Chapter 17
Learning on the Safety Issues of Reconstructed Houses from the 2004 Great Indian Ocean Earthquake and Tsunami in Aceh, Indonesia

Kenji Okazaki, Krishna S. Pribadi, and Dyah Kusumastuti

Abstract The 2004 Great Indian Ocean Earthquake and Tsunami has provided an opportunity to build a safer Aceh, Indonesia, through reconstruction of houses, buildings and infrastructures during the recovery process. A research conducted in 2006 to investigate and assess the house rebuilding practices of various actors in the reconstruction process produced the following findings. To improve the safety of the houses, planning and design should be improved so that the needs of the communities match with the reconstruction efforts, proper seismic designs should be ensured to avoid severe damage from future earthquakes, building materials should be improved to meet minimum requirements, quality of workmanship should be enhanced and good project management and supervision should be introduced to improve structural quality.

It was expected that the lessons learned from the study and the recommendations based on the findings were implemented to make Aceh houses safer from future earthquakes. However, almost a decade later, recent earthquakes in Aceh have shown that these lessons were hardly incorporated in the building practices in the area, and that more serious efforts are needed to really address the safety issues of houses. Stronger measures should be put into place to ensure continuously that appropriate building practices are observed in all over the province.

Keywords Aceh • Houses • Reconstruction • Structural safety

K. Okazaki (✉)
Graduate School of Global Environmental Studies, Kyoto University, Kyoto, Japan
e-mail: okazaki@archi.kyoto-u.ac.jp

K.S. Pribadi • D. Kusumastuti
Institute of Technology Bandung, Bandung, Indonesia

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17.1 Introduction

During 4 years (from 2005 to 2008), the Executing Agency for Rehabilitation and Reconstruction (BRR) of Aceh–Nias accomplished the reconstruction and rehabilitation of around 140,000 houses, exceeding the need to recover from the Great Indian Ocean Earthquake and Tsunami in December 2004 and the Nias Earthquake in March 2005, which had destroyed 139,000 housing units (BRR 2009).

One year after the disaster, progress was achieved in the reconstruction projects, albeit slower than expected, where 16,200 new houses had been completed and other 13,200 were underway construction (BRR 2005). School buildings were also reconstructed at a rate almost identical to that of houses. However, in the effort to achieve reconstruction at the expected pace and produce the targeted number of buildings, it seems that the quality control for the newly reconstructed houses and buildings was being overlooked. In the ongoing reconstruction process, the quality of the structures should have been taken as a serious issue, in addition to the issue of the large quantity of structures to be built in the region. Recognizing the geological and seismological conditions of Aceh Province as one of Indonesia's most earthquake-prone areas, "rebuilding a safer Aceh" should have been pursued as the ultimate goal of the post-disaster reconstruction process. To improve the safety of Aceh's communities, it was very important to ensure that building regulations should be implemented to minimize the earthquake vulnerability of the newly reconstructed buildings.

A look back reflection on whether the lessons from the reconstruction process after the 2004 Great Indian Ocean Tsunami and Earthquake were learned effectively or otherwise will be presented. In 2006 a research with the objectives of investigating and assessing the capacity and building practices of various actors during the ongoing reconstruction process, focusing on the vulnerability of houses, was conducted, and recommendations for technological interventions to prevent unsafe practices in future building construction in the province were proposed (Okazaki et al. 2008, 2011). Yet almost a decade later after the catastrophe, recent earthquakes in the province showed however that there were still more efforts are needed to realize and implement the recommended measures in order to make Aceh safer against earthquakes.

17.2 Survey in 2006

17.2.1 Outline of the Survey

The field survey was conducted among various reconstruction projects in Banda Aceh and Aceh Besar from January to February of 2006. Due to the limited time frame and the vastness of reconstruction activities in the area, the survey was limited to several selected samples of housings, school buildings, and small scale public buildings.

The buildings were randomly selected, and included those constructed by the communities, local government, and donors (NGOs). In total, 53 buildings were visited for the field survey (34 houses, 12 schools, 2 mosques, 5 other types).

