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HYTECH Aquatic Interfaces

Sensitivity of the flow to the inclination of a single submerged groyne in a curved flume

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LWI

Outline

- Background
- Objective of the measurements
- Methodology & experimental setup
- Results
- Conclusions

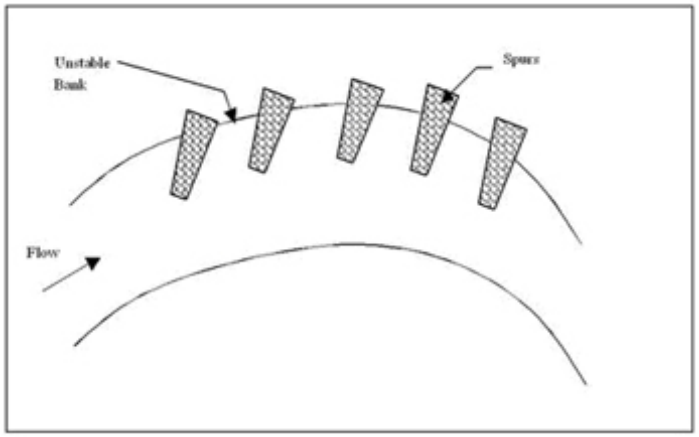
Background

- River bank protection in an ecologically-appropriate manner is an increasing demand nowadays.
- Due to the potential habitat improvements of the nature-oriented structures (Shields Jr. et al. 1995), they have become increasingly popular.
- Yet, detailed hydraulic design guidelines are lacking behind.

Backgroud - sumberged groynes

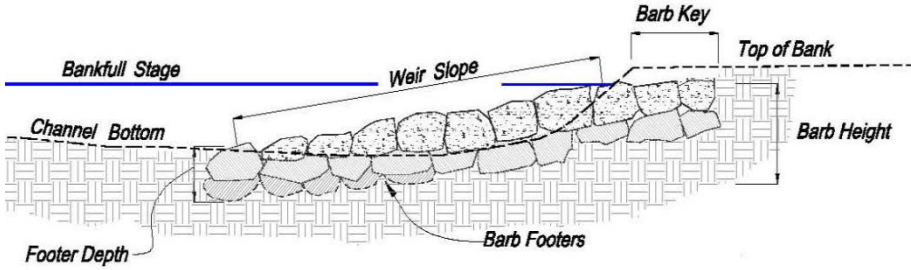
In-stream structures

- e.g. barbs, bendway weirs, vanes and groynes
- Anchored to the outer bank
- Projected into the river with an angle



Submerged groynes

- Flat crest (zero crest inclination)
- Submerged throughout it's length
- Submerged during low flow



Barbs-USDA 2013

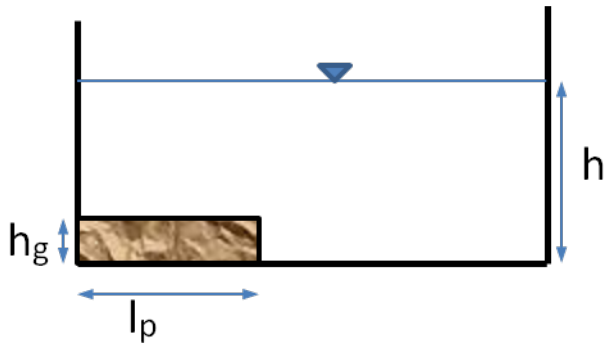
Advantages

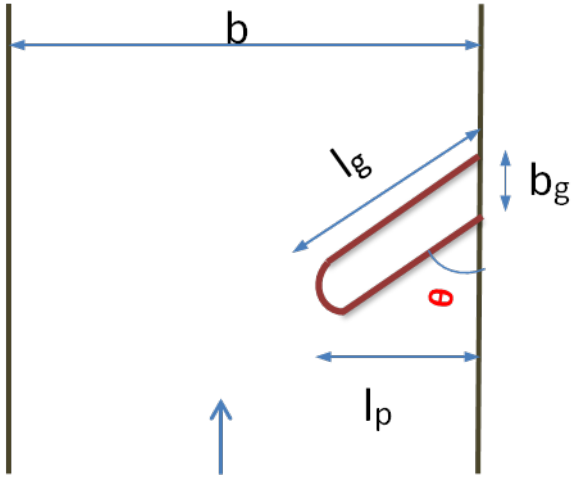
- Low effect on the flood level
- Less obstructions

Objectives of the measurements

- Development of design guidelines for submerged groynes depending on various parameters.

