*Coastal Dynamics 2017*
*Paper No. 246*

# BEACH EROSION AND STRUCTURAL DAMAGE BY HIGH SWELL WAVES

Sungwon Shin[1], In-Ho Kim[2], Jinhoon Kim[3], Jungmin Nam[4], Dongsoo Hur[5], Hyung-Seok Lee[6], and Kideok Do[7]

**Abstract**

In this study, field observations were conducted to investigate the damage mechanism of the coastal structures on a sandy beach by large waves. Series of surveys on bottom bathymetry, beach profile, and beach width were performed in order to figure out the seasonal variations of shoreline and bathymetry. Field observation results in Jundonjin beach, located on the east coast of Korea, showed the seasonal change of the beach width due to alongshore sediment transport. The coastal structures, such as sea wall and rails, with the narrowed beach during the particular season were vulnerable to the large waves, which occurs more frequently on the east coast of Korea nowadays. This study found that, in Jeongdongjin beach, the northern area near the railroad was collapsed in winter and the southern area near the coastal road was collapsed in summer by high swell waves.

**Key words:** beach erosion, sediment transport, coastal structures, high swell waves, shoreline change, field observation

## 1. Introduction

For a past decade, the occurrence frequency of high swell waves has significantly increased and caused to serious damages on the east coast of Korea. Oh and Jeong (2013) defined these types of waves as high waves and categorized as the waves that the heights are larger than 3 m and the periods are longer than 9 s. They described the reason of the occurrence is induced by extra-tropical low-pressure systems which generate strong winds. These long period and narrow banded waves reach the east coast of Korea and last 1~3 days with giving serious damages on the coast. Earlie et al. (1984) also mentioned the similar type of waves on the west coast of North America generated by the storm. Both studies focused on the generation and propagation of the high waves to the coast.
The present study conducted field observation to investigate and understand the characteristics of impacts on the beach area including coastal structures in Jeongdongjin beach. This study includes the brief introduction of the study site, the field observation results, and concluding remark.

## 2. Field Observations

### 2.1. *Historical record of Jeongdongjin beach*

There are 41 littoral drift cells in the Gangwon-do province, Korea. Jeongdongjin beach is located on the east coast of Korea as shown in Figure 1 and the Jeongdongjin beach is marked with a red dot on the map. Three beaches are in a littoral drift cell which includes the Jeongdongjin beach. Figure 1(b) shows the

[1]Dept. of Marine Science and Convergence Engineering, Hanyang University, Ansan, Korea. sungwshin@hanyang.ac.kr
[2]Dept. of Earth and Environmental Eng., Kangwon National University, Samcheok, Korea. kimih@kangwon.ac.kr
[3]Dept. of Earth and Environmental Eng., Kangwon National University, Samcheok, Korea. jinhoon-kim@hanmail.net
[4]Dept. of Earth and Environmental Eng., Kangwon National University, Samcheok, Korea. jmnam@kangwon.ac.kr
[5]Dept. of Earth and Environmental Eng., Kangwon National University, Samcheok, Korea. jmnam@kangwon.ac.kr
[6]Dept. of Civil Eng., Hanzhong University, Donghae, Korea. lhs0815@empal.com
[7]Korea Maritime University, Busan, Korea. kddo@kmou.ac.kr

survey lines and Jeongdongjin beach includes line GW29-10 through GW29-12. On the northern part of this beach, there is a rocky area as a tombolo-type area and a groin has been built on the southern area of the beach so that the sediment can somehow be trapped in between two headland-like structures. which Field observation includes the beach widths, beach profiles, bottom morphology, and incident waves at Jeongdongjin beach, which is located on the east coast of Korea.

