MAIDESC-T4-D6: Interface meshing for unsteady simulations M18-April 2015

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Summary. Ce court rapport intermediaire illustre le passage d'une technologie isotrope à une technologie anisotrope 3D avec comme illustration le cas ITC2, Rupture de barrage proposé par Lemma pour le projet MAIDESC. Une comparaison entre l'ancien calcul et un nouveau calcul est proposée.

Key words: Multi-fluide, interface, adaptation de maillage

1 Introduction

Lemma a défini un critère d'adaptation anisotrope et a introduit dans sa plateforme ANANAS le nouveau remailleur anisotrope 3D de l'INRIA. Ce prérapport montre les progrès obtenus sur le cas test ITC2, Rupture de barrage proposé par Lemma pour le projet MAIDESC.

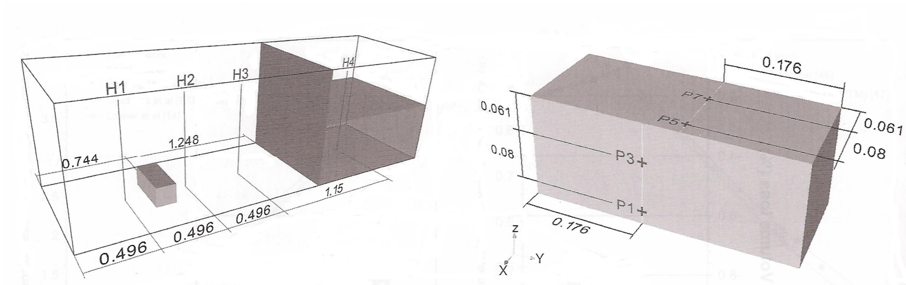

Fig. 1. 3D falling water column on a obstacle. Left, the simulation geometry with the initial conditions and the position of the water height sensors. Right, the position of the pressure sensors on the obstacle. Pictures courtesy of R.N. Elias and A.L.G.A. Coutinho extracted from [1].

2 ITC2: 3D dam break

This three-dimensional example aims at validating the proposed method on a long-time simulation involving a 3D complex interface. The problem consists in a water column falling in a parallelepipedic box containing a cubic obstacle. This experiment has been performed by the Maritime Research Institute Netherlands (MARIN)[1]. Water height and pressure measurements are available on a series of points as functions of time. Their positions in the computational domain are shown in Figure 1. All the test case and experiment data are available on the Smoothed Particle Hydrodynamics European Research Interest Community (SPHERIC)[2].

The experiment involves a violent transient flow with a very complex interface when the water impacts the obstacle and the opposite wall (at a physical time close to 2 seconds). Then, the flow returns to a smooth sloshing mode. Several calculations of this case have been presented in the litterature, see for instance [1] and [3]. They illustrate that long-term accuracy is a difficult challenge. The computations presented here were performed by D. Guégan, [2].

[1] http://www.marin.nl/web/show.

