

Tohoku Chapter, Architectural Institute of Japan
Reconnaissance Report (16) on Mangoku-ura and Onagawa-cho
The 2011 off the Pacific Coast of Tohoku Earthquake
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This report describes the earthquake damage in Mangoku-ura (bay) and Onagawa-cho (town) of Miyagi Prefecture. The route maps of survey are shown in Map A for Mangoku-ura and Map B for Onagawa-cho.

1. Damage in Mangoku-ura, Ishinomaki City, Miyagi Prefecture (No. 1 in Map A)

Mangoku-ura is located approximately 6 km to the east of Ishinomaki City, facing a small bay (Photo 1), and east of Onagawa-cho. Tsunami attacked the area, and the third tsunami wave was the highest flowing over a 4-m high breakwater. The damage was very small in this area (Photo 2).



The Sanriku Railway was slightly flooded by tsunami water, but no damage was observed. Photo 3 shows the view to west, and Photo 4 to east from the railway line. There were some washed away items of tsunami (Photo 5).



Photo 3: View to west from the Sanriku Railway



Photo 4: View to east from the Sanriku Railway.



Photo 5: Some washed away items by tsunami near the railway.

2. Damage in Onagawa-cho, Miyagi Prefecture (Map B)

Onagawa-cho is famous for the fishery Port Onagawa. The population of the town is 9,965; 354 were killed and 873 were missing as of April 5, 2011. According to IOC (Intergovernmental Oceanographic Commission)/UNESCO Bulletin No. 17, as of April 5, 2011, the tsunami height (run-up) was 18.4 m at Onagawa port determined by Port and Airport Research Institute; tsunami height at Onagawa Hospital was 17.4 m, Town Office 13;5 m and Takenoura 9 to 12 m.

The town is surrounded by hills on three sides and open to the sea only on side (Fig. 1). The X-X cross section forms a U-shape valley; high altitude Zone A and intermediate altitude Zone B surround the low land Zone C in a horseshoe shape. The altitude of Zone C also increases with distance from the shore (see Y-Y cross section).

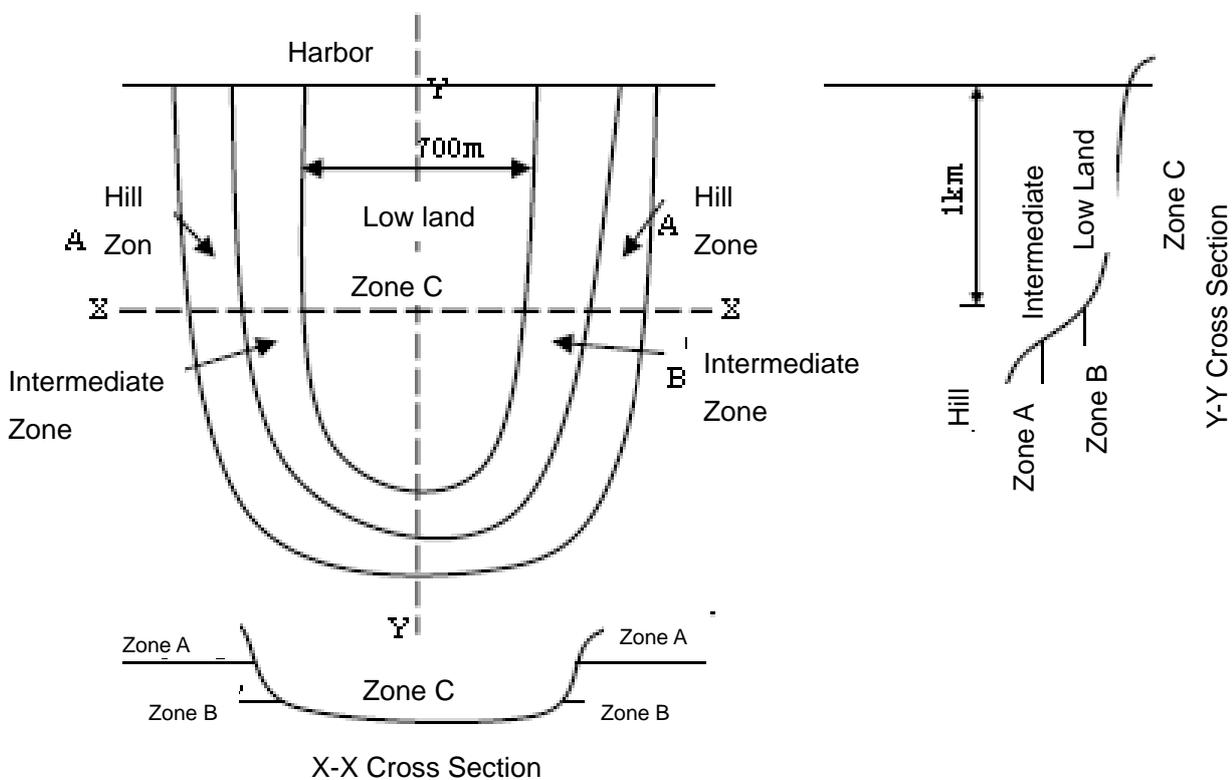


Fig. 1: Plan view and cross sections of Onagawa-cho (Zones A, B and C)

