

PILES FOR RC/STEEL-FRAME BUILDINGS PULLED UP BY TSUNAMI AT ONAGAWA TOWN, IN THE MARCH 11th 2011 EAST JAPAN EARTHQUAKE

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ABSTRACT: The entire stretch of indented Tohoku-Pacific coast was seriously engulfed by tsunami caused by the East Japan earthquake on March 11th, 2011. One of the most noteworthy events seen in Onagawa was that piles supporting RC and/or steel-frame buildings were uprooted, and the buildings were carried over several ten meters distances. This report describes details of the tsunami-driven four buildings.

Key Words: East Japan earthquake, Tsunami, RC/Steel-Frame building, Piled foundation

INTRODUCTION

Onagawa town was one of the most seriously tsunami-engulfed towns/cities along the Sanriku indented coast line. It was shocking that RC and steel-frame buildings with pre-stressed high-strength concrete piles were uprooted at several locations in Onagawa, all the more pile-supported RC and/or steel-frame structures had been considered to be possibly good for tsunami shelters. Identifying its causes will need thorough investigations that may take some long time, but simultaneously current states of the tsunami-driven buildings are to be recorded with accuracy before they are cleared up.



Figure 1 Location of Onagawa Town (after Google Terrain Map)

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TSUNAMI DRIVEN PILE-SUPPORTED BUILDINGS

The tsunami reached about 15m in height at this town and surged 1km inland, destroying its downtown center spreading along two major valleys of late Pleistocene to Holocene marine and non-marine deposits¹⁾, leaving over 1000 people missing, with over 300 confirmed dead.

Figure 2 shows the downtown center of Onagawa, facing Onagawa Bay. There were at least four pile-supported buildings found toppled and /or carried over some distances. Piles are all of PHC (Pretension type centrifugal High strength pre-stressed Concrete) type.

