ALTERNATIVE STRIP METHOD FOR A LATERALLY DRIFTING SHIP IN WAVES

MUHAMAD BIN RAMLI

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Universiti Teknologi Malaysia

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To my dear wife and my family, whose prayers always afforded me the power to accomplish this work. To all I dedicate this work with great respect and love.

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ABSTRACT

This thesis describes a study on an alternative strip method for a laterally drifting ship in waves. Currently, in an attempt the seakeeping performance, Faizul A. A. (2006) has included the lateral drift caused by wind forces and/or wave drifting forces in his studies of New Strip Method. Thereby, this research will validate the ship motions results from previous study that analyse on symmetrical body. On the other hand, this research will investigate the unsymmetrical body, including the consideration of lateral drift effect. Hence, offset data of several angles were obtained from the SR108 containership model. The mathematical formulations have been derived to suit with unsymmetrical body with lateral drift effect case. In addition, modifications on the computer program were carried out. Then, computed results of this research were than being compared to the results from previous study. It is found that there is a disagreement between the findings from both studies. Based on the researcher's investigation, this is due to some problems related to wave exciting forces.

ABSTRAK

Kajian ini adalah lanjutan untuk mengesahkan kaedah jalur bagi kapal yang bergerak dan mempunyai kesan hanyutan ke sisi. Pada kajian tersebut, permasalahan mengenai kesan hanyutan sisi yang disebabkan oleh daya yang dihasilkan oleh ombak dan/atau angin telah diaplikasikan di dalam kajian *New Strip Method* oleh Faizul A.A. (2006) bagi meramal pergerakkan kapal untuk disesuaikan dengan keadaan lautan. Sehubungan dengan itu, penyelidikan ini dijalankan untuk mengesahkan hasil keputusan yang dibuat daripada kajian terdahulu yang menganalisa pada badan simetri manakala untuk kajian masa sekarang akan menyiasat pada badan tidak simetri dengan mengambil kira kesan pergerakan kapal ke sisi. Berikutnya, maklumat mengenai ofset bagi sebilangan sudut kecil ke sisi diperolehi daripada model kapal kontena SR108. Formulasi matematik juga telah dirangka untuk disesuaikan dengan badan tidak bersimetri yang mempunyai kesan pergerakan kapal ke sisi. Di samping itu, modifikasi pada komputer program juga telah disediakan. Didapati keputusan tidak menepati ataupun kurang baik. Menurut kajian ini disebabkan terdapat masalah yang berkaitan dengan daya gelombang ombak.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	iv
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRACT	vii
	ABSTRAK	viii
	TABLE OF CONTENTS	ix
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
	LIST OF SYMBOLS	xv
1	**INTRODUCTION**	**1**
	1.1 Introduction	1
	1.2 Backgrounds of the Problem	2
	1.3 Problem Statements	4
	1.4 Objectives	5
	1.5 Scope of Study	5
	1.6 Significance of the Research	6
	1.7 Structure of Dissertation	6
2	**LITERATURE REVIEW**	**8**
	2.1 Introduction	8
	2.2 Coordinate Systems	10

	2.3	Sign Convention of Ship Oscillation	12
	2.4	Boundary Value Problem	13
	2.5	Pressure and Forces	15
	2.6	Conclusion	20
3	**RESEARCH METHODOLOGY**		**22**
	3.1	Introduction	22
	3.2	Research Flowchart	23
	3.3	Research Procedures	24
	3.4	New Offset Data	25
	3.5	Derivations of Mathematical Formulations	29
	3.6	Modification of Computer Programming	29
	3.7	Generating Computational Results	29
	3.8	Conclusion	30
4	**MATHEMATICAL FORMULATIONS**		**31**
	4.1	Introduction	31
	4.2	Modified Boundary Value Problems	31
	4.3	Pressure and Forces	35
		4.3.1 Pressure Acting on 2D Ship Section	35
		4.3.2 2D Hydrodynamic Force Coefficients	38
		4.3.3 Force and Moment Acting on 2D Ship Section	38
	4.4	Time Domain Equation of Motions	42
		4.4.1 Heaving Motion	43
		4.4.2 Pitching Motion	43
		4.4.3 Swaying Motion	44
		4.4.4 Yawing Motion	44
		4.4.5 Rolling Motion	45
	4.5	Frequency Domain on the Equations of Motions	45
	4.6	Conclusion	48
5	**COMPUTATIONAL PROGRAM**		**49**
	5.1	Introduction	49
	5.2	Flowchart	49

