Coastal Structures in Kagoshima Coastline, Japan

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Report for International Training Program to improve the study ability in biodiversity

1.0 INTRODUCTION

Kagoshima is located at the southwestern tip of the Kyushu Island, Japan (Figure 1). It is home of 180000 population. Kagoshima total area is estimated about 546.71 km² form of 2,643km long of picturesque coastline. Generally this area is experience hot climate and its famous land mark is the impressive straovolcano, Sakurajima.

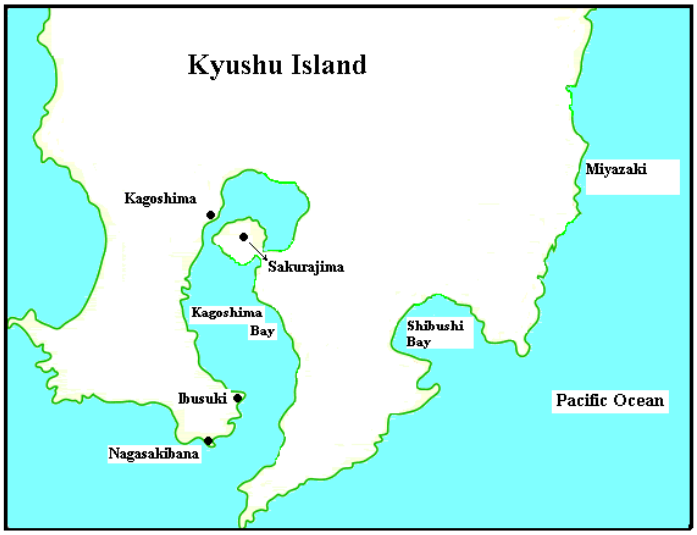

Figure 1: Location of the study area

Recently scientists predicted that the number and intensity of natural disasters has increased in many places in the world. Numbers of natural disasters were affected Kagoshima in the past. Kagoshima prefecture is surrounding by many active volcanoes such as Sakurajima which contribute to air pollution within these area (Iino, et al. 2006). Kagoshima has experienced on typhoon (Takata et al, 2004), heavy rainfall (Takahashi, 1996) and landslide and flood (Moriwaki, et. al. 1995). Other potential natural disasters are severe storms and tsunami from earthquake or landslide. Severe storm could contribute to shoreline erosion. Natural disasters contributed to the lost of life and properties, damage of public properties and ecosystems which affect to economy. The main purpose of this study is to identify how Kagoshima protects their coastline from natural disasters. The coastal assessments were conducted through the following activities;

1. Determine development a long the coastline
2. Identify coastal protection
3. Evaluate existing coastal adaptation

2.0 METHODOLOGY

Site visits were conducted from 17 July 2010 to 12 August 2010 (Table 1). During the visit, coastal development were determined based on the types of public facilities, historical places and housings a long the coastline. Existing coastal protection were also identified. Evaluate of existing coastal adaptation were carried out based on the published information (secondary data) such as evacuation areas, shelters scheme, effective warning and precaution, and hazards mitigating system.

Table 1: Program schedule between 12 July 2010 to 12 August 2010

No	Activities	Date (8/7-12/8/2010
1	Literature reviews	8-16 July
2.	Field surveys a. Shibushi Bay b. Sakurajima c. Kagoshima city d. Ibusuki/Nagasakibana e. Miyazaki bay	17-10 August 17 July 19 July 25 July 10 August 12 August
3.	Data analysis	26-30 July
4.	Results and discussion	2-12 August

3.0 RESULTS

Site Visit I: Shibushi Bay, Kagoshima Prefecture- 17 July 2010

1.0 Introduction

Shibushi Bay is located at eastern part of Kagoshima Prefecture. It takes about 2.5 hour from Kagoshima City (Figure 1). The bay formed sandy beach of about 14.2km of Kashiwabara coast. Southern part of the area is located the artificial island (approximately 22.5 km^2). Detail information of the coastal processes related to the artificial island has been explained by Nishi et al. (1998). There are numbers of important structures along the shoreline. Southern part of the Bay located a fishermen port and estuary of Kimotsuki River. This area is shaded by the artificial island and is the most affected by sedimentation processes. Littoral drift from the north accumulated the sediment in the southern part. Beautiful pine trees planted behind the sandy beach is important as natural habitats and as protection of inland area from strong wind. Shibushi bay is experiencing strong wind directly from the Pacific Ocean. The objective of this site visit was to observe the shoreline protections and investigate environment condition in that area (Figure 2).

