The Resistance Coefficient of Perforated Walls for Jarlan-type Caissons

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Background

Jarlan-type perforated caissons (See Figs. 1 and 2)

Caisson front walls are punched (wave absorbing chamber between front and rear walls)

Merits of low reflection coefficients and small wave forces

Often used for building breakwaters and quaywalls

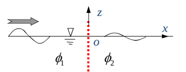
Estimating reflection coefficient C_R

The reflection coefficient can be generally well estimated by linear potential theory

The effect of perforated wall (energy dissipation and phase shift) must be known a prior

An often used perforated wall condition (Yu, 1995)

Horizontal fluid velocity passing through the perforated wall is proportional to the pressure difference between two sides of the wall



$$\frac{\partial \phi_1}{\partial x} = \frac{\partial \phi_2}{\partial x} = \mathrm{i}k_0 G(\phi_1 - \phi_2)$$

$$G = \frac{\varepsilon}{k_0 \delta (f - \mathrm{i}s)}$$

Porosity of perforated wall

Inertial coefficient (can be simply treated as unity)

Wave number

Wall thickness

Resistance coefficient of perforated wall Determined by model tests

Objective of present study

Develop new method to estimate resistance coefficient (including wave parameter effects)

Fig. 1 Coal quaywall in Qinhuangdao, China

Fig. 2 Perforated breakwater in Dalian, China

Resistance Coefficient Formula

Method for getting many values of resistance coefficients on different conditions

A most simple single-chamber fully perforated caisson (See Fig. 3)

For fixed wave height and period, *f* is assumed be invariable with the changing chamber width *B*

Calculate C_R using analytical solution, then fit experimental data and obtain many *f* values

The index of Willmott (1982) is used to evaluate the best agreement between analytical and experimental results of reflection coefficient

An empirical formula for estimating *f* in terms of Keulegan-Carpenter (*KC*) number (See Fig. 4)

$KC = \bar{U}T/\delta = HL/(2d\delta)$ *H*, *T* and *L*: Incident wave height, wave period and wavelength. *d*: water depth.

Depth-averaged value of the amplitude of horizontal fluid velocity for incident wave

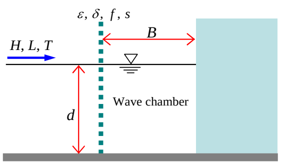


Fig. 3 Single-chamber perforated caisson

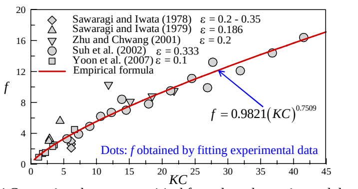


Fig. 4 Comparison between empirical formula and experimental data

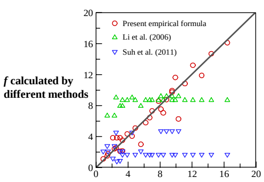
Validations

Comparison between present and previous formulas (See Fig. 5)

Li et al. (2006): a single parameter of perforated wall thickness

Suh et al. (2011): two parameters of wall thickness and porosity; perforated wall without rear wall

Present method: wall parameters and wave parameters; perforated front walls of Jarlan-type caissons



f obtained by fitting experimental data of literatures given in Fig. 4

Present formula $f = 0.9821(KC)^{0.7509}$

Li et al. (2006) $f = -3338.7\left(\frac{\delta}{d}\right)^2 + 82.769\left(\frac{\delta}{d}\right) + 8.711$

Suh et al. (2011) $f = 0.0584\left(\frac{\varepsilon\delta}{d}\right)^{-0.7}$

Fig. 5 Comparison between present and previous resistance coefficient formulas

Single-chamber perforated caissons

Estimate reflection coefficient C_R based on the new formula of resistance coefficient

Compare calculated C_R with experimental data from literatures given in Fig. 4 (See Fig. 6)

Compare calculated C_R with experimental data in Kondo (1979) and Kakuno et al. (1992) (See Fig. 7)

