Report No. 937

Annual Report 1991

September 1992

TU Delft

Technische Universiteit Delft

Faculty of Mechanical Engineering and Marine Technology
Ship Hydromechanics Laboratory
Mekelweg 2, 2628 CD Delft, The Netherlands

ANNUAL REPORT 1991

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Delft University of Technology
Dep. of Mechanical Engineering
and Marine Technology

Ship Hydromechanics Laboratory

INTRODUCTION

This anual report gives a review of the activities of the Shiphydromechanics Laboratory of the Delft University of Technology over the year 1991.
These activities include publications, reports and developments in the field of research as carried out by the permanent staff members, the Phd. students and the graduate students.

In our laboratory, the research effort has ever been a balance between the development and verification of theoretical methods on the one hand and the exploration of phenomena of which there is relatively little detailed knowledge using model experiments on the other hand. Based on such exploratory experimental work, which is often aimed at behaviour in extreme conditions, approximate mathematical models are developed. As can be seen from excerpts, given in this annual report, 1991 is no exception.

J.A. Pinkster

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1. ORGANIZATION OF THE SHIP HYDROMECHANICS LABORATORY

Phone: 31 15 786882
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	Phone:
General secretariate:	015-78....
Chairman:	
Prof.dr.ir. J.A. Pinkster	..3598
Secretary:	
Ir. J.A. Keuning	..1897
Members:	
Ing. W. Beukelman	..1859
Ing. A. Goeman	..1893

Permanent Staff:

Prof.dr.ir. J.A. Pinkster	..3598
Prof.dr.ir. G. Kuiper	..6860
Ing. W. Beukelman	..1859
Ir. J.M.J. Journée	..3881
Ir. J.A. Keuning	..1897
Ir. J. Ooms	..3876
Ir. P.F. van Terwisga	..1570
Ing. A. Versluis	..3871

Instruction- and Research Assistants:

Ing. C.J. Bom	..6870
Ing. A. Goeman	..1893
P.W. de Heer	..6873
R. Onnink	..6872
A.J. van Strien	..6872

Ph.D. Students:

Ir. L.J.M. Adegeest ..5562
Ir. H.J. de Koning-Gans ..1852

Mathematician:

Ing. A.P. de Zwaan ..4684

Secretary:

Mrs. P.J. Trijzelaar-Verduin ..6882

Librarian:

P.W. de Heer ..6873

<u>Laboratory</u>

Manager:

Ing. A. Goeman ..1893

Drawing office:

Ing. C.P. Poot ..3745

Electronic section:

Ir. J. Ooms ..3876

Modelshop:

C.A.C.M. van der Bergh ..6875

Mechanical section:

~~B. Dammers (chief) ..6877~~
H. van der Hek ..6877

During this year the following persons left the Ship Hydromechanics Laboratory:

New at the Ship Hydromechanics Laboratory:

15-11-1991, Ir. P.F. van Terwisga,

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2. PROMOTIONS

At the Ship Hydromechanics Laboratory the following persons were working on their doctor's degree:

- **Ir. J.A. Keuning** on the theme:
  'Dynamic behaviour of fast ships'
  Supervisor: Prof. ir. J. Gerritsma

- **Ir. J.J. Blok** on the theme:
  'resistance of ships in a seaway'
  Supervisor: Prof. ir. J. Gerritsma

- **Ir. J.H. de Koning-Gans** (Ph.D Student) on the theme:
  'Instationary cavitation on a 3 dimensional foil'
  Supervisor: Prof. dr. ir. G. Kuiper

- **Ir. J.L.M. Adegeest** (Ph.D Student) on the theme:
  'Short and long term wave loads'
  Supervisor: Prof. dr. ir. J.A. Pinkster

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3. <u>EDUCATIONAL PROGRAM</u> (in Dutch)

Prof. dr. ir. J.A. Pinkster

MT513, 'Ship Motions and Steering I'
Part 1: Ship Motions
Part 2: Steering and Manoeuvring

