

# Wave Loads On And Beneath Bonded Permeable Revetments

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## Motivation

Permeable revetments made of bonded mineral aggregates may increasingly be favoured compared to standard revetments. However, the physical processes associated with the water-structure-soil-interaction for a wide range of wave conditions are still not well understood. Therefore, systematic large-scale model tests have been performed in the Large Wave Flume (GWK) of the Coastal Research Centre (FZK) in Hannover, with the intention of improving the understanding of these processes.

## Experimental Set Up and Test Programme

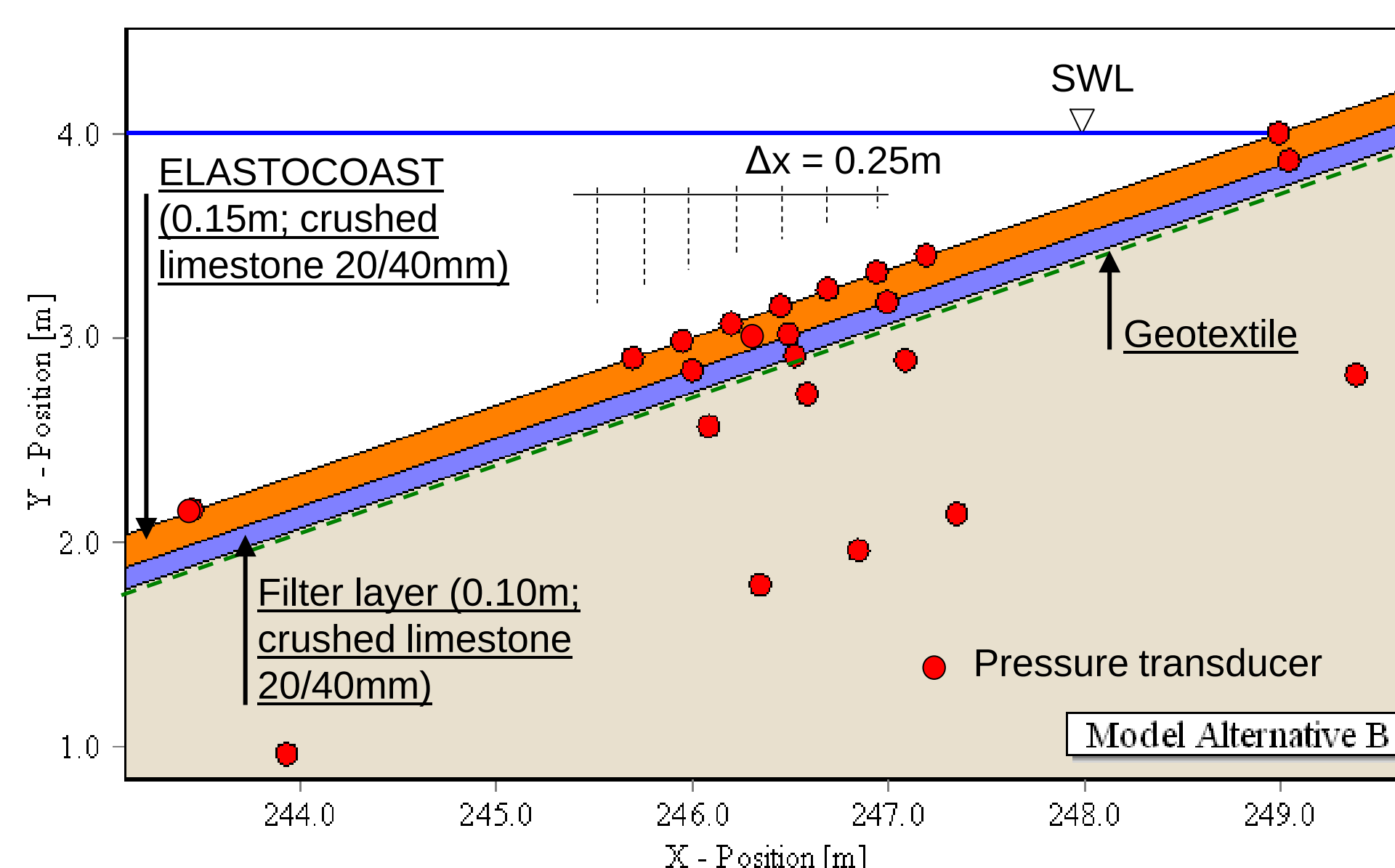


Fig. 1 Pressure transducers in and around the wave breaking zone for model alternative B

