TANJUNG PIAI COASTLINE

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Civil – Hydraulics and Hydrology)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

MAY 2008

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To the people I love

and

to the people who love knowledge

ACKNOWLEDGEMENT

I would like to express my gratitude to all those who gave me the possibility to complete this project report. Special thank you to my supervisor, Professor Dr. Ahmad Khairi Abdul Wahab for his detailed and constructive comments, and for his important support throughout this work. I want to thank En. Roslee Ibrahim and En. Abd Rahman Mohamad Yusof from Jabatan Laut Semenanjung Malaysia (Wilayah Selatan) and Pn. Rubiatun Adawiah Ali from Jabatan Pengairan dan Saliran, Pontian for giving me the information and permission to use departmental data, and to all the staff for their kindness and warmth.

I would also like to thank Assoc. Prof. Dr. Omar Yaakob and Dr. Mohamad Pauzi Abdul Ghani from Department of Marine Technology, Faculty of Mechanical for giving me some ideas and lending of material. Also to Dr. Zulhilmi Ismail who involved in the process.

I am grateful to my mother for being supportive despite my determination to continue the degree and support me all this while, financially and mentally, during hard times. Not to forget my father and family members for their unconditional love and understanding.

To all my friends, thank you for being helpful and supportive in any way.

ABSTRACT

Tanjung Piai coastline has been facing critical erosion for years but recently the erosion rate is escalating. Numerical analysis of ship induced waves was carried out to determine the contribution of shipping traffic from Pelabuhan Tanjung Pelepas to the stability of Tanjung Piai coastline. The analysis includes the generation of waves from ships, propagation, transformation from deep water to shallow water and energy formation. Waves generated by ships decrease gradually when it propagate away from the sailing line and then increase near to the shore due to shoaling and damping factor. Bigger waves break near to the shore but smaller waves reach the shore without breaking. Maximum wave height generated by ships at the shoreline is 0.51 meter and the wave period is 3.23 seconds. Wave heights generated by wind were recorded to be between 1.2 and 1.7 meters with periods ranging from 4 to 8 seconds. Energy is related exponentially to wave height and bigger waves form higher energy to the beach. Based on wave energy to the shore, the analyses conducted showed that ship induced waves does not contribute to the erosion at Tanjung Piai coastline because of the small energy formation compare to wind induced waves.

ABSTRAK

Pantai Tanjung Piai berhadapan dengan masalah hakisan yang kritikal sejak bertahun yang lalu tetapi kadar hakisan semakin bertambah sejak kebelakangan ini. Analisis berangka terhadap ombak yang dihasilkan oleh kapal telah dijalankan untuk menentukan sumbangan lalulintas kapal daripada Pelabuhan Tanjung Pelepas kepada kestabilan pantai Tanjung Piai. Analisis yang telah dijalankan melibatkan penghasilan ombak daripada kapal, penyebaran, perubahan bentuk daripada air dalam kepada air cetek dan penghasilan tenaga. Ombak yang dihasilkan oleh kapal merosot sedikit demi sedikit apabila semakin menjauhi laluan kapal dan kemudian bertambah apabila berhampiran pantai disebabkan oleh faktor pencetekan dan redaman. Ombak besar pecah berhampiran pantai tetapi ombak kecil sampai ke pantai tanpa pecah. Ketinggian maksimum ombak yang sampai ke pantai ialah 0.51 meter dan tempohnya ialah 3.23 saat. Ketinggian ombak yang dihasilkan oleh angin yang direkodkan adalah di antara 1.2 dan 1.7 meter dengan tempoh 4 hingga 7 saat. Tenaga berhubung secara exponen terhadap ketinggian ombak dan ombak yang lebih besar menghasilkan kuasa yang tinggi kepada pantai. Berpandukan tenaga ombak terhadap pantai, analisis yang dijalankan menunjukkan bahawa ombak yang dihasilkan oleh kapal tidak menyumbang kepada hakisan di Tanjung Piai kerana penghasilan tenaga yang kecil berbanding tenaga yang dihasilkan oleh ombak janaan angin.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