MT514, 'Ship Motions and Steering II'
Part 1: Steering
Part 2: Ship Motions

Prof. dr. ir. G. Kuiper

MT512, 'Resistance and Propulsion' (in English)

Ir. J.M.J. Journée

X2MT1, 'Offshore Hydromechanics'

X1, 'Offshore Technology'

Ir. J.A. Keuning

Wbm107, 'Technical Systems'

MT510, 'Geometry and Stability'

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4. STUDENT THESES

24-01-1991 **Reumer, J.G.**
'Een ontwerp voor een eenvoudige polynoombenadering van de toegevoegde weerstand van zeiljachten in golven'

22-02-1991 **Schaik, M. van**
'Zeilprestaties van een Lemsteraak op ondiep water'

12-08-1991 **Komst, m.j.**
'Resistance prediction method catres'

12-08-1991 **Goudriaan, A.J.**
'Repellervoortstuwing een gekoppeld lucht- en waterschroefsysteem'

14-10-1991 **Buchner, B.**
'An evaluation and extension of the shallow draft diffraction theory'

5. VISITORS AND RESEARCH FELLOWS

During this period the following guest was working at the Ship Hydromechanics Laboratory:

- **Radev, Dr. D.,**
  Bulgarian Ship Hydromechanics Centre (BSHC),
  Varna, Bulgaria
  October 1990 - June 1991

- **Dev, Arun Kr., BScEngg. MSc. CEng.**
  BARISAL - 1000, Bangladesh
  February 1991 -

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6. CONTRIBUTIONS TO SYMPOSIA, CONGRESSES, ETC.

1. The Tenth Chesapeake Sailing Yacht Symposium (CSYS), The Society Of Naval Architects and Marine Engineers (SNAME), February 9, 1991, Annapolis, Maryland, USA.

   'The Delft Systematic Yacht Hull Series II Experiments' by J. Gerritsma, J.A. Keuning and R. Onnink.

2. The Second Henri Kummerman Foundation, International Conference on Ro-Ro Safety and Vulnerability the Way Ahead, Volume 1, 17-19 April 1991, London, United Kingdom. (R.I.N.A.).

   'Roll motions of ships due to sudden water ingress, calculations and experiments' by A.W. Vredeveldt (TNO-Delft) and J.M.J. Journée (TU Delft).

3. Proceedings of the 10th International Conference on Offshore Mechanics and Arctic Engineering (OMAE), Volume 1 - Part B, Offshore Technology, June 23-28, 1991 - Stavanger, Norway.

   'Motions of Rectangular Barges' by J.M.J. Journée.

4. Written discussion on: Paper No.2 of the SNAME Annual Meeting 1991, by J.M.J. Journée.

   'Resistance and Seakeeping Characteristics of fast Transom Stern Hulls with Systematically Varied Form by E. Lahtiharju, T. Karppinen ea.

5. International Symposium on Hydro- and Aerodynamics in Marine Engineering, HADMAR'91, Incorporating the 20 Jubilee Session of the Scientific and Methodological Seminar on Ship Hydrodynamics dedicated to the 20 Anniversary of the Bulgarian Ship Hydrodynamics Centre, Proceedings, Volume 2 28 October - 1 November 1991, Varna, Bulgaria.

'Slamming simulation on penetrating wedges at forward speed' by W. Beukelman, (TU Delft) and D. Radev (B.S.H.C.)

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7. PUBLIC ASSISTANCE

During the period considered the Laboratory, besides its normal research, provided (payed) services for industry and government. This included model tests, full scale trials, studies etc.
In 1990 the next projects have been carried out:

- 'On frequency and Time Domain Simulations of Sway, Roll and Yaw Motions', TNO-CMC at Delft.
  'DYNING, a computerprogram to calculate sway, roll and yaw motions due to arbitrary loads', TNO-CMC at Delft.

- 'Model tests with the Contest 58, including the effect of fins for wave reduction, Conyflex bv at Medemblik.

- 'Meetrapport van modelproeven aan ronde en platbodem jachten', Hoek Design te Edam.

