NEARSHORE WAVE ANALYSIS OF BATU PAHAT RIVER ESTUARY

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To my beloved husband, daughter and parent

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ABSTRACT

Estuary, like other coastal systems, is ephemeral; undergo continuous geological evolution and very active coastal region. In this study, Batu Pahat river estuary is chosen, to observe wave conditions nearshore. Estuary of Sungai Batu Pahat is facing critical erosion due to navigation channel and exposed to high energy wave conditions from the Strait of Melacca. The offshore wave data are analyzed for various design waves of average one third of maximum wave heights ($H_{1/3}$) and extreme value of Gumbel and Weibull statistical distribution with three wave scenarios of Annual, Northeast Monsoon and Southwest Monsoon. This was followed by calculation of wave transformation nearshore using linear wave theory of Regular Wave theory and SWAN (Simulation Wave Nearshore) modeling formulated from Irregular Wave theory of spectral method. Gumbel statistical distribution predicted higher wave height nearshore compared to Weibull statistical distribution. $H_{1/3}$ gives the smallest. Then, in SWAN analysis results of finer grid size of 25m x 25m and coarse grid size of 50m x 50m grid size were compared. Finer grid size gave smaller results of wave heights at the same depth of coarse grid size. Furthermore, bathymetry of Sungai Batu Pahat is digitized and interpolated using SURFER program to provide with dredging and reclamation effects at the site. The bathymetry data was then exported to SWAN as SWAN bottom data. Dredging and reclamation activities had affected wave condition nearshore. Wave height, period, direction and energy dissipation is increased at nearshore area when compared to without dredging and reclamation effects. Thus, nearshore wave analysis had been successfully determined for various conditions and scenarios at Batu Pahat river estuary.

ABSTRAK

Muara sungai, seperti sistem pantai yang lain adalah tidak kekal; sentiasa mengalami evolusi geologi dan merupakan bahagian pantai yang aktif. Muara Sungai Batu Pahat dipilih sebagai kawasan kajian untuk memerhati keadaan ombak di kawasan pantai. Muara Sungai Batu Pahat mengalami hakisan yang agak kritikal disebabkan oleh laluan pelayaran untuk pelabuhan dan terdedah kepada tenaga ombak yang tinggi dari Selat Melaka. Data ombak laut dalam dianalisa untuk pelbagai ketinggian ombak terdiri daripada satu pertiga purata maksimum ketinggian ombak ($H_{1/3}$) dan nilai ekstrem taburan statistik Gumbel dan Weibull dengan tiga senario keadaan ombak iaitu Tahunan, Monsun Timur Laut dan Monsun Barat Daya. Ini diikuti oleh pengiraan perubahan ombak ke kawasan pantai menggunakan teori ombak lurus yang merupakan salah satu teori ombak seragam dan model ombak SWAN (Simulation Wave Nearshore) dirumuskan dari teori ombak tak seragam yang mengaplikasikan kaedah spektrum. Taburan statistik Gumbel memberikan nilai ketinggian ombak lebih besar berbanding dengan taburan statistik Weibull. $H_{1/3}$ memberi nilai ketinggian ombak terkecil. Kemudian, dalam analisis SWAN, saiz grid jarak kecil 25m x 25m dan saiz grid jarak besar 50m x 50m dibuat perbandingan. Saiz grid jarak kecil memberi nilai ketinggian ombak lebih kecil pada kedalaman yang sama dengan saiz grid jarak besar. Seterusnya, batimetri Sungai Batu Pahat didigitalkan dan diinterpolasi menggunakan program SURFER bagi menyediakan kesan mengorek dan menambak di kawasan kajian. Batimetri data kemudiannya dieksport ke SWAN sebagai data dasar. Aktiviti penambakan dan pengorekan memberi kesan kepada keadaan ombak di kawasan pantai. Tinggi, tempoh, arah dan pelesapan tenaga ombak bertambah di kawasan pantai kesan pengorekan dan penambakan. Daripada kajian, ombak di kawasan pantai Muara Sungai Batu Pahat telah berjaya dianalisa untuk pelbagai situasi dan senario.

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LIST OF ABBREVIATIONS

Ann	-	Annual Monsoon
CEM	-	Coastal Engineering Manual
DID	-	Department of Irrigation and Drainage
EFDC	-	Environmental Fluid Dynamics Code
EIA	-	Environmental Impact Assessment
FFT	-	Fast Fourier Transform
GUI	-	Graphical User Interface
HAT	-	Highest Astronomical Tide
MMS	-	Malaysian Meteorological Services
NEM	-	Northeast Monsoon
SPM	-	Shore Protection Manual
SSMO	-	Summary of Synoptic Meteorological Observations
SWAN	-	Simulating Wave Nearshore
SWM	-	Southwest Monsoon
UTM	-	University Technology Malaysia
VOSP	-	Voluntary Observer Ship Programme

