

SURVIVAL OF SHRINES FROM THE 2011 GREAT TSUNAMI

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ABSTRACT: A massive earthquake with a magnitude of 9.0 occurred on March 11, 2011, and a powerful tsunami devastated a large area along Japan's eastern coastline. We investigated the tsunami damage using satellite images and aerial photographs, and visited damaged sites including 27 shrines near the coast in 2011 and 2012. It was found that all but two of these shrines survived the tsunami, even though the tsunami height differed from place to place. As a memorial to people who lost their lives in previous tsunamis, shrines were built on safe places where people can evacuate. Many of these shrines were undamaged because their elevation was higher than the tsunami height, and the lives of people who evacuated to the shrines were saved.

Keywords: 2011 Great Tsunami, tsunami damage, shrines

INTRODUCTION

A massive earthquake with a magnitude of 9.0 occurred on March 11, 2011, with an epicenter 130 km offshore of the Oshika Peninsula in Miyagi Prefecture (Fig. 1). After the earthquake, a powerful tsunami, which was generated by the abrupt crustal subsidence and uplift, devastated a large area along Japan's eastern coastline, which was extensively investigated by the engineers and scientists of JSCE (Joint Research Group of 2011 Great Tsunami of JSCE, 2011; Shibayama, 2011). The damage was particularly severe along the coasts of Iwate and Miyagi Prefectures, and damage also occurred on the coasts of Fukushima, Ibaraki and Chiba Prefectures (Fig. 1). After the tsunami, we also carried out field observations to evaluate the effect of the tsunami along the coasts. It was found that all but two of the 27 shrines built near the coastline that we investigated survived the tsunami, even though the tsunami height varied along the coastline, as shown in Table 1, which includes the ground elevations of shrines and tsunami heights measured near the shrines. In the tsunami-prone areas in northeast Japan, where families often have histories stretching back many generations, the lives of family members and their properties have occasionally been lost to tsunamis. As a memorial to people who lost their lives in previous tsunamis, shrines were built on safe places where people can evacuate. These shrines were mainly undamaged because they were built at elevations higher than the tsunami height, and the lives of people who evacuated from the tsunami to the shrines were saved. Here, we describe the cases of four shrines: Ootsuchinari (No. 5 in Fig. 1 and Table 1) and Kozuchi shrines

(No. 6) in Iwate, Gosha Shrine (No. 18) in Miyagi and Suwa Shrine (No. 20) in Fukushima Prefecture.

SHRINES IN OOTSUCHI CITY IN IWATE PREFECTURE

(1) Location and Tsunami Damage

Ootsuchi Bay is a deep bay with a slender shape in Iwate Prefecture. Ootsuchi City and Ootsuchi Port are located at the bottom of the bay. Figure 2 shows satellite images of Ootsuchi City taken on April 27, 2005 and April 1, 2011, before and after the great earthquake, respectively. Comparing both images, it can be seen that the tsunami inundated a large area of lowland along the Ootsuchi and Kozuchi Rivers, and destroyed all the houses built in this coastal lowland. The tsunami height

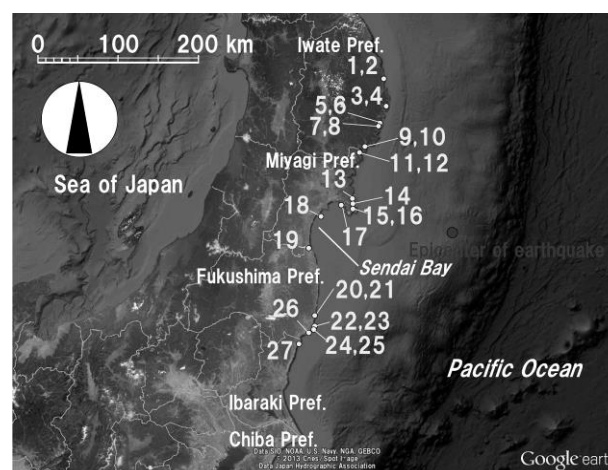


Fig. 1 Location of shrines in Iwate, Miyagi, Fukushima and Ibaraki Prefectures.