- Here: Investigation of the effect on the flow field due to changes in the inclination of a submerged groyne.

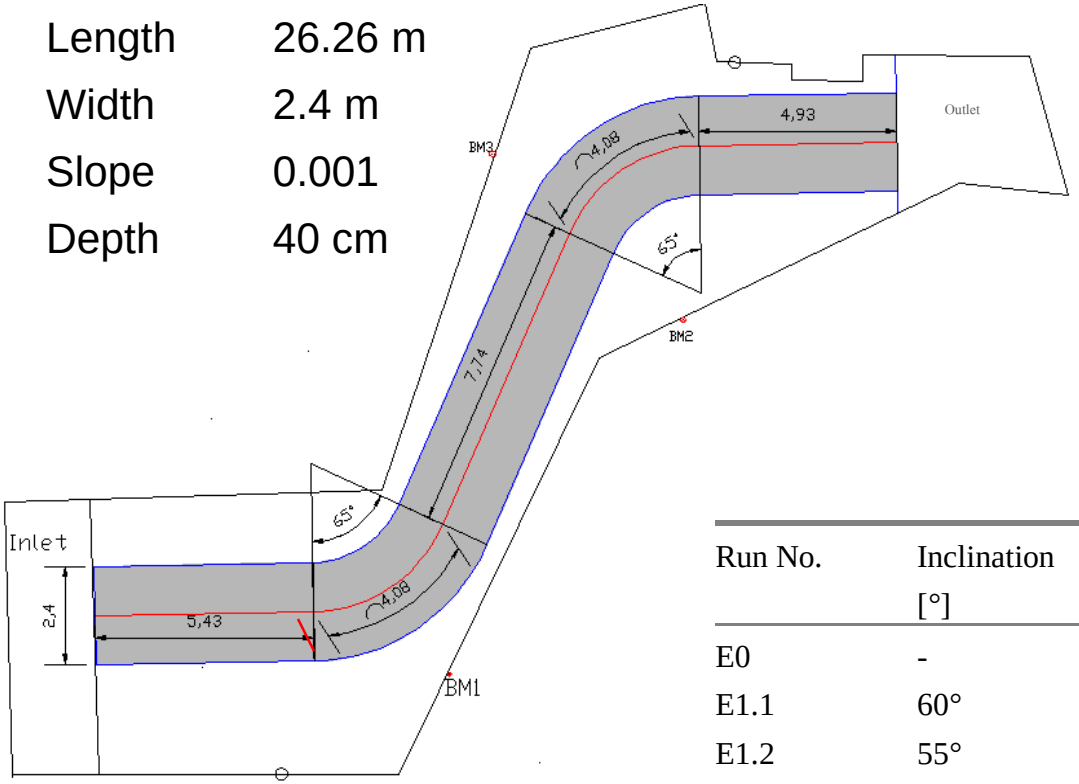




Methodology & experimental setup

Rectangular Flume

Length	26.26 m
Width	2.4 m
Slope	0.001
Depth	40 cm



Single groyne installed at the first cross-section

Groyne

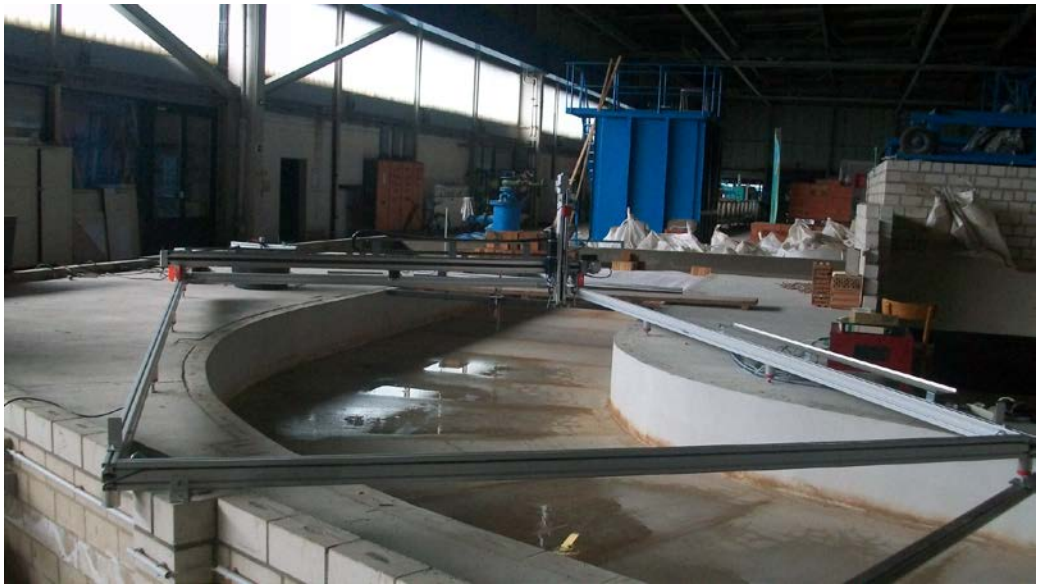
Material	12-16 mm
Projected length	80 cm
Width	6 cm
Height	2.5 cm