COEI	-	Coastal and Offshore Engineering Institute
DANCED	-	Danish Cooperation on Environmental Development
DWT	-	deadweight tons
JPS	-	Jabatan Pengairan dan Saliran
LAT	-	Lowest Astronomical Tide
MSL	-	Mean Sea Level
PTP	-	Pelabuhan Tanjung Pelepas
SWPE	-	Ship Wave Pattern Evaluations
TEUs	-	Twenty foot Equivalent Units
ULCC	-	Ultra Large Crude Carrier

LIST OF SYMBOLS

B	-	beam
C	-	celerity
C_B	-	block coefficient
cm	-	centimeter
D	-	draught
d	-	depth
d_b	-	breaking depth
Fr_d	-	depth Froude Number
Fr_l	-	length Froude Number
ft	-	foot
g	-	gravity acceleration
H	-	wave height
H_b	-	breaking height
H_o	-	deep water wave height
K_d^l	-	relative damping coefficient
K_r^l	-	relative refraction coefficient
K_s^l	-	relative shoaling coefficient
kJ/m	-	kilojoules per meter
L	-	length/wave length
L_o	-	deep water wave length
L_{OA}	-	overall length
m	-	meter
m/s	-	meter per second
m/s^2	-	meter per square seconds

m/yr	-	meter per year
n	-	damping coefficient
s	-	second
T	-	wave period
V	-	speed of vessel
y	-	distance from sailing line
α	-	cups line angle
β	-	incident wave angle
γ	-	coefficient due to vessel size effect
ρ	-	water density
ζ	-	surface water elevation
ξ_b	-	surf similarity parameter
∇	-	volume of displacement
θ	-	propagation of direction
%	-	percent
^{o}	-	degree

CHAPTER 1

INTRODUCTION

1.1 Tanjung Piai

Tanjung Piai is the southern-most tip of mainland asia located in Pontian, Johor, Malaysia. Tanjung Piai is unique for its mudflats coast and mangroves forest which consist of many flora and fauna. Tanjung Piai has attained Ramsar status with two other sites namely Pulau Kukup and Sungai Pulai in 2003 (Mustapha, 2003). Tanjung Piai Ramsar Site is part of the larger southwest Johor wetlands. The southwest Johor wetland safeguard enormous biological diversity while providing important benefits and services of national interest and supports the livelihood of local communities.

Tanjung Piai is suffering from coastal erosion for many years and the area has been identified as one of the critical area for coastal erosion under National Coastal Erosion Study (Economic Planning Unit, 1985). However, in recent years the erosion has escalated significantly. Mangrove trees are being uprooted hence exposing the shoreline. It is predicted that this will contribute to the loss of ecological integrity and characteristics in this Ramsar Site.

The coast is facing critical beach erosion since 1992 and the erosion rate has been reported between 2.5 meter per year and 4.0 meter per year by Ministry of Science, Technology and the Environment. Geotubes has been installed at Tanjung Piai by Jabatan Pengairan dan Saliran (JPS), Malaysia in 2004 to mitigate the erosion problem. The geotubes seems to be ineffective in short term because the sedimentation rate is slow (Wong, 2006).

The geotubes reduce wave energy effectively except during high tide. The height of geotubes unable to reduce most of the wave energy and thus, the wave height behind the geotubes are almost the same as the incident wave height.

Figure 1.1: Geotubes installed at Tanjung Piai **(**Source: JPS, 2005)

It is believed that the erosion accelerated during the busy ship traffic from Pelabuhan Tanjung Pelepas (PTP) which operates since October 1999. Repetitive waves actions on the same spot from the ships worsen the already vulnerable beach. Not long after the Ramsar acceptance, international experts were promptly offered by the Bureau of Environment, Science and Technology to study and recommend remedial action to Tanjung Piai, in cooperation with the state of Johor.

Perbadanan Taman Negara, Johor (2007) stated that the study by Danish Cooperation on Environmental Development (DANCED) showed that the erosion from the west of Tanjung Piai results in sedimentation built up to the west of Tanjung Piai. An approximate of 70 hectares of mangroves forest has diminished due to erosion over two decades ago. Erosion currently has reached JPS bund protecting the agricultural hinterland. The occurrence could be because of several factor such as:

i) Wave and flow change from nearby reclamation activities
ii) Oil spill incident in Pontian – Selat Melaka water in 1997
iii) Forefront mangroves died because of water pollution
iv) Growth of ship traffic in Selat Melaka and Selat Tebrau water
v) Dredging activities
vi) Wind wave

Tanjung Piai might disappear from the map and loss the status as southern-most tip of mainland asia if the erosion . Listing Tanjung Piai as a Ramsar Sites is one of the legal action to preserve the coastline area. Several other attempts such as installing seawall and mangroves planting have been implemented but the outcomes do not show expected results.

