

# EROSION MECHANICS OF A CARBONATE-TOMBOLO BEACH IN MIYAKOJIMA ISLAND, OKINAWA PREFECTURE, JAPAN.

Ryuichiro NISHI<sup>1</sup>, Takaaki UDA<sup>2</sup>, Kazuo KIKUCHI<sup>3</sup> and Kou FURUIKE<sup>4</sup>

<sup>1</sup>Associate Prof. Dept. of Ocean Civil Eng., Kagoshima University; Email:sediment@oce.kagoshima-u.ac.jp

<sup>2</sup>Senior Research Coordinator, Public works research Institute. Email: uda-t92tr@nilim.go.jp

<sup>3</sup>President of Coastal Techno, Co., Ltd., Email:coastal@ii-okinawa.ne.jp

<sup>4</sup> Research Engineer, Coastal Engineering Laboratory Co., Ltd.

## **PREFACE:**

There is a carbonate tombolo beach in Miyakojima Island, Okinawa Prefecture. The beach locates inside a wide coral reef which is developed between Shimoji and Kurima Islands as shown in Photograph 1. The length and width of the tombolo are nearly 1,600 m and 200 m, respectively. The shape of tombolo beach tended to deviate towards the Northwest direction in the last decade, thus the Southeast side of the beach eroded significantly while a causeway had been constructed from the Miyakojima Island to the Kurimajima Island, since 1990.

This carbonate beach has been recognized as one of the most beautiful and densely populated beach in Okinawa Prefecture where the tourism is one of the major industry. Therefore, it is requested to reveal a cause of erosion to consider a further shore protection method. Nakaza et. al. (1996) reported that a main reason of beach erosion was caused by the Westward deviation of typhoon course since 1990 for which the beach probably be suffered from more erosive waves and higher storm surges than in the case of the Eastward typhoon approach. However, there was no report about severe beach erosion in 1960s while the typhoon course tended to concentrate to the Western side of the island, thus it is possible to say that some other mechanics would cause the beach erosion.

The other possible mechanics that would be able to cause the beach erosion seems to be the causeway construction in 1990s. Piers of the causeway are relatively thin compared to the distance of the two islands and the

representative wave length. However, large areas around the piers were enclosed by the steel sheets during the construction, then sea bed around the piers were dried up while the causeway construction was conducted from the Miyakojima Island to the Kurima Island. This kind of construction methodology created a quasi-state for which several detached breakwaters had been shifted by certain duration of the construction project. Even though the piers were set further offshore, the techniques of pier construction could cause the sheltering effect to the sandy beach just the same as the sheltering effect of detached breakwaters. Therefore, literature survey including the news reports, an analysis of typhoon course, data analysis of tidal record, movement of coastal forest and vegetation boundaries, field investigation of coastal erosion, and some numerical analysis have been conducted to reveal the possible mechanics of beach erosion in a coral reef.



Photo. 1 Aerial photograph of Maehama Beach

**ANALYSIS:**

The following studies have been carried out;

**(1)analysis of aerial photographs:**

Shoreline changes, coastal processes, and movement of coastal forest and vegetation boundaries since 1947 to date have been analyzed by using the aerial photographs. It is seen that the southeast side of the tombolo beach was eroded by the typhoon waves approached from southeast. In contrast, eroded material was accumulated in the northwest side of the tombolo and was deposited over the reef flat in the form of underwater dunes in 1995.

**(2)change in cross-shore profile:** the bathymetry maps supported by the Okinawa Prefecture Government Office were digitized first, then change in cross-shore profile at each transects were estimated. Maximum shoreline recession and advance were 50 m and 60 m in the southeast and northwest sides of tombolo beach, respectively while the beach scarp was the very pronounced.

**(3)estimation of the longshore sediment transport rate:** longshore sediment transport rate around the tombolo was estimated by using the information of the changes in shoreline position and cross-shore profile. The annual longshore sediment transport rate during the period from 1989 to 1996 was calculated and the maximum rate was 7000 m<sup>3</sup>/year to northwest.