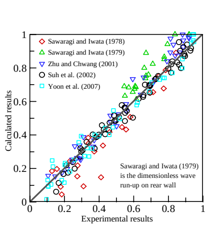


Fig. 6 Comparison between calculated and measured C_R

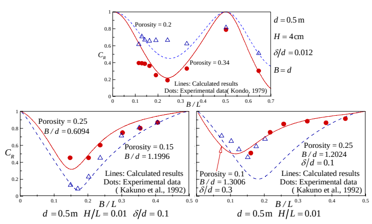


Fig. 7 Comparison of C_R between calculated results and experimental data (*B* is fixed and *L* is changed)

Two-chamber perforated caissons

Compare calculated C_R with experimental data of two-chamber perforated caissons (See Fig. 8)

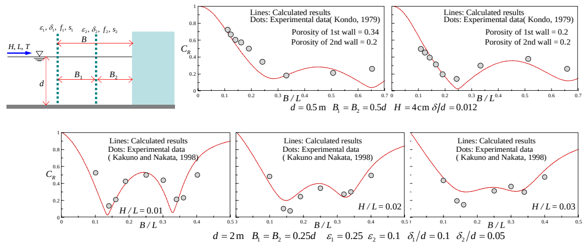


Fig. 8 Comparison of C_R for two-chamber caissons between calculated results and experimental data

Reflection coefficient of irregular waves (See Fig. 9)

The spectrum of irregular waves are divided into many bands

For each component wave, the resistance coefficient *f* is calculated using: 1) wave period of component wave; 2) Root-mean-squared wave height

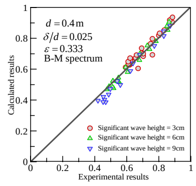


Fig. 9 Comparison of C_R for irregular waves between calculated results and experimental data (Suh et al., 2001)

Scale Effect

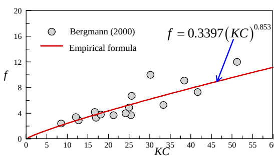
Resistance coefficient formula based on large scale model tests (Bergmann, 2000)

For each incident wave: two data of single-chamber caissons; two data of three-chamber caissons

Fitting the four data gives a value of the resistance coefficient for one incident wave condition

Develop a resistance coefficient formula based on large scale model tests (See Fig. 10)

Estimate C_R using the resistance coefficient formula of large scale tests (See Fig. 11)



Experimental conditions of Bergmann (2000)

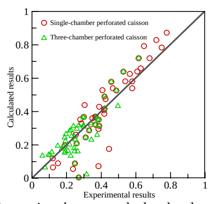
T = 4.5–12s, H = 0.5–1.5m, d = 3.25–4.75m, δ = 0.18m

Single-chamber caissons: Porosity = 0.2

Three-chamber caissons: Porosities = 0.265, 0.2, 0.11

(Decrease along wave propagation direction)

Fig. 10 Comparison between empirical formula and experimental data of large scale tests



Reflection coefficients are calculated using empirical formula in Fig. 10

Experimental data: Bergmann (2000)

Fig. 11 Comparison between calculated and measured reflection coefficients

Scale effect on the resistance coefficient *f* （See Fig. 12）

The resistance coefficient formula obtained by large scale model tests gives lower results

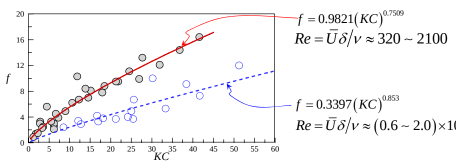


Fig. 12 Scale effect on the resistance coefficient

We present new formulas for estimating resistance coefficients of perforated walls.
The resistance coefficient has a remarkable correlation with *KC* number.
Wave height and period have significant effects on the resistance coefficient.
The scale effect exists in the resistance coefficient formula.
More complicated Jarlan-type caissons will be examined in the next study.

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Acknowledgments

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