2.0 Shoreline protection

Development of an artificial island in 1985 with size of 1.5km long to 1.5 km wide has changed the marine environment in Shibushi Bay. The size of the bay is about 16.8km long where 14.2km is a sandy beach. Some are is developed for small industries (dry fish industry) and public facilities (e.g ports and hospital). Northern part of the bay is Shibushi Port which is importance for the sea transportation in Shibushi city.

The Littoral drift from north to south of the bay has accumulated the sediment sheltered area created by the artificial island and other human activities (e.g development of ports and reduced of sediment supply from river. To solve this problem, number of shoreline protections has been set up along the bay as following;

1. 1 T shape groin

Groin has been developed to reduce the longshore sediment transport into sheltered area in the southwest. The groin block would prevent additional coastal erosion along the non sheltered beach. The groin has control about 60% of the sediment transport to the south of the area. Another groin is built near the estuary of Tabaru River located at northeast side of the bay. The groin is build to protect sediment accumulated in the river mouth especially strong waves. Sediment may prevent the water from river flow to the sea and create flood in the hinterland. During the site visit, small amount of sediment accumulated near the river mouth.

2. Submerge breakwaters

There were 4 submerge breakwaters installed in Shibushi Bay. The breakwater is important to reduce the wave energy to reach the shoreline. The wave energy will be slowed down in front of the breakwater and accumulation of sediment occurred in that shade area. Sandy beach is important as recreational area for local communities. Therefore submerge breakwaters were built to preserve the nature beauty of the area.

3. Beach nourishment

Beach nourishment in Shibushi Bay was the biggest in Japan. The sediment accumulated at sheltered area was transferred to erosion area in the north. The beach nourishment was conducted before the groins built to slow down the sediment transport to the south. Groin has reduced the littoral drift in Kashiwabara coast and reducing sedimentation processes in the south.

4. Revetments

Strong erosion is occurred almost along the sandy beach of Kashiwabara Coast. The local authorities did the best the can do to reduce the lost of sediment in that area such as built a beach revetment near the fish industry. Revetment consists of small rocks and nicely arranged inside the gabions. The revetment is arranged into 3 different layers to respond the different wave energy attacked the area. Soil planted by

grass is field up behind the gabion to form natural dune. The gabions are designed to protect the dry fish industry. During the site visit toe scouring is occurred at southern part of the gabion. Therefore, another stone structures is pleased in that area to prevent continuously the sediment loss in that area.

Revetments were placed along the Tabaru river bank. The shoreline protections are built in such way to defence the variable wave energy throughout the year. Wave energy is higher during the typhoons of the peak of summer (June-August) compared to winter. In the that time, wave direction is slightly southward direction with seaward wind direction. This area experience high waves from open sea. Tidal range is about 2.5m.

5. Coastal Trees Re-plantation

Re-plantation of trees is made in some areas of Shibushi bay. The small and new trees (mainly casuarinas trees) are protected with fences. The trees are essential to reduce strong wind from open sea of Pacific Ocean. Vegetated area is important to hold sediment of along the beach and reduce coastal erosion.

The beach of Kashiwabara coast is continuously maintained from natural disasters. No coastal development is observed immediately to the coastline except the Dry Fish Industry and the ports. The coastline is protected by man made structures from the sea (breakers), or built along the shoreline (revetment). Agriculture activities are separated with forested dune formed parallel to the beach.

Site Visit II: Sakurajima, Kagoshima Prefecture - 19 July 2010

Introduction

Sakurajima also literally means Cherry Blossom Island is symbol of Kagoshima Prefecture in Kyushu, Japan (Figure 3). It take about 15 minutes by ferry from Kagoshima ferry terminal (Kagoshima side) to Sakurajima port. Sakurajima was a small island with a circumference of 52 km in Kagoshima Bay. In 1914 eruption of Sakurajima was the most powerful in twentieth-century Japan. The lava gushed out from the volcano for about a month and connected the island about 400m wide with Osumi Peninsula. This year, the volcanic fumes rising from Sakurajima can be seen almost everyday.

Shoreline protection in Sakurajima

During the Sakurajima eruption 1914, lave was accumulated in the shoreline. Volcanic sediment and ash descends to the beach. Shoreline protection in Sakurajima has specially designed both to minimize wave action from sea and future eruptions. West side of the island is well protected by revetments. Sheltered area (embayment) are developed for ports facilities. Aquaculture activities such floating cages can be seen along the beach. Seawall was built at soft beach (e.g sandy beach), road or developed areas (e.g port and recreational area) and toe protection sometime place near the seawalls to protect scouring processes.

