Fully Nonlinear Models of Wave Transformation in Coastal Areas

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Fully nonlinear two-dimensional (2D) and three-dimensional (3D) models of ocean wave generation and propagation, i.e., so-called "Numerical Wave Tanks" (NWT), have recently become powerful tools for engineering design and scientific research in coastal and littoral processes. NWTs are now used to carry out many investigations for which, until recently, only physical laboratory wave tanks could be used. Despite their necessary idealization of actual problems, NWTs are often advantageous because of their rapid set-up time and use, and thus lower cost, as compared to laboratory experiments. This is particularly true if many configurations of the same problem are to be studied in order to identify the optimal geometry or siting of, say, an offshore or a coastal structure. Also, in many cases, NWTs provide unperturbed access to hydrodynamic wave parameters, such as pressure, velocity and acceleration, which often can only be measured in the laboratory using invasive gages and probes.

This keynote lecture will present an overview of the author's own and collaborative recent experience in developing and applying NWTs, mostly based on potential flow theory. The coupling of such NWTs with VOF-based Navier-Stokes solver will also be briefly discussed. Specific applications will include : (i) shoaling and breaking of long-crested 2D swells over sandy beaches, with comparison to laboratory experiments (wave and particle velocity measurements); (ii) shoaling and plunging breaking of 3D waves with specific analysis of velocity and acceleration in the plunging jet; (iii) generation and propagation of waves (tsunamis) caused by submarine mass failure, with comparison with field case studies and laboratory experiments; and (iv) 3D wave energy focusing leading to freak waves formation.

Modélisation nonlinéaire des transformations des vagues en zone côtière

Les modèles bi- (2D) et tri-dimensionnels (3D) de génération et propagation de vagues océaniques, c-à-d, les "Canaux à Houle Numériques" (CHN) se sont récemment révélés être des outils très puissants au service des ingénieurs et chercheurs étudiant les processus côtiers et littoraux. Les CHNs sont à présent utilisés pour mener à bien de nombreuses investigations pour lesquelles, jusqu'à très récemment, seuls les bassins à houle de laboratoire pouvaient être utilisés. En dépit des limitations et approximations nécessaires à leur développement, les CHNs présentent souvent l'avantage de fournir une réponse rapide à ces problèmes, et donc d'être moins coûteux en temps et efforts, par comparaison avec les expériences de laboratoire. Ceci s'avère particulièrement si de nombreuses configurations du même problème doivent être étudiées afin d'identifier les valeurs optimales des paramètres géométriques du problème, et de la localisation de, par exemple, une plateforme offshore ou d'une structure de protection côtière. Dans de nombreux cas, les CHNs permettent également d'obtenir des valeur non-perturbées des champs hydrodynamiques des vagues, tels que pression, vitesse et accélération, alors que

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des mesures de laboratoires sont souvent entachées d'erreurs causées par les capteurs de mesure eux-mêmes.

Cette lecture spéciale présente un résumé des résultats obtenus récemment par le conférencier et ses collaborateurs concernant le développement et l'application de CHNs, principalement sur la base de la théorie potentielle. Le couplage de CHNs de ce genre avec des modèles VOF des equations de Navier-Stokes est également brièvement discuté. Les applications spécifiques présentées incluent : (i) la levée et le déferlement d'une houle 2D sur les plages sableuses, avec comparaison des résultats à des expériences de laboratoire (élévation des vagues et vitesse des particules); (ii) levée et déferlement plongeant de vagues 3D avec une analyse des vitesses et accélérations dans le jet déferlant; (iii) génération et propagation de vagues (tsunamis) causées par des glissements de terrain sous-marins; et (iv) focalisation 3D de l'énergie, conduisant à la formation de vagues scélérates ("freak waves").

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(see http://www.oce.uri.edu/~grilli for pdf files of recent papers)

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