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Table 1 Locations of shrines, damage to shrines, ground elevations of shrines and tsunami heights.

No	Prefecture	Location of shrine	Name of shrine	Damage to shrine	Ground elevation of shrine (m)	Tsunami height (m)
1	Iwate	Taro, Miyako City	Dewa			12.5
2		Taro, Miyako City	Kumano			12.8
3		Oosawa, Yamada-cho	Uogahama		15.0	7.9
4		Yamada City	Konpira			8.5
5		Ootsuchi City	Ootsuchi-Inari			13.7
6		Ootsuchi City	Kozuchi			10.1
7		Unosumai, Kamaishi City	Unosumai			9.6
8		Ryogoku, Kamaishi City	Katsurashimizu-myojin			21.5
9		Nonoda, Oofunato City	Kamo		15.0	11.0
10		Matsuzaki-cho, Oofunato City	Hachidai-ryujin		17.0	14.0
11		Rikuzentakata City	Suwa			13.7
12		Rikuzentakata City	Imaizumi-tenmangu	☒		13.7
13	Miyagi	Ogatsu City	Niiyama	☒		15.5
14		Omaehama, Onagawa City	Kumano			13.0
15		Ishihama, Onagawa City	Kumano			13.2
16		Onagawa City	Yamatsumi			20.7
17		Ishinomaki City	Ikohayawakenomikoto		5.6	7.0
18		Shobuta Beach, Shichigahama City,	Gosha		9.7	8.6
19		Isohama, Shinchi-cho	-		17.7	16.2
20	Fukushima	Hisanohama, Iwaki City	Suwa		7.8	7.9
21		Hisanohama, Iwaki City	Inari		6.4	7.9
22		Usuiso, Toyoma, Iwaki City	Inari		10.9	8.6
23		Usuiso, Toyoma, Iwaki City	Usui			8.6
24		Toyoma, Iwaki City	Hachiman			10.6
25		Toyoma, Iwaki City	Suwa			8.7
26		Obama, Iwaki City	Nachi		6.7	6.2
27	Ibaraki	Ootsu	Tsuno		7.5	4.9

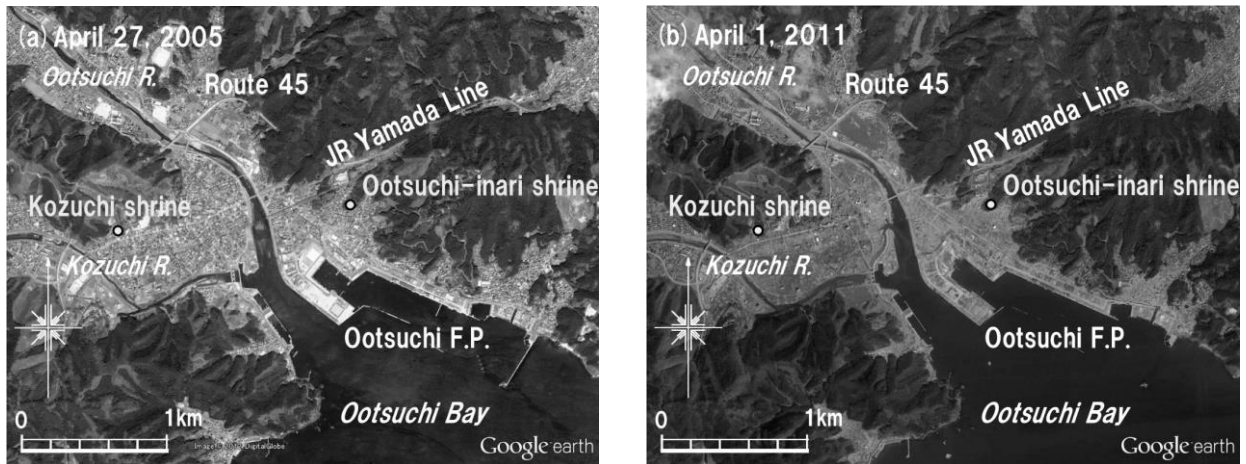


Fig. 2 Satellite images of Ootsuchi City and Ootsuchi Bay.

was 13.7 m above the mean sea level (MSL) in this area (Joint Research Group of 2011 Great Tsunami of JSCE, 2011).

