EVALUATION OF THE RESISTANCE POWER OF THE MARITIME FOREST TO TSUNAMI IN TOHOKU REGION

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KEY WORDS: earthquake, remote sensing, satellite photograph, topographic map,

ABSTRACT

Tohoku region of Japan was seriously damaged by the big earthquake in March 2011 (the Tohoku Earthquake). Especially, the damage by the tsunami after the earthquake (the Tsunami) was so serious. Maritime forest is generally established around sea shore to resist tsunami damage and stone surge. Although, in Tohoku region, maritime forests had been established to resist tsunami damage, several parts of them were not well functioned when the Tsunami attacked the area. As the result of it, the areas inside of those forests were seriously damaged. So, it is important to review maritime forests of Tohoku never to suffer such a serious damage from tsunami. The difference of the efficiency of maritime forests against tsunami was caused by geographical features around maritime forests and tree species of them. The information about the situation of maritime forest of Tohoku region was collected using satellite images and topographic maps, and the tree species in maritime forests were investigated. The study sites of maritime forest were selected from the area where the heights of tsunami were reported almost same. We could find that the damages of maritime forest by the Tsunami were different although the heights of the Tsunami were same. After integrating and analyzing those gathered data, a plan of maritime forests is proposed.

1. INTRODUCTION

Tohoku region of Japan was seriously damaged by the big earthquake in March 2011 (the Tohoku Earthquake). Especially, the damage by the tsunami after the earthquake (the Tsunami) was so serious. In recent years, using maritime forests to resist Tsunami is remarked. The effect of maritime forests to lessen the energy of tsunami is known as the result of simulation[a], but maritime forests are originally designated as blowing sand break forests, wind break forests, tidal wave and salty wind prevention forests and so on by the Forest Act, and not made for the purpose of preventing tsunami. It is also not clear how much effect maritime forests have quantitatively to tsunami.

In this research, we examined the capability of maritime forests to resist tsunami targeting the areas where the Tsunami damaged from the point of the site conditions like sizes of maritime forests, geomorphological features, and so on. We selected the sites where the heights of the Tsunami were reported almost same, and evaluated the function of maritime forests to resist tsunami by investigating elevations, scales, positions and situations of hinterlands of each areas.

We referred to the paper of Toshiyuki Asano and Chikako Matsumoto (2009)[b], in this evaluating method.

2. METHODOLOGY

We interpreted various factors of maritime forests shown in Figure.2-1 like width of forests, distance from seashore and so on from satellite images. The elevation and position of maritime forests were obtained from topographical maps provided by Geospatial Information Authority of Japan. Then, we made the cross-section views which show the elevation profile of the sites, the position of maritime forests and settlements behind them using those data. The results are shown in Figure.3-2 to Figure.3-8 in the next chapter. The horizontal axis shows the distance from seashore, the vertical axis shows the elevation, and the value of y in figures shows the distance from the end of maritime forest. The images of houses or trees in figures show the distribution of them, although they do not show the real sizes nor density. The data of the Tsunami in each site are quoted from the result of investigation by Port and Airport Research Institute and Yoshinobu Tsuji of the University of Tokyo[c], showing the heights of the Tsunami from the ordinary tide levels. Damage levels of each maritime forest are quoted from the result of investigation by Forestry Agency[d].

Figure.2-1

name of maritime forest	Hachinohe	Kamaishi	Ishinomaki	Higashi-matsushima	Souma	Hirakata	Iioka
average of width of forest zone (m)	169.168	60.1	163.185	111.64	308.02	52.889	92.47
maximum width of forest zone (m)	267.04	60.1	236.42	207.45	491.07	113.08	149.42
distance from shoreline (m)	222.68	27.68	98.02	40.33	77.43	108	178.71
full length (m)	6701.48	335.43	1370.43	6252.45	4593.67	2927.82	3239.49
height of Tsunami (m)	8.4	9	7.7	7.7	8.9	7.2	7.6
damage level	～25%	25～75%	25%	75%	75%～	～25%	25～75%