The survey intended to obtain general pictures of ongoing reconstruction projects and their actual building practices. Therefore, field testing for building materials and interviews with various parties involved in the reconstruction process were conducted. Documentations including structural drawings, specifications, pictures, and notes were also obtained in the survey. A few samples of building materials were collected to be analyzed in the laboratory. Local actors—consisting of workers, contractors, related local government agencies, NGOs, and local community groups—were interviewed to obtain information concerning building technology capacity as well as the building procurement process and mechanisms. Input from the owners or future occupants of the buildings as well as other interested parties were also collected.

17.2.2 Assessment of Quality of Structures

The purpose of the assessment was to examine several aspects of the building practices: structural design, project management, materials, workmanship, infrastructure and supporting facilities, and policies, in order to understand whether the buildings were reconstructed with adequate safety or otherwise during the reconstruction process, and to find out the difference between existing and post disaster construction. The quality of structural design in terms of earthquake resistant design was analyzed based on the buildings' documentation. The structural drawings and specifications were reviewed to ensure that the original documents endorse seismic building design. The project management aspect, which includes construction technology, procurement process, and tools used, was reviewed to assess the effectiveness of the project. These assessments were followed by the analysis of the quality of the materials used in the structures. In addition to the results from the field testing, several material samples were tested in the laboratory to determine their properties and structural qualities. The quality of workers was analyzed to observe the adequacy of workmanship.

In addition to the buildings, the environment required for conducting a reconstruction project was also reviewed. Infrastructure and other supporting facilities such as roads, electricity, and drainage, necessary to ensure the smoothness of the reconstruction projects and to support the communities after the completion of the projects were investigated. Local/national codes and other policies used for the reconstruction projects were also studied to determine the adequacy of regulations for these projects.

Based on the results from the field survey and laboratory tests of materials, an analytical study was conducted to examine the structural performance of the buildings. A few buildings from the reconstruction projects were selected to examine their weaknesses and to find ways to improve the quality of the structures.

Structural analysis was conducted and the building performances were analyzed based on the calculated force/stress and displacement responses.

From the field observation and structural analysis, an appropriate technological intervention was developed to reduce the vulnerability of the buildings. This intervention is based on the available capacity, culture, local materials and tools, and also the supporting environment. A workshop was then conducted in Banda Aceh on 22 February 2006 to share the findings from the survey and analytical results.

17.3 Findings from the 2006 Survey

17.3.1 Construction Practices in Aceh

During the 2006 survey, it was found that, from an engineering perspective, about two thirds of the buildings in Aceh were non-engineered buildings, meaning that they were built traditionally with little or no assistance from qualified engineers (IAEE Committee on Non-Engineered Construction 1986). Most masonry houses fall into this category. Engineered buildings are characterized to be properly designed and constructed for satisfactory performance under applicable loading conditions. Most public facilities fall into this category, including school buildings, government offices, and mosques.

Most buildings in Aceh in the time of the survey were found to be masonry structures with one or two stories. This type of structure gained popularity during the 1970s and continues to be the first choice in Indonesia. The existing structures show that they can survive earthquakes with little or no damage, provided that they were built properly using materials and workmanship of good quality. The survey, consisting of field surveys on damaged houses and a series of interviews of researchers, workers, and government officials, reveals that masonry structures built in the 1970s or 1980s performed better than those built in the 1990s. Almost all damaged structures from the 1990s were not designed properly according to the seismic codes.

17.3.2 Planning and Design

The planning and design aspect relates to the needs and demands of the reconstruction projects. The survey showed that some problems arose due to limited study of feasibility prior to implementing reconstruction projects. Examples of planning problems include temporary and permanent houses being built at the same time as well as construction plans/schedules not being well coordinated with those of infrastructure for housing. There were several completed projects that were uninhabitable because of lack of infrastructure such as electricity and drainage, or because the community refused to live in the project area. The interviews in communities revealed several serious problems. First, some communities were relocated apart

Fig. 17.1 (**a**) Type 36 houses under construction by BRR. (**b**) Houses with imported materials

from their former villages and were thus uprooted from their previous background. A typical example is the relocation of a fishing village to a location about 2 km from the coastline. The fishermen refused to be moved because easy access to their boats and to the sea is part of their lifestyle. Second, as mentioned above, many houses were found to be uninhabitable because of lack of electricity, drainage, or water supply. Third, the lack of planning also leads to houses being built very far from public facilities. Finally, some communities refused to move due to inadequate delivery of correct information and non-transparency in official procedures.

