RGC Ref. No.:
UGC/FDS13/E06/18
(please insert ref. above)

RESEARCH GRANTS COUNCIL
COMPETITIVE RESEARCH FUNDING SCHEMES FOR
THE LOCAL SELF-FINANCING DEGREE SECTOR

FACULTY DEVELOPMENT SCHEME (FDS)

Completion Report
(for completed projects only)

Submission Deadlines:
1. *Auditor's report with unspent balance, if any: within **six** months of the approved project completion date.*
2. *Completion report: within **12** months of the approved project completion date.*

Part A: The Project and Investigator(s)

1. Project Title

Coupled material point method and discrete element method modeling for debris flows

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

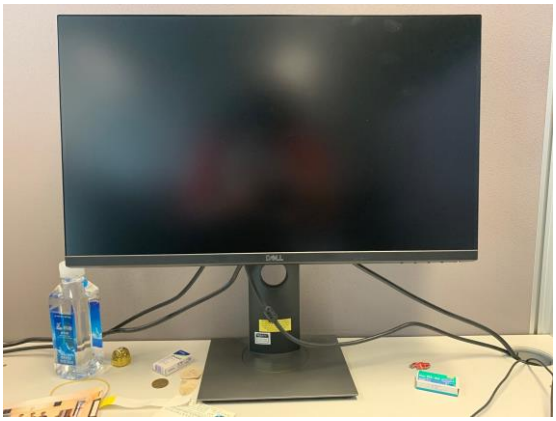
Research Team	Name / Post	Unit / Department / Institution
Principal Investigator	Dr. YANG Yi / Assistant Professor	Department of Civil Engineering, Chu Hai College of Higher Education
Co-Investigator(s)	Dr. CHENG Yunming / Associate Professor (Retired from May 2019)	Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University
Others	N.A.	

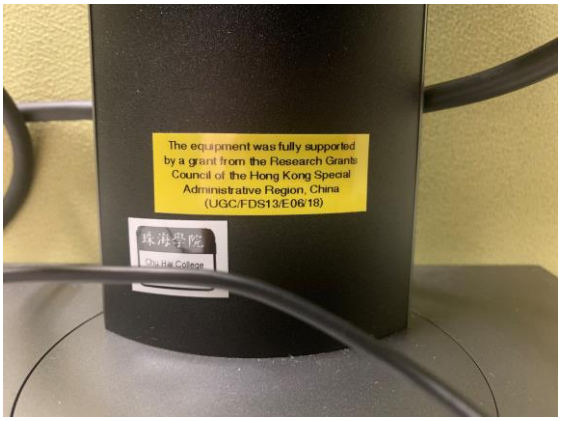
3. Project Duration

	Original	Revised	Date of RGC / Institution Approval *(must be quoted)*
Project Start Date	01/01/2019	01/01/2019	N/A
Project Completion Date	31/12/2021	30/06/2022	Institutional approval on 11/03/2021
Duration *(in month)*	36	42	Institutional approval on 11/03/2021

Deadline for Submission of Completion Report	31/12/2022	30/06/2023	Institutional approval on 11/03/2021

4.4 Please attach photo(s) of acknowledgement of RGC-funded facilities / equipment.





Part B: The Final Report

5. Project Objectives

5.1 Objectives as per original application

1. Develop and verify a new coupled MPM-DEM approach which can simulate granular mass flows from 2D to 3D
2. Develop and verify a fully coupled hydro-mechanical MPM to evaluate the fully saturated debris flows, and then generate a combined hydro-mechanical MPM-DEM package from 2D to 3D

3. Develop the hydro-mechanical MPM-DEM to study partially saturated soils
4. Evaluate and quantify the macro and micro characteristics of debris flow by investigating the flow mobility, impact and internal particle contact behavior

5.2 Revised objectives

Date of approval from the RGC: N/A

Reasons for the change:

1.

2.

3. ....

