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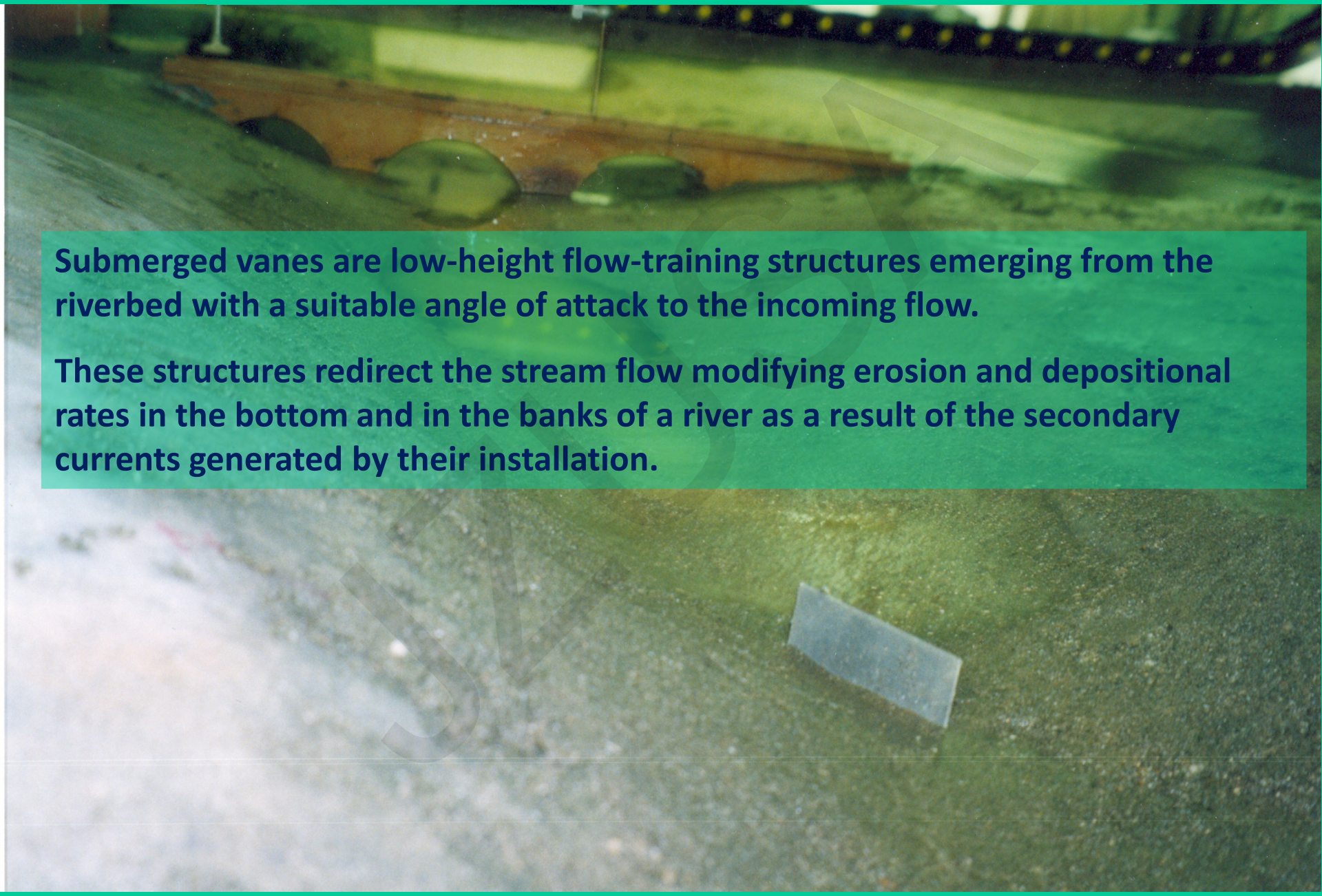
Effects of submerged sheet pile vanes on mobile river beds

Key words:
vanes, sediment, scour, river hydraulics, experimental hydraulics

Submerged vanes



Submerged vanes are low-height flow-training structures emerging from the riverbed with a suitable angle of attack to the incoming flow.

These structures redirect the stream flow modifying erosion and depositional rates in the bottom and in the banks of a river as a result of the secondary currents generated by their installation.