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8. RESEARCH

The main theme of the research activities of the Delft Shiphydromechanics Laboratory is the optimization of the hydromechanic behaviour of ships and maritime structures.

The main research areas and topics in this field were:

Hullforms, Resistance and Propulsion:
- Resistance of Sailing Yachts
- Cavitation

Behaviour in a Seaway:
- Hydrodynamic Aspects of Moored Semi-submersibles
- Development of a 3-D Diffraction Program
- Motion Calculations by the Strip Theory
- Model Experiments on Ship Motions
- Long- and Short-Term Wave-Induced Loads
- Dynamic Behaviour of Fast Ships in Waves
- Research on Slamming
- Generation of Desired Irregular Waves
- International Towing Tank Conference 1993

Manoeuvring:
- Manoeuvring Coefficients of a Wing Model

Safety:
- Ship Behaviour after a Collision
- Human Performance

Resistance of Sailing Yachts.
During the last year extensive research has been carried out in order to improve the sailing performance of a challenger for the 1992 America's Cup. This work was commissioned by one of the Australian America's Cup syndicates and involved extensive tank testing and analysis of hull, keel and rudder performances. Some innovative concepts have been tested and evaluated to determine their possible beneficial influence on the performance of the yacht.

Another research project dealed with the possible application of horizontal fins on the after body of a yacht to reduce the wave making resistance of the yacht hull under speed. A systematic series of fins, positions and incidence angles have been tested in order to be able to find a possible optimum with respect to the reduction of the total resistance of the yacht. This work was supported by CMO Rotterdam.

Also supported by CMO Rotterdam were a series of experiments, using the standard procedure of the Delft Shiphydromechanics Laboratory, to test four different traditional Dutch sailing yacht hulls. The results of these tests were to be elaborated to yield a velocity prediction program for these traditional sailing yachts, in which a sharply growing commercial interest is quite noticable during the last 5 to 10 years.

Finally the work on the Delft Systematic Yacht Hull Series was continued to improve on the velocity prediction of sailing yachts in general. Results of the latest series have been elaborated and analysed. Polynomial expressions have been derived for the resistance and the side force, including the effects of heelangle and leeway. The results cover a large range of Froude numbers upto Fn = 0.75. Free surface effects on the transverse stability have been included too. Particular emphasis has been placed on the performance decrease of sailing yachts due to the added resistance in waves. All of this has been incorporated in the Velocity Prediction Program of the Delft Shiphydromechanics Laboratory.

Cavitation

The research on cavitation is aimed at profile design with respect to cavitation control. In present technologies it is possible to predict the shape of cavities on an arbitrary 2-dimensional profile in stationary flows. To improve the modelling of cavitation, a new method is set up with extension to 3-dimensional flows and instationary cavitation. A new computer program had to be developed for the extensions.

To compute the (stationary) flow around an arbitrary profile, a higher order 3-D panel method program has been developed. The main algorithm used in this program is based on a special case of the Green's theorem, called "de Morino formulation". This computer program (flow program) can determine the potential on the body and the velocities at the surface of the body or in the flow field. A grid generation program has been set up for use of the of the flow program.

The numerical results of this computer program have been compared with a 2-dimensional flow around profiles and also with a 3-dimensional flow around a sphere.

Further new results will be compared with results of tests in the cavitation tunnel. Therefore the cavitation tunnel is updated with a new measurement system. For measuring the local velocities and the shape of the cavity, the tunnel has been equipped with a laser-doppler anometry system.

The computer program has been extended for time simulation of dynamical sheet cavitation. The concept of this extension is based as follows.

The potential will be calculated at the body. The potential and velocity at the cavity sheet will be calculated with a normal Taylor expansion. This expansion uses the divergence and rotation theorems of potential flows. The pressure at the sheet will be determined at every time step. When knowing this pressure, the normal velocity of the sheet can be determined and after integrating this velocity the new cavity thickness and geometry will be computed. A "Shen YS 920" profile has been chosen for testing the new cavitation theory. This profile was developed, to have good cavitation behaviour for a large variation of the incoming flow direction. The tests have been carried out for several angles of entrance, different flow speeds and different environmental pressures. Further testing is planned.

