Deliverable 7: Construction of the scaled-down physical model

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ABSTRACT

Deliverable D7 pertains to the development of a scaled-down prototype. The nature of this deliverable encompasses the delivery of said prototype. For the sake of thoroughness, a concise description of the model is provided, accompanied by an overview of the materials and structural components utilized during the construction phase. This deliverable is further enhanced by the inclusion of representative drawings, three-dimensional views, and photographs documenting the construction process.

1. Introduction

Scaled down experiments of Oscillating Water Column (OWCs) devices serve as a practical and insightful endeavor in the field of renewable energy research, aimed at elucidating the mechanisms of wave energy conversion. This deliverable D7 details the meticulous construction process, from initial design elements and material selection to assembly techniques, with the objective of providing a comprehensive framework for building a functional model. This deliverable is further enhanced by the inclusion of representative drawings, three-dimensional views, and photographs documenting the construction process.

2. Physical model components

The physical model constructed for the experimental verification of the **ETHOS** design followed a geometric similarity to the real structure (refer to D4). A 1:20 scaling ratio was selected, after considering the wave climates prevailing at the **ETHOS** candidate installation locations and the wave making capacity of the experimental tank.

The tests are planned to be conducted in the experimental seakeeping tank of NTUA, having dimensions of 90m length x 3m depth x 4m width (see Figure 1). The model will be placed in front of the wave making facility, which will be used for the simulation of the examined sea states.

Figure 1: Experimental wave flume, Laboratory for Ship and Marine Hydrodynamics NTUA.

The model is composed by the following main parts:

- A cylindrical air chamber designed with a reduced draft.
- A cylindrical air chamber featuring an increased draft, which encases the chamber with reduced draft.
- A conical dome that serves as the upper portion of the OWC chambers.

- Mooring wires and an anchor base that form part of the mooring system.
- Various types of orifices situated at the apex of the conical dome.

The design of the above parts is shown in the following figures, together with representative dimensions of each component at model scale.

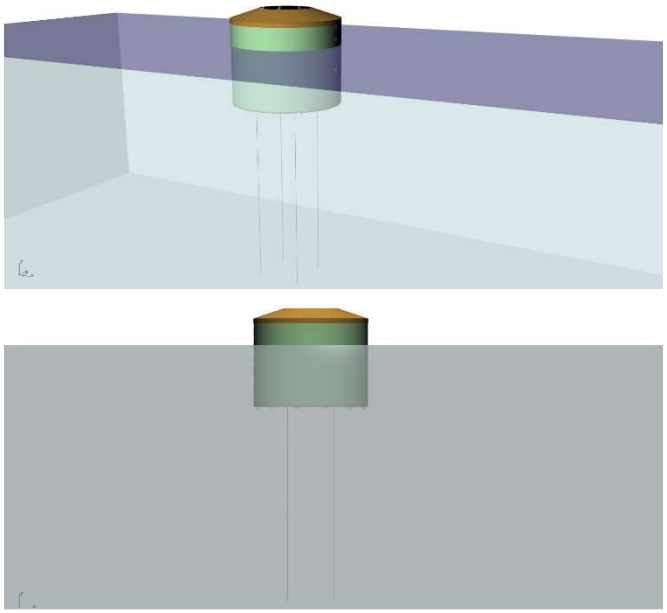
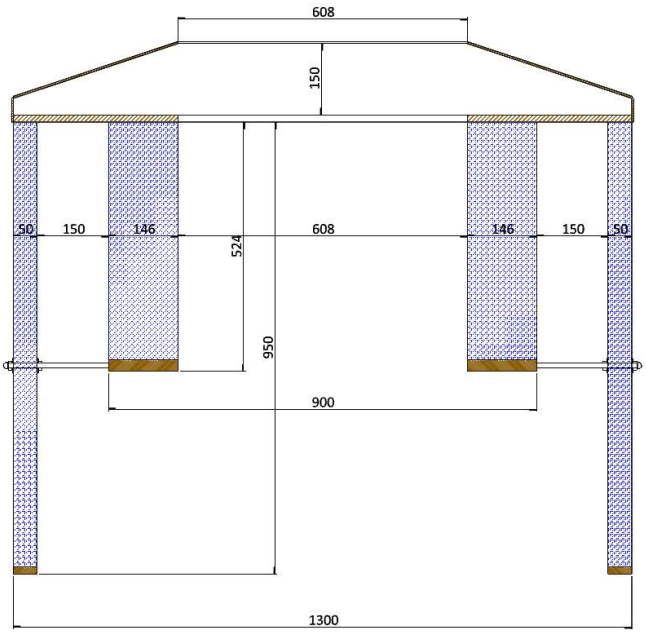


