NEW BREAKER INDEX FORMULA IN PARAMETRIC WAVE MODEL

Chi Zhang, Hohai University, zhangchi@hhu.edu.cn
Yuan Li, Hohai University, yuanli@hhu.edu.cn
Yu Cai, Hohai University, yucai@hhu.edu.cn
Jian Shi, Hohai University, jianshi@hhu.edu.cn
Jinhai Zheng, Hohai University, jhzheng@hhu.edu.cn

INTRODUCTION

Phase-averaged parametric wave models have been widely used to predict nearshore wave height transformation. The performance of parametric models depends significantly on the wave breaker index (γ), which controls the amount of breaking energy dissipation. Previous parameterizations improved the model predictability by considering the breaker index as a tunable coefficient, while made less effort to the physical interpretation for the proposed formulas. Indeed, inconsistency from the physical perspectives might exist. For example, several studies proposed γ increases with the increasing offshore wave steepness (s_0) or wave height (H_0), and increases with the increasing local normalized water depth (kh). However, according to the surf similarity parameter, the spilling breaker (with a smaller wave height-to-depth ratio) more likely occurs far away from the shoreline (with a larger kh), is corresponding to a larger s_0. Therefore, the parameterization of γ still requires further investigation by considering the comprehensive influences of the offshore wave parameters and the local water depth, as well as the possible relationships with the breaker type and the surf zone state.

INVERSED MODELLING

For model calibration, we use the 313-h H_{rms} data collected at 14 cross-shore locations (extending to the water depth of about 4.5 m) during Duck94 experiment from September 21, 1994 to October 4, 1994. For model verification, the 529-h data collected in Duck from October 4, 1994 to October 26, 1994, 841-h data collected in Egmond from October 15, 1998 to November 19, 1998 and 816-h data collected in Terschelling from May 25, 1994 to June 28, 1994 are used.

On the basis of the work by Ruessink et al. (2003), the present study uses the inverse modelling approach to revisit the γ with respect to a wide variety of conditions. Based on field datasets, variation of the γ is inversely calculated using the wave breaking model proposed by Baldock et al. (1998). Detailed description of the inversed modelling approach can be found in Ruessink et al. (2003).

It is noted that Ruessink et al. (2003) only retained the γ values for D_b > 15 N/ms to avoid spurious results. However, we find this treatment is not necessary in the present study as it may cause the miss of some important information. In this study, all γ values for D_b > 0 N/ms are retained. It is found that the data of D_b > 15 N/ms accounts for only a small portion (18%) of all data, and it mainly represents the wave conditions when s_0 is relatively large (approximately > 0.02). Therefore, the calibration of γ under wave conditions with smaller offshore wave steepness is likely not included in Ruessink et al. (2003).

RESULTS

Figure 1 presents the relationship between γ and kh. As shown, the γ data for D_b >15 N/ms is in good agreement with the formula (γ = 0.76kh + 0.29) of Ruessink et al. (2003), which describes a positive correlation between γ and kh. However, this relationship no longer applies if all γ data is considered. Especially, the γ data seems to follow a different trend under wave conditions with smaller s_0 and D_b. Moreover, the γ data for D_b > 15 N/ms (mainly corresponding to the energetic wave conditions with large s_0) is generally higher than other data, implying that the breaker index depends on both the local water depth and the offshore wave parameters.

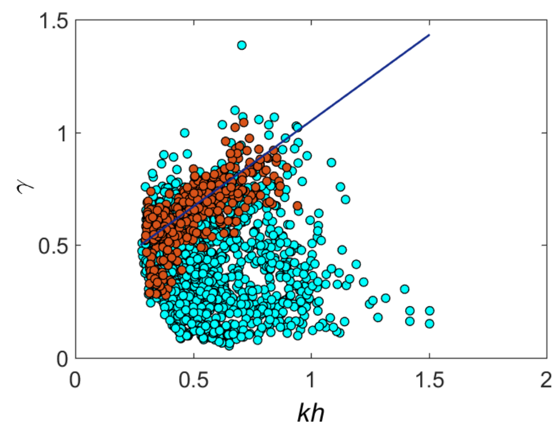

Figure 1 The breaker index γ versus kh based on estimates with D_b > 15 N/ms (filemot points) and all estimates with D_b > 0 N/ms (cyan points). The solid line is the γ formula of Ruessink et al. (2003).

Based on the inverse model results, a composite dependence of γ on both s_0 and kh is found. As provided in Figure 2, we reveal a positive γ-kh relationship for larger s_0, and a negative γ-kh relationship for smaller s_0. Based on such composite relationships, a new γ formula is proposed as,

$$\gamma = (237 s_0^2 - 34.81 s_0 + 1.46)\exp[1.96\ln(38.64 s_0) * kh] \quad (1)$$

The model (Hereafter **ZL2020**) performance in predicting H_{rms} using the new breaker index formula (Equation 1) together with the breaking dissipation model of Baldock et al. (1998) is quantitatively evaluated with the root-mean-square percentage error (RMSPE).