[2] http://wiki.manchester.ac.uk/spheric/index.php/SPHERIC_Home_Page

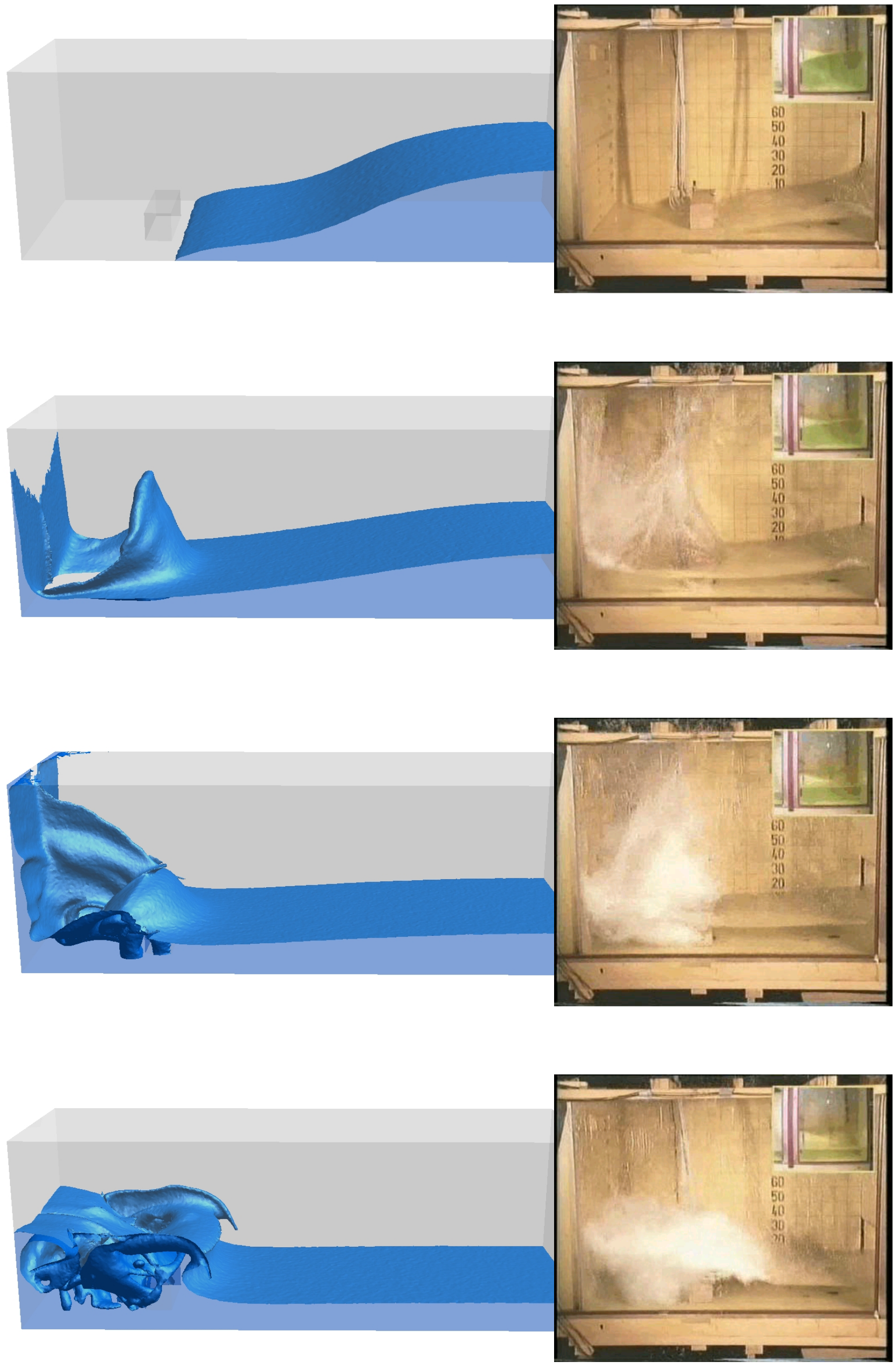

Fig. 2. 3D falling water column on a obstacle. Comparison between the interface obtained in the simulation (left) and the pictures from the MARIN experiment (right). From top to bottom, snapshots for every 0.4 seconds, from time $t = 0.4$s to $t = 1.6$s.

