6.6 Damage to Nonstructural Components

6.6.1 Introduction

This section is based on the surveys by the Joint Survey Team after March 11th 2011. External surveys were conducted to various buildings in three prefectures of Miyagi, Fukushima and Ibaraki, and external and internal ones were also done in Ibaraki prefecture to gymnasiums and an airport passenger terminal building. This section describes the outline of the damage to exterior walls, openings, suspended ceilings, interior walls focusing on the buildings without severe structural damage patterns such as story collapse.

6.6.2 Damage to exterior walls

Many damaged exterior walls, including walls finished with ceramic wall tiles, cement mortar and metal lath wall and AAC (Autoclaved lightweight Aerated Concrete) panel walls, were observed.

Detachment of ceramic wall tiles was often observed at buildings of RC nonstructural exterior walls. Types of the detachment were classified according to existence or nonexistence of crack on the damaged RC wall.[6.6-1) 6.6-2)] In Photo 6.6-1, ceramic wall tile detached from RC exterior wall. Cracks were observed on the damaged RC wall. Photo 6.6-2 shows detachment of ceramic wall tiles installed on a cylindrical RC wall above the building entrance (within a circle). No crack was externally observed on the undersurface RC wall. A net was placed over the damaged area to catch falling tiles.

Photo 6.6-1 Detachment of ceramic wall tiles from damaged RC exterior wall

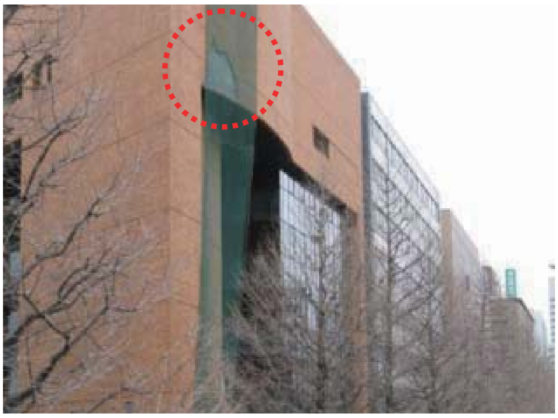

Photo 6.6-2 Detachment of ceramic wall tiles from RC wall

Damage to cement mortar and metal lath exterior walls was often observed in steel buildings. Photo 6.6-3 shows detachment of cement mortar and metal lath exterior wall in a 3-story building. Damage to the window glass was not observed, but cement mortar and metal lath fell from the exterior wall (shown in Photo 6.6-3) and from the parapet on another side. Photo 6.6-4 shows a one-story steel building in which cement mortar and metal lath detached from an exterior wall and from an eaves soffit. Photo 6.6-5 shows a damaged gable end wall of a gymnasium. This wall consisted of two layers. The undersurface wall was cement mortar and metal lath exterior wall. The surface one was exterior boards nailed to furring installed on the undersurface wall. Both were damaged and fell by the earthquake.

Photo 6.6-3 Falling of cement mortar and metal lath wall

Photo 6.6-4 Falling of cement mortar and metal lath from eaves soffit

Photo 6.6-5 Damage to gymnasium gable end wall

Photo from 6.6-6 to 6.6-7 shows damage to AAC panel exterior walls. Photo 6.6-6 shows falling of finishing ceramic wall tiles on AAC panels and broken light-weight aerated concrete in a 3-story building. Ceramic wall tiles on all faces of the exterior walls detached and the corners of the AAC panels were chipped. AAC panel was broken and internal iron wires were exposed at the circular broken line in the photo. AAC panels fell from another side. The construction method of the AAC panel exterior wall was not observed in the external survey. Photo 6.6-7 shows falling of AAC panels from the top-floor of a 5-story building. The damaged AAC panels were observed to be installed to the support metal with cement mortar and steel bar. This AAC construction method appeared in 3rd edition of Japanese Architectural Specification Standard JASS 12 as one of standard construction methods for AAC panel exterior wall but not included in its 4th edition.[6.6-3)] [6.6-4)] AAC panels installed with this AAC construction method were frequently observed to be damaged.

Photo 6.6-6 Falling of ceramic wall tiles and breakage of AAC panels

Photo 6.6-7 Detachment of AAC panels

6.6.3 Damage to openings

Damage to openings was observed in window glasses and window frames.

Photo 6.6-8 shows broken window glasses in the upper area of a windbreak room on the ground level of a 5-story building. Exterior ceramic wall tiles fell from another side.

