DAMAGE INVESTIGATIONS of PUBLIC HALLS IN NAGAOKA CITYAFTER NIIGATA-CHUETSU EARTHQUAKE

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ABSTRACT: This paper reports the results of damage survey to some public halls in Nagaoka city, the closest urban area to the epicenters of Niigata-Chuetsu earthquake. Because of the distance from the epicenter less structural damage to them was found. However the damage that these facilities were suffered, damage to suspended facilities especially to suspended ceilings, was so serious that they could not continue their functions after the earthquake.

Key Words: Public halls, Suspended ceilings, Architectural elements, Nagaoka city

INTRODUCTION

Since the epicenters of the Niigata-Chuetsu earthquake were in rather local area less damage to buildings structures have been reported and major damage were found in infrastructures such as roads and tunnels. Furthermore the area was of heavy snow and structures were designed comparatively stronger than those in usual part of Japan. Apart from the damage to the old wooden residential houses the most commonly reported damage to building structures was that to school buildings. Damage to school gymnasiums close to the epicenter have been also already well reported by many other researchers. Since researchers walk around the epicenter for their survey similar investigation reports were repeated for same buildings. However less information was available about the general situation of the building structures in Nagaoka city, the closest urban city to the epicenter. Nagaoka City is located about sixteen kilometers of distance in north from the epicenters (Figure.1). The population in Nagaoka City is about two hundred thousand and the city is well equipped with urban facilities, such as public halls. Therefore we decided to carry out damage survey to some public halls in Nagaoka city to collect damage data to such urban facilities.

Major records of the earthquake intensity on the JMA scale in Nagaoka City were

1. 6- (17:56 on Oct.23)
2. 5- (18:12 on Oct.23)
3. 5+ (18:34 on Oct.23)
4. 5+ (10:40 on Oct.27)

They are naturally rather moderate than the records at closer area to the epicenter and actually we found less damage to building structures in Nagaoka city. However most of the public halls that we surveyed were not able to open to the public after the earthquake because of the damage to non-structural, or rather say architectural, elements, especially suspended ceilings.

In the following sections we report the damage to the four public halls and one swimming pool in Nagaoka City.

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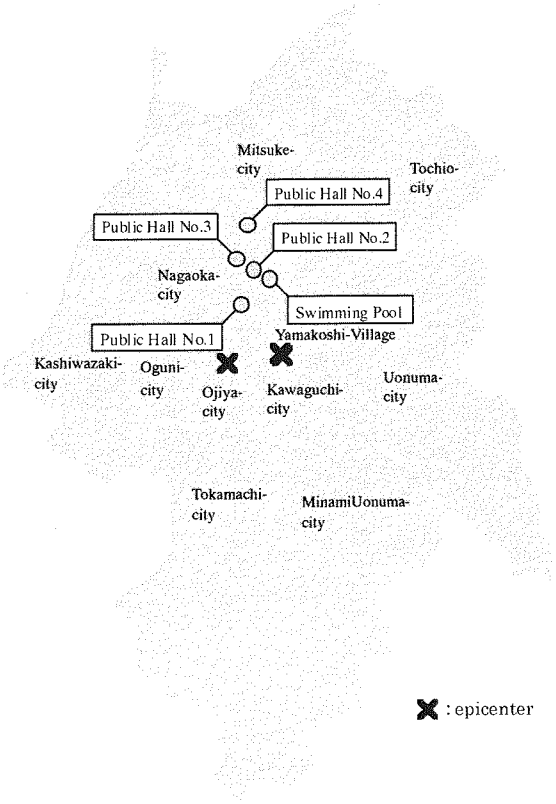


Figure 1. Location of Nagaoka City and the Public Halls Investigated

1. Public Hall No.1

This public hall is located most south area in the city and close to the epicenter. However the damage to the structure was rather minor. Some minor cracks on seismic walls and crash of grout under beam base were found. Many ceiling panels have fallen off near the boundary age area, where the horizontal ceiling panels connected to inclined ceiling, of the arena. Some panels have also fallen in the middle part of the arena. Ceiling panels were made of glass wool. Slide, deformation and cut of connections between cross furrings or hooks between cross furring and main runners were observed. No brace member was seen in the hanger bolt systems.