The tests were performed in the GWK (330 m x 7 m x 5 m) using:

- irregular waves ( $\approx 1000$  waves:  $H_{m0} \leq 1.2$  m,  $T_{m-1,0} \leq 8$  s)
- water depths  $h = 3.4$  to  $4.2$  m
- 48 pressure transducers (Model B: Fig. 1)
- two synchronously tested models (all three model alternatives: Fig. 2)
- surf similarity parameter

$$\xi = \xi_{m-1,0} = \frac{\tan \alpha}{\sqrt{H_{m0}/L_0}} = 1.22 \text{ to } 8.05$$

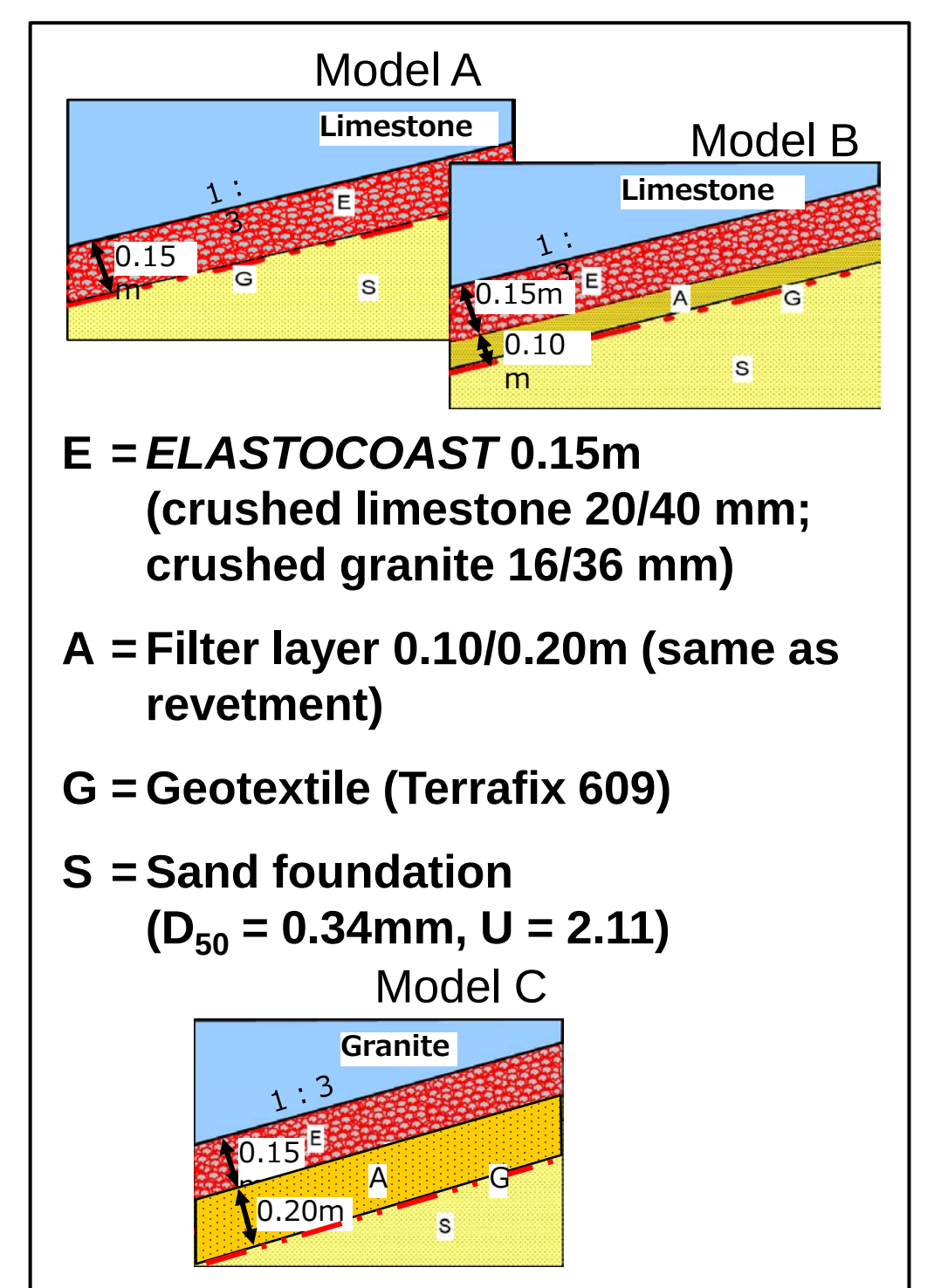


Fig. 2 Model alternatives A, B, C

## Classification and Parameterization

Before starting the detailed analysis, a preliminary analysis was performed in order to check and pre-process the data, but primarily to classify the type of wave loads. For irregular waves, impact loads occur for  $\xi < 2.5$  and non-impact loads for  $\xi > 2.9$  (Fig. 3). The range of intermediate  $\xi$ -values ( $\xi = 2.5 - 2.9$ ), called hereafter "transition zone", exhibits mixed features of both impact and non-impact loads. The parameterization of the pressure in the time domain and in space is given in Figs. 4 to 6 for impact and non-impact loads.