The design of structures for housing and schools generally follow typical design structures. Most school buildings surveyed showed that one- or two-story buildings were commonly used for school buildings, and the two-story buildings were often engineered buildings while most of the one-story buildings were categorized as non-engineered buildings. The houses were mostly what is called type 36 houses, meaning total floor area is 36 m^2, most of them can be categorized as non-engineered, one story buildings. Type 36 houses were endorsed by the government as replacement houses for the victims. Most buildings were made of burnt brick walls with reinforced concrete columns and beams. Roofs were constructed with wood trusses and galvanized iron sheets or roof tiles. Because these materials are commonly used for buildings in Indonesia, these buildings conformed with the local culture. Figure 17.1a shows a typical example of this type constructed by BRR. However, some projects used imported materials and technology, which resulted in questionable maintenance and sustainability (Fig. 17.1b).

17.3.3 Contracting

The construction industry in Aceh was not as powerful nor active as that in Java Island or other more developed regions. The political conflict in Aceh for more than three decades limited the growth of private sector investment, resulting in a relatively smaller private sector construction market. The main construction market

Fig. 17.2 Local builders in housing reconstruction

consisted of government infrastructure investment, while large international investment (oil and gas processing and related industry) was limited to large scale contractors, usually coming from outside the province. Many local contractors depended mainly on government works, resulting in tight and unhealthy competition among the local contractors. As a result, the local contractors did not invest in developing their human resources, construction plants, and technology. The tsunami disaster worsened the situation, as it caused the loss of contractors and family members, construction facilities, skilled human resources, and financial networks, reducing capacity and competitiveness.

Local small scale contractors (SSCs) were generally involved in small/medium sized infrastructure works such as road and small bridge construction and their maintenance, small scale irrigation schemes and their maintenance, residential and non-engineered public facilities (school buildings, government offices, tertiary health centers, etc.), and building maintenance and rehabilitation (Fig. 17.2). A typical SSC employed only a few (generally less than ten) permanent staff members (managerial and technical); most of them were not skilled technical personnel. This situation did not allow SSCs to develop their capacity and accumulate experiences and knowledge. Another problem for SSCs was the complicated procedures (proposals, supporting letters, collateral, etc.) that made it difficult for them to obtain financing from formal financing institutions.

Community contracting by implementing agencies was also used in reconstruction of Aceh, particularly in donor-driven projects. This process was mostly utilized together with a community participatory and bottom-up planning process, where the implementing agency provided a block grant and the community decided what it wanted at the local level. These programs became popular in recent years and the community perceived that they were efficient and cost effective. Community contracting were implemented in the following three modalities: (i) Community procures the services of (local) contractors to implement works using their own funds provided by donors; (ii) Community is contracted by government or donor agencies to implement infrastructure construction such as drainage and sewage; (iii) Community is contracted by the contractors who are requested to sublet part of the work to local communities.

17.3.4 Construction Aspects

(1) Materials and workmanship

The procurement of materials for the projects was crucial but the supply of materials was scarce. The survey found some projects were halted or cancelled due to the unavailability of materials. Materials found in the area could be divided into two categories: local and imported. The local materials supplied from Aceh included sand, gravel, bricks, and wood. Imported materials from outside Aceh came mostly from North Sumatra, but some were from Java, or even as far away as Australia, South Africa, or Europe. Usually, these imported materials were chosen by the donors. Examples included bricks from North Sumatra and Jakarta, cement from West Sumatra, roof tiles from East Java, and metal frames from Australia. As long as the materials were widely used in Aceh Province, maintenance and sustainability of the imported materials could be ensured. However, if the materials used were new for the locals, maintenance and sustainability would be a problem in the future. Some projects were indeed found to be using imported materials that were new and rare in Aceh, such as prefabricated steel frames and lightweight concrete panels.

