Experimental Investigation of Beach Efficiency in Wave Tank

Thomas Hannasvik (thomhann@stud.ntnu.no)

Academic Supervisor: Trygve Kristiansen

NTNU – Trondheim
Norwegian University of Science and Technology

Objective

To investigate how beach efficiency in a wave tank is affected for a number of wave periods, wave steepness and beach positions by comparison of calculated reflection coefficients.

Introduction

Despite increasingly advanced numerical methods, model testing still has a very important place in the development of marine technology. Model testing mainly have three different aims; to achieve design data to verify performance of different structures, to verify and calibrate theoretical methods and numerical codes, and to obtain better understanding of physical problems. These aims require a controlled and well-defined environment for reliable results, which is easier to acquire without waves reflecting from the tank walls. Some type of wave absorption device is therefore often installed in wave tanks to minimize wave reflection, where beaches are most common. However, the effectiveness of a beach depends on a number of parameters, such as wave period, wave height and beach geometry.

Method

To separate the incident and reflected wave amplitude from the measurement series a least-squares technique was applied. This method was first described by Mansard and Funke (1980) [1]. Five quantities were measured; the wave elevation at three wave probes, A_1, A_2 and A_3, the phase difference between probe 1 and 2, δ_2, and 1 and 3, δ_3. The distance between the probes are written in dimensionless form as $\Delta_n = k\lambda_n$, where k is the wave number and λ_n is the distance from the first probe to probe n. The amplitude of the incident and reflected wave may now be expressed as:

$$a_i = |X_i| = |\frac{s_2 s_3 - 3s_4}{s_5}|$$
$$a_r = |X_r| = |\frac{s_1 s_4 - 3s_3}{s_5}| \quad (1)$$

where

$$s_1 = \sum_{n=1}^{3} exp(i2\Delta_n)$$
$$s_2 = \sum_{n=1}^{3} exp(-i2\Delta_n)$$
$$s_3 = \sum_{n=1}^{3} A_n exp[i(\delta_n + \Delta_n)] \quad (2)$$
$$s_4 = \sum_{n=1}^{3} A_n exp[i(\delta_n - \Delta_n)]$$
$$s_5 = s_1 s_2 - 9$$

The reflection coefficient is given as:

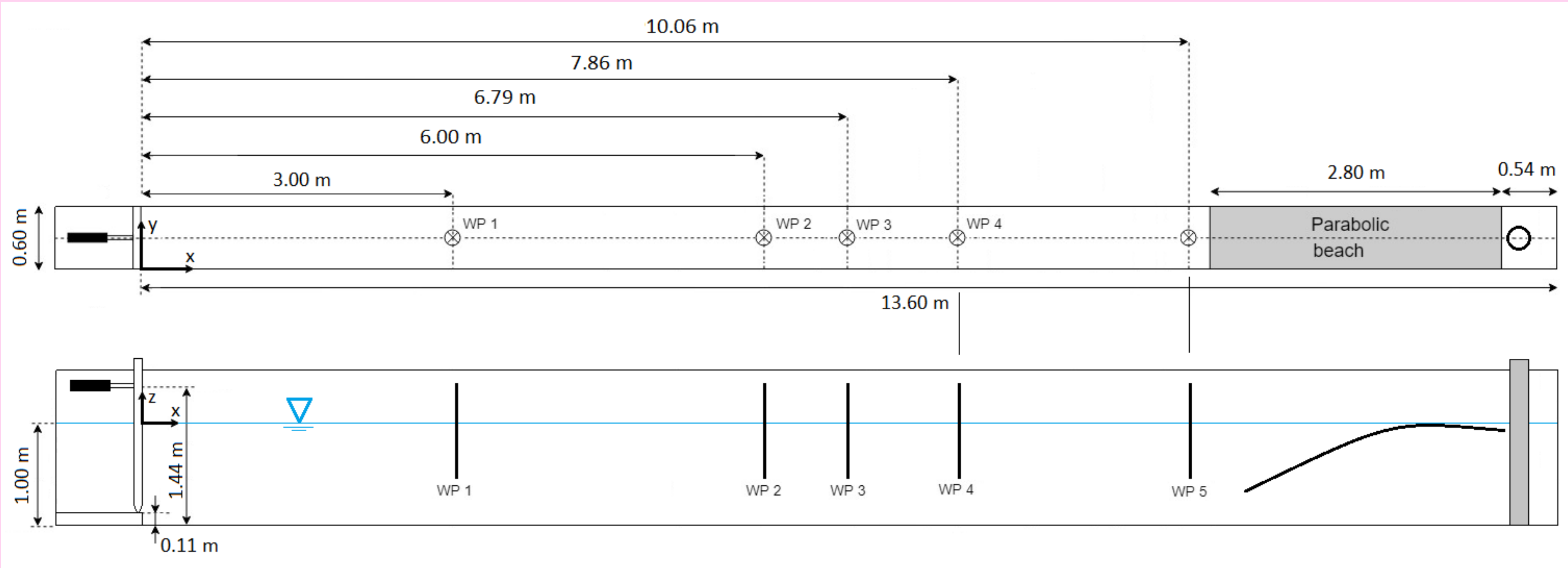
$$K = \frac{a_r}{a_i} \quad (3)$$

References

[1] Mansard, E.P.D. and Funke, E.R.: *The measurement of incident and reflected spectra using a least squares method.*, Proceedings of the 17th Coastal Engineering Conference, Vol. 1. (1980)

