FIELD OBSERVATIONS OF WATER CONTENT AND MICROTOPOGRAPHIC CHANGES DURING TIDAL CYCLES IN THE SWASH ZONE

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INTRODUCTION

Many studies have been conducted on topographic changes within and around the surf and swash zones. In the nearshore area, a large amount of sediment transport occurs in the surf zone, resulting in frequent profile changes[1), 2)]. Moreover, dynamic sediment movement occurred in the swash zone where the wave condition changes due to tides and the wave run-up and run-down of individual waves[3)]. The soil moisture content of the sediment layer also fluctuates greatly, impacting the stability of the seabed. In this study, we conducted field measurements of the water content of the sand layer in the swash zone and ground elevation of the location using an ultrasonic distance meter. Our analysis shows the characteristics of the water content fluctuations during the tidal motion due to changing wave forcings, and the correlation with microtopographic changes is discussed.

DATA DESCRIPTION AND METHOD

Field observations were conducted from September 6 to 21, 2022, at the Hasaki Coast, Japan, where the Hasaki Oceanographycal Research Station (HORS) is located (Fig. 1). A measuring point was selected in the swash zone where the ground was higher than the mean high tide level and lower than the wave run-up height (Fig. 1, right box, and Fig. 2a). Water content meters were placed at three points inside the sand layer; 5, 15, and 25 cm from the initial ground level (Fig. 2b). An ultrasonic distance meter was installed on the pier; the same location of the measuring point was also used to measure ground height. The mean significant wave height and period were 2.50 m and 10.10 s, respectively, during the observation period at NOWPHAS Kashima (Fig. 3).

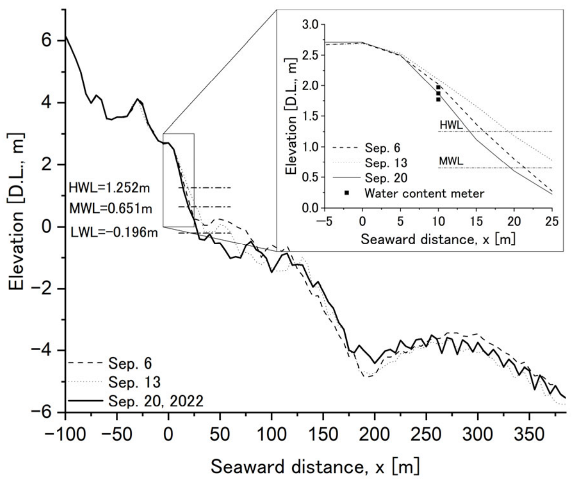

Figure 1. Measuring points of water content in the swash zone and beach profiles during the experiments.

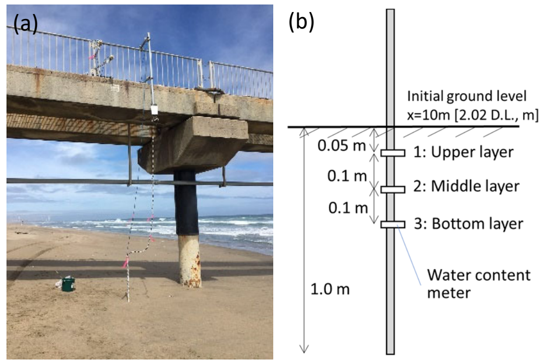

Figure 2. Location of the measuring point. (a) site photo, and (b) arrangement of water content meters.

Figure 4a shows the measured soil water content and the wave run-up height calculated from the wave and topography conditions. Relatively high wave run-up occurred on the 8th and after the 13th. Figure 4b shows the fluctuation of the water contents at each depth. A laboratory experiment conducted separately showed that the soil moisture content in the saturated condition was 0.684 m^3/m^3. Thus, larger than this value indicates that the instruments are in the seawater. Soil moisture content fluctuates with tidal change, especially in the upper sand layer (black line). It increased rapidly with the flood tide, and the value remained constant depending on each installed depth. On the other hand, during the ebb tide, the values of the water content levels decreased sharply and then slowly approached a constant value for each depth. The ground level change was small during the observation period. However, erosion occurred at the end of the observation period, and the equipment was exposed. Therefore, the analysis was conducted from September 7 to 18, when the output values stabilized after installing the equipment.

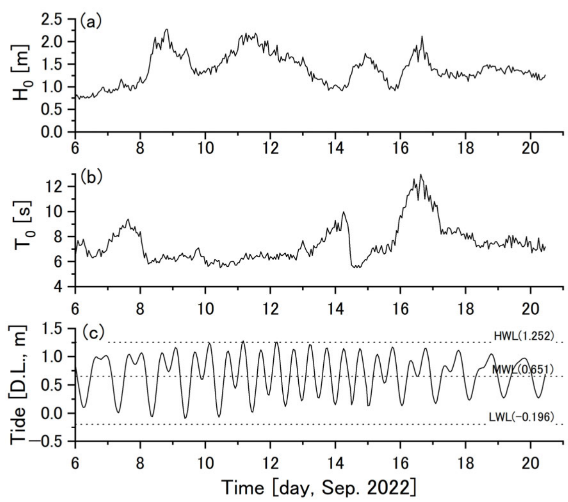

Figure 3. Offshore conditions: (a) significant wave height, (b) corresponding wave period, and (c) tide fluctuation.

