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Procedia Engineering 116 (2015) 171 – 178

Procedia Engineering

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8th International Conference on Asian and Pacific Coasts (APAC 2015)

Shoreline devastation of Hota coast by man-made causes

Akio Kobayashi[a,*], Takaaki Uda[b], Yasuhito Noshi[a]

[a]*Department of Oceanic Architecture & Engineering, College of Science & Technology, Nihon University, 7-24-1 Narashinodai, Funabashi, Chiba 274-8501, Japan*

[b]*Public Works Research Center, 1-6-4 Taito, Taito, Tokyo 110-0016, Japan*

Abstract

The impact of the removal of a river mouth bar as a measure against river mouth closure to the surrounding coasts was investigated, taking the Hota coast as an example. Also, on this coast, landfilling was extensively carried out to build a coastal road along the coastline, resulting in the narrowing of the natural sandy beach. These anthropogenic factors affected the overall shoreline on a pocket beach, devastating the natural coastal environment. We investigated the effects of these impacts using aerial photographs and field observations.

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Keywords: River mouth bar; removal of sand; landfill; shoreline changes; beach erosion; man-made causes

1. Introduction

In Japan, beach erosion has extensively occurred owing to various anthropogenic factors, for example, shoreline recession outside the wave-shelter zone formed by the extension of offshore breakwaters and downcoast erosion owing to the obstruction of predominant longshore sand transport by man-made structures (Uda, 2010). River mouth dredging as one of the measures for flood control could be another cause. At a mouth of a small river flowing into a pocket beach, river mouth closure often occurs owing to the sand transport by waves, necessitating the maintenance dredging of a river mouth. This has long been a regular maintenance method in small rivers in Japan, causing beach erosion on the surrounding coasts. Also, excess landfill on a coast triggered the narrowing of

* Corresponding author. Tel.: +81-47-469-5284; fax: +81-47-467-9446.
E-mail address: kobayashi.akio@nihon-u.ac.jp

Peer- Review under responsibility of organizing committee , IIT Madras , and International Steering Committee of APAC 2015
doi:10.1016/j.proeng.2015.08.279

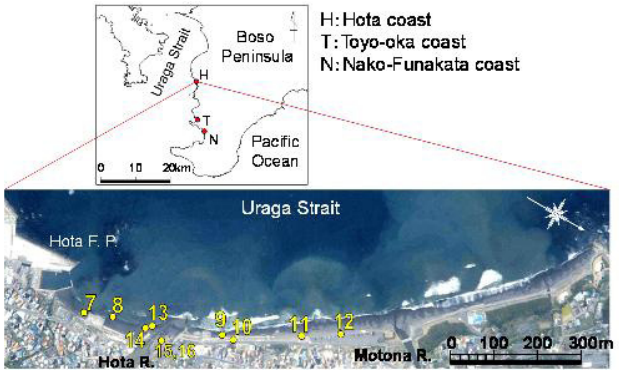

Fig. 1. Location of Hota coast facing Uraga Strait.

the natural sandy beach as a buffer zone against storm waves. We are interested in investigating the shoreline devastation owing to the change in land use, and have already investigated this issue, taking the Haraoka and Tatara coasts in Chiba Prefecture as examples (Kobayashi et al., 2013). In this study, the beach changes triggered by the excess landfill and the maintenance dredging at a river mouth were investigated. For this purpose, field observations were carried out, together with the analysis of the shoreline changes using aerial photographs. The study area is the Hota coast located in the Boso Peninsula in Chiba Prefecture and is a pocket with an approximately 1.4 km length separated by the Hota fishing port breakwater and a natural rocky headland at the south and north ends, respectively, as shown in Fig. 1. On October 13, 2012, overall conditions of the beach were observed, and then a second observation was carried out during low tide on January 5, 2013 to investigate the relationship between the river mouth dredging and the erosion of the nearby coast.

2. Analysis of shoreline changes using aerial photographs

2.1. Change in land use in hinterland

The changes in land use of the Hota coast were investigated using aerial photographs. Figure 2 shows the aerial photographs taken in 1967, 1981, 1991, and 2012. In 1967, a natural sandy beach with an approximately 50 m width extended on the Hota coast. In what follows, the boundary between the sandy beach and the hinterland in 1967 is drawn by a solid line in each aerial photograph, along with the landfill areas. By 1981, the landfill mainly to produce a parking lot had been carried out on both sides of the Motona River mouth and on the public beach immediately north of the Hota River mouth. By 1991, a concrete slope for fishing boats was constructed on the sandy beach 160 m south of the Hota River, while burying the natural sandy beach. At this time, however, a sandy beach was left on both sides of the concrete slope, and the foot of the concrete slope coincided with the shoreline. By 2012, the landfill area expanded on both sides of the Hota River mouth and a coastal road was constructed, resulting in the narrowing of the natural sandy beach. Furthermore, the beach south of the Hota River has been eroded, exposing the seawall protecting the landfill area to waves. Thus, on the Hota coast, beach changes were closely related to anthropogenic factors.

