O-Tube Laboratory Report

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Since 2008 UWA has been developing a unique recirculating flume concept called the O-Tube, to support the development of new techniques for the stability design of subsea pipelines as well as research on other fluid-soil-structure interaction topics. This work has been driven at UWA by Liang Cheng of the School of Civil & Resource Engineering (SCRE) and David White, Hongwei An and Scott Draper from COFS. Over the past four years we've developed two types of O-Tube at UWA. Our Large O-Tube (Figure 8, Figure 9) is comprised of a huge closed-loop flume with a 20m-long bed of natural seabed soil. This O-Tube contains 60 tonnes of water which can be rapidly circulated to simulate wave and current velocities close to the seabed in cyclonic conditions. The second is the Mini O-Tube, (Figure 11) approximately 5 times smaller than the larger O-Tube in all dimensions. The design and assembly of the O-Tubes was undertaken by UWA's in-house technical team, and the control and actuation systems are evolved versions of the technologies developed for the geotechnical centrifuges.

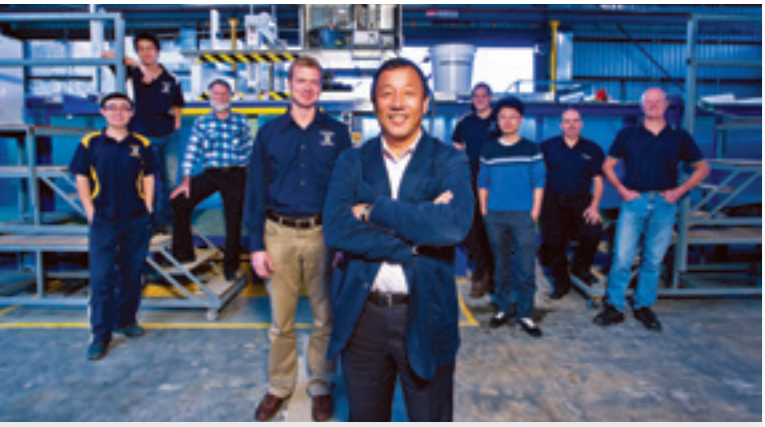

Figure 8: Liang Cheng with the O-Tube team

Figure 9: Overview of the large O-Tube

The O-Tubes have significant advantages over conventional laboratory flumes because they can reproduce combined wave and current action, up to very large velocities typical of cyclonic and tidal conditions. The O-Tubes have positioned COFS at the forefront of research on stability analysis of subsea pipelines, with applications for oil and gas developments offshore North West Australia, and worldwide. The first PhD student to use the large O-Tube – Chengcai Luo – submitted his PhD during 2012.

In 2012 the O-Tube research program at UWA was recognised through a number of state and national engineering awards, including winner of the Innovation and Design category of the Engineers Australia state engineering excellence awards and finalist at national level (Figure 10). We were also the winners of the Subsea Energy Australia industry innovation and technology award. This success followed after the O-Tube was named the Western Australian Oil and Gas Innovation of the Year in 2011.

Figure 10: O-Tube awards: winner of the Innovation and Design category of the Engineers Australia state engineering excellence awards and finalist at national level

The O-Tube concept was initiated by UWA in partnership with Woodside, Chevron and the Australian Research Council, with support from local engineering consultancies Atteris and JP Kenny and significant funding from UWA's internal strategic research fund. This industry involvement has underpinned the applied research focus of the O-Tube facilities. Since its inception the Large O-Tube has been used in numerous industry research projects to support offshore engineering design, including the Woodside-operated STABLEpipe Joint Industry Project. This work has mainly focused on pipeline stability, both for existing and proposed pipelines, but also includes work to assess the stability of rock berms, scour around pile groups and scour around rectangular caissons.

The research being performed in the Large O-Tube is already making a significant difference to pipeline stability design. To date, our research findings have already yielded technical outcomes with a benefit-to-cost ratio greater than 10:1 for industry partners, according to an investor

advisory briefing published by Woodside. An independent study by engineering consultants JP Kenny suggests that experimental testing in the Large O-Tube is the most cost-effective research activity to improve the stability design of pipelines and could yield up to a 100-time return on investment in the long term.

The Mini O-Tube, managed by Scott Draper and laboratory technician Sun Wei, has established a niche as a small scale facility to complement the larger O-Tube. A particular advantage of the Mini O-Tube is that it can be used to easily investigate sediment transport mechanisms in a variety of different soils. The small scale of the facility allows tube samples from field investigations to be used, with a rapid turnaround time. Ground breaking work on ex-situ soil erosion testing is also being performed in the Mini O-Tube, through collaboration with local engineering consultants Advanced Geomechanics and, more recently, through the research by PhD student Henning Mohr. This erosion testing is beginning to paint a picture of the varying erosion resistance of in situ seabed sediments across offshore North West Australia.

Figure 11: The Mini O-Tube

To share the innovative thinking behind O-Tube design, the Mini O-Tube was showcased at the 2012 UWA open day, drawing crowds of potential young engineers to watch experiments of scour beneath model scale pipelines. The spectacle of the Mini and Large O-Tubes in full flow has been a hit with visiting academics and research groups passing through the UWA Faculty of Engineering.

In late 2012 the O-Tube team, with ex-UWA colleague Ming Zhao (now at the University of Western Sydney), were been awarded a 3-year ARC Discovery Grant to tackle the fundamentals of seabed scour near pipelines.

Figure 12: The O-tube team in Canberra