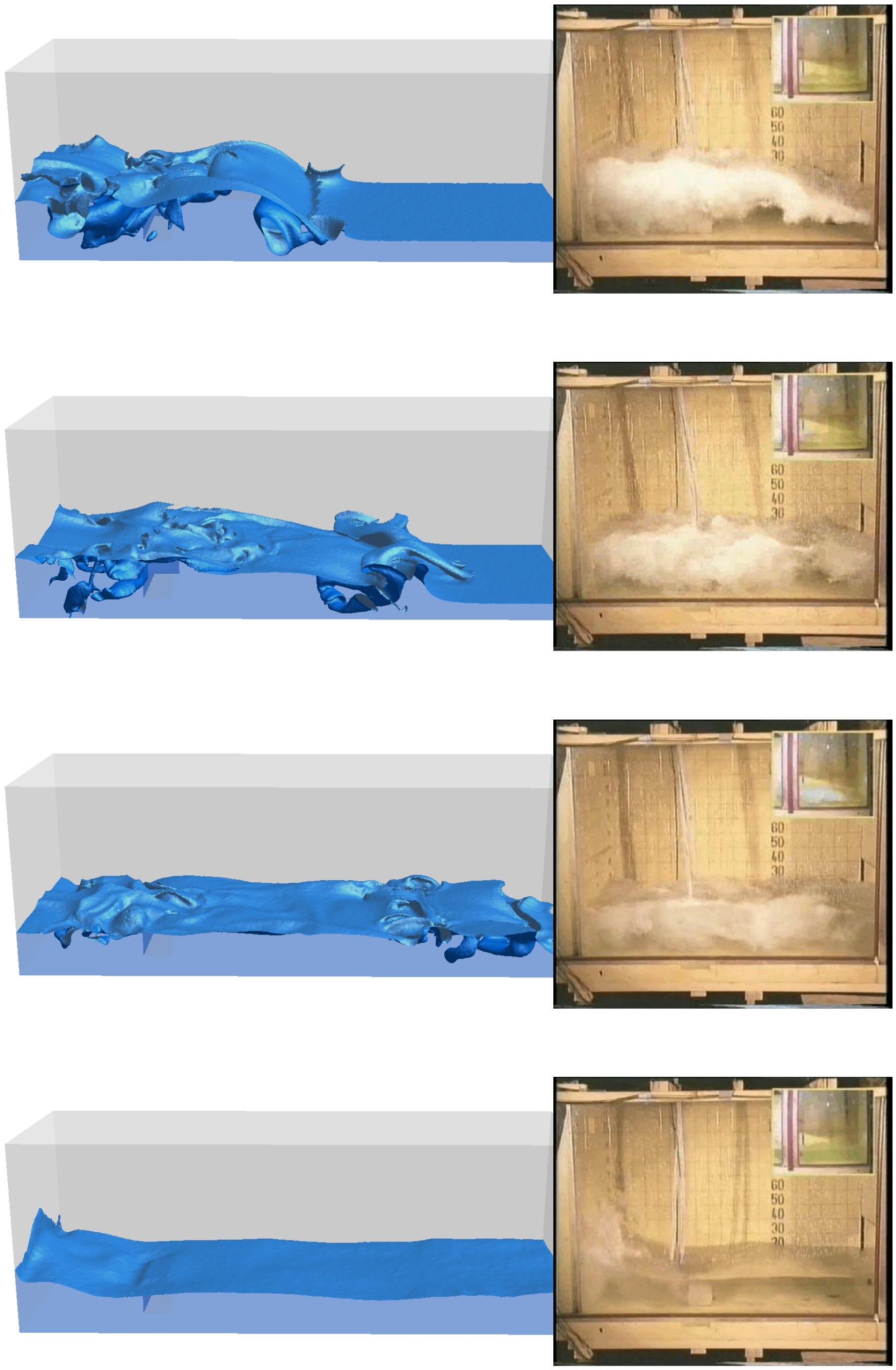

Fig. 3. 3D falling water column on a obstacle. Comparison between the interface obtained in the simulation (left) and the pictures from the MARIN experiment (right). From top to bottom, snapshots for $t = 2$s, $t = 2.4$s, $t = 2.8$s and $t = 5.6$s.

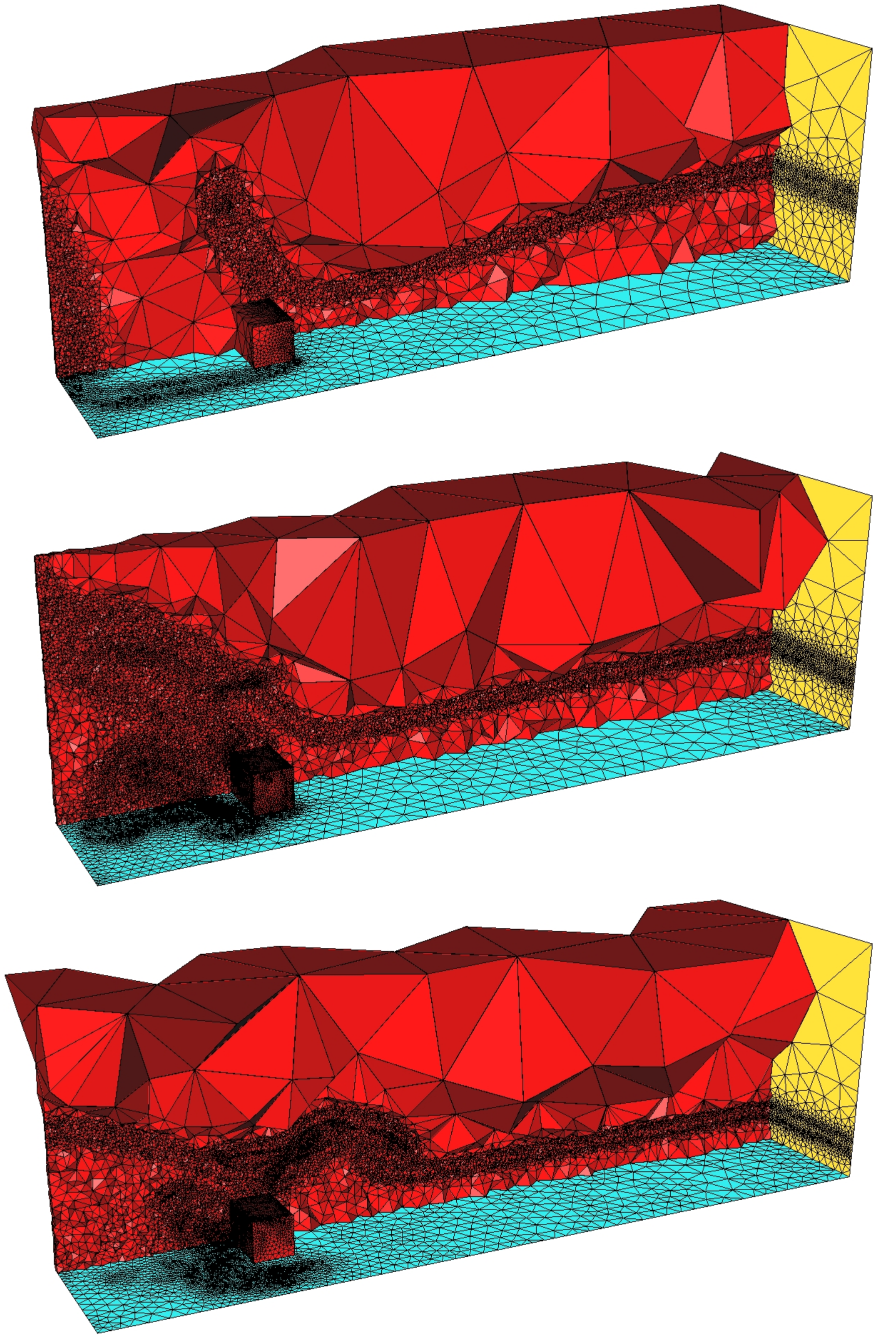

Fig. 4. 3D falling water column on a obstacle. Mesh adaptation based on the interface and moments. Some view of instantaneous meshes on a section of domain at $y = 0.5$m - Top, the mesh at $t = 0.8$s (≈ 250000 vertices) - Middle, the mesh at $t = 1.2$s (≈ 500000 vertices) - Bottom, the mesh at $t = 1.8$s (≈ 900000 vertices).

