SOFT CORALS VORTEX-INDUCED DYNAMICS: EXPERIMENTAL AND NUMERICAL STUDY

Alexandre Villié1, Mauricio Vanzulli2, Jorge M. Pérez Zerpa3, Jérome Vétel1, Stéphane Etienne1, Frédérick Gosselin1

1Department of mechanical engineering, Polytechnique Montreal, Montreal, Canada
2Instituto de Ingeniería Mecánica y Producción Industrial, Facultad de Ingeniería, Universidad de la República, Montevideo, Uruguay
3Instituto de Estructuras y Transporte, Facultad de Ingeniería, Universidad de la República, Montevideo, Uruguay

* alexandre.villie@polymtl.ca

ABSTRACT

Soft corals in the Caribbean Sea like the bipinnate sea plume, have a branched geometry and are soft enough to bend under the waves. Due to their cylindrical cross section, a vortex street forms in the coral’s wake inducing vibrations transverse to the flow. These vortex-induced vibrations (VIV) are a feeding asset for the coral, enabling it to catch up to 40% more nutrients brought by the flow. If the 2D motion of a cylinder cross section with VIV has been widely studied, the 3D dynamics of a branched structure remains unknown. In this numerical and experimental study, we show how this 3D motion affects the coral feeding. We develop a finite element model of the coral where the cross-flow and in-line VIV are modelled with the wake-oscillator model (WOM). The Euler-Bernoulli beam theory combined with the WOM allow to study the coupled dynamics of the flexible structure. The frame finite element model of the coral colony structure uses the corotational framework to consider large displacements and rotations. The WOM is a phenomenological model for assessing VIV where the action of the wake is modelled by an oscillating lift force, avoiding a costly fully coupled fluid-structure simulation. The lift coefficient follows a Van der Pol oscillator model. Proper orthogonal decomposition separates the trunk and branch motion into vibration modes and characterizes the dynamics. Experimental measurements validate the numerical modes and frequencies. A flexible and elastic model of the soft coral colony is 3D-printed by selective laser sintering. The coral is clamped inside a water loop under a constant uniform flow. Its transverse displacements, captured with a high-speed camera, are compared with the simulations. The influence of the reduced velocity and the number of branches is discussed. Eventually, we conclude on the ability of the coral to feed itself during VIV lock-in better than in static conditions. When engineers usually seek VIV removal from constructions to prevent fatigue, soft corals draw benefits from this instability.