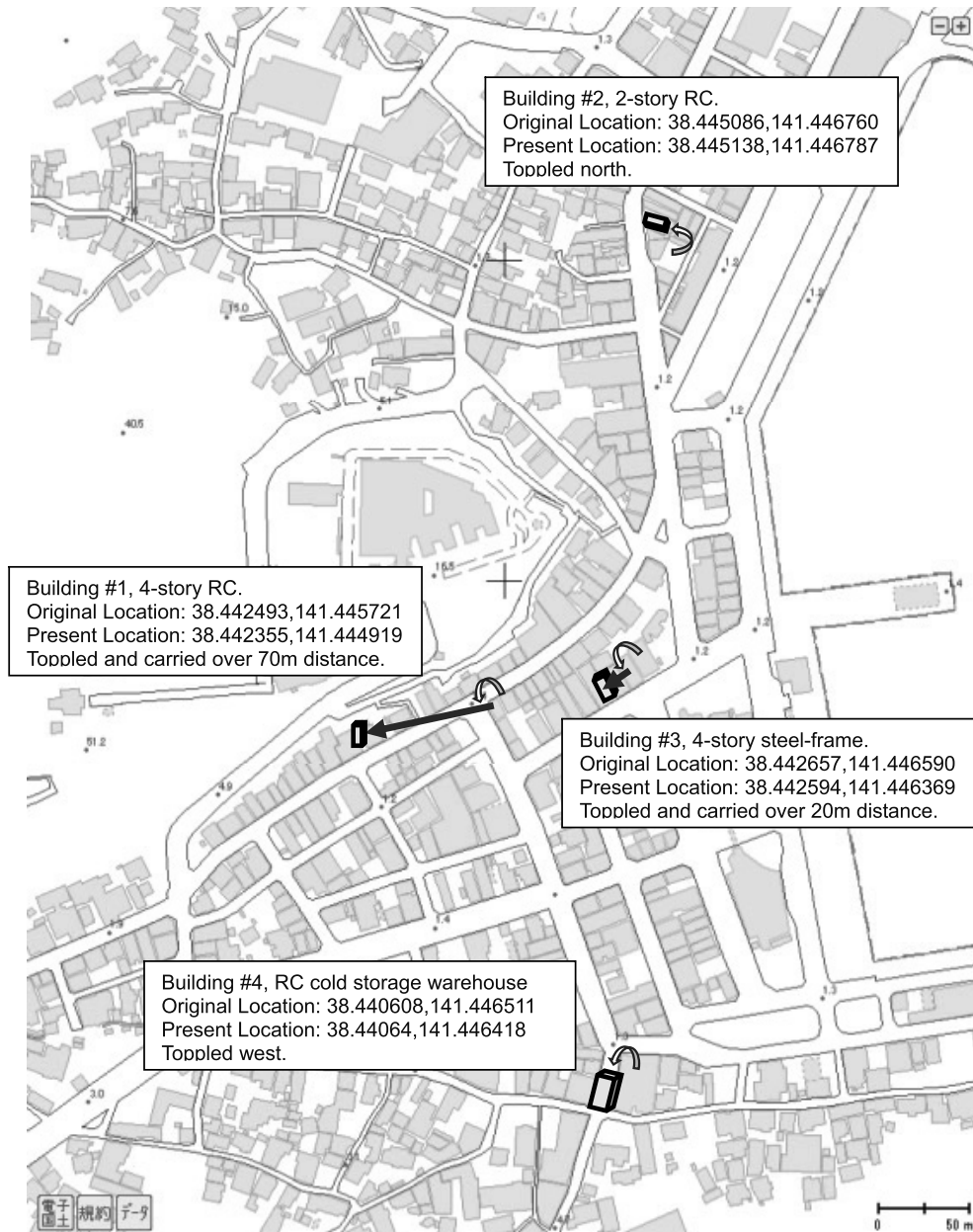


Figure 2 Locations of uprooted pile-supported buildings in Onagawa (after Cyber-Japan²⁾)



Figure 3 Original location of Building #1 (38.442482, 141.445728): This 4-story building was carried over 70m distance to the west.

Building #1 was a thin and tall 4-story RC building (5.6m wide, 5.6m deep and 14.5m high) at N38.442482, E141.445728, which was carried over a 70m distance and lying west-face down with its bottom pushed against the cut-hillside of Onagawa Hospital (see Figure 4).

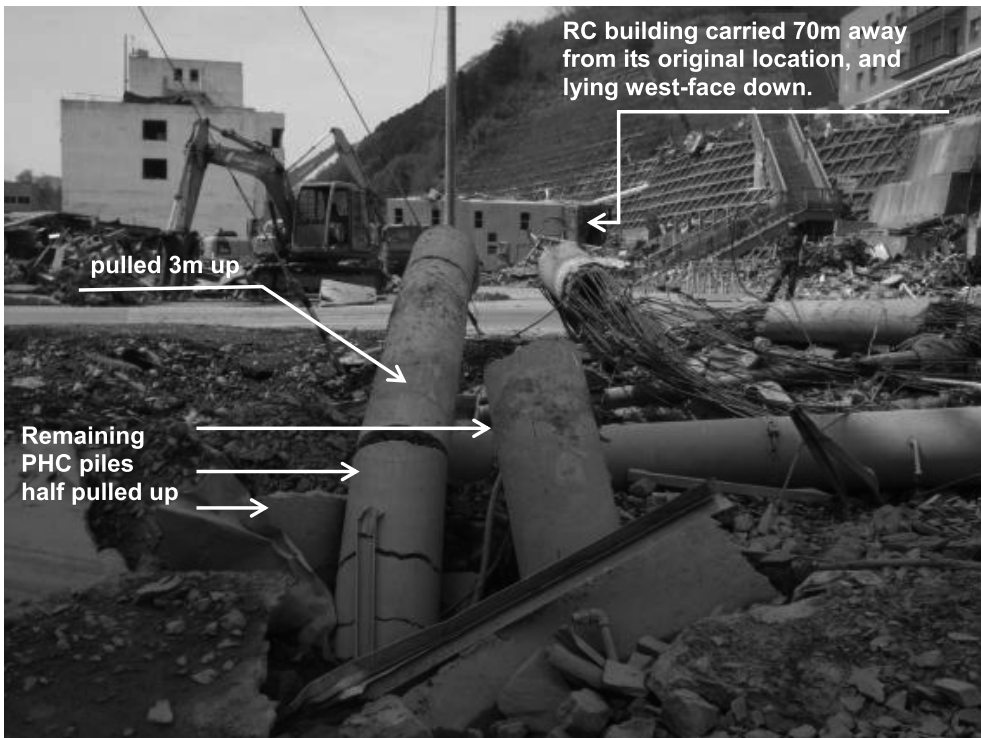
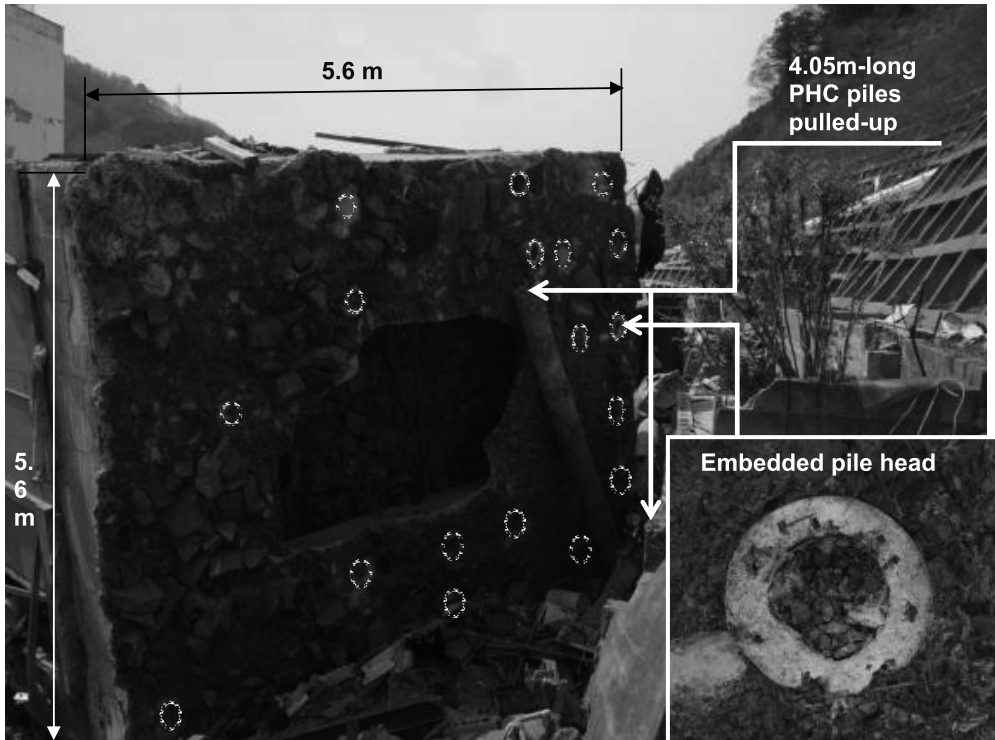


