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POTENTIAL OF FLOW ENERGY REDUCTION BY CORAL REEF: HYDRODYNAMIC ANALYSIS ON ACROPORA SPECIES

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Abstract

One of the most crucial components of the ocean ecology is coral reefs. Being environmentally sustainable and requiring minimal capital investment, natural structures like coral reefs have recently drawn a lot of attention as a means of reducing the flow energy. The absence of scientific validations on the potential of coral reefs in reducing high-energy flow limits engineering applications of coral reefs to the benefit of civilization. In this research, extensive experimental studies were carried out to investigate the capabilities of healthy coral reefs to reduce high-energy waves. To determine the high-energy wave reduction by coral reefs, the coral roughness coefficient along with the coral structure is a major factor. To investigate the mitigative potential of coral reefs, we conducted an experimental study, where our primary objective was to assess the roughness of Acropora corals, which are most prevalent in the Arabian Sea, for the reduction in flow energy. Due to marine life preservation, using actual corals was neglected, instead a better method i.e., the 3D printing method was used to make coral models which ensured the accuracy of the surface roughness and the structure of the coral. To investigate the flow characteristics through the coral reef we measured flow depth and flow velocity in front, in between, and at the end of the coral extent using electromagnetic current meters and point gauges. This experiment was carried out on a large-scale flume with steady flow conditions in the Fluids Lab at the United Arab Emirates University. We used non – dimensional parameters such as Froude number (Fr), depth effect (DE), and length effect (LE) to compare flow characteristics across different coral reef environments and scales and make more accurate predictions about the potential effects of flow on coral reefs. The findings showed that corals reduced flow depth and flow velocity by up to 27.5% and 25%, respectively, near the end of the coral extent. Velocity profiles were assessed to better understand the behavior of flow with corals in comparison to without corals. Two Layered flow, which is the ratio of the velocity through the corals, and on top of it were low in number at the beginning of the extent, with a significant increase in between the extent (LE) and then gradually decreasing for all Froude Number (Fr) cases. It was observed that with a low Froude number of 0.06, the ratio was as high as 5.67. In the case of energy loss gradient, the value was low with low LE and gradually increased as the reef was at its highest LE for all Fr cases. It showed that the head loss gradient at Fr - 1.05 was as high as 0.5 at the lowest LE. Manning's roughness coefficient was discovered to vary from 0.03 to 0.26 indicating that Manning’s roughness coefficient is a function of Froude number and length-depth effects. Therefore, a constant coefficient is not warranted for numerical simulations of coral-flow interaction.

Keywords: Flow Energy Reduction, Wide Flume Experimental Setup, Electromagnetic Current Meter, 3D Coral Models, Non-Dimensional Parameters, Roughness, Two-Layer Flow Analysis