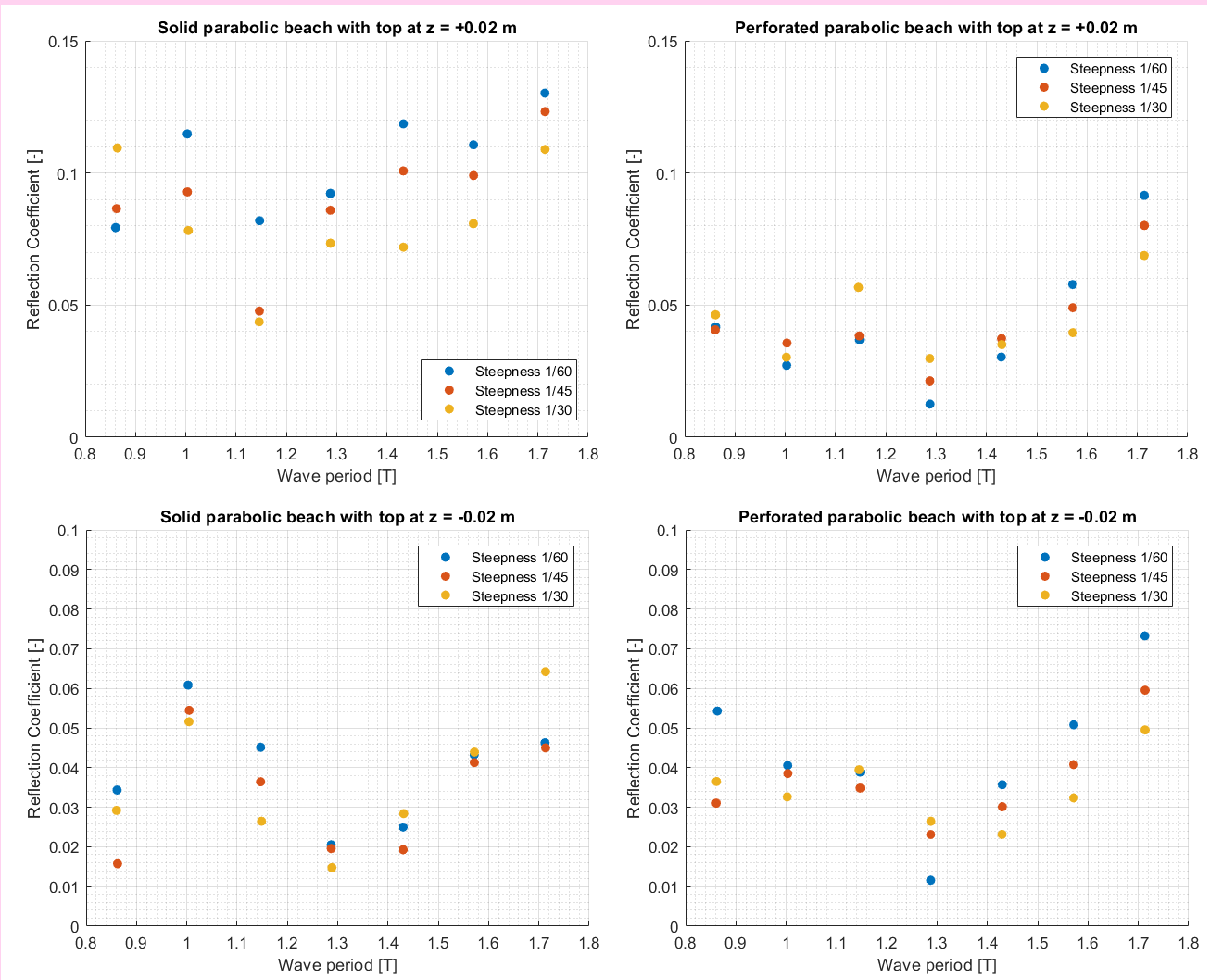
Experimental Set-up

Experimental investigations were carried out to determine the reflection coefficient of two different parabolic beaches subject to regular wave action. The set-up used for this purpose consists of a wave tank with dimensions 13.60 m x 0.60 m x 1.00 meter (see figure below). The tank was equipped with a hinged flap wavemaker, which was used to generate regular waves. In the other end the beaches were mounted, one with a solid non-perforated surface and one with 7.07 % perforation. Both beaches had the same geometry.



The wave elevation was sampled simultaneously at five wave probe positions, but only three probes (WP2, WP3 and WP4) were used to find the wave reflection from the beaches with positions indicated. The generated waves had seven periods ranging from 0.85 s to 1.72 s and steepness 1/60, 1/45 and 1/30. Three different beach positions were tested; with the top of the beach at the mean waterline (z = 0) and with the beach 0.02 m higher and 0.02 m lower. This was done for both beaches, making a total of 126 cases for this experiment.

Preliminary Results and Discussion



The figure above shows data for two out of three beach positions for both beaches. As the two uppermost graphs indicates, the perforated beach seems more efficient than the solid beach for the **tested wave periods and wave steepness** when the beach is **piercing the surface** (upper position). The mean reflection coefficient for the solid beach is 9.2 % in this position and 4.3 % for the perforated beach. This was also the case for the middle position (4.2 % vs 5.0 %) but not for the submerged beach seen in the two lowermost graphs where **no significant difference** was found with mean reflection coefficients of 3.6 % (solid) and 3.8 % (perforated). The general trend is that **a longer wave leads to a higher reflection coefficient** and **a steeper wave leads to a lower reflection coefficient** but the results are not consistent, thus can't be concluded. The waves with a period of 1.29 s had the overall lowest reflection coefficients. The lowest beach position seems to be the most efficient for almost all waves **in this experiment** but with greater submersion the effect of the beach will eventually decrease.