The damage in the three zones is as follows;

Zone C (low land): Timber houses were totally destroyed, but those at 1 km from the shore did not suffer damage. Reinforced concrete (RC) and steel buildings were standing.

Zone B (intermediate high land): Lightly damaged and no damaged houses survived tsunami.

Zone C (high land): Most timber houses suffered no damage.

Onagawa Daiichi Elementary School is located on a hill at the approach to Onagawa-cho (Photo 1, No. 1

in Map B). No damage was observed in the school building (Photo 2). Temporary houses (Photo 3) were under construction on the play ground of the school. Tsunami wave reached the road just beneath the school (Photo 4). Those houses, protected by concrete block walls at the periphery of the lot, survived without damage (Photo 5). The area near the school is on the hill, and damage was very limited (Zones A and B in Fig.1) . As one moves toward the port, the damage view changed significantly.



Photo 1: Onagawa Daiichi elementary school



Photo 2: No damage in the school building.



Photo 3: Temporary houses were under construction on the play ground.



Photo 4: Tsunami wave reached the road beneath the school..



Photo 5: Houses protected by concrete walls suffered no damage.

Onagawa High School near the elementary school is also located on the hill (Photos 6 and 7, No. 2 in Map

B). Photo 8 shows the gymnasium. Window glasses were broken (Photo 9). Photo 10 shows the school building, and no damage was observed. Photo 11 shows north view; shear cracks were seen on a mullion wall. In only one column with a wing wall suffered a shear crack.



Photo 6: Onagawa High School.



Photo 7: Onagawa High School is located on a hill.



Photo 8: Window glasses were broken in the gymnasium (1).



Photo 9: Window glasses were broken in the gymnasium (2).



Photo 10: The school building suffered no damage.

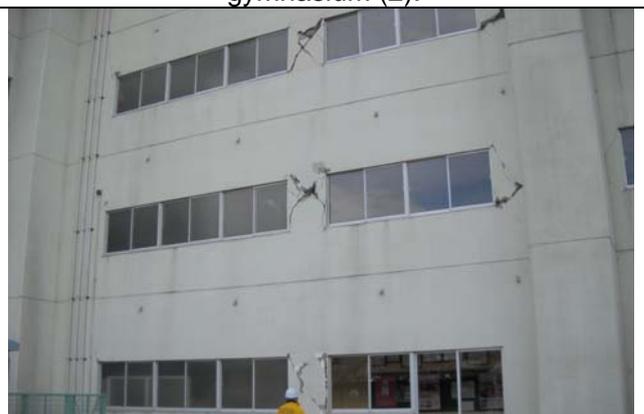


Photo 11: Shear cracks in mullion walls in the north.

As one moved downward to Zone B of the Onagawa port, the damage increased (Photos 12 and 13, No. 3 in Map B). The place where tsunami wave reached 1.8 m high just to the eaves of a timber house, the damage became obvious (Photo 14). The inside of the house was totally wrecked by the tsunami (Photo 15). However, houses remained standing. There were some places high enough to avoid tsunami waves

(Photo 16).



Photo 12: Damage increased with descending height (1)



Photo 13: Damage increased with descending height (2)



Photo 14: Damage became significant as the tsunami height reached approx. 1.8 m.



Photo 15: In the area where tsunami wave reached 1.8 m high, the first story was wrecked.



Photo 16: Not much damage in houses on the hill side in Zone B.

When one moved further down toward the port, the damage of houses by tsunami attacks increased and some houses collapsed in this area (Photo 17, No. 4 in Map B). Some houses were standing and others collapsed; the area is called Zone B.



Photo 17: Some houses were standing and others collapsed in Zone B.

Further toward the port, all timber houses were washed away and heavily damaged (Photos 18 and 19, No. 5 in Map B). Such area is called Zone C. There were sidewalks sloping upward and houses at higher locations were not damaged by tsunami (Photo 20). Such higher places may be classified to be Zone B. Photo 21 shows a building of reinforced concrete construction in the first story and timber construction in the second story in the midst of Zone C. This may be a good example for a tsunami resistant structure.



Photo 18: Most timber houses were washed away in Zone C (1).