Ootsuchi-inari Shrine is located at the southern tip of a hill extending southwestward from the mountains and is only 500 m from Ootsuchi Fishing Port, as shown in Fig. 2. Kozuchi Shrine is located at the south end of a hill separating the Ootsuchi and Kozuchi Rivers, which join each other at the mouth of the Ootsuchi River. Both shrines were undamaged by the tsunami, in strong contrast to the houses completely destroyed in front of these shrines. On July 20, 2012, we visited these shrines and interviewed the chief priest of each shrine to find out about his experience of the tsunami as part of our investigation.

(2) Case of Ootsuchi-inari Shrine

Figure 3 shows an overall view of the hill with Ootsuchi-inari Shrine located on top. The south side is protected by a high concrete wall, and the shrine is located on top of the hill and surrounded by dense forest. The chief priest living at the house, as shown by arrow A in Fig. 3, witnessed the tsunami on March 11, 2011 in front of his house. He testified that the Showa Great Tsunami in 1933 inundated land up to the first torii (an archway in front of the shrine), as shown in Fig. 4. When we carefully observed the surface of the concrete wall protecting the shrine (Fig. 4), many scars could be seen on the wall, which were made by driftwood scratching the wall, as shown by an arrow. The torii was carried away by the tsunami, but it was found undamaged in the next town. After the tsunami, it was rebuilt at the same location. The tsunami reached the second step below the top of the stairway, as shown by arrow B in Figs. 4 and 5, which was 12 m above the elevation of the intersection of the roads in the city, as shown by arrow C in Fig. 5.

Figure 6 shows an overview of Ootsuchi Fishing Port from the top of the stairway shown in Fig. 4. All the houses behind the seawall were completely destroyed. Approximately 1300 people were killed in Ootsuchi City and almost 500 people were still missing on July 20, 2012. Figure 7 shows a photograph of the east side of the shrine, which was taken from the same position as in Fig. 6, facing east. The houses built above the straight line shown in Fig. 7 belong to people who were moved to higher land after the Showa-Sanriku Tsunami in 1933, and they were left intact by the 2011 tsunami. In contrast, the houses built below the line were all destroyed by the tsunami.

Figure 8 shows an overview of the lowland that was inundated and the steep stairway from the precinct of the shrine. Both sides of the stairway were surrounded by Japanese cedars over 100 years old. Figure 9 shows the



Fig. 3 Isolated hill with Ootsuchi-inari Shrine.



Fig. 4 First torii of Ootsuchi-inari Shrine and many scars left on concrete wall.



Fig. 5 The tsunami reached the second step below the top of the stairway (arrow B).



Fig. 6 Seawall along Ootsuchi Bay and damaged area.



Fig. 7 Houses belonging to people who moved to higher land after the Showa-Sanriku Tsunami in 1933.



Fig. 8 Overview of lowland inundated to the second torii and steep stairway.



Fig. 9 Precinct of Ootsuchi-inari Shrine.



Fig. 10 Main shrine along with first, second and third torii of Kozuchi Shrine.

precinct of the shrine. According to the chief priest of the shrine, this precinct of the shrine was used as a refuge for 160 people after the tsunami, who stayed there for six months. Thus, Ootsuchi-inari Shrine not only survived the tsunami but also the precinct of the shrine was used as a refuge for many people of the town because of its location on top of a hill. The shrine worshiped at by the residents of the town for a long time saved the lives of many people.