1.2 Pelabuhan Tanjung Pelepas

Pelabuhan Tanjung Pelepas (PTP) has been operating since October 1999 situated at the mouth of Sungai Pulai. Currently, PTP has the capacity to handle up to 6 million TEUs per annum. Phase Two of the port involves dredging and reclamation of Bunker Island to upgrade the port bunkering facilities, and construction of additional eight berths measuring a total of 208 km. The first two berths of Phase II are now in operations and remaining berths will be constructed in

line with demand. The dredging project will widen the channel approach from 250 m to 400 m to enable two-way access for vessel traffic entering or leaving the port's harbour.

Meanwhile, widening and deepening the shipping access channel are to receive the Super Post Panamax container vessels in the future. Also, the draught will be deepened from 14 to 17 meters, allowing the port to accommodate the latest vessels which have an average capacity of 6,000 to 8,000 TEUs without any tidewater restrictions. The Port of Tanjung Pelepas is becoming a very busy port and attracts the world's largest liners, Maersk Line and Evergreen Marine Corporation (ASEAN Ports Association, 2003).

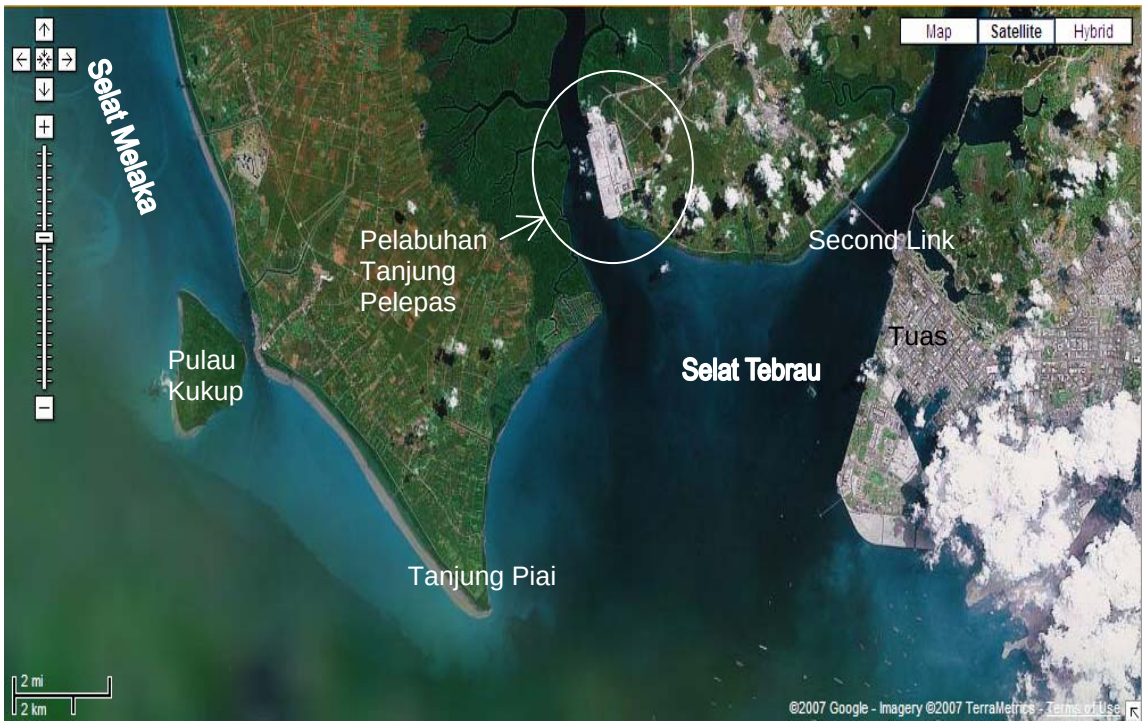

Figure 1.2: Satellite Image of Pelabuhan Tanjung Pelepas (Source: Google Map)

Figure 2 shows the satellite image of Pelabuhan Tanjung Pelepas, situated at the mouth of Sungai Pulai. Ships navigate through Selat Melaka and Selat Tebrau from one port to another.

