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Analysis of Damaged Ship Behavior in Sea Waves

Hamid Zeraatgar, Reyhaneh Mehri and Hamidreza Jafaryeganeh

ABSTRACT

Damage of a ship may cause flooding of some compartment. In extreme case it may result in the total loss of the vessel. As far as the probability of damage of a ship in seaway is concerned, there is no confidence for not happening damage of a ship. In a case of damaged ship, motion in wave is coupled with mass of flooded water where the rate of flooding itself is also coupled with the damaged ship motions. Normally damage is happening in harsh sea conditions where sea waves are the main feature of such environment. On that basis, it is needed to analyze damaged ship motions in waves. In this article, an attempt has been made to analyze a damaged ship motions in sea wave focusing on three motions, heave, pitch and roll. A mathematical model is developed in which the equation of ship motions and mass of flooding are solved simultaneously in time domain. A computer code is developed and validated by comparing with some published results. A damaged naval ship behaviors in sea waves are calculated and results are discussed.

KEYWORD : Damage, ship, flooding, roll, pitch and heave

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۲-۱- موج منظم

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$$\zeta = \zeta_a \cos(kx - \omega_e t)$$

$$\omega_e = \omega - kV \cos \mu$$

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 : ω
 : ω_e
 :K
 :V
 : μ

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۲-۲- معادلات حرکت شناور سالم

$$\sum_{k=1}^6 \Delta_{jk} \ddot{\eta}_k(t) = F_j(t)$$

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 j = ...
 ()
 : j,k
 : Δ_{jk}
 : $\ddot{\eta}_k(t)$
 : $F_j(t)$

۱-۲-۲- معادله حرکت رول شناور سالم

۱-۳- معادلات حرکات شناور صدمه دیده

$$(I_{44} + A_{44})\ddot{\eta}_4 + B_{44}\dot{\eta}_4 + C_{44}\eta_4 = F_{EX4} \quad ()$$

: A₄₄
: I₄₄
: B₄₄
: C₄₄
: F_{EX4}

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۲-۲-۲- معادله حرکت هیو و پیچ شناور سالم

$$(M + A_{33})\ddot{\eta}_3 + B_{33}\dot{\eta}_3 + C_{33}\eta_3 + A_{35}\ddot{\eta}_5 + B_{35}\dot{\eta}_5 + C_{35}\eta_5 = F_{EX3} + F_{Dam3}(t) \quad ()$$

$$(A_{55} + I)\ddot{\eta}_5 + B_{55}\dot{\eta}_5 + C_{55}\eta_5 + A_{53}\ddot{\eta}_3 + B_{53}\dot{\eta}_3 + C_{53}\eta_3 = F_{EX5} + F_{Dam5}(t) \quad ()$$

$$(I_{44} + A_{44})\ddot{\eta}_4 + B_{44}\dot{\eta}_4 + C_{44}\eta_4 = F_{EX4} + F_{Dam4}(t) \quad ()$$

$$V(t) = \int_0^t Q(t) dt \quad ()$$

: M
: A
: B
: C
: F
: F_{EX3}
: F_{EX4}
: F_{EX5}

$$F_{EX3} = \zeta \int_L \left\{ e^{ikx} e^{-kT^*(x)} \left[c_{33}(x) - \omega_0 [\omega_a a_{33}(x) - ib_{33}(x)] \right] \right\} dx \quad ()$$

$$F_{EX4} = \zeta_a \cdot \sin \mu \left[(\rho \sqrt{GM} - A_{42}) \omega^2 \sin \omega t + \omega B_{42} \cos \omega t \right] \quad ()$$



$$Q = C_d v_2 A$$

$$F_{EX5} = -\bar{\zeta} \int \{e^{ikx} e^{-kt^*(x)} x [c_{33}(x) - \omega_0 [\omega_e a_{33}(x) - ib_{33}(x)]]\} dx$$