RESULTS AND DISCUSSION

This analysis defines the time duration for investigation as the period from the low tide level to the next low tide level. By using those data, ensemble-averaged values are calculated, and water content and topography changes are examined during this period. However, if the tide level was not lower than the mean tide level of the Hasaki Coast, the duration was considered from the low tide level to the next low tide level. As a result, the cases were classified into 13 cases with one high tide and 4 cases with two high tides.

Events include one high tide (total of 13 Cases):
Figure 5a displays the ensemble mean water content changes, and Figure 5b illustrates the tide level and ground elevation for the one high tide case, accompanied by standard deviations. The x-axis of both figures is nondimensionalized with one tidal time duration.
The upper water content exhibited the most variation (black line), while the middle and lower water content fluctuated at similar levels. The ground elevation shifted as the tide level changed: from deposition to erosion during the flood and high tide duration. Then, the elevation again deposited during the ebb tide. The ground elevation variance during tide level reduction had a significant standard deviation, possibly related to water content variations.

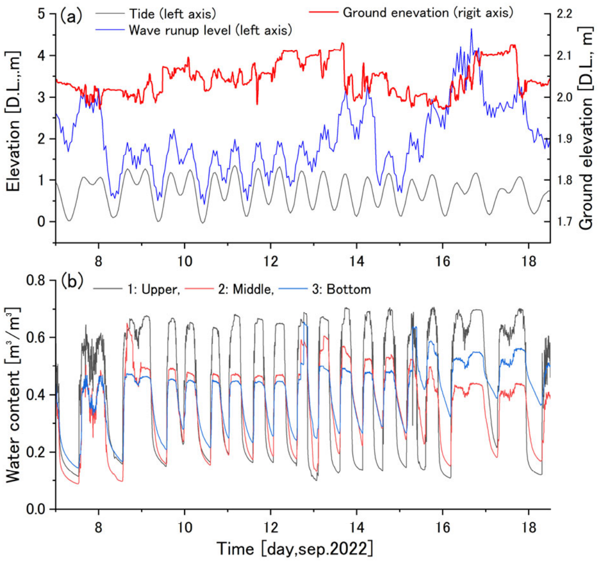

Figure 4. Observed data during the investigation period. (a) tide, ground elevation, and wave run-up elevation. (b) water content at each sand layer.

Events include two high tides (total of 4 cases):
The case of two high tides is also analyzed (Figure is not shown). Although the standard deviations were large, the topographic changes were variations that repeated the pattern of the first high tide. The water content, especially at the second high tide, was the lowest in the middle layer. This may be due to seepage from above and below caused by wave run-ups and groundwater levels. The topographic change was more significant at the second high tide, possibly due to the influence of water content fluctuations.

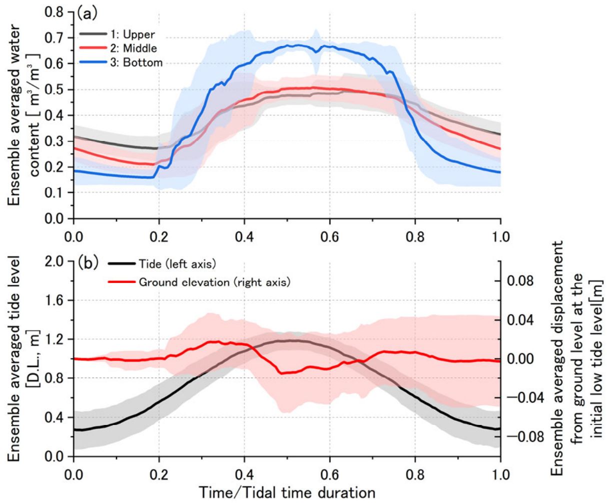

Figure 5. Ensemble mean values of observed data for one high tide case. (a) water content, and (b) tide and ground elevation.

PRELIMINARY FINDINGS

Field observations were conducted in the surf zone at a dissipative barred beach in Japan to investigate the characteristics of water content in the sand layer and the relationship with microtopographic change. The water content at each depth varied significantly with tidal fluctuations and wave run-up levels, and the vertical gradient of water content temporally fluctuated. Nevertheless, further research is needed to explore the connection between water content variations and topographic changes.
At the conference, we will present the temporal distribution of water content in the swash zone and investigate the correlation with tidal fluctuation and wave run-up level. Moreover, the relation between water content and microtopography changes is discussed.

REFERENCES

1) Takayuki Suzuki, Yu Inami, Shin-ichi Yanagishima, Shuhei Sakihama, and Daniel T. Cox (2019): Sediment particle movements observed using tracers under accretive wave conditions in the nearshore zone, Coastal Engineering Journal, 61(4), 472-485.
2) Takayuki Suzuki, Tomoki Hayashi, and Mustarakh Gelfi (2022): Field observations of sediment particle movements in the swash zone using fluorescent sand. Coastal Engineering Proceedings, (37), 7-7.
3) Takayuki Suzuki, Temma Fujino, Tomoki Hayashi, and Masayuki Banno (2023): A preliminary field study on water content and microtopography changes in the swash zone, Journal of Japan Society of Civil Engineers, Ser. B2 (Coastal Engineering), 79(2), in print (in Japanese with an English abstract).