In 2004, PTP set a new throughput handling record, with 4,020,421 TEUs handled to maintain its position as Malaysia's number one container terminal. The throughout figure represented a 15.2% increase over last year's 3,487,320 TEUs. Local cargo handled, which represents 4.17% of total cargo handled, increased by 12%, from 150,000 TEUs in 2003 to 168,000 TEUs in 2004. Vessel calls shown a rise of 1.4% (Figure 1.3), with 3,193 vessels calling at the port in 2004 compared to 3,148 vessels in 2003 (PTP Portfolio, 2005).

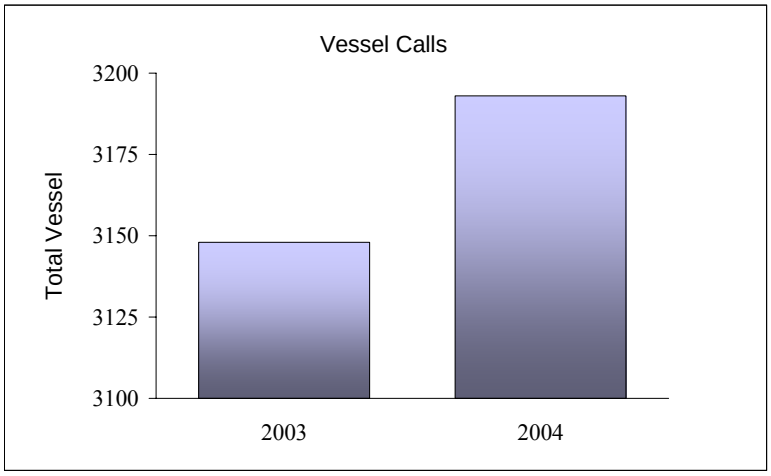

Figure 1.3: Vessel calls for 2003 and 2004

1.3 Objective

The objective of this project is to investigate the generation and propagation of ship waves onto the coast of Tanjung Piai and their contribution to the stability of the coastline.

1.4 Scope of work

This project will focus on wave properties generated by ships plying to and from PTP within the area of the southern part of Selat Tebrau, between Tanjung Piai and Tuas, Singapore.

REFERENCES

Allen T. Chwang and Yuhai Chen (2003). Field Measurement in Victoria Harbor. *Journal of Engineering Mechanics*. 129(10): 113-1148. ASCE.

Arbeitsausschuss "Ufereinfassungen" (2004). *Recommendations of the committee for Waterfront Structures Harbours and Waterways: EAU 2004* (8th ed., English translation of the 10th German ed.). Berlin: Ernst & Sohn.

ASEAN Ports Association (2003, December). Port of Tanjung Pelepas Phase II Progress Report. *APA Newsletter*. Retrieve July 26, 2007, from http://www.aseanports.com/news/2apa03/info_link2.htm

Battjes, J. A. (1974). Surf Similarity. *Proceedings 14th Coastal Engineering*. 1: 466-480. New York: ASCE.

Bernard, O. B., Mark, S. L. and Douglas J. S. (2002). Estimating Boat-Wake-Induced Levee Erosion using Sediment Suspension Measurements. *Journal of Waterway, Port, Coastal, and Ocean Engineering.* 128(4): 152-162. ASCE.

Blauuw, H., van der Knaap, F., de Groot, M., and Pilarczyk, K. (1984). *Design of Bank Protetion of Inland Navigation Fairways*. Delft Hydraulics Laboratary No. 320. Delft: Netherlands.

Bourne, J. (2000). Louisiana's Vanishing Wetlands: going, going... *Science* 289(5486): 1860–1863. Advancing Science, Serving Society (AAAS).

Bowditch – The American Practical Navigator. http://www.irbs.com/bowditch/

Coastal and Offshore Engineering Institute. *Report on Tanjung Piai Coastal Change*. Unpublished.

Committee on Coastal Erosion Zone Management and National Research Council (1990). *Managing Coastal Erosion*. Washington: National Academy Press.

Daidu Fan, Yanxia Guo, Ping Wang, and John Z. Shi (2006). Cross-Shore Variations in Morphodynamic Processes of an Open-Coast Mudflat in The Changjiang Delta, China: With an Emphasis on Storm Impacts. *Continental Shelf Research*. 26 (4): 517–538. Elsevier.

