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ANALYSIS OF WAVE BREAKING INDUCED BY WAVE GROUPS

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ABSTRACT

This project investigates wave breaking induced by wave groups and their effects on the breaking location. The wave group influence during breaking was observed in the form of variation of the breaking point of the waves which was shown to move further offshore for greater wave group periods. The origins of this phenomenon were explored through three mechanisms: energy redistribution, long wave influence and second order non-linear wave-wave interactions.

INTRODUCTION

Wave breaking affects the wave heights close to the shoreline and is the main driver for a number of hydrodynamic processes. It has a strong influence on the design and operationality of coastal structures. Data comprising bichromatic cases with varying group periods and similar energy content was chosen for the analysis. This representation is the simplest way of examining a group to understand interactions between the two frequencies which can be extended to n-frequencies in a real, random sea state.

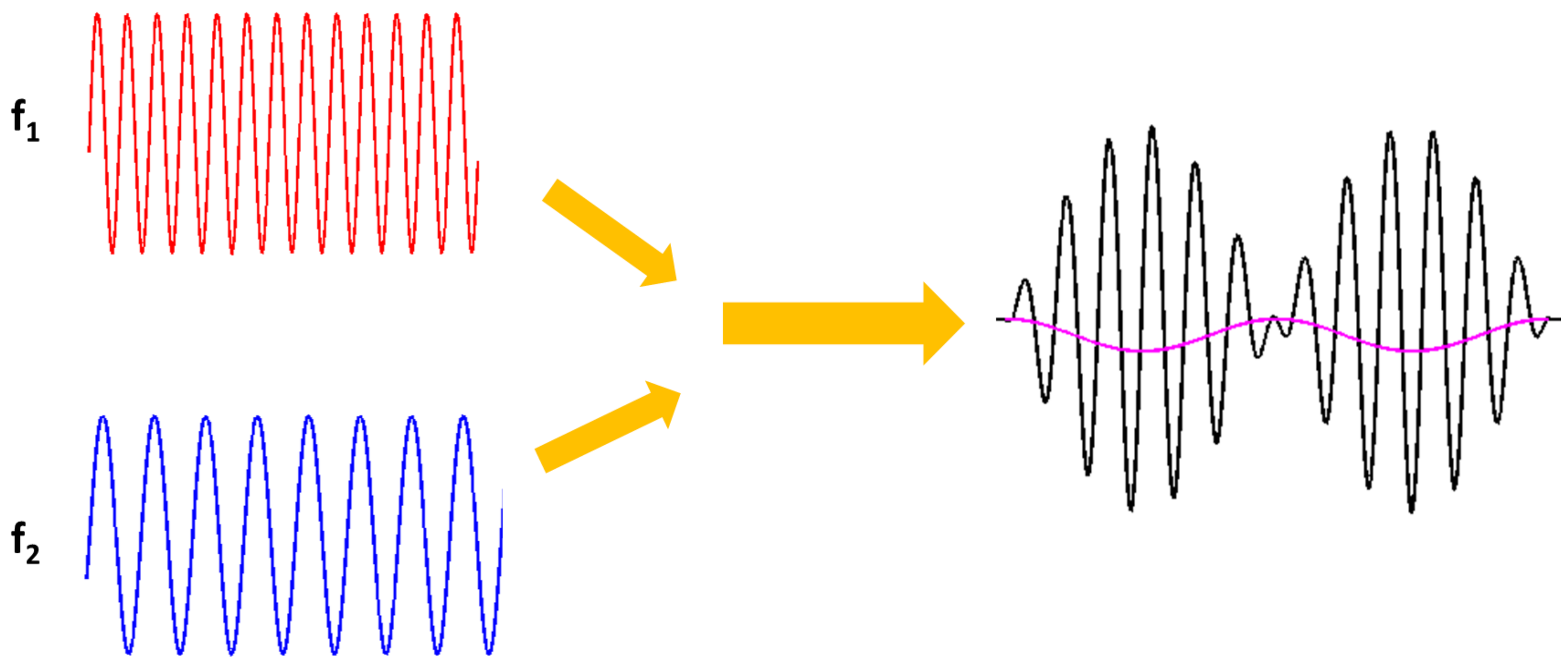

Figure 1: Schematic of a bichromatic wave group formed from frequencies f_1 and f_2 which are different.

