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Report on Buildings and Houses Damaged by the Jogjakarta Earthquake, Indonesia on June 27, 2006

Housing Production Division

1. Introduction

An earthquake with magnitude (USGS*1) M_W = 6.2, depth 17 km; (BMG, Indonesia*2) Mb = 5.9, depth 11.87 km took place inland in the center of the island of Java in the Republic of Indonesia at 5.54 a.m. local time on May 27, 2006. A large number of houses collapsed in the special province of Jogjakarta and Central Java province, causing many deaths and injuries (Tables 1 and 2). The total numbers of deaths, injuries and refugees were 5,778, 37,883, and 2,111,872 respectively (Source: Media Centre and Bakornas, June 27, 2006). Those areas that suffered heavy damage had high population densities.

In connection with this earthquake, NILIM carried out a field survey between June 6-12, 2006. During the survey, NILIM was accompanied by a JICA*3 Team. The aim of the survey was to observe the damage to houses and buildings caused by the earthquake. Through the observation results, technology improvements and restoration and reconstruction techniques can be developed. The survey was carried out in the severely damaged area around Jogjakarta city and its districts such as Bantul, Gunungkidul and Sleman in the special province of Jogjakarta, and one district in the Central Java province, Klaten (Fig. 1). The buildings surveyed included public buildings, commercial buildings and houses. This report focuses on damage to houses and buildings.

*1 USGS: U.S. Geological Survey
*2 BMG,Indonesia: The Meteorological and Geophysical Agency of Indonesia
*3 JICA: Japan International Cooperation Agency

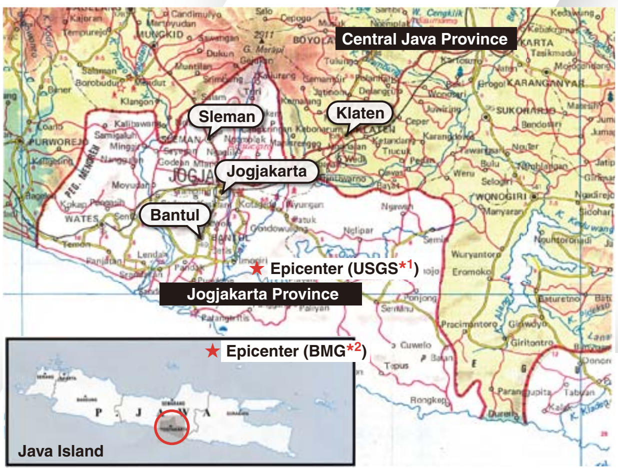

Fig. 1 Map of the disaster area

Table 1 Data of damage to government buildings

JOGJAKARTA PROVINCE	Heavy	Medium	Light
Bantul district	-	-	-
Sleman district	-	-	-
Kulon Progo district	39	-	57
Jogjakarta district	-	-	-
Gunung Kidul district	120	-	-
SUB TOTAL	159	-	57
CENTRAL JAVA PROVINCE			
Klaten district	76	430	439
Boyolali district	-	2	1
Magelang district	56	36	60
Purworejo district	-	-	-
Sukoharjo district	6	14	7
Wonogiri district	25	-	-
SUB TOTAL	163	482	507
TOTAL	322	482	564

Source: Media Center DIJ: June 27, 2006

Table 2 Data of damage to school buildings

JOGJAKARTA PROVINCE	Heavy	Medium	Light
Bantul district	71,763	71,372	73,669
Sleman district	19,113	27,687	49,065
Kulon Progo district	4,685	8,430	9,672
Jogjakarta district	6,085	5,408	15,364
Gunung Kidul district	7,454	11,033	27,218
SUB TOTAL	109,100	123,930	174,988
CENTRAL JAVA PROVINCE			
Klaten district	29,988	62,979	98,552
Boyolali district	307	696	708
Magelang district	386	386	546
Purworejo district	10	214	780
Sukoharjo district	51	1,808	2,476
Wonogiri district	17	12	74
SUB TOTAL	30,759	66,095	103,136
TOTAL	139,859	190,025	278,124

Source: Media Center DIJ: June 27, 2006

2. General damage to masonry houses and reinforced concrete buildings

1) Masonry houses

(1) Features of masonry houses

The most common type of housing in this area is single-story masonry houses. In accordance with the tropical climate, houses are characterized by their high floors and large openings. In the disaster area, most of the housing can be categorized as "non-engineered construction", meaning housing not constructed according to common architectural and structural standards. The bricks used for masonry houses are handmade and fired by using rice husks and wood (measured brick size: 95×210×45mm, 115×245×45mm, 120×255×45mm). These bricks are usually used for any kind of buildings or houses. Roofs are generally the wooden roof truss type, and tiled roofs are constructed without any roof boards.