To investigate the changes in foreshore area associated with the change in land use, the foreshore area of the sandy beach shown in Fig. 2 was calculated and is shown in Fig. 3. The foreshore area monotonically decreased between 1967 and 2012 with some scatters. Therefore, the beach widths in 1967 and 2012 at the beginning and the end, respectively, are shown in Fig. 4. The sandy beach of 30-80 m width extended in 1967, but it was markedly narrowed up to less than 20 m by 2012 owing to the erosion and the seaward advance of the landfill areas.

Because the foreshore area monotonically decreased since 1991, as shown in Fig. 3, the shoreline changes between 1991 and 2012 were calculated, as shown in Fig. 5. It is seen that a large amount of sand disappeared from the shoreline area. At the Hota River mouth, river mouth dredging has been recurrently carried out to remove sand deposited at the river mouth as one of the measures against the deposition of sand in the river mouth, and this is

assumed to result in the decrease in the sand volume of the beach under the condition that the concrete jetties subsided and failed to prevent sand from flowing into the river mouth from the nearby coasts. Thus, the man-made impact was considered to be a primary cause of the shoreline devastation of the Hota coast.

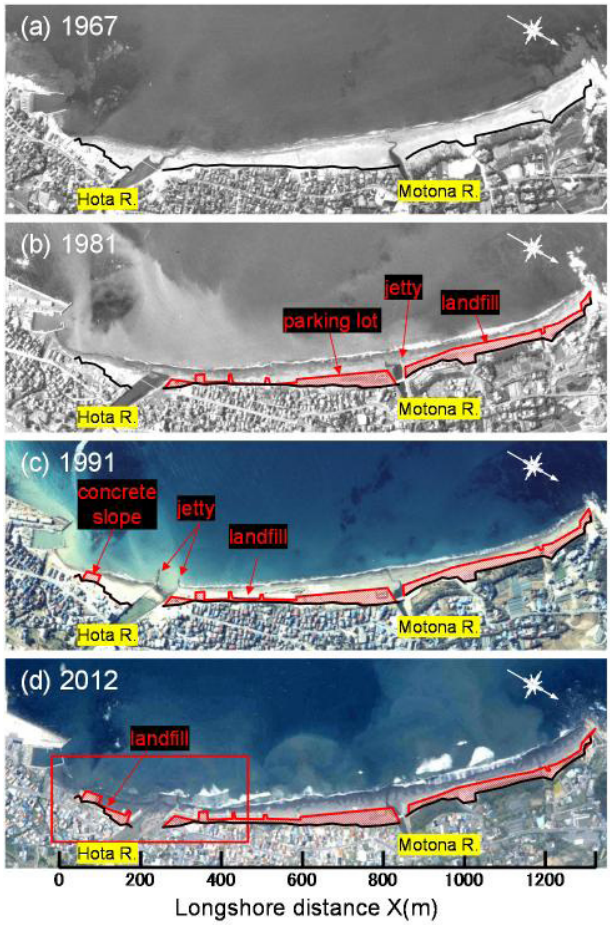

Fig. 2. Aerial photographs of Hota coast taken between 1967 and 2012.

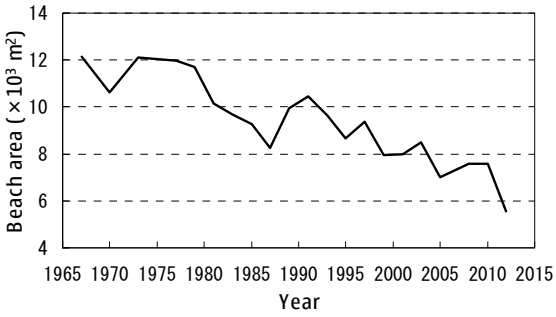

Fig. 3. Change in foreshore area since 1965.

