NUMERICAL SIMULATION OF SIDE SHIP LAUNCHING

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INTRODUCTION

- MOTIVATION
- OBJECTIVE
- RECENT RESEARCH
WHY IS IT IMPORTANT?

Predict launching phenomena

Less time consuming of calculation

Simple application to show motion behavior

Minimize potential risks of capsizing or hitting seabed

2/18/2019
OBJECTIVE

01 To develop an automated numerical simulation of side launching

02 To predict the whole process of launching

03 Investigate the effect of different water level on side launching

TOOL:

A programming language and numerical computing developed by MathWorks
## RECENT RESEARCH

<table>
<thead>
<tr>
<th>Author</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ye. Z. (1994)</td>
<td>Mathematical model of 2D box shape with 3 DOF motion, 4 phases, and added mass</td>
</tr>
<tr>
<td>Kraskowski M. (2007)</td>
<td>Simplified RANSE simulation of a side launching for small vessel compared with experiment result</td>
</tr>
<tr>
<td>Fitriadhy A. and Malek A. (2017)</td>
<td>CFD analysis of a ship’s side launching with variation of slipway angle and slipway distance</td>
</tr>
<tr>
<td>Cardona J. S. (2017)</td>
<td>Controlled design of side launching system for tugboats, introducing simplified two-dimension simulation and new design of tipping table cradle</td>
</tr>
</tbody>
</table>
LAUNCHING CONFIGURATION

• GEOMETRY MODEL
CRADLE Data:
L = 22.5 m
B = 2.225 m
T = 3.194 m
Δ = 301.7 Ton

SLIPWAY data:
L = 100 m
B = 64 m
D = 10.5 m
θ = 7.13 deg

SHIP Data:
Lpp = 74.68 m
B = 16.2 m
T = 2.652 m
Δ = 1933.76 Ton
COMPUTATION PROCEDURE

• COMPUTATION STRATEGY
• MATHEMATIC MODEL
• LAUNCHING PHASES
• LAUNCHING SCENARIO
COMPUTATION STRATEGY

Start

Initialize 3D space & grid

Input ship & cradle properties and coordinate data

Display 3D model

Declare all variable

Calculate force (t), Acc (t), vel(t) & Displ (t)

B ≥ W

B ≤ W

X(t) ≥ Xtarget

Continue iteration

Finish

Σforce ≈ 0

yes

no

Cal force (t), X(t), φ(t), V(t), ϕ(t), a(t) & ϕ(t)

Declare dynamic properties

Initialize object motion

Display output graph

Display output graph

Initialize object motion

Σforce ≈ 0

Display output graph

Initialize object motion

Σforce ≈ 0

Display output graph

Initialize object motion

Σforce ≈ 0

Display output graph
EQUATION OF MOTION

Sliding Equation of Motion Phases

\[ m x'' = \sum P + Fs + Fn + Fd \]

Free damped equation of motion

\[ (m + ma) X(\omega)\omega^2 + B X(\omega)\omega + K_h X(\omega) = 0 \]

Frequency domain to Time domain

\[ X(t) = X(\omega) e^{-\zeta \omega t + \varphi} \cos(\omega_d t + \varphi) \]

Computation condition:

- Friction coefficient (\( \mu \)) = 0.03
- Velocity at initial condition = 0 m/s
- Critical damping coefficient = 5 %
- Density of water = 1 ton/m³
- No environment condition
PHASE 1
the static of an inclined plane.

PHASE 2
The Static Of An Inclined Plane + Drag Force on cradle

PHASE 3
The static of an inclined plane + drag force on cradle & ship

TIPPING
the static rotation motion with constant forces

IMMERSION
the translation and rotation of motion + drag force and bouyancy

FREE DAMPED OSCILLATION
**Case 1** (Optimistic condition)
water level : +4.84 m above edge of slipway

**Case 2** (Worst condition)
water level : +2.6 m above edge of slipway
COMPUTATION RESULTS

• LAUNCHING PLOT
• COMPARISON RESULT
• SUMMARY RESULT
• LAUNCHING RESULT
LAUNCHING PLOT

1st scenario

2nd scenario

PHASE 1

PHASE 2
LAUNCHING PLOT

1\textsuperscript{st} scenario

2\textsuperscript{nd} scenario

PHASE 3

No tipping

TIPPING
<table>
<thead>
<tr>
<th>1\textsuperscript{st} scenario</th>
<th>2\textsuperscript{nd} scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Immersion</td>
<td>Free Damped Oscillation</td>
</tr>
</tbody>
</table>