(2)Unreinforced masonry houses and damage to them

The masonry walls of old and traditional houses are mainly unreinforced masonry structures, in which the mortar bed is generally made of mud and lime; pozzolanic sand and lime; or red brick powder and lime, owing to the high price of cement. This combination material causes a low bonding strength between bricks and mortar, which could be the main damage factor as so many people were killed or seriously injured by the earthquake due to the shear or out-of-plane rupture

Photo 1 Damage to unreinforced concrete building

mechanism. Another cause of damage was rupture of the roof frame and its roof cover (Photo 1).

(3) Reinforced masonry houses and damage to them

Masonry houses constructed in recent years have been strengthened by an additional reinforced concrete frame surrounding the masonry wall. Recently, some structures of this type have been built by structural engineers, foremen and technicians. In these houses, cement and river sand are used for the mortar bed on laid bricks. The perimeter of the masonry walls is strengthened by reinforced concrete and the wall surfaces are finished with cement mortar. Observations showed that not many houses of this type experienced severe damage. However, many houses collapsed or were irreparably damaged due to insufficient bar arrangement of the joint sections of the tie beams and columns and due to imperfect masonry work. It is therefore very important to improve the technology related to this type of structure in this particular area.

2) Reinforced concrete structures and damage to them

(1) Reinforced concrete rigid frame structures are used for schools, public buildings, and commercial buildings. In the case of reinforced concrete structures, hand-made bricks and hollow concrete blocks are used for partition walls as well as for external walls. These are known as infill walls and are used as non-structural walls.

(2) The earthquake caused typical damage such as shear failure and out-of-plane rupture of the infill walls, and hence building collapse leading to death and injury (Photo 2).

Photo 2 Damage to reinforced concrete building

Observation of the structural conditions of the reinforced walls that collapsed (shear failure and out-of-plane damage) showed that the failure was due to incorrect bar arrangement of the practical columns of the walls and large wall openings.

It is necessary to consider the structural details of the design and building construction methods that would ensure infill walls of buildings do not collapse in order to prevent human injury.

(3) Many reinforced concrete structures were damaged and collapsed during the observation. The main causes of the damage and collapse for reinforced concrete

buildings were the building configuration, structural performance (effect of the infill walls), and the quality of the materials and building construction. Thus, it is hard to identify a single cause of building damage or collapse.

The detailing of the stirrups with 90-degree hooks on reinforced concrete columns were observed to have caused shear failure on those buildings that collapsed. This type of stirrup detailing does not comply with the Indonesian Earthquake Resistance Building Code. It is considered that if buildings had strictly followed the 135-degree hook bar detailing as mentioned in the Code, perhaps some buildings might not have collapsed, and failure or damage would have been prevented.

3. Conclusions

The Central Java Earthquake caused many deaths and injuries resulting from the collapse of houses mainly caused by the vibration. The houses that completely or partially collapsed included those with unreinforced masonry structures and masonry buildings constructed recently. However, it should be observed that there were several houses with reinforced masonry structures that remained without severe damage. The important points that will need to be considered when restoring or constructing new housing are as follows:

1) The lessons learned from this earthquake need to be considered for housing and building construction in the future.
2) When planning the restoration of housing, a housing design consultation bureau needs to be established in order for houses or building owners to get advice on building restoration for single-story extension-type housing by implementing reinforced masonry techniques.
3) Foremen, technicians and engineers should be trained to understand the meaning of strengthening masonry walls and must be given technical information on methods of arranging reinforcement.
4) Regular workshops in connection with on-site testing methods for confirming the quality of masonry walls should be organized in cooperation with related institutions.

The above improvements would lead to better construction quality, and lead to the creation of municipalities, regions and a nation that is more resistant to disasters affecting houses, buildings and infrastructure facilities (Fig. 2).

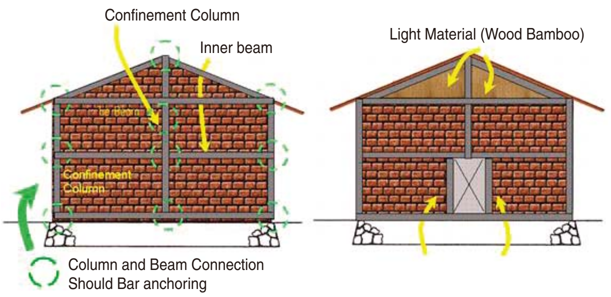

Fig. 2 Improvement of reinforced masonry house construction

Toward the Establishment of Safe and Secure Regional Communities against Disasters

Planning and Research Administration Department

1. Introduction

Japan, which has suffered and recovered from various kinds of disasters, has continuously implemented diverse safety measures, which have greatly improved the safety of communities. Such efforts must be continued in the future.

