

## ON THE SHELTER EFFECT OF COASTAL FOREST AGAINST TSUNAMI

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# ON THE SHELTER EFFECT OF COASTAL FOREST AGAINST TSUNAMI

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Several houses have remained standing behind the coastal forests, despite most of the coastal forests having been knocked down or swept away due to the Tohoku Region tsunami that occurred on March 11, 2011. Some of this is due to the robust strength of the houses themselves, but there are also cases where they are clearly judged to be due to the tsunami reduction effect of the coastal forest. This research, based on the aerial photographs taken after the tsunami, studies some examples of houses located behind the coastal forest that have been able to withstand the tsunami flow and discusses the existence of tsunami - reducing effects of the coastal forest.

**Key Words :** *tsunami, coastal forest, Tohoku tsunami, tsunami inundation depth, tsunami mitigation*

## 1. INTRODUCTION

The establishment of coastal forests to function as a component of tsunami disaster prevention was promoted in the Tohoku region, especially on the coast of the Sendai Plain, as the coastal forest acted to reduce the Chile earthquake tsunami that came in 1960. Shutho (1985) summarizes the mitigation effects of coastal forests on tsunamis. However, it is also stated that the disaster prevention function of coastal forest against tsunami may be lost depending on the scale of the tsunami.<sup>1)</sup>

On the coast of Sendai City in Miyagi prefecture, a 500-meter wide coastal forest zone had been built, but the Tohoku district tsunami destroyed most of the region's coastal forests into driftwood and most of the houses behind it were swept away, leaving the foundation or basement parts to remain.<sup>2)</sup> However, examining the situation in detail, after the disaster based on aerial photographs, several cases were confirmed which included the existence of houses that avoided being swept away in places where the vegetation belt remained somewhat intact.

In this research, we show the relationship between the remaining coastal forest and the houses left behind, using cautionary aerial photographs (released by Google Earth) taken after the disaster.

## 2. ANALYZING RESULTS AND DISCUSSIONS

The survey area is along the coastal area of Sendai City, Miyagi prefecture, as shown in Figure 1. It has been reported that the height of the tsunami reached 10 m in this area.<sup>3)</sup> Photo 2 was taken directly at the site, and shows the damaged state of the houses. Leaving only the foundation parts, most of the houses were swept away in the area. In the distance of the photo, we can see several parts of the remaining

coastal forest.

Photo 3 is an aerial photograph showing the damage situation on the coast of Sendai City, focusing on the positions of ① to ④ shown in the figure, and the comparison of the situations before and after the tsunami is shown below. In the comparison, aerial photographs released by the Google Earth (April 4, 2010 and April 6, 2011) were used.

In Photos 4 to 7, the left and the right sides show the situations before and after the disaster individually. As shown in Photo 4, around the point of ①, it is a residential area but there is no coastal forest on the sea side. Most of the structures in this area were swept away.

Around point ② shown in Photo 5, the houses collectively avoided run off. Most of the coastal forest was swept away but the density of the remaining coastal forest is high in places where the houses located behind also remained in place during the tsunami. In Photo 6, the point of ③ is an area where a residential land zone was close to the coastal line; almost all the houses as a result were swept away. However, in the upper left portion of the photo, it was possible to confirm several houses remaining behind the forest zone, which is about four times of the size of the right area. The remaining houses exist along the streaking patches of trees that endured against tsunami.

Photo 7 shows the interspersed patches left in a comb shape and the houses remained along directions extending from them. The parts where the frontal trees of the coastal forest endured the tsunami tend to be selectively remaining in a streak shape by its own shelter effect.

## 3. CONCLUSIONS

Using the aerial photographs released by Google Earth, we investigated shelter effects of the coastal forest against tsunami by comparing the states of the pine trees and houses before and after the tsunami.

As a result, several houses were found to survive behind the remaining coastal forest, suggesting a tsunami-reducing effect. Differences in the degree of damages were found by the existence of coastal forest zone and the residential land zone close to the coastal line. The site where the front of the forest stands resistant to the tsunami has a mechanism that the backside is selectively left in a form of a streak due to its own shelter effect, and there is a mechanism that trees are protected by themselves in a chain manner.

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**Figure 1** Location of study area



**Photo 1** The tsunami washing away the residential area beyond the coastal forest.



**Photo 2** The state of the most of the houses swept away, and left only its foundation parts. In the distance, several trees of the forest that endured against the tsunami can be seen.



**Photo 3** The coastal forest and the houses that remained after the tsunami



**Photo 4** Damages of the residential area where there was little coastal forest on the seaside front of it. (location ①)



**Photo 5** A part of the coastal forest and a part of the houses that escaped from the tsunami. (location ②)



**Photo 6** Photo 6. Damage to the residential area where the coastal forest had a short width (some houses remained on the left side where the width of the vegetation area was about four times of that of the right side. (location ③).



**Photo 7** Forest and houses that withstood the runoff of the tsunami (location ④). Trees are left in a comb shape and the houses remained along the directions extending from them.