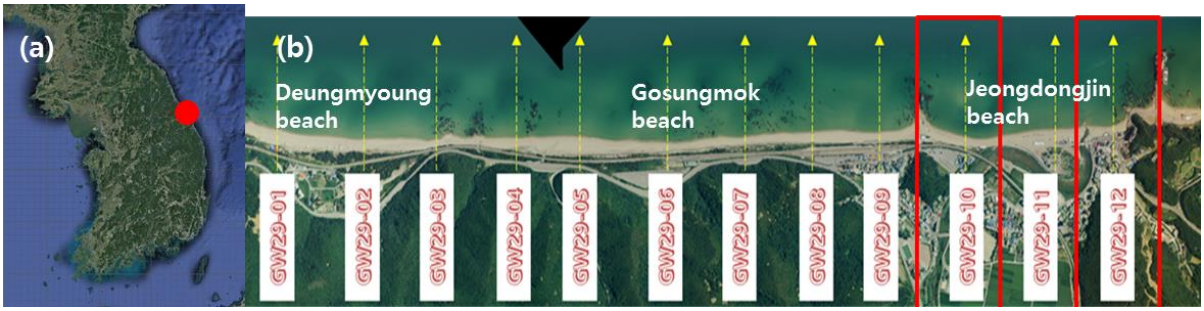


Figure 1. Location and local aerial photograph of Jeongdongjin beach.

Figure 2 shows the damaged area of Jeongdongjin beach. The rail at the beach area at GW29-10 in Figure 2 was collapsed on January 20, 2016 and the coastal deck was broken on August 30, 2016. In both cases, significant high swell waves came to the east coast of Korea for 2~3 days. On January 20, the second day of the high swell wave attack, the coastal railroad had been collapsed after the waves washed away the beach sands in front of the vertical seawall as shown on the left-hand side of Figure 2. On the other hand, from August 29, 2016, similar high swell waves came to the beach and the coastal deck was collapsed and the road was cracked on the second day of the high swell wave attack as shown in the right-hand side of Figure 2. The photographs evidenced that the high swell waves attacked and gave a damage to the different area during the different seasons, summer and winter.


Figure 2. Structural damages in the northern (left) and southern (right) sides of the Jeongdongjin beach.

### 2.2. *Field Observation in Jeongdongjin beach*

Field observation includes the beach widths, beach profiles, bottom morphology, and incident waves at Jungdongjin beach. Beach widths and beach profile above the shoreline were surveyed by using portable RTK-GPS. The underwater beach profile and bathymetry were surveyed using a ship mounted single-beam echo-sounder. All surveys were conducted in four seasons to investigate the seasonal morphologic changes. An AWAC (Acoustic Waves and Currents) was installed on the offshore side of the beach to measure the incident wave condition. Figure 3 shows the survey equipment and procedure for beach topography and

bottom bathymetry.

Figure 3. Survey procedure for beach topography and bottom bathymetry; a survey vessel (left), single-beam echo sounder and GPS (middle), and RTK-GPS (right).

### 2.3. *Field Observation Results*

Typically on the east coast of Korea, waves come to the beach in NE(north-east)-direction and produce alongshore current in south direction during the winter. In the summer season, the waves mostly approach the beach in SE(south-east)-direction and generate alongshore current toward the northern side of the beach. However, when the high waves reach the coast, the wave direction is almost sixty degrees which are normal to the shoreline regardless of the season.

Figure 4 shows the incident wave conditions when the coastal structures were damaged in Jeongdongjin beach during the winter and summer seasons. The left-hand side of Figure 4 shows the wave heights (top), wave periods (middle), and mean wave directions (bottom) from January 14 to March 18, 2016. As shown in the figure, the high swell waves with the significant wave height ($H_s$) of 5.1m and the significant wave period ($T_s$) of 13.0 s came to the beach in sixty degrees. However, in calm wave condition with smaller wave height and shorter wave period, the wave directions were around 45 degrees and 120 degrees in winter and summer respectively.