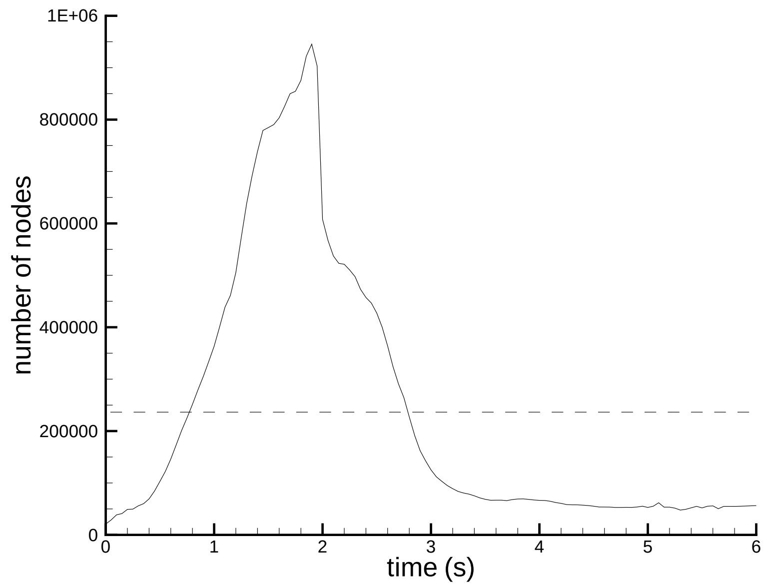

Fig. 5. 3D falling water column on a obstacle. Variation of the number of mesh vertices as a function of time. The dashed line represent the average number of vertices for the whole simulation ≈ 236 400 vertices.

2.1 Previous isotropicly-adapted reference solution

The simulation has been run until a physical time of 6 seconds which corresponds to a forward wave motion, a backward one, and then a second forward motion. As regards mesh adaptation, we apply the method presented in [2] where the mesh is adapted to the interface and the dynamic of the flow. The mesh adaptation is chosen to be isotropic. 120 mesh adaptations have been performed. That is to say, the simulation time interval has been split into 120 sub-intervals of 0.05 seconds.

The interface evolution obtained in this simulation is depicted in Figures 2 and 3 at different physical times. It is compared to pictures of the MARIN experiment[3] (on the right).

The violence of the transient flow at the impact on the obstacle and the opposite wall is illustrated between time 0.8 and 1.2 seconds. First, the impact of the water column on the obstacle produces a powerful jet that falls behind the obstacle. Then, the flow climbs the opposite wall and breaks. The combination of the jet and the breaking results in a turbulent

[3] It is important to note that in MARIN pictures only a part of the domain is represented. The part of the domain where the water was initially held back by the hatch is missing. It represents one third of the domain total length. This missing part is shown by the icon top right of the picture.

flow behind the obstacle. This makes the visual comparison between numerical results and experiment very hard, even if we remark that the simulation is in phase with the experiment. To refine the comparison, the simulation will be confronted to experiment thanks to the water height and pressure sensors. The interface geometry between the physical times of 1.6 and 2.4 seconds demonstrates the complexity of the simulation, notably by the presence of several tube- and veil-shaped structures for the interface. As remarked in the 2D case, with a capillarity model, these structures would transform into drops. The bottom picture of Figure 3 shows the return to equilibrium of the flow at time 5.6 seconds.

Associated adapted meshes used to compute these solutions are presented in Figure 4.

We clearly notice the mesh refinement in the neighboring region of the interface. The behavior of the interface is visible inside the mesh. The top picture shows the jet and the water climbing the opposite wall. The middle picture shows the interaction between the jet and the breaking. The bottom one is the mesh for computing the end of the breaking with the formation of tubes. Figure 5 plots the evolution of the number of vertices with respect to the physical time. We observe that the mesh size is highly dependent of the flow behavior. At the beginning of the simulation and for physical times greater than 3 seconds when the flow is smooth, adapted meshes with only 50 000 vertices have been generated to achieve the prescribed accuracy. On the contrary, an adapted mesh with almost 860 000 vertices has been generated just before $t = 2$ seconds to simulate accurately the breaking wave after the impact on the wall when the flow becomes complex. The average number of vertices for the whole simulation is approximately 236 400.

2.2 Anisotropicly-adapted new computation

The new computation has been performed with a mean number of vertices of about 1000000, notably coarser. The calculation was stable and took a four times smaller cpu time.