:A

:C_d

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$$:F_{Dam3}(t)$$

$$:F_{Dam4}(t)$$

$$:F_{Dam5}(t)$$

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$$F_{Dam3}(t) = \rho \cdot g V(t) \quad ()$$

$$F_{Dam4}(t) = y_G \cdot \rho \cdot g V(t) \cdot \cos \eta_5 \cdot \cos \eta_4 - z_G \cdot \rho \cdot g V(t) \cdot \cos \eta_5 \cdot \sin \eta_4 \quad ()$$

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$$\frac{1}{2g} v_1^2 + \frac{P_1}{\rho g} + H_1 = \frac{1}{2g} v_2^2 + \frac{P_2}{\rho g} + H_2 \quad ()$$

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:G

:G_w

:dG

$$v_2 = \sqrt{2g(H_1 - H_2)} \quad ()$$

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YZ

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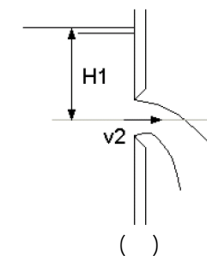
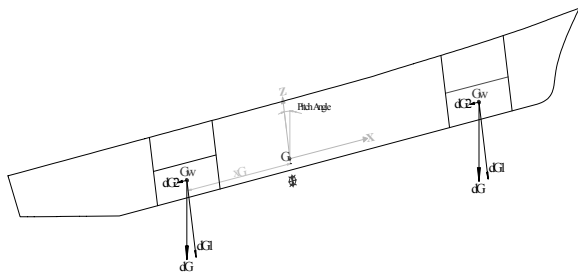
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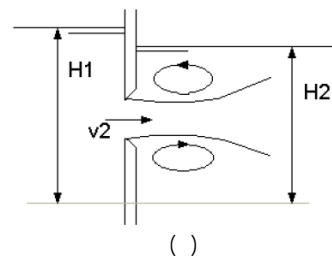
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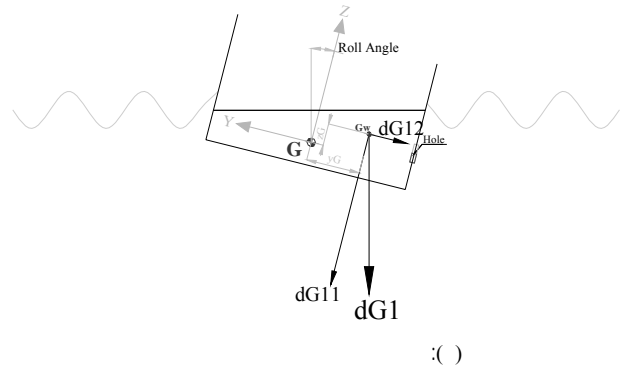
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 ۷-۱- مقایسه حجم آب وارد شده
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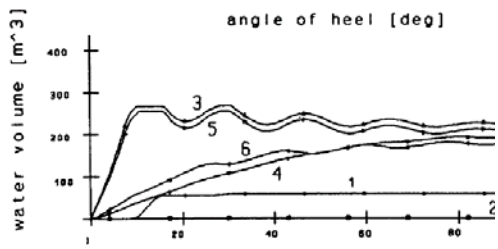
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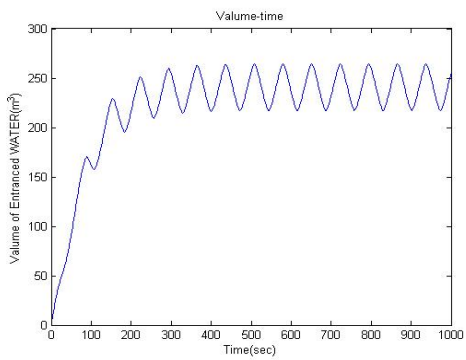
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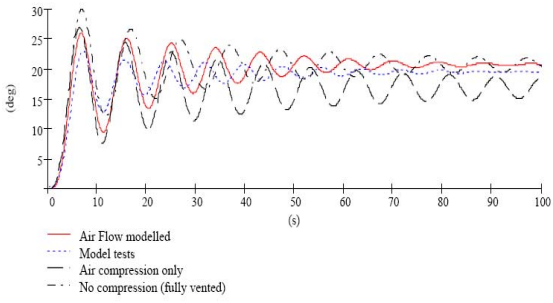
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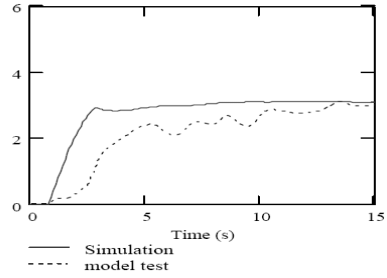
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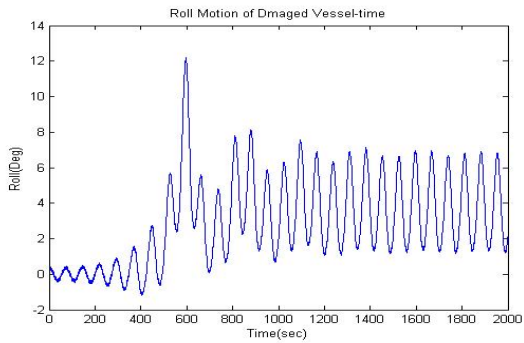
۲-۷ - مقایسه حرکت رول