(3) Case of Kozuchi shrine

Kozuchi shrine was founded in 1629. Figure 10 shows a photograph of the main shrine along with the first, second and third torii taken from the approach to the shrine. The first wave of the tsunami inundated land up to the first torii. Then, the second wave reached an elevation of 0.56 m below the level of the precinct of the shrine and 5.8 m above the elevation of the road, as shown in Fig. 11. Figure 12 shows the village in front of the shrine; the tsunami propagated along the narrow valley bounded by mountains from east to west. Figure 13 shows the main shrine. After the tsunami, approximately 200 people evacuated to the area in front of the main shrine.

The chief priest of the shrine testified that a large-scale fire occurred, which was ignited by the large amount of floating debris including cars immediately after the tsunami, and this fire reached the forest behind



Fig. 11 Tsunami height of second wave.

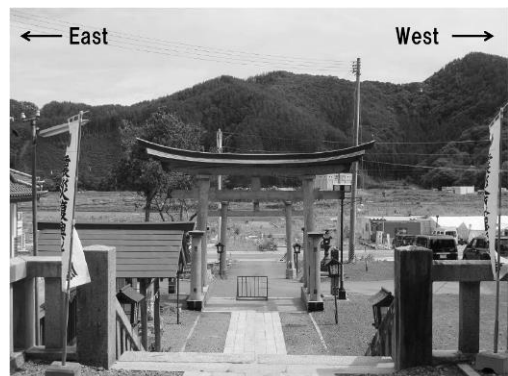


Fig. 12 Village in front of Kozuchi Shrine.

the main shrine covered with Japanese cedars. Although people moved to the back of the shrine to escape from this fire, the fire started to approach them. Therefore, most of the people climbed the steep slope of the mountain behind the shrine and escaped to the east from the fire. However, the evacuation of elderly people was difficult because of the very steep slope of the mountain densely covered by trees. Finally, five elderly people gave up their attempt to evacuate by climbing the mountain and stayed at the back of the shrine. As the fire approached the east of the mountain, the five elderly people removed the flammable dry leaves of the Japanese cedars to arrest the spread of the fire and they extinguished the fire using spring water from the back of the shrine. Figure 14 shows the charred remains of many trees on the mountain behind the shrine. The spread of the fire to the main shrine was prevented by the fire-fighting efforts. The chief priest of the shrine, who saved the lives of many evacuees, returned to the shrine on March 14, three days after the tsunami. First, he thought that the shrine would have been burned down by the fire. However, he found that the shrine was left intact owing to the effort of the five elderly people, who remained there and fought the fire.



Fig. 13 Main building of Kozuchi Shrine.



Fig. 14 Charred remains of many trees on mountain behind the shrine.

SHRINE NEAR SHOBUTA COAST IN MIYAGI PREFECTURE

(1) Location and Tsunami Damage

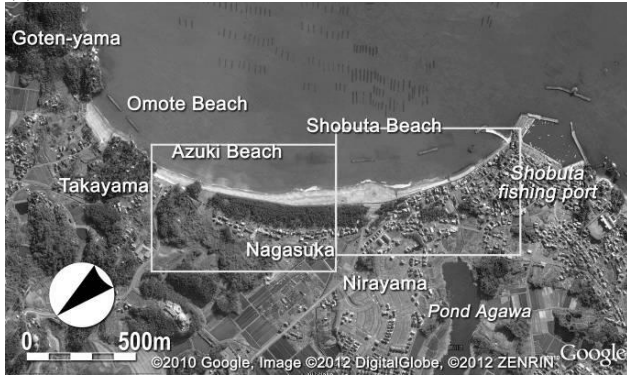
The Shobuta coast is located immediately north of Sendai-Shiogama Port in Sendai Bay, as shown in Fig. 1. Although this beach was a well-known beach for bathing near Sendai City, the coast was severely damaged by the tsunami (Uda et al., 2012). Figure 15 shows enlarged satellite images of the Shobuta coast. The study area is a pocket beach of 1.7 km length bounded by Shobuta fishing port and Point Takayama. In Fig. 15(a), the locations of Omote and Azuki Beaches are also shown along with the location of the Shobuta coast. In the northern half of the Shobuta coast, a dense coastal forest of 100 m width consisting of pine trees extended over a distance of 700 m as a protective measure against tsunamis, and two detached breakwaters of 100 m length and an artificial reef of 200 m length had been constructed offshore of the coast, resulting in the formation of cusped forelands owing to the wave-sheltering effect of these coastal structures.