Some applications

- Bank protection for curved channels
- Protection of bridge abutments and piers
- Prevention of sediment drift in hydropower or irrigation channel junctions
- Improving overall river navigability
- Production of a suitable habitat for aquatic fauna

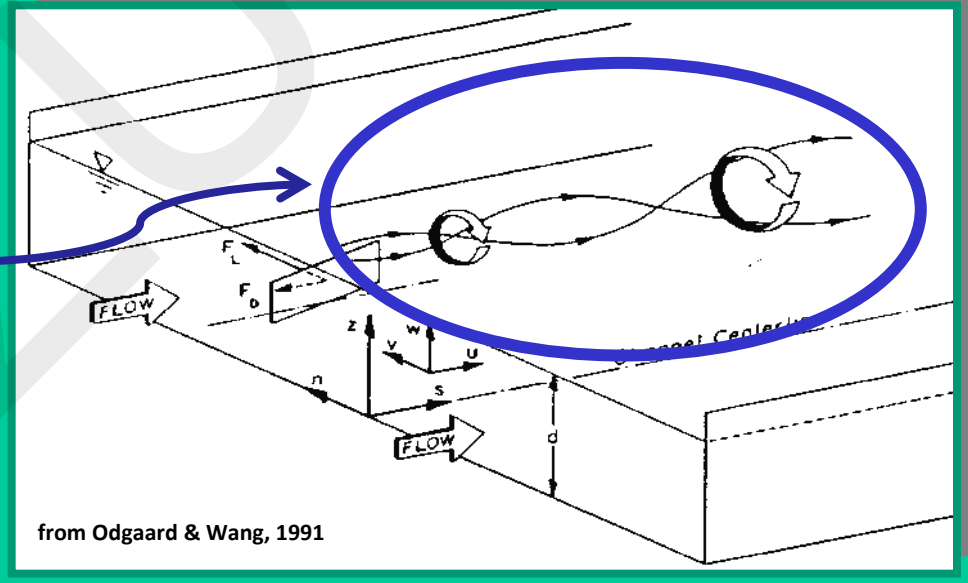
From USGS Scientific Report 2004-5272

The flow field

The two dimensional boundary layer of the incoming flow encounters the protrusion

