PHYSICAL AND 2D NUMERICAL MODELING OF WAVE FIELD IN THE VICINITY OF GAPS IN BRUSHWOOD FENCES USED AS SOFT SHORE PROTECTION STRUCTURES

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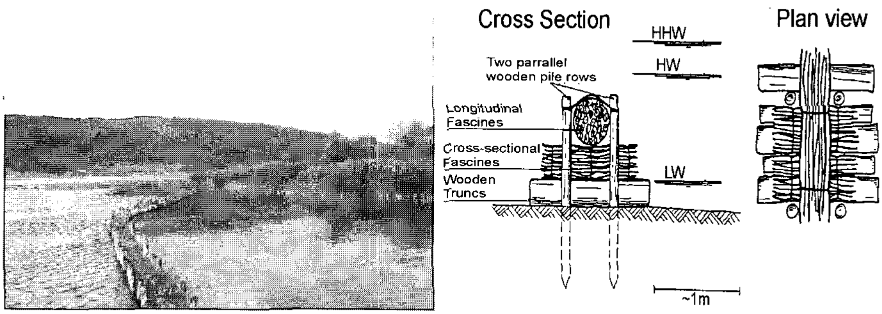
A common soft protection measure, called brushwood fences, is widely used in shallow regions of large lakes in Switzerland where high waves, during major wind events, are able to reach the shore and induce severe erosion. Mainly constructed of wooden piles and tree branches, brushwood fences are often used as porous coastal protection structures (see Fig. 1a-b). They are most commonly used in lakes to provide reliable, soft, and cheap shore protection. They are especially effective in shallow regions where hydrodynamic forces, generated by wind and currents, are not very significant. However, the scientific basis for their specific design still needs to be explored in detail.



(a) (b)

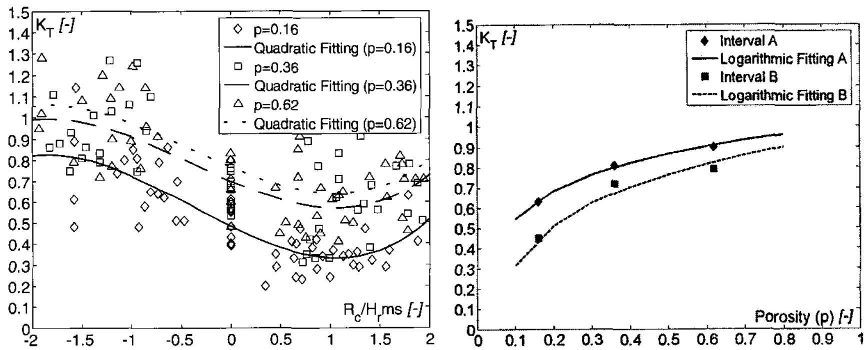
Fig. 1 (a) Brushwood fences in Lake Biel (Switzerland) used to protect reed plantation; (b) Typical design concept of brushwood fences

One of the major questions that remain to be answered, concerns the effect of gaps in the structure, on wave field in the protected area. The analysis focuses on the modification of the wave field behind the structure for a varying width of one gap and spacing between two gaps.

Based on 2D numerical modeling, the analysis uses the results of the physical tests carried out in a wave tank with downscaled brushwood fences. In a first stage, the experimental results are used to calibrate the numerical model using some major variables of wave breaking and bottom roughness. Afterwards, the transmission coefficients of the structure obtained by the physical tests are introduced in the model as friction coefficients.

It can be seen from Fig. 2a that the transmission coefficient, $K_T = H_{transmitted}/H_{incident}$, decreases almost linearly when the relative freeboard, R_c/H_{rms} increases. However, when the relative freeboard is lower than -1 (a negative value indicates that the structure is totally submerged), trends seem to reach constant values. Furthermore, when R_c/H_{rms} is higher than 1, K_T seems to increase after passing an inflection point.

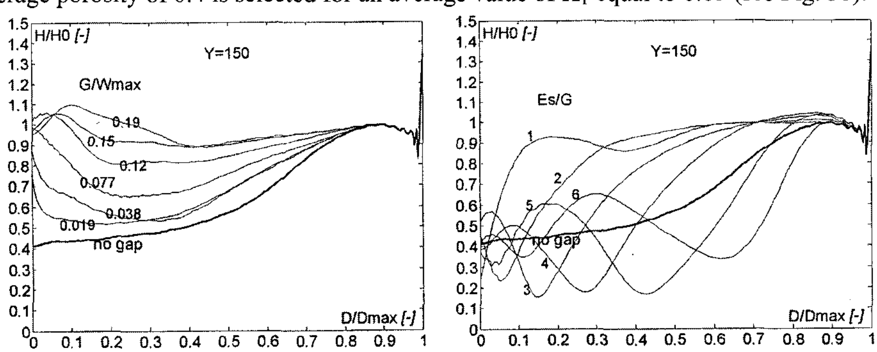
Fig. 3b reveals that a low porosity (p) of brushwood fences has a positive effect on wave damping. Nevertheless, it does not increase proportionally when porosity decreases. This result means that the effect of the variation of the porosity is slightly higher when the brushwood fences emerge (interval B), in comparison to a completely submerged situation (interval A). It also implies that the variation of porosity is not directly proportional with the variation of K_T.



(a) (b)

Fig. 3 (a) Experimental results showing the transmission coefficient K_T of brushwood fences for three porosities and for a structure height of h=0.7m; (b) Transmission coefficient K_T in function of porosity for the two main domains of the relative freeboard

The numerical modeling focuses on the evaluation of the damping in the interval B where the structure is most efficient. According to physical experiments and results, an average porosity of 0.4 is selected for an average value of K_T equal to 0.65 (see Fig. 3b).



(a) (b)

Fig. 4 Wave height H/H0 according to (a) gap width (G/W_{max}) in the case of a single gap and (b) gap spacing (Es/G) in the case of 2 gaps.

Wave field is then modeled for a varying width of a single gap, and a varying spacing between two gaps with a fixed width. In the case of a single gap (see Fig. 4a), high waves are concentrated in the middle of the protected area in the axe of the gap. At the sides of this area, wave heights are less influenced by the gap width. It appears to influence mainly wave heights in its axis. However, for big values of G/Wmax (≥0.12), wave heights are bigger than the initial wave heights without any protection. Wave field for two gaps (see Fig. 4b) is different and significantly influenced by the spacing between the gaps. For low spacing values (Es/G≤2), waves in the middle of the protected area are high along the structure and very low when approaching the shore. For high spacing values (Es/G≥5), wave field is also significantly deformed. However, the values of Es/G comprised between 3 and 4 appear to be most appropriate since wave field is less deformed.

Keywords: Soft Shore Protection; Wave Field; Gap; Brushwood Fences; Numerical Modeling.