In terms of materials and structure, most of the houses and school buildings conformably used typical local materials. The houses and school buildings were constructed in burnt brick confined masonry structure with sand and portland cement mortar, with RC columns and beams confinements. A typical flat footing was usually used for the column foundation in two-story buildings, while a stone masonry footing was commonly used for one-story buildings. Metal roof decks were the most popular choice for roofs due to their cost, workability, and durability.

The design of houses was similar to the designs used prior to the disaster. Post-earthquake design was not much improved, including the seismic aspect. Moreover, in most drawings, structural details that are important for seismic design were still left unclear, such as the beam-column connection, spacing for hoops, seismic stirrups, lap splices, and anchorage, so workers were left to "improvise" on these details. On the other hand, most designs for two-story school buildings showed a conservative approach regarding seismic loading,

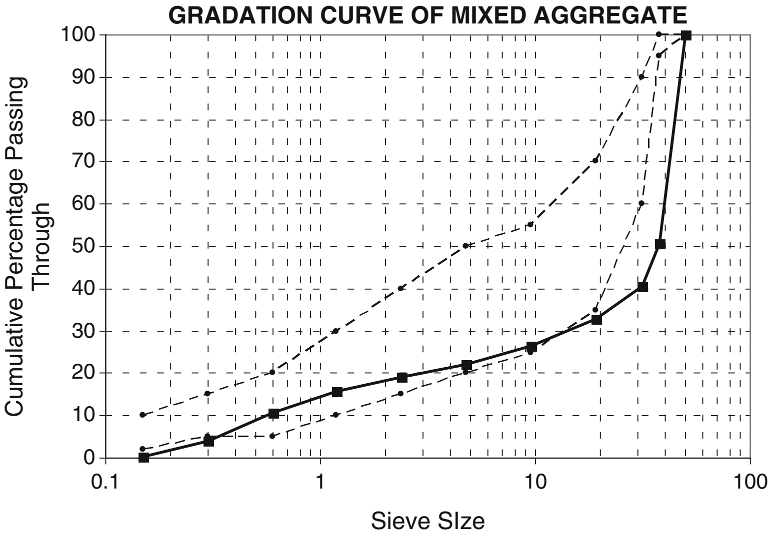

Fig. 17.3 Gradation curve of mixed aggregate of three samples (The two *dashed lines* show the range of ASTM C33-90)

emphasized by the large number of columns and the substantial dimension of structural elements. It should be noted that there was another big problem of the quality of construction. The field observations found that not a few of the materials used were different from the specifications and requirements of the drawings.

The concrete mixture was a serious problem for reconstruction of houses. The materials used for the mixture were adequate in most cases. However, almost no projects used the proper composition for the concrete mixture (volume ratio of 1 cement: 2 sand: 3 gravel). The most common mixture is cement and sand-gravel (sand with some gravel) with composition of 1 bag of cement for 3 carts of sand-gravel (about 1:5.25 in volume ratio). No sieving process was done to comply with the standard material gradation used for concrete mixture and no effort was made to avoid large aggregates getting into the mixture, which lead to a mixture having a very poor gradation with a high percentage of coarse aggregates. The laboratory tests conducted clearly illustrated this fact, as seen in Fig. 17.3.

Another critical issue concerning concrete was cement/water ratio. Excessive water was found in most of the cases. Proper curing for concrete was not common in the area. Considering all these facts, it was concluded that the quality of concrete was one of the most serious problems in the reconstruction projects.