The results, quite preliminary show a rather good accuracy, probably less good than for the first caculation. See Figures 6,7,8, 9,10.

3 Remerciements

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References

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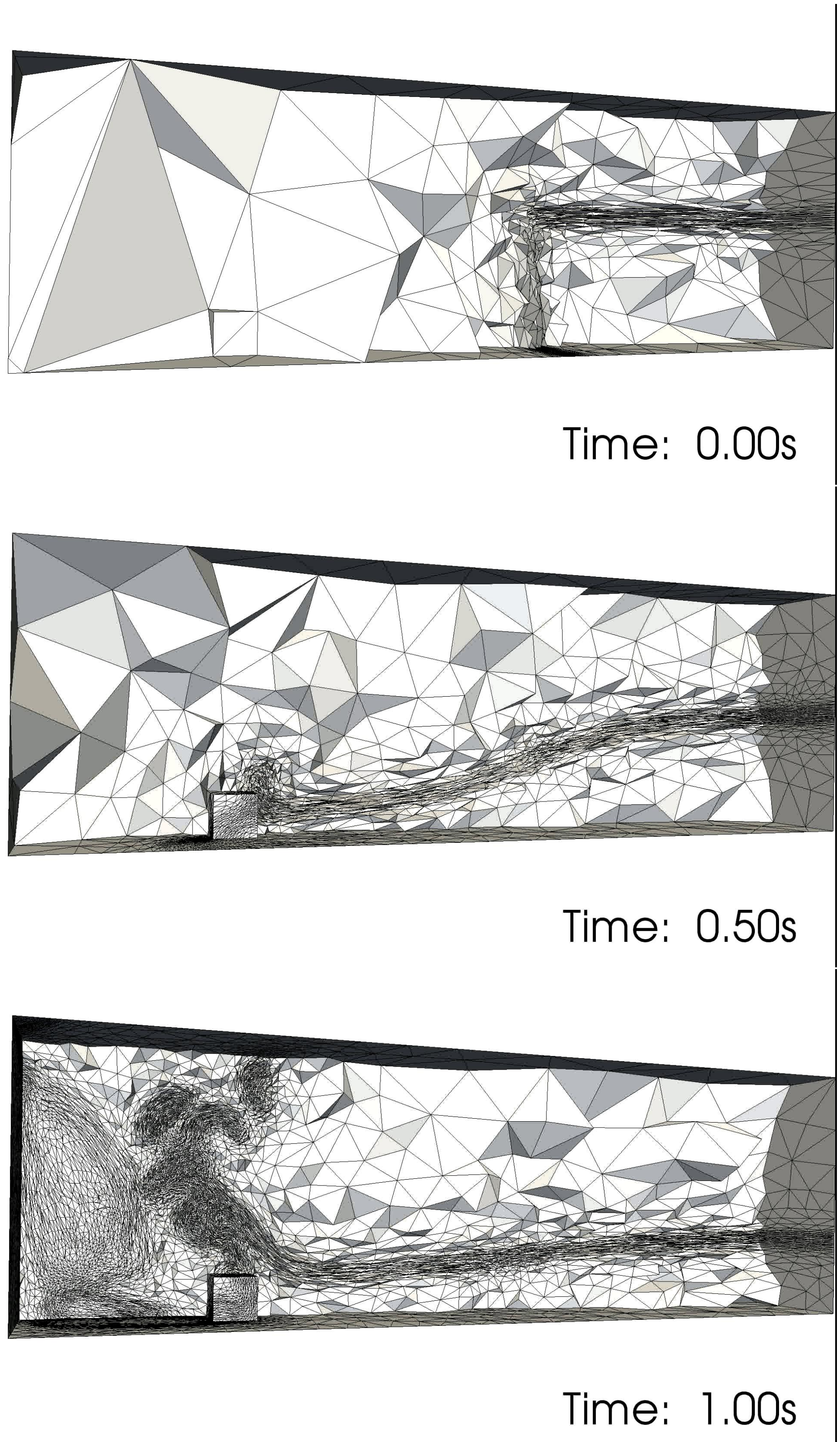