Behaviour in a Seaway

Hydrodynamic Aspects of Moored Semi-Submersibles

A literature study has been carried out on the subject of mean and low frequency second order wave loads, together with its related interests like viscous effects, low frequency hydrodynamic coefficients, wave directionality and grouping, mooring parameters and statistical estimates for moored offshore structures, like semi-submersibles. The present "state of the art" of predicting the second order mean and low frequency wave loads has more or less achieved its success, though new problems are still being addressed towards an exact solution of such a complex problem.
Almost all the numerical solutions were accomplished through the use of the linear potential 2-D or 3-D theory with some kind of approximations in their formulations, in order to ease the solution technique. Initially, experimental procedures were also adopted to understand the root of the second order force. With the space of time, more and more

related interests are being initiated by the researchers in this field. Some of them, like viscous effects, low frequency hydrodynamic coefficients like hydrodynamic mass, both potential and viscous (linear and non-linear) damping factors, need profound knowledge for further treating the problems. For a moored structure, the linear wave radiation damping is small and therefore non-linear potential effects and viscous effects are important. Great uncertainty lies in choosing the appropriate values of drag coefficients.
The environment, like wave-current interactions, low frequency turbulent wind spectra along with the dynamic effects of the mooring system including their damping contributions, have also significant effects on the low frequency response amplitude of a moored structure like semi-submersibles. Especially, the modification of the current and wave velocity fields and forces resulting from interaction of the velocity fields.
For greater accuracy, it is often suggested that the effect of wave directionality be accounted for while predicting the motion characteristics of a moored structure. Similar is the case with the wave grouping which is important for moored structures where the second order wave force produced by grouping may excite large resonant motions.

The research started with a literature study, followed by the development of computer programs to generate panels for different geometries. A simplified theory has been designed for calculating the mean drift forces on a vertical truncated fixed and floating cylinder in waves.

'3-Dimensional diffraction program DELFRAC'

During 1991, the 3-d diffraction program DELFRAC became operational. This program which is based on the 3-d sink and source approach, makes use of MIT's routine FINGREEN for the evaluation of the green functions and derivatives. For the solution

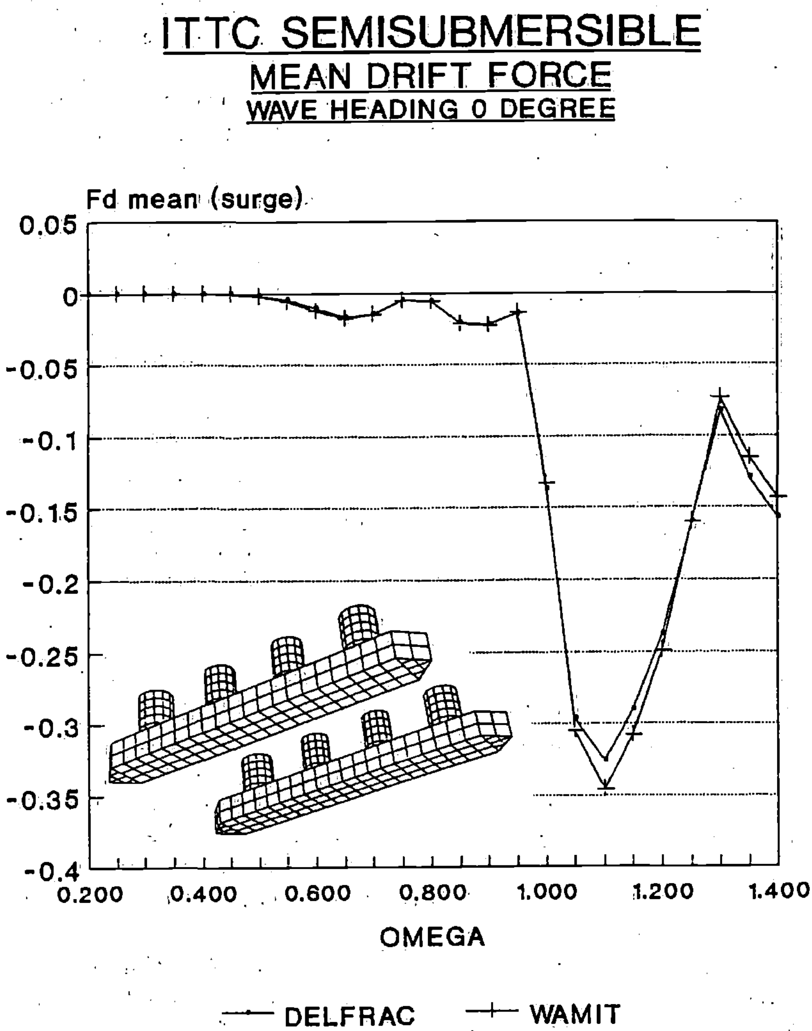
of the equations a direct solver and an iterative solver are used. The iterative solver is used for larger numbers of panels. At present quadrilateral or triangular plane facets with constant source density are applied. Full use is made of the symmetry of the body in filling the influence function matrices and in solving the equations. The program is run on pc/workstations and with an eye to carrying out computations for large numbers of panels, will also be transferred to the CONVEX mini-super-computer of Delft University.
The following quantities are calculated by DELFRAC:

- Added mass and damping
- 1st Order Wave pressures and forces - wave frequency motions
- Mean second order pressures and forces (pressure integration)
- Absolute and relative wave elevations

This program will be extended to include most of the features present in similar existing programs.

The department now has two indepently developed diffraction programs at its disposal since WAMIT is also in use for some time already. Having two programs available has turned out to be a valuable aid in evaluating the results of computations.
An example of the comparison of results obtained from both programs is given in the accompanying figure. The results apply to the semi-submersible study initiated by the ITTC Ocean Engineering Committee with the purpose of tracking the developments with respect to the mutual correlation of results of member institutes programs. The figure shows the mean second order wave drift force transfer function for head waves. The WAMIT results are based on the far field formulation while DELFRAC results are based on the near field or pressure integration method. In both cases exactly the same

panel distribution was used. This is also shown in the figure.



Motion Calculations by the Strip Theory

For frequency-domain strip theory ship calculations in six degrees of freedom, detailed attention has been paid to a number of subjects:

- the possibility to use the strip theory for twin hull configurations, such as semi-submersibles and catamarans
- an improvement of the present N-parameter conformal mapping method, to make this method suitable for bulbous cross sections too
- the possibility to use a general strip theory program in a preliminary design stage of a ship by generating and using Lewis hullforms
- the calculation of shearing forces and bending and torsional moments
- the linearization technique for the non-linear roll damping coefficients
- the calculation of slamming based on peak pressure criteria
- the in- and exclusion in the strip theory of the so-called "end terms".

The frequency-domain strip theory ship motions PC program for six degrees of freedom SEAWAY has been extended with the results of these studies and, to improve the access to the program for less specialists, an input editor has been made. New theoretical and user manuals will become available, early 1992.

For Computer Aided Ship Design purposes, a new very fast strip theory program, based on the parent program SEAWAY and named SEAQUICK, has been written. This program will be implemented in a design system. The results will be presented on the PRADS-1992 symposium.

In the PC program SEATIME, wich is developed for motion calculations of anchored ships in the time-domain, the non-lineair roll damping terms have been implemented. A pre-processing program, called SEAWAY-D and based on the parent strip theory program SEAWAY, delivers the required hydromechanical coefficients data base.

Model Experiments on Ship Motions

Experimental research with respect to motions and added resistances of rectangular barges in regular head and beam waves has been terminated. The experimental data have been compared with the results of the strip theory program SEAWAY. A fairly good agreement has been found and the results have been presented on the OMAE-1991 Symposium at Stavanger in Norway.