	5.3	Description for Main Program	51
	5.4	Conclusion	56
6	**RESULTS AND DISCUSSIONS**		**57**
	6.1	Introduction	57
	6.2	Result on Offset Data	57
	6.3	Exciting Force Coefficients	58
	6.4	Ship Motions	59
	6.5	Comparison ASM with NSM and Discussions	60
		6.5.1 Analysis on Exciting Force Coefficients	60
		6.5.2 Analysis on Ship Motions	66
7	**CONCLUDING REMARKS**		**78**
	7.1	Conclusions	78
	7.2	Recommendations for Future Work	79
	REFERENCES		**80**
	APPENDICES		**82**

LIST OF TABLES

TABLE NO.	TITLE	PAGE
3.1	Principle dimensions of container ship model, SR108	25
3.2	New Offset Table	27

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Principle of Strip Theory	2
1.2	Lateral Drift effect on ship movement	4
2.1	Coordinate systems	10
2.2	Sign convention of ship oscillations	12
3.1	Research Flowchart	23
3.2	Body plan of container ship model SR108	25
3.3	Comparison between strip sections	26
3.4	Measured value at section a-a for certain waterline	27
3.5	Plotted graph for unsymmetrical offset	28
5.1	Flow chart of the main program	50
5.2	Input data file format	54
5.3	Hull data file format	55
5.4	Output File	56
6.1	Computed results of exciting force coefficients for heave at various drift angles in head waves	60
6.2	Computed results of exciting force coefficients for pitch at various drift angles in head waves	61
6.3	Computed results of exciting force coefficients for sway at various drift angles in head waves	61
6.4	Computed results of exciting force coefficients for roll at various drift angles in head waves	62
6.5	Computed results of exciting force coefficients for yaw at various drift angles in head waves	62

6.6	Computed results of exciting force coefficients for heave at various drift angles in beam waves	63
6.7	Computed results of exciting force coefficients for pitch at various drift angles in beam waves	64
6.8	Computed results of exciting force coefficients for sway at various drift angles in beam waves	64
6.9	Computed results of exciting force coefficients for roll at various drift angles in beam waves	65
6.10	Computed results of exciting force coefficients for yaw at various drift angles in beam waves	66
6.11	Computed results of heave motion at various drift angles in head waves	68
6.12	Computed results of pitch motion at various drift angles in head waves	69
6.13	Computed results of sway motion at various drift angles in head waves	70
6.14	Computed results of roll motion at various drift angles in head waves	71
6.15	Computed results of yaw motion at various drift angles in head waves	72
6.16	Computed results of heave motion at various drift angles in beam waves	73
6.16	Computed results of pitch motion at various drift angles in beam waves	74
6.18	Computed results of sway motion at various drift angles in beam waves	75
6.19	Computed results of roll motion at various drift angles in beam waves	76
6.20	Computed results of yaw motion at various drift angles in beam waves	77
7.1	New Alternative Approach	79

LIST OF SYMBOLS

ω_e	: Frequency of encounter
ω	: Frequency of incident wave
υ	: Wave number of incident wave
U_0	: Forward speed
V_0	: Lateral speed
β_0	: Drift angle
$o-xyz$	: Body axis
$O-XYZ$	: Space coordinate systems
U^*	: Average forward velocity
ψ_o	: Yaw angle
χ	: Angle of incident waves
Ξ_i	: Time dependent motion displacement
ϕ_1	: Time dependent roll motion
θ_1	: Time dependent pitch motion
ψ_1	: Time dependent yaw motion
$X_o(t)$	: Ship position in longitudinal direction
$Y_o(t)$	: Ship position in transverse direction
$\Phi(x, y, z, t)$	: Perturbation potential around the ship
$G(P;Q)$	: Green’s Function
L	: Ship length
B	: Ship breadth
D	: Ship draft
$\Re$	: Real number

