Present day activities of the Ilawa experimental centre

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Abstract

Paper presents activities of the GUT Experimental Centre in Ilawa in the recent years. Its main tasks have been organizing international student scientific camps and sailing courses for GUT students. For that purpose the laboratory and hotel facilities of the Centre have been modernized and new measurement techniques implemented. The conclusions outline possibilities of future use of the Centre.

Keywords: *Gansk University of Technology, Faculty of Ocean Engineering and ShipTechnology, experimental centre, Fundation for Safety of Navigation and Enviroment*

At the beginning of the 1990s, administration of the Ilawa Centre was taken over by the Foundation for Navigation Safety and Environment Protection, established on 10 May 1990 by the Gdansk University of Technology, Maritime Academy in Gdynia and Town of Ilawa. That was caused by moving the ship master training courses to lake Silm (September 1990) and by shortage of research orders from the industry due to generally bad financial situation of the shipbuilding industry. In the following years some limited business activity was carried out in the Centre. Formal takeover of the Centre by the Foundation took place on 30 April 1993 and was based on an agreement with the Gdansk University of Technology, where 25% of the Centre capacity was put free of charge at the University's disposal. That was quite sufficient for the Ship Hydromechanics Division. At that time model tests were performed of fast craft, financed from the Scientific Research Committee grants won by prof. M. Krezelewski and assist. prof. W. Welnicki. At the same time the Centre business activity consisted mainly in constructing platforms on Jeziorak lake, carrying out technical work for the lake Silm Ship Handling Centre as well as hauling ashore, winter harbouring and summer mooring of private yachts.

In 1997, on the initiative of the then Dean of the Faculty of Ocean Engineering and Ship Technology prof. K. Rosochowicz, an International Ship Research Student Centre (ISRSC) was created in Ilawa, whose task was to run international scientific training camps for the shipbuilding faculty students from all over the world. It should be mentioned here that scientific training camps for the GUT Shipbuilding Faculty students were organized in Ilawa as early as the second half of the 1960s. In order to popularize the international student centre, an intensive information campaign was organized among the technical universities with ship technology faculties, coordinated by dr. M. Gerigk. The efforts of the Faculty were crowned by two international meetings in Ilawa in July and September 1998 - Ilawa-ISRSC-Workshop'98, presenting the Centre to the foreign partners. The participants were representatives of WEGEMT, ABS, VBD Duisburg, TU Berlin, TU Denmark. Also a leaflet was prepared and issued describing the Centre's facilities and a programme of possible practical training. It included also manoeuvring exercises in the lake Silm Ship Handling Centre run by the Foundation for Navigation Safety and Environment Protection.

Thanks to the very positive opinions about setting up the International Ship Research Student Centre received from foreign universities, liquidation of the Centre, looming at the end of 1990s, could be avoided. Its area was to be taken over by the town of Ilawa for recreation purposes. But a measurable effect of those meetings was obtaining financial means from the American Bureau of Shipping for procurement of the measurement equipment.

In the same year two scientific camps were organized for the GUT Faculty students and the second one coincided with the above mentioned July Workshop. One of their tasks was to prepare the Centre for student training, which included setting everything in order, preliminary preparation of models and presentation of the Ilawa Centre potential to the foreign observers. In practice, there were no critical opinions about the laboratory facilities - unique in the world - but there were some problems at that time with social amenities in the Centre. For that reason the maximum number of students in one course was limited to eight persons.

In July 1999 the Centre was taken over by the Gdansk University of Technology. Three scientific courses for the GUT students were organized from June to August of that year with a similar objective - preparing the Centre and working out a practical model of the international training courses.

In 2000 the international student courses started. Four courses were organized with participation, among others, 4 students from DTU in Lyngby.

Fig. 1. *Preparing a model for tests*

At the end of that year a complex restructuring of the Centre social part was begun. The Dean's representative for the Ilawa Centre development was appointed Mr. J. Światek. Workshop and motor store were liquidated and modern lavatories installed for students, employees and guests, including those for disabled persons. That part of work was finished in June 2001. A high capacity central heating boiler was installed, which allowed to liquidate the bathroom and kitchen water heaters and a separate hotel and boatswain's lodge central heating systems. Another major change made in 2001 and 2002 was rebuilding of the former joiner's shop. It was divided into two parts. One was made a store of the fast craft small models and the other - a store of measurement apparatus and a computer room where test results may be processed. In 2002 the hotel part was modernized. Small single-bed rooms were combined into two larger dormitories. Now the Centre can lodge twelve persons in a decent standard conditions. In the spring of 2005 the old roof of the social building was replaced by a new light roof with thermal insulation. At the same time replaced were all windows as well as the central heating, gas and electrical installation, and also the kitchen equipment - cookers, fume hoods etc..

