LONGSHORE SEDIMENT TRANSPORT IN THE SWASH ZONE AT DESARU BEACH

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Specially dedicated to my beloved father, mother, sisters and brother

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ABSTRACT

This study examined the processes of longshore sediment transport in the swash zone at Desaru beach, Johor. It focused the suitability of sediment trap on sandy beach and beach profile's survey to determine the direction of longshore transport. Field measurements were carried out by using sediment trap, Global Positioning System (GPS) kit and water level logger. Data collected are sediment samples, beach profile and tides. Laboratory sediment analysis also conducted to determine the size, density and porosity at the area. It was found that the sediment trap is unsuitable to be used at Desaru beach. This could be due to highly turbulent waves and sediment transport from the cross-shore direction that had fully covered the trap with sediment. The beach profile survey shows that the direction of the longshore transport is coming from northwest to southeast of the beach. From the analysis of sediment samples, it was found that the sediment size ranges from 0.33 mm to 0.35 mm with median diameter of 0.34 mm. From the experiment, the average porosity is approximately 0.43, whereas the average density is about 2635 kg/m^3. As conclusions, the sediment trap is unsuitable to be used at sandy Desaru beach. The direction of the longshore transport is from northwest to southeast of the area during Northeast monsoon.

ABSTRAK

Kajian ini mengenai proses pengangkutan sedimen pesisiran pantai di dalam zon swash di pantai Desaru, Johor. Ia memberi tumpuan untuk menguji kesesuaian perangkap sedimen di pantai berpasir dan profil pantai diukur untuk menentukan arah pengangkutan pesisiran pantai. Kajian dijalankan dengan menggunakan perangkap sedimen, alat GPS dan pengukur kedalaman air. Data yang diambil adalah sampel sedimen, profil pantai dan air pasang surut. Analisis sedimen dijalankan di makmal untuk mengenal pasti saiz, ketumpatan dan keliangan sedimen di kawasan kajian. Hasil kajian mendapati bahawa perangkap sedimen tidak sesuai digunakan di pantai Desaru. Ini mungkin disebabkan oleh gelombang yang bergelora dan pengangkutan sedimen dari arah merentasi pantai yang telah menimbus sepenuhnya perangkap sedimen. Hasil keputusan juga menunjukkan bahawa arah pengangkutan pesisiran pantai itu dari arah barat laut ke tenggara di kawasan kajian. Daripada analisis sedimen mendapati bahawa saiz sedimen adalah daripada 0.33 mm ke 0.35 mm dengan diameter median ialah 0.34 mm. Hasil ujikaji yang dijalankan, keliangan purata sedimen adalah kira-kira 0.43 manakala ketumpatan purata adalah kira-kira 2635 kg/m^3. Kesimpulannya, perangkap sedimen tidak sesuai digunakan di pantai berpasir. Arah pengangkutan pesisiran pantai adalah dari arah barat laut ke tenggara di kawasan kajian semasa monsun timur laut.

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LIST OF ABBREVIATIONS

ACD	-	Admiralty Chart Datum
LSD	-	Land Survey Datum
MHHW	-	Mean Higher High Water
MLHW	-	Mean Lower High Water
MSL	-	Mean Sea Level
MHLW	-	Mean Higher Low Water
MLLW	-	Mean Lower Low Water
GPS	-	Global Positioning System
RTK	-	Real Time Kinematic

LIST OF SYMBOLS

β	-	Beach slope
H_0	-	Deep water wave height
L_0	-	Deep water wave length
ζ_0	-	Iribarren number
I	-	Immersed weight longshore transport rate
E	-	Wave energy at breaker line
$H_{rms,br}$	-	rms wave height at breaker line
$c_{g,br}$	-	Wave group celerity at breaker line
θ_{br}	-	Wave angle at breaker line
K	-	Coefficient
$Q_{t,vol}$	-	Longshore sediment transport by volume including pores
$Q_{t,mass}$	-	Sediment transport by dry mass
$H_{s,br}$	-	Significant wave height at the breaker line
c_{br}	-	Phase velocity of the waves at the breaker line
n_{br}	-	Coefficient at breaker line
θ_{br}	-	Wave angle at the breaker line
h_{br}	-	Water depth at the breaker line
p	-	Porosity factor
ρ_s	-	Sediment density
$Q_{t,im}$	-	Immersed mass longshore sediment transport
$Q_{t,mass}$	-	Dry mass
d_{50}	-	Median particle size in surfzone
T_p	-	Peak wave period
V_s	-	Volume of loose sand
V_w	-	Volume of water
V_T	-	Total volume