3. Characteristic of each maritime forest

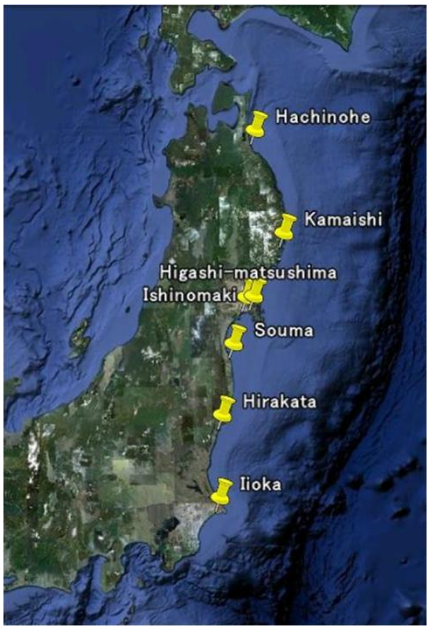

Figure.3-1

We selected maritime forests from the area where the heights of the Tsunami were reported almost same, and expressed the features of them as the establishment to resist tsunami. Then we evaluated the efficiency of them to real tsunami on the basis of the damage level of maritime forests reported by Forestry Agency. And we viewed what kind of maritime forests are effective in the prevention of tsunami. The positions of maritime forests which we selected are shown in Figure.3-1. The names of maritime forests are assigned by the authors for convenience from the name of neighboring area, which are different from the real names.

3.1 Hachinohe maritime forest in Aomori

Hachinohe maritime forest, in Aomori prefecture, is the biggest one in the maritime forests which are selected in this research. The full length of it is about 7 km. Figure.3-2 is the cross-section view at the point which is 2890m from the south end of this maritime forest. The height of the Tsunami at this point is 8.4m, but the damage level of the forest is lower than 25%. We considered the reasons why the damage level was low are that the elevation of the area of the maritime forest is high and the slope of it is steep. From Figure.3-2, it is clear that the elevation of the maritime forest is much higher than the height of the Tsunami and the slope at the middle point of the maritime forest is steep. So it is considered that this maritime forest is effective to resist tsunami.

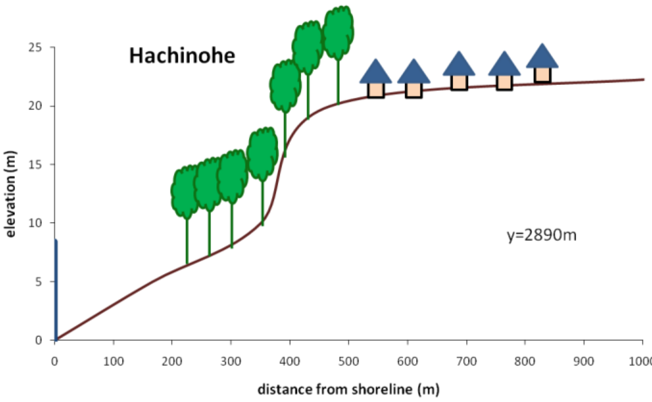

Figure.3-2

3.2 Kamaishi maritime forest in Iwate

Kamaishi maritime forest, in Iwate prefecture, is the smallest one in the maritime forests which are selected in this research. This forest extends in north-south direction. Figure.3-3 is the cross-section view at the point which is 220m from the south end of this maritime forest. The damage level of the forest

