PROGRESSION OF MEAN DAMAGE ON A MOUND BREAKWATER IN ITS SERVICE LIFE

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JUSTIFICATION AND MOTIVATION

Because of the expected sea level rise, most of the human properties located on the coast have to be protected during the present century. One of the engineering alternatives is to build rock sloping coastal structures. Currently, their design has to include procedures for aging and deteriorating to forecast their maintenance and reparation costs during its service life. The objective of the present research is to reformulate the rate of mean damage proposed by Melby and Kobayashi (1998) to predict the progression of mean damage $\bar{S}$ on a given mound breakwater typology under sequences of storms with varying wave conditions and water levels. The proposal is based on the interplay of water depth, h, incident significant wave height, H_s and mean wave period, T_m at the toe of the slope, and the impinging number of waves, N_w (Losada et al. (2021)).

PROGRESSION AND VARIABILITY OF DAMAGE

Melby and Kobayashi (1998) proposed a predictive method for the cumulative damage on a conventional mound breakwater exposed to depth-limited breaking waves. The empirical formula of Van der Meer (1987) was modified to predict the mean damage and to include the cumulative effects of antecedent storm conditions. The dependence on the water depth at the toe of the structure was not explicitly considered. Thus, the rate of mean damage, $\bar{S}$ under constant sea state descriptors, H_s and T_m, (assuming to be valid at arbitrary time t) is given by,

$$\frac{d\bar{S}}{dt} = a_s b N_s^5 T_m^{-b} t^{b-1}; \; N_s = \frac{H_s}{\Delta D_{n50}}; \; N_w = \frac{t}{T_m} \qquad (1)$$

Assuming the values of H_s and T_m to be constant for a short duration, $t=t_n$ to $t=t_{n+1}$, the integration of eq.(1) yields the mean damage at arbitrary time t,

$$\bar{S}(t) = \bar{S}(t_n) + a_s N_s^5 T_m^{-b}(t^b - t_n^b); \; t_n \le t \le t_{n+1} \qquad (2)$$

Although their data are not directly comparable with Van der Meer´s experiments, Melby and Kobayashi (1988) tested Eq. (2) on a 1:2 armor slope with an underlayer core exposed to intense breaking waves at the toe of the slope.

REFORMULATION OF THE RATE OF MEAN DAMAGE

Recently, Losada (2021), reanalyzed Van der Meer`s experimental results and showed that, (1) the surf similarity parameter is not the sole factor for the normalized stability of the slope, (2) the progression of damage under sea state conditions depends on the relative water depth h/L at the toe of the slope. Moreover, the term, $\frac{\bar{S}}{\sqrt{N_w}}$ (the origin of the classical relationship, $\bar{S} \sim N_s^5$) does not reliably replicate the mean damage evolution observed in the wave flume. Thus, for a given breakwater typology, height, width B and core properties, slope, nominal diameter, and relative rock density, the total rate of mean damage progress under constant sea state descriptors is given by

$$\frac{D\bar{S}}{Dt^*} = f\left(\frac{h}{L}, \frac{H_s}{L}, \frac{t}{T_m}\right); \; N_s = \frac{H_s}{\Delta D_{n50}}; \; N_w = \frac{t}{T_m} = t^* \qquad (3)$$

Damage can progress because the concomitant time evolution of the three sea sate descriptors, h, H_s and T_m. Integration of eq. (3) yields the modified equation to predict the mean damage at arbitrary time, and an arbitrary storm,

$$\bar{S}(t) = \bar{S}(t_n) + \psi_n\left(\frac{h}{L}, \frac{H_s}{L}\right) T_m^{-b}(t^b - t_n^b); \; t_n \le t \le t_{n+1} \qquad (4)$$

The value of N_s depends on H_s, L and h at the toe of the slope, and assumed to be constant for a short duration, $t=t_n$ to $t=t_{n+1}$.

PRIMARY RESULTS

Figure 1 shows the interplay of N_w, h/L and H_s/L on the mean damage progression of Melby and Kobayashi (1998) data. If accepted, the final presentation will include the fit of the modified equations tested against former data (Van der Meer 1988, Vidal et al. 2006). These primary results will be the core of the discussion and conclusions.

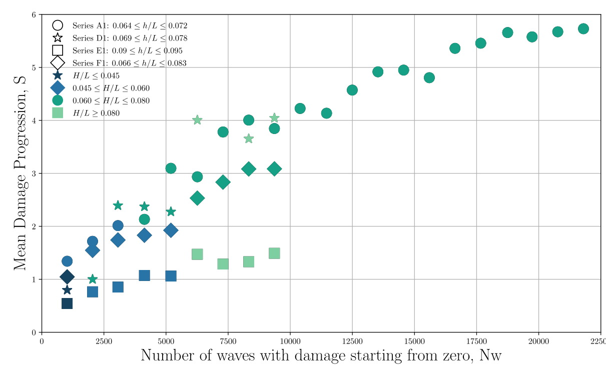

Figure 1 Dependence of damage progression on the interplay of N_w, h/L and H_s/L

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