Figure 5 shows typical shoreline change patterns in winter and summer seasons in Jeongdongjin beach (red-colored boxes) based on the data collected in 2015. In Figure 5(a), dominant waves come to the beach in NE direction and the beach sand moved to the south in winter while dominant waves reach the beach in SE direction and the sediment moved the north in summer (Figure 5(b)). Also, the figure shows the crescentic sand bar formation and movement in different season due to the different incident wave conditions.

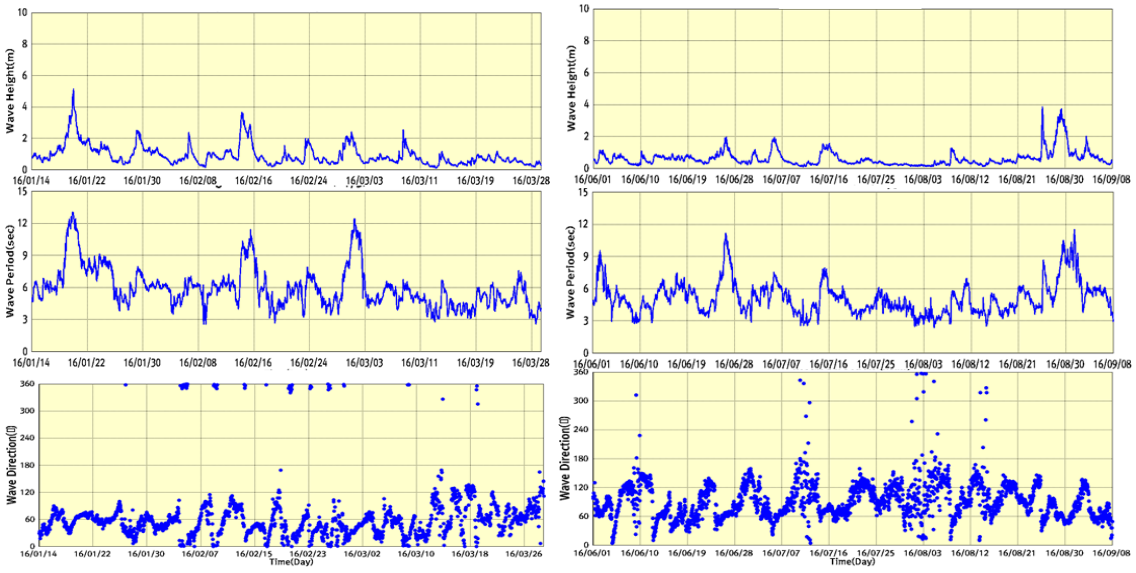


Figure 4. Incident wave conditions by using AWAC in winter (left) and summer (right) seasons. Top panels, middle panels, and bottom panels indicate the significant wave heights, significant wave periods, and mean wave directions

respectively.

