RGC Ref.: X-HKUST601/14
(please insert ref. above)

The Research Grants Council of Hong Kong
SFC/RGC Joint Research Scheme
Completion Report

(Please attach a copy of the completion report submitted to the Scottish Funding Council by the Scottish researcher)

Part A: The Project and Investigator(s)

1. Project Title

The impact of marine renewable energy devices on marine environment

2. Investigator(s) and Academic Department/Units Involved

	Hong Kong Team	Scottish Team
Name of Principal Investigator *(with title)*	Prof Limin Zhang	Prof Yakun Guo
Post	Professor	Reader
Unit / Department / Institution	Department of Civil and Environmental Engineering / The Hong Kong University of Science and Technology	School of Engineering / The University of Aberdeen
Contact Information	cezhangl@ust.hk	Y.Guo16@Bradford.ac.uk
Co-investigator(s) *(with title and Institution)*	NA	NA

3. Project Duration

	Original	Revised	Date of RGC/ Institution Approval *(must be quoted)*
Project Start date	01 Dec 2014		
Project Completion date	30 Nov 2015		
Duration *(in month)*	12		
Deadline for Submission of Completion Report	30 Nov 2016		

Part B: The Completion Report

5. Project Objectives

5.1 Objectives as per original application

1. To extend a team-developed fluid-structure interaction model to simulate the flow and pressure field around the foundations of marine renewable energy devices;
2. To investigate the seabed sediment/soil dynamics and local and global scour patterns around marine renewable energy devices;

3. To establish long-term research partnership with Scottish colleagues.

5.2 Revised Objectives

Date of approval from the RGC: _____

Reasons for the change: _____

_____

1.
2.
3. ....

6. Research Outcome

Major findings and research outcome
(maximum 1 page; please make reference to Part C where necessary)

This research project aims at developing methodologies for investigating the impact of offshore wind energy devices on the flow and pressure field around the foundation, and the subsequent seabed sediment/soil dynamics and local and global scour induced by the altered flow and pressure field.

Shallow water flow formulations have been developed to simulate the flow and pressure fields around the foundation of offshore wind energy devices, or a baffle considering a range of parameters, including bed soil characteristics, topographic conditions and rheological properties.

An erosion-deposition-flow analysis model (EDDA 1.0) has been developed which is capable of simulating seabed sediment scour and transportation, given the flow and pressure field around the foundations. The erosion process is affected by two major factors: the flow pattern and the seabed sediment properties. The flow exerts shear force on the sediment surface, which is a function of fluid rheological properties (e.g., Manning's coefficient, dynamic viscosity and yield stress) and flow features (e.g., flow depth and velocity). The shear resistance of the seabed sediment is determined by the material properties, such as the particle size distribution and degree of compaction. If the shear force exceeds the shear resistance of the sediment material, scour or erosion will occur. The flow field far away from the foundations can be used as boundary conditions for EDDA 1.0 to simulate seabed sediment erosion and transportation. Different seabed topography and the shape and size of foundations can be considered with the input of terrain data. The process of scour and deposition of the seabed sediment can be simulated. The methodology has been presented in a conference paper (Part 9). A journal paper is being prepared on this topic (Part 8).

Potential for further development of the research and the proposed course of action
(maximum half a page)

The current research can be extended

(1) to evaluate the effect of arrays of large-scale offshore wind energy devices on the marine environment, and

(2) to investigate the effect of sediment transport and turbidity currents generated near the seabed on the marine eco-system and water animals.

7. The Layman's Summary

(describe in layman's language the nature, significance and value of the research project, in no more than 200 words)

Offshore wind energy is an important source of clean energy. Installation of marine renewable energy devices (e.g. offshore wind and tidal turbines) alters flow patterns around the foundation. It enhances the sediment transport and scour, leading to the instability of foundation**s** and eventually the failure of the whole system. The phenomenon is a complex fluid-soil-structure interaction. Under certain wave load and local scour conditions, soil liquefaction takes place, which further destabilizes the foundation. The changes in the flow patterns and seabed conditions also affect the seabed eco-system and water animals.

The primary objectives of this joint research project between Hong Kong and Scotland are to extend a fluid-structure interaction model to simulate the flow and pressure field around the foundations of marine renewable energy devices and to investigate the seabed sediment dynamics and local and global scour patterns around marine renewable energy devices. In this research project, a shallow water flow model is used to simulate the flow and pressure field around the foundations of marine renewable energy devices. An erosion-deposition-flow analysis model (EDDA 2.0) is developed to investigate the seabed sediment/soil dynamics and local and global scour patterns given the flow and pressure field around the foundations of offshore energy devices.

This research provides a means to analyse the stability of the foundations of the offshore wind energy devices under wave and current conditions. The same methodology has also been successfully used to simulate the bed scour and erosion during a debris flow process, which occurs in Hong Kong frequently.

Part C: Research Output

8. Peer-reviewed journal publication(s) arising directly from this research project

(Please attach a copy of each publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.))

The Latest Status of Publications				Author(s) ***(bold** the authors belonging to the project teams and denote the corresponding author with an asterisk*)*	Title and Journal/ Book *(with the volume, pages and other necessary publishing details specified)*	Submitted to RGC *(indicate the year ending of the relevant progress report)*	Attached to this report *(Yes or No)*	Acknowledged the support of this Joint Research Scheme *(Yes or No)*	Accessible from the institutional repository *(Yes or No)*
Year of publication	Year of Acceptance *(For paper accepted but not yet published)*	Under Review	Under Preparation *(optional)*						

			Yes	Shen, P. and Zhang, L.M.	EDDA 2.0: integrated simulation of bed erosion and debris flow initiation	No	No	Yes	No

9. Recognized international conference(s) in which paper(s) related to this research project was/were delivered *(Please attach a copy of each delivered paper. All listed papers must acknowledge RGC's funding support by quoting the specific grant reference.)*

Month/Year/ Place	Title	Conference Name	Submitted to RGC *(indicate the year ending of the relevant progress report)*	Attached to this report *(Yes or No)*	Acknowledged the support of this Joint Research Scheme *(Yes or No)*	Accessible from the institutional repository *(Yes or No)*
Nov. 2016, Taipei	An integrated numerical analysis program for simulating debris flow initiation and mobility	International Symposium on Sustainability and Resiliency of Infrastructure (ISSRI)	Yes	Yes	Yes	Yes

10. Student(s) trained *(Please attach a copy of the title page of the thesis.)*

Name	Degree registered for	Date of registration	Date of thesis submission/ graduation
Ping SHEN	PhD	Sept. 2014	Expected in August 2018

11. Other impact *(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, etc.)*

We are extending the techniques for fluid-structure interaction and seabed sediment scour modelling in this project to simulate the initiation and mobility of debris flows in two recently funded group projects "Coping with landslide risks in Hong Kong under extreme storms: Storm scenarios, cascading landslide hazards and multi-hazard risk assessment" (RGC Collaborative Research Fund C6012-15G) and "Understanding debris flow mechanisms and mitigating risks for a sustainable Hong Kong" (RGC Theme-based Research Scheme, T22-603/15N).