LIST OF SYMBOLS

A	-	Scale parameter function of Weibull
B	-	Location parameter function of Weibull
k	-	Shape parameter function of Weibull
N	-	Number of individual wave heights
H_i	-	Wave height record ranked highest to lowest
T_r	-	Return period
$\bar{x}$	-	Mean wave height
σ	-	Standard deviation
α	-	Parameter distribution function
u	-	Parameter distribution function
$P(x)$	-	Extreme value distribution
x	-	Wave height parameter
θ_1, θ_2	-	Angles between wave crest and bottom contour at successive points along an orthogonal,
C_1, C_2	-	Celerities at point where 1 and 2 are measured.
K_s	-	Shoaling coefficient
H_s	-	Significant wave height
$H_{1/3}$	-	Average one third of maximum wave height
T_s	-	Significant wave period
d	-	Depth
L	-	Wave length
K_r	-	Wave refraction coefficient

C	-	Celerity
H_i	-	Incident wave height
T	-	Wave period
g	-	gravity
$N(\sigma,\theta)$	-	Action density spectrum
$E(\sigma,\theta)$	-	Energy density spectrum
θ	-	Wave direction
σ	-	Relative frequency
c_x , c_y	-	Propagation velocities in x and y dimensions
c_σ	-	Propagation velocity in σ dimension
$S(=S(\sigma,\theta))$	-	Source term in terms of energy density representing the effects of generation, dissipation and non-linear wave-wave interactions.
$S_{ds,w}(\sigma,\theta)$	-	Wave energy dissipation of whitecapping
$\overline{\sigma}$	-	Mean frequency
$\overline{k}$	-	Mean wave number
Γ	-	Wave steepness dependent
$S_{ds,b}(\sigma,\theta)$	-	Wave energy dissipation of bottom friction
C_{bottom}	-	Bottom friction coefficient
$S_{ds,br}(\sigma,\theta)$	-	Wave energy dissipation of depth-induced breaking
$S_{ds.br.tot}$	-	Mean rate of energy dissipation per unit horizontal area due to wave breaking and
E_{tot}	-	Total wave energy
Δt	-	Constant time step
Δx , Δy	-	Geographic space with constant resolutions in x and y-direction
$\Delta\theta$	-	Constant directional solution

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Water covers 71 percent of the Earth, and thus a large part of the Sun's radiant energy that is not reflected back into space are absorbed by the water of the oceans. This absorbed energy warms the water, which in turns warms the air above the oceans, and forms air currents caused by differences in air temperature. These air currents blow across the water, returning some energy to the water by generating wind waves (SPM, 1984). Winds that blow over the surface of oceans will generate waves. In a wave, water travels in loops. The waves then travel across the oceans until they reach land where their remaining energy is expanded on the shore. Waves and winds along the coast are both eroding rock and depositing sediment on a continuous basis, and the rates of erosion and deposition vary considerably from day to day along such zones. Wind waves are, by far, the largest contribution of energy from the sea to the beach and nearshore physical system. The energy reaching the coast can become high during storms, and such high energies make coastal zones areas of high vulnerability to natural hazards.

Malaysia has about 4,800 km of coastline comprising two distinctly different physical formations, namely the mangrove fringed mud flats and sandy beaches. The east coast of Peninsular Malaysia consists of straight sandy formations in the north and a series of hook or spiral shaped bays to the south. The west coast of Peninsular Malaysia, however, comprises mainly muddy formations, with limited areas of pocket sandy beaches (Shahrizaila.A, 1993). The coastal zone is broadly defined as the areas where terrestrial and marine processes interact. These include the coastal plains, deltaic areas, coastal wetlands, estuaries and lagoons. Coastal Zone covers a land area of about 4.43 million hectares or 13% of the total land mass in Malaysia (Shahrizaila.A, 1993). The coastal zone of Malaysia has a special socio-economic and environmental significance. It supports a large percentage of the population and it is also the center of economic activities encompassing urbanization, agriculture, fisheries, aquaculture, oil and gas exploitation, transportation and communication, recreation, etc. The coastal zone represents a unique environment which requires special attention in its planning, development and management. While the coastal zone is generally rich in resources which can be harnessed for the socio-economic growth of the country, it is important to recognize that the sustainable development of utilization of these resources must be founded on an approach that gives due consideration to the importance and sensitivity of the coastal processes and environment (Shahrizaila.A, 1993).

Coastal erosion is a natural phenomenon resulting from the interactions between natural processes and system. This phenomenon will continue to occur in the passage of time. Coastal landforms exist because hydrodynamic of waves, currents, tides and wind processes erode, transport and deposit particles of sediment. Coastline and beaches are constantly on the move. Land in the coastal area comes and goes, and land which nature provides at one time may later be reclaimed by the sea. Changes in the position of the coastline are a normal process on virtually every part of the region’s coastline. The change in position or shape of the coastline is almost always the result of both human activities and natural processes.

In Malaysia, coastal erosion has resulted in damage and loss of agriculture land, mangrove forests, houses, roads and recreation beaches (Zamali.M, 1988). In most cases erosion occurs due to natural causes but there are cases of erosion due to interference of nature by man. A study conducted by National Coastal Erosion Study in