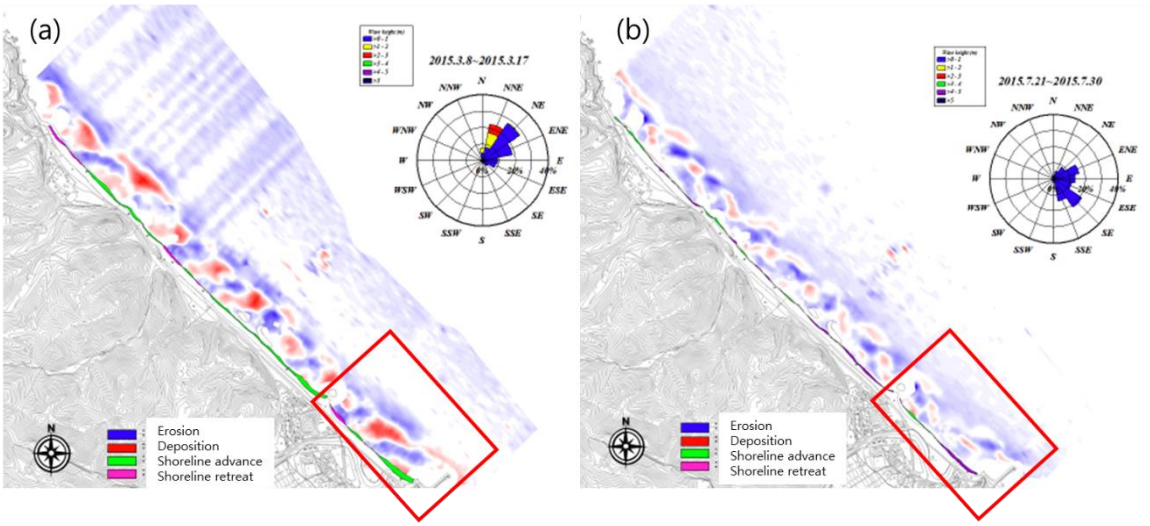


Figure 5. Incident wave conditions by using AWAC in winter (left) and summer (right) seasons. Top panels, middle panels, and bottom panels indicate the significant wave heights, significant wave periods, and mean wave directions respectively.

## 3. Discussion

In order to investigate the long-term shoreline change pattern, the survey data for beach width at GW29-10 and GW29-12 for past 6 years. Figure 6 shows the temporal variation of the beach width of northern side (GW29-10) and southern side (GW29-12) of Jeongdongjin beach. It is clear that the beach width change patterns in two survey lines are opposite. Therefore, this result shows that a seasonal longshore sediment transport is dominant in this area.

Especially, the beach widths decrease by 20m in both northern and southern side of the beach in winter and summer seasons respectively. Therefore, the filed observation results show that the beach width decreases due to the longshore sediment transport in the particular season and then the high swell waves attack the eroded beach so that the coastal structures on the beach were destructed. This mechanism can be applied to the case of January 20 and August 30 in 2016.

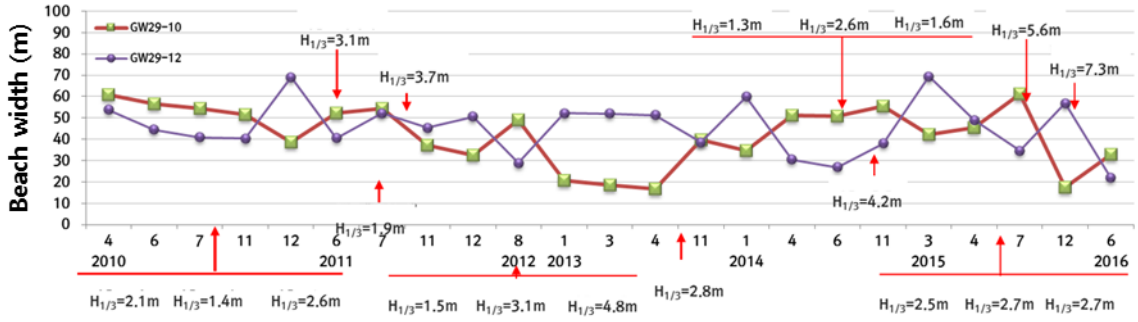


Figure 6. Temporal variation of the shoreline change based on the beach width in Jeongdongjin beach.

Figure 7 also shows the temporal variation of the beach profile of GW29-10 and GW29-12 in cross-shore direction. In this figure, it is found that longshore sediment transport is dominant compared to the cross-shore sediment transport because the beach profile change near the swash zone is much larger than the profile change near the offshore sand bar. Therefore, the beach sands near the swash zone mostly move to north and south along the shoreline.

