. The majority of residents are farmers who still live in their previous homes.

B: Historic district of Yogyakarta built mostly of little-damaged 50+-year-old wooden houses with brick infill. Most residents are government employees and merchants.

C: Suburban area mostly comprising houses of brick masonry with/without reinforcement. The majority of residents still live in temporary shelters or tents. Residents include former merchants, employed workers, and construction laborers.

D: Suburban area made up mostly of houses built using brick masonry with/without reinforcement plus some wooden houses still standing and capable of reuse. People whose houses collapsed still reside in temporary shelters.

3 PHYSICAL ASPECTS

3.1 House structure and seismic performance

This section discusses the relationship of house structure type to building strength and earthquake resistance. The four categories of house structures adopted for the purposes of analysis are shown in figure 2.

Figure 3a classifies houses in the six sub-villages estimated to have experienced strong ground motion (over 7.5 MSK; bottom half of table 1) according to damage level and structure type. Over 90% of houses using unreinforced brick masonry and about 80% of those using confined brick masonry "entirely collapsed." By contrast, none of the wholly wooden structures with wood walls and only about 50% of the wooden structures with brick infill "entirely collapsed." Data for the remaining six sub-villages that experienced intensity levels of less than 7.5 MSK are shown in figure 3b. Even in relatively mild ground motion, nearly 80% of unreinforced brick buildings "entirely collapsed," while 80% of wholly wooden ones received no damage.

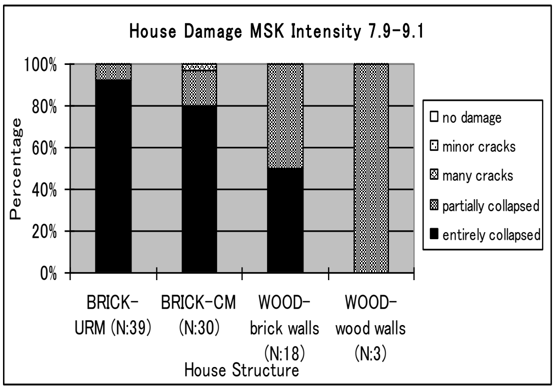
(a) Unreinforced masonry (URM)

(b) Confined masonry (CM)

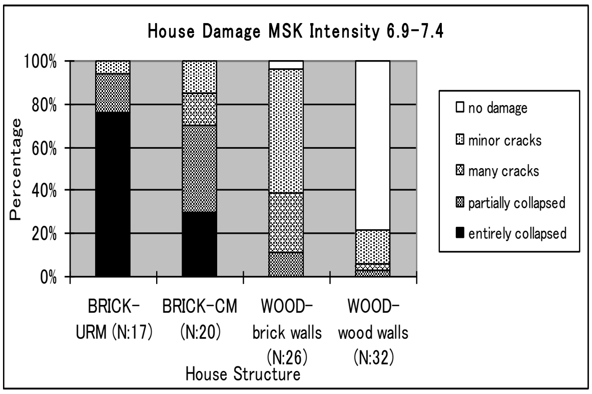
（c) Wood with brick walls

(d) Wood with wood walls

Figure 2. Four types of house structures



(a) House damage for areas of 7.9–9.1 MSK



(b) House damage for areas of 6.9–7.4 MSK

Figure 3. Differences in seismic performance according to house structure type

From these results, we can well conclude that brick houses with/without reinforcement are much more vulnerable than wooden structures to earthquakes of this level. The damage to brick buildings was mostly attributable to structural failure resulting from insufficient quality and amount of material used for reinforcement. Most of the damage in wooden structures with brick walls was likewise due to collapse of the brick parts, while the majority of wholly wooden structures received minimal harm because their structural characteristics and high deformation capacity allowed them to absorb seismic energy.

3.2 Influence of house structure type on entrapment and injury

House structure type also influenced rate of entrapment and injuries. Figures 4 and 5 show that of residents who lived in unreinforced brick masonry, over 55% were trapped, about 20% seriously injured, and 12% killed. Meanwhile, wholly wooden houses accounted for less than 9% of entrapment and none of the injuries. Interviews and data reveal that many of the cases of entrapment and injury came from falling house parts, mostly heavy debris such as brick walls and roof components. By contrast, lightweight materials such as wood and bamboo did not cause serious injuries and were easier to escape from.