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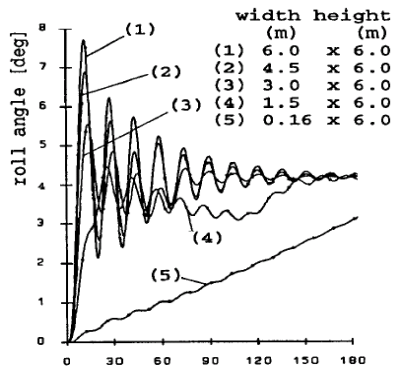
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۳-۷ - مقایسه نتایج برای یک شناور بارج

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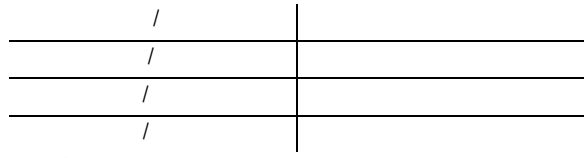


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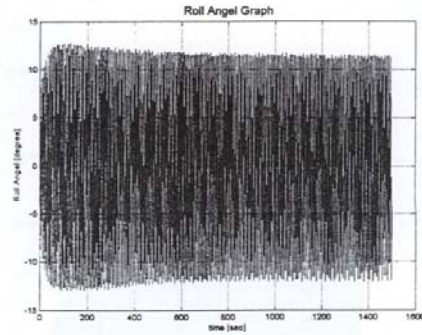
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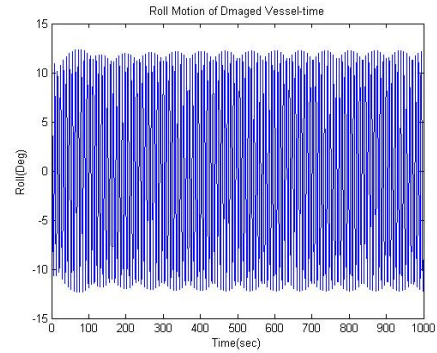
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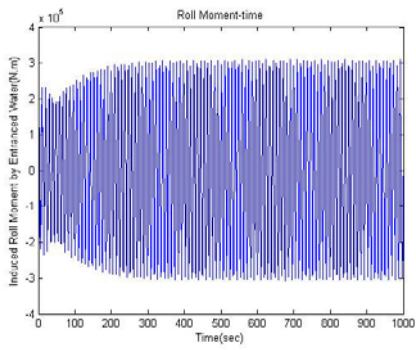
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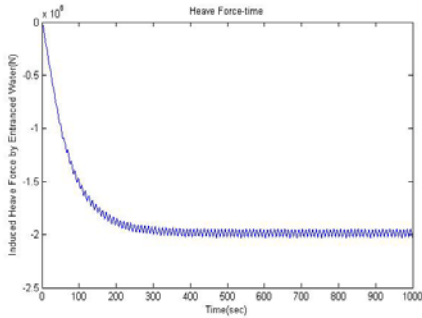
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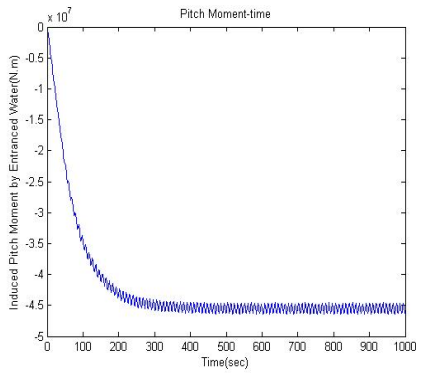