BREAKING LOCATION

The gradient of the beach slope was 1:15 and the breaking location was computed as location where approximately half the offshore incident energy would be dissipated. It was observed that the location of wave breaking for every bichromatic case would change, as shown in Figure 2 (bottom). It can be seen that there is an offshore shift in the position of breaking as the wave group period increases. It seems that groupiness has an influence on the phenomenon.

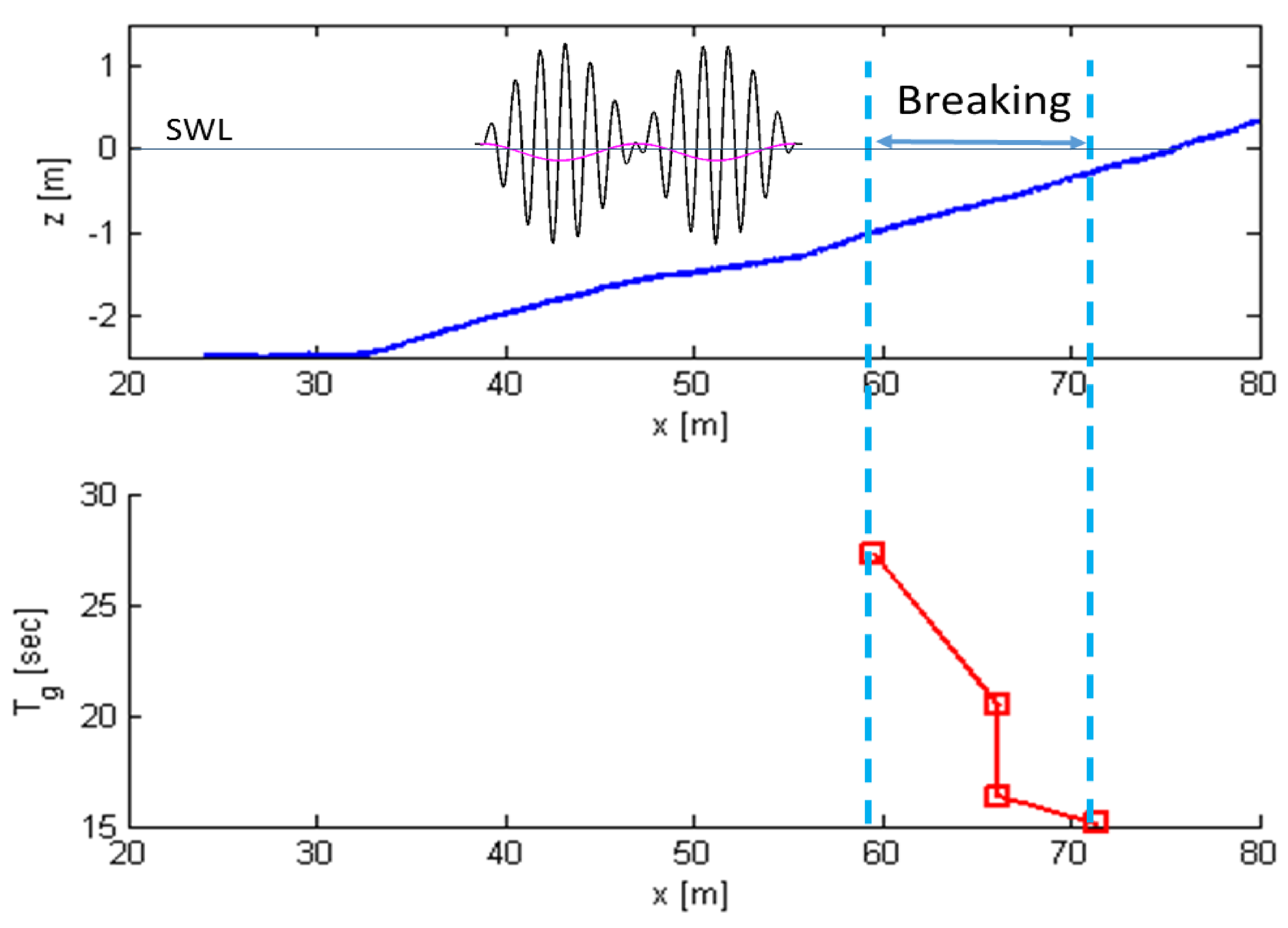

Figure 2: Top – bathymetry of the beach with a schematic bichromatic wave during shoaling and an extent of the mean breaking location. Bottom – variation of the mean breaking location as a function of wave group period.

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Longuet-Higgins, M.S. & Stewart, R. w. (1964) Radiation stresses in water waves; a physical discussion, with applications. *Deep Sea Research and Oceanographic Abstracts*. 11 (4), 529–562.

Rapp, R.J. & Melville, W.K. (1990) Laboratory Measurements of Deep-Water Breaking Waves. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*. 331, 735–800.

ENERGY REDISTRIBUTION

For a regular monochromatic wave the energy is dissipated as the wave breaks. For bichromatic waves it is more complex as the waves within a wave group do not break at the same time. A transfer between different frequencies within the energy spectrum was observed. This is shown in Figure 3. A significant increase in the peak associated to the group frequency happens at the expense of f_2 for T_g = 15s.