Complex and interacting vortical systems appear

A large trailing vortex develops downstream



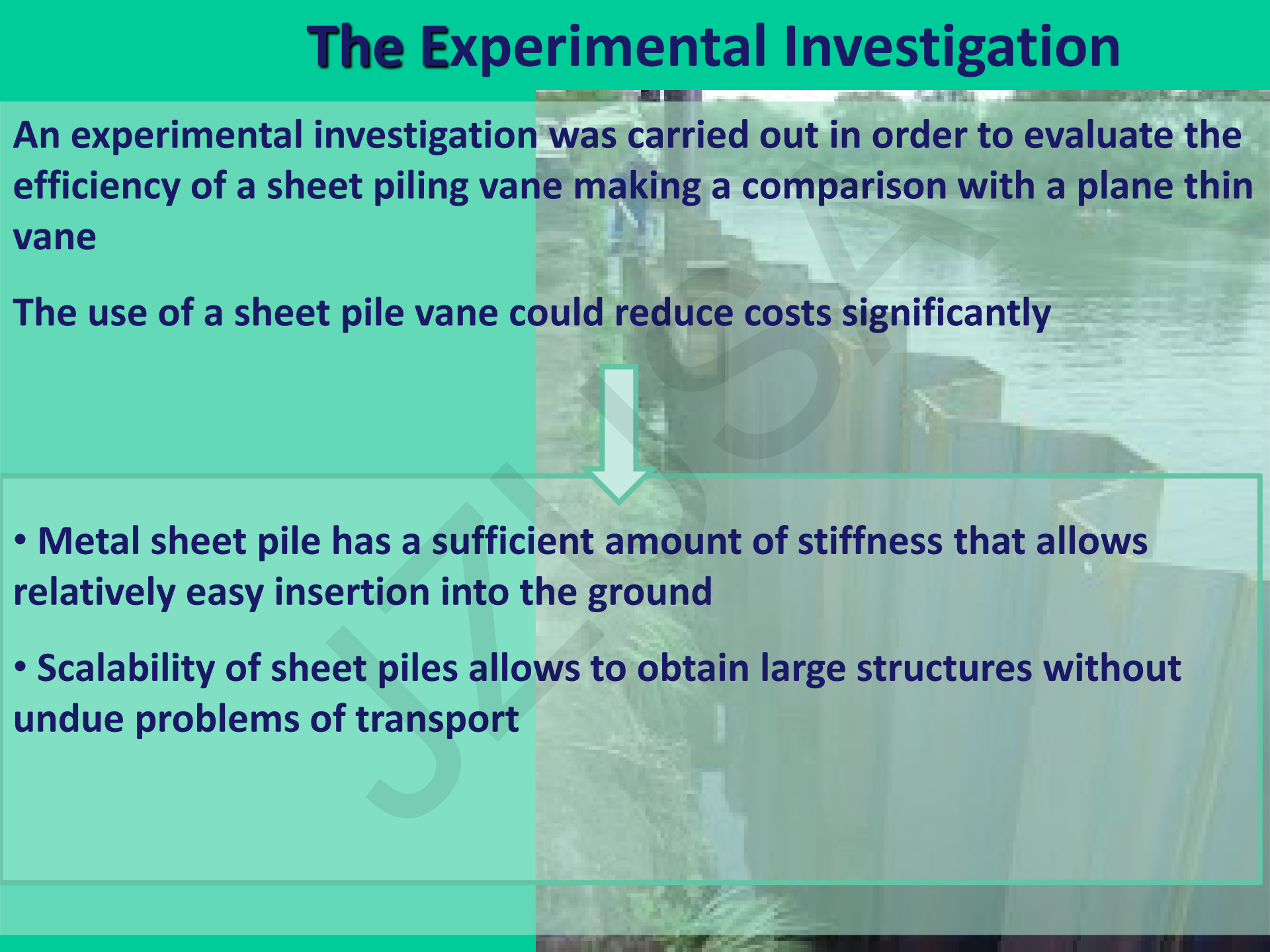
from Odgaard & Wang, 1991

the river bed morphology is modified!

The Experimental Investigation

An experimental investigation was carried out in order to evaluate the efficiency of a sheet piling vane making a comparison with a plane thin vane

The use of a sheet pile vane could reduce costs significantly



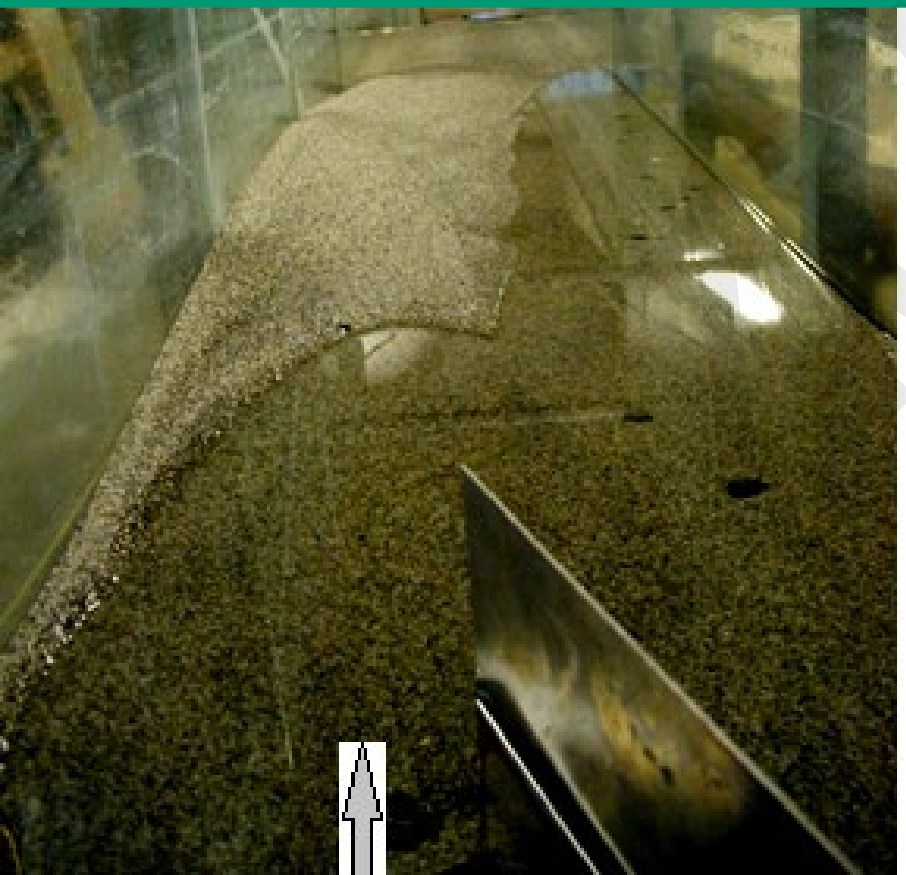
- Metal sheet pile has a sufficient amount of stiffness that allows relatively easy insertion into the ground
- Scalability of sheet piles allows to obtain large structures without undue problems of transport

