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改进的二维数值波浪水槽在波浪破碎中的应用

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摘要 Song和Banner（2002，简称SB02）利用二维数值波浪水槽（Drimer和Agnon开发，并被Segre改进，简称DAS）研究了深水及中等水深下波群破碎，并依据波群内部能量调制和演变特性提出一个新的波浪破碎阈值.本文利用两个DAS改进模型对SB02的波浪破碎结果进行检验和比较，并研究底面斜坡坡度对SB02破碎判据的影响，其中第一个改进模型（简称MDAS1）修正了DAS中某些积分的计算错误，第二个改进模型（简称MDAS2）在自由表面上用三阶元取代原来的线性元.研究表明： MDAS1和DAS的结果非常一致；而MDAS2和MDAS1相比，波浪临界破碎时的造波板振幅、破碎时刻和局部能量极大值的最大平均变化率δ_{max}都会发生变化，但MDAS2仍然符合SB02提出的破碎阈值.由MDAS1模拟中等水深下波群在坡度为1∶500、1∶300、1∶150和1∶100斜坡上的破碎结果表明：随着斜坡变陡，波群的局部能量极大值μ增大，δ_{max}在临界非破碎情况下微弱变小，在临界破碎情况下急剧增大，SB02提出的破碎阈值在中等水深下坡度小于1∶100的斜坡上仍然有效.

关键词 数值波浪水槽 边界元方法 波浪破碎 破碎判据

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Applications of improved 2-D numerical wave tanks in wave breaking

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Abstract Song and Banner (2002, henceforth referred to as SB02) used a numerical wave tank (developed by Drimer and Agnon, and further refined by Segre, henceforth referred to as DAS) to study the wave breaking in the deep water, and proposed a dimensionless breaking threshold that based on the behaviour of the wave energy modulation and focusing during the evolution of the wave group. In this paper, two modified DAS models are used to further test the SB02′s results, the first one (referred to MDAS1) corrected many integral calculation errors appeared in the DAS code, and the second one (referred to MDAS2) replaced the linear boundary element approximation of DAS into the cubic element on the free surface. Researches show that the results of MDAS1 are the same with those of DAS for the simulations of deep water wave breaking, but, the different values of the wavemaker amplitude, the breaking time and the maximum local average energy growth rate δ_{max} for the marginal breaking cases are founded by MDAS2 and MDAS1. However, MDAS2 still satisfies the SB02′s breaking threshold. Furthermore, MDAS1 is utilized to study the marginal breaking case in the intermediate water depth when wave passes over a submerged slope, where the slope is given by 1∶500, 1∶300, 1∶150 or 1∶100. It is found that the maximum local energy density μ increases significantly if the slope becomes steeper, and the δ_{max} decreases weakly and increases intensively for the marginal recurrence case and marginal breaking case respectively. SB02′s breaking threshold is still valid for the wave passing over a submerged slope gentler than 1∶100 in the intermediate water depth.

Key words Numerical wave tank Boundary element method Wave breaking Breaking criteria

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