Fig. 6. 3D falling water column on a obstacle: Anisotropic mesh

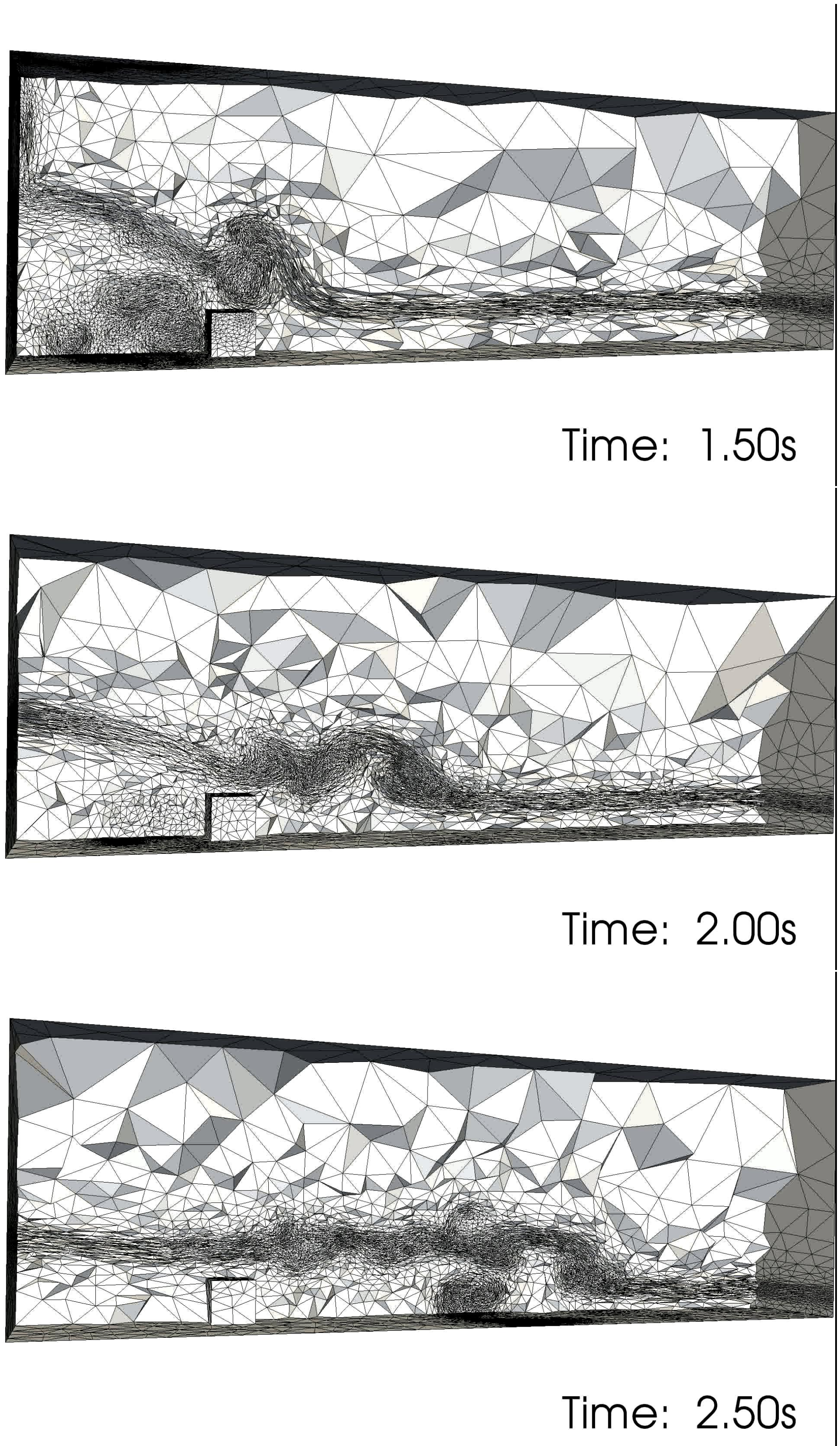

Fig. 7. 3D falling water column on a obstacle: Anisotropic mesh

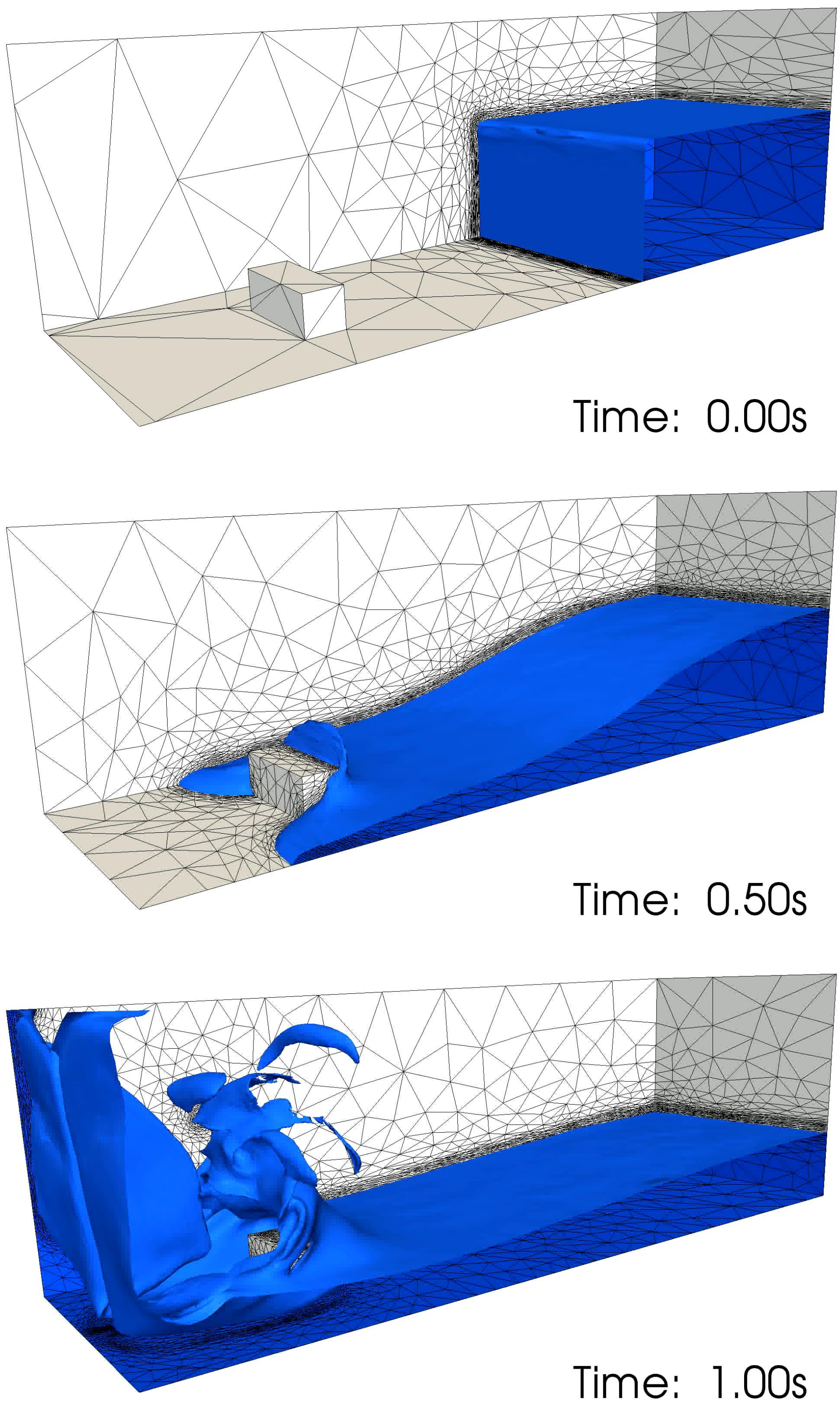

