WAVE FRICTION FACTOR OVER ROUGH SEABEDS

Damien Sous, Université de Toulon/Université de Pau et des Pays de l'Adour, sous@univ-tln.fr
Solène Déalbéra, Université de Pau et des Pays de l'Adour, solene.dealbera@univ-pau.fr
Denis Morichon, Université de Pau et des Pays de l'Adour, denis.morichon@univ-pau.fr
Héloïse Michaud, SHOM Toulouse, heloise.michaud@shom.fr

INTRODUCTION

In the presence of large roughness, such coral reef or rocks, frictional wave dissipation is expected to play a crucial role in wave transformation, possibly dominating over depth-induced breaking dissipation (Monismith et al. 2015). The wave friction factor, f_w, is a key parameter for the representation of frictional wave dissipation in phase-averaged numerical models. Observations performed in coral reef or rocky seabed contexts consistently showed an increase of f_w with the roughness height (Lowe et al. 2005, Poate et al. 2018, Gon et al. 2020, Sous et al. 2023). The classical approach in moderate roughness context, such as sand ripples or gravel, is to connect f_w with the ratio between near-bed wave orbital amplitude A_o and a roughness length-scale called the hydraulic roughness K_r (Swart 1974, Madsen 1995). The application of such models remains an open question in very rough environments, i.e. when A_o/K_r becomes small, typically below 1. Another important issue is to assess the potential relationship between K_r and the architectural complexity of the seabed roughness. Practically, this remains a challenging question due to operational costs for retrieving simultaneously fine data on wave dynamics, allowing robust estimates of f_w, and high-resolution survey of the seabed topography, providing reliable statistical description of the roughness architectural structuring. The existing data tend to show that K_r should primarily scale with the standard deviation of the seabed elevation (Lowe et al. 2005, Gon et al. 2020, Sous et al. 2023). However, discrepancies are observed between sites, potentially indicating that finer roughness metrics should be involved in the definition of K_r.

Based on laboratory experiments of surf zone dynamics over a series of roughness layouts, the present study aims to provide further insight on (I) the validity of the existing f_w in low ranges of A_o/K_r, i.e. in the presence of large roughness, and (ii) to decipher the connection between wave frictional dissipation and the architectural structure of the seabed roughness.

FLUME EXPERIMENTS

The experiments were performed in the CASH wave flume (MIO/SEATECH), 6m long. Irregular waves generated by a piston wave-maker propagate over a 1m long horizontal bottom before shoaling and breaking over a linearly sloping (1:20) bed. Wave dissipation are estimated from the short-wave frequency-integrated energy flux balance, assuming linear waves and extracting breaking-induced dissipation from an adapted version of the classical Thorton and Guza parameterization (Thornton and Guza 1983). A total of 27 types of roughness were successively deployed on the seabed slope, allowing to vary roughness statistical properties (standard deviation, skewness, kurtosis), effective slope, directionality and clustering.

RESULTS

The first observation is that wave dissipation can be correctly predicted using classical formulation of breaking-induced and bottom frictional dissipation even in the larger roughness studied here, reaching A_o/K_r down to 0.05 and emerging roughness elements in the surf zone. The skewness, directionality and effective slope have been shown to affect the frictional dissipation. Including these contributions, a new multi-varied model is proposed for K_r. Combined with the Madsen's parameterization (Madsen 1985) adapted by Sous et al. (2023), the multi-varied K_r allows a good collapse of the complete laboratory dataset, together with existing in-situ data available in the literature (Figure 1).

CONCLUSION AND PERSPECTIVES

The present laboratory study aimed to explore the frictional wave dissipation in the surf zone, in the presence of large roughness. A novel parametrization of the hydraulic roughness is proposed, allowing to account for the roughness geometrical structure in the bottom frictional dissipation. Further efforts must be engaged to test the friction model at field scale.

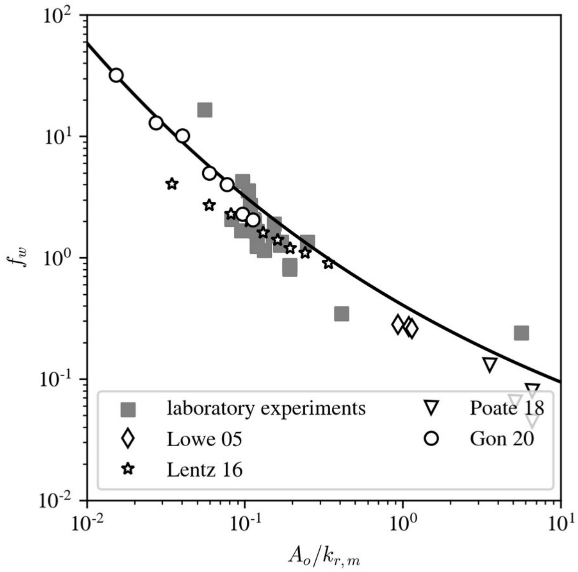

Figure 1 – Wave friction factor vs ratio between near-bed orbital amplitude and hydraulic roughness. Empty symbols denote the existing field data while filled symbols represent the laboratory data.

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