However, the country still suffers much human and property damage every year, and new threats to safety occurred surfaced. Dramatic technological advances are needed in addition to cooperation with human and social sciences in order to enhance the capacity of society to resist dangerous phenomena and construct safe and secure infrastructures that enable people to enjoy a high quality of life.

Photo1 Rescuing pupils from the isolated elementary school on the next day (Niigata flood in July 2004)

With such a background, we propose the directions for safety efforts in Japan, which were decided by referring to those in the United States. We hope that this proposal will be used to develop a core of shared understanding, which will serve as the basis of measures for all parties involved.

2. What are safe and secure communities?

By referring to “Grand Challenges for Disaster Reduction” of the United States and reports by the Working Group on Science and Technology Policy for a Safe and Secure Society established by the Ministry of Education, Culture, Sports, Science and Technology, we decided to implement the following three basic points in our studies on the directions of safety measures in Japan:

1) Investigate safety and secure issues from the viewpoint of regional communities,
2) Comprehensively investigate what should be done, and
3) Develop shared recognition among all parties involved and consider it as a process of constantly understanding the actual states and spreading collaboration.

Based on this recognition, the first task was to identify what constitutes a safe and secure community. Then, concrete methods should be developed for all parties involved to jointly construct and sustain safe and secure regional communities, which:

1) Have maximum potential for saving human life,
2) Are resistant against dangerous phenomena, and
3) Can quickly recover from damaged states.

3. Directions of measures (draft)

The policies of the measures (draft) for constructing communities that satisfy the aforementioned conditions are summarized as the "Ten challenges" in Table 1.

The draft has been prepared based on the concept that all parties involved should share the same recognition based on present states and collaborate with each other. To attain this goal, the Ministry of Land, Infrastructure and Transport needs to encourage the parties to collaborate, and the draft states the contents and directions of the measures to be taken by its development bureaus.

4. Conclusion

We propose the measures for constructing safe and secure regional communities against disasters in the form of "Ten challenges" based on the actual states of this country. Future actions will include:

1) Establishing concrete contents of the challenges, and

2) Executing the challenges mainly by the regional development bureaus of the Ministry of Land, Infrastructure and Transport by encouraging as many parties as possible to collaborate, such as residents, regional communities, municipal governments, infrastructure managers, private companies, and economic communities.

Table 1 Ten challenges

Classification	Ten challenges
1. Knowledge	1-1 Learning from disasters
	1-2 Supporting communications that lead to risk-preventive behavior
	1-3 Assessing the effects on the economy and business activities in a disaster-stricken region
2. Cooperation	2-1 Sharing information and knowledge with regional communities even under normal circumstances
	2-2 Promoting the creation of communities, which are capable of disaster prevention through self-support and mutual-support
3. Real-time information	3-1 Providing information in real time
	3-2 Utilizing emergency earthquake information
4. Recovery	4-1 Improving the resistance and recovery power of basic infrastructures as a whole
	4-2 Developing innovative technologies to improve the resistance of facilities
	4-3 Preparing for recovery

■ Revising the Guideline for Designing Gentle Slope-type Coastal Dikes

Coast Division

The Guideline for Designing Gentle Slope-type Dikes was revised jointly by the Coast Division of the River Bureau and the Coast Division of the River Department, National Institute for Land and Infrastructure Management.

A dike which has a slope gentler than 1:3 reduces the run-up height of waves and enables access to beaches. Thus, the Guideline for Designing Gentle Slope-type Dikes was issued in 1989, encouraging the construction of gentle slope-type dikes to promote shore protection and coast utilization.

Gentle slope-type dikes have been reported to cover large areas of beaches since they have long sectional bases, destroying the habitats of marine organisms and impeding the use of the beach. Since most gentle slope-type dikes were constructed on the sea side of existing steep slope-type dikes, the footings are located under the sea and cause waves to run up higher than in steep slope-type dikes.

Thus, the revised guideline clarifies the range of application; for instance, it requires footings to be constructed above the low-water level and advises reconsideration of the construction of gentle slope-type dikes when the width of the beach may become narrower than 20 m after the construction due to coastal erosion or other causes, and to use alternative measures, such as constructing steep-slope banks.

In the revised guideline, performance-based standards were introduced to enable engineers in the field to devise measures, and coordination among coastal protection, environment, and utilization was set as the goal of the Coast Law in 1999. Points to note regarding the environment are also included. In addition, new knowledge, such as to assess whether a gentle-slope bank accelerates or curbs erosion, as well as safety and performance assessment methods were added.

■ The English Version of "2006 Annual Report of NILIM" is now on our website

We publish the English Version of "2006 Annual Report of NILIM" to show our research activities and accomplishments, and you can see all of contents on our website, www.nilim.go.jp.

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