

TURBULENCE CHARACTERISTICS IN THE BOTTOM WAVE-CURRENT BOUNDARY LAYER

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INTRODUCTION

The topic of wave-current interaction (WCI) has received much attention in the past few decades due to its significant applications in sediment transport and marine energy exploitation. For example, prediction of sediment transport rate and coastal morphology, design of harbour structures, pipelines and tidal turbines all require an improved understanding of wave-current interaction. Past studies have identified the non-linear characteristics of WCI, with experimental studies describing the phenomena and analytical models attempting to quantify them. The main objective of this project is to provide new experimental results for the turbulence characteristics in the bottom boundary layer of a combined wave-current flow.

METHODOLOGY

Experiments have been carried out in a wave-current flume at UCL. The flume is 16.165m long and 0.455m wide. The desired water waves were generated by a piston-type wave maker. Two wave paddles were positioned at the inlet and outlet of the flume, allowing waves to be generated by one while the other is for reflection absorption. The flume has a recirculating system, allowing generation of a steady turbulent current and propagating with the waves. Two permeable metal plates were placed at the outlet to further absorb reflected waves. Velocities were measured by a two-dimensional Particle Image Velocimetry (PIV) system. The illuminated area was photographed by a digital camera with a resolution of 2K×2K pixel and 16 frames-per-second (fps), with a 60mm Nikon AF Micro Nikkor camera lens. A 532nm green filter was applied to filter out other wavelengths during the tests.

RESULTS AND DISCUSSIONS

Figure 1 shows the quadrant analysis of Reynolds shear stress in a unidirectional turbulent current. Good agreements were found with previous studies in turbulent boundary layers (Moser et al., 1999), suggesting that ejections contribute to 70% of Reynolds shear stress in the vicinity of the bed. Figure 2 illustrates that when waves are propagating with the turbulent current, the contributions from ejections are increased to 77%. This indicates that stronger ejections events occur within the wave-current bottom boundary layer. Further analysis shows that an increase in wave frequency leads to a decreased contribution from the ejections events.

CONCLUSIONS

Quadrant analysis suggests that ejections events contribute more to Reynolds shear stress when waves are added, compared with a unidirectional turbulent current. The differences are less significant with a

higher-frequency wave. This can provide an insight into sediment transport.

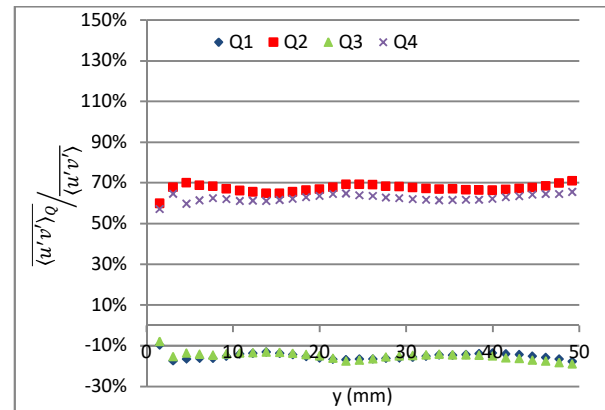


Figure 1 - Quadrant analysis of Reynolds shear stress, current-only.

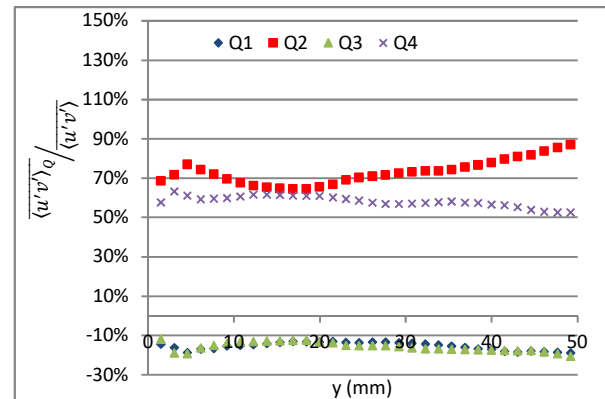


Figure 2 - Quadrant analysis of Reynolds shear stress, combined wave-current flow, wave frequency $f=0.6\text{Hz}$, wave amplitude $A=120\text{mm}$.

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