Run No.	Inclination [°]	Projected length [cm]	Groyne length [cm]
E0	-	-	-
E1.1	60°	80	92.4
E1.2	55°	80	88.3
E1.3	65°	80	85.1
E1.4	50°	80	97.7
E1.5	70°	80	100.04

Experimental setup

Measuring Devices

- 3D velocity ADV measurement with Vectrino Plus
- Moving traverse for mounting system

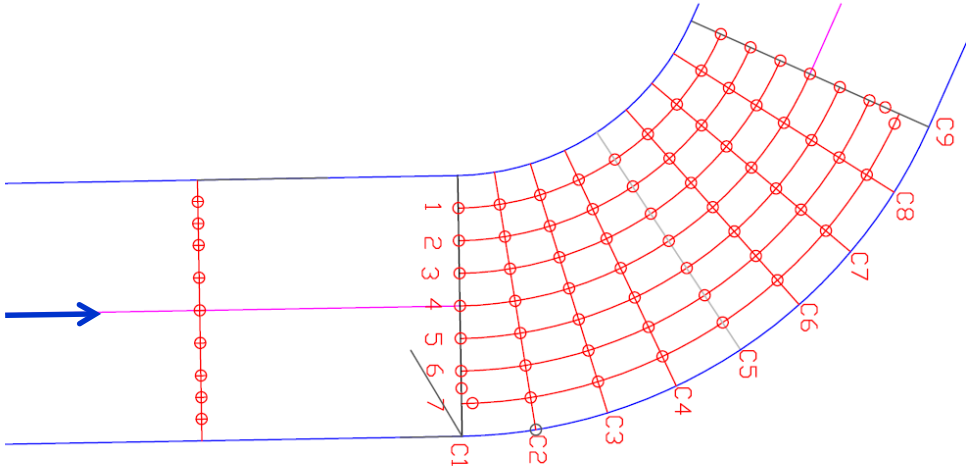


Experimental setup

Hydraulic conditions

Discharge 130.6 l/s

Water depth 10 cm



Measuring grid

Upstream condition

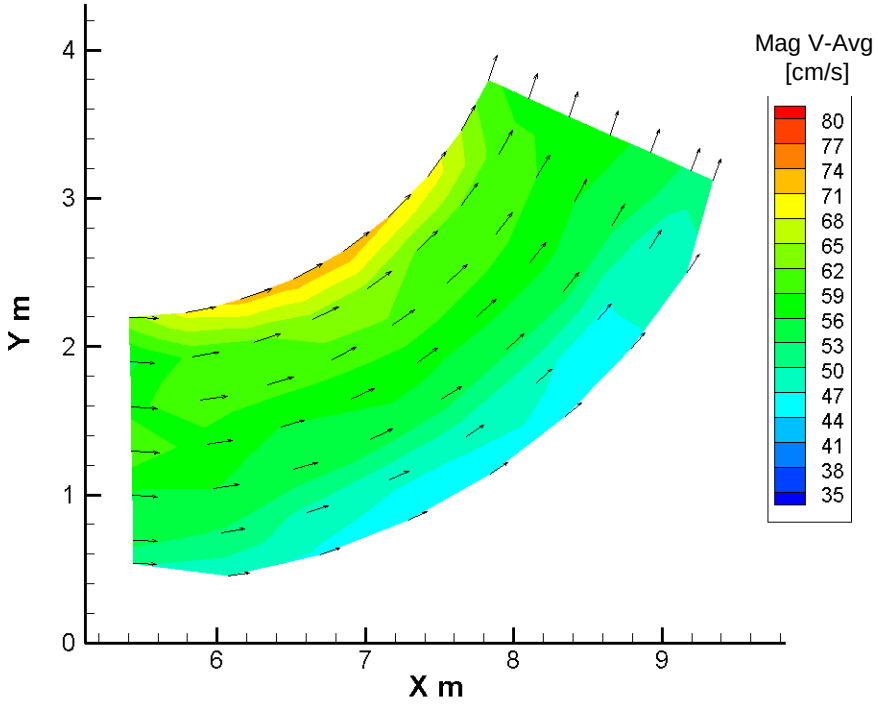
- 1 cross-section with 9 verticals
- 4 point at each vertical (propeller)