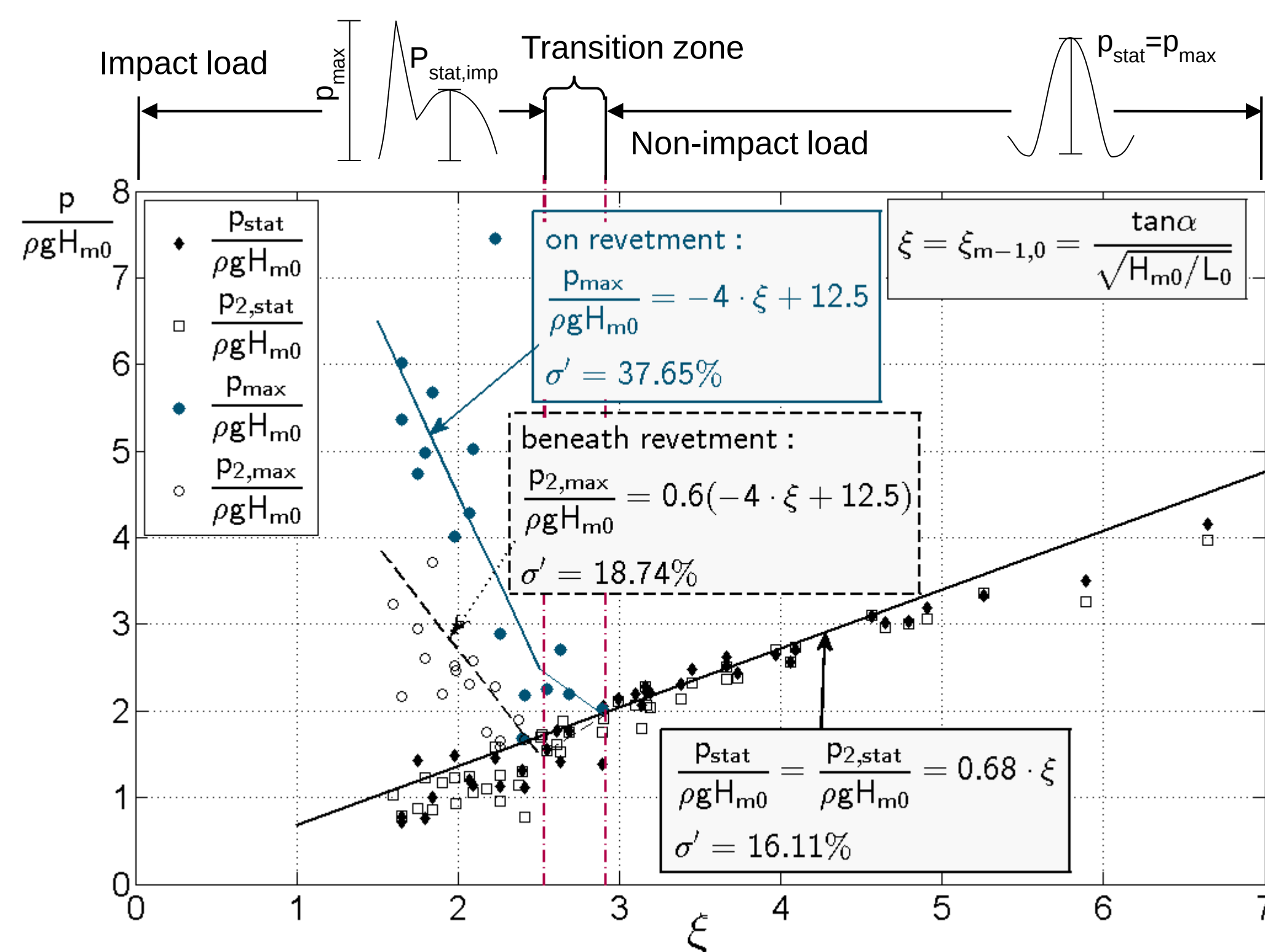


Fig. 3 Wave pressure and load classification

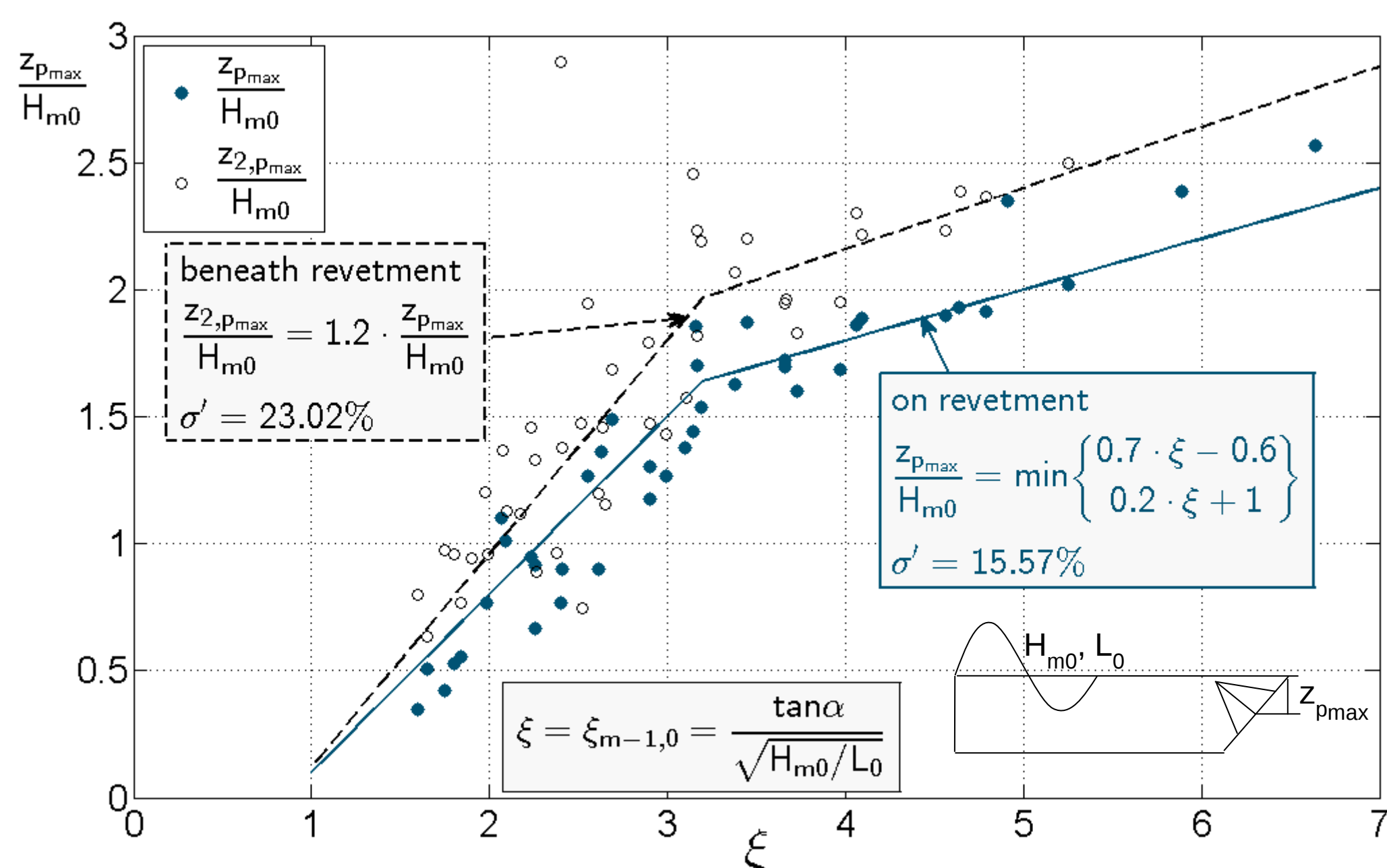


Fig. 4 Location of maximum pressure

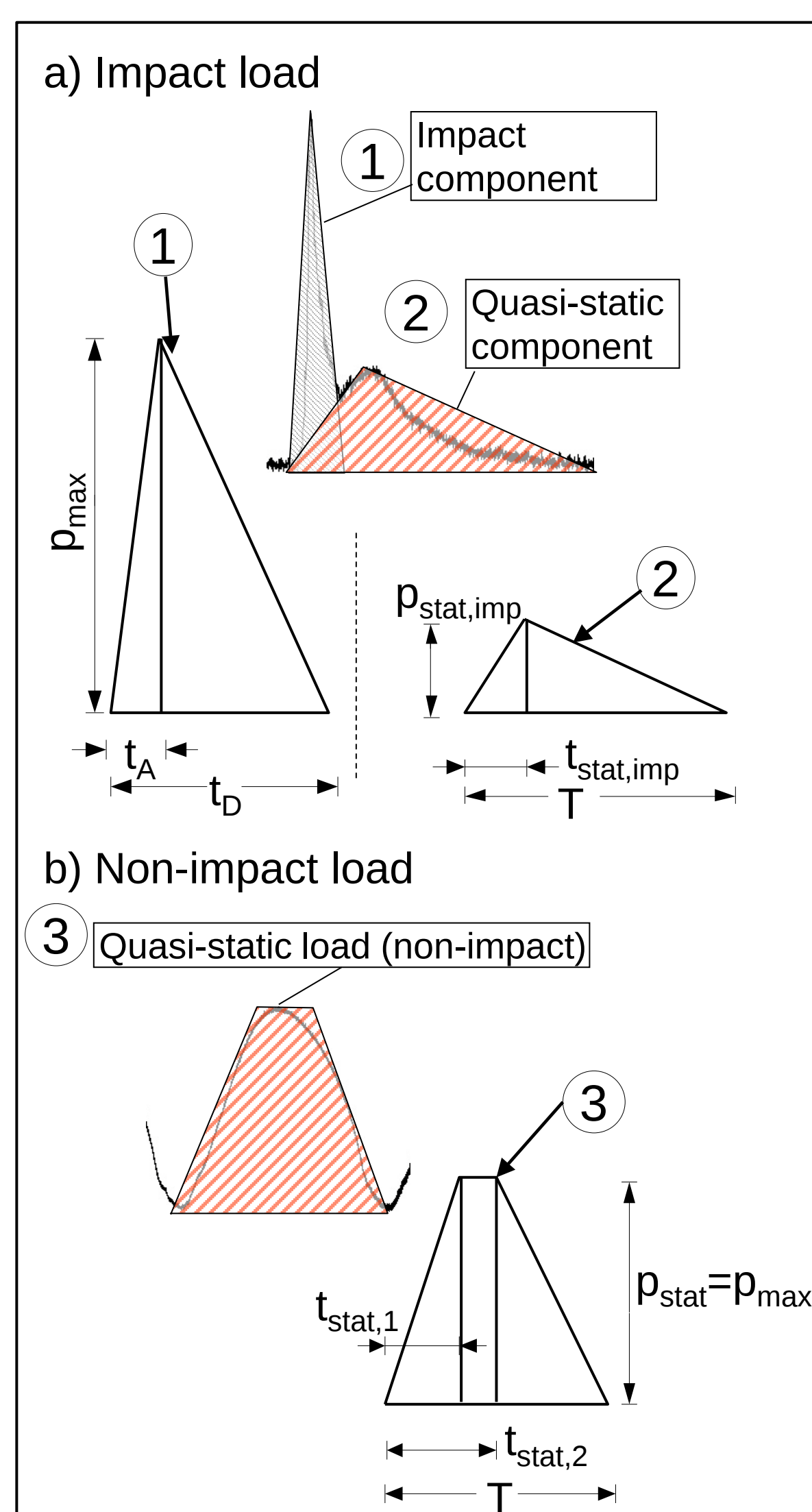


Fig. 5 Parameterization in time

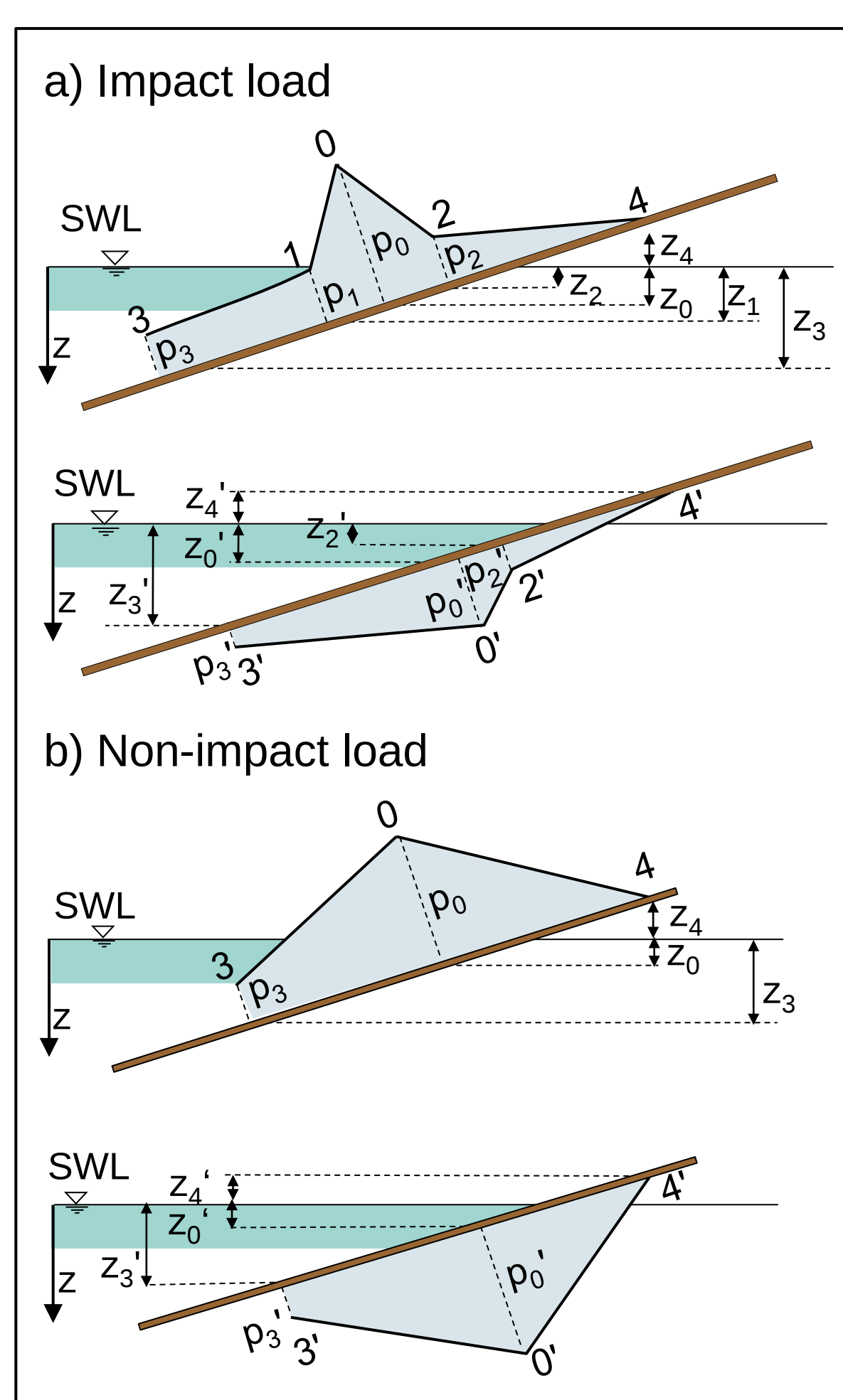


Fig. 6 Parameterization in space

## Results

Using empirical approaches the parameters were determined based on the surf similarity parameter  $\xi = \xi_{m-1,0}$  (Tabs. 1 to 4). While the wave-induced pressure is substantially damped through the porous revetment for impact loads, this is not the case for the non-impact loads, which are almost fully transmitted through the revetment.

Tab. 1 Time related parameters for impact loads on the revetment (see also Fig. 5a)

|                        |                                 |                                 |
