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2차원 경계요소법을 이용한 부유체의 운동 특성 연구

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Analysis on motions characteristics of Floaters using two-dimensional Boundary Element Method.

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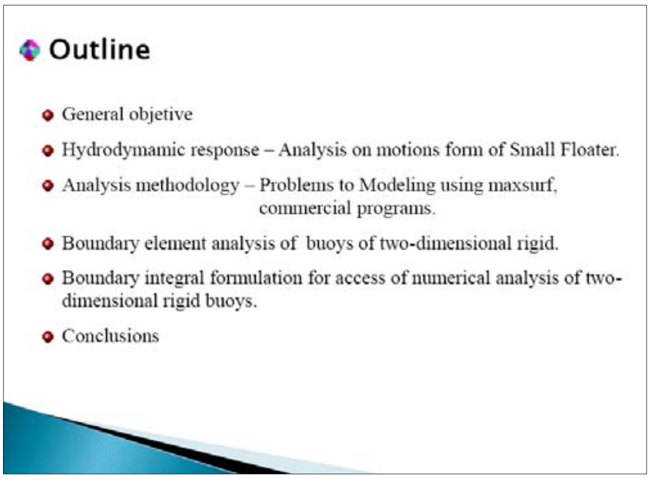
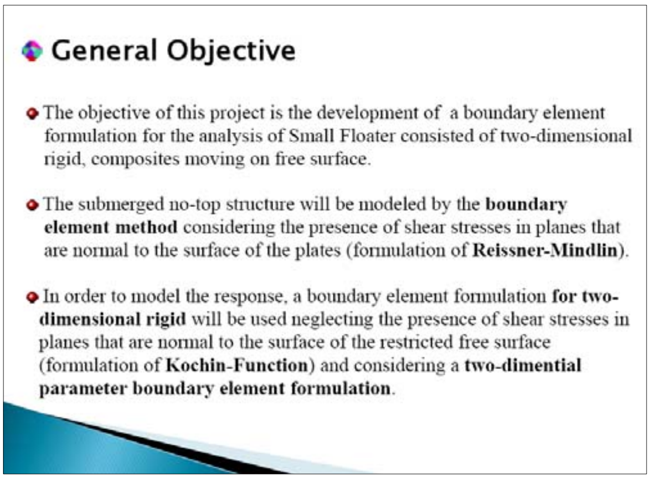
요　약 : 현재 해상교통안전시설인 표준등부표의 종류는 10가지이며, 가장 작은 등부표가 4.4m로 대형인 것이 현실이다. 따라서 제작, 교체 및 수리가 용이한 부유형의 소형 등부표를 제안하고자 하였다. 한편 부유형의 경우 환경적 외력에 의한 위치 신뢰도가 떨어지며, 특히 유실 등의 사고에 대비하기 위한 안정성 검토가 필요하다. 이 논문에서는 새로운 등부표의 운동성(Heave, Sway, Pitch)을 상용프로그램을 사용하여 Encounter Frequency별 분석하고, 2차원 경계요소법(Boundary Element Method, BEM)을 이용하여 부유체의 단면형상에 따른 유체력을 수치시뮬레이션하였다.

핵심용어 : 소형 등부표, 경계요소법, 유체력, 부유체

Abstract : Current, standards light buoys as maritime traffic safety facilities have 10 different types of buoys and the smallest size of those is 4.4m. Therefore, making for easy replacement and repair parts for the type of small light buoys is proposed. Meanwhile, position reliability of floaters by external forces in the environment fall and stability examination should be considered for prohibiting accidents as loss. In this paper, a new light buoy is analyzed on Encounter Frequency types using commercial program and fluid forces is simulated on cross-sectional shape of the float using two-dimensional Boundary Element Method(BEM).