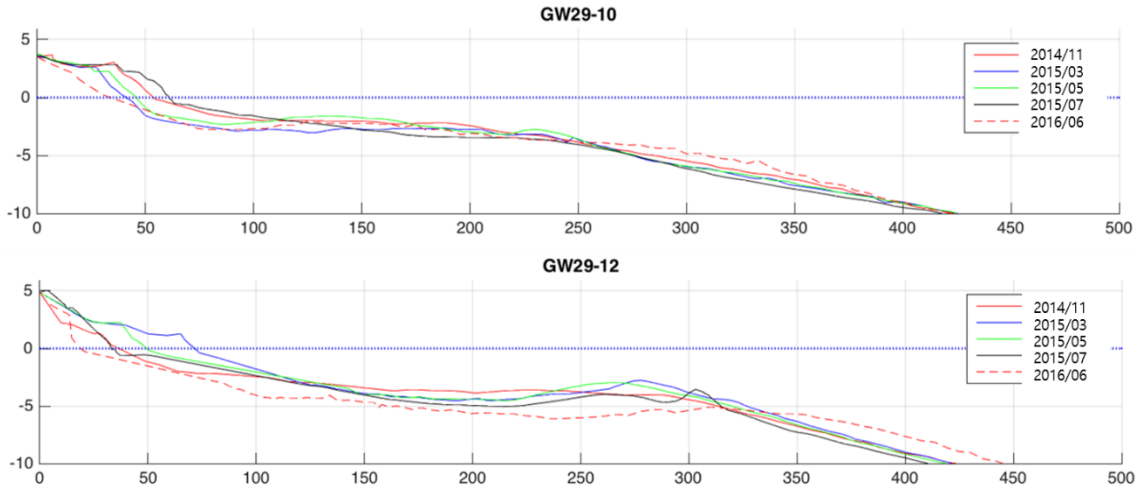


Figure 7. Temporal variation of the beach profile of GW29-10 and GW29-12.

## 4. Discussion

In 2016, coastal structures were damaged in both northern and southern side of Jeongdongjin beach by high swell waves in the different season. Magnitude and frequency of high swell waves are increasing for a past decade. Series of field observation have been conducted to investigate the destruction phenomena in this beach. The field observation included beach topography, bottom bathymetry, shoreline, and beach profile surveys as well as incident wave conditions. Based on the field observation results, the following conclusion can be drawn;

First, long-term variation of the shoreline is affected by incident wave direction. Incident waves typically come to the beach in NE and SE direction during the winter and summer seasons respectively. Those obliquely incident waves to the shoreline generate alongshore currents in south and north directions. On the other hand, the high swell waves approach to the beach in shore-normal direction for two or three days. These waves may affect the cross-shore sediment transport during the short period of time.

Second, shoreline change results also show that longshore sediment transport is dominant. Therefore, beaches are narrow in norther and southern sides in winter and summer seasons respectively.

Third, when the high swell waves come to the beach, the coastal structures on the narrow beach in particular season are vulnerable. Therefore, it can be found that the railroad in northern side of the beach was collapsed in winter and the coastal deck and road were damaged in summer.

As shown in the bathymetry survey, the shape of the sand bars in this area are not straight but curved. This crescentic sand bars affect not only the wave refraction and diffraction but rip current generation. Therefore, this investigation will continue to accumulate the data and the study will be extended to the dynamics of the crescentic sand bars and nearshore current mechanisms.

## Acknowledgements

This research was partially supported by the project titled “Development of coastal erosion control technology”, funded by the Ministry of Oceans and Fisheries and the National Research Foundation of Korea(NRF) grant funded by the Korea government(2017R1A2B4010108)

## References

Earlie, M.D., Bush, K.A. and Hamilton, G.D., 1984. High-height long period ocean waves generated by a severe storm in the northeast Pacific Ocean during February 1983.*Journal of Physical Oceanography*, 14: 1286 – 1299.

Oh, S.-H. and Jeong, W.-M. 2013. Characteristics of high waves observed at multiple stations along the east coast of Korea. *Natural Hazards and Earth System Sciences*, 13: 3503-3514.

East coast regional headquarters, 2015. *Beach erosion monitoring in Gangwon-do province*, Gangwon provincial Government.