SALME LAEV hydrodynamic experiments in towing tank of SCC

Introduction

Salme Laev is a historic vessel from the epoch of Vikings which remains were found in Salme (Saaremaa Island, Estonia). Found details told the maritime historians that it was a Swedish boat that may have sailed either by oars or under the sail. **Length of the boat is about 17,5 m** and this is the only size that we can trust, because the boat was totally crumbled into dust. **Approximate width of the boat is 3,40 m**.

The lack of accurate information about dimensions of the vessel and its elements makes it difficult to recreate the hull shape. Therefore, assumptions about the hull shape had to be done on better-preserved vessels from the same era. Also assumptions regarding the regions of origin had to be made.

According to the historian's version, Swedes used to sail on Danish or Norwegian type of boats. For sea voyages and crossing Baltic Sea they had to use sailing boats. The Norwegian type of Viking sailing boat is represented in Gokstad as a full copy of the historical vessel. Therefore, as a basis we take the Gokstad Viking ship, believing that the shape of Salme Laev is similar to that ship. It means that we know more or less the range for the block coefficient of our boat.

Using this knowledge, we found all boat dimensions including displacement and draught. Following the taken assumptions, displacement is about 9,5 t and draught is 0,8 m.

Partly we can check the truth of this hypothesis, trying to estimate the weight displacement of the boat. We know that Norwegian Viking ships were made of oak. Regarding Swedish boats, we can also suppose that they used to build their vessels with combination of oak and pine, because there are much more pine forests at Sweden coasts than in Norway. Keel and beams were made of oak and planking made of pine. Medium thickness of this planking was 15 mm… In addition to their conclusions, historians detected that the number of rowers aboard the vessel was 16. It means that they travelled in crews of 16-20 people in total.

All this information will be taken into account in drawing and milling of model.

So, we have a drawing of historic Salme Laev based on hypothesis and assumptions. The following towing test might confirm some of them or disprove it.

Analysis of the experiment results in towing tank must answer the following questions:

1. What was the stability of the vessel?
2. How fast were Viking boats?
3. How good was the shape of the boat from hydrodynamic point of view?
4. How Viking boat kept the speed in the stormy sea?
5. Does the vertical position of propulsion significantly change the performance of the vessel in speed performance?
6. How would the Salme boat comply with the today's stability requirements?

Technical specification

1. Salme Laev

The main dimensions of the boat are followings:

- LOA = 17,5 m
- BOA = 3,4 m
- Displacement = 9,5 t (TBC):
- Dmin = 9,5 t
- Dmax = Dmin + full loading

The Salme Laev has wooden planking that makes a shape of the boat ribbed. In addition, the original vessel could sail under the rectangular sails as well as be driven by oars. All these facts must be taken into account in the experiment.

2. Model

The test model will be produced at Composite Plus factory in **model scale 1:5.83** (length of the model is 3 m). Model should be equipped with accelerometers to measure the acceleration at bow, aft and at LCG as well as gauges for measuring the water resistance and vertical movements of model (at bow, aft and at LCG).

The position of Load Cell should be different for two types of sailing. When we test model simulating the rowing it is logical to locate the Load Cell in crossing point of the LCG and WL, because the propulsion force from roars is approximately in the water flat. But in case of sailing under the sail we should use other arguments. The propulsion force from the wind is gathered on the sail and transfer to the hall by the mast. So, it would be correct to locate the Load Cell at the middle of the mast.

The test programme includes resistance test, roll decay test and head see test. It would be interesting also to make a following seas test for the case of sailing under the sail, but it is difficult to execute the following sea test in SCC towing tank. So, to run the test we should make a radio controlled version of the model and test it outdoors.

The model test result will be scaled to a full scale using the ITTC-78 extrapolation method.

The test program

Before the experimental part, we arrange all static characteristics of the Salme laev basing on theoretical design and technical drawings of the vessel. It gives us more information about the exploitation limits of the original vessel.

1. **Resistance test**

   During this test the following parameters should be measured:

   - Speed
   - Towing force
   - Draft change at bow and stern

The resistance test should be done at 2 loadings (design and maximum loads) and for the range of the vessel speeds between **3 and 13 knots**. (for example, 3, 5, 7, 9, 10, 12, 13). The arguments for choosing this range are following:

> We know that after Gokstad boat crossing the Atlantic it was announced, that she had maximum speed of 15 knots under the sail. It means that the same limit for Salme boat (17,5 m) will be about 13 knots and even less. Speed of 13 knots (6,7 m/s) corresponds to model speed of 2,8 m/s. In the same time the minimum speed is taken as a reasonable speed for leisure rowing or sailing in light wind. Therefore the range of model speeds could be about 0,5 - 3 m/s.

Resistance test will be performed for different position of the Load Cell (modeling the rowing and sailing conditions correspondently). Inside the sailing conditions experiment we also will check the influence of the sails height for the boat speed performance by changing the vertical position of LC.

2. **LCG optimization**

This test should help us to find out how the loads were distributed along the length of the boat. This information will allow to look at the propulsion quality of the boat in loaded condition, when Vikings went back home after their voyages across the Baltic sea.

LCG optimization test comprising resistance test with different position of LCG.

3. Roll decay test

Roll decay test will be carried out to determine the roll damping characteristics of the vessel, to estimate the natural roll period and the coefficient of damping. The model of Salme boat will be tested for dynamic stability for 2 loading conditions. The model should be ballasted to correct GM. At 0 speed and design speed the model will be given a heel impulse and the roll motion will be measured by gyro.

4. Head sea test

During this test the following parameters should be measured:

- Speed
- Towing force
- Draft change at bow and stern
- Accelerations at three positions; bow, stern, LCG

The head sea test will be done on irregular waves for two loading conditions and only one position of LCG (only rowing) at the same range of speeds with the resistance test.
The typical for the Baltic sea wave height in rough weather is about 2,0-3,5 m. We should use one of the wave profile with significant wave's height.

The tests will be documented by photos and video (above the water surface). The evaluation and analysis, report and test documentation, comments and photo/video copies will be included.