WEEG NEWSLETTER October 2020

The newsletter is published monthly by the University of Southampton's Water and Environmental Engineering Group WEEG, and reports things of interest in this field worldwide, as well as ongoing undergraduate student and research work in WEEG itself.

We believe that water and energy are the most important topics worldwide for the next decades. Our work covers river and coastal engineering, water and wastewater and energy related to water.

Editorial: water is incompressible - at least in the world of hydraulic engineering. Well, mostly. There are however some scenarios where water - or rather a water-air mixture – can become compressible, with some surprising results.

Hydraulic Engineering International: *Aerated flow*

In spillways, hydraulic jumps, stepped ramps and other energy dissipation structures, air is entrained into the water as bubbles by the turbulence. This is called white water, since the colour of the water is changed by the air content. The high energy of these flows means that air bubbles are kept in suspension.

This has several effects, the first one being that the volume of the flow – and therefore the required channel depth – increases. This is fairly evident: but a second consequence of the air entrainment is less obvious. The bulk modulus of elasticity of water is $2x10^9$ Pa, the modulus of elasticity of air is 10^5 Pa. If we add 1% of air to water, the density of the mixture is reduced by 1.25% whilst the modulus of elasticity reduces by a factor of 200! And 10% of air reduces the bulk modulus of the two-phase fluid by a factor of 2000.

Fig. 1: Oroville dam spillway

This means that, if we apply a pressure of 5 m of water on a water block of 1 m^3, it shortens by 33 mm; if we had 40% of air it would shorten by 133 mm. In other words, the water-air mixture is not incompressible anymore, and we now enter the area of *compressible flow* – usually thought of as belonging firmly in the field of aeronautical engineering.

Compressible flow can have certain characteristics which make it very different from incompressible flow.

(1) The flow can go supersonic! The speed of sound is a function of the density and the elasticity of a fluid or medium. In our two-phase medium, the water has a speed of sound of 1450 m/s, the air of 300 m/s. Adding 1% of air reduces the speed of sound to 100 m/s; adding 10% to 30 m/s and 40% to 22 m/s - much lower than the speed of sound in either constituent medium. Considering the fact that velocities of 40 m/s and more have been recorded on spillways with aeration ratios between 20 and 40%, the possibility of supersonic flow in spillways certainly exists.

(2) When passing through a constriction, the flow velocity cannot exceed the speed of sound: this is called choking. The dragon teeth on the ski jump shown in Fig. 1 may create such an effect.

(3) When transiting to subsonic speed, stationary or fluctuating pressure discontinuities or shock waves can develop. How such waves manifest themselves, is anybody's guess.

Fig. 2: Steep chute in an irrigation canal in Wyoming

Lastly, we may also get very fast, highly aerated flows in irrigation systems. Fig. 2 shows a steep chute designed to dissipate energy in turbulence and friction in an irrigation canal. The turbulence leads to air entrainment. From drop heights of 30 m or more, the speed of sound could be reached.

One troublesome aspect of all of this is that the effects require certain aeration ratios, and absolute pressures and velocities; so that re-creation in a laboratory is very difficult.

Currently, we rely on theoretical work only to try to probe this new field of civil engineering hydraulics.

Third year (Individual) Project IP: *Tsunami Engineering*

Tsunamis are of course well known, as huge waves with very long periods between 90 and 2000 seconds which are mostly generated by subsea earthquakes with large horizontal movements of the seabed.
What is less well known is that the information on engineering for tsunamis is actually very limited: in fact only one textbook from 1980 by Camfield is available on this topic – just one, despite the importance of the problem. This comes down to very basic issues such as "what height and velocity does a tsunami wave have at landfall" for which there is no ready guidance. So, at Southampton University we have two third year students working on the development of simple fluid mechanics models for a=wave transformation, run-up and run-down to develop design guidance for this special field of hydraulic engineering.

Fig. 3: Artist's rendering of a tsunami. Can a wave like this actually exist? We are trying to find out

Ongoing work: *Tsunami Engineering*

The lack of information on design for tsunami is a serious issue for coastal engineering. So, at WEEG we have started to develop engineering theory, and novel experimental methods to look at the actual engineering information required for design, such as maximum wave heights, propagation velocities, inundation depths, loadings etc.

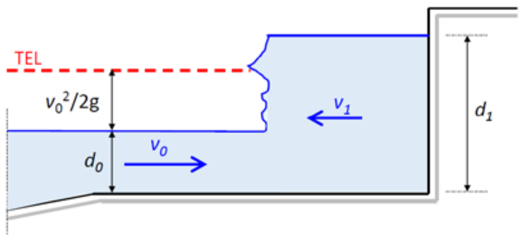

Fig. 4: Model for tsunami-induced run-up at a vertical wall

The work has already brought some very interesting results regarding wave heights, and e.g. the tsunami induced run-up on walls which can be higher than the energy line. This has also been demonstrated experimentally.

For more information, contact Dr Gerald Muller, g.muller@soton.ac.uk

Webinar series: Sustainable N & P removal and recovery (1 Dec 2020)

WEEG staff will feature in another of EBNet's webinar series, on nutrient recovery from wastewater. Speakers are Juhani Kostianien from Plantwork Systems Ltd, Prof Ana Soares from Cranfield, and Nopa Maulidiany from WEEG - with Dr Yongqang Liu chairing.

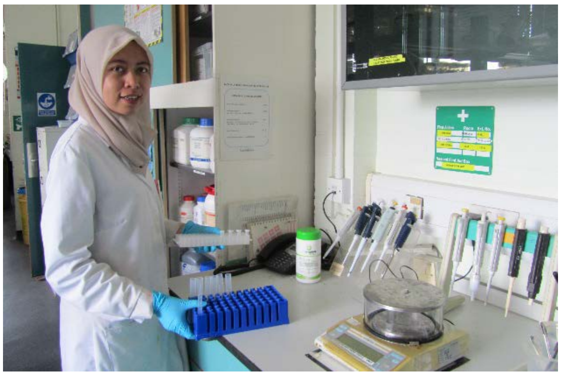

Fig. 4: Nopa at work in the Environment lab

More info on https://ebnet.ac.uk/biological-np-removal or from EBNet on EBNet@EBNet.ac.uk

Jobs in water engineering:

This section gives you an idea of the type of work you can do when working in industry.

Civil and Environmental Engineering at Southampton University:

WEEG: the Civil and Environmental Engineering pathway offers the chance to deepen your knowledge in water-related areas, and gives you a better preparation for environmental engineering projects.

Contact: Dr Sonia Heaven, s.heaven@soton.ac.uk, Bldg. 178, Room 5008

Further information:

We have two Facebook pages, which provide a logbook of our laboratory activities:

www.facebook.com/Hydraulicslaboratory/

www.facebook.com/environmental.lab.university.of.southampton/

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