Dam, K. T., Tanimoto, K., Thuy, N. B., and Akagawa Y. (2006). Numerical Study of Propagation of Ship Waves on a Sloping Coast. *Journal of Ocean Engineering*. 33(3-4): 350–364. Elsevier.

Dand, I. (2004). Access Channels and Basins. In Hans, Agerschou (Ed.) *Planning and Design of Ports and Marine Terminals.* (2nd ed.). (pp. 83-107). London: Thomas Telfort.

Economic Planning Unit (EPU), Malysia (1985) National Coastal Erosion Study: Phase I Report. Government of Malaysia.

Goda, Y., (1970). Numerical Experiments on Wave Statistics with Spectral Simulation. *Port and Harbour Res. Inst., Japan*. 9(3).

Havelock, T. H. (1908). The Propagation of Groups of Waves in Dispersive Media, with Application to Waves on Water Produced by a Travelling Disturbance. *Proceedings of the Royal Society of London* A81 pp. 398-430.

Hong, C. B. and Doi, Y. (2006). Numerical and Experimental Study on Ship Wash Including Wave-Breaking on Shore. *Journal of Waterway, Port, Coastal, and Ocean Engineering*. 132(5): 369-378. ASCE.

Ippen, A. T. (1966). *Estuary and Coastline Hydrodynamics*. New York: McGraw-Hill

Jabatan Pengairan dan Saliran, Malaysia (2005). *Strategi Kawalan Hakisan di Kawasan Taman Negara Johor, Tanjung Piai.* Jabatan Pengairan dan Saliran, Malaysia.

Kamphuis, J. W. (2000) *Introduction to Coastal Engineering and Management*. Singapore: World Scientific.

Knight, S. (1999). *Wave Height Predictive Techniques for Commercial Tows on the Upper Mississippi River-Illinois Waterway System*. ENV Report 15, U.S. Army Engineer Research and Development Center.

Maynord, S. T. (2007). *Ship Forces on the Shoreline of the Savannah Harbor Project. U.S. Army Engineer Research and Development Center*. CHL TR-07-7, 150. U.S. Army of Corps of Engineers.

Ministry of Science, Technology and the Environment (MOSTE) (1992). *The Costal Resources Management Plan for South Johor, Malaysia*. Ministry of Science, Technology and Environment.

Mustapha, N. (2003). *Top News on Environment in Asia*. Malaysia: Institute of Strategic and International Studies.

Othman, M. A. (1991) *Value of Mangroves in Coastal Protection*. Jabatan Pengairan dan Saliran, Malaysia.

Pelabuhan Tanjung Pelepas (2005). *Portfolio: Overview 2004*. Issue 1.

Perbadanan Taman Negara, Johor (2007) *Perbentangan Laporan Hakisan Pantai Taman Negara Johor Tanjung Piai*

Pusat Hidrografi National (2005). *MAL 5123: Pelabuhan Tanjung Pelepas*. [Nautical Charts]. Tentera Laut Diraja Malaysia: Selangor.

Pusat Hidrografi National (2008). *Jadual Pasang Surut Malaysia 2008.*. Tentera Laut Diraja Malaysia: Selangor.

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

Somere T. (2007). Nonlinear Components of Ship Wake Waves. *Applied Mechanics Reviews*. Volume 60. ASME.

Sorensen, R. M. (1973). Ship Generated Waves. *Advances in Hydroscience*. 9:49-83. New York: Academic Press

Thomson, W. (1887). On Ship Waves. *Trans. Inst. Mech. Eng*. 8: pp. 409-433

USACE (2003). *EM 1110-2-1100*. Washington: USACE.

USACE (2006). *EM 1110-2-1613*. Washington: USACE.

Vincent, C. L. and Briggs, M. J. (1989). Refraction-Diffraction of Irregular Waves Over A Mound. Journal of Waterway, Port, Coastal and Ocean Engineering. 115(2): 269-284. American Society of Civil Engineers (ASCE).

Weggel, J. R., and Sorensen, R. M. (1986). Ship Wave Prediction for Port and Channel Design, *Proceedings, Ports '86 Conference*, American Society of Civil Engineers.

Wong Chui Ching. *The Effectiveness of Geotube System to Control Muddy Coast Erosion*. Thesis Bachelor Degree. Universiti Teknologi Malaysia: 2006.