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HYDRODYNAMIC AND SEDIMENT TRANSPORT MODELLING IN THE PADAS ESTUARY

MOHAMMAD SADEQ ASADI

A project report submitted in partial fulfillment 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 2011

I declare that this thesis entitled *"*Hydrodynamic and Sediment Transport Modeling in the Padas Estuary*"* is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ACKNOWLEDGEMENT

Praises to Allah SWT, the Most gracious and Most Merciful, Who has created the mankind with knowledge, wisdom and power. Being the best creation of Allah, one still has to depend on others for many aspects directly and indirectly. In preparing this dissertation, the author was indebted to many personnel, academics and practitioners. They have contributed towards my understanding and thoughts. Therefore, I would like to thank all those who gave me the possibility to complete this dissertation.

First and foremost, I would like to express my sincere gratitude to my supervisor, Professor Hadibah Binti Ismail who has supported me with her guidance, encouragement, patience and knowledge throughout the accomplishment of this thesis. My gratitude also been extended to all personnel of the Coastal and Offshore Engineering Institute (COEI) for their support, cooperation and constructive criticisms during the research period.

ABSTRACT

The quantification and monitoring of sediment dynamics in estuaries has received plenty of attention in recent years due to both economic and environmental interest. Accurate prediction of sediment transport in the Padas Estuary is essential for optimum location of jetty and navigation channel. A numerical model has been applied to predict the morphodynamic evolution in this area. The hydrodynamic and sediment transport in the Padas estuary was estimated by means of a two-dimensional hydrodynamic model (TELEMAC) coupled to a morphodynamic model (SISYPHE). Hydrodynamic characteristics calculated with the numerical model were compared to field measured data. The model calibration was achieved by comparing speed and direction at several stations in the sea, and comparing free surface water elevation (tidal) along the river. Model results and field data were generally in good agreement. The differences between model results and observed data were from 1.95% to 23% for current speeds, 5% to 15% for current directions and 4.6% to 14.5% for water level. Based on the results of hydrodynamic and morphodynamic models the following outcome have been achieved. The maximum water surface elevation is equal to 2.8 m and this occurred during flood tide. On the other hand, the minimum water surface elevation (1.5 m) occurred during ebb tide. It is observed that currents during ebb tide are stronger than those during flood tide and the deposition is a dominant phenomenon throughout the Padas estuary whereas erosion has been observed to occur only in a few places. The data resulting from this study could be used to determine the optimum location for jetty and navigation channel.

ABSTRAK

Pengaggaran dan pemantauan pergerakan sedimen di muara telah menerima banyak perhatian sejak akhir-akhir ini kerana kepentingan ekonomi dan persekitaran. Ramalan yang tepat mengenai pengangkutan sedimen di Muara Sg.Padas adalah penting untuk menentukan lokasi optimum jeti dan laluan kapal dikawasan itu. Di dalam kajian ini, model berangka telah dibina untuk meramalkan kadar pemendapan dengan menggunakan model hidrodinamik dua-dimensi (TELEMAC-2D) digabungkan dengan model pemendapan (SISYPHE). Ciri-ciri hidrodinamik daripada model berangka ini telah dibandingkan dengan data yang diambil di kawasan kajian. Kalibrasi model dicapai dengan membandingkan kelajuan dan arah arus di beberapa stesen di dalam kawasan kajian, dan membandingkan aras permukaan air (pasangsurut) di 2 buah lokasi. Keputusan model pada umumnya hampir kepada data lapangan. Perbezaan antara hasil model dan data yang diperolehi adalah antara 1.95% hingga 23% untuk kelajuan arus, 5% hingga 15% untuk arah arus dan 4.6% hingga 14.5% untuk aras permukaan air. Berdasarkan hasil model hidrodinamik dan pemendapan ini, keputusan berikut telah dicapai: Aras permukaan air maksimum adalah setinggi 2.8 m dan ini terjadi pada saat air pasang. Manakala, aras permukaan air minimum (1.5 m) terjadi pada saat air surut. Telah diperhatikan juga bahawa arus semasa air surut lebih kuat daripada arus semasa air pasang dan pemendapan adalah satu fenomena yang dominan di Muara Padas sedangkan hakisan hanya berlaku di beberapa tempat sahaja. Seterusnya, data yang dihasilkan daripada kajian ini boleh digunakan untuk menentukan lokasi optimum jeti dan laluan kapal di kawasan Muara Padas ini.

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CHAPTER 1

INTRODUCTION

1.1 General

The world's coastline has been engineered for many centuries, initially for the development of ports and maritime trade or fishing harbors to support local communities, for example, the Port of A-ur built on the Nile prior to 3000_{BC} and nearby the open coast the Port of Pharos around 2000_{BC}.