Bend flow

- 9 cross-sections with 7 verticals
- 5 points at each vertical (some verticals have 3-4 points due to super elevation)
- total points 325 (Vectrino)

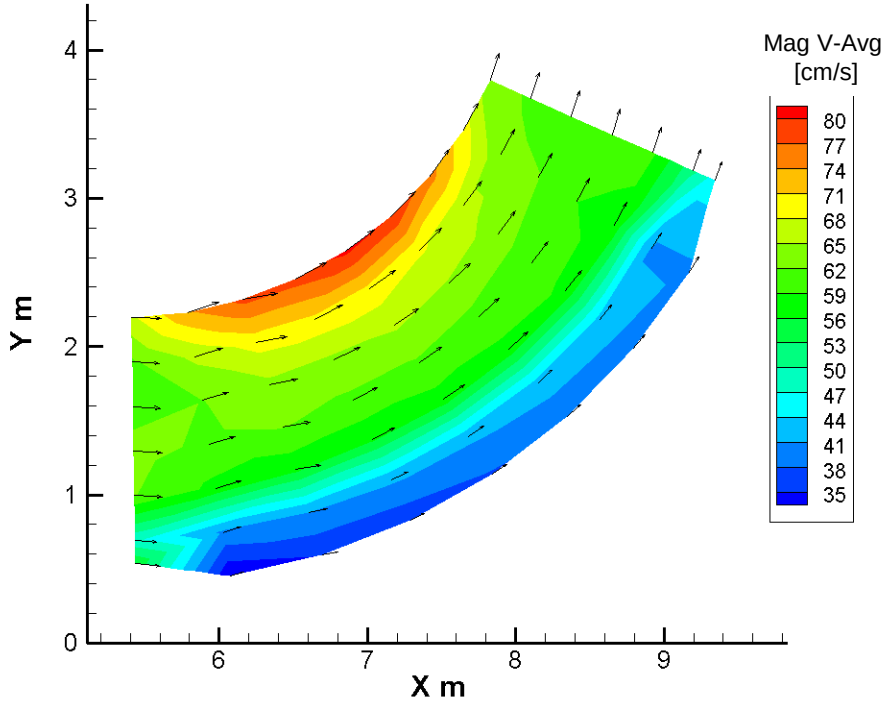
Results – 3D velocity field

E0 – 3 cm above the bed (no groyne)



Higher velocity at inner bank
due to rectangular cross-section

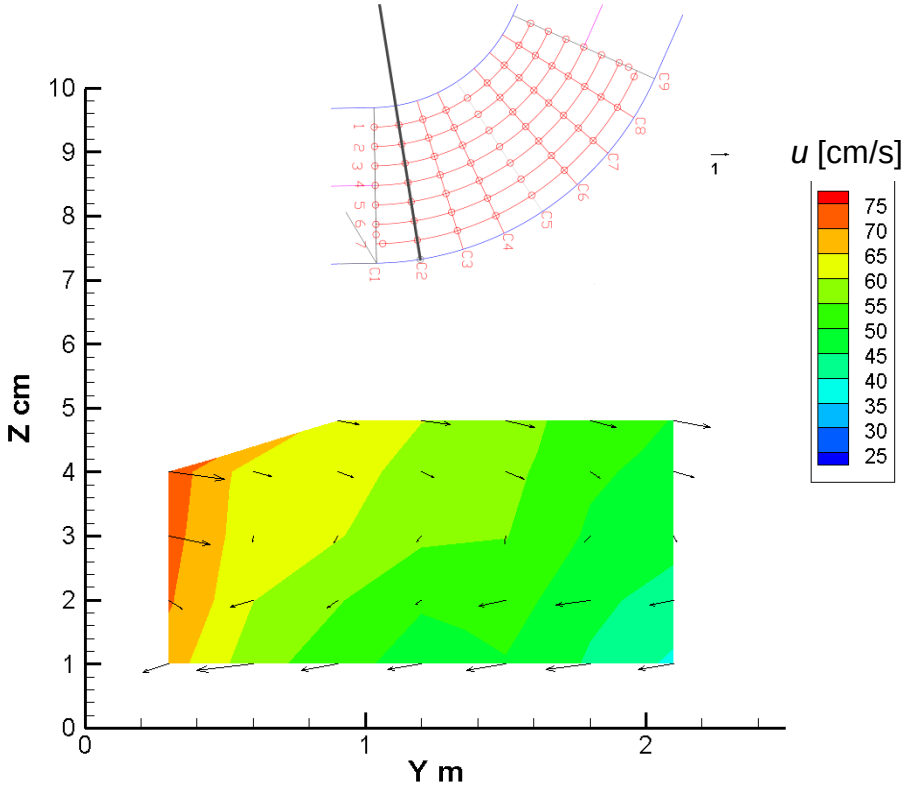
E1.1 – 3 cm above the bed (groyne 60°)