The usual reinforcements used in the buildings were plain rebars of diameter 10 mm for longitudinal, and plain rebars of diameter 6 mm for hoops. In some construction sites, even weaker reinforcements were found: diameter 8 mm for

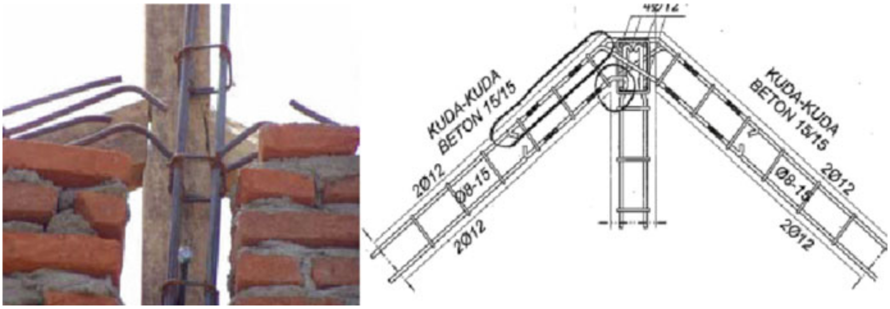

Fig. 17.4 Construction does not follow the drawing

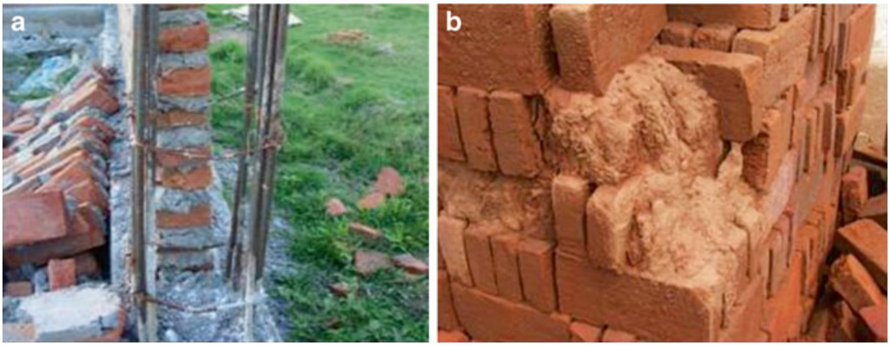

Fig. 17.5 (**a**) Wide spaced hoops. (**b**) Melting bricks

longitudinal plain rebars and diameter 4 mm for hoops. The Indonesian seismic code (Badan Standardisasi Nasional 2004a) specifies the following minimum diameters for materials to be used in earthquake resistant buildings: 12 mm deformed bars for column longitudinal reinforcements, 10 mm deformed bars for beam longitudinal reinforcements, and 8 mm plain bars for hoops. Most of the reinforcements found in the field survey violated the building codes (Badan Standardisasi Nasional 2004b). Even worse, detailing of reinforcement such as bending work did not satisfy seismic demands for safety. Figure 17.4 shows the contrast between the drawing (the intended design) and the actual situation, a difference that was quite common in the area. The spacing of the hoops also posed a problem, with spaces averaging 200–250 mm, in contrast to the code's requirement of minimum spacing of 150 mm or less (see Fig. 17.5a). The quality of bricks used in the area was very low. The lowest class of bricks in the Indonesian code is Class III, which requires strength of minimum 25 kg/cm2. Most bricks fell below the minimum strength and even "melt" when soaked with water (Fig. 17.5b).

Table 17.1 Tensile tests of steel reinforcements

Type of reinforcement	Average yield strength (kg/mm^2)	Standard yield strength (kg/mm^2)
Bj. TP 24	29.56	39
Bj. TP 30	43.95	49

The lab tests showed that the strength of the steel bar was also below standard (see Table 17.1). All these facts indicated that the strength capacity of the structural elements for bending and shear in the buildings being constructed could be much lower than what was expected.

The mortar quality was also questionable because of poor composition: too little cement and too much water. The bricks observed at construction sites were not installed in straight lines and mortar was often excessive (spacing of more than 15 mm). The structures were also lacking in structural integrity, due to insufficient connections between structural components. For example, connection did not comply with the requirements in the codes/drawings, and no anchorage was provided from the walls to the columns.