Photo 6.6-8 Broken window glass

Photo 6.6-9 shows damaged window glasses installed to the upper fixed window with hardening putty at a gymnasium gable end wall. Cracked wired window glasses were also observed at the lower double sliding window with hardening putty. Flaking of paints was observed on the center of an arch beam of the gymnasium. Photo 6.6-10 shows breakage of window glasses in a gymnasium. The window glasses were installed to fixed window frames with glazing bead and twelve window glasses were broken at three exterior surfaces. Flaking of concrete at the roof bearing support part, deformation of almost all roof horizontal braces and fracture of one roof horizontal brace in the gymnasium were observed.

Photo 6.6-9 Breakage of window glasses installed to fixed window frame with hardening putty

Photo 6.6-10 Breakage of window glasses installed to fixed window frame with glazing bead

Photo 6.6-11 shows broken window glasses on the longitudinal surface in a gymnasium. Twenty-six wired window glasses were broken, which were installed to double sliding window frames with glazing bead. On the windows of opposite side, there were no damage to the frosted window glasses and a detachment of a mullion cover of a window. No damage was observed in the structure.

Photo 6.6-11 Breakage of wired window glass installed to double sliding window frame with glazing bead

Photo 6.6-12 shows a damaged glass wall system at the 1st floor of a 6-story building. A glass mullion was broken in an area circled by a broken line (steel pipe adjacent to the broken glass were installed after the earthquake for the repair work).

Photo 6.6-13 shows damage to window frame in a gymnasium. The photo shows the window frames near the center of the longitudinal surface of the gymnasiums. The upper part of the window frame was dislocated and leaned to the outside. The same damage was observed also at the opposite side. Fracture or buckling was observed in most of the section loss parts by bolt holes on longitudinal direction frame braces. Braces were fractured in three of four frames.

Photo 6.6-12 Breakage of glass mullion of glass wall system

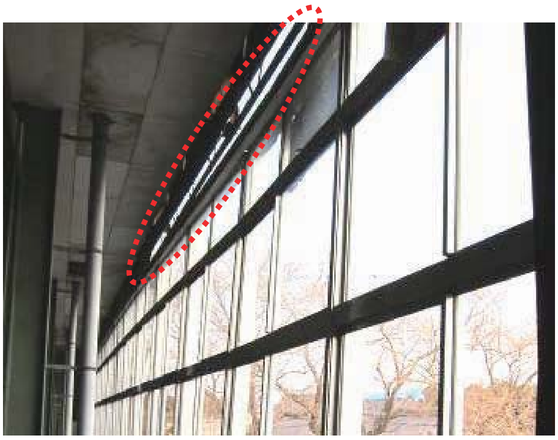

Photo 6.6-13 Dislocation of window frame

6.6.4 Damage to suspended ceilings

Many damaged suspended ceilings were observed in the damage investigation of gymnasiums and an airport passenger terminal building. The damaged suspended ceilings included wooden suspended ceilings faced with wooden boards, metal furring ones faced with plaster boards and absorption boards of rock wool, ones with exposed T system and glass wool boards and others.

Photo 6.6-14 shows a damaged wooden suspended ceiling in a gymnasium. The ceiling almost fell with light fittings except at perimeter. Partial falling of an eaves soffit, dislocation of a window frame and 33 broken window glasses were also observed.

Photo 6.6-14 Falling of wooden suspended ceiling

Photo 6.6-15 shows a metal furring suspended ceiling broken at the center of a pitched ceiling. Damage was also observed at interior walls above the stage. No damage was observed to the steel roof and supporting RC columns. Photo 6.6-16 shows damage to a high ceiling above the lobby of an airport passenger terminal building. There were five metal furring suspended ceilings of 3m x 11m. The metal-sheet clips hanging the metal furring channels were damaged by the earthquake and one of the ceilings fell. In the ceiling plenum, vertical diagonal members were unevenly installed and the members were complicatedly installed near the connection with the surrounding wall. No damage to the structure was observed.

Photo 6.6-15 Falling of metal furring suspended ceiling

Photo 6.6-16 Falling of metal furring suspended ceiling

Photo 6.6-17 shows damaged ceilings in a gymnasium. The horizontal ceiling marked with red dotted lines was composed of corrugated steel plates and steel members and the pitched ones were composed of metal furring channels and other steel members faced with gypsum board. Both ceilings fell. The broken window glasses and the leaned interior wall above the stage were also observed. Many roof horizontal braces were fractured.

In the gymnasium shown in Photo 6.6-18, many glass wool boards on exposed T system fell. Flaking of concrete was observed in the structure.