5.3 Realisation of the objectives
(Maximum 1 page; please state how and to what extent the project objectives have been achieved; give reasons for under-achievements and outline attempts to overcome problems, if any)

Objective 1 – Research collaboration with researchers from Mainland and Hong Kong to develop the coupled MPM-DEM from 2D to 3D.
Objective 2 – Research collaboration with researchers from Mainland and Hong Kong to evaluate the fully saturated debris flows.
Objective 3 – Research collaboration with researchers from Mainland and Hong Kong to study the partially saturated problems.
Objective 4 – Research collaboration with researchers from Mainland and Hong Kong to evaluate the macro and micro characteristics of debris flow problems.

5.4 Summary of objectives addressed to date

Objectives *(as per 5.1/5.2 above)*	**Addressed** *(please tick)*	**Percentage Achieved** *(please estimate)*
1. *Develop and verify a new coupled MPM-DEM approach which can simulate granular mass flows from 2D to 3D*	✓	100%
2. *Develop and verify a fully coupled hydro-mechanical MPM to evaluate the fully saturated debris flows, and then generate a combined hydro-mechanical MPM-DEM package from 2D to 3D*	✓	100%
3. *Develop the hydro-mechanical MPM-DEM to study partially saturated soils*	✓	100%
4. *Evaluate and quantify the macro and micro characteristics of debris flow by investigating the flow mobility, impact and internal particle contact behavior*	✓	100%

6. Research Outcome

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

A coupled MPM-DEM has been developed and 10 journal papers, 1 international paper and 1 international poster have been published. Details of the findings can be found in Part C. The macroscale and microscale mechanical features have been investigated under the project to show some interesting phenomenon through the coupled approach.

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

The numerical efficiency and unsaturated boundary value problems are still the challenges for the coupled analysis from microscale to macroscale and have the potentials to further develop.

7. Layman's Summary

(Describe <u>in layman's language</u> the nature, significance and value of the research project, in no more than 200 words)

Debris flows are the most destructive type of geoharzards that are often observed in mountainous areas. They can occur with little precursor and flow down with extremely high velocity and long runout distance, which cause severe damage to life and property. The present study will be achieved through the coupled material point method (MPM) and discrete element method (DEM) to simulate the debris flow problems from two dimension (2D) to three dimension (3D). The outcome of this research will be a significant advancement of the knowledge of debris flow, from 2D to 3D, from grain scale to macro scale. This improved fundamental understanding can provide a theoretical basis for addressing the increasing debris flow problems in Hong Kong.

Part C: Research Output

8. Peer-Reviewed Journal Publication(s) Arising Directly From This Research Project

(Please attach a copy of the 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)** *(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 RGC** *(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)*						
2022				Yi Yang, Weihang Ouyang, Ke Liu and Si-Wei Liu*	Efficient numerical algorithms for assessing the mechanical performance of corroded offshore steel sheet piles. Ocean Engineering, 266, 112776. https://doi.org/10.1016/j.oceaneng.2022.112776	**No**	**Yes**	**Yes (Attachment 1)**	N.A.
2022				Weihang Ouyang, Si-Wei Liu and Yi Yang*	An improved morgenstern-price method using gaussian quadrature. Computers and Geotechnics 148 (2022): 104754. https://doi.org/10.1016/j.compgeo.2022.104754	**No**	**Yes**	**Yes (Attachment 2)**	N.A.
2022				Kaihui Li, Dongya Han*, Xiang Fan, Yi Yang and Fei Wang	Shear rupture behaviors of intact and granulated Wombeyan marble with the flat-jointed model. Archives of Civil	**No**	**Yes**	**Yes (Attachment 3)**	N.A.

