INTRODUCTIONS
BACKGROUND

Floating Breakwaters belong to this specific category for wave protection and restoration of semi-protected coastal regions.

The breakwater generates a radiated wave which is propagated in offshore and onshore direction.
Two-dimensional flow characteristics of wave interactions with a fixed rectangular structure. (by Kwang Hyo jung, 2005)

Ct (coeff. Transmission) was measured before the reflection from the beach while the Cr(coeff. Reflection) was measured after the quasi-steady state was achieved. Therefore, in this research the amount of energy dissipated may not exact.
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Research aim

• To develop horizontal 2D wave model considering the energy dissipation behind the Double Barrier Floating Breakwater (DBFB).

• Modeling the new source term in wave-action balance equations relating to floating breakwater motion.

• To calculate the value of $CD$ (coeff. $Drag$) term and $CM$ (coeff. $Inertia$) term and thus to confirm the harm’s assumption that $CD$ is much larger than $CM$ term.
Laboratory measurements indicate that Floating Tire Breakwater (FTB) function predominantly as wave-energy dissipators, transforming into turbulence far more of the incident wave energy than they reflect.

\[ C_t = \frac{H_t}{H_i} \exp \left( -\frac{4\pi}{3} \frac{C_D}{P} \frac{H_i}{L} \frac{B}{L} \frac{1}{n} \right) \]
On Harm assumption $C_D$ term is much larger than $C_M$ term, so the $C_M$ term can be omitted in the transmits coefficient calculation. The harms assumption were generated by laboratory experiments using Floating Tire Breakwater (FTB).
LABORATORY EXPERIMENTS
DOUBLE BARRIER FLOATING BREAKWATER (DBFB)

- The Double Barrier Floating Breakwater (DBFB) has a rectangular body and double vertical plates.

\[ H_i : \text{wave height} \]
\[ L : \text{wave length} \]
\[ h : \text{water depth} \]
\[ B : \text{width of DBFB} \]
\[ d : \text{draft} \]
Experimental conditions

The experiments were conducted in the wave flume with the dimensions of the flume are 18m length, 0.6m width, and 0.8m depth.

Two configurations were examined in the experiments as follows: (a) Heave motion DBFB; (b) Fixed DBFB.

There are four variations on the experiments as follows: water depth, wave height, wave period, and wave length.
Illustration of experimental
Heave motion DBFB

Fixed DBFB
Experimental data

Channel 3

Water Level (No.3)

Time (s)

Water Level (m)

0 5 10 15 20 25 30

0 0.02 0.04 0.06

0 0.02 0.04 0.06

0 0.02 0.04 0.06

Channel 3

Experimental data
Calculations of $C_D$ and $C_M$

Morison et al. (1950)

$$F = \frac{1}{2} C_D \rho A u |u| + C_M \rho V \frac{D u}{D t}$$

$$C_D = \frac{2 \{F(t + \Delta t)\dot{u}(t) - F(t)\dot{u}(t + \Delta t)\}}{\rho A x}$$

$$C_M = \frac{\{F(t)u(t + \Delta t)|u(t + \Delta t)| - F(t + \Delta t)|u(t)|\}}{\rho V x}$$
Where:  \( C_D \) = drag coefficient

\( C_M \) = inertia coefficient

\( u, \dot{u} \) = horizontal component of water particles velocity and acceleration, respectively

\( t \) = time series

\( \Delta t \) = time difference

\( F \) = wave force

\( \rho \) = mass density of water

\( V \) = volume

\( A \) = Area
Heave motion

Water Level & Cd

Time (s)

Water Level (m)
\[ C_D = 31.8 \times \exp(-8.11 \times 10^{-5} \times Re) \]

CD term is more larger than CM term based on the experimental results using the wave flume. Therefore, CM term can omit in this study.

Hokamura et al., 2008
Tsujimoto et al (2009)
NUMERICAL SIMULATIONS
Extended Energy-Balance Equation with Diffraction (ExEBED)

Directly introduced a diffraction term, formulated from a parabolic approximation wave equation, into the energy balance equation (Mase 2001)

A simple equation of estimating wave energy dissipation number behind DBFB is proposed in numerical simulation

\[
\frac{\partial (v_x S)}{\partial x} + \frac{\partial (v_y S)}{\partial y} + \frac{\partial (v_\theta S)}{\partial \theta} = \frac{\kappa}{2\omega} \left\{ \left( CC_g \cos^2 \theta S_y \right)_y - \frac{1}{2} CC_g \cos^2 \theta S_{yy} \right\} - \varepsilon_b S
\]
Energy Balance Equation with Diffraction (ExEBED) is one of wave model to estimate near shore wave condition.

Two condition of incident wave was examined. Those conditions are normal distribution and oblique distribution.

Calculation of the horizontal distributions of wave height using the uniform $Ct$ variations along the lee side of DBFB.

Calculation of The spatial distributions of relative error, $(Err)_{ij}$ between the experimental and numerical results.
Numerical results

Normal incident condition

0° wave angle
Oblique incident condition

$25^\circ$ wave angle
The Relative error

Spatial distributions of relative error between the experimental and numerical wave height using the uniform \( Ct \) variations along the lee side of DBFB

\[
(Err)_{ij} = \left| \frac{(H \exp)_{ij} - (Hcal)_{ij}}{(H \exp)_{ij}} \right| \times 100 \, (\%) \]
The Relative error

Normal incident distribution

Cross-shore direction (cm)

Long shore direction (cm)

normal
Oblique incident distribution
CONCLUSION

• Harms assumption is fairly good to use in the numerical simulation based on the laboratory experiment results.

• The calculated horizontal distributions of wave height using the uniform \( C_t \) variations were reduced with changing the incident wave angle.

• The spatial distributions of relative error, \( (Err)_{ij} \) are generated fairly good accuracy.
Thank you for your attention
Fixed DBFB

Water Level (No. 3)

Time (s)

Water Level (m)
Water Level & Cd

Time (s)

Water Level (m)

-0.06

0

0.03

0.06

35