$P(t)$	: Phase shift due to lateral drift
A	: Amplitude of incident waves
i	: Complex number
n_i	: Outward normal unit vector of ship hull
N_i	: Outward normal unit vector in 2D
α	: Vector of motion displacement
φ_ω	: Time independent incident waves potential
φ	: Scattering and radiation potential due to ship motion
g	: Acceleration of gravity
ξ_i	: Time independent ship oscillation
ε	: Slenderness parameter
Φ_r	: Time dependent radiation potential
φ_I	: Simplified time independent incident wave potential
φ_j	: Radiation potential
φ_S	: Simplified scattering potential
$M_{\ell j}$	: 2D added mass coefficient
$N_{\ell j}$	: 2D damping coefficient
E_j	: 2D exciting force
A_{ij}	: 3D added mass coefficient for motion equation
B_{ij}	: 3D damping coefficient for motion equation
C_{ij}	: 3D hydrostatic restoring force coefficient for motion equation
F_{2c}	: 3D real exciting force for sway
F_{2s}	: 3D imaginary exciting force for sway
F_{3c}	: 3D real exciting force for heave
F_{3s}	: 3D imaginary exciting force for heave
F_{4c}	: 3D real exciting force for roll
F_{4s}	: 3D imaginary exciting force for roll
F_{5c}	: 3D real exciting force for pitch
F_{5s}	: 3D imaginary exciting force for pitch

F_{6c} : 3D real exciting force for yaw

F_{6s} : 3D imaginary exciting force for yaw

CHAPTER 1

INTRODUCTION

1.1 Introduction

Lateral drift is one of the effects that was included in the ship motion prediction to determine a rational ship seakeeping performance caused by wind forces and /or wave drifting forces acting on ships in actual seas. A research done by Faizul A. A. (2006) [1] has shown that lateral drift has a significant effect on the movement of ships. The method used in calculating the effects of lateral drift is the strip methods with asymptotic expansion method by including the small-τ theory referred as New Strip Method [1].

Another approach of identifying the lateral drift effect of ship motions is by using sets of offset data for each drift angle. The method, known as Alternative Strip Method (ASM) includes the offset data of the container ship (SR108) which is taken from different sets of drift angle in the strip method.

The result of equation of motions which based on the Alternative Strip Method (ASM) will be compared with New Strip Method [1].

1.2 Backgrounds of the Problem

Strip method is the most popular tool used for the approximation of the coefficient for the equations of motions such as added mass coefficients and damping coefficients for slender ships that cruise at certain forward. According to J. N. Newman (1978) [2], the slenderness of the ship occurs when the length of the ship is much greater than the beam and draught for that particular ship. Generally, strip method assumes small motion in vertical and horizontal modes for a ship with symmetrical geometry shapes at port and starboard. It can be illustrated as in Figure 1.1.

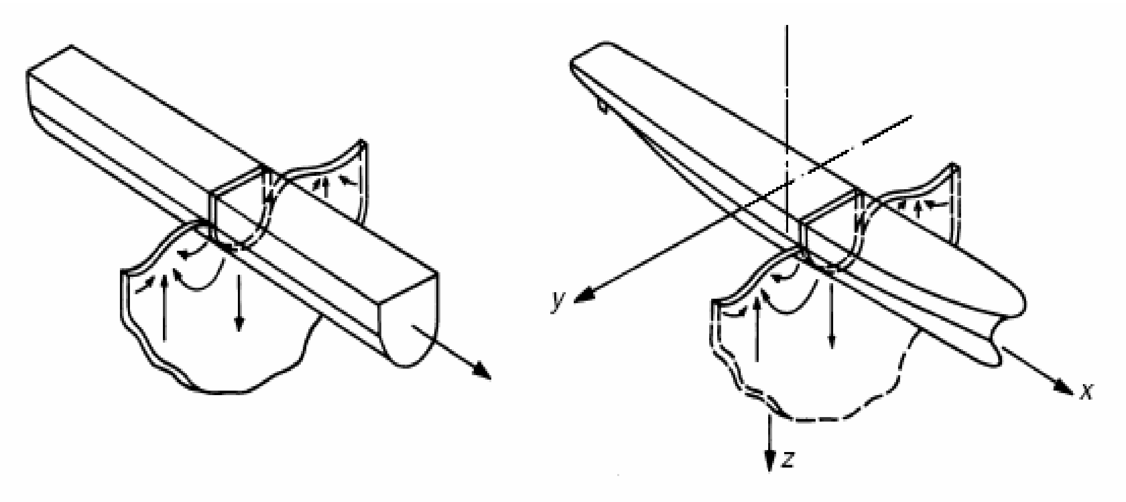

Figure 1.1: Principle of Strip Theory [2].

A two-dimensional ship section is analysed using the offset of the ship hull. Only hydrodynamic effects of the wetted hull are taken into accounted. The calculations of strip method have been divided into two major steps. The first step is an evaluation of the two-dimensional sectional hydrodynamic coefficients by utilizing the boundary-element method for the oscillating ship bodies near a free surface.

The second step is a calculation of the three-dimensional hydrodynamic coefficients which is done by integrating the two-dimensional sectional hydrodynamic coefficients along the longitudinal direction of the ship hull. Finally, the differential equations will be solved to obtain the equation of motions. These calculations can be performed either in the time domain or frequency domain.

When the ship is moving with certain forward speed, the strip method must take into account the possibility of the ships to deviate from the route caused by the wind forces and/or wave drifting forces acting on ships in rough sea condition.

Ships which move at sea will experience lateral drift forces. As seen in Figure 1.2, a ship has set its intended course to Point A. When the ship moves, it will experience external forces from waves and/or winds causing it to drift at an angle β. This will cause the ship to drift to the position of point B. The forces caused by waves and/or winds are known as lateral drift.

In order to include the calculation of lateral drift in the ship motion predictions, the Strip Method is used. Strip method is an approximation method to estimate the coefficient of the equation of motion. Strip methods are the most popular tool for ship seakeeping computations.

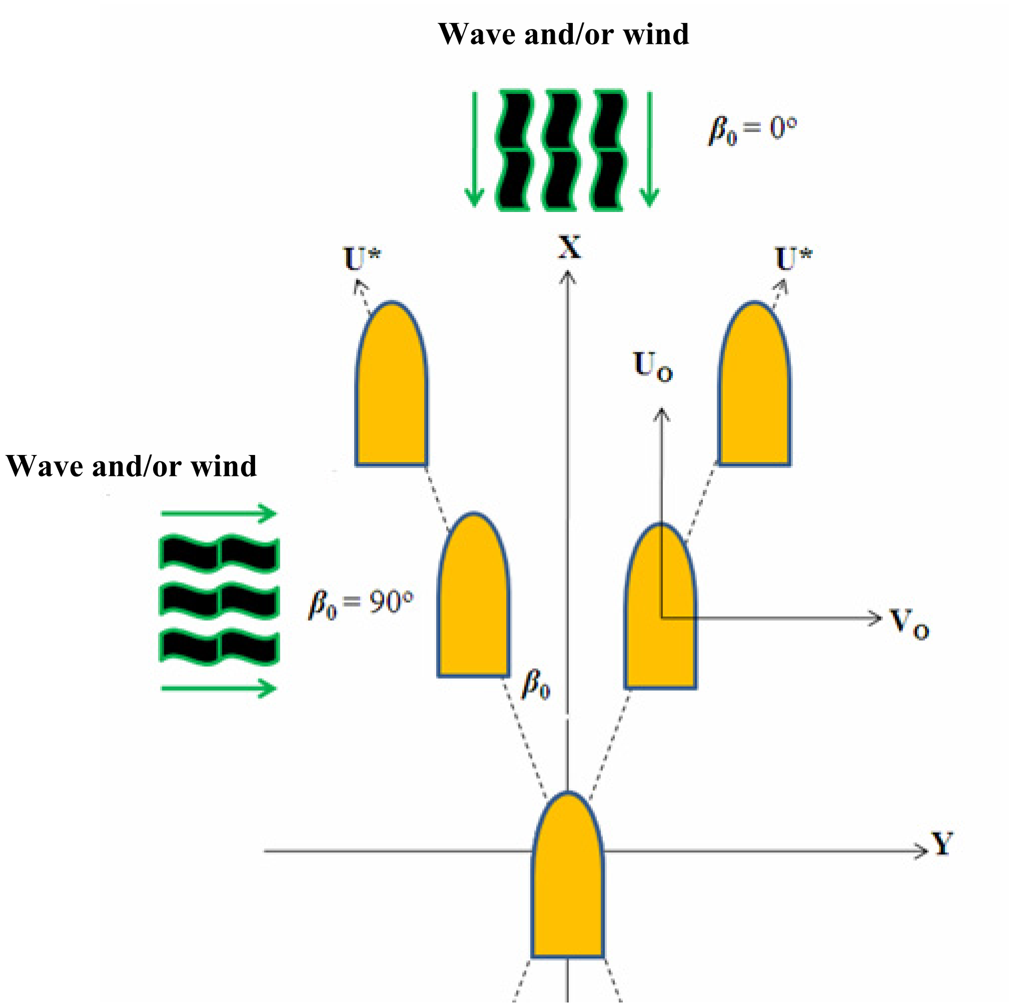

Figure 1.2: Lateral Drift effects on ship's movement.

1.3 Problem Statements

The problem statements of the study are as follows:

- What is the method to derive the equation of motions for Alternative Strip Method?
- How does Alternative Strip Method verified?

- What are the significant of the effects of lateral drift on ship motions?
- Is there any other simple approach to solve the problem related to lateral drift effect on wave-induce motion?
- Is it possible to use original New Strip Method for the specified problem?
- It is possible to include the effect of lateral drift in view of offset data?

1.4 Objectives

The objectives of this study are:

1. To develop an Alternative Strip Method for a laterally drifting ship in waves.
2. To further verify the computation result of ship motions using ASM.

1.5 Scope of Study

The scopes of this thesis are as follows:

1. The application of a Strip Method for ship motions prediction with lateral drift effect.
2. Derivations of the new mathematical formulation for ASM.
3. Modification of subroutine of source code using FORTRAN.

4. Analysis the results of ASM.

1.6 Significance of the Research

This study was carried out for the purpose of further validation of the effect of the lateral drift on wave-induced motion using the Alternative approach of the strip method. The outcome of this research will be used to verify whether the approach used in this research is applicable to solve recent problem and results pointed out by (Faizul A. A., 2006) [1]. The study will focus on the strip method for a lateral drifting ship in waves using unsymmetrical offset data. The finding of the study will be obtained through the research findings that will be conducted on container ship's model SR 108.

1.7 Structure of Dissertation

This dissertation has been divided into several chapters. Each chapter has their own subtopics The layout of this dissertation have been organized comprehensively as follows:

Chapter 1 begins with the general overview of the lateral drift effect on ship motion and their values in predicting the seakeeping performance. It follows the background of the problem, the problem statements need to verified, the describe of objective and scope of the study. Later on, this chapter is carried out with the significant of the research and the arrangement of dissertation structure.

Chapter 2 describes literature reviews. This section elaborate on the defined coordinate systems, the sign convention of ship oscillation and the use of boundary value problem with making some assumption.

Chapter 3 explains on the methodology for this research. It includes the research procedures and steps in obtaining the offset data and analysis data.

Chapter 4 discusses on the mathematical formulation. In addition, this chapter explains about the pressure and forces that need to be consideration and the equations of motion which define for heave, pitch sway, yaw and rolling motion and all equations have been modified to solve the unsymmetrical body with lateral drift effect.

Chapter 5 discusses the computational program. This chapter elaborates more on the flow of programming working process such as extract more subroutine of program for function of input data file and hull data file.

Chapter 6 discusses the comparison between results of unsymmetrical offset data and results of ASM.

Chapter 7 consist of the conclusion of this study together with some recommendation for further study.