Key Words : Small light buoys, Boundary Element Method(BEM), Fluid force, Floaters





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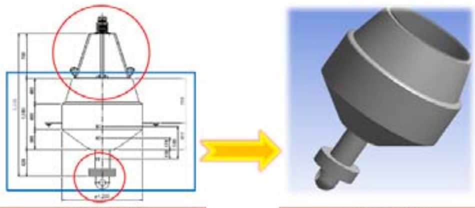
Modeling and Analysis on motions of Buoys using commercial programs



Designed Buoys　　Modeled Buoys

- Only BUOY BODY and WEIGHT BALANCE was modeled. Deciding Tower have a very small influence on value by calculation. ⇒ Modeling is needed more detail.
- Half-Breadth Plan and Sheer Plan of buoys are needed to modeling more detail

Modeling and Analysis on motions of Buoys using commercial programs

Main Data	Sign	Designed buoys	Modeled buoys
Weight of buoys	W(kg)	213.44	293
Weight of sinker	Ws(ton)	0.50	
Draft	d(m)	0.4	0.4
Position of buoyancy	KB(m)	0.15	0.185
Position of center	KG(m)	0.17	Input when calculating (0.17)

Compare main data between designed buoys and modeled buoys

- Half-Breadth Plan and Sheer Plan of Buoys are needed to modeling more detail.
  ⇒ Be capable of convergence KB data, considering designed buoys data.
- There' s an error about 30kg on sum of weight of buoys and sinker between designed buoys and modeled buoys.
  ⇒ Displacement, KB(kg) data is the most important, so should be adjusted as possible.

Advantages of BEM

1) Reduction of problem dimension by 1

Less data preparation time. Easier to change the applied mesh. Useful for problems that require re-meshing.

2) High Accuracy

Stresses are accurate as there are no approximations imposed on the solution in interior domain points. Suitable for modeling problems of rapidly changing stresses.

3) Less computer time and storage

For the same level of accuracy as other methods BEM uses less number of nodes and elements.

4) Filter out unwanted information.

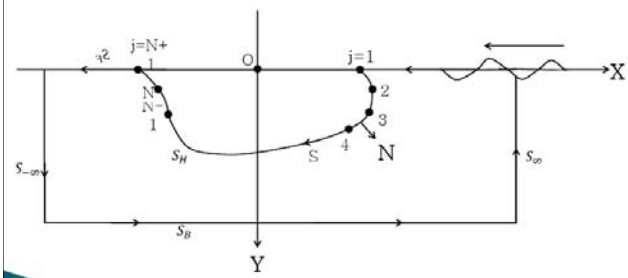
Internal points of the domain are optional. Focus on particular internal region. Further reduces computer time.

The 2D potential problem

- BEM can be applied where any potential problem is governed by a differential equation that satisfies the Laplace equation.
  In this case the 2D form.
- A potential problem can be mapped from higher to lower dimension using Green's second identity.
- Shown how to deal with the case of the singularity point.
- Derived the boundary integral equation (BIE)

Numerical Implementation

1. Set of boundary value of two-dimensional floaters.



Numerical Implementation

2. Application problems with integral equation of two-dimensional boundary value.

Incident Wave as moving of floaters is flowing.

$$\Phi_0 = R_e\left[\frac{g\zeta_a}{i\omega}\phi_0(x,y)e^{i\omega t}\right]$$

It's the same as : $\phi_0 = e^{-K_y+iK_x}, K = \omega^2/g$

$\Phi(x,y;t) = R_e[\phi(x,y)e^{i\omega t}]$

[L] $\nabla^2\phi_j = 0$ for $y \geq 0$

[F] $\frac{\partial\phi_j}{\partial y} + K\phi_j = 0$ on $y = 0$

[B] $\phi_j \to 0$ as $y \to \infty$

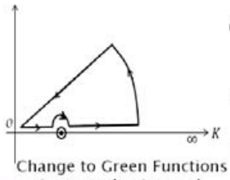
Each condition as Incident Wave

[L] Laplace Equation
[F] Conditions of free surface
[B] Conditions of sea floor

Numerical Implementation

3. Change of Green Functions of free surface and calculation of value.

$$G(x,y;\xi,n) = \frac{1}{2\pi}\log\frac{R}{R_1} + G_F(x-\xi, y+n)$$



Change to Green Functions using complex integral.