					and Mechanical Engineering, 22(1), 51. https://doi.org/10.1007/s43452-022-00377-w				
2021				Dongsheng Xu, Zhijie Zhang, Yue Qin and Yi Yang*	Effect of particle size on the failure behavior of cemented coral sand under impact loading. Soil Dynamics and Earthquake Engineering 149 (2021): 106884. https://doi.org/10.1016/j.soildyn.2021.106884	**No**	**Yes**	**Yes (Attachment 4)**	N.A.
2021				Weihang Ouyang; Si-Wei Liu; Jianhong Wan; and Yi Yang*	Euler–Bernoulli Pile Element for Nonlinear Buckling Analysis of Single Piles in Slope. International Journal of Geomechanics, 21(9), 04021170. DOI: 10.1061/(ASCE)GM.1943-5622.0002143.	**No**	**Yes**	**Yes (Attachment 5)**	N.A.
2021				Zhuang JIN, Zhao LU*, Yi YANG	Numerical analysis of column collapse by smoothed particle hydrodynamics with an advanced critical state-based model; J Zhejiang Univ-Sci A (Appl Phys & Eng) 2021 22(11):882-893 DOI:	**No**	**Yes**	**Yes (Attachment 6)**	N.A.

					http://dx.doi.org/10.1631/jzus.A2000598				
2021				Jian-Gu Qian, Wei-Yi Li, Zhen-Yu Yin*, Yi Yang	Influences of buried depth and grain size distribution on seepage erosion in granular soils around tunnel by coupled CFD-DEM approach. Transportation Geotechnics, 29, 100574. https://doi.org/10.1016/j.trgeo.2021.100574	**Yes (Under Review in the Mid-term Progress Report)**	**Yes**	**Yes (Attachment 7)**	N.A.
2021				Hao Xiong, Zhenyu Yin*,Jidong Zhao and Yi Yang	Investigating the effect of flow direction on suffusion and its impacts on gap-graded granular soils. Acta Geotechnica, 16, 399-419. https://doi.org/10.1007/s11440-020-01012-9(012345678().,-volV)(01234567 89,-().volV)	**Yes (Under Review in the Mid-term Progress Report)**	**Yes**	**Yes (Attachment 8)**	N.A.
2020				Ouyang, W.H., Yang, Y.*, Wan, J.H., and Liu, S.W.	Second-order analysis of steel piles by pile element considering nonlinear soil-structure interactions. Advanced Steel Construction, 16(4), 354-362. DOI:10.18057/IJASC.2020.16.4.8	**No**	**Yes**	**Yes (Attachment 9)**	N.A.
2020				Pin Zhang, Yin-Fu Jin∗, Zhen-Yu Yin∗, Yi Yang	Random forest based artificial intelligent model for predicting	**Yes (Accept in the Mid-term Progress report)**	**Yes**	**Yes (Attachment 10)**	N.A.

					failure envelopes of caisson foundations in sand. Applied Ocean Research, 101, 102223. https://doi.org/10.1016/j.apor.2020.102223				

9. Recognized International Conference(s) In Which Paper(s) Related To This Research Project Was / Were Delivered
(Please attach a copy of each conference abstract)

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 RGC** *(Yes or No)*	**Accessible from the Institutional Repository** *(Yes or No)*
November/2019/Tokyo, Japan	Modelling of granular pile collapse by using material point method and discrete element method	Geomate 2019 Geotechnique, Construction materials and Environment	Yes (Mid-term Progress report)	No	Yes	N.A.
July/2021/USA	Explore the impact forces with varied slope angle by using Material Point Method	16th U.S. National Congress on Computational Mechanics	No	Yes (Attachment 11)	Yes	N.A.

10. Whether Research Experience And New Knowledge Has Been Transferred / Has Contributed To Teaching And Learning
(Please elaborate)

The subject of 'Slope Engineering' was benefit from the project, which was also mentioned in the mid-term progress report.

11. 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
N.A.			

12. Other Impact

(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, teaching enhancement, etc.)

Research collaborations other Universities to submit and publish jointed journal papers. Details have been reported in the mid-term progress report.

13. Statistics on Research Outputs

	Peer-reviewed Journal Publications	Conference Papers	Scholarly Books, Monographs and Chapters	Patents Awarded	Other Research Outputs (please specify)	
No. of outputs arising directly from this research project	10	1 paper 1 poster	/	/	Type /	No. /

14. Public Access Of Completion Report

(Please specify the information, if any, that cannot be provided for public access and give the reasons.)

Information that Cannot Be Provided for Public Access	**Reasons**
Findings need further validation	Some of the findings or conclusions in the research still need to be validated or tested again.