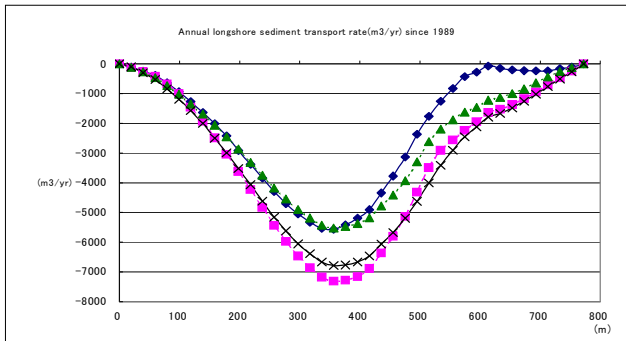


Fig. 1 Annual longshore sediment transport rates (est.)

**(4)news-report-database construction:** Kurima Island causeway construction had commenced since 1988, thus the news regarding to the beach erosion and causeway construction since then were compiled into a database.

**(5)analysis of typhoon passage:**

Three hundred fifty typhoons since 1951 were selected from the typhoon dictionary in Japan, then the course, pressure, wind velocity of each typhoons were compiled into a database. In addition, typhoons are classified into the typhoon categories for which the pressures are lesser than 960 hPa, 940 hPa, and 920 hPa, respectively. The number of typhoons which was categorized based on courses, and pressure is counted (see, Fig. 3).

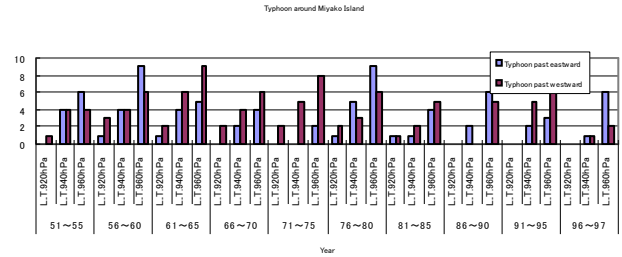


Fig. 2 Number of Typhoons in 5-year interval (left; eastward, right; westward)

**(6)numerical simulation of shoreline change:** shoreline change due to the pier constructions was simulated by using the ideal assumption that the dried up techniques can be represented by a series of quasi-detached offshore breakwaters alignment.

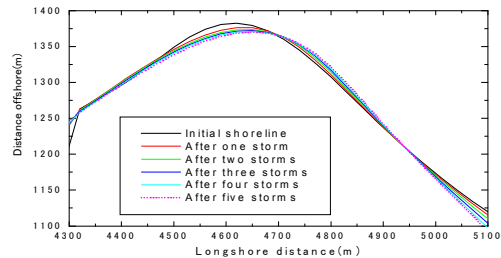


Fig. 3 Shoreline change by causeway construction (calc.)

In addition, tidal record in the last 27years has been analysed. The data shows a long-term trend of a sea level rise with a significant seasonal deviation.

**MAIN CONCLUSIONS:**

The major conclusions are as follows;

- (1) The major erosion in the southeastern side of tombolo beach was nearly 50 m and eroded material enhanced the shoreline advance nearly 60 m in the northwestern part of the beach. In addition, some material was deposited over the northern reef flat.
- (2) Maximum longshore sediment transport rate in the northwest direction is estimated as much as 7000m<sup>3</sup>/year during the same period.
- (3) Due to the news-database, beach erosion was known since the pier construction commenced. Then the beach erosion had continued since the completion of causeway project. However the coastal forest and vegetation boundaries had been advanced most seaward in 1987, thus the coast was most vulnerable to the typhoon waves and storm surges.
- (4) It is seen that typhoon passages were deviated toward the west of the island from 1989 to 1995. A similar deviation of the typhoon course was happened in the period of 1961 to 1975, however severe beach erosion was not reported.