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Towing Tank and Wave Basin Facility: First of Its Kind in the Philippines

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Abstract Ship design is an ongoing, never-ending challenge. With software calculation and simulation, modeling plays an integral part in making the design process more efficient and successful—the lack of testing facilities in the country. Ship designers tend to rely only on software simulation and calculation or experiment using alternative methods to test a new hull design model. Where inconsistency and lack of standards may lead to a misleading result, the team proposed a towing tank facility that could serve both the academic and industrial fields. It would open up a door of opportunities for ship designers, shipbuilders, and researchers to conduct model testing, which would help increase the efficiency and accuracy of new hull designs. For the first time in the country, the facility would make model testing available at various speeds and wave conditions. It would be capable of providing basic parameters including hull resistance, heave, pitch, roll, and trim heel angles. Those would be measured against a velocity range of 1 to 5 m/s. The facility should be a solid starting point to help individuals and groups implement hull design concepts, where fundamental data could be gathered, tabulated, and evaluated.

Keywords: *towing tank UCMETC, wave basin, simulator*

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1. Introduction

Current towing tanks are utilized as stages to play out an assortment of hydrodynamic trial examinations; nonetheless, the starting points of the towing tank are attached to the unmistakable motivation behind foreseeing transport obstruction by employing model testing. This work with transport models created modem day scaling methods, which have permitted the towing tank to be utilized in an assortment of scaled research tests [1].

Experimental research continues to be necessary for evaluating the presentation of seaward designs and ships in waves. The experimental research and leading functional studies would be invaluable to cultivating an elite execution retaining wave produce capable of producing both ordinary and unpredictable waves. This study investigates the development of such a wave-producer using the wavemaker and wave-retaining hypotheses. Concerns have recently been raised about the design of wave bowls, as experts question whether a rectangular wave tank setup is a reasonable calculation to direct tests [2].

Ships' dynamic instability can be avoided by adjusting the ship's course and speed are based on how the ship reacts to external forces. Ship designs evolve rapidly in response to market demands and the type of cargo to be transported. The current intact stability criteria are simple to handle because they disregard modern vessels' (dynamical) physical characteristics. Geometries of novel ship designs have deviated significantly from conventional forms. These geometric differences may result in dynamic behavior significantly different from previous experiences [3].

Model experiments on craft performance have shown the hydrodynamic properties of the double outrigger form and described essential characteristics of the crafts' design, construction, and operation. The presence of outriggers significantly impacts the heave, pitch, and roll motion of the ship.

The craft led to maritime incident data analysis compared to a hull without outriggers. According to reports, these motorized Banca boats capsize at a high rate, highlighting the danger. Regulation of their design and construction is required [4].

Developing a model and conducting experiments is necessary to develop the appropriate hull form for ships.

The most significant influence on the test accuracy in their 25 m-long ship model for the propulsion performance tested in the towing tank. Also noted is that uncertainty indicates the degree of trust in the measurement results; that is why this should be considered when conducting model tests [5].

This innovative move will advance the process of designing ships and floating structures in the country as a primary requirement in ship construction.

2. Objectives of the Study

The study aims to establish a facility that will cater to ship and floating structures design and tests.

Specifically, to develop and construct the following:

1. to design a towing tank and wave basin facility;
2. to develop design components for a working facility; and
3. construct a facility based on developed components to test ship models and floating structures.

3. Methodology

Towing Tank is a primary maritime research facility where researchers from industries and universities come to conduct experiments and collect data for evaluating and verifying results. The project team will construct a towing tank facility on the UC-METC Campus. Specific procedures will be carried over to establish such infrastructure.

