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Artificial intelligence methods in breakwater damage ratio estimation

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Abstract

The anticipation of damage ratio with an acceptable accuracy is a vital issue in breakwater design. The presented study covers the employment of three different artificial neural network methods and a fuzzy model for this problem. Inputs like mean wave period, wave steepness, significant wave height and the breakwater slope are used as input to estimate the corresponding damage ratio value. All artificial neural network methods and fuzzy logic model provided quite close estimations for the experimental values. The testing stage results were significantly superior to the conventional multi-linear regression method in terms of the selected performance criteria.

Keywords: Armor unit; Artificial intelligence; Breakwater; Damage ratio; Fuzzy logic; Neural network; Static stability

1. Introduction

Breakwater stability analysis has long been attracted the interest of coastal engineering researchers. The design of armor layer units on breakwater is one of the major problems for coastal engineers. The type, weight and placement technique of breakwaters′ armor layer units are designed considering anticipated damage ratio, which will occur under the estimated wave climate conditions. Therefore, the anticipation of damage ratio with an

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Nomenclature

AI	artificial intelligence
ANN	artificial neural networks
BADD	basic defuzzification distribution
COA	center of area
FFBP	feed forward back propagation
FL	fuzzy logic
GRNN	generalized regression neural networks
MOM	mean of maxima
MSE	mean square error
RBF	radial basis function
SLIDE	semi linear defuzzification

acceptable accuracy, which will occur through the life of the structure, is vital. In this context, description of the anticipated damage ratio has a special importance. In the literature, various damage concepts are adopted by different researchers (Losada et al., 1986; Vidal et al., 1991, 1995; Van Der Meer and Heydra, 1991; Melby and Kobayashi, 1998; Van Der Meer, 1988; Yagci and Kapdasli, 2003; Gunaydin and Kabdasli, 2003).

Further, Hudson et al. (1979) introduced a formula which is still commonly used by practitioners at the design stage of armor layer units of breakwaters. Hudson et al. (1979) determined the parameters affecting the armor layer stability and obtained an equation using dimensional analysis. This equation is a function of physical parameters like weight of an armor unit, characteristic wave height, specific weights of armor unit and water, the slope angle, and the empirical stability coefficient, K_D. The K_D values are presented in SPM (1984) for various armor units.

However, the disadvantage of Hudson Equation is that the equation characterizes the wave climate considering only the wave height of the wave series into account and neglecting the effect of the wave period and the wave steepness on breakwater stability. Therefore, at the experimental stage, various wave series having different representative wave characteristics (i.e. various combinations of wave heights, wave periods and wave steepness) are applied to the breakwater model in order to overcome this handicap. In this way the stability performance of the breakwater model is tested under different wave climate conditions. Next, the damage ratio-wave height regression equation is generated using best curve fitting technique. The data marks are scattered in the vicinity of the obtained regression curve with the effect of the wave period and the wave steepness (Yagci et al., 2004). The values of wave heights corresponding to various damage ratios are determined using the acquired regression equation. In this way, for different damage ratios, the 'K_D' stability coefficient is found by Hudson Equation employing the physical parameters mentioned above. However, this method provides accuracy to a certain degree, since the effect of wave period and the wave steepness is incorporated into Hudson Equation indirectly via the regression curve. The study of Yagci et al. (2004) is an example for this kind of procedure. In their study the authors found that the overall average of