Figure 2: **ETHOS** scaled down OWC assembly: plane view (upper image); side view (lower image)



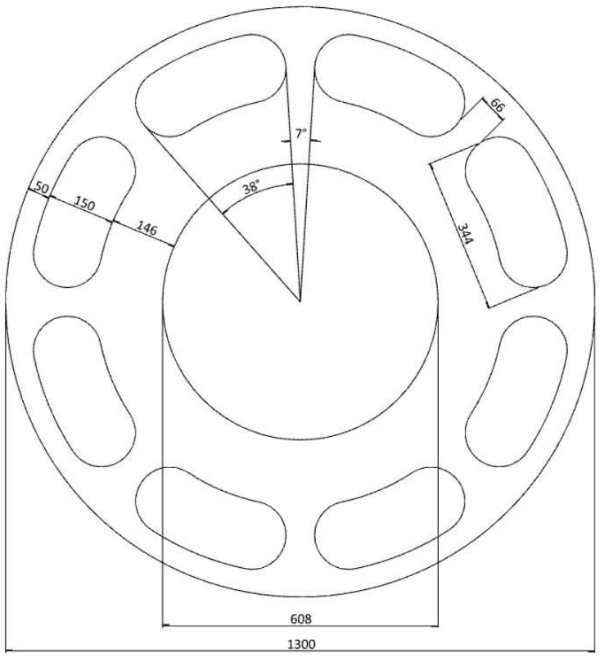
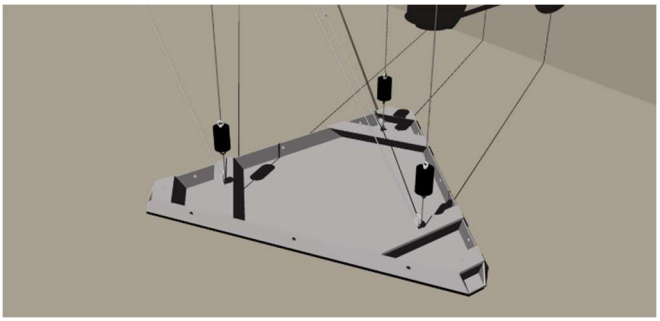


Figure 3: **ETHOS** scaled down OWC (sc. 1:20): dimensions of the floater in mm (upper image); dimensions of the oscillating chambers' cross section areas (lower image)