Coastal Development a long the coastline

Most of the Sakurajima shoreline consists of cliffs and narrow rocky shores. Development of fishing port and aquaculture activities conducted at sheltered area such as small bay. Most development is located near the Sakurajima Port to Kagoshima. The plan areas were mainly developed to support the tourist's activities such as hotels, schools and tourist information centre. Most agriculture and publics facilities are located in this area.

People reside in Sakurajima has responded and adapt to a major hazard from volcano eruption. Disaster prevention activities such as regular evacuation drills and Training of school children to use mask and bright hat for self protection has been introduce to the local community. Strong shelters are built along the main road or villages for people to take refuge

from falling volcanic debris. Precaution measures such as monitoring and prediction of Sakurajima large eruption are conducted as part of precaution program for the tourist visiting this area and for 680,000 residents of Kagoshima just a few kilometers from the volcano area. Some time the streets in Kagoshima city is covered with a thin layer of ash. The distribution of the volcanic ash is depending on the direction of the wind.

Site Visit III: Kagoshima City, Kagoshima Prefecture- 25 July 2010

Kagoshima is southern Kyushu's major city facing the Kagoshima bay. It is about 4 km separated from Sakurajiama (Figure 4). Good economic development need more space to support the increasing coastal population. Therefore, most of the Kagoshima coastline was extended into Kagoshima bay. The reclamation was carried out a few decades ago to build public facilities such as parks, transportation and ports. Most of the existing coastline now is protected by hard structures such as seawalls or revetments. Many of the original residence areas built near the foot of the hill or in the heart of the city. All river (e.g Kotsuki River and Inari River) and drainages banks within the Kagoshima city are also protected by revetment. Most of the man made structures along the river and shoreline are well maintained by local authorities.

Site Visit IV: Coastal area of Ibusuki- 8 August 2010

Ibusuki is located at entrance of Kagoshima Bay. The Ibusuki hot spring is famous tourists destination situated along the 5km coast on the southern eastern tip of the Satsuma Peninsula (Figure 5). That area is received windier and strong waves compared to Kagoshima city. Nagasakibana is a cape at the southernmost end of the Satsuma Peninsular in the southern part of Kagoshima Prefecture.

The shoreline from Kagoshima down to Nagasakibana is mainly protected by hard structures. Various shapes of revetments and breakwaters are found along the journey. The shoreline protections are built to protect the roads and some houses which are build along the narrow plan areas. During the strong wind and high waves, the water from sea flesh into the road or damaged the existing hard structures supporting the road. Therefore, wave breakers are built along the beach to reduce

wave energy reach the shoreline. Fisherman ports and other facilities were also protected by breakwaters.

Nagasakibana located at the most southern part of Kagoshima Prefecture. Lighthouse is built at the tip of the Nagasakibana to guide the ships to Kagoshima city. Beautiful beach is located in the right side. Rocky beach and cliff found facing the Kagoshima bay in the left. The beach is protected by submerge breakwaters. During the site visit, the existing revetment is built on the beach were coved by sediment.

Site Visit V: Miyazaki Beaches-12 August 2010

Miyazaki bay is located at Miyazaki Prefectures (Figure 6). It is located on the eastern coast of the island of Kyushu. The beach area is facing directly to the Pacific Ocean. Therefore, typhoon, waves and tsunami are some of the natural disaster affects this area. However, coastal construction such as port and dam are also contributing to the beach erosion. Many types of coastal protections have been built along the shoreline such as groin, beach nourishment and underwater breaker has been place on the beach to protect the beach from erosion.

The beach protection structures were designed based on the interest of both local communities and coastal engineers. The mild slope revetments were built in the recreational area so that the utilities of the beach can easily asses the area. The are numbers of groin placed perpendicular to the beach to reduce the littoral drift and transportation of the sediment to the south. The submerge breakwater are placed on the beach to reduce beach erosion and lost of sediment in between the two groins. Furthermore the is surfing activities would not affected by the submerge breakwater. Special designs of revetments are located in the certain part to support the turtle nesting area.

The northern part of the bay is Miyazaki port while the southern part is protected by Aoshima Island. It is about 1.5km circumference and play an important role to protect the Aoshima beach. Marine sports such as swimming, surfing, sailing and yachting are popular in this area especially in summer time.

Conclusion

Generally Kagoshima City and Sakurajima shoreline is located inside the Kagoshima bay and well protected by Osumi and Satsuma peninsulars. However, coastal reclamation were conducted in the Kagoshima city to support the demand of increasing development in this area. Therefore most of the shoreline is protected by seawalls. In the eastern part of the city is Iso swimming beach. It is beach nourishment to support the beach recreation areas. Some areas are protected by revetment to asses the waterline. All estuaries of the rivers are also protected by the stone revetment. Groins and breakwaters are built a long the beach to Nagasakibana to protect the roads, housing and fishing port.