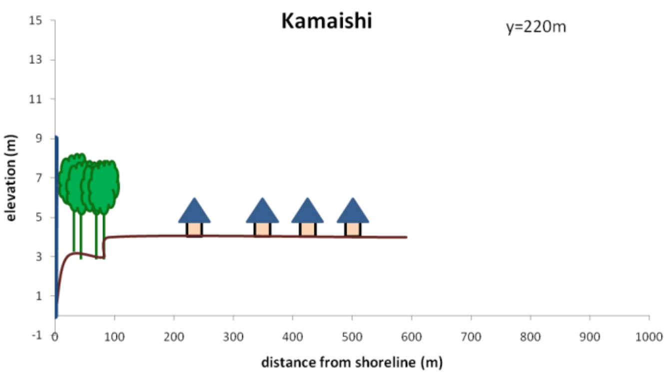

Figure.3-3

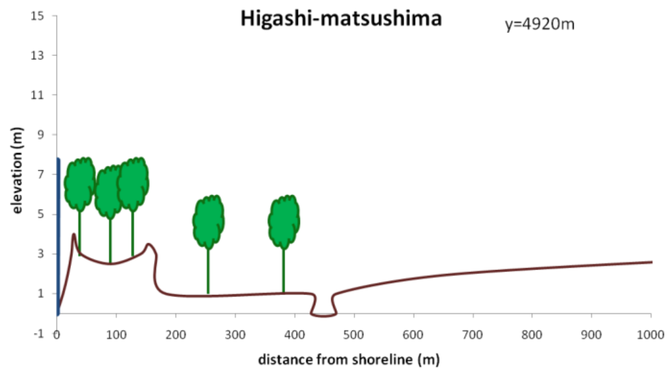

Figure.3-4

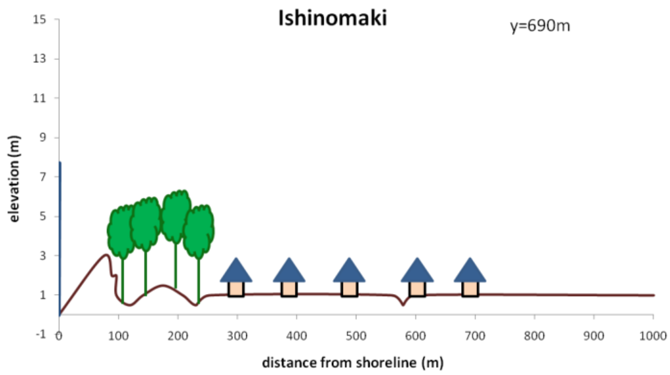

Figure.3-5

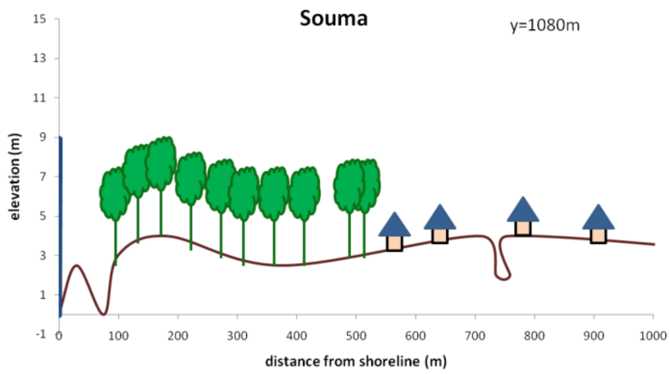

Figure.3-6

was higher than 75%, and almost all trees in this forest were knocked down. We consider the reasons why the damage level was high are that the elevation of the area of the maritime forest is lower than the height of the Tsunami and the width of the forest is narrow. In addition the slope to the hinterland is very gentle and it is considered that this maritime forest is not effective to resist tsunami.

3.3 Higashi-matsushima maritime forest in Miyagi

Higashi-matsushima maritime forest, in Miyagi prefecture, extends in northeast direction. The terrain of this area is very complex. Figure.3-4 is the cross-section view at the point which is 4920m from the south end of this maritime forest. The damage level of the forest was about 75%. We consider that the reasons why the damage level was high are that the elevation of the area of the maritime forest is lower than the height of tsunami and the density of trees is low. The hinterland is located more than 1 km far from this point, but almost all houses fell down. So, it is considered that this maritime forest has little effect to resist tsunami.

3.4 Ishinomaki maritime forest in Miyagi

Ishinomaki maritime forest, in Miyagi prefecture, is in the northeast of Higashi-matsushima maritime forest. This forest extends in east-west direction. Figure.3-5 is the cross-section view at the point which is 690m from the west end of this maritime forest. The damage level of the forest was about 25%. This damage level is much lower than that of Higashi-matsushima maritime forest although these two forests stand closely. We consider that the extending direction and the high density of this forest are the reasons of this low damage level.

