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Hydraulic Performance of Artificial Reefs: Global and Local Description

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Abstract
Artificial reefs are increasingly used as an active shore protection measure. Nevertheless, the physical processes occuring at these structures are still not well understood. Existing design formulae mostly take into account only the change in wave height over the reef (transmission coefficient). The energy transfer within the wave spectrum is not considered. Physical model tests on artificial reefs have been performed at Leichtweiß Institute for Hydraulic Engineering, focussing on the energy transfer and on local effects occuring at the reef. Among others new formulae are proposed to predict both height and period of the transmitted and reflected wave. With respect to the local effects, new breaking criteria and breaker classifications are proposed, together with a description of the generated vortices and their effects on the hydraulic performance of the reef.

1. Introduction

In nearly all existing design concepts for artificial reefs a global approach is adopted. The energy of the wave spectrum in front of the reef is com-pared to the spectrum behind the reef by means of the transmission coefficient $k_t = H_t / H_i$.

The fact that the shape of the spectrum is also deformed is only considered by using spectral wave parameters for the wave height. Nevertheless, the frequency of a wave (component) and thereby its period is a measure for the wave celerity, which is determinant for estimating the energy flux. Thus, the change of spectral shape can not be neglected for the design of coastal structures or for the assesment of sediment transport.

2. Experimental Study

At Leichtweiß Institute for Hydraulic Engineering physical model tests at an idealised artificial reef (Fig.1) have been conducted. A rectangular box with different heights (h = 0.4m; 0.5m; 0.6m) and widths (B = 0.5m; 1.0m) placed on the flume bottom has been used to represent the reef. In total six alternative geometries were investigated using regular waves and theoretical wave spectra (JONSWAP, TMA, etc.).

Water level elevations were recorded in front and behind the reef. In addition, a newly developed set-up for optical recordings of the flow has been applied to measure instaneous velocity fields based on PIV (Particle Image Velocimetry) principles (BLECK and OUMERACI; 2001). An example of the PIV recordings is given in Fig.2 a including the resulting velocity field (Fig. 2 b).

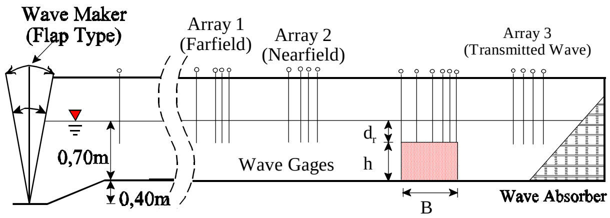

Fig.1: Model Set-Up

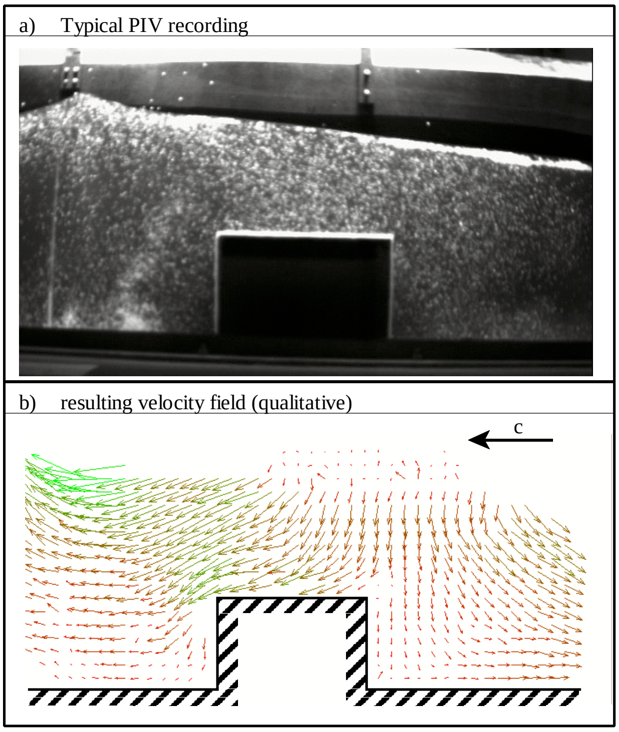

Fig.2: PIV results

3. Selected Results

The effects at the reef were divided in global and local effects (Fig.3), global energy loss and the energy transfer within the spectrum being global effects, wave breaking, vortex shedding and non-linear

