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Single Steep Waves as a Result of Evolution of Wide-Spectra Nonlinear Wave Groups

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Single unidirectional steep waves in a laboratory wave tank of constant depth can be generated by a superposition of a large number of waves at given location and instant. The focusing is more effective when the number of free wave harmonics generated at the wavemaker is large; hence, the spectrum of the initial wave group generated at the wavemaker has to be wide. Since longer gravity waves propagate faster, a wave group generated so that the wave length increases from the front to the tail, i.e. modulated both in amplitude and in frequency, may be designed to focus the wave energy at a desired location. If the initial envelope shape of the group is Gaussian, in the linear approximation this shape is conserved in the course of the group propagation along the wave tank and a comprehensive theoretical solution of the wave group evolution problem is possible. In this case, the frequency spectrum is also Gaussian. For steep waves, due to nonlinear interactions, considerable variation of the wave frequency spectrum along the tank is observed, thus a wave group designed to have the Gaussian shape at the focusing location will have quite a different frequency spectrum at the location of its excitation by the wavemaker. A theoretical model that is free of bandwidth constraints is the Zakharov equation. A refined version of the spatial Zakharov equation is applied in this study that combines numerical simulations with experiments. Numerical solutions of the spatial Zakharov equation were obtained when more than 100 interacting free modes were considered. The experimental study was carried out in the 330 m long Large Wave Channel (GWK) in Hanover, Germany, and in the 18 m long Tel-Aviv University wave tank. The proper selection of the location of the focusing point in both tanks eliminated contamination of results by reflections from the far end. In both facilities, experiments were carried out for a number of carrier frequencies and for various values of the maximum wave steepness at the focusing location. Video clips with records of single steep waves actually excited in both facilities at

the prescribed location will be shown. Detailed comparison between the experimental studies in both facilities and the corresponding numerical results is carried out. Very good quantitative and qualitative agreement was obtained between experiments and computations. The effects of nonlinearity, evanescent modes at the wavemaker, dissipation along the tank, bound waves and wave breaking will be discussed.