Figure 4 Bottom of foundation for Building #1 and piles left half-embedded in soil

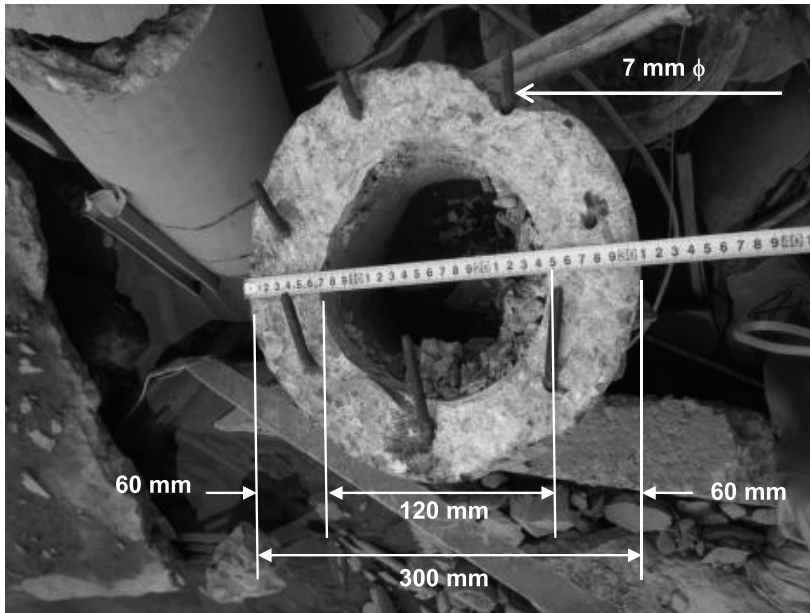


Figure 5 Fracture surface of PHC pile for Building #1: A fracture cross-section of PHC (Pretension type centrifugal High strength pre-stressed Concrete) pile used for Building #1, 300mm and 120mm in outer and inner diameters respectively, has 7 PC wires exposed with cut ends thinning to about 4mm diameter.



Figure 6 Toppled Building #2 (Onagawa Police Box, Original location at 38.445086,141.446760): Onagawa police box was overturned north. Piles were broken and upper halves of them were uprooted. There is a dent on the roof indicating that something massive was pushed against it.