Photo 19: Most timber houses were washed away in Zone C (2).



Photo 20: First story RC and second story timber house in Zone C.

Houses at intermediate altitude remained standing, but some were damaged. Most houses located in low elevation were total loss (Photos 21 to 23). A reinforced concrete building located in a slightly higher altitude suffered no damage (Photo 24). The tsunami height was estimated to be approx. 10 m. All timber houses were totally lost toward the port in Zone C (Photos 25 to 28).



Photo 21: Total destruction of houses in low land (1).



Photo 22: Total destruction of houses in low land (2).



Photo 23: Total destruction of houses in low land (3).



Photo 24: Undamaged reinforced concrete condominium buildings on slightly higher altitude



Photo 25: Totally destroyed houses in Zone C (1)



Photo 26: Totally destroyed houses in Zone C (2)



Photo 27: Totally destroyed houses in Zone C (3)



Photo 28: Totally destroyed houses in Zone C (4)

As one moved closer to the port, one could see more buildings standing (Photo 29); they were either reinforced concrete or steel construction.



Photo 29: Reinforced concrete and steel structures remained standing near the port.

Photo 30 shows the three story reinforced concrete Marinpai Onagawa building (sight-seeing spot), approximately 100 m from the harbor (No. 6 in Map B). Photo 31 shows the sea-side view of the building; the corridor connecting the adjacent buildings was washed away.

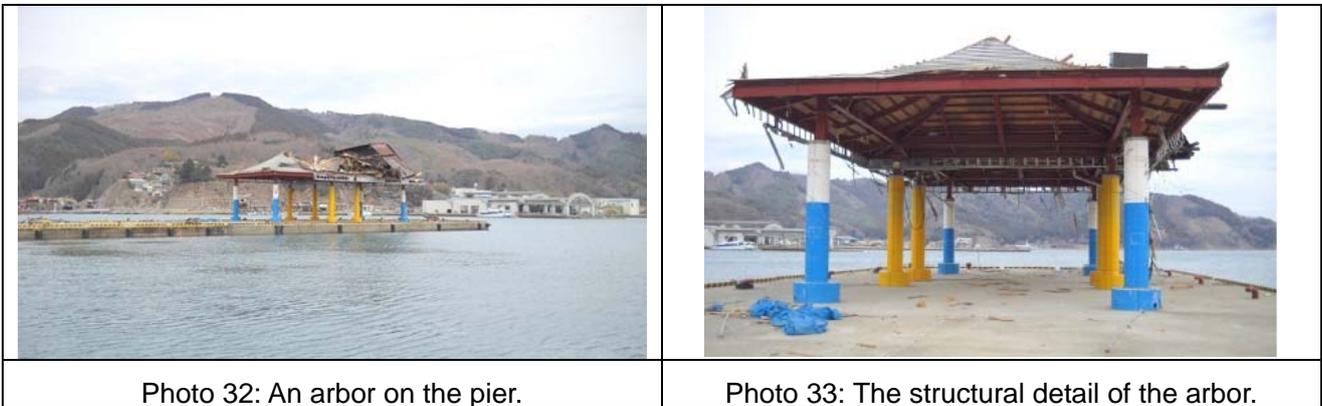


Photo 30: Sea-side view of the Marinpai Onagawa building



Photo 31: The corridor between the two buildings was washed away.

Photo 32 shows a pier sticking out to the shore. A simple steel arbor remained standing on the pier. Photo 33 shows the detail. Tsunami wave must have passed over the arbor, but no damage. This is an example that a structure with thin members can survive tsunami attack.



In the neighborhood of the Onagawa Harbor, there remained many reinforced concrete and steel buildings (Photos 34 to 37, No. 7 in Map B).



Photo 38 shows a four-story reinforced concrete condominium building near the harbor (No. 8 in Map 8).

The tsunami wave reached the third floor of the building. The tsunami wave height was estimated to be approx. 8 m on this site. Some rubbish can be seen at the corner of roof; the tsunami height could be higher. Near this building, there was a railway line (Photos 39 and 40, No. 9 in Map B). The rail was completely destroyed.



Photo 38: A four-story RC condominium.



Photo 39: Railway near the condominium

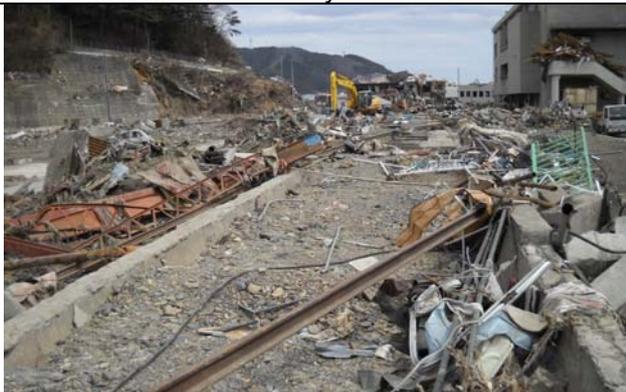


Photo 40: Rail was destroyed.

