Behavior of a human body drifting in water at laboratory scale

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Introduction

The search for a human body drowned in water is a problem encountered by firemen. The behaviors of a corpse in water are not well known, essentially due to the complexity of the human body. Its shape, its interactions with the environment and its deformability make its study and its numerical modeling difficult. This experimental project aims to analyse the drag coefficient at laboratory scale, by using dolls in a fume. Three dolls have been chosen, with different morphologies. In the order, Hagrid is bigger, Bruce is at a normal size and Charlie is thinner and has long hair.

Collaboration

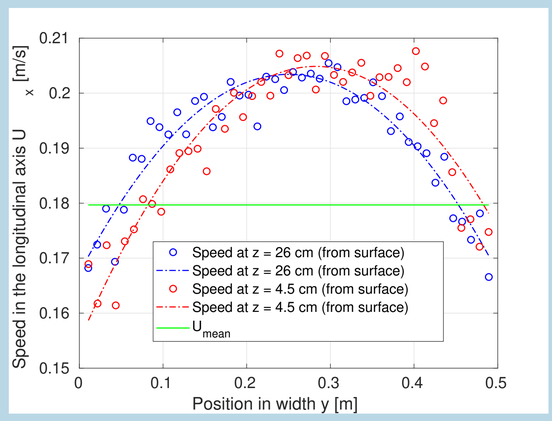
This experimental project was done in collaboration with Clément Delhez (for his master thesis), under the direction of Benjamin Dewals at the University of Liege (BE).

Velocity profile and drag coefficient

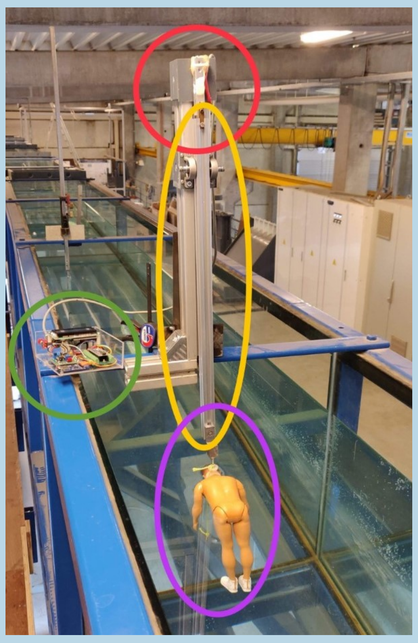
- Determination of the velocity profile: Acoustic Doppler Velocity Profiler (ADVP)

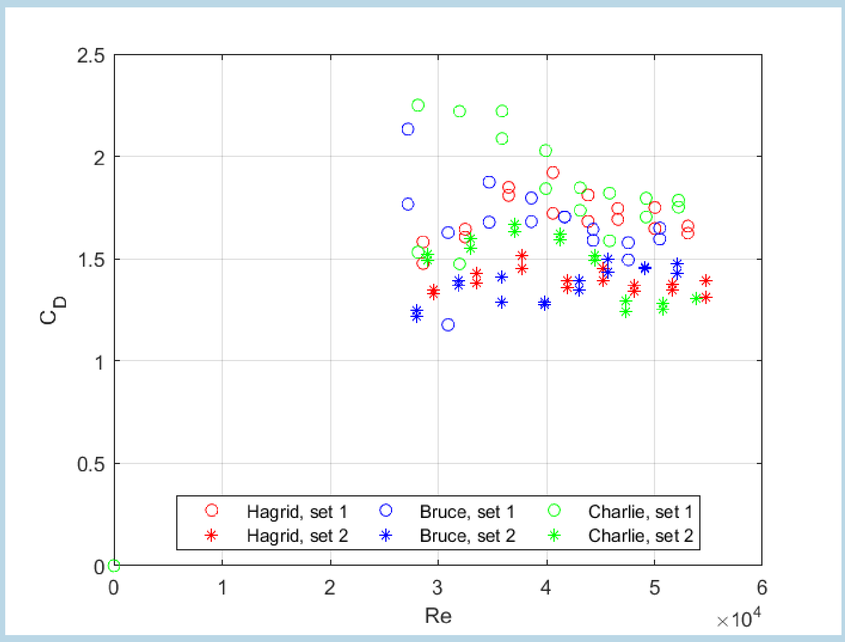
⊖ Velocity profile of the cross section for $Q = 55.7\text{l/s}$.