|------------------------|---------------------------------|---------------------------------|
| $t_D/T_{m-1,0} = 0.06$ | $t_A/t_D = 0.5 \cdot \xi - 0.8$ | $t_{stat,imp}/T_{m-1,0} = 0.12$ |
|------------------------|---------------------------------|---------------------------------|

Tab. 2 Space related parameters for impact loads (see also Fig. 6a)

|                          |     |     |     |                                                       |
|--------------------------|-----|-----|-----|-------------------------------------------------------|
| a) On the revetment      |     |     |     |                                                       |
| $p/p_{max}$              | 0   | 1   | 2   | 3                                                     |
| $z/z_{pmax}$             | 1   | 0.5 | 0.4 | 0.4                                                   |
|                          |     |     |     | 0                                                     |
|                          |     |     |     | $-\frac{H_{m0}}{z_{pmax}} \cdot 0.89 \cdot \xi$       |
| b) Beneath the revetment |     |     |     |                                                       |
| $p'/p_{max}$             | 0'  | 2'  | 3'  | 4'                                                    |
| $z'/z_{pmax}$            | 0.6 | 0.4 | 0.4 | 0                                                     |
|                          |     |     |     | $-\frac{H_{m0}}{z_{pmax}} \cdot 0.89 \cdot \xi + 0.2$ |

Tab. 3 Time related parameters for non-impact loads on the revetment (see also Fig. 5b)