Increase of lateral gradient
due to the groyne

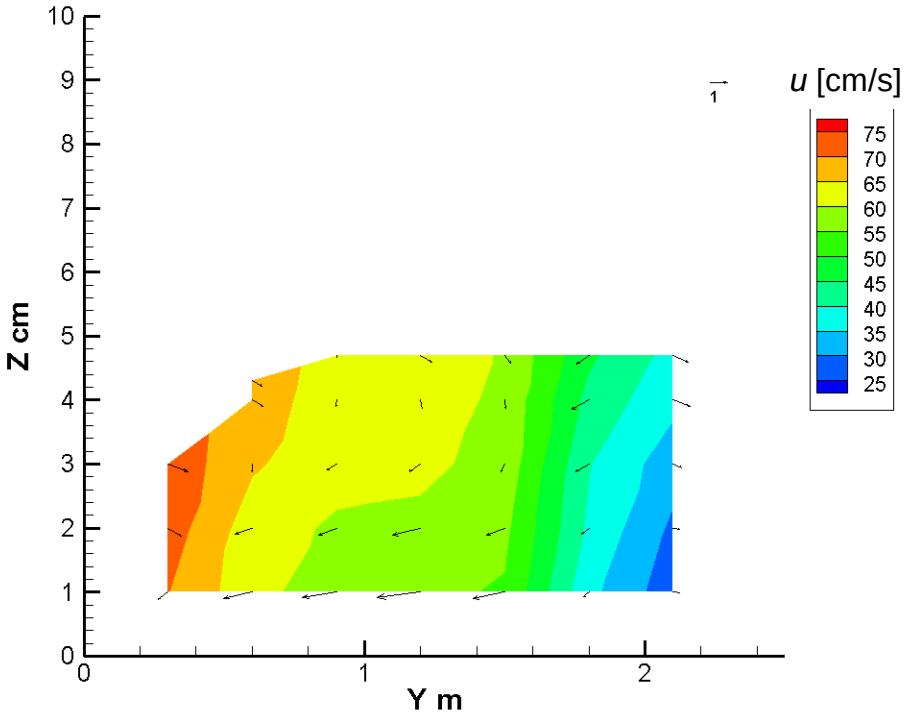
Results – 3D velocity field

E0, C2 (no groyne)



Secondary flow circulation

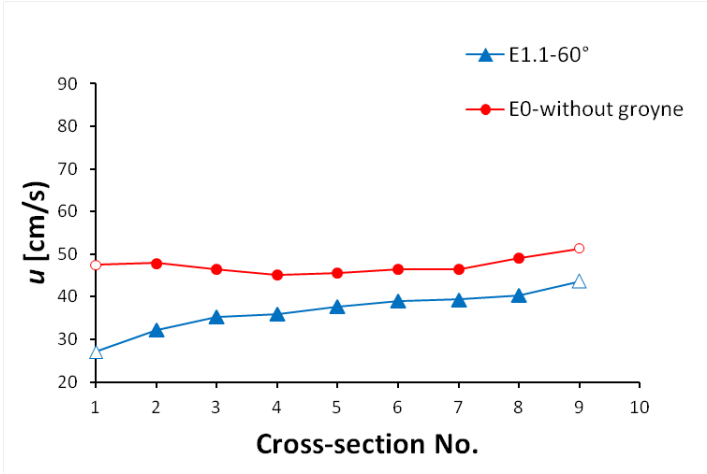
E1.1, C2 (groyne 60°)