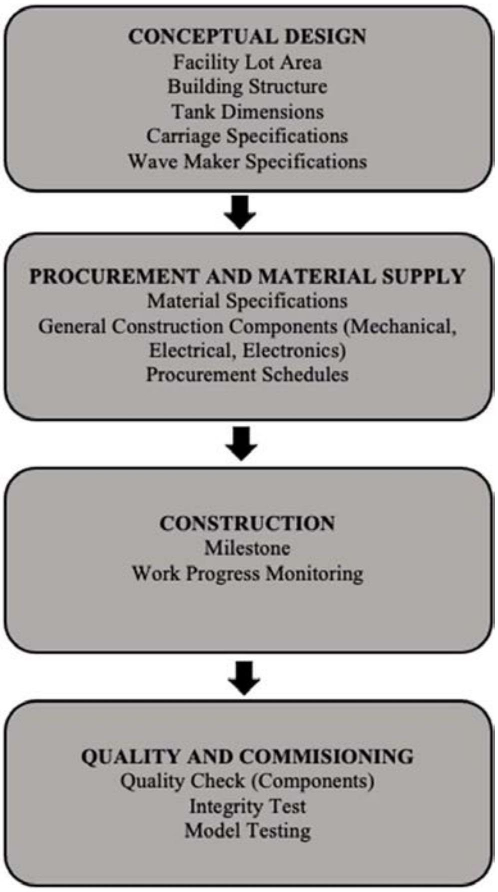

Figure 1. Methodology Block Diagram

The project will include a design and build scheme to construct a facility in the targeted area with a corresponding total lot area. The tank's dimensions will be determined by considering the available lot space and budget, comprising the length, width, and depth. Also, the maximum depth of the water and freeboard will be identified. Its maximum capacity will determine the carriage specifications. Following the specifications, the wave maker must be capable of producing regular waves with a maximum height. The wave maker software must include the ability to use a paddle motion to turn two functions on and off separately.

General Notes and Technical Specifications describe the type and quality of materials and equipment used, construction method, and general construction conditions. The procuring entity shall ensure that all necessary schedules for the submission, confirmation, and approval of the detailed engineering are followed. The design, as well as the details of the construction methods and procedures, must be included.

The National Building Code of the Philippines (PD 1096), the Accessibility Law (BP 344), the National Structural Code of the Philippines, the Electrical Engineering Law (RA 7920), the Mechanical Engineering Law (RA 5336), the Plumbing Code (RA 1378, 1993-1994 Revisions), the Fire Code (RA 9514), and other environmental and local ordinances and regulations must all be followed. The building structure will have one level or floor and will be completed following the project timeline. From groundbreaking to completion, all construction activities will be monitored.

Following the construction and installation of components, a quality check must be performed to ensure compliance with minimum material and quality standards and the facility's performance according to its design.

4. Results and Discussions

The structure was constructed at the University of Cebu - METC Campus in Cebu City, Philippines. Shown in Table 1 below are the general specifications of towing tank components.

Table 1. General Specifications

Towing Tank Dimensions	Length – 45 m Width – 3 m Depth - 1.2 m
Carriage	Motor Driven 2.5 m/s (maximum speed)
Flange Capacity and Dimensions	0.425 m x 0.15m 13 kg
Towing Tank Machine Specifications	Supply Voltage: 220V Control Voltage: 24V DC Phase: 1 HZ: 60 Power: 15 kW
Test Capabilities	Ship Model Resistance Test Roll, Pitch and Heave Motions
Wave Generator	Two independent Simple Wedge design paddle Variable Speed and Frequency 0.5 meter Maximum Wave Height

The length of the tank is 45 m, the width of 3m, and the depth of 1.2 m. The constant water depth will be adjusted to increase the freeboard but shall not exceed 0.9 m.

Figure 2. Towing Tank Facility

4.1. Mechanical System

4.1.1. Carriage and Flange Mechanism

It is composed of a carriage with a mounting system (flange). Figure 4 below shows the actual design of the mechanism. It carries a model of up to 2 meters long and up to 0.75 meters wide with a maximum speed of 2.5 m/s. For a better, more accurate reading, attach the flange at or as close to the model's center of gravity as possible; the initial center of gravity should be determined prior to testing. The flange weighs approximately 13KG, most of which is located above the center of gravity. This arrangement was made to serve as a preliminary procedure to expose a weak/inefficient design, in a way a model might tend to heel to one side or would be prone to capsizing at the slightest of a movement. In such a case, this model would not be tested any further.

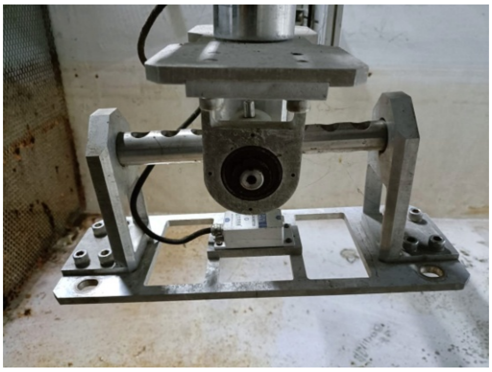

Figure 3. Carriage and Flange Mechanism

Below are the measurements of the flange, all in mm. To be followed and arranged on all models that are being tested.

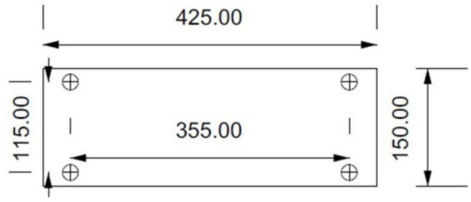

Figure 4. Flange Dimensions

It is highly not recommended, but the student could also tow the model by attaching it to the flange via a rope or wire. The accuracy of such a method might vary and could only be used if the flange cannot be adequately attached to the model.

