

UROP: Undergraduate Research Opportunities Programme

A Personal Perspective by Ryan Yin Wai LIU

Ryan had just completed the second year of an undergraduate degree in Civil Engineering, and embarked on an UROP research experience in the summer of 2015 under the supervision of Dr David Taborda (Department of Civil and Environmental Engineering).

Placement Title: Design and Modelling of Ground Source Energy Systems

Motivations for UROP

Last year, I participated in a UROP with Dr Jamie Standing on “The Effects of Tunnelling on Existing Tunnels”, and I really enjoyed it, and thought that I am the right kind of person to do research, and go for an academic career in the future.

Unlike other branches of civil engineering, Geotechnics is ever-changing and full of uncertainty, and perhaps this is the main reason I am so fascinated by it. Having noticed the versatility of numerical modelling in geotechnical analysis and the world-leading in-house software, Imperial College Finite Element Program (ICFEP), I thought it would be a nice experience to learn how to use it, as it is not part of the curriculum.

Through this research opportunity, I have learnt how to use ICFEP, which is a significant advantage for me to perform geotechnical analysis in the third year group design project and the final year individual research project.

How I secured the placement and preparation I undertook before my research experience commenced

In November 2014, I asked Dr Taborda, who was my lecturer in Mathematics last year, whether he could offer me a UROP placement during the summer, as I am extremely keen to learn numerical modelling. After a series of discussions, in February 2015, he agreed to offer me a placement and supported me to apply the UROP bursary from the College. Before the research commenced, Dr Taborda sent me some papers on ground source energy and borehole heat exchangers as pre-reading.

Skills and experiences gained from undertaking my research experience

This UROP experience has been extremely rewarding. In this UROP placement, I had the experience to use the world-leading in-house software, ICFEP, to perform geotechnical analysis. This research focuses on thermal analysis, which involves finding the distribution of temperature in the ground due to a borehole heat exchanger, or a water pipe with a continuous flow of hot water.

In order to perform an efficient and accurate finite element analysis, a finite element mesh has to be created prior to the analysis. A very precious skill that I have acquired in this research experience is to create this mesh. This mesh creating process is crucial to all finite element analysis, not only with ICFEP. This involves first drawing the mesh with AutoCAD, then defining the reference points with excel, and finally importing them into the ICFEP, which currently runs a Unix-based system. Before running the analysis, I had to define boundary conditions to the finite element mesh. Very often, the correct boundary conditions were not obvious. As a result, I had to perform multiple analyses with ICFEP with different boundary conditions and compare the obtained results with available analytical solutions I coded in MATLAB. Additionally, the graphs plotted with results had to be carefully analysed to identify the suitable boundary conditions for simulating reality. Moreover, I had the opportunity to handle the data in different operating environments, which I

think is again a very practical skill that I have obtained. This has made me more versatile than ever before, and I am sure that this would be helpful whether I am in the industry or academic world in the future.

Problems I experienced and how I resolved them

One of the problems that is worth mentioning is probably the plotting of graphs and listing the data with Unix at the beginning of the placement. At that time, I was unfamiliar with the system, and was unable to figure out why the plot file and the list file I created could not be opened. I spent a considerable amount of time struggling with that. Eventually, I found that there was a maximum file size that the Unix system can handle, and the files I created were too large for the system to open. As a result, I had to write a plot-only program and a list-only program, which are dedicated for plotting the required graphs and listing the required results only.

How the research experience might influence the remainder of my course and my future career plans

This research, together with the one last year, has strengthened my determination to step into the academic world in the future. Having learnt how to use ICFEP, I have one more option to perform geotechnical analysis in the group design project next year. In the final year research project, where I would probably choose a topic related to geotechnical analysis, a substantial amount of time can be saved by already being familiar with the software. I am looking forward to joining the UROP once again next summer taking part in other types of geotechnical analysis, like mechanical and hydraulic analysis.

Once again, I would like to express my sincerest gratitude to Dr Taborda for offering me the opportunity to take the UROP placement. The placement would not have been so enriching and successful without his wholehearted support. I would also like to thank British Petroleum for funding the project via the BP UROP Awards.