In cooperation with the University of Michigan (USA) and the Panel H-5 of the Hydrodynamics Committee of the SNAME extensive experimental research on forced vertical oscillations and wave loads, added resistances and motions in head waves has been carried out with four Wigley hullforms.
The experimental data have been compared with the results of several 2-D and 3-D computer programs.
This part of the project will be finished in 1992 with a comprehensive report with all experimental data and the results of the comparative study.
Further research and computer simulation will be continued.

Long- and /Short-Term Wave-Induced Loads

The aim of this project is to investigate the distribution of the extreme and long term moderate wave induced forces and moments in a ship hull. The final formulation has to be made useful in an early design stage with respect to the determination of the required maximum strength and fatigue strength. The project is supported by the Royal Dutch Navy and has been started in 1990.

When we consider a ship at sea, the vessel can be considered as a filter which transfers the input to an output. The input may be Gaussian or not, while the ship may react as a linear filter or not. For practical purposes, three levels of complexity can be distinguished:

1. Linear input and a linear transfer
2. Linear input and a non-linear transfer

3. Non-linear input and a non-linear transfer.
Concentrating on the input, we can separate the input or the excitation conditions of the vessel in environmental conditions and operational conditions. The environmental conditions are determined by a characteristic wave height and period, a spectral shape, spreading, current and so on. The operational conditions are determined by parameters such as speed, mass, weight distribution and heading. Study of the input requires a probabilistic approach. In most cases the input may be considered to be Gaussian, especially in the range of fatigue loads.
Depending on the response-acceptance of the ship and the severeness of the excitation a first- or a second-level approach can be applied.
In case of the extreme load conditions, the input is probably not Gaussian anymore. Third-level computational methods should be applied. As an alternative semi-empirical/deterministic methods can be applied.
From these reflections it was concluded that a study of the distribution of sealoads should exist of the following three parts:

- study of the deterministic internal loads in defined conditions
- study of deterministics and statistics of environmental and operational conditions
- study of the probabilistics of internal loads, based on knowledge of the response acceptance of the vessel and of the joint probability of the excitation conditions.

These facets are or will be studied by means of model tests and numerical simulations.

The typical non-linear phenomenon under consideration is the sag/hog-ratio which appears to be unequal to one for slender vessels. The main source of this non-linear behaviour is the change of immersed volume or the non-linear spring force. In order to investigate the relative importance of other contributions, i.e. pressure drop due to the square velocities in Bernoulli's equation, products of displacement and first order pressures and contributions from second order potentials, model experiments have been performed in which the second order hydrostatic effect has been eliminated. A suitable model for these experiments, was a Wigley model. A segmented model was used, divided in eight equal parts. Forced oscillation tests and wave force measurements have been carried out. It appeared that the second and higher harmonics of the wave loads were very small in every condition, compared with the second harmonics as found during the oscillation tests.

The development of a second-level simulation model, which was started in 1990, has been going on. The model is being developed for large amplitude motions in 6 degrees of freedom and makes use of 3-D potential solutions. Impact loads are not dealt with. The effect of the body-wave system is ignored. It is assumed that the ship is moving with a relatively low forward speed and that the ship is slender enough to validate this assumption.

Dynamic Behaviour of Fast Ships in Waves.
The mathematical model to discribe the non-linear forces and motions of fast ships in head waves has been extended with the implementation of non-linear wave exciting forces due to the large motions of the craft in "not small" waves related to the actual momentaneous submerged volume of the craft. Polynomials for the determination of the trim and sinkage of the ship at speed have been derived from the Delft systematic planing yacht hull series and implemented in the motion calculation routines.
An improved formulation for the pressure distribution over the length of the craft due to the high forward speed has also been implemented in the computer program. Al these changes proved to be important for the proper prediction of the motions

and in particular the accelerations of fast moving craft in waves. The results of the computations using the new mathematical model have been compared with experimental results. In particular the results of the peak accelerations were considered, which are proven to be the most important factor for limiting the operability of these fast craft in head seas. A sensitivity analysis has been carried out for various parts of the mathematical model. Finally the computerprogram has been improved to be able to cope better with the peak phenomena involved. The research will continue in the comming year and will finally lead to a doctors thesis by the end of 1992.