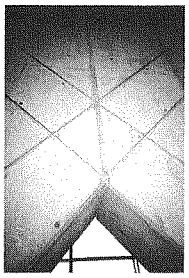
During the earthquake several people were using the arena and, fortunately, nobody was injured. Because of this damage the arena could not continue its function. In spite of all the request from neighbors the arena could not serve as the refugee space.

Table 1. Public Hall No.1

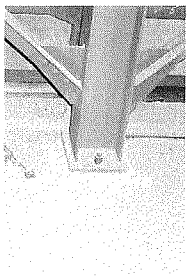
Location	Structure	Dimension	Completed
Kyokushin-Cho	Columns and walls: RC Roof: Steel Truss Girders 1F/3F: Sub Arena 2 & 3F/3F: Main arena and gallery space	Plan: 35m x 35m Height: 23m	1992

(a) Exterior view

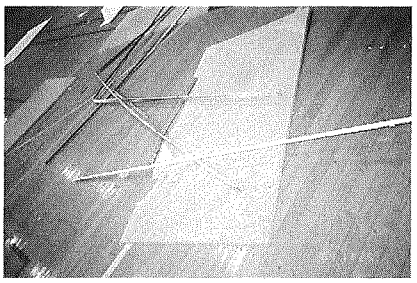
(b) Interior view



(c) Minor cracks on a seismic wall

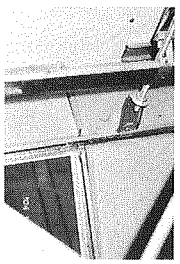


(d) Crash of grout under a beam bearing

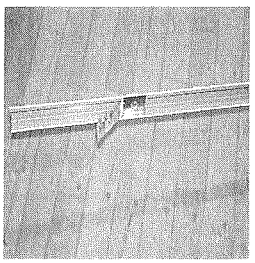


(e) Ceiling panels, cross furring and main runners fallen off

(f) Upper side of the ceiling system



(g) Bent furring connection



(h) Detail of a connection of furring

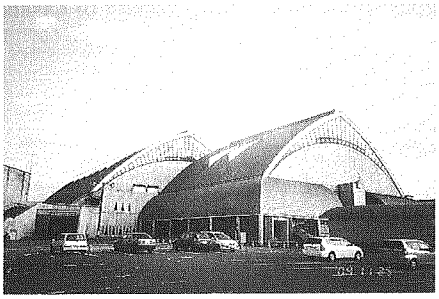
Photo 1. Public Hall No.1

2. Public Hall No.2

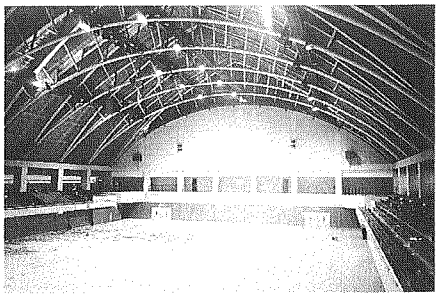
Structural skeletons are non-conventional system combining space truss and arch principle. No structural damage was found in the skeletons. Heavy suspended ceiling panels in the north side of the roof have fallen off in a wide scale. A large part of the north gallery seats were buried under the wreck of ceilings. A lot of hooks, which connect the furrings to the main runners, were deformed and removed with the furrings. During the earthquake the arena was in use and a student was badly injured by the fallen ceilings. The arena has been closed since soon after the earthquake.