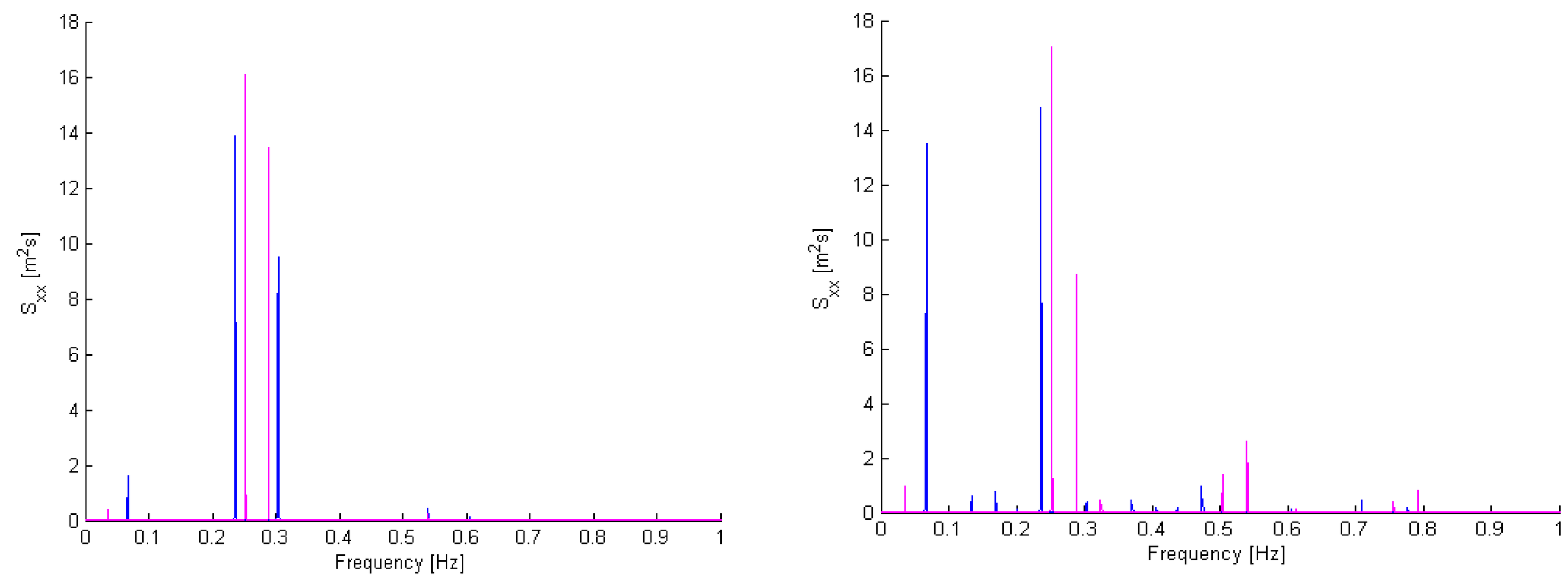

Figure 3: Energy spectra at locations x=7.72m (left) and x=64.26m (right) for cases with group periods T_g=15s (blue) and T_g=28s (magenta).

LONG WAVE INFLUENCE

Long waves are an intrinsic element of wave groups. This is due to wave height variation within a group which induces the radiation stress (Longuet-Higgins & Stewart, 1964). Figure 4 shows an influence of the long wave amplitude on the total depth.

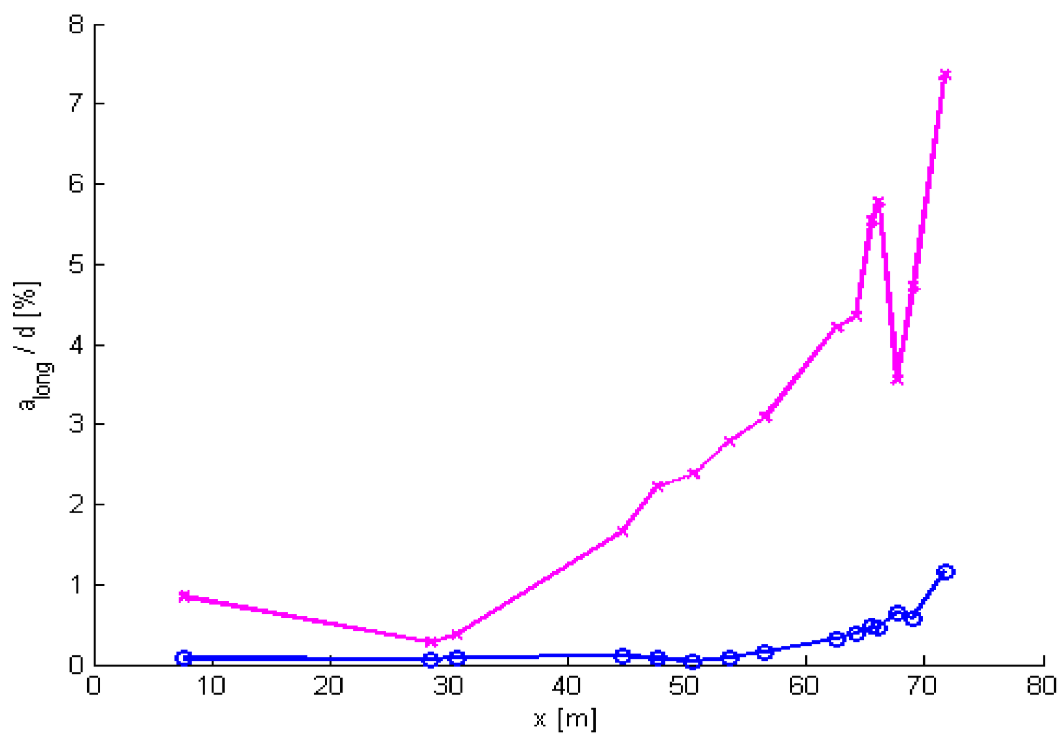

Figure 4: Cross-shore variation in the contribution of the amplitude due to the long wave, expressed in term of the percentage of the total depth, for cases with group periods T_g=15s (blue) and T_g=28s (magenta).

