News Article for RISUD Strategic Focus Area (SFA) Scheme

		Name	Department
1.	**Principal Investigator**:	Prof. JG DAI	CEE
2.	**Name of SFA:**	Very Large Floating Structures	
3.	**Project Title:**	High-Performance Materials and Structural Elements for Sustainable Floating Structures	

4. **Second Year Progress/Achievement**

The current land shortage in Hong Kong has led to various challenges in the society. In 2018, Chief Executive Carrie Lam presented the solution to create new space for her inhabitants involving large scale land reclamation projects called Lantau Tomorrow. The responses from the country are quite diluted and many people are worried on how this large scale project will affect the seawater quality, current flow, marine biology or the national reserves. A methodology for creating new land that is much less invasive is using the very large floating structures (VLFS) technology. Examples of VLFSs include floating islands, floating airports, floating storage structures, floating wind farms and floating solar farms. For these existing floating structures, conventional steel-reinforced concrete (RC) structures, constructed of normal concrete and steel, have been commonly used. Steel floating structures suffer from steel corrosion in the marine environment and should be avoided if possible as regular maintenance using anti-corrosion coatings is expensive; these coatings could also have an adverse effect on marine life. Steel corrosion is also a concern with RC floating structures, where the deterioration due to corrosion of steel reinforcement has been widely recognized as a hugely costly problem. Thus, research on the construction of floating structures with emerging high-performance materials is of great importance to enable coastal cities to benefit effectively from the space and resources offered by oceans.

In the second year of the project, the project team has explored the use of fiber-reinforced polymer (FRP) and further developed new types of cementitious composites for various possible applications in the VLFSs and had made the following progress:

(1) Further research has been conducted on the development of high-strength seawater sea-sand Engineered Cementitious Composites (SS-ECC) for marine and coastal applications. SS-ECC with tensile strength over 8 MPa, ultimate tensile strain about 6% and compressive strength over 130 MPa were achieved. The effects of sea-sand size (1.18/2.36/4.75 mm), polyethylene fiber length (6/12/18 mm) and fiber volume dosage (0.5/1.0/1.5/2.0%) on both the compressive and tensile properties of SS-ECC were extensively investigated. A probabilistic-based method was proposed to analyze the reliability of the tensile strain capacity of SS-ECC, and it showed good agreement with the experimental results. The findings provide insights into the future design and applications of ECC in marine and coastal infrastructures for improving safety, durability, sustainability, and reliability. It is expected that, together with corrosion-resistant fibre-reinforced polymer composites, the durability of the resulting structures (i.e. hybrid fibre-reinforced polymer–ultra-high-performance seawater sea-sand concrete structures) in a harsh environment can be expected to be outstanding.

(2) A thorough review has been conducted on the state-of-the-art of the VLFS, including existing applications, structural forms, construction materials, research focuses, design procedures, and computation software.

To meet the local needs of land creation in Hong Kong, modular semi-submerged type of VLFS has been recommended for future application in Hong Kong. The design will follow the modular construction concept. Each modular will be constructed through the combined use of FRP materials, UHP-SSC and UHP-SSECC, and conventional steel and concrete in an optimal form. These individual modulars will be assembly in-situ through connections in-situ to form a VLFS. Preliminary analyses have been conducted to analyze the structural responses of modular VLFS with different connection details using ANSYS-AQWA. Wave and climatic data are also being collected from Hong Kong authorities for a case study with the Tomorrow Lau Tau project as the benchmark.

(3) Considering that the reclamation method needs to be incorporated with the VLFS for land development in Hong Kong, FRP composites have been also used to replace conventional steel to make a pile wall system with sufficient strength and stiffness, to facilitate reliable enclosure and water-tightness for a reclaimed land area. Two types of FRP pile systems (i.e., FRP sheet pile system, and FRP tubular pile system) and their possible combinations have been proposed. FRP cables have been also considered as the lateral strengthening of the pile wall system to increase its lateral stiffness (*i.e.*, reduce its lateral movement) during the different period of land reclamation. Numerical analyses have been conducted to how to simulate the interaction between the reclaimed soil/sea-sand and the FRP pile walls considering the large deformation and anchor system, with the aim to form an economical marine reclamation method for large-area infrastructural developments.

(4) VLFSs are susceptible to translational movements and rotations in all the three directions due to the existence of wind, waves, current, etc. in marine environments. The load-induced hydrodynamic responses would lead to the structural deformation or even structural failure. The environmental loads acting on the VLFS are ultimately resisted by the mooring restoring force, keeping the system on station and allowing various operations to be safely conducted under specific conditions. Thus, as an essential part of VLFS, the mooring system has been numerically investigated with the focus on the interaction between the suction anchor and the surrounding soil as well as the FRP cable system. Although the suction anchor has been adopted in offshore engineering for several decades, engineers are still using empirical methods in design, leading to some limitations, especially the difficulty in installation controlling and uncertainty in foundation performance predicting. The most important factors influencing the suction anchor behavior, including the caisson material, soil behavior, combined loadings and anchor-structure interaction have been numerically investigated. Experimental and numerical tests of the caisson anchor are being conducted to study the essential problems during the anchor installation process and lifecycle. By investigating the macro, meso and micro properties of the caisson and surrounding soils under combined loadings, the short-term and long-term performance of the suction anchor will be described and predicted accurately. The theoretical framework from experiments and simulations to practical design for suction anchor would be constructed through the project, providing guidance to lifecycle analysis and optimum design of suction anchor for VLFS construction in Hong Kong

It is expected that upon the project completion, a new generation of VLFSs will be formed that are much more sustainable and cost-effective than the current generation, through the material development, understanding of structural behavior and case study.