Table 2. Public Hall No.2

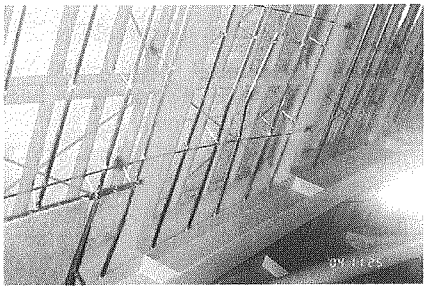
Location	Structure	Dimension	Completed
Gakko-Cho	Columns and walls: RC Roof: Steel Pipe Truss Arches	Plan: 34m x 56m	1988



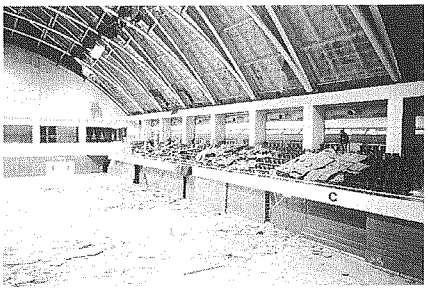
(a) Exterior View



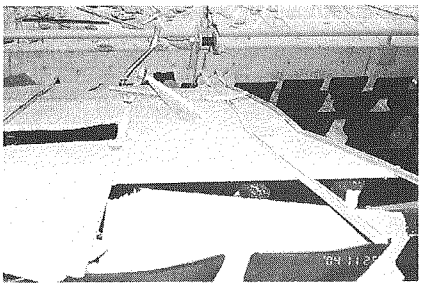
(b) Interior view



(c) Runners and furrings for the ceiling system



(d) Ceilings fallen onto the gallery seats



(e) Ceiling panels with the furrings

(f) Deformed hooks

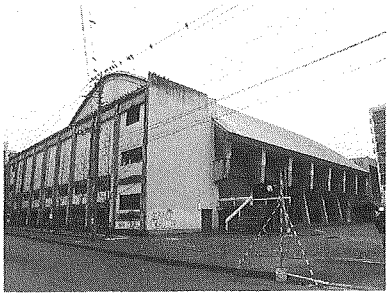
Photo 2. Public Hall No.2

3. Public Hall No.3

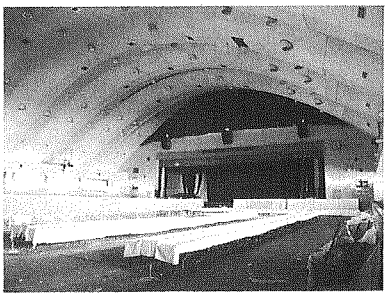
Some cracks were found on the RC seismic walls. No structural damage was found in the roof structures. The ceilings with plasterboards were designed in an arch shape with wavy pattern. The ceiling panels have fallen off in a wide scale, especially at the top of the both gable ends, probably because of collision with the end walls. Again many cross furrings and deformed hooks were also found on the floor. Fortunately nobody was using the arena during the earthquake.

Table 3. Public Hall No.3

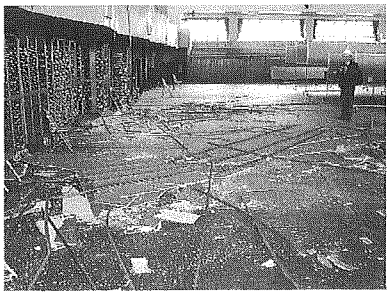
Location	Structure	Dimension	Completed
Oote-Doori	Columns and walls: RC Roof: Steel Truss Arches 1F/3F: Sub Hall 2 & 3F/ 3F: Main Hall and Gallery Space	Plan: 42m x 34m	1958



