Supercritical flow in curved tunnels and horseshoe cross-section

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INTRODUCTION

Tunnels with large radius curvature and horseshoe cross-section are typical for dam emergency outlets. However, the hydraulic behaviour of this type of structures, often defined by supercritical flow, is not fully described in the literature since most of the approaches are dedicated to open channels and rectangular cross-sections.

The model analysis reports the experience on a physical model of an outlet reservoir discharge tunnel.

OBJECTIVE:

- Describe the behaviour of the water surface in a curved tunnel with a closed cross-section by estimating the local head loss and superelevation coefficients. This can help to improve the design of tunnels with these characteristics.

MODEL SET-UP

CHARACTERISTICS OF THE PHYSICAL MODEL

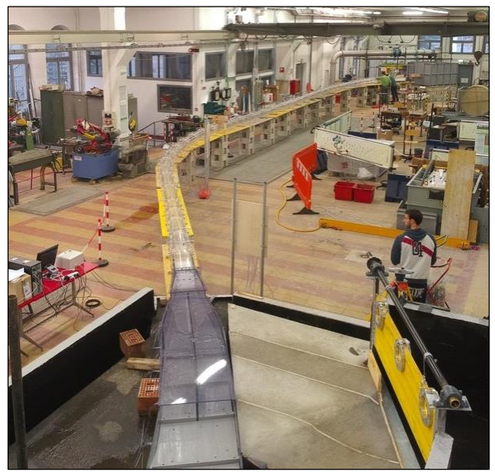
- Geometric scale and Froude similarity 1:30.
- Q_{max} = 67 l/s ($Q_{T=1000\ years}$)
- Materials: Plexiglass and PVC.

GEOMETRY

- Main straight reach.
- **Curve (32° and r_c=10.3m)**
- Final straight reach.
- **Horseshoe section (h = b = 23.2cm)**

CONFIGURATIONS:

1. Main straight reach and curve with a slope equal to 0.85%.
2. Chute of 12% slope before the curve.



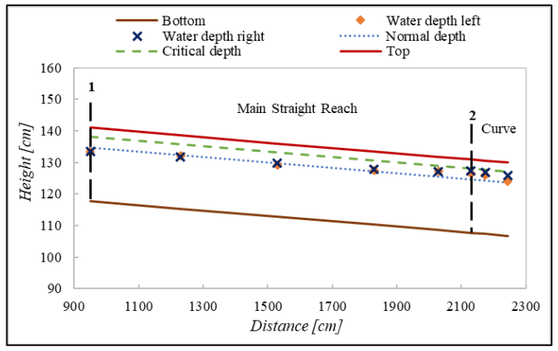
Photography of the physical model at Lab. Fantolii, Politecnico di Milano

CONCLUSIONS

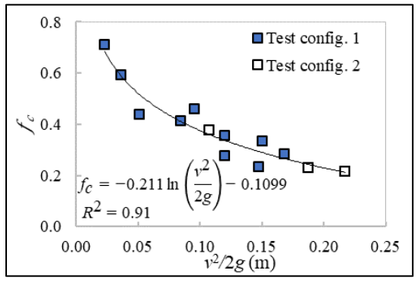
- Superelevation and head losses in curves may determine instantaneous section clogging with an abrupt reduction of tunnel discharge capacity.
- The study determines the experimental values, for horseshoe cross-sections, of the head loss coefficient f_c and C superelevation coefficient. These coefficients decrease by increasing the discharge and the relative water depth.

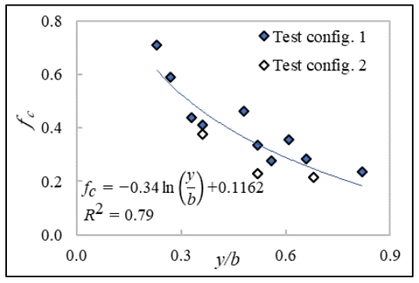
RESULTS

The increase observed in the water depth is conditioned by the local head loss induced by the curve.

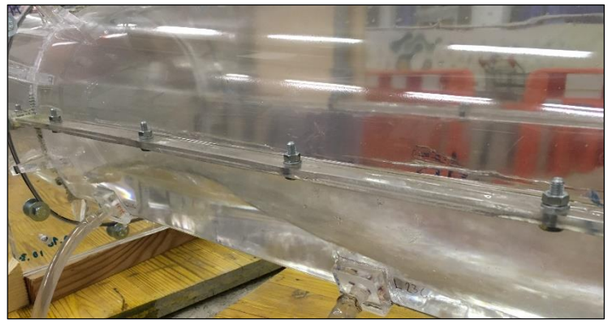


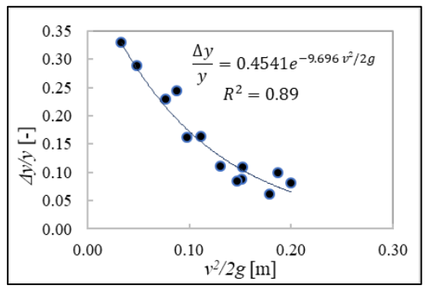
The local head loss coefficient f_c decreases by increasing kinetic head ($v^2/2g$) and water depth.

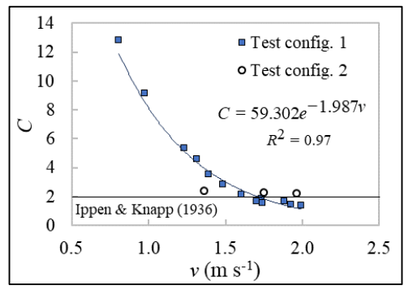




The superelevation coefficient C is greater for lower values of kinetic head and water depth.







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