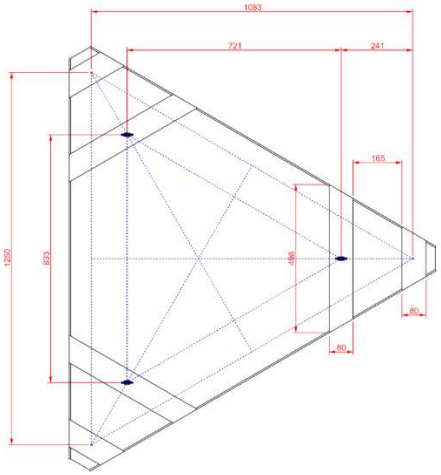


Figure 4: Mooring tendons and bottom base

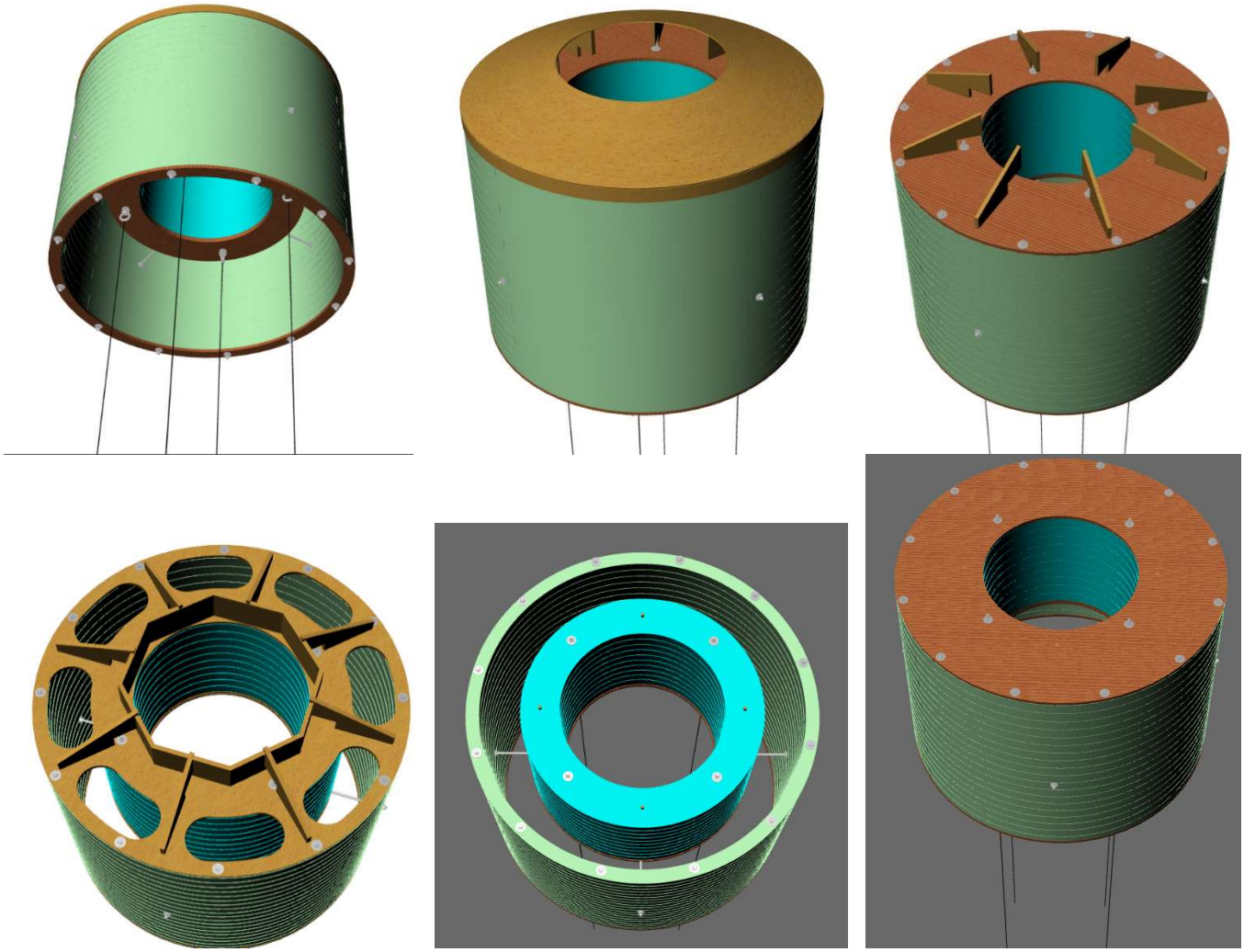


Figure 5**:** 1:20 **ETHOS** model general views

Table 1 presents a summary of the principal geometric characteristics of the OWC under consideration in full scale and scaled down.

Table 1. Floating cylindrical body geometry.

Dimensions	Full Scale	1:20
Depth of the outer pontoon below Sea Water Level (SWL)	14m	0.7m
Depth of the inner pontoon below SWL	5.5m	0.275
Elevation of the oscillating chamber above SWL	5m	0.25m
Outer radius of outer pontoon	13m	0.65m
Inner radius of outer pontoon	12m	0.6m
Outer radius of inner pontoon	9m	0.45m
Inner radius of inner pontoon	6.08m	0.304m
Height of the conical dome	3m	0.15m
Initial diameter of the orifice	6.08m	0.304m

3. Model construction

The ETHOS model was constructed using a variety of materials, each selected based on the specific role of its corresponding component within the converter. The two coaxial cylindrical floaters were created from Expanded Polystyrene (EPS) (refer to Figure 6), while the total volumes were fabricated by composite materials, thereby creating a smooth waterproof exterior for the composite structure. For the formation of the orifice area, specialized diaphragms were crafted from plywood (see Figure 7). Additionally, plywood was employed in the construction of the conical dome (refer to Figure 8). The orifices, featuring various diameters, were also constructed from plywood (see Figure 9).