SECOND ORDER NON-LINEAR WAVE-WAVE INTERACTIONS

Second order non-linear wave-wave interactions may also affect breaking location (Rapp & Melville, 1990). As shown in Figure 5, the interactions are minimal and are almost constant over the horizontal section of the flume for both cases. Their significance gradually increases in a non-linear manner as the wave is shoaling up the beach slope.

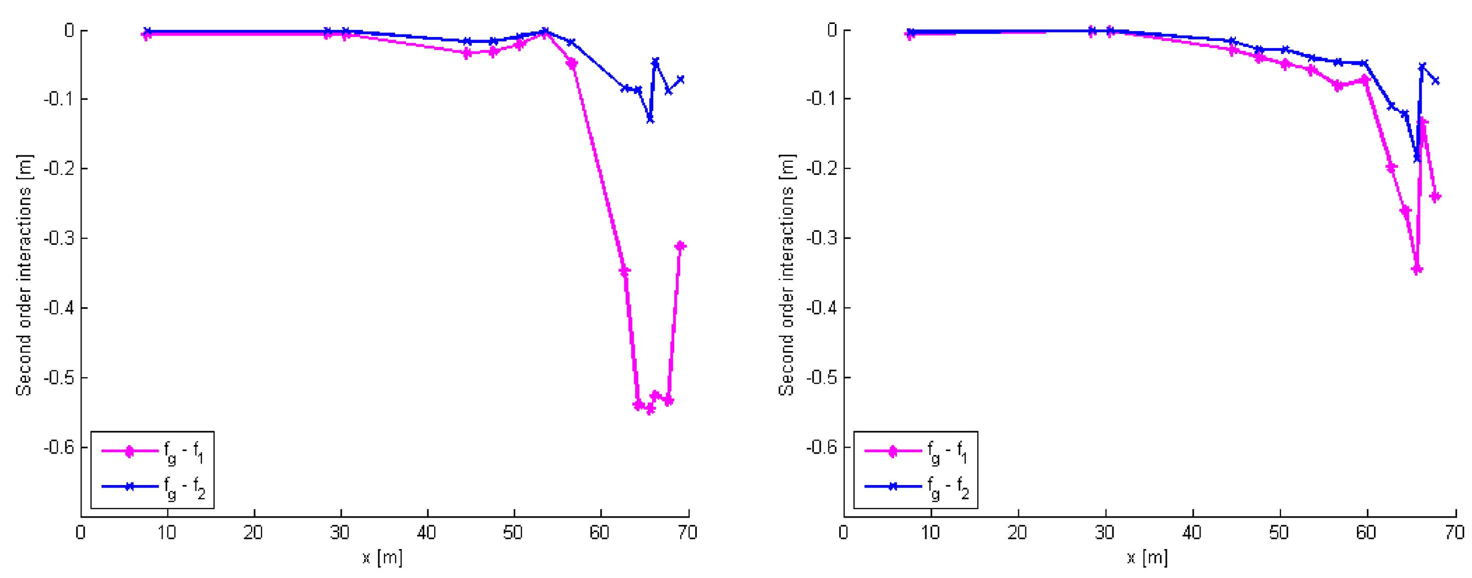

Figure 5: Cross-shore variation in second order non-linear wave-wave interactions between the group and the first primary frequencies (magenta) and between the group and the second primary frequencies (blue) for cases with group periods T_g=15s (left) and T_g=28s (right).

CONCLUSIONS

From the data analysed, it can be concluded that the mean breaking location of incident bichromatic waves shifts further offshore as the wave group period increases. It seems that the greatest influence on the phenomenon can be attributed to the long waves and energy redistribution within the groups. Current design guidelines do not take into account the described phenomenon. Therefore, further work is recommended to fully understand the process which will allow to include it in the engineering practice guides.