$$G_F(x,y) = -\frac{1}{\pi}\lim_{\mu\to\infty}\int_0^\infty \frac{e^{-ky}\cos kx}{k-(K-i\mu)}dk$$

$$= -\frac{1}{\pi}\oint_0^\infty \frac{e^{-ky}\cos kx}{k-K}dk + ie^{-ky}\cos Kx$$

$$= -\frac{1}{\pi}\int_0^\infty \frac{k\cos ky - K\sin ky}{k^2-\nu^2}e^{-k|x|}dk + ie^{-Ky-iK|x|}$$

Numerical Implementation

6. Equations of motions of two-dimensional floaters.

Disturbance Amplitude of Buoys on G, center of Buoys, is flowing :

$$X_1 = X_1^G + \ell_G X_3^G,\ X_2 = X_2^G, X_3 = X_3^G$$

$$\phi_3^G = \phi_3 + \ell_G\phi_1$$

Force on a Fluid on G, center of a Buoy, is flowing :

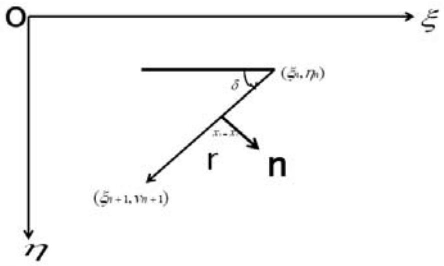
$$F_1^G = T_{11}X_1^G + T_{12}X_2^G + (T_{13}+\ell_G T_{11})X_3^G$$

$$F_2^G = T_{21}X_1^G + T_{22}X_2^G + (T_{23}+\ell_G T_{21})X_3^G$$

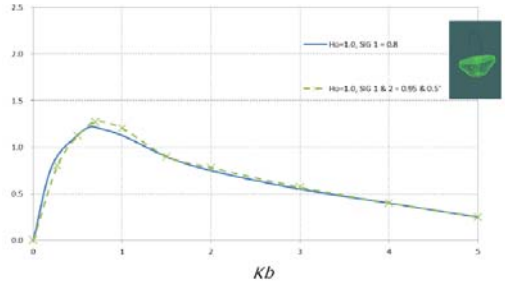
$$F_3^G = (T_{31}+\ell_G T_{11})X_1^G + (T_{32}+\ell_G T_{12})X_2^G + \{(T_{33}+\ell_G T_{13}) + \ell_G(T_{31}+\ell_G T_{11})X_3^G$$

Numerical Implementation

4. Numerical Analysis on integral equation of two-dimensional floaters.



Numerical Implementation



Amplitude of Wave Exciting Force in Sway Mode

Numerical Implementation

5. Calculation on force of fluid of two-dimensional floaters.

D(boundary integral) is expressed using foregoing n(local coordinate system)

$$D_{mn} = \int_{S_n}\frac{\partial}{\partial n_Q}\{\log\frac{R}{R_1} - 2F_c(x_m-\xi, y_m+n)\}ds(\xi,n),$$

D(boundary integral) could be changed to S by change in Laplace.

$$S_{mn} = \int_{S_n}\{\log\frac{R}{R_1} - 2F_c(x_m-\xi, y_m+n)\}ds(\xi,n)$$

$$P(x,y;t) = R_e[\{pD(x,y) + pR(x,y) + ps(x,y)\}e^{i\omega t}]$$

$pD(x,y) = -pq\xi_a\phi_D(x,y)$ $ps(x,y) = p\rho(X_2 + xX_3)$ $pR(x,y) = -pi\omega\sum_{j=1}^{3} i\omega X_j\phi_j(x,y)$

Conclusions

- A boundary element method formulation for the analysis of
- A two-dimensional parameter formulation based on, was presented.
- Results obtained for submerged no-top structure with two-dimensional rigid are similar with those reported in the literature, but more research work is needed in order to obtain accurate SIGs.
- Results shows good agreement with those reported in the literature. More research work must be done to improve the three parameter formulation proposed in this work to model the responses.