Chapter 7

Damage to Buildings

The building in the region of the earthquake can be broadly classified as follows:

- Wooden houses,
- Masonry (brick) houses,
- Reinforced Concrete buildings and
- Mosques and Minarets.

The cause of damage to buildings was ground shaking, tsunami or both. While the story number of buildings in the populated cities such as Banda Aceh and Meulaboh could be greater than 3, most of the buildings along the west coast of Sumatra were mainly single story or two story buildings.

7.1 Wooden Houses

Wooden houses are generally single story or two story buildings. These buildings were almost non-damaged in the regions, which were not affected by the tsunami. Therefore the main cause of the damage was tsunami. The tsunami may impose at least four types of loading, namely, impact force, drag force, hydrostatic water loading and buoyancy (uplift) force on wooden buildings. While impact and drag forces directly related to the velocity of tsunami, the hydrostatic and buoyancy forces depend upon the tsunami height and relative density differences between the building material and tsunami waves. Photo 7.1 shows some examples of damage to wooden houses.

Photo 7.1 Damage to wooden houses

7.2 Masonry (Brick) Houses

Masonry (brick) houses are generally single story buildings and some of them could be 2 story buildings. Solid red clay bricks or hollow concrete blocks were used for constructing the adobe houses. Although concrete column and slabs are utilized during the construction, they are merely used for achieving structural integrity. These buildings were not damaged in non-tsunami affected area. However, they were completely destroyed when the tsunami waves hit these structures. It seems that the impact force of the tsunami waves were quite high from the state of debris and the fallen tree trunks. The other force components of the tsunami waves could be drag forces and hydrostatic water loads. When the masonry (brick) houses are still standing, their walls were punched out. Photo 7.2 shows some example of damage to masonry (brick) houses.

Photo 7.2 Damage to masonry (brick) buildings

7.3 Reinforced Concrete (RC) Buildings

Most of RC buildings have 2 to 3 stories. Nevertheless, new buildings for governmental offices and shopping malls have more than 3 stories. Commonly their story number is 5. The common construction procedure for RC buildings is to construct the walls first and then cast the concrete columns and finally the slab concrete for a typical story and repeat the same procedure for the rest of stories. However, the new buildings are constructed as a frame structure by casting concrete columns and then slab concrete first and finally filling the space with solid brick in-fill walls. The floor height ranges between 3 and 4m. There was no structural damage to RC buildings having stories 3 or less than that in non-tsunami affected area. However, almost all new buildings having heavy weight on upper stories collapsed or heavily damaged in non-tsunami affected area (Photo 7.3). The collapses were mainly due to plastic hinging at column-beam connections due to the lack of required column size and stir-ups, hooking and confinement. Furthermore, the quality of concrete and workmanship were quite poor and the diameter of reinforcement bars was insufficient. The in-fill walls were too slender and they were easily separated from the concrete frame and came down by out-of plane failure mode. Besides the structural and constructional problems of RC buildings, the soft ground conditions may also play some roles on the collapses or heavy damage. The collapsed or heavily damaged RC buildings were constructed nearby rivers or swampy areas.

Photo 7.3(a) Collapsed or heavily damaged RC buildings







Photo 7.3(b) Collapsed or heavily damaged RC buildings

The RC structures in tsunami-affected areas have stories ranging between 2 and 3. Some of columns were broken and in-fill walls were punched out by the impact forces of tsunami waves and tsunami-dragged objects (Photo 7.4). Nevertheless, some of them survived against the ground shaking and also the forces resulting from tsunami waves. The columns were generally ruptured or fractured at their mid-height, which implies that there were subjected to high bending forces. Furthermore, the broken columns and punched-out walls were facing the direction of the in-coming tsunami waves.

Photo 7.4 Damage to RC buildings in tsunami-affected area

7.4 Mosques and Minarets

Mosques are generally built as single story RC structures. Due to tropical climate of the area, there are almost no in-fill walls. Most of the Mosques survived against the ground shaking and tsunami waves even in the severely hit areas (Photo 7.5). The possible reason for such a good performance against tsunami may be associated with its columnar structure without in-fill walls. One of the few mosques damaged in this earthquake is in Ulehle district. The central RC column of the wall facing the sea was fractured by bending at mid-height. Many mosques built as masjid having no minarets. The grand mosques in Banda Aceh and Meulaboh have only minarets. Their minarets were lightly damaged.

Photo 7.5 Damage to mosques and minarets

(Author of this chapter: Ö. Aydan)