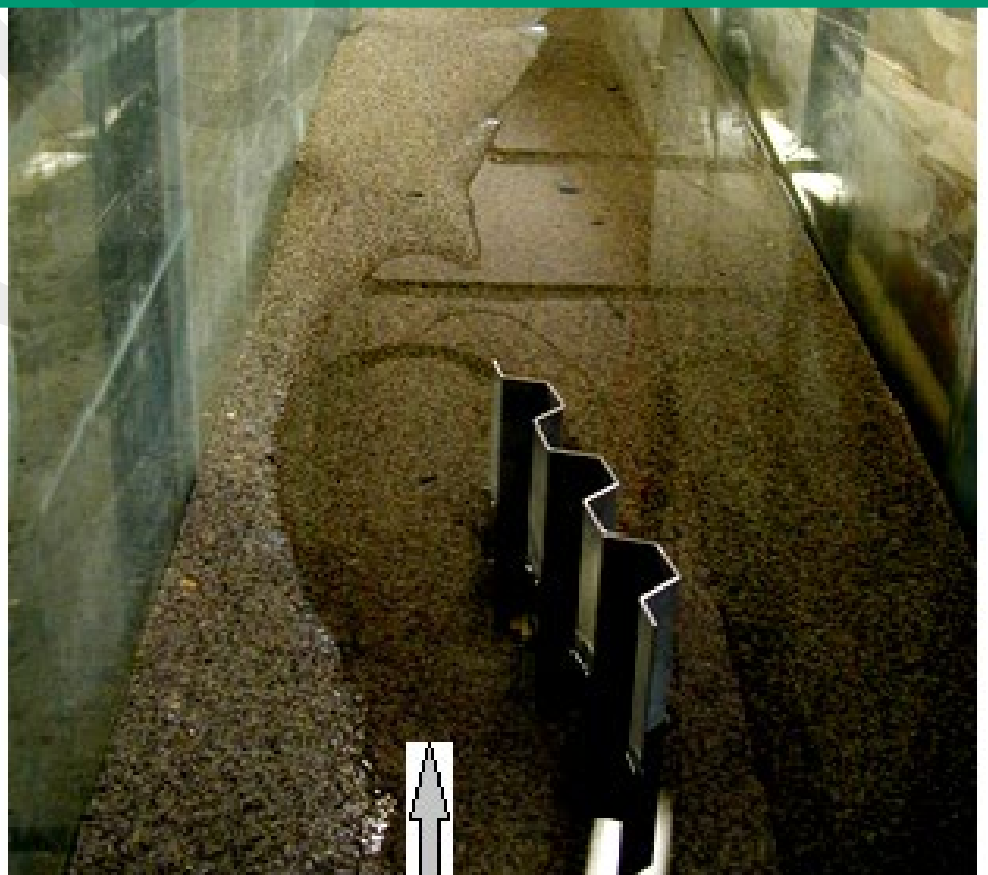
The Experimental Investigation

Channel 12 m long and 0.40 m wide

Flow rate 0.022 m^3/s, flow depth 0.15 m and mean velocity 0.36 m/s

Quartz sand uniform in size with diameter D_{90} =0.5 mm





The Experimental Investigation

Four different shapes and two submergence ratios T/d_0 were tested

- aluminium sheet **plane thin vane** 17 cm x 5 cm (T/d_0 =0.7)
- aluminium sheet **plane thin vane** 25 cm x 7.5 cm (T/d_0 =0.5)
- aluminium **sheet-piling vane** 603 K 17 cm x 5cm (T/d_0 =0.7)
- aluminium **sheet-piling vane** 603 K 25 cm x 7.5 cm (T/d_0 =0.5)

Two different angles of attack were tested for each of the shapes

- α=10°
- α= 20°

All experiments were realized in conditions of **incipient motion** of the bed material

The **morphology of the river bed** was investigated both close to the obstacle and in the area downstream which is not affected by local scour phenomena

CONCLUSIONS

• Results show that both the **shape of the vanes** as well as the **angle of attack** affect their performance in terms of the effects on the bed morphology, especially for greater submergence parameters

• **Thin plane** and **sheet-piling vanes** produce **comparable remodelings** of the channel bed in the downstream region.

• When the angle of attack is increased the **thin plane vane** causes deeper scour holes close to the structure

• This effect is due to the erosive strength of the local vortical systems close to the surface of the thin plane vane, while the uneven surface of the sheet piling vane mitigates the erosive strength of these vortical systems.