Shibushi and Miyazaki bays are located at the western side of the Kagoshima Prefecture. These areas affected directly by the waves and wind from Pacific Ocean. The main problem of the beach in this area is coastal erosion but it is well maintained by the local government through beach protections.

Acknowledgments

This program is supported by the Japanese Society for The Promotion of Science (JSPS) under International Training Program to improve the study ability in biodiversity at Kagoshima University. Special thanks to Prof. Ryuichiro Nishi for his help and guidance during my stay in Kagoshima. Also, all of the members of Physical Oceanography Laboratory (Lusia Manu, Tommy Jensen and Arthur Thambas), Faculty of Fisheries, Kagoshima University for their accompany and help during fieldtrip to various places in Kagoshima Prefecture.

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Figure 3: Sakurajima

Eruption of Sakurajima

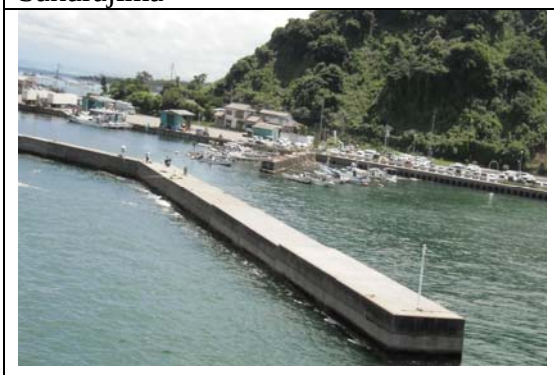
Some of tourists facilities in Sakurajima

Beautiful shoreline protection

Seawall toe protection

Rocky shore at certain part of Sakurajima

Aquaculture activities near at sheltered area



Shoreline protection near the port

Housing area in Sakurajima

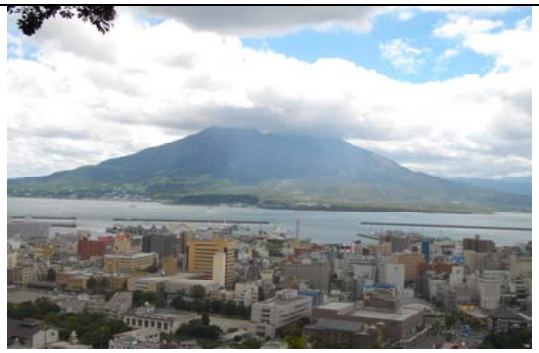
Figure 4: Kagoshima	
 Kagoshima city from Sakurajima	 Kagoshima from Shyroyama observation centre
 Popular beach nourishment area in Iso beach	 Shoreline protection at southern part of Kagoshima City
 Rocky beach next to seawall	 Shoreline protection of reclaimed Kagoshima area
 Formation of tombolo behind the wave breaker	 Beautiful design of protection

Figure 5: Ibusuki	
 Underwater breaker	 Sedimentation on revertment
 Breaking wave on underwater breaker	 Seawall at southern part of Kagoshima
 Lighthouse at the tip of Nagasakibana	 Cliff and rocky shore at entrance of Kagoshima bay.
 Shoreline at entrance of Kagoshima Bay	 Agriculture activities at low land area of Southernpart of Kagoshima

Figure 2: Shibushi bay

Groin at southern part of Shibushi Bay

Shoreline at Shibushi bay

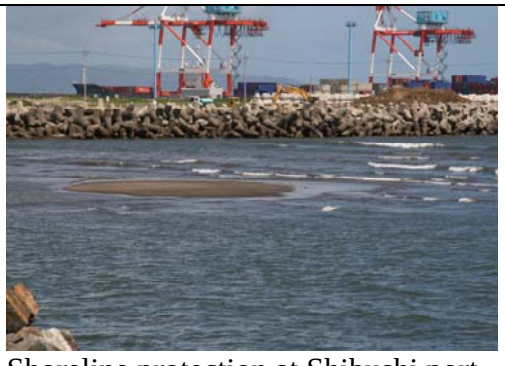
Fence protected the young vegetation from strong wind

Artificial Island

Revetment to protect the dry fish industry

River banks protection

Revetments in front the dry fish building



Shoreline protection at Shibushi port

Figure 6: Miyazaki bay

Aoshima Island

Aoshima Beach

Submerge breakwater on beach

Beach revetment

Groin in Miyazaki beach

High waves important of surfing

Mild slope revetment to asses the beach

Coastal villages protected by shoreline structures