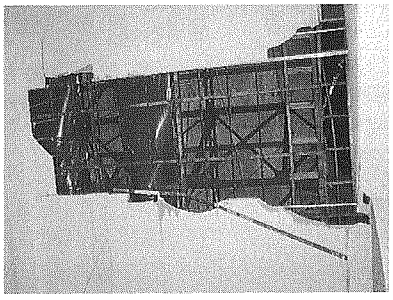
(a) Exterior View



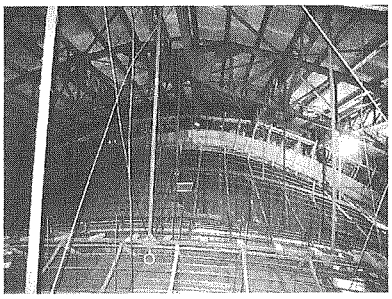
(b) Interior view



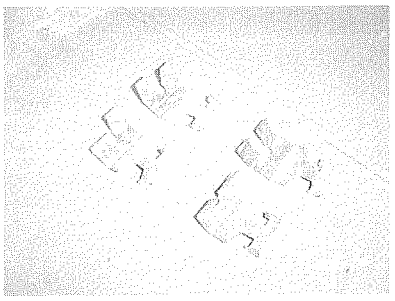
(c) Ceilings fallen off



(d) Ceiling furring left



(e) Over the ceiling systems



(f) Loosened hooks

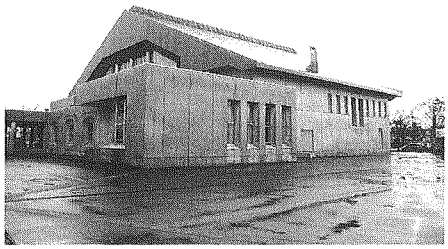
Photo 3. Public Hall No.3

4. Public Hall No.4

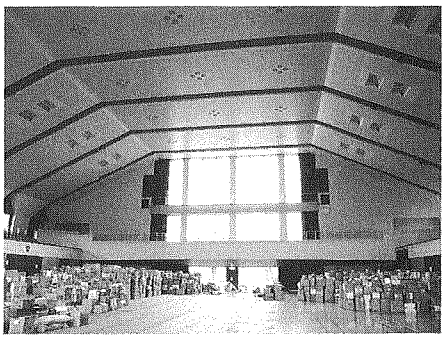
This public hall is located in north area of the city comparatively far from the epicenter. Minor cracks were found on the RC seismic walls. No damage to the roof structure nor roof bearings were found. For architectural finishing, ceiling panels of plasterboard were removed at the edge area of the arena, where inclination of the ceiling changes. The removals are also comparatively small. The arena could open as the relay point of the commodities for refugee.

Table 4. Public Hall No.4

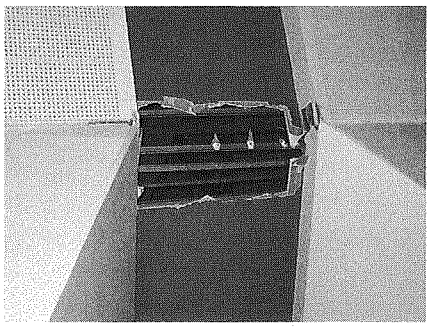
Location	Structure	Dimension	Completed
Higashi Zao	Columns and walls: RC Roof: Steel Space Truss 1 & 2F/ 2F: Main Hall and Gallery Space	Plan: 44m x 42m	1984