(2) Workers
While the low quality of materials caused low structural quality, the low quality of workmanship amplified these problems. With the huge amount of work arising from reconstruction activities, trained and qualified workers were scarce in the area. The results of most projects showed that the workers were not adequately skilled for the job. They tended to ignore the important issues for producing safe structures, such as the sieving process for aggregates, curing of concrete, soaking of bricks before placement, water ratio for concrete mixture, and bending details. All these problems arose due to the workers' lack of the concept of quality of structures. The workers simply did what they thought of as the easiest way to construct the buildings—without concern for the quality—because they were not equipped with knowledge of proper construction methods nor basic concepts of quality of structures.

(3) Project management and supervision
The investigation showed that there were two types of reconstruction projects. In the first type, NGOs or other donors assigned the construction project to a contractor. This type of reconstruction project is usually called the "project type". In second type, the NGOs or other donors provided full or partial funding to owners or groups of owners while the construction project is carried out. This type of project is called the "community-driven type".

Each method shows advantages and disadvantages. The project type is prone to sub-contracting, which is done an average of 2–3 times, and in some cases up to 4–5 times. Every time a project is sub-contracted, each involved party gains a profit of a certain percentage of the original budget. This causes serious friction between parties, which often caused political upsets and scandals.

In contrast, the community-driven type is affected by the shortage of qualified construction workers and supervisors.

The survey also showed that quality controls were not implemented due to the shortage of trained and qualified supervisors. The shortage of supervisors made daily inspections difficult and resulted in less frequent inspections; cases of weekly, bi-weekly, or even monthly inspections were found. Unfortunately, the building permit system, which can be one of the mechanisms to ensure the quality of the structure, was suspended due to the massive number of construction projects and the limited capacity of the authorities. Thus, houses and other facilities damaged by the earthquake and tsunami were allowed to be repaired or reconstructed without building permits.

(4) Problems in official procedures

The victims of the earthquake and tsunami disasters were eligible to receive assistance for rebuilding houses based on their own reporting. The victims were requested to report the damage to their houses to the head of the village (known as Keuchik) or other village officials. However, this was not an easy procedure for the victims: because most of their official documents were lost or damaged in the disasters, it was difficult for them to provide proof of their ownership of land and houses. Many people had difficulty in securing assistance or had to wait a very long time for their assistance to be provided. On the other hand, governmental agencies had difficulties in confirming that each victim received only a single unit of housing for each family, causing some people to end up with no houses while others received two or more units.

17.3.5 Structural Analysis

A case study of structural analysis on a house funded by a donor was conducted. The type was selected mainly because of the availability of complete documentation and technical information. The house had a floor area of 45 m^2 and was a single story confined masonry structure with burnt brick walls. All of its structural elements were common in Aceh. Modal analysis in an elastic range was employed for the study. For structural analysis, the house was modeled as a confined masonry structure in which both the frame and walls supported earthquake loads. All structural components including columns, beams, roof, and walls were modeled as frame and shell elements. The properties for these materials were taken from the results of the field survey and material testing. The analysis found that the house for the case study had sufficient structural capacity in terms of the Building Codes and Standards of Indonesia when it was constructed according to the structural drawing and specifications with adequate quality of materials and construction. This meant that safe structures could be realized under the severe conditions in Aceh and many other places in Indonesia if appropriate designs, materials, and construction work were made available.

Fig. 17.6 Workshop on dissemination of the survey results

17.3.6 Stakeholders' Feedback

A one-day workshop was conducted on 22 February 2006, with the purpose of disseminating facts obtained from the survey and preliminary analyses, to obtain input from all related parties in the reconstruction process, and to find solutions for problems in the reconstruction process (Fig. 17.6). During the workshop, findings from the field survey, material tests, and structural analyses were presented to the audience.