Research on Slamming
Forced oscillation experiments with 4 wedges showed a dominant influence on the peak slamming pressures for both the vertical and forward speed. The existing calculation model did not sufficiently take into account this forward speed influence. The computer program has been extended with forward speed and 3-D influence, which results into a reasonable agreement with the measurements. The preliminary results were presented at the "International Symposium on Hydro- and Aerodynamics in Marine Engineering HADMAR'91" at Bulgaria. The final and extensive results will be published in the "International Shipbuilding Progress" (ISP). The project is closed now.

Generation of Desired Irregular Waves
The main object of this research project is to find a method to generate irregular waves in a model basin with desired spectral properties. The project is divided into three parts.
The first part is to determine the transfer properties of the wave generator and the reflection characteristics of the beach of the model basin as function of the frequency, amplitude and water height.

Part two of the project is to find ways to automatically generate a steering signal for the wave generator that will result in the desired waves. There are basically two ways to generate this signal, namely a multiple sine signal and filtered white noise. The latter approach has been chosen. It calls for a fitting procedure that fits an Auto Regressive Moving Average (ARMA) model to a desired spectral distribution. This model must then be extended to account for the transfer properties of the wave generator and the tank properties.
The third and final part of the project is the implementation and verification stage. A program must be written to generate the desired wave generator signals and the results must be verified experimentally.

In november 1991 experiments were carried out to determine the wave generator transfer function and reflection properties of the small model basin of the laboratory. In addition, the tuning effect of the basin was studied. This is an effect that starts to develop when waves are in the tank for such a period of time that they could have travelled at least four or five times the length of the basin. It is caused by reflected waves from the beach that upon arrival at the wave flap bounce back again to the beach. Their effect on the original wave being generated at the same time can be either constructive or destructive depending on their phase on arrival at the flap. So, the generated wave can become either larger or smaller then the wave being generated before reflections arrived. The effect is strongly frequency dependent and clearly observable when generating regular waves. In principle it could result in undesired peaks and dips in a required wave spectrum. So, it is important that the effect is properly understood and accounted for. Of course, the best way to minimize it is to make sure that the reflection coefficient of the beach is as low as possible.

It is hoped that the project will ultimately result in an easy to use, PC-based, irregular wave generating system that can generate irregular waves with a desired spectral distribution on the fly.

International Towing Tank Conference 1993

There was an active participation in comparative computations of a semi-submersible for the Ocean Engineering Committee of the International Towing Tank Conference 1993. Comparative computations have been made with the 3-D programs WAMIT and DELFRAC and the 2-D program SEAWAY. The results will be compared with experimental data and will be presented in a report by the ITTC, together with the computational results of other institutes.

Manoeuvring

Manoeuvring Coefficients of a Wing Model

For conventional ships the directional or course stability may sufficiently be determined from data obtained by full size experiments or forced oscillation tests with a ship model. In this way, it is possible to predict a required track or manoeuvre. Determination of hydrodynamic manoeuvring coefficients by potential theory fails, because of the viscous influence by flow separation at the aft part of the ship. In the physical model for predicting the manoeuvring coefficients, the ship is considered to be a wing profile with a very low aspect ratio.

For fast modern ships, such as Ro-Ro ferry boats, it is not easy to obtain these manoeuvring characteristics especially for particular circumstances, such as shallow water and in waves. As a first step it is thought to be useful to design a series of tests with a wing profile in shallow and deep water to obtain the required experimental data.

For this reason the model of a wing profile has been manufactured and prepared for measurements. Afterwards, the drag and lift force measurements started in deep and shallow water for three aspect ratio's dependent on angle of attack (drift angle) and forward speed, followed by forced horizontal oscillations to determine the hydrodynamic manoeuvring coefficents. Calculations of these coefficients with potential theory have been performed and will be compared with the measurements. Other calculation methods including "lifting" influence will also be introduced.
It is intended to carry out similar measurements with a segmented model.