Using the available field datasets in three coasts, the present model (**ZL2020**) is compared with seven previous models [**R2003** in Ruessink et al. (2003), **TG1983** in Thornton and Guza (1983), **JB2007** in Janssen and Battjes (2007), **B1998** in Baldock et al. (1998), **BJ1978** in Battjes and Janssen (1978)], which are widely used in parametric wave modelling. Since Apotsos et al. (2008) have significantly improved the accuracy of TG1983, JB2007, B1998 and BJ1978 by tuning γ for each model based on the similar datasets, here we will employ the newly tuned γ formulas of Apotsos et al. (2008) in these models (hereafter TG1983_t, JB2007_t, B1998_t, BJ1978_t) for a more rigorous inter-comparison.

Figure 3 compares the median percentage errors of eight models. All models have the errors between 5% and 20%, consistent with the results of Apotsos et al. (2008). The model error is generally lower at Duck than at two other sites, possibly because most of the models have been calibrated with part of (or full) Duck data. ZL2020 shows lowest errors at Duck and Egmond, and very slightly higher error than TG1983_t but still remarkably lower than other models at Terschelling. The BSS values in Table 1 indicated that using ZL2020 model reduces the errors averagely by 16% at Duck, 19% at Egmond, 21% at Terschelling, and by 22% over R2003, 10% over TG1983_t, 15% over JB2007_t, 17% over B1998_t, 20%
319 over BJ1978_t, 23%.

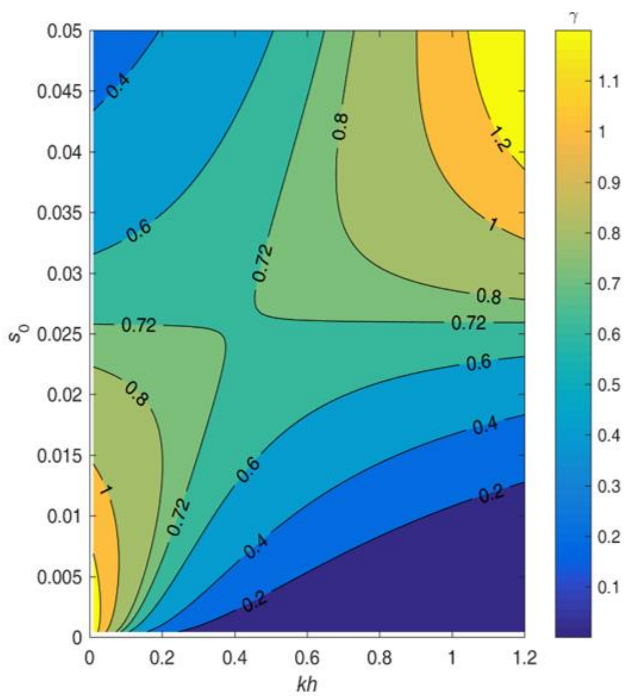

Figure 2 Composite dependence of wave breaker index (γ) on the offshore wave steepness (s_0) and the normalized local water depth (kh) represented by the new formula.

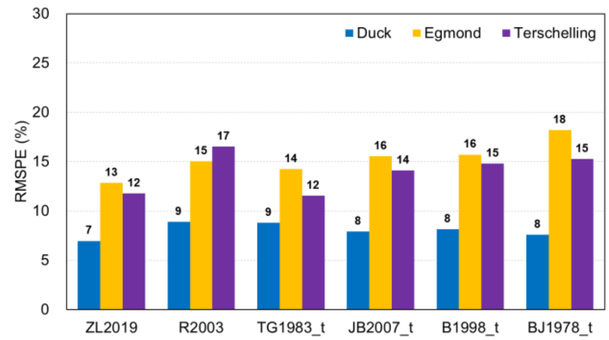

Figure 3 Median percentage errors of eight models in field tests.

CONCLUSIONS

A composite dependence of γ on both the offshore wave steepness (s_0) and the normalized local water depth (kh) is revealed. A new γ formula is proposed to take such composite relationships into consideration. The model implementing this new γ formula systematically reduces the prediction error of wave height compared with five widely used models in previous literatures.

REFERENCES

Apotsos, Raubenheimer, Elgar, Guza (2008): Testing and calibrating parametric wave transformation models on natural beaches, Coastal Engineering, ELSEVIER, vol. 55, pp. 224-235.

Baldock, Holmes, Bunker, Van Weert (1998): Cross-shore hydrodynamics within an unsaturated surf zone, Coastal Engineering, ELSEVIER, vol. 34, pp. 173-196.

Battjes, Janssen (1978): Energy loss and set-up due to breaking of random waves, Proceedings of the 16th International Conference on Coastal Engineering 1978, pp. 569-587.

Janssen, Battjes (2007): A note on wave energy dissipation over steep beaches, Coastal Engineering, ELSEVIER, vol. 54, pp. 711-716.

Thornton, Guza (1983): Transformation of wave height distribution, Journal of Geophysical Research: Oceans, AGU, vol. 88, no. C10, pp. 5925-5938.

Ruessink, Walstra, Southgate (2003): Calibration and verification of a parametric wave model on barred beaches, Coastal Engineering, ELSEVIER, vol. 48, pp. 139-149.