Some reinforced concrete buildings collapsed in this area (No. 7 and 8 in Map B). The collapse was not due to the failure of structural members, but entire buildings were overturned (Photos 41 to 43). The reasons for the collapse needs to be studied.



Photo 41: Overturned RC buildings (1).



Photo 42: Overturned RC buildings (2).



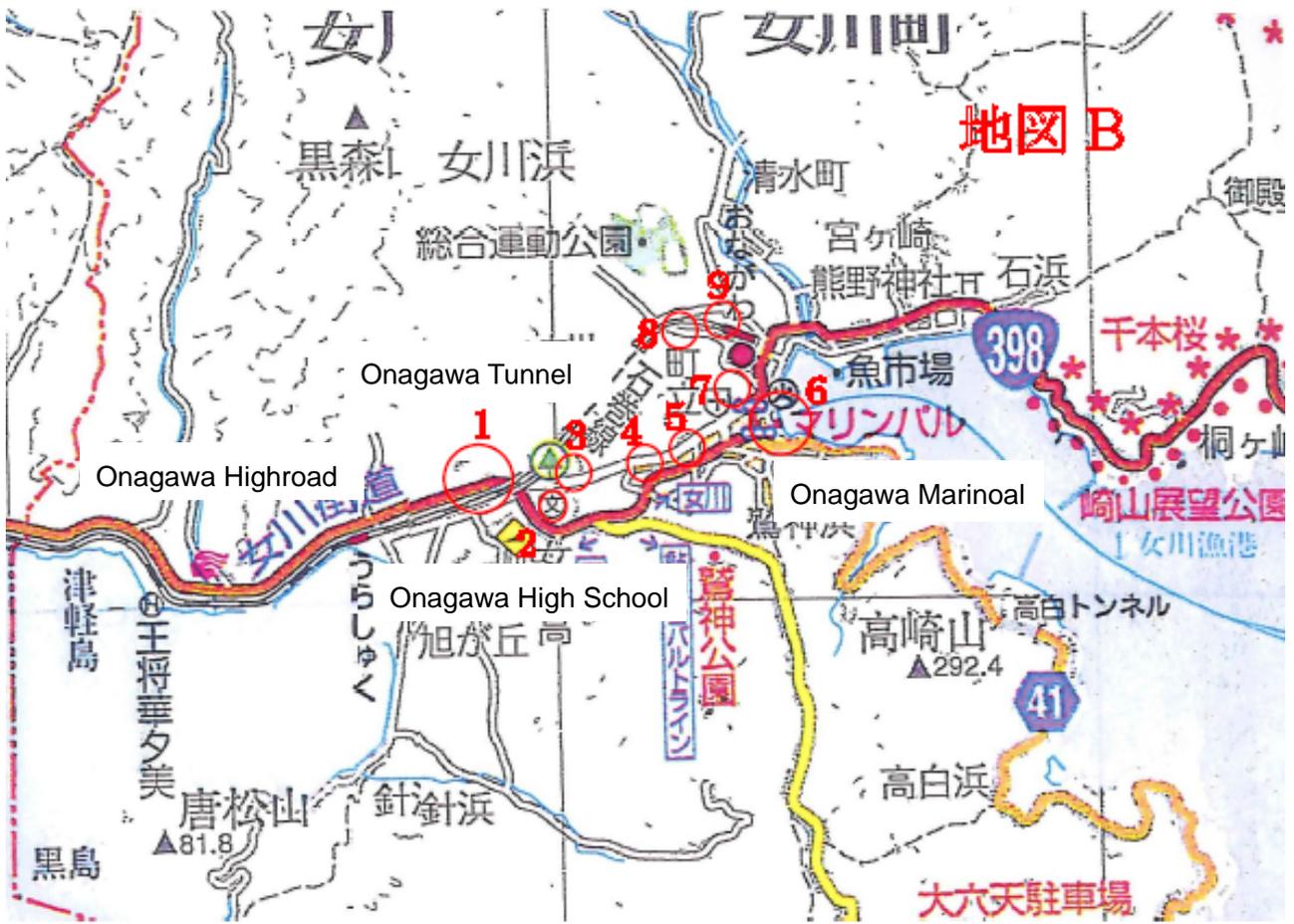
Photo 43: Overturned RC buildings (3).



Photo 44: Overturned RC buildings (4).



Map A



Map B