Malaysia is a coastal nation with a coastline of 4809 km and rich in biodiversity and natural resources. The country is divided into two landmasses by the South China Sea. Peninsular Malaysia is located to the west of South China Sea with a coastline of 2031 km and the other part is East Malaysia, consisting of Sabah and Sarawak. The Federal Territory of Labuan is located in the northwestern coast of Borneo island. Sabah has a coastline of 1743 km while Sarawak has a coastline of 1035 km. A map of the Malaysia coastline is shown in Figure 1.1.

Malaysia being a maritime nation has a need to develop its coastal zones. One of the results of this development is the planning for new ports and improves the infrastructure of existing ports.

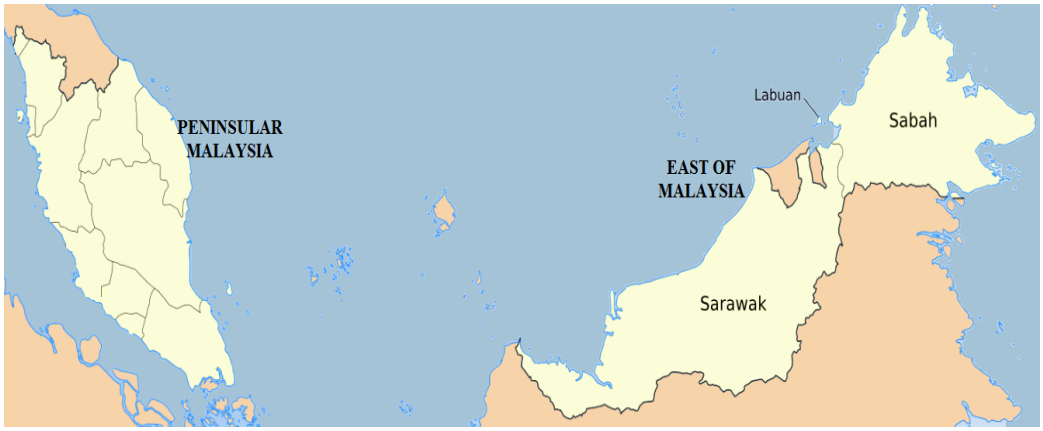

Figure 1.1: Map of Malaysia Coastline

Summary of coastline length
Peninsular = 2031 km
Sabah and Sarawak = 2778 km

This study is carried out to assist the Malaysia Marine Department to identify the best location of a new landing facility and navigation channel in the Padas estuary, Sabah. A two dimensional numerical model has been applied to simulate the hydrodynamic and sediment transport in the Padas estuary in the south western coast of Sabah.

1.2 Research Background

An old timber jetty was found to be abandoned 20 years ago due to river mouth sedimentation which restricts navigation traffic from the inland area to the sea. There is a need to construct a new jetty in the area to transport building materials in order to support development in the inland area along Sungai Padas especially the area to the south of the river bank. Therefore it is important to understand the behaviour of the hydrodynamics and morphodynamics of the Padas estuary. By considering the sediment and hydrodynamic characteristics the optimum location for the proposed landing facility and navigational channel could be determined.

Sediment transport plays a vital role in many aspects of river, coastal and offshore engineering. The dynamics of sediment influences the construction of infrastructures (bridges, dams), embankments, harbours and approach channels, power stations, the integrity of beaches, dredging and dumping activities, the safety of offshore platforms and pipelines, and many other activities. Moreover, sediment dynamics have a large impact on biodiversity. Despite its importance, the study and prediction of sediment dynamics still remains a challenging discipline where the margins of uncertainties are still very high. The difficulty of this discipline arises from many different reasons.

Sediment characteristics are often scarcely known and their spatial variability too high to be correctly represented by a limited number of variables. The moving agents of sediments (currents and waves) besides varying in time and space interact with each other and with the sediments at the bottom. This makes the relationship between flow properties and sediment dynamics not straightforward, even for very simple situations.

Predicting the rate of sedimentation in a domain can be difficult and inexact due to the complexity of the nature of sediment transport process and especially because parameter for calculating sediment transport is changeable due to time and space. The important variables to consider include: (1) hydrodynamic characteristics such as velocity, tidal fluctuation, and wave, and (2) sediment characteristics such as suspended sediment concentration, particle size, fall velocity, and sediment type (i.e., sand, silt, clay, etc.).

For understanding the behavior of a coastal area for construction of port or navigation channel or other important issues, it is compulsory to have plenty of data. Because the procedure of data collection is costly most of the time it is not possible to have enough data for this purpose. Nowadays for simulation of coastal area several computer codes have been used to overcome the sparcity of data and thus become more economical to study the behavior of the area.

1.3 Study Area

Sungai Padas is situated on the western coast of Sabah. The river mouth is about 15 km to the south-west of the town of Beaufort in Sabah which is about 90 km south of the Sabah state capital, Kota Kinabalu.

The Padas River is a relatively long river, about 200 km long, originating in the mountain in the middle of Sabah state and flowing into the South China Sea. The location of Padas estuary and origin of the river is presented in Figure 1.2.