One important feature of traditional Javanese wooden houses (especially in the Yogyakarta region) is the frame, known as *saka guru*, that provides the main structure of the house and that in many cases is the only part to survive in an earthquake (figure 6a). The *saka guru* comprises four main columns topped with a *brunjung*, a wooden framework in the shape of a reverse pyramid (figure 6b) that holds up the roof. Joints in *saka guru* are formed using *takik/cantokan* techniques similar to *nuki* joint systems in Japanese architecture (figure 6c). This joint construction provides structures with more resistance to the lateral force of an earthquake. As a result, in most wooden houses the only damage done by the earthquake was tilted or slightly dislocated columns.

Another characteristic of *saka guru* is that it is usually located in the center of the house, creating a semiopen space generally used as a family or guest area and connecting to the other rooms. Because of its seismic resistance and central location, the *saka guru* functions as a “survival space” in emergency situations.

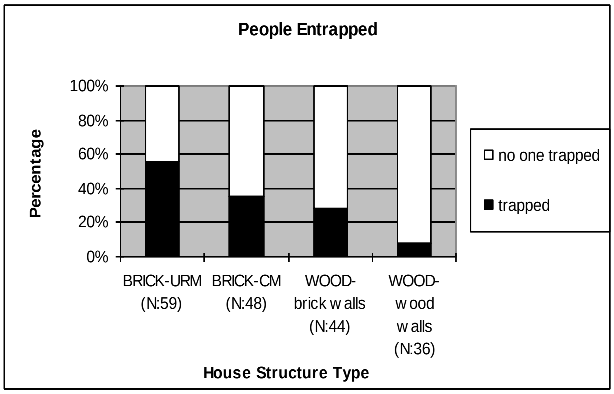


Figure 4. House structure type and entrapment

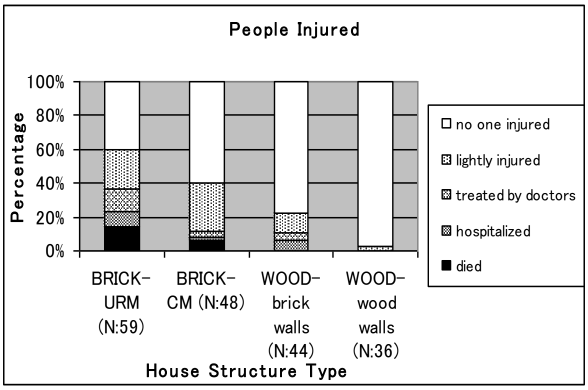
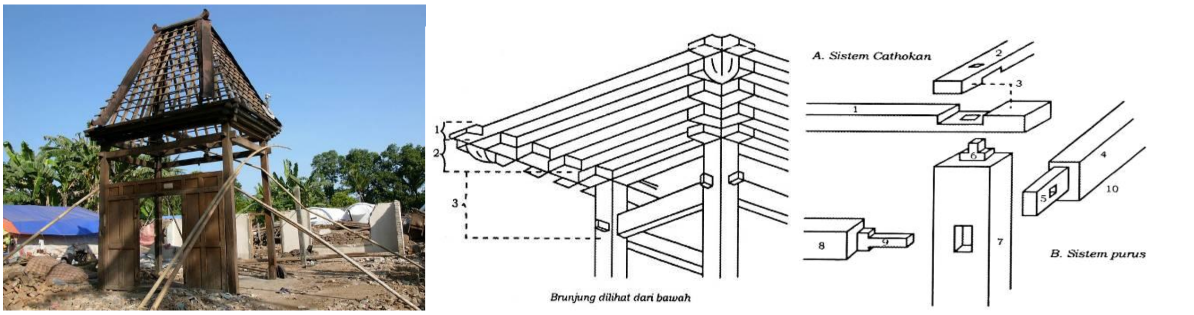


Figure 5. House structure type and injury



(a) *Saka guru* structure (b) Detail of *brunjung* (c) *Takik/cantokan* joint construction (Ismunandar 2001)

Figure 6. Traditional Javanese wooden construction techniques

3.3 Preferences for future dwellings

Despite the above evidence for the advantages of wooden houses and the considerable number of residents who indicate a psychological reluctance toward living in brick structures, preference for using brick masonry in future dwellings, as shown in figure 7, still remains high. This tendency seems due to a number of factors: (1) psychological image (i.e., the perception that brick houses are more modern and for people of higher status), (2) easier maintenance of brick buildings in terms of cleaning and ventilation, (3) better protection against the elements (e.g., insects, winds, humidity), and (4) greater security from theft or from invasion by animals.

