WEEG NEWSLETTER March 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 often behaves in very strange, unexpected, counterintuitive ways. Examples for this are the hydraulic jump, subcritical and supercritical flow, waves etc. The most counterintuitive phenomena are called paradoxes, and in this edition we will look at two such things, and their practical effects.

Hydraulic Engineering International: *two hydraulic paradoxes, and their importance for engineering*

1. The hydrostatic paradoxon: We all know that hydrostatic pressure p_{hyd} is given by $p_{hyd} = \rho g H$, where ρ is the density of water, g the acceleration of gravity and H the height (or rather depth) of the water. This means that the pressure is a function of the height only, which has some interesting consequences: the force F e.g. acting on the base plate of the three containers shown in Fig. 1 is exactly the same, despite the fact that in the third vessel there is a lot more fluid than in the first.

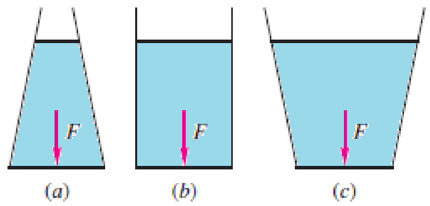

Fig. 1: Pressure in differently shaped containers

The equation also means, that the pressure acting on a dam does not depend on the length of the reservoir.

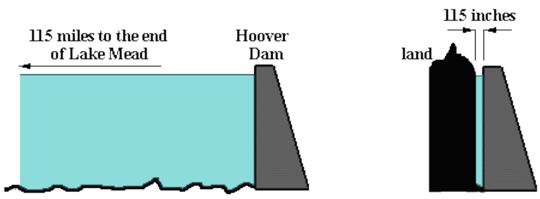

Fig. 2: Hydrostatic pressure on dams

In Fig. 2, the pressure on the dam is exactly the same for both situations, despite the fact that the water in the second picture has a length of only 115 inches (292 cm), whilst the reservoir in the first picture, with a length of 115 miles (185 km), is 63,400 times longer.

So, where is the practical application? Well, for example in the Alps. The bedrock in the Alps has fissures, which derive form the cooling of metamorphic rocks. These fissures are usually filled with ice, which has been there for so long, it no longer puts any pressure on the rock. With global warming, however, the south-facing rocks have warmed up, ice near the surface has melted, the fissure – which can be several hundred metres deep but with widths of 50 to 150 mm only - becomes water-filled: and suddenly we have horizontal pressures of several thousand kPa acting on the bedrock and causing large rock falls, as seen in Fig. 3.

Fig. 3: Rock fall in Randa / Switzerland, 2015

Such rock falls have triggered a large programme on tsunami research in landlocked Switzerland, of all places! The reason is that if a large rock fall hits one of the lakes, such as Lake Geneva, it can trigger a tsunami wave which could have serious consequences for the cities on that lake.

2. Du Buat's pardoxon: Now, this paradoxon is not so well known. In fact, there are even textbooks which suggest that it does not exist at all – which probably says something about those books. Anyway, *Pierre Louis George du Buat* was a French hydraulic engineer of the late 18th Century who published a two-volume book *Principes d'Hydraulique* in 1786. In this he describes, amongst many other things of interest, the tests he did on the drag forces on a plate. Being very thorough, he did not just put the plate into a river, but also dragged it at the same speed through a canal, i.e. through stagnant water.

Usually, we would assume that this is exactly the same, with the reference frame – i.e. the location of the observer – just moved from the river bank to the plate itself. But the force on the plate in the river was 30% higher than that in the canal, although the relative speed of the water was the same. This is known as *Du Buat's paradoxon*. An explanation for this, and its experimental proof, were finally given in the 1890s by the Russian scientist *Nikolay Egorovich Zhukovsky*,

In a real flow of water (or air, for that matter), we know there are turbulent structures, i.e. very short fluctuations in actual speed over the average velocity of the flow. These lead to an effective increase in the maximum pressure generated by the flow. Now, most structural design for flow-induced loads uses forces or drag coefficients determined from flows with very low turbulence, in wind tunnels or hydraulic flumes. This can lead to under-estimation of actual loads when the structure encounters turbulent flow at full scale. For example, the 16 m diameter blades of SeaGen – a 1.2 MW tidal stream turbine - have broken three times since it was installed in Strangford Narrows (Northern Ireland) in April 2008. Fig. 4 shows a tidal turbine with a broken blade. Since *Du Buat's paradoxon* is so little known, its effects are often simply overlooked.

Fig. 4: Tidal turbine with broken turbine blades

3. Lastly, a more or less completely unknown thing is the fact that a thin circular steel plate can actually float on water – if and when a load *F* is applied on it, see Fig. 5.

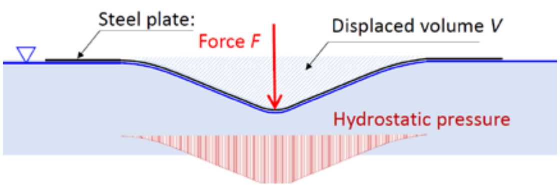

Fig. 5: Elastic plate floating on water

Yes, you heard right: a thin sheet of metal, which is heavier than water, can float if a large enough force is applied in the middle. The deflection of the plate creates a displaced volume and a buoyancy-induced uplift which balances the weight of the plate and the applied force. This effect was described by Heinrich Hertz in 1884, but to our knowledge has not yet found any practical application.

New flume facility

We are planning to apply for funding to build a new advanced hydraulic flume facility that includes bi-directional flow, sediment transport and wave current interaction. This will be the most advanced of its type in the world, and will allow us to deal with complex problems in rivers, estuaries and the coastline where currents, waves and sediment all interact.
Contact: G.deAlmeida@soton.ac.uk

Covid-19 and lab closures

It is a rare news item that does not mention that virus, and like most other labs we have had to close down for now - stopping several student Individual and Group Design projects, and 8 long-term bioreactor experiments which had been running for many months. Our sympathy to all affected, and please keep safe!

Fig. 6: Sad but brave face - PhD researcher Maria Ramos Suarez taking down long-term experiment

Jobs in water engineering:

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

Civil and Environmental Engineering at Southampton University:

WEEG modules allow you to deepen your knowledge in water-related areas, and prepare you for environmental engineering projects.

Contact: Dr Sonia Heaven, s.heaven@soton.ac.uk, Bldg 178, Room 5015

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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