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# **Calculation of Wave Transmission through Single Perforated Sheets**

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#### Abstract

The prediction of reflection and transmission coefficients through single perforated sheets plays an important role in the assessment of the hydraulic responses of screen breakwaters and upright perforated wave filters and absorbers and their efficient design.

This paper reviews the result of laboratory tests in wave flumes to determine the reflection and transmission coefficients ( $C_r$  and  $C_t$ , respectively) through single perforated sheets. It has been shown that these coefficients can be calculated by using two new formulas which relate  $C_r$  and  $C_t$  to the wave-screen parameter. This parameter is the ratio of the product of discharge coefficient and the porosity of the sheet to the root square of wave steepness in deep water.

#### Introduction

When waves impinge on a perforated sheet, a series of jet is created which dissipate the incident wave energy through the formation of turbulence and eddies.

Theoretical models for dissipation of waves through a single perforated sheet were presented by tuck (19Y), Porter (19Y7), Guiney et al. (19Y7), Packham and Williams (19Y7), Hattori (19Y7), Chwang and Dong (19A<sup>¢</sup>), Macaskill (19Y9), Owen and Bhatt (19A<sup>¢</sup>), Chegini (1994 & 199Y) and Isaacson et al.(1994 & 7...).

Hattori (197) performed a series of laboratory tests to measure the reflection and transmission coefficients of waves through perforated walls. He found that the dissipation of wave energy due to the perforated wall depends on the porosity of the wall, the discharge coefficient of the perforated holes, the incident wave steepness and relative water depth.

Faure (1997) performed an empirical study on single sheets made of expanded metals as the porosity was increased by deforming sheet above each perforation. He carried out all the tests in the flume of the National Research Council of Canada (NRCC) with a depth of 1 m. The periods of regular waves were  $1, 1, \Delta^{\circ}, 7, 1^{\circ}, 7, \Lambda^{\circ}$  and  $7, 9^{\circ}$  seconds. The porosity of the sheets was  $\Delta, 1\Delta, 7 \cdot, 7 \cdot, 9^{\circ}$  and  $\Delta^{\circ}$  percent. Faure measured the reflection and transmission coefficients and concluded that four factors determine the characteristics of reflected and transmitted waves through a perforated plate, which are: sheet porosity, shape of perforation, incident wave steepness and wave period.

McBride et al. (1997) carried out a series of laboratory tests on single perforated sheets to measure the reflection coefficients of irregular waves from these wave absorbers. The

porosity of sheets was  $\vee, \uparrow$ ,  $\vee, \wedge$  and  $\uparrow, \uparrow$  percent. The mean wave height was  $\cdot, \uparrow$  and  $\vee, \uparrow \wedge$  meters.

RostamiNia  $(\uparrow \cdot \cdot \uparrow)$  carried out a series of laboratory tests on perforated sheets in the  $\uparrow\uparrow, \diamond$ m length,  $\diamond, \diamond$  m wide and  $\uparrow$  m deep wave flume of Soil Conservation and Watershed Management Research Center (SCWMRC), the Ministry of Jihad-e-Agriculture, IR of Iran. This flume is divided into three parts (figure  $\uparrow$ ). The tests were performed in the middle part of the flume. The coefficients of wave reflection and transmissions were measured using five wave gauges installed in front and the rear of the perforated sheet (figure  $\uparrow$ ). Goda's method was employed to calculate the reflection coefficients (Goda and Suzuki,  $\uparrow \P \lor \uparrow$ ). To prevent the reflection of waves from the end wall of the flume, a gravel beach absorber was used. The porosity or the sheets were  $\uparrow \uparrow$ ,  $\clubsuit$  and  $\clubsuit \land$  percent. The tests were performed using regular waves of  $\uparrow, \uparrow \diamond$  to  $\uparrow, \diamond$  seconds period. The wave heights were ranged from  $\lor, \uparrow$  to  $\uparrow \land$ .<sup>§</sup> centimeters.



Figure ('): Plan of SCWMRC wave flume

# Wave – Screen Parameter

Chegini (1993 & 7...) introduced the wave-screen parameter to describe the hydraulic responses of single perforate sheets. This parameter is:

$$\Gamma = \frac{C_d P}{\sqrt{\frac{H_i}{L_i}}} \tag{1}$$

So that:

 $C_d$  = discharge coefficient of perforated sheet

P =porosity of perforated sheet

 $H_i$  = incident wave height

L. = deepwater wave length

# Discussion

The results of experimental tests performed by Hattori (1977), Faure (1997), McBride et al. (1997), Chegini ( $199\Delta$ ) and RostamiNia ( $7 \cdot \cdot 1$ ) have shown that the reflection and transmission coefficients of waves through a perforated sheet are functions of the following parameter:

- porosity of perforated sheet
- shape of perforated sheet that can be expressed as the discharge coefficient of the sheet
- incident wave height
- incident wave period that can be described as the incident wave steepness

Therefore, it may be concluded that  $C_r$  and  $C_t$  can be determined from the wave-screen parameter ( $\Gamma$ ) introduced by Chegini (1993 & 7...).

The results of all laboratory tests are analyzed and it is concluded that reflection and transmission coefficients through single perforated sheets can be calculated using the following formulas:

i. 
$$C_r = -\tanh(\Upsilon, \Upsilon \Delta \Gamma) + \Upsilon$$
  $\Gamma < \cdot, \Upsilon \Delta$  ( $\Upsilon$ )  
 $C_r = -\cdot, \Upsilon \Delta$  ( $\Upsilon$ )  
ii.  $C_t = \tanh(\Upsilon, \Upsilon \Delta \Gamma) + \cdot, \Upsilon \Delta$   $\Gamma > \cdot, \Upsilon \Delta$  ( $\Upsilon$ )  
 $C_t = \cdot, \Upsilon \Delta + (\cdot, \Delta \Upsilon \Gamma) + \cdot, \Delta \Delta$   $\Gamma > \cdot, \Upsilon \Delta$  ( $\Delta$ )

The variations of  $C_r$  and  $C_t$  with  $\Gamma$  are depicted in figure ( $(\gamma)$ ).

# Conclusions

The results of laboratory tests have shown that:

- 1. The hydraulic responses of single perforated sheets can be described as functions of the wave-screen parameter.
- <sup>Y</sup>. Wave reflection coefficient from a perforated sheet decreases by increasing the wave-screen parameter.
- \*. Wave transmission coefficient through a perforated sheet increases by increasing the wave screen-parameter.



Figure ((): Variations of  $C_r$  and  $C_t$  with  $\Gamma$ 

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