⊖ Experimental results seem to agree with the theoretical expectation of a parabolic profile.



- Measurement of the drag coefficient at laboratory scale:





⊖ Experimental setup: strain gauge sensor (red), lever arm (yellow), doll fixed on the arm (purple) and digital converter (green).

⊖ Compromise between sensitivity and parasitic perturbations.

⊖ Limitation of the pump of the fume: range of relative Reynold numbers: $10^4 - 10^5$, when it is much lower for a body in river as it accelerates to reach the river speed.

⊖ In the graph here above, set 1 is measurements at the surface, set 2, at 25cm depth, for the three dolls.

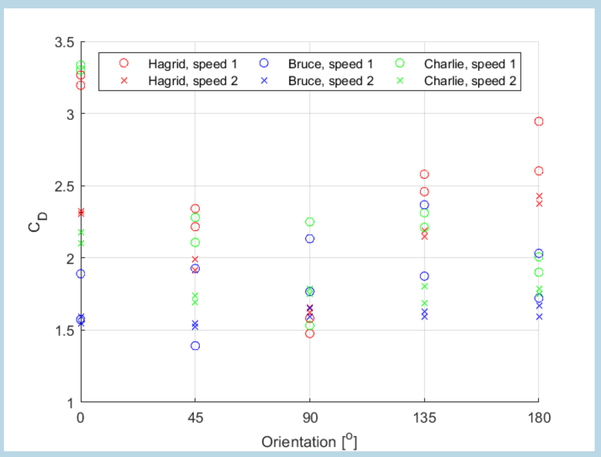
⊖ Drag coefficient: $C_D = 2F_D/\rho_w A U_w^2$
A corresponds to the projected surface area and will be discussed in the next section. Drag coefficient is between 1.4 and 2.3 for the human body. It shows the influence of the morphology and the presence of long hair.

Validation

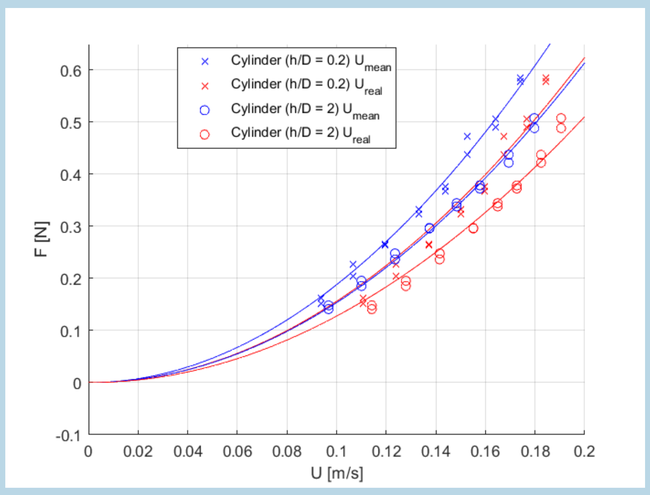
- Body position and angle:

⊖ Position of the body, determined from previous work [1], represented on the right.

⊖ Study of C_D for different angles, and subsequent projected area A with respect to the flow direction. For two speed configurations: U_1=0.94m/s and U_2=0.175m/s.



- Test of the experimental setup with a cylinder:



⊖ Drag coefficient of cylinder is a well known variable.

⊖ Experimental results correspond perfectly to the theoretical expectation, with a correlation coefficient $r^2 > 0.95$. However, for a human body, there is uncertainty due to projected surface area.

References

[1] M. Matheus, de Pablo H. and N. Vaz *An investigation on body displacement after two drowning accidents*, Forensic Science International V.229 pp.6-12 (2013)

Conclusion

-Validation of an experimental setup to determine the drag coefficient for a range of Reynold numbers.

-Tests carried out at real scale in the *Bassin de Carènes*, which highlight that the position extremely affects the drag.

-This project only approaches the final goal of the study, which is being able to model the entire body movement in water, and to make probability charts for finding some drowned bodies in the rivers. To do so, the drag coefficient is essential to model the 2D movement, when the vertical motion is influenced by the biological characteristics of the body (sinking and decomposition). As this project (and the TFE) is one of the first covering this topic, it outlooks many possibilities to study the human body and its characteristics in water.