Photo 6.6-17 Falling of metal furring suspended ceiling and corrugated steel plates

Photo 6.6-18 Falling of glass wool board of T system ceiling

Photo 6.6-19 shows a damaged metal furring suspended ceiling in a gymnasium. Significant visual damage was not observed, but the ceiling board sagged near the center of pitched ceiling marked with a red dotted oval line in the photo. This was possibly due to the displacement of ceiling members in the plenum. Cement mortar finish of interior wall above the stage was flaked as shown in Photo 6.6-23, and the exterior boards were broken at the gable end wall. No damage to the structure was observed.

Photo 6.6-20 shows damaged ceiling at the connection with surrounding wall in a gymnasium. Bending of the metal furring channels and detachment of ceiling boards were observed. In the corner of the ceiling, the sheet-metal clips were damaged and the ceiling sagged in several meters long. The gymnasium is composed of lower RC frame and upper steel frame.

Photo 6.6-19 Sagging of metal furring suspended ceiling

Photo 6.6-20 Damage to metal furring ceiling at the connection wall

Photo 6.6-21shows damaged ceiling boards at the connection with the structure of a gymnasium. It was reported that one window glass was broken. No damage to the structure was observed.

Photo 6.6-22 shows damaged ceilings at an office building. The ceiling was damaged at the connection with the partition. Bending of a metal furring channels and falling of ceiling boards were observed.

Photo 6.6-21 Damage to metal furring suspended ceiling at the connection

Photo 6.6-22 Damage to metal furring suspended ceiling at the connection

6.6.5 Damage to interior walls

Photo 6.6-23 shows damaged walls above the stage in the gymnasium shown in Photo 6.6-19. Cement mortar finishes on the studs were broken and fell. Damage to the walls above the stage was observed also in some gymnasiums such as shown in Photo 6.6-15 or Photo 6.6-17.

Photo 6.6-23 Falling of cement mortar finish above stage

Photo 6.6-24 shows a lift of the nail fixing interior wall boards to the studs in the arena of gymnasium.

Photo 6.6-25 shows damaged interior walls in a gymnasium. Interior walls around the supports leaned at two of three basketball hoops. The damaged hoops were temporarily supported with ropes.

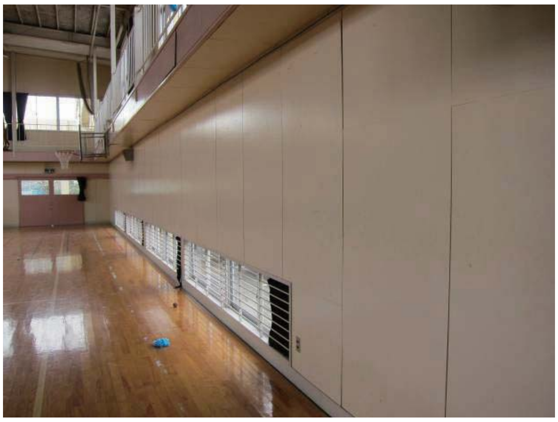

Photo 6.6-24 Loosen nails fixing board

Photo 6.6-25 Damaged interior wall

6.6.6 Conclusion

This section described the outline of damage to nonstructural components. Damage to nonstructural components constructed with relatively older building methods was often observed. Breakage and falling of nonstructural components placed on relatively higher parts were also observed.

The frequently observed damage to each nonstructural component is summarized as below:

Exterior wall

Ceramic wall tiles were detached from RC nonstructural walls. Cement mortar and metal lath were detached from steel buildings. AAC panels installed to support metal with cement mortar and steel bar were also detached from steel buildings.

Openings

Glasses of fixed window were broken, mostly installed with hardening putty.

Suspended ceiling

Various types of suspended ceilings were damaged. Breakage at connection with interior walls was frequently observed at gymnasiums.

Interior wall

Walls were broken and fell above the stage of gymnasiums.

References

6.6-1) Manual for Seismic Design of Exterior Walls – For Mid-rise Buildings -, 2nd edition, supervised by Building Guidance Division, Housing Bureau, Ministry of Construction and Japan Conference of Building Officials, published by Building Center of Japan, 1998

6.6-2) Akio BABA and Hiroshi ITO, Full Scale Experiment on the Seismic Safety of Exterior Finishing Material and Construction Method, Cement & Concrete No.376, published by the Cement Association of Japan, 1978

6.6-3) Japanese Architectural Standard Specification JASS 21 AAC Panel Work, 3rd edition, Architectural Institute of Japan, 1998

6.6-4) Japanese Architectural Standard Specification JASS 21 AAC Panel Work, 4th edition, Architectural Institute of Japan, 2005