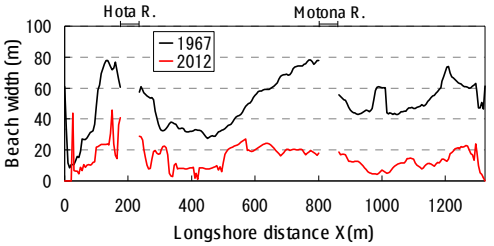

Fig. 4. Changes in beach width between 1967 and 2012.

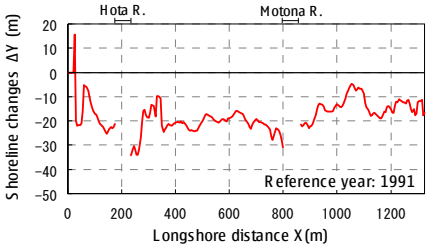

Fig. 5. Shoreline changes up to 2012 with reference to that in 1991.

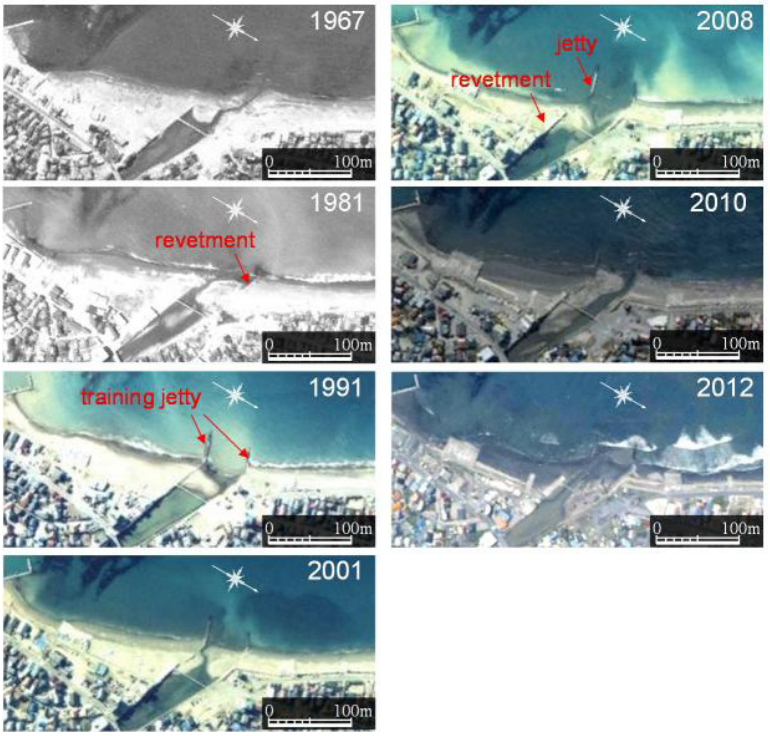

Fig. 6. Change in river mouth topography of Hota River between 1967 and 2012.

2.2. Change in Hota River mouth

Although the beach has been eroded in the entire Hota coast, as mentioned in 2.1, the total volume of sand on a pocket beach should be maintained or increased owing to the sand supply from rivers without the artificial removal of sand from the beach, taking into consideration that this pocket beach separated by a fishing port breakwater and a natural rocky headland at the south and north ends, respectively, has a closed system of sand movement. The erosion of this coast is contradictory to the state inferred from the physical conditions of the coast.

At the Hota River mouth, the removal of sand has been carried out as a measure against the river mouth closure, and this is assumed to be the primary cause of the beach erosion, resulting in the net loss of sand volume of the beach. Therefore, the shoreline changes of the river mouth bar were investigated, as shown in Fig. 6. In 1967, a narrow river channel was formed across the river mouth bar, and a wide sandy beach extended on both sides of the river mouth, which is the natural beach before the artificial alteration. In 1981, a river mouth bar had still developed in front of

the right bank revetment, while forcing the stream toward the left bank, and a wide sandy beach existed on both sides of the river mouth, similarly to that in 1967.

By 1991, the training jetties were extended on both sides of the river mouth normal to the direction of the mean coastline. After the construction of the jetties, the sand deposited at the river mouth was removed, and then a river mouth bar newly developed from the left bank, in the direction opposite to that in 1981, while leaving a narrow channel along the right bank revetment. In 2001, a river mouth bar reversely developed from the right bank, closing the river mouth, and sand was also transported into the river mouth through the gap in the left bank jetty, resulting in the formation of a sand bar along the left bank. The almost complete closure of the river as shown in this figure demonstrates the necessity of the excavation of the river mouth bar. In 2008, sand was further transported through the gap in the left bank jetty, resulting in the shoreline recession immediately north of the concrete slope for fishing boats. The same condition continued up to 2012, and the seawall was exposed to waves because of severe beach erosion south of the river mouth. The sandy beach north of the concrete slope for fishing boats was severely eroded, leaving no dry beach. Similarly, the beach was eroded between 2001 and 2012 north of the river mouth. Thus, the beach erosion of the Hota coast is strongly related to the river mouth dredging, which was carried out recurrently after the closure of the river mouth owing to the excess sand deposition.