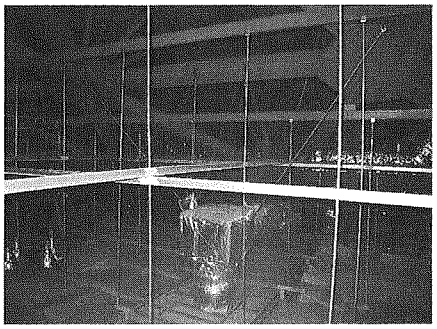
(a) Exterior View



(b) Interior view



(c) Location of the fall



(d) Ceiling systems from upper side

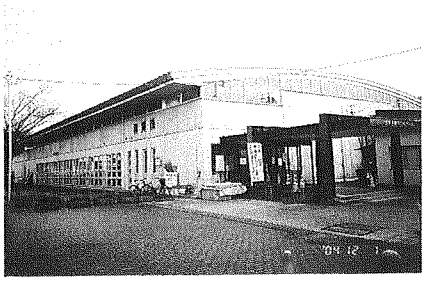
Photo 4. Public Hall No.4

5. Swimming Pool

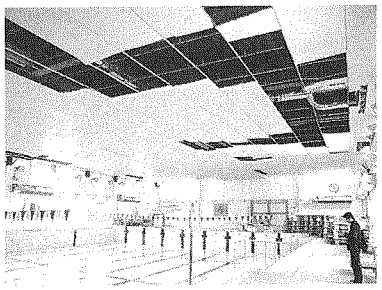
Location of this swimming is closer area to the epicenter. No structural damage was found in the structures of the swimming pool while some major cracks could observed in the structures of smaller annex rooms attached to the buildings. In the swimming pool arena large part of the ceiling panels have fallen off. Larger removal could found at edge area where suspended ceilings might have collided against walls. Panels around opening for air-conditionings were also removed. Metal work for openings have also fallen off. The ceiling panels were made of rather highly hygroscopic material, which seemed not appropriate for swimming pools. Although many pupils were in the pool during the earthquake nobody was injured, fortunately.

Table 5. Swimming Pool

Location	Structure	Dimension	Completed
Yukyu-cho	Columns and walls: SRC Roof: Steel Gable Girder	Plan: 45m x 25m	1994

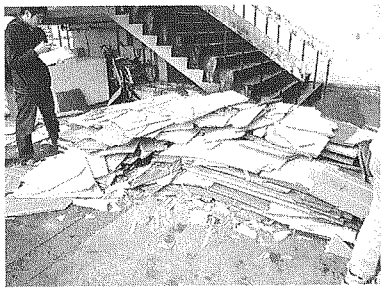


(a) Exterior View

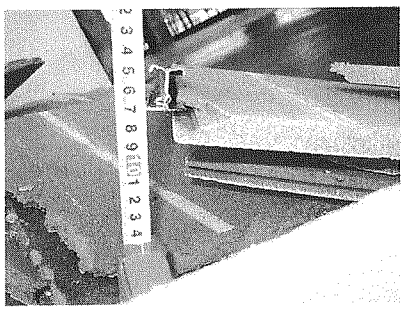


(b) Interior view

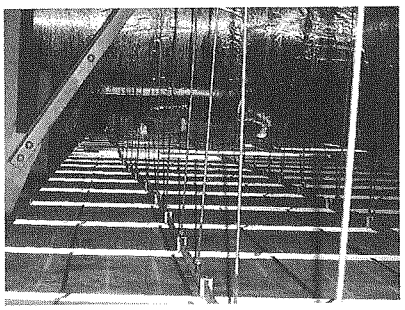
(c) No damage to the structural elements



(d) Piled up fallen ceiling members



(e) Detail of a ceiling panel connection



(f) Dislocation of main runners

Photo 5. Swimming Pool

CONCLUSIVE REMARKS

In Niigata region structures must be designed for heavy snow. Therefore skeleton of the buildings in this area are even stronger than usual structures in Japan. Further Nagaoka city is about 16 kilometers distance from the epicenters. Because of these factors less damage was generally expected in this area and as the results less information about damage to buildings was available. However, as we have seen above, urban facilities, such as public halls, were suffered from different kind of damage. Although very little structural damage was occurred the function of public spaces are heavily spoiled. Main problems were found in the vulnerability in architectural finishing, especially suspended ceilings. In large span buildings ceilings are suspended at a considerable height in a vast scale. Even worse thing is that many people gather under it when the space is in use.

After the Great Hanshin Earthquake we carried out damage survey of large span roof structures and found the vulnerability of suspended facilities, including suspended ceilings, in the large span halls. This type of damage occurs in comparatively lower impact level than structural damage. However it cause same danger to the people inside as structural damage and it occurs in a wider scale at the same time. Public halls usually store numerous people when they are in use. Fall off of them causes extreme danger to the people in the space. It may harm many people in an instant. Further public halls are usually converted to refugee shelter for those who lost their houses after earthquakes. Damage to interior space by fall of suspended facilities spoils such very important role of them after the earthquake and block its recover for long time.

Since engineers do not pay much attention to architectural finishes such as suspended ceilings however for large span buildings the scale of them is no longer the one that engineers should overlook. Appropriate treatment should be done for the existing buildings urgently and clever design scheme should be established.

REFERENCES

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