Some time at the turn of the century a student practical training programme was shaped. Students of our Faculty had the practical training after the third year of the MSc studies. It was decided that the training would be concentrated on testing non-conventional units, in accordance with the Centre's tradition, and on manoeuvrability exercises on the Silm lake Ship Handling Centre facilities. Four standard models were prepared: a skimmer unit, SWATH type catamaran and two hydrofoils: single hull and twin-hull units. The models are towed by the „Badacz-2" towing platform. The number of trainees should not exceed eight persons. This is in order to maintain the necessary safety conditions on the relatively small „Badacz-2" catamaran.

The first days are devoted to learning the measurement technique used and operating the measurement apparatus and also the gauge calibration. Besides, instruction is given on the industrial safety requirements and general behaviour during the exercises. Simultaneously lectures are presented on the fast craft problems and the manoeuvring qualities of modern ships. During a two-week stay students visit the town of Ilawa and its surroundings on a full day trip by the „Konrad" motorboat around Jeziorak lake.

Standard tests consist of the measurements of resistance, towing speed and position of the unit in relation to water. An extension of those tests is testing of the transverse and longitudinal standstill stability and stability as a function of speed. Besides, dynamical stability at the operational speed is also tested. All the test results are subject to real time computer recording, which allows to analyse and interpret them later in full scope.

Another objective of those exercises is practical learning of the manoeuvring qualities of contemporary ships. Therefore, students perform personally a cycle of manoeuvring tests, in accordance with the IMO requirements, on a selected model from the Ship Handling Centre fleet on Slim lake. During the manoeuvres the model motion trajectory and other characteristic values are currently recorded. Then students analyse the results and compare them with the IMO manoeuvring standards. One course comprises approximately 60 teaching hours (40 hours of lectures and 20 hours of laboratory work).

In the years 1998 to 2005, the student scientific camps in Ilawa received 203 students, including 45 students from foreign universities, mainly from DTU Lyngby, TU Berlin and TH Bremen. Details are given in Table 1.

Fig. 2. *Hydrofoil model during tests*

In 2002 Rector of the Gdansk University of Technology, prof. J. Rachoń, put forward an idea that each student of our University should have a yachtsman certificate, which is to underline the maritime character of the University. The sailing courses were to be organized in the Ilawa Centre. The „UniSail" programme was started to put the idea into practice. The hotel facilities needed extension and the former hovercraft hangar H1 was converted into two four-bed dormitories and a lecture and recreation room. Also a small kitchen was arranged there. The former measurement equipment store was transformed into living compartments for six persons. Today, 22 persons may be lodged in two camping huts and in the above mentioned additional compartments. After all those extensions of the Centre hotel facilities, altogether 34 beds are available.

The Centre was prepared in 2003 for the sailing courses. However, the courses started in 2004 and 60 students were trained in that year. In 2004/2005 two Micro Polo type yachts were built within the „UniSail" programme for the sailing courses. In 2005, in four courses some 70 students were trained for the lowest yachtsman rank. This year four training courses are planned, organized by the Gdansk University of Technology Yachting Section of the Academic Sports Association (AZS).

The Centre is partly financed from its own activity. The network of yacht mooring jetties has been developed in recent years and now up to 25 bigger yachts can be moored there. The users pay for stay, hauling ashore and winter harbouring and considerable sums of money support the Centre budget. Worth mentioning here is the contribution of Mr. S. Urbański, who was personally involved in the development of jetties in the Centre in Ilawa.

Finally, I would like to underline the uniqueness of our Centre. Nowhere in Europe (and, I presume, in the world) are there such student training facilities available. This has been confirmed by numerous very positive opinions from the Shipbuilding Faculties which sent their students to those training camps. This is also a place and opportunity of cooperation between Polish and foreign students, which may prove fruitful and profitable in the future.