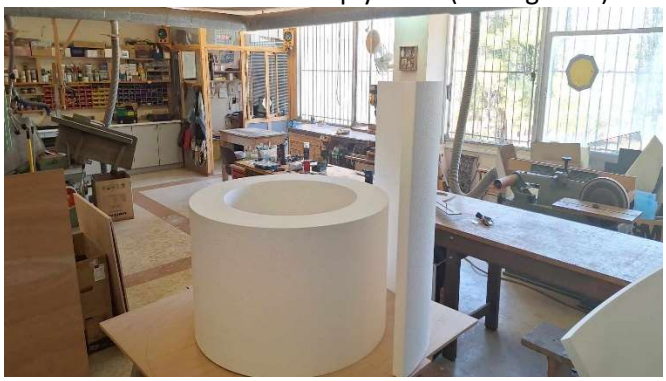


Figure 6: Construction process of the two coaxial cylindrical floaters made of expanded polystyrene

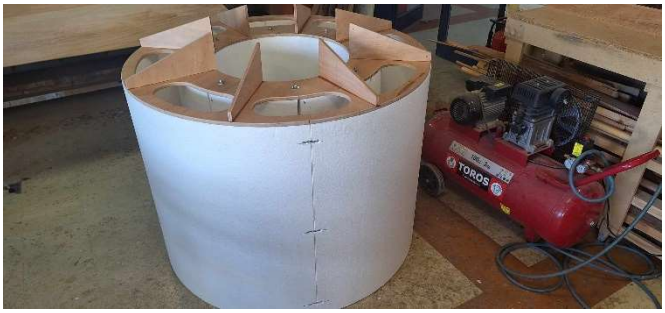


Figure 7: Construction process of the openings in the air oscillating chambers made from ply wood

Figure 8: Construction process of the conical dome made from ply wood

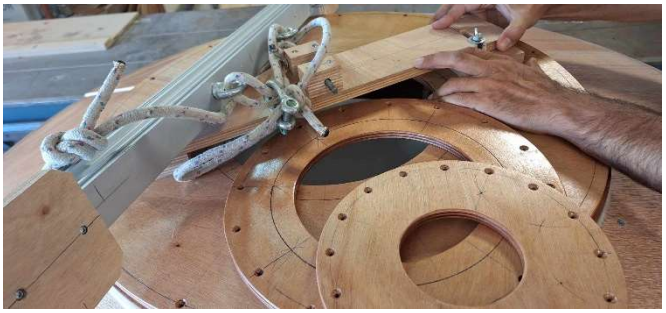


Figure 9: Construction process of the different orifices made from ply wood

The aforementioned materials were chosen for their ability to provide adequate strength while maintaining a lightweight structure for the converter. to achieve the desired displacement. The total weight of the initial model was measured to 38.2 Kg. The center of gravity of the construction was experimentally measured (fig. 10), 70cm from the bottom of the model. The model was hanged from various in height positions until it balanced at a horizontal position. To reach the desired draft without pretension (45cm) extra weight were distributed inside the model chambers, underneath the inner cylinder and at the top of the deck. The new center of mass was calculated to 77.465cm from the model's bottom, or 7.465 cm above the initial CG. In

light of this, a detailed weight breakdown is provided in Table 2.

Figure 10. The initial vertical CG of the model measured experimentally

Table 2. Weight breakdown

Description	**Weight (kg)**	**Vertical Position from the model's base (cm)**
Initial Model	38.2	70
Weights Underneath the inside cylinder	19.050	40
Weights inside the chamber	35.45	98.5
Weights at the top deck	4.5	116.3
Sum	97.2	------

Finally, a side view of the constructed ETHOS scaled model is presented in Figure 11. Additionally, Figure 12 illustrates the openings in the air oscillating chambers.

Figure 11: ETHOS scaled down model

Figure 12: Inside view of the ETHOS oscillating chamber

4. Conclusion

A scaled-down model of the **ETHOS** device was constructed for experimental work at the LSMH of the National Technical University of Athens (NTUA). The model was designed in accordance with the dimensions of the wave tank to accommodate the specific general arrangement of the OWC (refer to D4), as well as to simulate operational and extreme sea state conditions relevant to the selected location in the Aegean Sea (refer to D2). The chosen scaling parameter for this model was 1:20. The present prototype will be utilized in the wave tank for the proposed scaled-down experiments.

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Competing Interests

The authors declare that that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript