FURTHER VALIDATIONS OF THE HYDRODYNAMIC FORCE COEFFICIENTS FOR LATERALLY DRIFTING SHIP IN WAVES

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To my beloved Father and Mother, my dearest Wife and my Son, whose prayers always accompanies me. To all I dedicate this work with great respect and love.

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ABSTRACT

Lateral drift effects are caused by the effects of wind forces and /or wave drifting forces acting on ships in actual seas Lateral drift effect has been found to have significant effects in the ship motion.(Faizul A. A. 2006). . The lateral drift effect are one of the effects that is included in the ship motion prediction to determine a good seakeeping performance of the ship

Another approach to determine the effects of lateral drift has been done in this project. The approach is by taking several sets of offset data at different drift angle. The new approach is named The Alternative Strip Method (ASM). The ASM will be another method to calculate the effects of lateral drift on the ship motion prediction. From the results obtained from the ASM calculations, the lateral drift effects are further verified on 2D/3D hydrodynamic force coefficients on floating body and 3D ship.

ABSTRAK

Kesan aliran sisian disebabkan oleh kesan daya aliran sisian angin atau ombal yang bertindal ke atas kapal-kapal di lautan. Kesan aliran sisian ditemui mempunyai kesan penting pada pergerakan kapal (Faizul A. A. 2006). Kesan aliran sisian adalah salah satu kesan yang dimasukkan ke dalam ramalan pergerakan kapal untuk menentukan prestasi pergerakan kapal yang baik. Satu lagi pendekatan telah digunakan untuk menetuukur kesan-kesan aliran sisian di dalam projek ini. Pendekatan yang digunakan ialah dengan mengambil beberapa set *offset data* pada sudut aliran berlainan. Pendekatan baru in dinamakan "Alternative Strip Method (ASM). ASM akan menjadi sebuah lagi cara untuk mengira kesan aliran sisian ke atas ramalan pergerakan kapal. Keputusan yang diperolehi daripada pengiraan ASM lebih mengesahkan kesan aliran sisian ke atas 2D/3D *hydrodynamic force coefficents* ke atas jasad terapung dan kapal 3D.

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o-xyz	-	body axis
z_G	-	centre of gravity
$O-XYZ$	-	space coordinate system
t	-	time factor
ψ_0	-	yaw angle
$X_0(t)$	-	ship position in longitudinal direction
$Y_0(t)$	-	ship position in transverse direction
χ	-	angle of incidence wave
g	-	acceleration of gravity
G(P,Q)	-	Green's function
L	-	ship length
B	-	ship breadth
D	-	ship draft
L_{pp}	-	length between perpendicular
ϕ_I	-	time dependent incident waves potential
$\Re$	-	real number
3D	-	three dimensional
2D	-	two dimensional
A	-	amplitude of incident waves
i	-	complex number
ω	-	wave frequency of incident waves
v	-	wave number of incident waves
$P(t)$	-	phase shift due to lateral drift
$\dot{X}_0$	-	time differentiation due of longitudinal position

$\dot{Y}_0$	-	time differentiation of transverse position
$\dot{\psi}_0$	-	time differentiation of yaw angle
ω_e	-	frequency of encounter
ω_{e0}	-	frequency of encounter due to change in lateral drift
U^*	-	averaged forward velocity
β_0	-	drift angle
U_0	-	forward velocity
V_0	-	lateral velocity
$\dot{U}$	-	time differentiation of forward Velocity
$\dot{V}$	-	time differentiation of lateral Velocity
φ_w	-	time independent incident waves potential
φ	-	scattering and radiation potential due to ship motion
$\Phi(x, y, z, t)$	-	perturbation potential around the ship
Φ_r	-	time dependent radiation potential
ξ_i	-	time independent ship oscillation
$\xi_i^{'}$	-	nondimensionalized time independent ship oscillation
α	-	vector of motion displacement
Ξ_i	-	time dependent motion displacement
ϕ_1	-	time dependent roll motion
θ_1	-	time dependent pitch motion
ψ_1	-	time dependent yaw motion
n_i	-	outward normal unit vector of ship hull
N_i	-	outward normal unit vector in 2D
k	-	order of ship motion problem
μ	-	coefficient due to change in lateral drift
υ	-	Rayleigh viscosity coefficient
$\varphi^{(1)}$	-	velocity potential O(1)
β_j	-	motion coefficient
φ_j	-	radiation potential

φ_4	-	scattering potential
φ_S	-	simplified scattering potential
φ_I	-	simplified time independent incident waves potential
$M_{\ell j}$	-	2D added mass coefficient
$N_{\ell j}$	-	2D damping coefficient
E_j	-	2D exciting force
$\overline{A}_{ij}^{2D}$	-	2D nondimensionalized added mass coefficient
$\overline{B}_{ij}^{2D}$	-	2D nondimensionalized damping coefficient
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
$\overline{A}_{ij}$	-	3D nondimensionalized added mass coefficient
$\overline{B}_{ij}$	-	3D nondimensionalized damping coefficient
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_{4s}	-	3D imaginary exciting force for roll
T_{ϕ}	-	roll period
∇	-	ship displacement
$\overline{KM}$	-	vertical distance between keel and metacentre
k_{xx}	-	moment of inertia about *x*-axis
k_{yy}	-	moment of inertia about *y*-axis
H_w	-	wave height