Fig. 8. 3D falling water column on a obstacle: Anisotropic case : interface

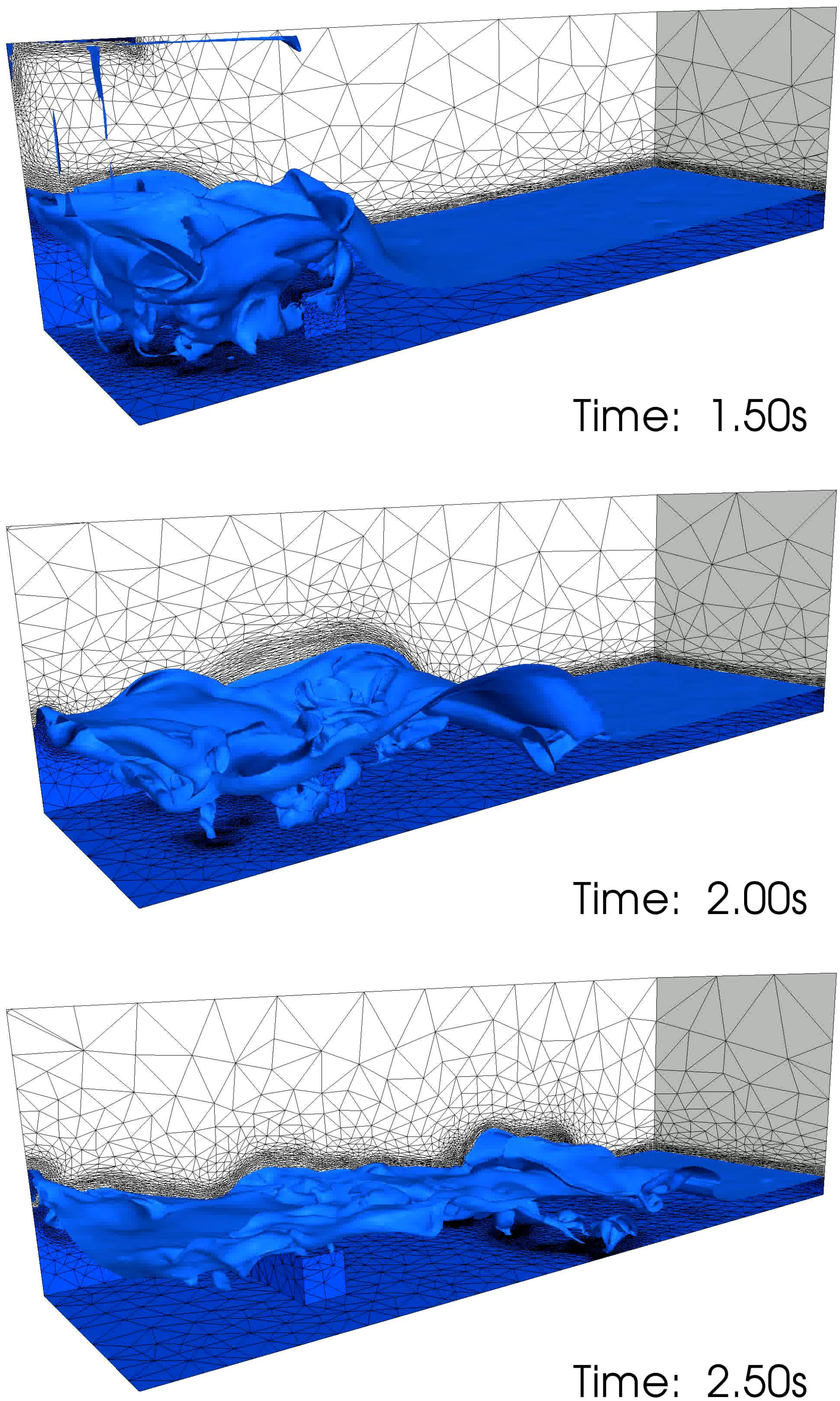

Fig. 9. 3D falling water column on a obstacle: Anisotropic case : interface

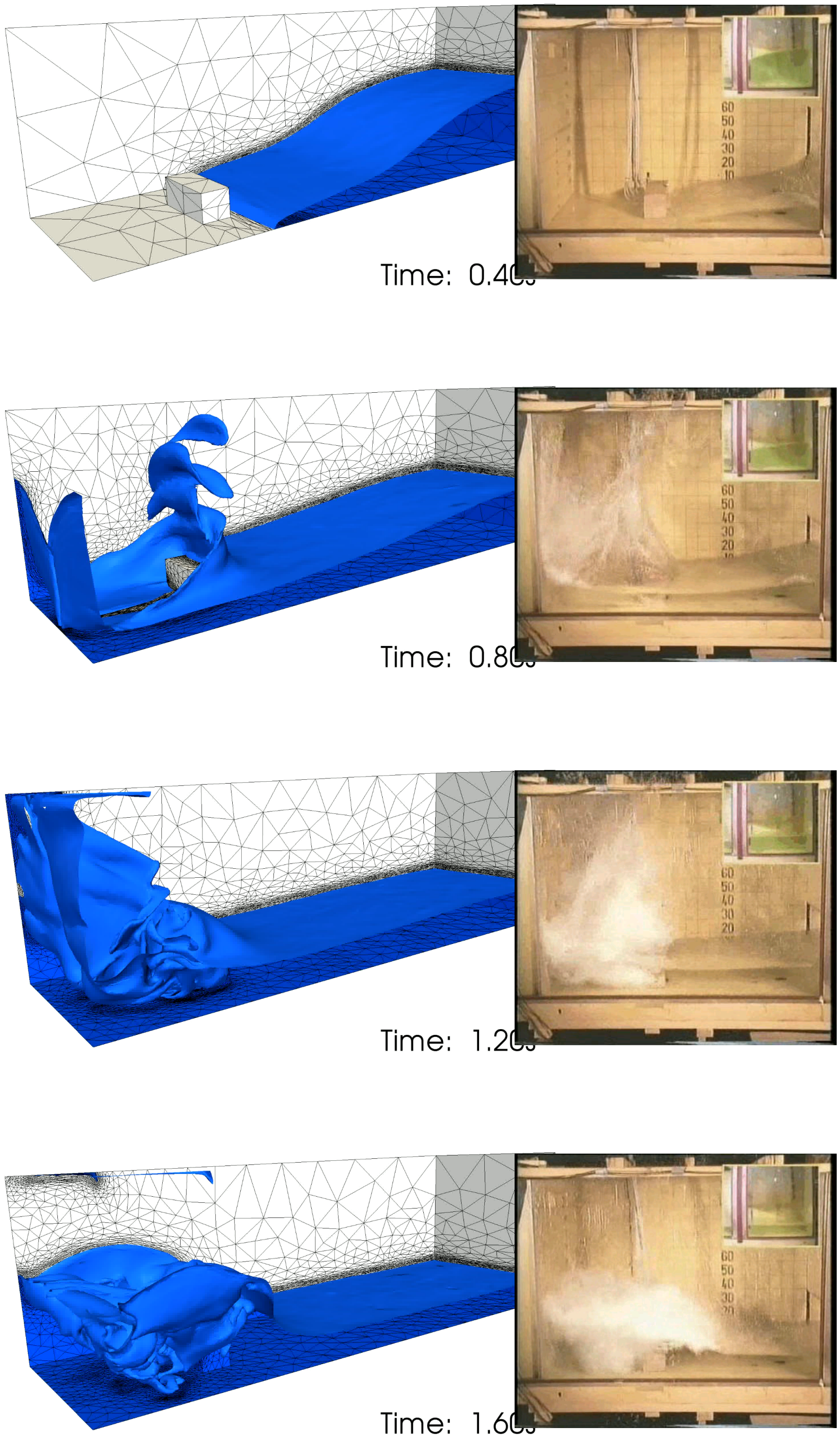

Fig. 10. 3D falling water column on a obstacle. Comparison between the interface obtained in the simulation (left) and the pictures from the MARIN experiment (right). From top to bottom, snapshots for every 0.4 seconds, from time $t = 0.4$s to $t = 1.6$s.