COMPUTER MODEL ON LINEAR WAVE PROPAGATION

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To

Almighty God,

My beloved father, mother, brother and sisters

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ABSTRACT

Many studies have been carried out by researchers over the years in attempt to understand waves. In conjunction to this, different wave theories were published. In this study, linear wave theory which is the simplest and mostly used theory to describe the wave motion is used. Microsoft Visual Basic 2008 is chosen as the programming language to develop a tool for the calculations of wave transformation based on linear wave theory. At the end of this study, a tool, WaveProp 1.0 is developed for the intended calculations of wave transformation based on linear wave theory. The model will be beneficial for industries and educational purposes. The wave length result from WaveProp 1.0 is compared to Eckart's approximation and Fenton and McKee's approximation, with varying wave period and water depth. Same percentages of error are obtained from both comparisons of wave length with varying wave period and water depth. Fenton and McKee's approximation is able to provide accuracy up to 1.66%, while Eckart's approximation is only able to calculate the wave length within accuracy of 5.23%.

ABSTRAK

Banyak kajian telah dijalankan oleh para penyelidik sejak zaman dahulu dengan tujuan untuk memahami ombak. Sehubungan dengan itu, teori-teori ombak yang berbeza telah diterbitkan. Untuk kajian ini, teori ombak linear yang merupakan teori yang paling mudah dan banyak digunakan untuk menerangkan pergerakan ombak telah dipakai. Microsoft Visual Basic 2008 telah dipilih sebagai bahasa pengaturcaraan untuk menghasilkan perisian bagi pengiraan transformasi ombak berdasarkan teori ombak linear. Di akhir kajian ini, suatu perisian, WaveProp 1.0 telah dihasilkan untuk tujuan pengiraan transformasi ombak berdasarkan teori ombak linear. Model ini akan berguna untuk bidang industri dan untuk tujuan pendidikan. Panjang gelombang daripada keputusan WaveProp 1.0 dibandingkan dengan penghampiran daripada Eckart serta penghampiran daripada Fenton dan McKee, dengan tempoh gelombang dan kedalaman air yang berbeza. Peratusan ralat yang sama diperoleh daripada kedua-dua perbandingan panjang gelombang dengan tempoh gelombang dan kedalaman air yang berbeza. Penghampiran daripada Fenton dan McKee berupaya untuk memberikan ketepatan sehingga 1.66%, manakala penghampiran daripada Eckart hanya dapat mengira panjang gelombang dalam ketepatan 5.23%.

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LIST OF ABBREVIATIONS

ASCE	-	American Society of Civil Engineers
BASIC	-	Beginner's All-purpose Symbolic Instruction Code
CERC	-	Coastal Engineering Research Center
Co.	-	Company
ed.	-	Edition
et al.	-	And others
Inc.	-	Incorporated
Ltd.	-	Limited
NA	-	Not available
Pte.	-	Private
MHW	-	Mean high water
MLW	-	Mean low water
MWL	-	Mean water level
SWL	-	Still water level

LIST OF SYMBOLS

A	-	Wave amplitude
b	-	Distance between adjacent wave rays
b_o	-	Distance between adjacent wave rays at location 0
b_1	-	Distance between adjacent wave rays at location 1
C	-	Wave celerity
C_o	-	Deep water wave celerity
C_g	-	Group celerity
C_{go}	-	Deep water group velocity
C_s	-	Shallow water wave celerity
d	-	Water depth
d_b	-	Breaking depth
d_0	-	Diameter of the circular orbit at sea bed
d_{orbit}	-	Diameter of the circular orbit
E	-	Wave energy
f	-	Wave frequency
g	-	Gravitational acceleration
H	-	Wave height
H_b	-	Breaking height
H_c	-	Deep water wave height
H_i	-	Incident wave height
k	-	Wave number
K_s	-	Shoaling coefficient
K_R	-	Refraction coefficient
L	-	Wave length
L_o	-	Deep water wave length

L_s	-	Shallow water wave length
n	-	Wave celerity ratio
P	-	Wave power
R	-	Wave run-up
T	-	Wave period
t	-	Time
u_m	-	Maximum orbital velocity
u_b	-	Maximum orbital velocity at sea bed
z	-	Depth below the water surface
α	-	Refracted wave angle
α_o	-	Incoming wave angle
β	-	Beach slope
γ	-	Breaking index
η	-	Surface displacement
$\overline{\eta_b}$	-	Wave set-down
$\overline{\eta_s}$	-	Wave set-up
ξ	-	Surf similarity parameter
π	-	Pi value
ρ	-	Density of water
σ	-	Wave angular frequency

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Water covers more than twice as much as the land out of the total surface area of the earth. The earth's surface consists of 71 percent water and 29 percent land. Marine waters are the water that exists in oceans and seas. The marine waters cover an area of 361 million square kilometers around the world. Marine waters comprise of 97 percent or 1.4 billion cubic kilometers of the water on earth. The other 3 percent of water exists in other environments such as lakes, rivers, ground water and ice (Davis, 1977).