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CHAPTER 1

INTRODUCTION

1.1 Introduction

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

Lateral drift has been found to influence the ship motion at specific drift angle by using New Strip Method (Faizul A. A., 2006). Another approach of identifying the lateral drift effect of ship motions will be studied by using different sets of offset data for each drift angle. The method will include taking the offset data of the ship taken at different sets of angle in the strip method . The method is called Alternative Strip Method (ASM)

Comparison between the two approaches of Strip Method will be focused in this study.

1.2 Background of the Problem

Ships moving in the sea will experience lateral drift forces. Referring to Figure 1.0, 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 named lateral drift.

The Strip Theory is used with the additional mathematical formulations to calculate the lateral drift in the ship motion predictions. Strip theory is an approximation to estimate the coefficient of the equation of motion. Strip methods are the standard tool for ship seakeeping computations. An essential part of each strip method is the computation of hydrodynamic masses, damping, and exciting forces for each strip. This computation was traditionally based on conformal mapping techniques, where an analytical solution for a semicircle was transformed to a shape resembling a ship section by source distribution technique..

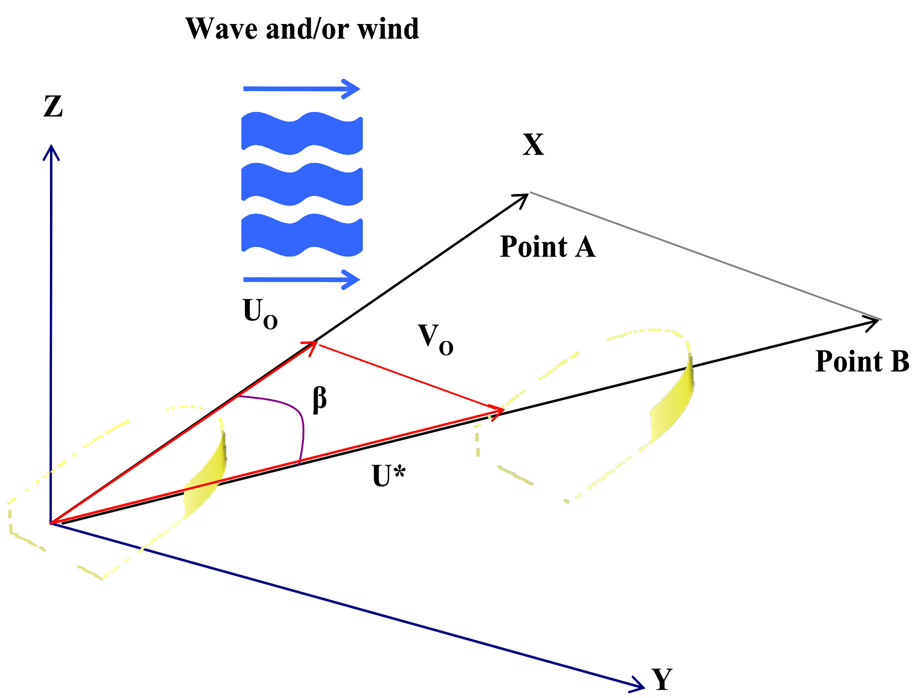

Figure 1.0: Lateral Drift effects on ship's movement

1.3 Objectives

The objectives of this study are:

1. To calculate the hydrodynamic force coefficients for a laterally drifting ship in waves by using several sets of offset data at specified drift angle.
2. To produce the computed results of the hydrodynamic force coefficients for a laterally drifting ship in waves

1.4 Scope of Study

The scope of the study will include:

1. Literature review on potential flow theory and 2D floating body
2. Development of several sets of offset data for respective drift angle
3. Familiarization of FORTRAN language
4. Modification of computer program using FORTRAN

1.5 Significance of the study

The significance of the study is as the following:

1. An alternative approach is used to calculate the hydrodynamic forces coefficients in comparison with the strip method that was proposed by Faizul A. A. (2006).

2. Further verification on the effects of lateral drift effect on 2D/3D hydrodynamic force coefficients on floating body and 3D Ship.

1.6 Problem Statement

In carrying out this research work, the following issues will be addressed;

1. What is the method used to predict the hydrodynamic force coefficients for a laterally drifting ship in waves?
2. How accurate is the calculation using different sets of offset data at different drift angle in predicting the hydrodynamic force coefficients?
3. If improvement is needed, what will be a good method to further verify the lateral drift effect on 2D and 3D hydrodynamic force coefficients?

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