A massive tsunami hit the coast, resulting in major damage to the coastal area and destroying many houses built along the coastline. The largest change was the destruction of the coastal dike in front of Nirayama Town owing to the currents of the returning tsunami, leaving a deep wedge-shaped scouring hole in the hinterland. The destruction of the coastal dike occurred at the opening of the detached breakwaters, implying the concentration of tsunami currents. Although the shoreline changes at Azuki Beach, north of the Shobuta coast, were small, the shoreline markedly retreated at Omote Beach, resulting in the disappearance of the beach of 50 m width. In the southern part of this coast, Agawa pond, which was surrounded by reclaimed coastal lowland, was markedly enlarged owing to tsunami inundation. The location of the destruction of the coastal dike corresponded not only to the mouth of a small river but also to the landward location of the artificial reef constructed in the opening of the detached breakwaters, implying that such a location with these characteristics is difficult to protect from a tsunami, in accordance with the results of Tanaka et al. (2011).

(2) Case of Gosha Shrine

On April 20, 2011, site observation was carried out on the Shobuta coast to investigate the tsunami damage. Figure 16 shows enlarged images of the rectangular area shown in Fig. 15.

(a) November 29, 2002



(b) April 6, 2011



Fig. 15 Satellite images of Shobuta coast taken on November 29, 2002 and March 14, 2011.

(a) November 29, 2002



(b) April 6, 2011



Fig. 16 Enlarged satellite images of southern Shobuta coast.

Figure 17, taken on top of the coastal dike facing north, shows the coastal condition. The tsunami flooded over the crown of the coastal dike, strong currents flowed down the back slope of the dike, and all the houses built along the coastal dike were completely destroyed, leaving only their foundations. An isolated hill surrounded by pine trees could be seen 150 m inland of the coastal dike, which seemed to be unaffected by the tsunami. On top of the hill is Gosha Shrine, which survived the tsunami, as did many shrines in other areas subjected to the large tsunami. Figure 18 shows the front of the shrine. Tsunami debris was scattered around the shrine, implying that the ground level was approximately equal to the tsunami inundation height. From this, the tsunami inundation height was measured to be +9.7 m above MSL at this location, taking the debris scattered around the shrine into account. The tsunami inundation height measured on the sand dune immediately south of Sendai-Shiogama Port, 5 km southwest of this shrine, was 15.6 m above MSL (Public Works Research Center, 2011). Even though such a high tsunami struck the shrine, the shrine survived.

Figure 19 shows the scouring hole formed by the overflow of the tsunami over the top of the coastal dike, where houses had been built before the tsunami, as shown in Fig. 16(a). All the houses were destroyed by the tsunami currents. Figures 20 and 21 show the site of the complete destruction of the coastal dike; a large hole



Fig. 17 Devastated houses with only their foundations left and Gosha Shrine located on top of isolated hill.



Fig. 18 Front of Gosha Shrine.

was formed by the tsunami currents that severely damaged the concrete coastal dike. Figure 22 shows a two-story house (indicated by arrow D in Fig. 21) severely damaged by the tsunami. A car and debris from other houses were carried into the rooms of this house.

SHRINE ON HISANOHAMA COAST IN FUKUSHIMA PREFECTURE

(1) Location and Tsunami Damage

Figure 23 shows satellite images of the Hisanohama coast taken on March 18, 2011 after the tsunami. This coast is a pocket beach of 3 km length located in the south part of Fukushima Prefecture and bounded by Hisanohama Port and Yotsukura fishing port at the north and south ends, respectively. The Hisanohama coast is the northern half of this beach. Fluvial lowland extends along the Oohisa River, and the residential area is concentrated in the south part of this lowland. Severe tsunami damage occurred in this lowland.