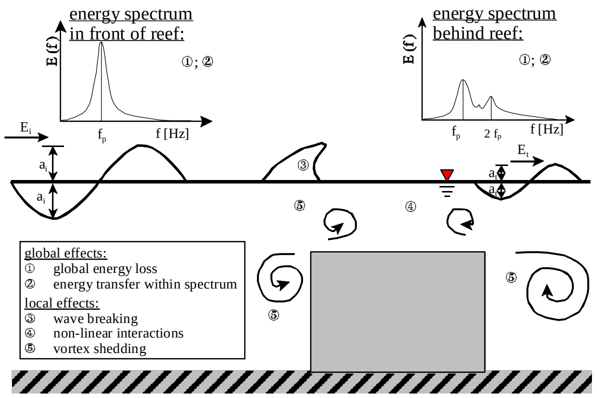

Fig.3: Effects at Artificial Reefs

interactions being the local effects causing the global effects.

a) Global Effects

Transmission coefficients k_t were calculated using wave height H_{m0} directly in front of the reef and behind the reef. Most critical parameter for the transmission coefficient showed to be the relative water depth over the reef crest (d_r/H_i) which can be regarded as a shallow water non linearity parameter (Fig. 4).

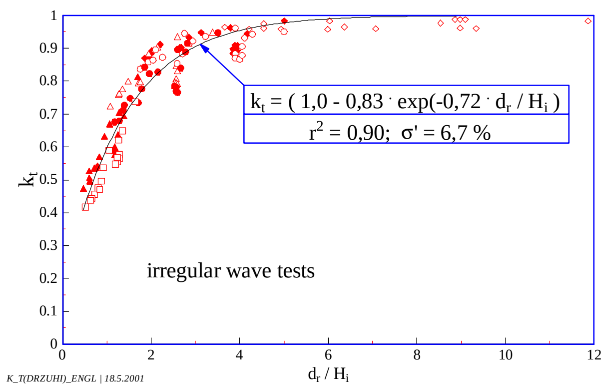

Fig.4: Relationship between transmission coefficient and dimensionless water depth

For describing the energy transfer in the spectrum the mean wave period T_{-10} has been applied as the significant parameter for the spectral shape, following results of overtopping investigations using actual measured spectra in the field (OUMERACI et al.; 2000). Again a good correlation with the relative water depth d_r/H_i can be observed (Fig.5).

b) Local Effects

Regarding wave breaking the breaker types occuring at artifical reefs have been classified including breaker types not observable on plain slopes (drop-type-breaker, two-step-breaker, etc.). New breaking criteria have been developed.

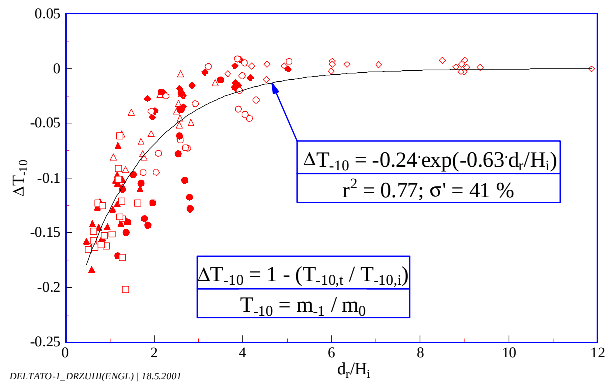

Fig.5: Evolution of the mean wave period T_{-10}

The vortex generation at the edges of the reef has been evaluated giving criteria for the vortex shedding and investigating the importance of these vortices for the wave evolution at the reefs.

The non-linear interactions stating the unability of the linear wave theory and thereon based analysis methods to describe the waves at reefs will be explained based on the measured velocity fields.

4. Conclusion

Based on the results of this work for the first time it is possible to consider both change in wave height and period for the design of artificial reefs. Also the gained knowledge of the local effects can improve the desig of this structures regarding the hydraulic performance.

5. Acknowledgments

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6. References

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