Year	1998	1999	2000	2001	2002	2003	2004	2005
Number of camps	2	3	4	4	4	4	3	3
Number of participants	16	20	32	32	32	31	23	17
Foreign participants	-	-	5	7	6	8	7	12

Table 1 *This year (2006) four camps are planned with many foreign students participating.*

A Historical Review of Ship Model Testing in Open Waters

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Abstract

Specific features of model testing on hydrodynamic ship behaviour will be discussed, in particular with respect to extreme motions in a natural seaway of open waters. Ship model features described are model scale, water tightness, auto - pilot and remote control, data recording, testing procedures and choice of model situations. Wave gauges supported by buoys allowed measuring seaway. Logistics of open water model testing is compared with new procedures in water tanks generating seaway extremes. A short glimpse is given concerning results found with respect to ship capsizing in random seas. Some photographs allow a lively remembrance of early activities in model runs on a lake many decades ago.

Keywords: *Capsizing of ships, free-running ship model, open water testing, random seaway*

INTRODUCTION

It has been a great pleasure to have been invited for the celebration of the 50th anniversary of founding the Ilawa Research Centre. For the last years, this Research Centre has become very popular among Bremen N.A. students. They like to come here attending your wonderful summer classes with a lot of instructions and lively demonstrations on various ship and boat types and their hydrodynamic qualities. This year we can also celebrate 30 years of official co-operation of the cities of Gdansk and Bremen, inaugurated in 1976. Both our Naval Architecure Departments of TU Gdansk and of Bremen University of Applied Sciences started to co-operate in 1981. These 25 years of our co-operation has been filled with life on many research projects.

The Ilawa Centre is a very special research facility: It is situated right at the border of a wonderful lake, using the natural waters as a testing ground for ship models. This allows demonstrating the hydrodynamic qualities of various designs, and giving a good insight for students and research. Having the research facilities right at a lake required little investment in the "model basin" itself. Water basin, wind and waves are there just by nature. This idea of using the lake as a testing ground has even led to establishing the Ilawa Foundation for Safety of Navigation and Environment Protection. Pilots and ship officers can use automotive ship models for training of handling and manoeuvring in critical situations. This really has been a success story.

Plön Lake and Eckernförde tests 1961-1968

When the Ilawa Research Centre was founded in 1956, shipping safety was of particular concern due to many ship losses because of the influence of the seaway. Regulations at that time relied solely on the Rahola still water criteria established 20 years before. The general feeling was that a mathematical solution of the extreme ship motions was not within reach for years to come. So conducting model experiments with wave makers in a tank was started. In Hamburg, Grim 1951 was one of the first to study resonance phenomena of extreme roll in following seas. Arndt and Roden 1958 presented their experiments on roll motion in following seas in a Hamburg tank. In the U.S.A., Paulling 1961 published his results on extreme roll motion in following seas measured in a towing tank.

The today 50th anniversary of the Ilawa Research Centre is a nice opportunity to remember the old days when model testing in open waters was started. In the founding year 1956 I was still a student of N.A. However, two years later, after some time at ship-yard, I was very happy to join the young team of Professor Wendel in Hamburg working on new stability criteria. Kurt Wendel (1908-2003) at both the Hanover and Hamburg Universities started thinking on a revolutionary probability approach for safe subdivision of ships (at the same time Robertson independently in the U.S.), which was the basis of the SOLAS equivalent subdivision concept on damage stability (IMO Resolution A.684(17) adopted on 6 November 1991).

Wendel had always been open for new ideas. When Siegmund Roden came up with the proposal to conduct ship model tests on a lake using the natural wind generated irregular seaway, research was started with the aid of Deutsche Forschungsgemeinschaft (DFG). Tests on a lake allowed running the ship model a long distance in any heading towards the waves. Thus it should be possible to detect and study severe conditions of the ship even in irregular seas. This seems to be very simple. However, the seaway at the lake must be measured, and the ship model must be free-running. At that time even information on Ocean seaway spectra was very scarce, but was needed to prove similarity of the waves.

Our very first free running model trial at Plön Lake in the North of Germany was on 15 March 1961. In 1962 at the Symposium on Ship Hydrodynamics in the Institut für Schiffbau of Hamburg University, celebrating the 65th anniversary of Professor Georg Weinblum (1897-1974), Roden and Kastner reported on the results of these capsizing model tests. For the next years we set up some electronic Laboratory in the boat station of the Plön Biological Research Institute, and in 1968 we also used the facilities of the Navy Development Centre in Eckernförde.

It was in these early years, that our team in Hamburg was very excited to learn about a scientist in Poland who had started using a lake for conducting ship model testing. This young Polish scientist was Professor Lech Kobylinski of Gdansk Technical University.

So open water model testing was the new tool to generate a data base for the development of safety criteria of righting arms in a seaway. The Navy had asked Professor Wendel to establish new stability requirements, so we tested various models to cover different ship types and hull shapes. Arndt 1965 reported on the new Navy regulations at STG, and Arndt et al on the working experience with the new requirements at STAB 1982. In fact, those criteria developed in the sixties are still in force today, so they have been quite successful. I always could observe with some satisfaction the improved freeboard on Navy ships that was necessary to fulfil the stability required.

San Francisco Bay tests 1969-1974

To cope with a new ship type, the container vessel, having a fine hull form at large speed, the U.S. Coast Guard supported extensive research by Professor J. R. Paulling at the U. C. Berkeley on ship motion extremes in open waters. I had the opportunity to join the team. Paulling constructed a catamaran research vessel "Froude-Kriloff" to support the measurements in S.F. Bay, with 35 feet length and 12 ½ feet beam, photo at the end of this paper. The vessel carried all equipment for each testing day to the site and back again. The wave buoy was carried at the bow, while the ship model was heaved up between the two cat hulls.

To make the model watertight while allowing quick opening of the hatches we used some special O-Ring construction. Clamps pressed the circularly shaped soft rubber profile into a rectangular shape of the hatch profile, filling the rectangle completely. Any change the vertical position of the centre of gravity of the ship model required opening of a hatch. Two ballast weights had been situated around the main section as far to the side as possible to keep a correct transverse radius of gyration. The weights were bolted to vertical beams allowing 8 different pre-defined height positions. So the vertical centre of gravity G could be changed (example American Challenger, light condition) in predefined increments of 9.2cm, covering a range of initial stability GM up to about 60cm. The roll radius of gyration versus beam was within 0.335 through 0.394.

After launching the wave buoy, it was levelled from a rubber boat, and then this boat was anchored nearby. Test runs were controlled from the large catamaran. The wave buoy was in fact a three-column tension platform that allowed measuring the directional seaway spectrum. Depending on wind velocity, fetch and duration we could find quite stable repeatable conditions. Usually in the afternoon we encountered a typical wind sea with the right model waves. Good guidance was given by observation of the waves in comparison with the length of the ship model.

The initial heading of the ship model to the waves was given by remote control, while during the run a gyro controlled the course automatically. Capsizing could rarely be foreseen by the observers, but followed some probability distribution. A photo of one 1972 extreme roll amplitude measured 1972 is shown on the last page. Kobylinski and Kastner give more details in a book published recently with Elsevier 2003.

Model scale

The Plön models had a scale λ from 25 to 40, which lead to a model length between about 2 m and 3m depending on ship type and design to be tested. In S. F. Bay, model scale of the American Challenger cargo ship was about 30, and of the Sealand-7 container vessel the scale was 55. The models were about 5m in length, which resulted in a model displacement of up to 725 kg! It was naturally hard to handle those large weights in the Bay. So we had a special gantry crane between Froude and Kriloff for launching and retrieval. To right the capsized model by hand was impossible, so we used a long pole with a weight at the end to be attached to the bottom of the model after she had capsized. The new weight balance of model plus pole turned the model to the right position again. The pole fell off and was recovered by a safety rope.
The motion behaviour of the ship model follows Froude's Law. Ship and model quantities according to Froude correspond as follows:

Length: $$\frac{L_S}{L_M} = \lambda$$

Time: $$\frac{t_S}{t_M} = \sqrt{L_S / L_M} = \sqrt{\lambda} \qquad (1)$$

Weight force: $$\frac{F_S}{F_M} = \frac{\rho_S}{\rho_M}\sqrt{\frac{L_S^3}{L_M^3}} = \frac{\rho_S}{\rho_M}\cdot\lambda^3$$

Speed: $$\frac{V_S}{V_M} = \sqrt{\lambda} \qquad (2)$$

Angular velocity: $$\frac{d\alpha / dt_S}{d\alpha / dt_M} = \lambda^{-0.5}$$

Acceleration: $$\frac{a_S}{a_M} = \lambda^{-1} \qquad (3)$$

The scale effects must be taken into account not only in evaluation of the measurements, but already in the model preparation. The choice of the geometric scale λ of the ship model depends on the length of the waves in the test area and the displacement needed to carry the measuring equipment. Scale λ determines the model weight to be handled. Of particular concern is the time scale. It affects the motion frequency of the ship model, the required angular rate of rudder motion, the course control, and the roll damping.
The frequencies of the model motions were from 5 to 7.4 times larger than at the full ship size. In order to give a closer view at the real motions of the full-scale ship, we tried to take film at larger speed and reduce the speed when showing it. With mechanical cameras at that time, this reduction was limited by a factor of not more than 2. Motion picture in Plön had been taken on 16mm film, black and white, while Paulling in Berkeley took colour super 8mm.
The models have been run with an autopilot. A gyro keeps the track, while deviation of the model will be automatically corrected. The control system has been set up as an electronic proportional differential control circuit with dead band, a so-called PD – control. The rudder angle δ is determined by the yaw deviation β, which is in fact the course error, and by the yaw rate $\dot{\beta}$, as follows:

$$\delta = a_1\beta + a_2\dot{\beta} \quad \text{for} \quad |\beta| \geq \beta_0 \qquad (4)$$

The parameters of the control were chosen as follows, example American Challenger:

β_0 = +/- 3.5 deg	dead band
$a_1 = 1.6$	rudder-yaw ratio /-/
a_{2M}=2.12 sec	rudder angle-yaw rate ratio

The ratio of both coefficients at model scale is 1.33, corresponding to the full scale ratio as:

$$(a_2 / a_1)_S = \sqrt{\lambda}\cdot(a_2 / a_1)_M = 5.5\cdot 1.3 \ = 7.3 \qquad (5)$$

Due to the time scale, the helm response rate of the model must also be larger than at the ship. Based on +/-30 degree rudder action within 25sec, the helm rate at the model is:

$$\dot{\delta}_M = \sqrt{\lambda} \cdot 60\,\text{deg}/25\,\text{sec} = 5.5 \cdot 2.4 = 13.2\,\text{deg}/\text{sec} \qquad (6)$$

Evaluation procedure of random capsizing

Even for long runs, in order to end up with at least some capsizing, a comparatively small GM had to be established. To give some idea, initial ship stability GM in still water could be in the range from 10cm to 50cm, naturally depending on ship type and hull form.

The duration of running time until capsizing corresponds to a probability density distribution of exponential type versus time t

$$p_C(t) = \frac{1}{T_C}\exp\left(-\frac{t}{T_C}\right) \qquad T_C = \int_0^\infty t \cdot p_c(t)\,dt \qquad (7)$$

Based on the distribution of measured model capsizing, a method was used to extrapolate to GZ values of the hydrostatic righting levers at heel that made the ship safe from capsizing. Kastner presented the method in the 1964 paper on "The capsizing of M.V. "Lohengrin".

The same procedure was applied to developing the Navy standards (1966). In my view, the practical application to setting up the stability criteria of German Navy ships demonstrated the effectiveness of the method, considering the knowledge on ship stability in random seas available at that time.

Current numerical simulation and tank testing

Today research on numerical solving of coupled non-linear motion equations allows an analysis with good results and is the tool for coping with safety in severe seas. I want to cite just the one paper presented in Gdansk by Cramer and Krüger in 2001. The state of the art can be followed in the Transactions of the STAB Conferences.

At the STG Meeting in Berlin 2005, J. Hennig described a very new method for the pre-calculated generation of not just random seaway, but of specific extreme irregular time sequences that can occur in Ocean seas. Therefore even in a closed water basin specific random extremes of the seaway can be generated, allowing detailed studies of severe ship motion.

I have tried to give you a short glimpse at some first stages of conducting open water model tests from my experience. Most of the known testing in open waters has been set up for specific projects and for a limited time. Of course testing is not restricted to motion extremes. Hydrodynamic behaviour of new design ideas on various ship types and boats can be measured, analysed and demonstrated. On top of that, the Ilawa Foundation has been demonstrating the effective use of larger ship models in open waters to train pilots and ship officers to cope with severe situations.

Here in Ilawa you have managed to keep the open water testing alive, so students, researchers and ship operators can be grateful to the Gdansk University of Technology and to the persons who made it work. I wish you at least another 50 years of excellent academic life in your Research Centre.

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