When respondents were asked whether they would be willing to switch to a wooden house if it was stronger than one that could be built out of brick masonry for the same budget, the results, as shown in figure 8, were almost 50:50. Thus preference for wooden as compared to brick structures remained relatively low, owing perhaps not only to poor understanding of the structural advantages of wood but also the persistent image of wooden houses as being uncomfortable and oldfashioned.

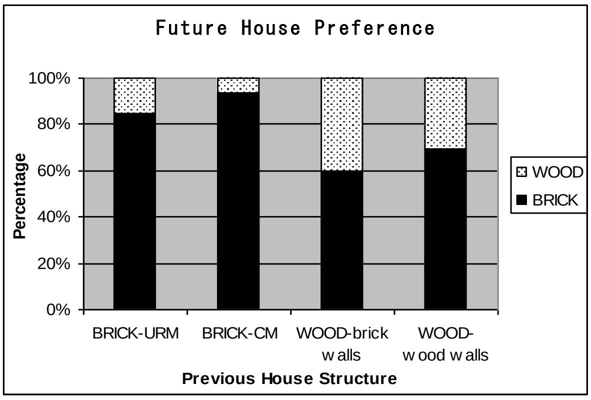


Figure 7. Preference for future dwellings

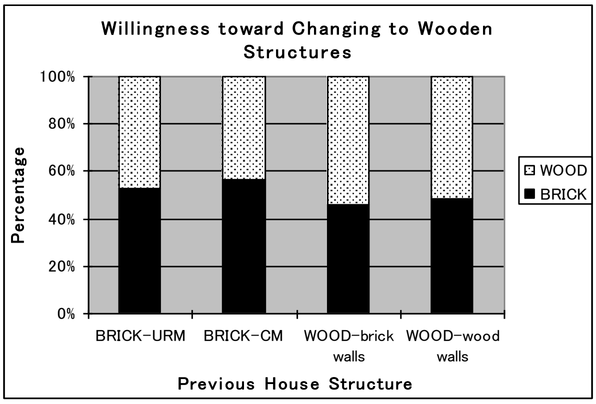


Figure 8. Willingness to change to wooden structures

4 BEHAVIORAL AND CULTURAL ASPECTS

4.1 Role of traditional living practices and community values

Regardless of whether they received heavy or little/no damage, over 90% of residents said they still cherished traditional Javanese living practices and community values such as *gotong royong* (spirit of helping one another through good and bad) and *kekeluargaan* (feeling of extended kinship in which the community is considered to be one big family). Over 60% said these values grew even more significant to them following the earthquake (figure 9). Many recovery programs operated by NGOs and the government were community-based and designed to incorporate such traditional practices into the rehabilitation process.

(a) A temporary tent shared by five different families bound together by having gone through the same experiences and feelings

(b) *Kekeluargaan*: Housewives gather to share a well that is still usable

(c) *Gotong royong*: Youths and elders help each other clear rubble and construct temporary shelters

Figure 9. Traditional Javanese living practices and community values

Preexisting community networks also played vital roles in the rehabilitation process. Neighborhood associations known as *rukun tetangga* (RT) functioned not only as sociopolitical territorial units but also as community units within which residents could work and help one another. Other groups such as the Karung Taruna (a youth organization) and Pembinaan Kesejahteraan Keluargan (a women's organization) contributed greatly to recovery programs. The living practices, values, and social networks of the kinds described above have all endured in Javanese communities for centuries.

4.2 Role of community facilities

The influence of culture on responses to the earthquake was revealed not only in the ways in which residents turned to community living practices and values but also their use of traditional public gathering places including the *alun-alun* (an open area/field owned and used by the community for sports, night markets, and other events), *gardu ronda* (public security guardpost), and *balai desa* (community hall used for holding public discussions and meetings). Immediately after the earthquake, the *alun-alun* became a shelter and evacuation area, the *gardu ronda* an emergency information post, and the *balai desa* a station for gathering people and donations. Six months afterwards at the time of the survey, the *alun-alun* had become a temporary schoolgrounds, the *gardu ronda* had been turned back to its original use, and the *balai desa* was functioning as an information and training center.

