GENERATION OF EXTREME TRANSIENT WAVES IN EXPERIMENTAL MODELS

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INTRODUCTION

The transfer of natural waves and sea states into small- and large-scale model teste contributes to the proper design of offshore and coastal structure. Such shallow-water ocean surface waves are highly nonlinear and subject to wave transformation and nonlinear wave-wave interactions. However, the standard methods of wave generation according to conventional wave theories and wave analysis methods are limited to simple regular waves, simple sea states and low-order wave generation without considering the nonlinear wave-wave interactions. The research project *Generation of Extreme Transient Waves in Experimental Models* (ExTraWaG) aims to accurately generate target transient wave profile at a pre-defined position in the wave flume (transfer point) under shallow water conditions. For this purpose, the KdV-based nonlinear Fourier transform is introduced as a continuative wave analysis method and is applied to investigate the nonlinear spectral character of experimental wave data. Furthermore, the method is applied to generate transient nonlinear waves as specific locations in the wave flume, considering the nonlinear transformation and interactions of the propagating waves.

THEORETICAL BACKGROUND

The propagation and interaction of shallow-water waves are described by the Korteweg-deVries equation (KdV-equation). However, the nonlinear effects due to wave-wave interactions are not taken into account in conventional wave theories (e.g. Airy, Stokes, cnoidal and solitary wave theory) and wave analysis methods (e.g. conventional Fourier, wavelet or Hilbert-Huang transform). Therefore, a continuative wave analysis method is required for the generation of extreme wave events which do not conform to conventional wave theories or wave spectra, e.g. long-period ship-induced waves, tsunami bores, highly nonlinear freak waves or arbitrary wave shapes.

The nonlinear Fourier transform (NLFT) is able to explicitly decompose a given surface elevation into underlying spectral cnoidal wave components and their nonlinear interactions based on KdV-equation for shallow-water or based on nonlinear Schroedinger equation for deep-water conditions (Osborne 2010). Therefore, the nonlinear Fourier transform based on Korteweg-deVries equation (KdV-NLFT) enables the explicitly spectral decomposition of the shallow-water waves considering the nonlinear wave-wave interactions (Brühl 2014). By means of direct KdV-NLFT, the target transient wave at transfer point can be decomposed into the underlying nonlinear cnoidal waves and allows their separation from the nonlinear interactions (Brühl und Oumeraci 2016, Zhang und Brühl 2017). The number and form of these spectral basic components are only related to the input target wave. Note that the nonlinear cnoidal waves are stable in shallow water. Therefore, the analytical calculation of the spatial and temporal evolution of each of these nonlinear cnoidal waves a specific transfer point in the wave flume to the generation point is possible. But the nonlinear wave-wave interaction is a local parameter and varies continuously with time and space. Next, superposition of the evolved cnoidal waves and their nonlinear interactions at the generation point by application of the inverse KdV-NLFT will provide the free surface as the input signal for the wave maker.

ANALYTICAL MODEL

The KdV-NLFT has been implemented and applied for the direct and inverse KdV-NLFT by Brühl (2014). This code will be expanded and modified for the research project ExTraWaG to carry out the generation of desired transient shallow water wave at pre-defined position in wave flume. It will take the target transient wave profile at transfer point as input and computes the corresponding wave profile at generation point considering the nonlinear wave-wave interactions between the underlying nonlinear waves. Ultimately, the feasibility and accuracy of this procedure will be confirmed through laboratory test in the Large Wave Flume (GWK) at Forschungszentrum Küste, Hannover. Then the range of feasible wave parameters for large-scale model tests in GWK will be significantly extended. Actual results from the project and examples for the application of direct and inverse KdV-NLFT will be presented at the conference.

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