**IMMERSION**

**FREE DAMPED OSCILLATION**
## COMPARISON RESULTS BETWEEN NUMERICAL AND COMPUTATIONAL FROM REFERENCE

### DURATION

<table>
<thead>
<tr>
<th></th>
<th>Simulation</th>
<th>Real Case</th>
<th>Simulation</th>
<th>Data</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHASE 1</td>
<td>5.53 s</td>
<td>5.53 s</td>
<td>x = 14.22 m</td>
<td>x = [-]</td>
<td>&lt; 2.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>v = 5.15 m/s</td>
<td>V = 5.3 m/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a = 0.932 m/s²</td>
<td>a = 0.93 m/s²</td>
<td></td>
</tr>
<tr>
<td>PHASE 2</td>
<td>4.05 s</td>
<td>± 4 – 5 s</td>
<td>x = 42.44 m</td>
<td>x = 44.27</td>
<td>&lt; 5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>v = 7.69 m/s</td>
<td>V = - m/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a = 0.181 m/s²</td>
<td>a = - m/s²</td>
<td></td>
</tr>
<tr>
<td>PHASE 3</td>
<td>3.2 s</td>
<td>± 3 – 4 s</td>
<td>x = 63.79 m</td>
<td>x = 63.657 m</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>v = 5.18 m/s</td>
<td>V = - m/s</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a = - 1.11 m/s²</td>
<td>a = - m/s²</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>12.78 s</td>
<td>± 12 - 14 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phases</td>
<td>Case 1</td>
<td>Case 2</td>
<td>Duration of Case 1</td>
<td>Duration of Case 2</td>
<td></td>
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<tr>
<td>-----------------</td>
<td>---------------------------------------------</td>
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<td></td>
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<tr>
<td>(Optimistic Scenario)</td>
<td></td>
<td></td>
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<tr>
<td>Phase 1</td>
<td>x = 14.22 m, v = 5.15 m/s, a = 0.932 m/s^2</td>
<td>x = 33.63 m, v = 7.92 m/s, a = 0.932 m/s^2</td>
<td>5.53 s</td>
<td>8.5 s</td>
<td></td>
</tr>
<tr>
<td>Phase 2</td>
<td>x = 28.22 m, v = 7.69 m/s, a = 0.181 m/s^2</td>
<td>x = 25.84 m, v = 9.38 m/s, a = 0.112 m/s^2</td>
<td></td>
<td></td>
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<tr>
<td>Phase 3</td>
<td>x = 21.35 m, v = 5.18 m/s, a = -1.11 m/s^2</td>
<td>x = 4.68 m, v = 9.21 m/s, a = -0.74 m/s^2</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>3.2 s</td>
<td>0.5 s</td>
<td></td>
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<tr>
<td>Tipping and immersion</td>
<td>-</td>
<td>φ = 0.215 rad, ϕ = 0.473 rad/s, a = -1.453 m/s^2</td>
<td></td>
<td>2.3 s</td>
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<td></td>
<td></td>
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<tr>
<td>Free damped oscillation</td>
<td>ζ_{heave} = 0.23 m, x = 22.73 m, a = -0.0063 m/s^2</td>
<td>ζ_{heave} = 1.229 m, x = 38.8 m, a = -0.066 m/s^2</td>
<td>10 s</td>
<td>18.8 s</td>
<td></td>
</tr>
</tbody>
</table>
**LAUNCHING RESULTS**

### EVOLUTION OF FORCE

**Phases** | **Case 1 (x10^6 N)** | **Case 2 (x10^6 N)**
--- | --- | ---
**Phase 1** | 1.79 | -0.217 | 1.79 | -0.217
**Phase 2** | 0.54 | -0.217 | 0.0054 | -0.217
**Phase 3** | -1.51 | 0 | -2.29 | -0.173
**Tipping and immersion** | - | 0 | -2.37 | 0
**Free damped oscillation** | -0.09 | 0 | -0.089 | 0

### SHIP ACCELERATION

**Phases** | **Case 1** | **Case 2**
--- | --- | ---
**Phase 1** | 0.932 m/s^2 | 0.932 m/s^2
**Phase 2** | 0.181 m/s^2 | 0.112 m/s^2
**Phase 3** | -1.11 m/s^2 | -0.74 m/s^2
**Tipping and immersion** | - | -1.453 m/s^2
**Free damped oscillation** | -0.0063 m/s^2 | -0.066 m/s^2
LAUNCHING RESULTS

SHIP RESULTANT MOTION

- Motion (m) vs Time (s)
- 2nd scenario
- 1st scenario

SHIP TRAJECTORY

- Trajectory motion (m) vs Time (s)
- 2nd scenario (Y-axis)
- 2nd scenario (Z-axis)
- 1st scenario (Y-axis)
- 1st scenario (Z-axis)

Phase 1:
- Case 1: 14.22 m
- Case 2: 33.64 m
- Tipping and immersion: -87.33 m
- Free damped oscillation: 100.71 m

Phase 2:
- Case 1: 42.44 m
- Case 2: 59.45 m
- Tipping and immersion: 87.33 m
- Free damped oscillation: -0.066 m

Phase 3:
- Case 1: 63.79 m
- Case 2: 64.13 m
- Tipping and immersion: -86.78 m
- Free damped oscillation: 100.7 m

Tipping and immersion:
- Case 1: 100.71 m
- Case 2: -0.066 m

Free damped oscillation:
- Case 1: 100.7 m
- Case 2: -7.95 m
- 2nd scenario: 129.27 m
- 1st scenario: -8.81 m
**LAUNCHING RESULTS**

**FREE DAMPED HEAVE OSCILLATION**

- **Case 1**
  - $\omega = 1.27 \text{ rad/s}$
  - $\xi = 0.23 \text{ m}$

- **Case 2**
  - $\omega = 1.344 \text{ rad/s}$
  - $\xi = 1.229 \text{ m}$

**FREE DAMPED ROLL OSCILLATION**

- **Case 2**
  - $\omega = 0.598 \text{ rad/s}$
  - $\varphi = 0.218 \text{ rad}$
CONCLUSION AND FUTURE WORK
CONCLUSION

The results from phase 1 to 3 of scenario 1 present good agreement to computation from reference by the indication of less than 5% differences.

Two scenarios of launching has been successfully automated into six phases by converting frequency domain into time domain.

Overall comparison of two scenarios, launching in higher water level provide a safer condition with less oscillation motion.
FUTURE WORK

- An upgrade of code is required to automate the program and create free surface effect
- Cradle as a part of launching components needs to be analyzed since it gives influence of ship motion
- Experimental analysis as a comparison to justify the result

A progress of work has been made using FINE™/Marine

Set up model:
- Initial mesh about 1.4 – 8 million cells.
- Use overset grid mesh and adaptive grid refinement
- Assumptions reaction force as vertical load on Cog
- Impose sway velocity to slide down

Problem:
Difficulties to maintain continuity equation due to overset grid and adaptive grid refinement
Thank You