V_{sw}	-	Volume of sand and water
Ws	-	Weight of sand
n	-	Porosity
D_{50}	-	Median size of sediment distribution

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The study of sediment transport processes is fundamental to the understanding of coastal evolution, which is necessary for effective coastal engineering design. Generally, sediment transport can be divided into longshore sediment transport and cross-shore sediment transport. Longshore sediment transport is primarily driven by an alongshore wave-induced current produced by waves approaching at an angle to the shore, whereas cross-shore sediment transport is considerably generated during storm (Won and In, 2008). Longshore transport plays a large role in the evolution of shoreline. If there are slight changes in sediment supply, wind direction or coastal influence, the formation and evolution of beach profile will be effected. The present study is focused on the longshore sediment transport.

The swash zone has been considered as an important role in shaping natural beaches. Thus, the understanding of processes in this zone is very important for the estimating of coastal erosion and accretion. Elfrink and Baldock (2002) stated that littoral sediment transport often occurs in the swash zone as sediment concentrations are often high in the swash zone. The swash zone is the most dynamic part of the nearshore region and characterised by large flow velocities, high turbulence levels and large suspended sediment concentrations (Elfrink and Baldock, 2002).

Beach monitoring provides a way of understanding beach dynamics and the factors that influence the volumetric gains and losses along the coast (Morton *et al*., 1993). Changes in cross-shore beach profiles are controlled by many factors, which include waves, tidal flows and sediment characteristics (Karunarathna *et al.*, 2012). By measuring the dimensions of a particular beach repeatedly, the amounts of erosion or accretion can be determined over the period of the surveys, as well as some indications of where the material may be going. Details about the behaviour of the particular beach can be provided when measured the beach profiles at the same location over a period of time.

People utilise the coast for many purposes such as commercial fishing, tourism and recreation. The coastal environment is dynamic and it is one of the most rapidly changing physical environments on earth. Due to the strong link between society and coastal changes, it is advisable that we understand this environment and what causes it to change its state. Although natural processes are shaping the earth's natural coastal landscape, but these processes can give trouble to people that live along the coasts, where their homes are built right on or near the beaches. This is because of the process that carries sediments away from the shore can lead to erosion. Therefore, we should make every effort to control this from happening.

1.2 Statement of Problem

Johor is one of the coastal states in Malaysia with the longest coastline facing the South China Sea in the east, the Strait of Malacca in the west and the Strait of Johor in the south. Coastal resources are the main source of income towards industrialisation and economic development in Johor especially along the coastal area. Tourism plays an important role in the state's economy. In Johor, Desaru beach is most popular beach and situated on the southeast coast of the district. It is located approximately 88 kilometres east of Johor Bahru and very close to the developing country, Singapore. Figure 1.1 shows the location of Desaru beach in Peninsular Malaysia.

The National Coastal Erosion Study (NCES) reported cases of coastal erosion and established for three categories (ASEAN/US CRMP, 1991). First category is critical erosion, second category is significant erosion and third category is acceptable erosion. Thus, Desaru is in category one which is critical erosion. Desaru beach also can be categorised as a steep beach slope. In coastal area, waves mobilise and currents transport coastal sediments. Erosion occurs when the amount of sediment transported away from an area exceeds the amount transported to it. Therefore, further investigation in this area is needed to predict accurately coastal erosion trends along Johor's coast.