Suwa Shrine is located 170 m inland from the coastline, as shown in Fig. 23. Figure 24 shows the approach to the shrine facing the road, which extends from the first torii to the main shrine. The house built on the left of the approach was completely destroyed by the tsunami, but the main shrine survived. Figure 25 shows

the front of Suwa Shrine. The ground elevation of the shrine was 7.8 m above MSL. In general, shrines have a raised floor, and Suwa Shrine was built with a clearance of 0.8 m above the basement, as shown in Fig. 26. The chief priest of the shrine revealed that the tsunami flooded the clearance below the floor. Two reasons were considered as to why this shrine escaped tsunami damage: the basement of the shrine was slightly raised, and it had a raised floor with a clearance below the floor, as shown in Fig. 26. Finally, Fig. 27 shows the approach from the shrine to the sea. Even though this shrine was built at a location only 170 m from the coastline and was not built on top of a hill, it escaped tsunami damage.



Fig. 21 Destroyed coastal dike.



Fig. 22 Destroyed house and debris inside it.



Fig. 19 Tsunami damage immediately inland of coastal dike.



Fig. 20 Large body of water left behind coastal dike after its destruction.

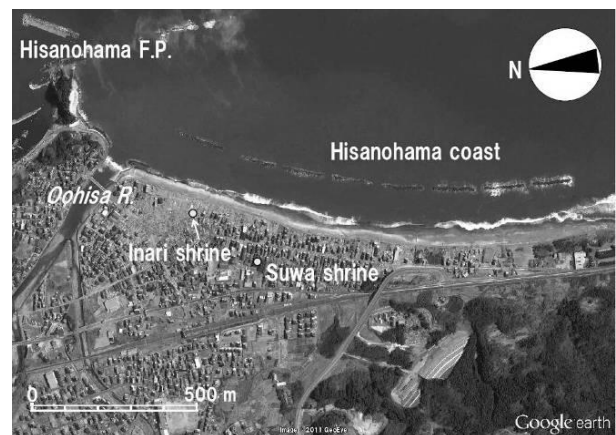


Fig. 23 Satellite images of Hisanohama coast in Fukushima Prefecture.



Fig. 24 Destroyed house next to Suwa Shrine.



Fig. 25 Main building of Suwa Shrine.



Fig. 26 Clearance under floor of the shrine.



Fig. 27 Scene looking from the shrine toward the sea.

CONCLUDING REMARKS

In this tsunami-prone area, where families had often lived for many generations, the lives of a number of people were lost every time a large tsunami inundated

the area. Such events were profoundly remembered in the local area, and people must have discovered the places where they could safely evacuate during a tsunami. However, even if such places were safe against a tsunami, their safety is not guaranteed against future larger tsunami. Therefore, safe places where shrines could be built were selected from sites higher than the height of past large tsunamis. Although a radio system for disaster prevention is presently employed in Japan, it is considered that the most reliable method of preventing tsunami disaster for a long time was to build shrines at locations where local people can safely evacuate from tsunamis, and such shrines have a role in reminding people of previous tsunami disasters for many generations. In this sense, it is meaningful that each shrine has long continued to exist in the local area.

As discussed in this paper, the precincts of such shrines were used for the evacuation of many people after the tsunami. In the case of Kozuchi Shrine, the spread of the fire to the main building of the shrine was prevented by the fire fighting efforts of five elderly people who gave up on further evacuation attempts. Although they were saved, it is noteworthy that they maintained calm judgment during the tsunami and subsequent fire, and successfully protected the shrine. Moreover, it should be remembered that shrines in local towns were protected by the efforts of local people, and that in the case of Suwa Shrine, the tsunami flowed through the clearance under the floor of the building without damaging the main shine. It is of interest that this method is also used as a modern measure against tsunamis, since shelter buildings with a raised floor are constructed to withstand tsunamis.

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