The following recommendations after incorporating the input from the workshop were produced:

- Community awareness about building safety should be raised so that the community becomes involved in improving the quality of the structures.
- Good communication and coordination between donors, community, and government agencies should be built so that the society can participate.
- Building codes and standards should be enforced.
- Internal mechanisms for quality control should be set up by each related party, such as owner, consultant, contractor, donor, and government agency. If necessary, each party should have its own supervisor for each project to ensure the quality of the structure.
- Appropriate building construction methods should be disseminated.
- Feasibility studies should be done prior to conducting reconstruction processes. These should include the participation of the community so that the reconstruction efforts match the needs and demands of the community.
- Training for workers and supervisors should be carried out to ensure proper construction methods, which will lead to better construction.
- A pocket guide for building construction should be developed to facilitate dissemination of proper construction methods.

17.4 Experiences from Recent Earthquakes in Aceh

The following question arose when there were several recent earthquakes in Aceh Province: Did Aceh learn from the 2004 Great Indian Ocean Earthquake? A typical answer to the question can be concluded from the following surveys in two earthquakes both of which occurred in the province in 2013.

17.4.1 Earthquakes and Impacts on Houses

Two earthquakes which occurred respectively in Central Aceh and Bener Meriah Districts (M 6.1 on 3rd July, 2013 at 10 km depth) and Pidie District (M 5.3 on 22nd October, 2013 at 48 km depth) are presented to illustrate the earthquake vulnerability situation in typical earthquake prone areas in Indonesia. The distance between the two epicenters is about 80 km (Fig. 17.7). The first earthquake affected 370 out of 553 villages in the two districts, killing 49 people and injured more than 2,000. It also caused the damage (in various levels) of more than 18,000 houses and more than 1,000 public facilities (schools, hospitals, mosques and churches etc.). The second earthquake, with much lower energy, affected 19 villages in the district. It has nevertheless caused the damage of 616 houses and 47 public facilities, at mostly light and medium damage level.

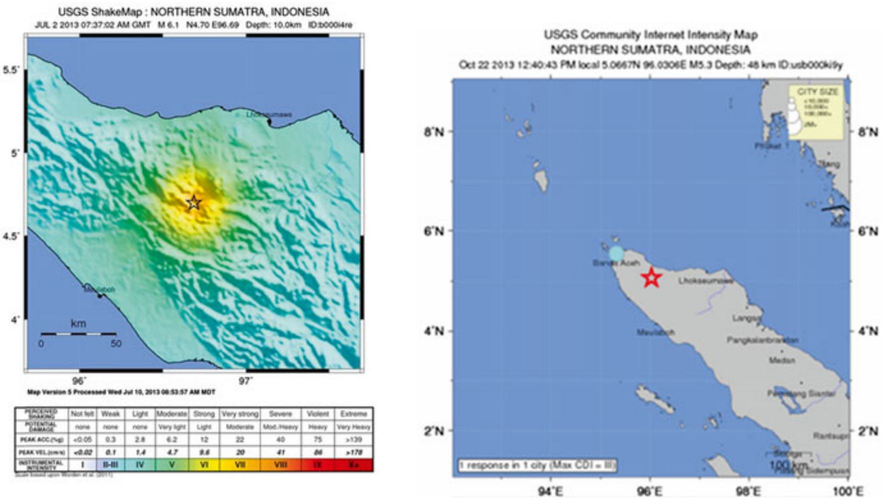

Fig. 17.7 Two earthquakes in Aceh Province (*left*: 3rd July 2013, *right*: 22nd October 2013). *Source*: www.usgs.gov

Fig. 17.8 Typical damaged houses (mixed masonry and timber house, cement brick material, diagonal cracks, collapse of adjoining walls)

17.4.2 Field Surveys in 2013

Surveys to the affected sites in 2013 revealed the characteristics of the damages. Despite the difference in the earthquakes characteristics, there are more or less similar damage patterns of the buildings and houses. For the non-engineered buildings and houses, that are built by local masons with local knowledge and do not involve architects or engineers during the design and construction process, damages were observed particularly in three types of non-engineered structures, i.e. mixed brick-timber structure, unconfined masonry, confined masonry, while for the engineered structure, that involve architectural engineering during the construction process, damages were observed in many in-filled reinforced concrete frame structures.