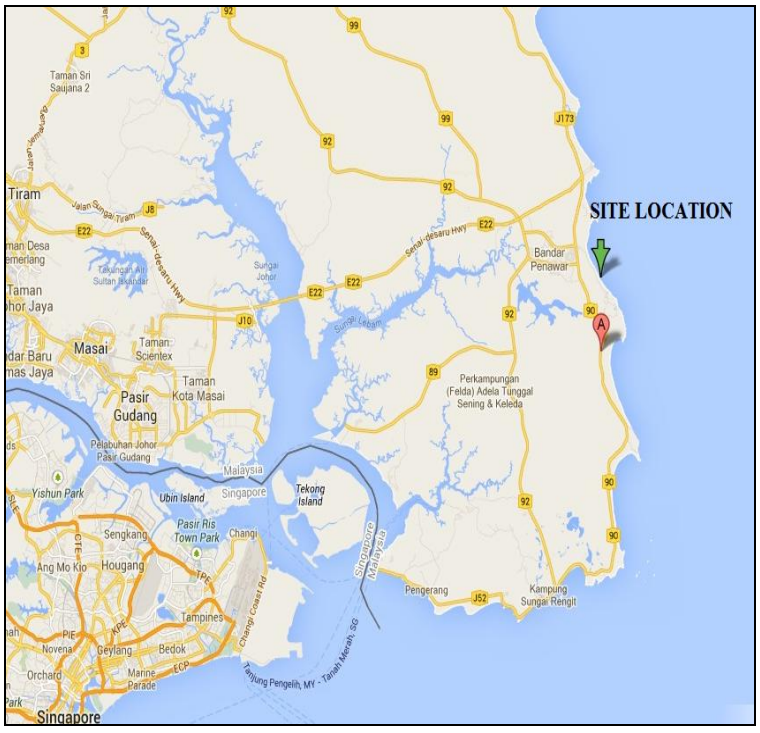

Figure 1.1: Location of Desaru beach

1.3 Importance of the Study

Desaru beach is a resort located at east of Johor. It is a very famous spot for tourists mostly from Singapore and the locals. This study is conducted to examine the suitability of the sediment trap on sandy beach by using different size of sediment trap. The sediment trap is used to collect moving sediment so that the transport rate

can be measured. The analysis of sample also is conducted in the laboratory to determine the size, density and porosity of sediment at the area. Beach profile change is measured to determine the erosion and accretion of the study area and also to analyse the direction of longshore sediment transport. Thus, the coastal erosion trends can be predicted at Desaru beach.

1.4 Objective of the Study

The objectives of the study are to:

1. Examine the suitability of sediment trap on sandy beach.
2. Analyse the sediment properties on the beach.
3. Analyse the direction of longshore transport by measuring beach profile.

1.5 Scope of the Study

Field work is conducted in order to achieve all the objectives of the study of longshore sediment transport in the swash zone at Desaru beach. The scopes of this study are:

1. Tide table is referred to determine the neap and spring in order to conduct beach profile measurement and to install the sediment trap.
2. Sediment trap is used to examine the suitability of the trap on sandy beach with different size and duration of study.
3. Analyse the sample to determine the grain size, porosity and density of the sediment.
4. Wind and wave rose are obtained from Malaysian Meteorological Department for analysis of the effect of wave to beach profile change.

REFERENCES

ASEAN/US CRMP (Association of Southeast Asian Nations/United States of Coastal Resources Management Project). (1991). The Coastal Environment Profile of South Johore, Malaysia. *ICLARM Technical Report*. 24:65.

Baba, Y. and Camenen, B. (2007). Importance of the Swash Longshore Sediment Transport in Morphodynamics Models. *Coastal Sediments '07*.

Bird, E. (2008). *Coastal Geomorphology: An Introduction*. (2nd ed.) . England: John Wiley & Sons Ltd.

CEM (Coastal Engineering Manual). (2002). Lonngshore Transport. Part III Chapter 2.

Davidson-Arnott, R. (2010). *An Introduction to Coastal Processes and Geomorphology*. United States of America: Cambridge University Press.

Dean, R. G. and Dalrymple, R. A. (2004). *Coastal Processes with Engineering Applications*. Cambridge, United Kingdom: Cambridge University Press.

Elfrink, B. and Baldock, T. (2002). Hydrodynamics and Sediment Transport in the Swash Zone: A Review and Perspectives. *Coastal Engineering*. 45, 149-169.

Fredsøe, J. and Deigaard, R. (1992). *Mechanics of Coastal Sediment Transport*. Singapore: World Scientific Publishing Co. Pte. Ltd.