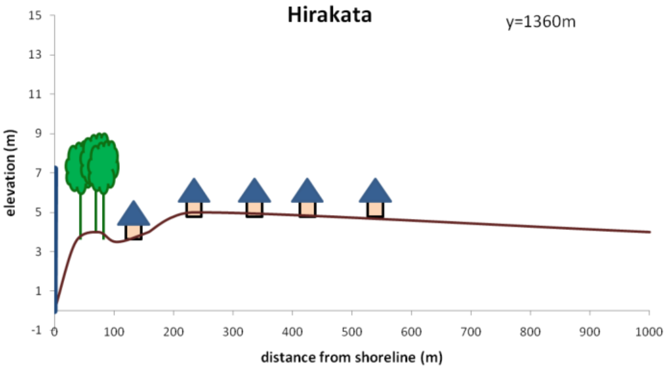

Figure.3-7

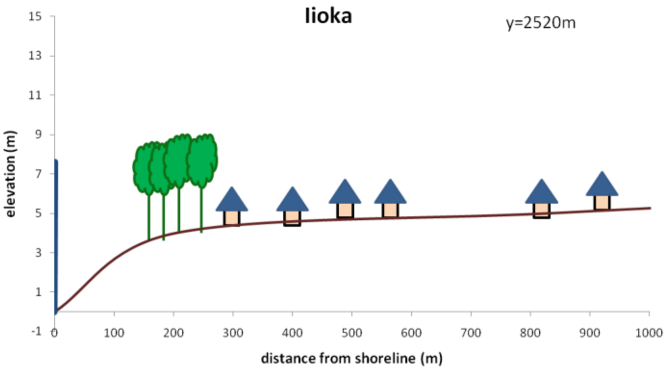

Figure.3-8

3.5 Souma maritime forest in Fukushima

Souma maritime forest, Fukushima prefecture, is very big scale in both full-length and width of forest, and extends in north-south direction. Figure.3-6 is the cross-section view at the point which is 1080m from the south end of this maritime forest. The damage level of the forest is higher than 75%, and almost all trees were fallen. We consider that the reason why the damage level is high is that the elevation of the area of the maritime forest is lower than the height of tsunami. We consider that the slope of the area is also the cause of the high damage level.

3.6 Hirakata maritime forest in Ibaraki

Hirakata maritime forest, in Ibaraki prefecture, is in the northern part of Ibaraki and extends in north-south direction. Figure.3-7 is the cross-section view at the point which is 1360m from the south end of this maritime forest. This maritime forest is the smallest one in the maritime forests which are selected in this research, and the elevation of this area is not so high. However the damage level was not so high. Although the reason of it is not clear, there is possibility that the wave dissipating concrete blocks which are settled along the shoreline are effective to resist the Tsunami.

3.7 Iioka maritime forest in Chiba

Iioka maritime forest, in Chiba prefecture, extends in east-west direction. Figure.3-8 is the cross-section view at the point which is 2520m from the west end of this maritime forest. The damage level of the forest was about 50%, and many trees were fallen. We consider that the reasons why the damage level was high are the low elevation and gentle slope of this area.

4. Result and consideration

The result of this research is summarized as blow.

・The higher elevation is, the stronger the ability of maritime forests to resist tsunami is.

・The steeper slope is, the stronger the ability of maritime forests to resist tsunami is.

・The more populated density of trees is, the stronger the ability of maritime forests to resist tsunami is.

・The ability of maritime forests to resist tsunami becomes strong dramatically settling wave dissipating concrete blocks in combination with maritime forests.

It becomes clear that there is close relationship between topographical factors and the ability of maritime forests to resist tsunami and it is effective to make dens maritime forests and settle wave dissipating concrete blocks for making strong the ability of maritime forests to tsunami.

But it is not easy to change topographical factors like elevation and slope. So, it is necessary to make den forest and settle wave dissipating concrete blocks in combination.

In the future research, we are planning to investigate the environmental situations like geology or vegetation of maritime forests with field survey and make clear the way to establish appropriate maritime forest management considering tsunami event.

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