3. Site observation

3.1. Overall conditions of Hota coast

The number of observation sites on the Hota coast, which is the same as the number of figures, is shown in Fig. 1. First, Fig. 7 shows a concrete slope of 1/7 protruding from the shoreline. Although this concrete slope was originally built for small fishing boats on a sandy beach, it was abandoned for the boating slope because of erosion, and the shoreline scenery was spoiled because of the protrusion. Taking into consideration that the foot of this concrete slope coincided with the shoreline position in 1991, as shown in Fig. 2, it is seen that the area shown in Fig. 7 had been eroded, and gravel particles of large diameter and concrete debris buried under the sandy beach were left on the surface of the seabed, while forming the armor coat.

Although a wide sandy beach of a gentle slope extended north of the concrete slope, a gentle slope revetment, which was constructed along the shoreline and covered with a sand layer, was exposed to waves and a scarp was formed on the concrete slope because of the erosion (Fig. 8). There was a sandy beach in this area up to 1991, as shown in Fig. 6, and a large amount of sand was transported away from this beach toward the river mouth through a gap in the left bank jetty. It is inferred that a sandy beach of a gentle slope was left behind as a result of the erosion, and no dry beaches were left seaward of the gently sloping revetment.

North of the Hota River mouth, a road extended in parallel with the coastline from a location 120 m north of the river mouth, and a seawall was built along the road. On the other hand, an old seawall was found in front of the houses, as shown in Fig. 9. Several gaps can be seen along this old seawall shown in Fig. 9, and the winches for raising small boats from the shoreline to the backshore were placed in these gaps. An example is shown in Fig. 10; a rusted winch was left in the gap of the seawall.

Fig. 7. Isolated concrete slope for boating and eroded beach.

Fig. 8. Eroded beach of a gentle slope and scarp formation on gently sloping revetment.

Fig. 9. Gaps in old seawall left on landward side of road.

Fig. 10. Rusted winch left in gap of seawall.

Fig. 11. Parking lot markedly protruded on backshore.

Fig. 12. Relation between parking lot and sandy beach.

The ground elevation of the hinterland was 1.2 m above the elevation of the road, as shown in Fig. 9, and the area with a slightly high elevation was a sand dune in the past, with a seawall constructed on top of the sand dune. Small fishing boats were placed inside the gaps of the seawall near the top of the sand dune. From these facts, it is clear that the past coastline was located along the line smoothly connecting the past seawall, and small fishing boats placed on the sand dune were moved down to the shoreline across the backshore. However, a landfill was formed on the backshore to build a new coastal road in parallel with the coastline.

In the north part of this road, a parking lot markedly protruded seaward, while burying the natural sandy beach, as shown in Fig. 11. The coastal vegetation was destroyed and covered with concrete structures by the excess seaward advance of the parking lot. Figure 12 clearly shows the devastation of the coastal vegetation, as a result of the high utilization of the land close to the shoreline. The elevation of the backshore in front of the seawall was low and coastal vegetation was barely being grown.

3.2. Detailed observation of Hota River mouth

Figure 13 shows the tip of the permeable-type left bank jetty composed of concrete armor units. The concrete block near the low tide shoreline, as shown by arrow A, had markedly subsided, and there was an opening between the river mouth and the south beach, implying that longshore sand transport from the south beach to the river mouth is barely blocked by the left bank jetty. This implies that sand transport from the south beach to the river mouth could be possible through the gap, as shown in Fig. 6, since 2001. Figure 14 shows the foundation of the left bank jetty. On the south side of the jetty, a steel curtain wall was exposed by a height of 0.8 m, and also, a change in color was found on the surface of the concrete wall at an elevation of 1.5 m above the present ground level. This means that the sandy beach with an approximately 1.5 m thickness was eroded, decreasing the ground level.

Figure 15 shows a photograph of the left bank jetty. At the tip of the left bank jetty, concrete armor units of low crown height were placed as a result of the subsidence. From this fact, it is inferred that sand movement between the south beach and the river mouth was possible, and each time that the sand dredging inside the river mouth was carried out, sand was transported from the south beach to the mouth. Figure 16 shows the inside of the sidewall on the left bank of the river mouth, and the change in the color of the seawall shows that the ground elevation was lowered in this area, showing evidence of the removal of the sand deposited inside the river mouth. Finally, Fig. 17

Fig. 13. Opening in left bank jetty caused by subsidence of concrete blocks.