(a) Tents for volunteers (b) Tents for evacuees (c) Temporary school

Figure 10. Use of *alun-alun* (a & b) two weeks and (c) six months after the earthquake

Table 2. Use of community facilities

Community facility	Activities before earthquake	Frequency of use	Activities after earthquake	Time period of use
balai desa	*Rukun tetangga/rukun warga* meetings, information sharing, organization of events	1–2 times a month	Food distribution	1st week–2nd month
			Medical services	1st week–1st month
			Psychological care	2nd–3rd month
			Lectures	As scheduled
			Information distribution	1st week
mosque	Preaching, Friday prayers, information distribution	Once a week	Preaching, Friday prayers, information distribution	1st week–present
			Medical services	1st week–1st month
			Psychological care	
alun-alun	Specific events such as independence day, sports, night markets	As scheduled; every afternoon for sports	Temporary shelter	2nd week–present
			Food distribution	1st week–2nd month
			Psychological care	2nd–3rd month
			Medical services	1st week–1st month
			Clearing of debris	1st week–1st month
gardu ronda	*pos kamling* (night watch), community security	Every night	*pos kamling*	Every night
			Information distribution	1st week

4.3 Role of cultural and personal expression

Respecting needs for expressing cultural and personal identities also proved essential to promoting recovery. In one community-based reconstruction project led by local architect Eko Prawoto in Jetis Bantul, traditional rituals were carried out after completing the highest part of each newly rebuilt house. Although constructed using the same modules, each house could also be personalized by the people who were to live in it (figure 11). Both measures were part of an effort to encourage residents to regard their new house not merely as a "shelter" but as a "home" capable of giving them identity, or a sense of who they were. Reconstruction is not only about making sure everyone has a place to live, but also about promoting the recovery process through restoring residents' self-confidence.

(a) & (b) Houses built using the same modules but given different façades

(c) Personalization achieved using parts from the family's old home

Figure 11. Personalization of houses sharing the same module structure in Jetis Bantul

5 INFORMATIONAL ASPECTS

5.1 Types of needed information

As already mentioned, the chief causes of damage done to residences by the earthquake were poor structural design and insufficient quality and amount of material used for reinforcement. These factors were brought about not only by economic reasons but also lack of education about proper construction methods.

In ratings of information residents thought they most needed, "how to build safe houses" came in first with over 60% of respondents giving this answer, followed by "what to do if there is another earthquake," "whether one's previous house is safe enough to live in again," and "general knowledge about earthquakes." Residents also said they wanted to know "how to obtain donations."

5.2 Information distribution (disaster education)

During the survey, we had the chance to join community lectures about earthquakes and safer building given by Jogya Architecture Response (JAR) of Gadjah Mada University in collaboration with the International Organization of Migration (IOM). Similar lectures were given every night to communities with the help of architects, academics, and other experts and volunteers (figure 12a). Information was also distributed through posters and construction manuals given out on-site (figures 12b & 12c). Interviews, however, revealed that less than 50% of suburban residents and less than 20% of rural residents had access to these kinds of information about earthquake and disaster prevention and mitigation, a gap that seems due to unequal distribution of information throughout affected areas. In particular, rural areas had information available only through mass media such as television and radio. Such inadequacies in information distribution seems to be one reason for the continuing high rates of residents (more than 40%) who claim to suffer trauma from the earthquake.

(a) Lectures given to the community by experts

(b) Posters and manuals for safer building

Figure 12. Disaster education; distribution of information on safer construction

6 CONCLUSION

The following summarizes some implications of our study results that we believe should be considered in developing relief programs and precautionary measures for future disasters.

The survey revealed that residents tended to prefer brick masonry for rebuilding their homes due to their belief that brick houses are better than wooden ones. The safety merits of traditional timber-frame dwellings should be given renewed recognition, and residents should be presented with more varied building options to encourage them to rethink their preference for fragile brick masonry.

Traditional living practices and community values such as *gotong royong* and *kekeluargaan* play quite important roles in the reconstruction process and therefore should be taken into consideration in assisting rehabilitation of disaster areas. Housing aid involves not merely providing "shelters" but creating "homes" for residents as a firm basis on which to rebuild their confidence in life.

Lack of information and disaster education exacerbates trauma and distress for earthquake victims. Distribution of information is crucial to speeding physical and psychological recovery of residents in both heavily and not so heavily affected areas. More attention needs to be paid to promoting disaster prevention and mitigation within the community, not only to help residents recover from this earthquake, but also to educate them on how to prepare for, prevent, and cope with the effects of future disasters.

Such information programs will require cooperation between the government, NGOs, and local communities. They should not only include formal education in schools and campaigns carried out through television, radio, newspapers, and other media but also utilize traditional community networks and facilities such as information billboards and *balai desa*. Information given out through lectures and meetings needs also to be followed by on-site training so that residents will be able to consolidate their understanding through hands-on experience.

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