WEEG NEWSLETTER February 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: usually when looking at sediment transport, the properties of the water are thought to be independent of that of the sediment. The Huang He or Yellow River shows, however, that this need not be the case:

Hydraulic Engineering International: *the Yellow River is different...*

The Huang He, or Yellow River, is China's second longest river with a length of 5,500 km. It has a catchment area of 795,000 km^2, an average flow volume of 2,571 m^3/s and a maximum flow of 58,000 m^3/s. Its name is, of course derived from the yellow colour of its water – it has this colour due to the fine loess sediment it carries, see Fig, 1.

Fig. 1: The river bend at Yanan Shaanxi

And here's the unique thing about the Huang He: it carries a huge amount of fine sediment, around 16 bn tonnes per year or a staggering 4.38 million tonnes *PER DAY*! This makes it easily the world record holder. The material it carries comes from the inland Loess plains and is very fine sediment carried in suspension. During flood events, the water can contain on average 300 kg of sediment per m^3; in the mid reaches this can go up to 1,600 kg/m^3! This sediment content actually changes not only the density, but also other characteristics of the water. This type of flow is termed 'hyperconcentrated flow', and has several characteristics which make it very different from ordinary water flows.

The high density and sediment content increase the viscosity and thereby reduce turbulence. Thus, the flow in the river can actually be laminar rather than turbulent, with a surface layer of clear water. This can lead to increased deposition of material, since the sediment is not kept in suspension anymore. As deposition increases, the flow velocity and the water level must increase. At some point, the deposition layer abruptly disintegrates. The velocity then reduces, and the pattern – a so-called 'blast flow' – repeats itself.

Fig. 2: Sediment transport

And, most fascinating: when a certain sediment concentration is reached, with the flow velocity reducing somewhat, then the flow can suddenly stop completely, becoming locally stagnant. This effect is caused by an instability of the water-sediment mixture, and is known as 'clogging'. It happens mostly in smaller tributaries e.g. when the volume of a hyperconcentrated flow is reducing, or when the river comes from a narrow channel and enters a wider flood plain. The river then stops for a while, as if it were frozen. If flowing at all, then it moves only with very low velocities. The water level rises, because there is more water coming into the river section than exiting. After a while, the gradient becomes too large and the river starts to flow again, until the previous state is reached, and the cycle repeats itself. An event like this happened in the Yellow River in 1977. The water level in a mid-reach section suddenly fell, then after some hours, the water level increased by 2.84 m and the discharge was more than 40% higher than previously. This was attributed to clogging in an upstream section where the river exited from a narrow section into a wide valley.

The reason for this type of behaviour is seen in the rheological characteristics of the water-sediment mixture, which is in effect a non-Newtonian or Bingham fluid with some characteristics of a thixotropic fluid. Such fluids (e.g. water-bentonite mixtures) can 'gel', i.e. become more or less solid when at rest, only to liquefy again when disturbed.

Fig. 3: Hyperconcentrated flow at the Beiluo River, a tributary of Yellow River, 1994

Fig. 3 shows a hyperconcentrated flow with approximately 600 kg of sediment per m^3. Although there is no real comparison to a pure water flow, it appears that the spray formation is much smaller, and that the downstream turbulence is very small – again, the properties of the flow suppress turbulence and dissipate energy.

Third year (Individual) Project: *The added mass of river sediments*

When an object immersed in a fluid accelerates, it behaves as if its mass were larger than it really is. This is because any force accelerating the object must also accelerate the fluid around it: this is called the added mass effect. Grains of sand and gravel at the bed of a river accelerate all the time when being transported by the river flow. Thus, engineers trying to model the transport of sediments must account for their added mass via some coefficient – but what value this coefficient should take, we do not know. Vicky Webb (MEng Civil student) is trying to solve this problem as part of her IP by experimental study of an idealised version of sediment transport in rivers, as shown in Fig. 4.

Fig. 4: The motion of a sphere rolling on top of other spheres (immersed in water) is tracked via a high-speed camera. This is used to obtain the added mass of the white sphere.

If you want to find out more or even get involved (e.g. for your IP) please contact Dr Sergio Maldonado (s.maldonado@soton.ac.uk).

Ongoing work: *Tsunami Engineering*

Despite the fact that Engineering for Tsunamis is a very important aspect of coastal engineering, there is in fact little information about actual engineering for tsunamis, and only one textbook on the subject exists (from1980!). So, at WEEG we 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.

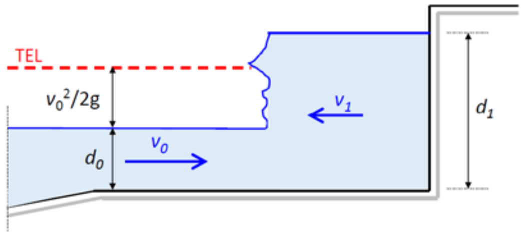

Fig. 5: Model for tsunami induced run-up at a vertical wall

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 was also demonstrated in an experiment.

For information, please contact

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Jobs in water engineering:

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

Advert: A very topical example for this week...

Flood Risk Manager

https://www.icerecruit.com/job/193981/flood-risk-manager/

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/

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