Students must maintain safe produce when mounting or unmounting the model. Using proper tools (spanners, players, and others alike.)

4.2. Wave Maker

Two pedals operate simultaneously or alternately. It could generate waves up to 0.5 meters high. For safety reasons and to avoid accidents, wave maker could only be operated to test models that had already been tested and showed a decent degree of stability in calm water conditions first.

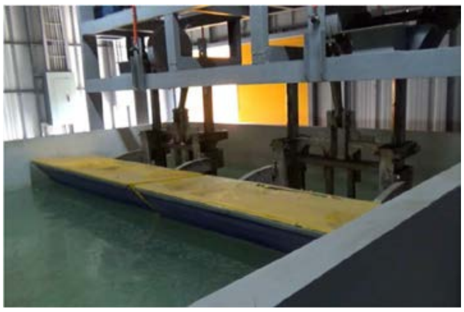

Figure 5. Wave Maker Paddle

4.3. Electrical and Electronic System

Set of sensors placed strategically to measure various resistance and stability components such as forward resistance, roll, pitch, and heave.

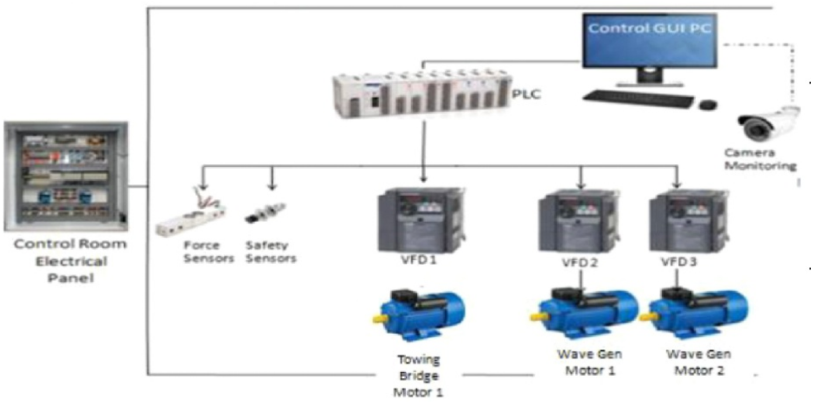

Figure 6. Electrical and Electronic Diagram for Towing Tank

5. Conclusion

The University of Cebu necessitates a towing tank facility for three reasons: generating revenue, leading academic research projects, and benefiting students in the Naval Architecture and Marine Engineering program. By using the towing tank, the University of Cebu could expand maritime education not only to students but as well as to industry. Their future goals include generating more revenue for research and benefiting future studies of their naval architecture and marine engineering students.

Figure 7. Towing Tank Facility Inauguration

The construction began on December 7, 2018, and was inaugurated on January 24, 2020, as shown in Figure 7. The facility was first used by students and faculty last March 2020, before the world's pandemic. The graduating Naval Architecture and Marine Engineering (BS NAME) students with their respective faculty advisers were the first to use the facility present research study results to faculty panelists.

6. Recommendations

After nearly two years of rest, the facility is now fully operational and is used by several groups of students and faculty researchers. It has been instilled in the faculty researchers' minds of the Naval Architecture and Marine Engineering Department throughout the entire process of this achievement to improve the existing facility through the recommendations below:

1. Evaluate the wave maker's motor capacity and make recommendations for improvement;
2. Evaluate the model carriage setup and identify areas of improvement;
3. Evaluate all camera positions and make recommendations for the best positions;
4. Evaluate all sensors used to read forward and side forces, upward motion (Heave), side heeling motion (Roll), and rising or falling of the ship's bow and stern (Pitch), and recommend additional sensors to read other ship motions;
5. Examine the existing computer program link to the facility's electromechanical and sensor components that provide data results;
6. Include a sensor to read the maximum and minimum wave height produced by the wave maker at a given motor capacity; and

Construct an additional laboratory in the hydrodynamic facility to complete all necessary research experiments when designing vessels and floating structures.

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References

[1] Васильева, И. С. (2006). *Рэт-Инфо №4 2006*. 1-6.

[2] Naito, S. (2006). Wave Generation And Absorption In Wave Basins: Theory And Application. *International Journal of Offshore and Polar Engineering*, *16*(02).

[3] Hanzu-Pazara, R., Duse, Varsami, C., Andrei, C., & Dumitrache,

[4] R. (2016). The influence of ship's stability on safety of navigation. *IOP Conference Series: Materials Science and Engineering*, *145*(8).

[5] Aguilar, G. D. (2006). The Philippine indigenous outrigger boat: Scaling up, performance and safety. *Marine Technology Society Journal*, *40*(3), 69-78.