Waves are a common natural phenomenon that occurs on the surface of the water and we may witness them from time to time in our everyday lives. Surface waves are the most often observed and easily recognized form of motion in the oceans and seas. Waves are always present and can be seen almost everywhere in the vast ocean because the wind is always blowing (Komar, 1998).

Waves exist in all shapes and sizes which are determined by the magnitude of the forces that created them. Waves can be generated from different sources, but the main source of generation is the wind. Other sources include volcano eruptions, gravitational attraction between sun and moon, underwater explosions, movements of earth's crust on the ocean floor, and others. The gravity force is the main restoring force for most of the ocean surface waves to propagate.

The stored energy in waves will release a great amount of on the beach face when they break. This energy has the ability to alter the location of the sand and modify the shape and form at the bottom of the sea bed. This is one of the major contributing forces for erosion and sediment transport that will lead to the formation of different coastal landforms over a period of time. That is reason for coastal engineers who are involved in the control of erosion to take much interest in the effects of the waves when they break upon the coastline.

As far as coastal engineering is concern, the planning and design of harbors and marinas, waterways, shore protection measures, hydraulic structures, and other civil and military coastal works are affected by waves and the forces that are generated by these waves. Therefore, knowledge in waves and its forces is important for the design of many coastal projects. Apart from that, almost all coastal engineering studies are required to estimate the wave conditions (Demirbilek and Vincent, 2002). Figure 1.1 shows the general view of areas that is deal by coastal, ocean engineers and oceanographers.

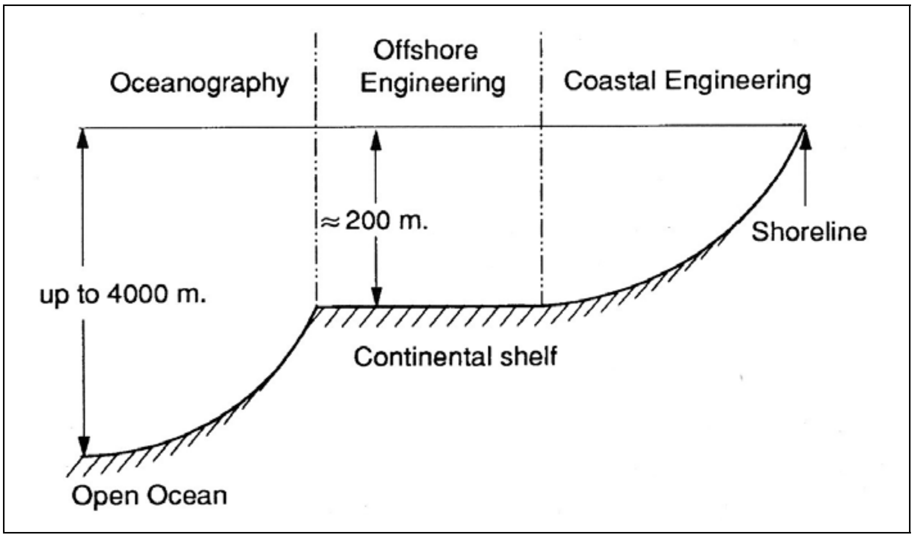

Figure 1.1 : General view of engineering territory (Source: Shibayama, 2009)

1.2 Objectives of Study

The objectives of this study are as follows:

i) To study and understand the wave transformation from deep water to shallow water and its calculations based on linear wave theory.

ii) To develop a tool for the calculations of wave transformations and its characteristics based on linear wave theory.

iii) To compare the wave lengths from Airy's linear wave theory with Eckart's approximation and Fenton and McKee's approximation with varying wave period and water depth.

1.3 Scopes of Study

The scopes of study are as follows:

i) Wave theory adopted in this study is based on linear wave theory developed by Airy, which include wave length, wave celerity, group velocity, orbital velocity, wave energy, and wave power. The wave transformations in shallow water included in this study are wave refraction, wave shoaling, and wave breaking.

ii) Microsoft Visual Basic 2008 is used to develop the tool for the calculations of wave transformation based on linear wave theory.

iii) The wave length results obtained from the iteration method developed by Airy that is used in the tool which serves as an exact value is compared with the Eckart's approximation and approximation developed by Fenton and McKee which do not require numerical iteration. The percentage of error between the exact value and the approximations is then calculated and compared. The comparisons between the calculations consist of wave length with varying wave period and water depth.

1.4 Importance of Study

Malaysia is a country which is surrounded by coastal areas. Waves are the major force of coastal process that affects the coastal formation. Wave transformation is important in coastal engineering, which include the contribution to the understanding of nearshore circulation, sediment transport and coastal morphology. In many parts of the world, problems may arise due to erosion of the coastline, therefore an increased understanding of waves and its characteristics will further enhance the protection works of coasts from erosion. The usage of computer models is an important part in the study of the coasts. The importance of computer models will continue to increase in the future, as computer models continue to develop more thorough and more complex features, which will lead to more detailed and accurate results. Computer models are very helpful because they can provide simplification of the real condition. By using computer models, the user is able to control the variables and examine one variable at a time. Any numerical results can be obtained by using computer models without having to go through the tedious processes in the days before computers.

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