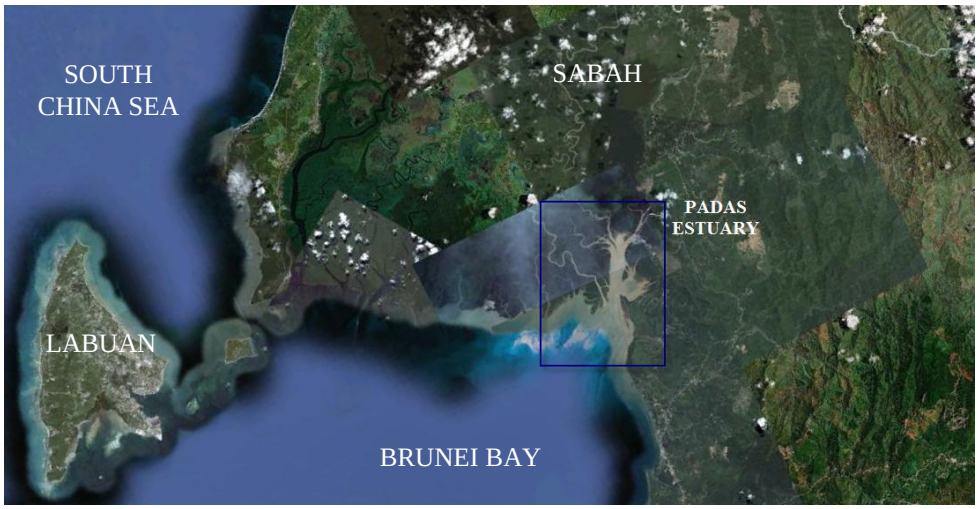

Figure 1.2: Study Area Location

The upper reaches of this 200 km river is one of the most popular destination for white water rafting (COEI, 2010). The lower reach passes through low lying marshy land that is inaccessible by land. The site location of Sungai Padas estuary and river system is illustrated in Figure 1.3 below. The upper reaches of Sungai Padas especially area close to Beaufort are prone to floods. The nearest town to Sungai Padas estuary is Weston. It is located 3 hours by road from Kota Kinabalu and 6 km from the river. From field observation, it is noted that the river mouth area is fringed by mangrove and other wetland species of fauna.

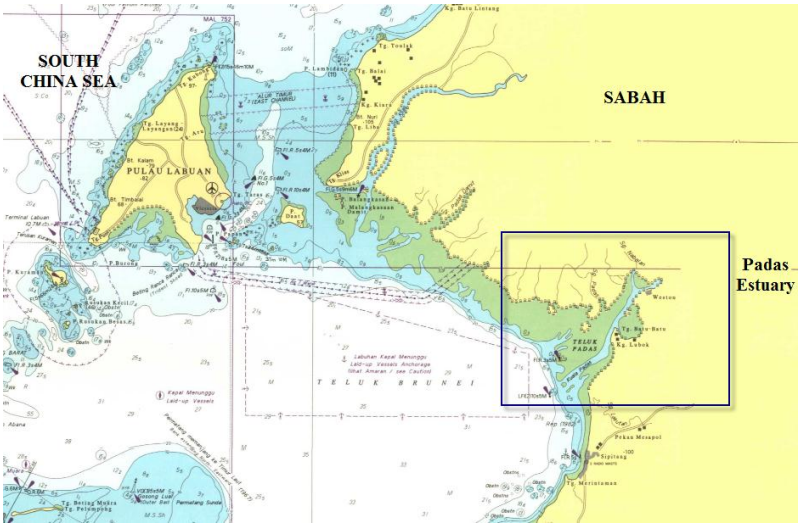

Figure 1.3 Location of the Sungai Padas estuary

1.4 Objectives of Study

The main objective of this study is to simulate the hydrodynamic and morphological behavior of the Padas estuary, by using a two dimensional computer code for numerical modeling. The specific objectives are described as follows:

i. To apply, calibrate and run a two dimensional hydrodynamic computer code on Padas estuary and to use the result of the model to provide a better understanding of the estuarine hydrodynamics.

ii. To find an approach and apply a two dimensional computer code to create a reliable and accurate model in order to describe the sediment transport behavior in the domain of study.

1.5 Scope of Study

The scope of this study can best be described as follows:

i. To choose a suitable domain around Padas estuary for numerical modeling.

ii. To construct the meshing elements for the domain using MATISSE programme.

iii. To conduct the hydrodynamic modelling by using TELEMAC2D programme and calibrate the model by available field data.

iv. To execute SISYPHE programme for the simulation of sediment transport.

1.6 Significance of Study

The findings from this study are expected to provide:

- The hydrodynamic characteristics such as velocity, water level and direction of flow at every time step.

- The sediment characteristics such as suspended load, bed load and bed evolution and by considering these parameters, the optimum location for navigation channel can be obtained.

- Considering the above, the optimum location for the proposed landing facility and alignment of the navigational channel could be determined. Thereupon the maintenance cost for navigation channel and jetty area may be reduced.