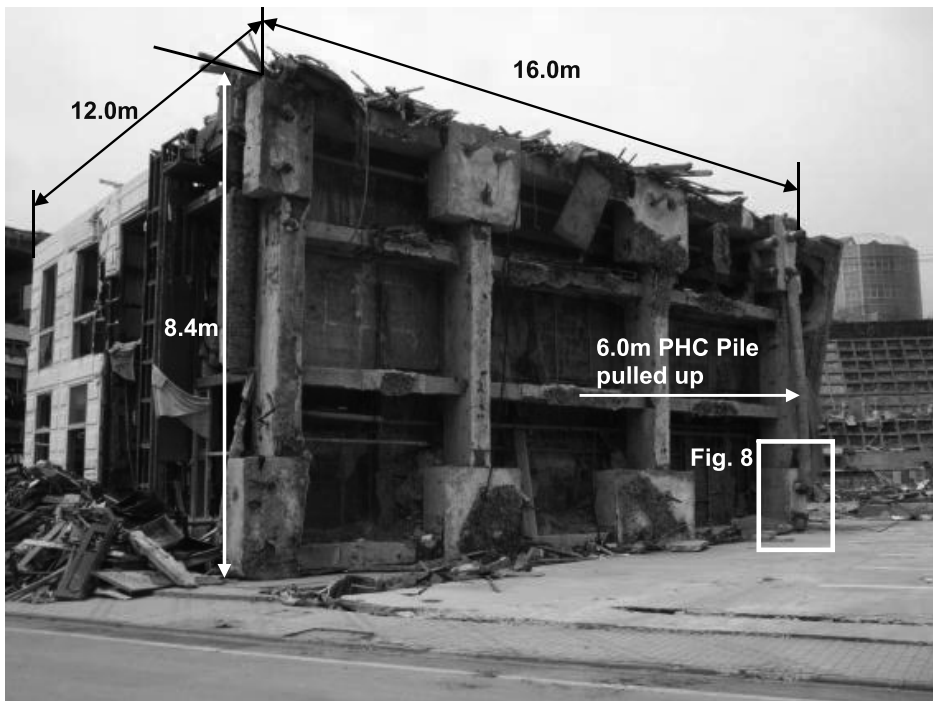
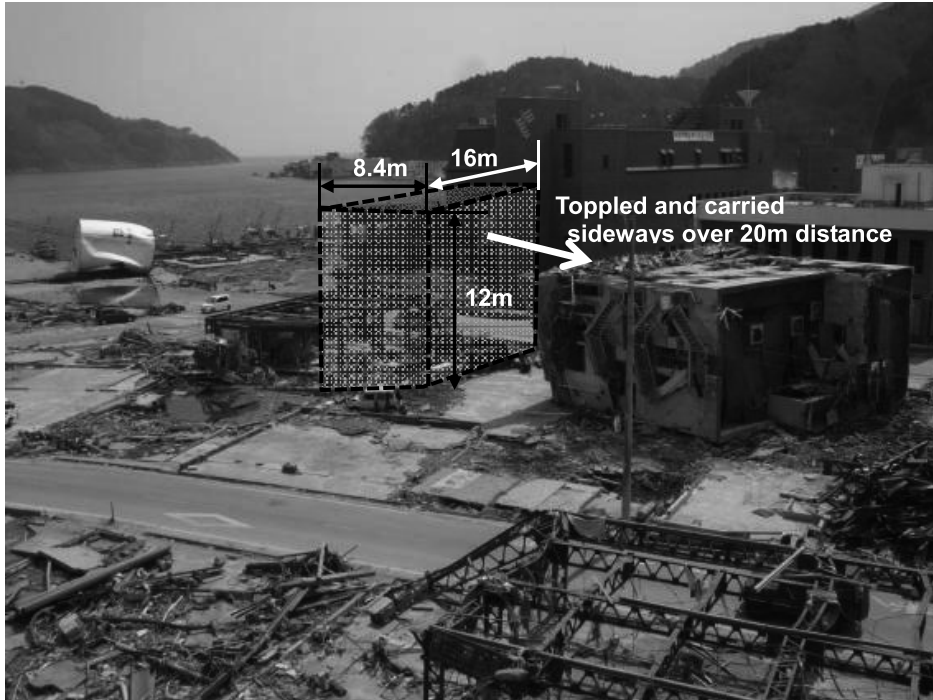


Fig. 7 Building #3 (Original location at Original Location: 38.442657,141.446590), A steel frame 4-story building was toppled and carried sideways over about 20m distance. A PHC pile of about 6m long is found hanging down from the upper right corner.

