News Article for RISUD Strategic Focus Area (SFA) Scheme

		Name	Department
1.	**Principal Investigator**:	Jian-Guo Dai	CEE
2.	**Name of SFA:**	Very Large Floating Structures	
3.	**Project Title:**	High-performance Materials and Structural Elements for Sustainable Floating Structures	

4. **First Year Progress/Achievement**

Land shortage and the need to minimize carbon emissions/pollution are two of the major challenges facing many coastal cities such as Hong Kong. An attractive solution to address these challenges is to seek help from the sea through the construction of very large floating structures (VLFSs). Examples of VLFSs include floating islands, floating airports, floating storage structures, floating wind farms and floating solar farms. With the 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. Another challenge for VLFSs is to do with their dynamic movements in the sea: it is necessary to develop novel methods to monitor and minimize such movements and to understand the loadings imposed on VLFSs associated with such movements. These issues are uniquely challenging and differ from those to be considered for land-based structures. As a result, from construction to operation, special technologies need to be developed for cost-effective construction and operation of VLFSs.

This project serves the first stage of a transformative research programme to develop a new generation of VLFSs that are much more sustainable and cost-effective than the current generation, including material development, understanding of structural behavior and case study. In the first year of the project, the project team has made the following major progress: (1) Ultra-high-performance sea-water sea-sand concrete (UHPSSC) and ultra-ductile sea-water sea-sand concrete (UDSSC) have been developed. The developed UHPSSC could achieve a 28-day compressive strength of over 180 MPa under an ambient temperature curing condition while the developed UDSSC could achieve a tensile strength of over 8 MPa and a rupture strain of over 8%. The success of the above material development has facilitated the development of high-strength and light-weight floating structures that are highly durable under marine environments. (2) Laboratory scale tests have been conducted to investigate the wave-structures interaction under a wave channel simulating irregular wave conditions. The 1:30 scale bridge model consisted of a flat plate with six girders evenly distributed along the width of the deck. The span length and width of the deck were 580 mm and 320 mm, respectively, and the thickness was 20 mm. All six girders had a height of 38 mm and a width of 20 mm. Solitary waves were generated and the forces acting on and movement of the bridge model were monitored. Both 2-dimentional and 2-dimensional Computational Fluid Dynamics (CFD) modeling was also conducted to predict the test results and achieved good agreement in terms of the uplift force by the wave on the structures. The validated model will serve as a useful tool for the design and analysis of floating structures with other geometries. (3) A case study has been conducted on the Fourth Macau Taipa bridge, which connects the peninsula to the island of Taipa and is expected to be completed by the end of 2025, according to the plan of Macau Government in 2018. In the preliminary design, the bridge was a continuous beam type. Due to the large vertical navigation clearance needed, the project team has proposed to replace the continuous beam bridge using a floating bridge, which is a large truss bridge structure floating on two steel pontoons and horizontally supported by two mooring dolphins with rubber fenders. (4) A preliminary proposal has been made by the project team to the Civil Engineering and Development Department (CEDD) of Hong Kong SAR to incorporate the floating solution to Tomorrow Lantau Vision. The combined use of land reclamation and floating structures is expected to lead to reduction of the expensive land reclamation works and construction time and protection of the surrounding environments as much as possible.

The project has involved actively several world-leading experts in the area of VLFS such as Prof CM Wong from University of Queensland, Dr Karina Goldman-Czapiewska from Delft University of Technology and Prof Torgeir Moan from Norwegian Center of Research Excellence. It is anticipated that through the project execution new strengths will be created for PolyU RISUD in the strategic focused area of VLFS, to increase the visibility of PolyU in the large infrastructure projects in Hong Kong, and facilitate Hong Kong with a new avenue to solve the land shortage problem.