[6] Zhou, G., Wang, Y., Zhao, D., & Lin, J. (2020). Uncertainty Analysis of Ship Model Propulsion Test on Actual Seas Based on Monte Carlo Method.

[7] Drzewiecki, M. (2017). Modelling, simulation and optimization of the wavemaker in a towing tank. *Advances in Intelligent Systems and Computing*, *577*, 570-579.

[8] Centre, O. S. (2021). PROSJEKT OCEAN SPACE CENTRE REQUIREMENTS FOR TOWING TANK WAVE. 1-8.

[9] CNR-INSEAN. (2002). International towing tank conference catalogue of facilities towing tanks, seakeeping and manoeuvring basins. 7250. http://www.insean.cnr.it/sites/default/files/ITTC-CoF-2.pdf

[10] Str, W. F. (2016). Name of organization Bulgarian Ship Hydrodynamics Length – 200 m Width - 16 m Depth - up to 1. 5 m. 5-6.

[11] Geerts, S., Delefortrie, G., Lataire, E., & Troch, P. (2018). Flanders Maritime Laboratory, new large scale facilities for towing tank and wave basin research. *Proceedings of the 2nd International Symposium on Hydraulic Modelling and MeasuringTechnology-China*. http://documentatiecentrum.watlab.be/owa/imis.php?module=ref&refid=3112 19.

[12] R. Sutton, S. D. H. Taylor, and G. N. Roberts, "Neuro-Fuzzy Techniques Applied to a Ship Autopilot Design," *Journal of Navigation*, vol. 49, no. 3, pp. 410-430, 1996.

[13] A. Vrijdag, "Potential of Hardware-in-the-Loop simulation in the Towing Tank," OCEANS 2016 MTS/IEEE Monterey, 2016, pp. 1-6.

[14] L. Li, P. Liu and J. Du, "Experiment and Numerical Simulation on Collision of Box Girder Hull Model in Towing Tank," 2018 IEEE 8th International Conference on Underwater System Technology: Theory and Applications (USYS), 2018, pp. 1-6.

[15] H. Khan, A. Ahsan and K. A. Chauhdhry, "Review of Modern Trend for Numerical Model Testing in Worldwide Towing Tanks," 2019 16th International Bhurban Conference on Applied Sciences and Technology (IBCAST), 2019, pp. 732-743.

[16] F. L. Peña, A. Deibe, B. Priego and M. M. González, "A speed control strategy for an autonomous ship model for towing tank testing," 2015 IEEE 8th International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS), 2015, pp. 108-112.

[17] A. T. Phan, K. Shoji, K. Minami and S. Mita, “Increasing ship roll stability by using anti-rolling tanks,” OCEANS 2008, 2008, pp. 1-7.

[18] S. Seo, K. Shin, M. Koo, K. Hong, I. Yoon and J. Choi, “Experimentally Verifying the Generation Characteristics of a Double-Sided Linear Permanent Magnet Synchronous Generator for Ocean Wave Energy Conversion,” in IEEE Transactions on Applied Superconductivity, vol. 30, no. 4, pp. 1-4, June 2020, Art no. 5206804.

[19] T. Kuroda, N. Hirata, H. Kobayashi and K. Tanizawa, “Generation method of wash wave by wave generator in model basin,” 2012 Oceans, 2012, pp. 1-6.

[20] K. Maeda, N. Hosotani, K. Tamura and H. Ando, “Wave making properties of circular basin,” Proceedings of the 2004 International Symposium on Underwater Technology (IEEE Cat. No.04EX869), 2004, pp. 349-354.

[21] Gad-el-Hak, M. The water towing tank as an experimental facility. Exp. Fluids 5, 289-297 (1987).

[22] Gui, L., Longo, J. & Stern, F. Towing tank PIV measurement system, data and uncertainty assessment for DTMB Model 5512. *Experiments in Fluids* 31, 336-346 (2001).

[23] Drzewiecki, M. (2017). Modelling, Simulation and Optimization of the Wavemaker in a Towing Tank. In: Mitkowski, W., Kacprzyk, J., Oprzędkiewicz, K., Skruch, P. (eds) Trends in Advanced Intelligent Control, Optimization and Automation. KKA 2017. Advances in Intelligent Systems and Computing, vol 577. Springer, Cham.

[24] The Specialist Committee on Waves, “Final Report and Recommendations to the 23rd ITTC”, Proceedings of the 23rd ITTC, vol. II, no. 23, pp. 544-551, Sep. 2002.

[25] Graf, Kai, and Christoph Bohm. “A New Velocity Prediction Method for Post-Processing of Towing Tank Test Results” Paper presented at the SNAME 17th Chesapeake Sailing Yacht Symposium, Annapolis, Maryland, USA, March 2005.