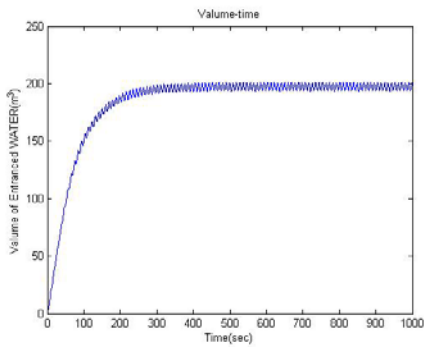
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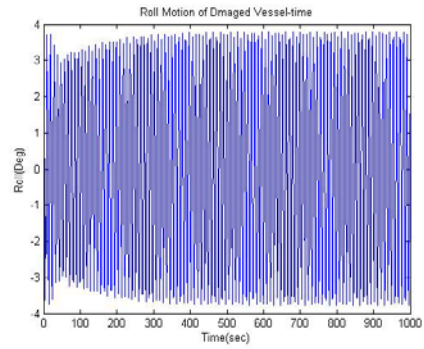


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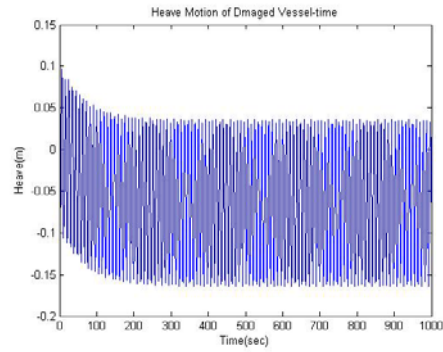
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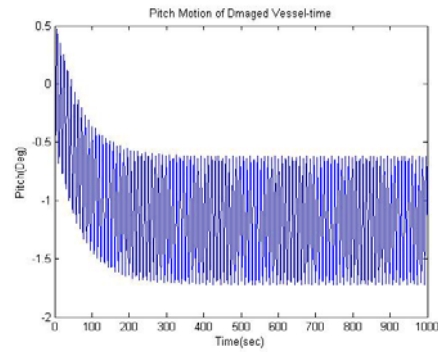
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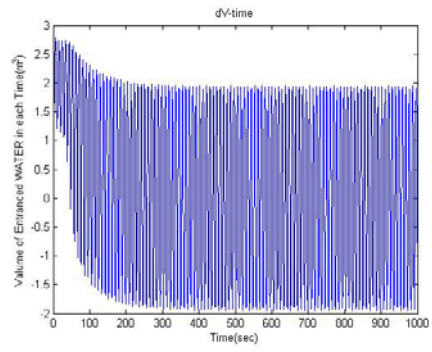
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¹ Finite-difference
² Ingress tests
³ Residual stability
⁴ Shock wave
⁵ Anti-rolling
⁶ Air flow
⁷ Roll transients
⁸ Rate of flow
⁹ Beam Sea
¹⁰ Foresea