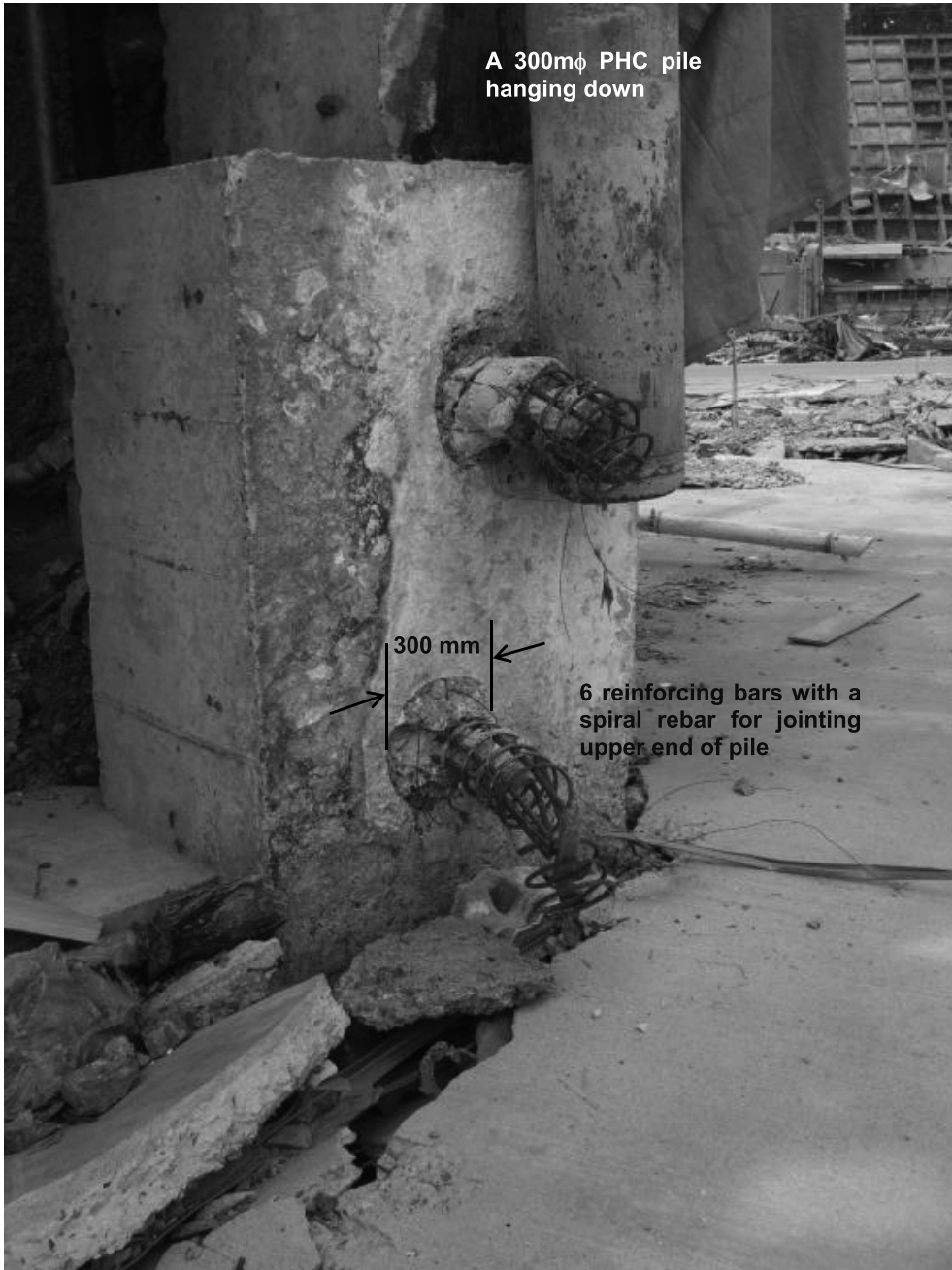


Figure 8 Detail for Jointing pile heads for Building #3: Detail of rebars for jointing a pile head was exposed. There are 6 rebars coiled in a spiral bar for each pile head.



Fig. 9 Building #4: toppled west from its original Location at N38.440608, E141.446511. This was a steel-frame cold storage warehouse for fishes and seafood products. Dim marks of pile head are seen indicating the building was just resting on piles. This warehouse had a small door/window aperture.

SUMMARY

There were at least four pile-supported buildings toppled and /or carried over some distances in Onagawa. They were mostly supported by PHC piles of 300mm diameter. Jointing details of the PHC pile heads differed from building to building. Some were identified as fixed ends (Buildings #1, #2), and others were more likely moment-free ends (Buildings #3, #4). Building #1 took the longest drift over 70m distance dragging at least two piles. According to the geological map, the town center spreads over late Pleistocene to Holocene marine and non-marine deposits. However, detail soil profiles for the original locations of these buildings are not known yet, with all locations covered thick with tsunami debris. Further investigations are now being planned.

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