Damages in mixed brick-timber structure mostly are due to the absence of good foundation supporting the lower part masonry wall as well as the failure of the lower part masonry wall. The damages of unconfined masonry are particularly due to out of plane loading to the masonry walls although damages to walls due to in-plane loading were observed in many cases, with typical diagonal cracking of the walls. Damages in confined masonry are due to the failure of the concrete frames, mainly in the column and beam joints due to the bad connection of the main reinforcement bars as well as shear failure of the column due to lack of stirrups. The failure of the gable walls due to the out of plane loading are often observed in many unconfined and confined structures, due to inadequate framing (Fig. 17.8). Damages in in-filled

Fig. 17.9 Soft story failure of two storied house

Fig. 17.10 Damaged school buildings

RC buildings (mostly two stories) are due to the failure of the RC frames, as well as the weakness of the lower story (soft story effect), where the weak first story absorbs most of the lateral forces transferred by the more rigid upper story (Fig. 17.9).

Damages due to short column effect are also observed in many buildings. Some building failures due to ground failure (landslide) are particularly observed in the first earthquake site, as the site is particularly hilly and many houses were built on steep slope. Typical school building damages are also observed (Fig. 17.10).

Further field investigations show the following facts:

- Good earthquake resistant building practices as well as the prevailing building codes in Indonesia were not observed in many of the damaged buildings and houses. The size and quality of reinforcement bars, proper dimension and spacing of hoops, quality of construction materials, in particular concrete materials, do not comply with the minimum key requirements such as those found in government guidelines.
- Many damaged houses were found to be using heavy concrete canopy in front of the house, tied to the small RC tie beams that connect the walls to the roofs.
- Most of the local builders, masons, carpenters, concreters, and steel bar benders have very limited knowledge on earthquake resistance technology.

- Most of the house owners either build their house by themselves or assign builders to build their houses without awareness of the earthquake risk in the area. They just trust the local builders to design the structural features of the houses, without the capacity of ensuring whether the masons understand or not earthquake resistant technology.

The surveys found out that many of the damaged houses and buildings were built post-2004 following the recent economic growth brought by the post-disaster (and post-conflict) recovery programs. Some of the schools were even built with the government reconstruction aid, in the areas which were not affected by the 2004 Earthquake. This finding eventually shows that there is little learning from the past experiences, as mistakes in building construction similar to those occurring in the post-2004 earthquake reconstruction were found in recently constructed buildings.

17.5 Conclusions

Several important findings were obtained from this reflection. The 2006 survey on planning and design aspects showed that improvement was needed so that the reconstruction efforts would match the needs and demands of the communities. The study of design aspects found that proper seismic design should be ensured to avoid severe damage from future earthquakes. In this context reliable technical information should be delivered to engineers through seminars, publications, or other means. The construction aspect showed that materials used in the reconstruction projects should be improved so that they would meet the minimum qualifications for building materials as specified by the codes/standards. The quality of workmanship should be improved to reduce the vulnerability of the structures. For this purpose practical training programs should be implemented. Good project management and supervision should be conducted to ensure that the components in a building can work properly and together form an integrated structure. Studies by Pribadi et al. (2011) and Okazaki et al. (2012) showed that similar situations regarding non-engineered buildings were also observed in many other developing countries and made generic recommendations to address the issues of non-engineered building vulnerabilities in a similar approach.

Simple technical guidelines and manuals on earthquake resistant non-engineered houses are already available for dissemination to local builders and house owners (Boen 2010; BRR 2007; Ministry of Public Works 2006; Ministry of Public Works and JICA 2009). However, two earthquakes in Aceh Province in 2013 showed that the lessons learned from the 2004 Great Indian Ocean Earthquake and Tsunami and following reconstruction process were not adequately pursued in the other parts of the province which are prone to earthquakes, where building practices still produce unsafe houses. It is then again strongly recommended to look back at what lessons have been learned in the past and seriously take actions to really pursue the goal of a safer Aceh, through a series of systematic actions aimed at building the awareness of the relevant stakeholders to safer building practices in a more massive and sustained way. Simple guidelines and manuals need to be seriously communicated to the local communities in order that safer building practices can be internalized by the communities as part of their way of life.

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