Fig. 14. Exposed foundation of left bank jetty .

Fig. 15. Photograph of left bank jetty taken from right bank of river mouth.

Fig. 16. Change in color of inside wall in river mouth.

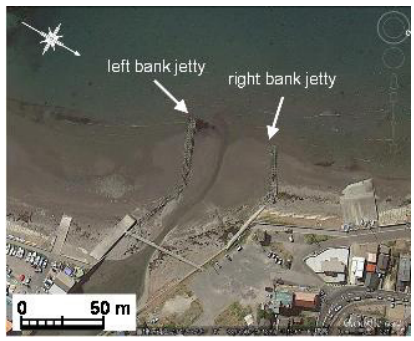

Fig. 17. Satellite image of Hota River mouth on March 29, 2012.

shows the satellite image of the Hota River mouth taken on March 29, 2012. The concrete armor units of the attachment of the left bank jetty to the impermeable jetty markedly subsided, making the sand transport from the south sandy beach to the river mouth possible.

4. Concluding remarks

As shown in Fig. 5, the shoreline of the Hota coast receded by 17 m on average between 1991 and 2012, resulting in an entire eroded area of 2.1×10^4 m^2 with a rate of the decrease of 1.0×10^3 m^2/yr. The characteristic height of beach changes, which is defined as a regression coefficient between the change in cross-sectional area of the beach and the shoreline changes, and by which the change in the foreshore area can be transformed into volumetric changes by multiplying the height by the change in the foreshore area, is unknown on this coast, because bathymetric surveys have not been carried out. Therefore, the characteristic height of beach changes of 2.4 m estimated on the Nako-Funakata coast (Hoshigami et al., 2002) located 15 km south of the present coast, and facing the Uraga Strait was used for the calculation. By multiplying the change in the foreshore area by 2.4 m, we obtained the change in sand volume of 5.0×10^4 m^3 between 1991 and 2012, with a rate of decrease of 2400 m^3/yr in the volume of the foreshore

sand. Although direct lines of evidence of the river mouth dredging on the Hota River mouth, such as records of the work, were not left, the sand volume of the coast actually decreased, as shown in the aerial photographs, implying the importance of the river mouth dredging indirectly. The dredging rate of 2400 m^3/yr is not very large, and the recurrent dredging could cause beach erosion around the river mouth in the long term. Thus, the river mouth dredging as a measure against the river mouth closure was considered to result in the decrease in the net sand volume of the pocket beach. This was synonymous with the direct excavation of sand on the nearby beach.

With regard to the erosion north of the river mouth, part of the longshore sand transport may pass the jetty because of the same permeable structure as the left bank jetty, and this may be one of the causes of the beach erosion on the coast north of the river mouth. The fact that the river mouth and the beaches on both sides of the river mouth were insufficiently separated by the impermeable jetties permitted sand from transporting into the river mouth. Under these conditions, every time sand dredging is carried out at the river mouth, the beach is eroded.

The management office of flood control of the city adopted a measure against floods, because they believed in the effectiveness of their method, and never considered the impact of their activity on the nearby beach beyond the river mouth area, where is responsible for their works. From this viewpoint, it is clearly realized that the comprehensive management of sand in the overall coastal area including the river mouth is necessary. Coastal protection and river management have been authorized by different organizations, i.e., the City Government and the Prefectural Office, and the difference in management offices became one of the fundamental causes of the beach erosion. Cooperative efforts are needed among the relevant organizations; particularly, the education of river engineers to let them know that the impact of river mouth dredging on nearby coasts is important.

References

Hoshigami, Y., Kumada, T., Uda, T., Serizawa, M., San-nami, T., Furuike, K., 2002. Beach changes around Funakata fishing port in Tateyama Bay, Proc. Civil Eng. in the Ocean, JSCE, Vol. 18, pp. 473-478. (in Japanese)

Kobayashi, A ., Uda, T., Endo, M., Noshi, Y., 2013. Beach erosion triggered by river mouth dredging as a measure against river mouth closure, Asian and Pacific Coasts 2013, Proc. 7th International Conf., pp. 113-120.

Uda, T., 2010. Japan's Beach Erosion - Reality and Future Measures, World Scientific, Singapore, p. 418.