|                              |                              |
|------------------------------|------------------------------|
| $t_{stat,1}/T_{m-1,0} = 0.3$ | $t_{stat,2}/T_{m-1,0} = 0.6$ |
|------------------------------|------------------------------|

Tab. 4 Space related parameters for non-impact loads (see also Fig. 6b)

|                          |     |     |    |                                                                                   |
|--------------------------|-----|-----|----|-----------------------------------------------------------------------------------|
| a) On the revetment      |     |     |    |                                                                                   |
| $p/p_{max}$              | 0   | 3   | 4  |                                                                                   |
| $z/z_{pmax}$             | 1   | 0.4 | 0  |                                                                                   |
|                          |     |     |    | $-\frac{H_{m0}}{z_{pmax}} \cdot \left[ 3 - \frac{1.15}{\sqrt{\xi}} \right]$       |
| b) Beneath the revetment |     |     |    |                                                                                   |
| $p'/p_{max}$             | 0'  | 3'  | 4' |                                                                                   |
| $z'/z_{pmax}$            | 1.2 | 2.8 | 0  |                                                                                   |
|                          |     |     |    | $-\frac{H_{m0}}{z_{pmax}} \cdot \left[ 3 - \frac{1.15}{\sqrt{\xi}} \right] + 0.2$ |