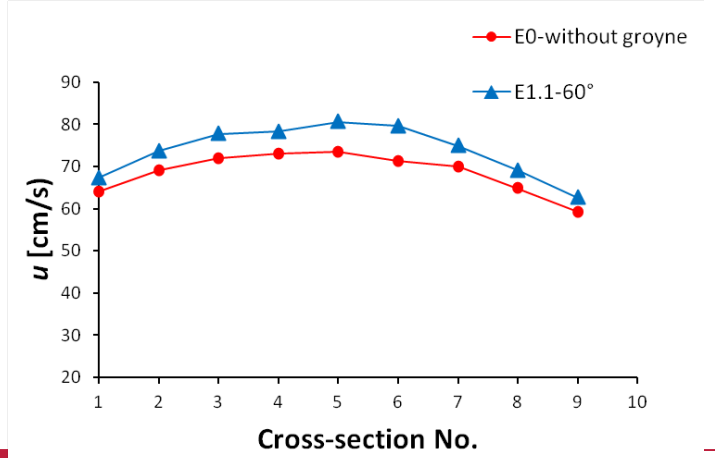
Circulation moved to the inner bank due to the groyne

Results – Stream-wise velocity *u*

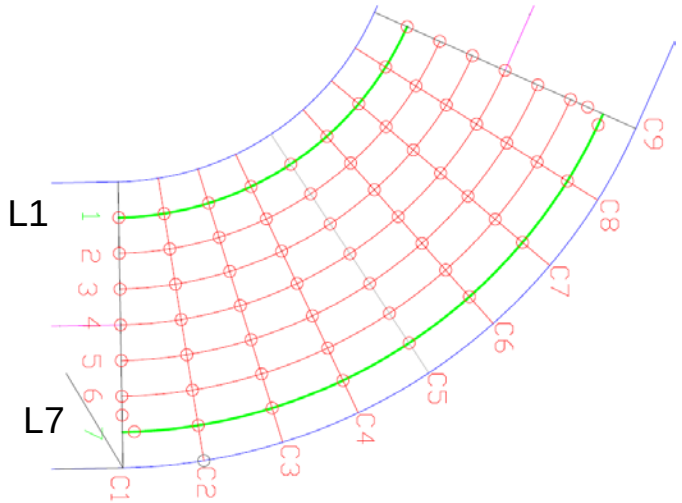
u at L7 at 3 cm above the bed



u at L1 at 3 cm above the bed



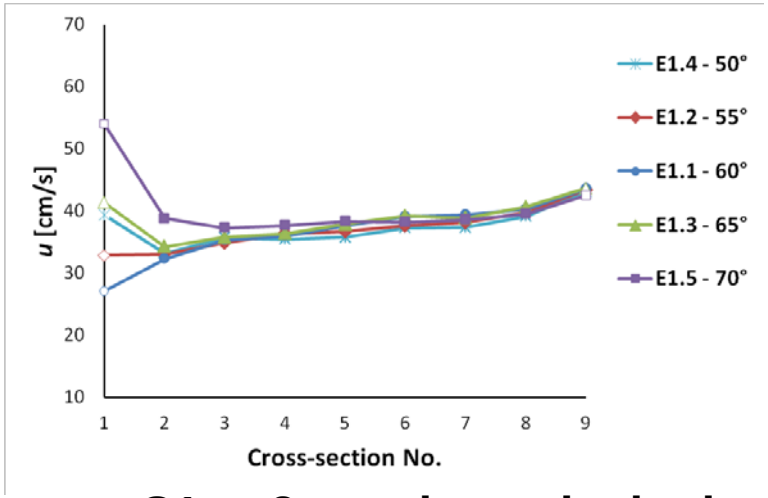
Longitudinal Profiles location



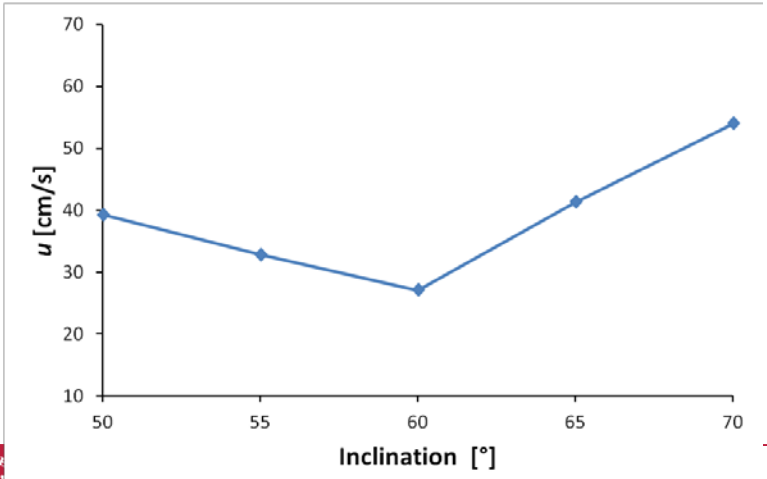
- In L7 the max. reduction of *u* is 44% at C1
- In L1 the max. increase in *u* is 11% at C6

Results

u at L7 at 3 cm above the bed



u at C1 at 3 cm above the bed



Local difference in u can be seen in C1.

The differences start to vanish from C3

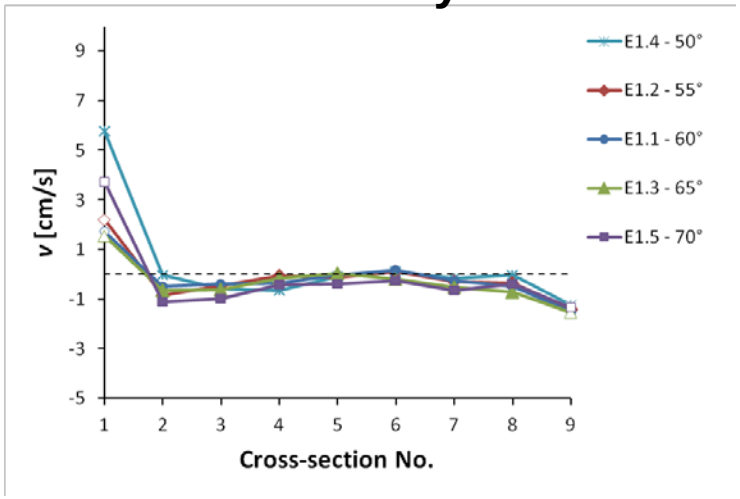
The differences are limited to L7 and L6, from L5 to L1 significant differences.

Systematic trend can be observed.

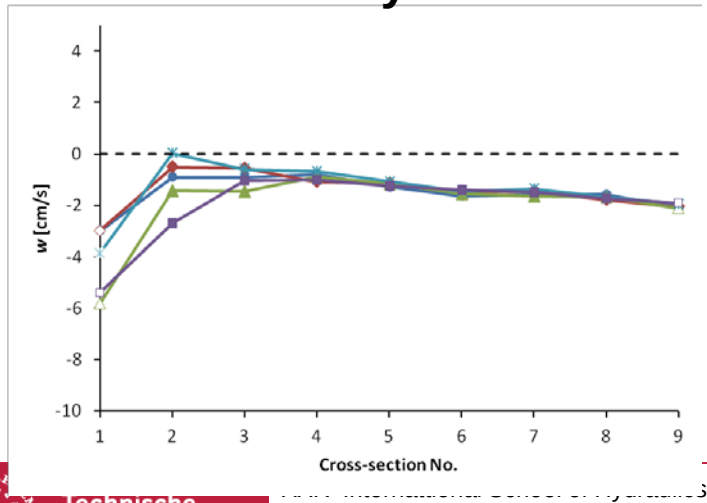
The inclination of 60° provides the lowest velocity at C1.

Results : L7

Transvers velocity v



Vertical velocity w



High differences in v at C1

Positive v velocities at C1 indicate redirection of the flow to the inner bank

From C2 the v velocities start to become close to each other with negative values.

At C9 the velocity is distinctly negative (transition from curve to straight reach)

High negative vertical velocities at C1 (plunging flow behind the groyne).

From C4 no significant differences in the vertical velocities.

Conclusions

- The submerged groyne reduced the velocity towards the outer bank and increased it towards the inner bank.
- The results support the applicability of the structure for bank protection.
- Changing the inclination by up to ±10° showed no significant effect on the flow field provided that the projected length was kept constant.
- Systematic local effect at C1 can be seen
- Further investigations are required;
  next step: variation of the projected length.

Thank you for your attention