Safety

Ship Behaviour after a Collision

Research has been carried out on ship motions after a collison. In behalf of TNO-CMC and DGSM, experimental and theoretical investigations have been carried out on the dynamic behaviour of a ship during and after a sudden inflow of water due to a collision. The first results have been presented at the "Conference on Ro-Ro Safety and Vulnerability 1991" at London in UK.
The development of a computer simulation program, called DYNING, has been started. Further research and computer simulation will be continued.

Human Performance

Research on the degradation of human performance on board of ships have been continued.
The results have been reported together with TNO-IZF and KM.
Furthermore was decided to participation in research together with a combined project of the Navy of USA-Canadian and UK. First measurements with a seasickness simulator are planned in 1992.

9. RESEARCH FACILITIES OF THE SHIP HYDROMECHANICS LABORATORY

For experimental research the Ship Hydromechanics Laboratory has at its disposal of the following facilities:

TOWING TANK NO. 1

Length	:	142.00 m
Width	:	4.22 m
Water-depth	:	2.50 m

Carriage	:	manned, motor driven
Carriage speed	:	7.00 m/s (maximum)
Capabilities	:	horizontal and vertical PMM can be fitted

Wavemaker type	:	flap type, electronic/hydraulic
Wavelength	:	length 0.30 - 6.00 m, regular and irregular

Tests performed	:	resistance in calm water and waves. Open Water propeller test. PMM-tests on floating and sub-merged bodies, foils etc. Wave induced motions and loads on ships and floating and moored structures Slamming phenomena. Upright and heeled sailing yacht tests.

TOWING TANK NO. 2

Length	:	85.00 m
Width	:	2.75 m
Water-depth	:	1.25 m

Carriage	:	manned, motor driven
Carriage speed	:	3.00 m/s (maximum)

Wavemaker type	:	flap type, electronic/hydraulic
Wavelength	:	length 0.40 - 6.50 m, regular and irregular

Tests performed	:	Resistance and self-propulsion in calm water and waves. Open water propeller tests. Wave induced motions and loads on ships and floating and moored structures Upright and heeled sailing yacht tests.

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CAVITATION TUNNEL

Facility	:	Kempf und Remmers, closed recirculation tunnel.
Drive system	:	4-bladed axial flow propeller with Ward Leonard control.
Motor power	:	15 Kw, (total) 2920 rpm.
Pressures	:	102 kPa(max) - 11 kPa(min)
Instrumentation	:	Propeller dynamometer, 5-hole pitot-tube, various pressure sensors, Laser Doppler Anemometry.
Type and location of torque and thrust dynamom.	:	balance T- and Q dynamometer at the end of propeller shaft, Tmax 400 N, Qmax 10Nm.
Propeller or Model size range	:	Propeller diameters from 50 - 160mm.
Tests performed	:	Propeller tests in uniform flows. Forces and pressure distributions on rudder, fins, etc.

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10. REPORTS AND PUBLICATIONS OF THE SHIP HYDROMECHANIC LABORATORY

Journée, Ir. J.M.J.,
'Theory and algorithms for two-dimensional hydrodynamic potential coefficients',
Report No. 884-1991, TU Delft.

Adegeest, Ir. L.J.M.,
'Wave induced loads in a ship hull',
Report No. 885-M-1991, TU Delft.

Binkhorst, B.J.,
'Toelichting op de module "Imschroef" in Fortran, voor het berekenen van zeilcoëfficiënten volgens het principe van het IMS',
Rapport No. 886-S-1991, TU Delft.

Gerritsma, Prof.ir. J.,
'Forced oscillation experiments',
Presented at The Royal Society, Discussion Meeting 'The dynamics of Ships' organized by Prof. W.G. Price and Prof. R.E.D. Bishop, June 28, 1990, London - United Kingdom,
Report No. 887-P-1991, TU Delft.

Beukelman, Ing. W.,
'Slamming on forced oscillating wedges at forward speed', Part I: Test results,
Report No. 888-1991, TU Delft.

Beukelman, Ing. W. and Dr. D. Radev),
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