Horn, D. P. and Mason, T. (1994). Swash Zone Sediment Transport Modes. *Marine Geology*. 120, 309-325.

Hughes, M. G., Masselink, G., Brander, R. W. (1997). Flow Velocity and Sediment Transport in the Swash Zone of a Steep Beach. *Marine Geology*. 138, 91-103.

Husain, M. L., Yaakob, R., Shahbudin, S. (1995). Beach Erosion Variability during a Northeast Monsoon: The Kuala Setiu Coastline, Terengganu, Malaysia. *Journal Science and Technology*. 3(2), 337-348.

Kamphuis, J. W. (1991). Alongshore Sediment Transport Rate. *Journal of Waterway, Port, Coastal and Ocean Engineering*. 117(6).

Karambas, T. V. (2006). Prediction of Sediment Trasnport in the Swash Zone by Using a Nonlinear Wave Model. *Continental Shelf Research.*

Karunarathna, H., Horrillo-Caraballo, J. M., Ranasinghe, R., Short, A. D., Reeve, D. E. (2012). An analysis of the Cross-Shore Beach Morphodynamics of a Sandy and a Composite Gravel Beach. *Marine Geology*. 299-3012, 33-42.

Larson, M., Kubota, S., Erikson, Li. (2004). Swash Zone Sediment Transport and Foreshore Evolution: Field Experiments and Mathematical Modeling. *Marine Geology*. 212, 61-79.

Liu, Z. (2001). *Sediment Transport*. (3rd ed.). Aalborg.

Morton, R. A., Leach, M. P., Paine, J. G., Cardoza, M. A. (1993). Monitoring Beach Changes Using GPS Surveying Techniques. *Journal of Coastal Research*. 9(3), 702-720.

Pedrozo-Acuña, A., Simmonds, D. J., Otta, A. K., Chadwick, A. J. (2005). On the Cross-Shore Profile Change of Gravel Beaches. *Coastal Engineering*. 53, 335-347.

Pieterse, J. J. (2009). *The Influence of an Ecobeach PEM on Beach Development*. Msc. Thesis. Technical University Delft.

Puleo, J. A., Beach, R. A., Holman, R. A., Allen, J. S. (2000). Swash Zone Sediment Suspension and Transport and the Importance of Bore Generated Turbulence. *Journal of Geophysical Research*. 105.

Reeve, D., Chadwick, A., Fleming, C. (2004). *Coastal Engineering: Processes, Theory and Design Practice*. Oxon: Spon Press.

Rosati, J. D. and Kraus, N. C. (1988). Hydraulic Test of Streamer Sediment Trap. *Journal of Hydraulic Engineering*. 14(12).

Shore Protection Manual (1984). Coastal Engineering Research Center. U.S. Army Corps of Engineers.

Sorensen, R. M. (2006). *Basic Coastal Engineering*. (3rd ed.). New York, USA: Springer Science + Business Media.

Trim, L. K., She, K., Pope, D. J. (2002). Tidal Effects on Cross-shore Sediment Transport on a Shingle Beach. Journal of Coastal Research. 36, 708-715.

Van Rijn, L. C. (2001). Longshore Sediment Transport. Report Z3054.20. Delft, The Netherlands.

Van Wellen, E., Chadwick, A. J., Lee, M., Baily, B., Morfett, J. (1998). Evaluation of Longshore Sediment Transport Models on Coarse Grained Beaches Using Field Data: A Preliminary Investigation. *Coastal Engineering*. 2640 – 2653.

Wang, P., Davis, R. A., Jr., Kraus, N. C. (1998). Cross-Shore Distribution of Sediment Texture Under Breaking Waves Along Low-Wave Energy Coasts. *Journal of Sedimentary Research*. 68(3), 497-506.

Won, C. C. and In, H. K. (2008). Cross-Shore Change of Beach Profile in Two Shapes of Beach Slopes Breakdown. *Proceedings of the Eighteenth (2008) International Offshore and Polar Engineering Conference*. July 6-18, 2008. Vancouver, Canada.

Wright, L. D. and Short, A. D. (1984). Morphodynamic Variability of Surf Zones and Beaches: A Synthesis. *Marine Geology*. 56, 93-118.