STUDY OF BOLLARD PULL HARBOUR TUG: FOCUSES ON STABILITY AND STRAIGHT MOVEMENT

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ABSTRACT: Method of design and analysis of bollard pull harbour tug focuses in its stability and straight movement. Research includes a brief review of general description of bollard pull harbour tug, tug boat functions, tug boat characteristics, functions, operation modes, requirements for tug boats, stability standard and factor affecting stability, stability requirements, displacement and buoyancy, fundamental of design and a very last, fundamental of analysis. This research also discuss about the methodology to implement the design and analysis to measure the stability and movement of the tug boat. The purpose of design modelling is to identify the error of the existing design and to redesign to eliminate or reduce errors. The error consists of the hull structure and skeg design. However to redesign the hull and skeg must be done during design stage. For this report, it will discuss only the basis of the design methodology. The analysis of the stability and straight movement of the bollard pull harbour tug are using software analysis. SolidWorks and ANSYS are the proposed analysis software that will implement for this thesis. The analysis of the tug boat is study on static and dynamic analysis that discuss about finite element analysis and hydrodynamic analysis. Dynamic analysis is important part because it deals with how the tug boat moving in a stable and balanced during its operation.

KEYWORDS: 2D Structural Systems, 3D Structural Systems, AutoCad, SolidWorks SolidWorks Simulation Xpress, Static Analysis software, ANSYS FLUENT, Fluid Flow Analysis.

1.0 INTRODUCTION

This project is study about the design and analysis of simulation of Bollard Pull Harbour Tug which shows the stability and straight movement of the tugboat during towing operation of the ship. Other than that, it is important to study on lines plan of the hull structure to make sure it suit with the specification of the ship rules. So, at the end of this project should understand and good practice on how to build the hull structure based on the lines plan and do the test about stability and movement of tugboat during completing the requirement for this project. Figure 1 shows the example of Bollard Pull Harbour Tug.

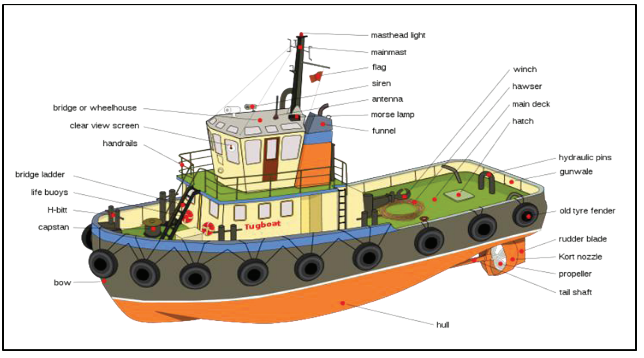


Figure 1: Bollard Pull Harbour Tug

The tasks consist of hull reconstruction and design a new skeg design. Skeg is one part which is at the bottom of hull. The function is to make the tugboat constantly stable during operation. After the completion of industrial training, the project engineer gave a permission to carry out analysis of the stability and straight movement of the tugboat. Stability is more on the hull construction and the straight movement is on the skeg design. The company willing to helps in terms of the tugboat design and assists on how to fabricate it into a small scale. To be done this project on PSM I, the engineering drawing of hull structure, skeg design, and lines plan must be done on time. In other hand, the design needs to be in 3-dimensional detail design using SolidWorks software in order to analysis task during PSM II. In the development of 3-dimensional drawing, analysis can be carried out using SolidWorks Simulation Xpress and SolidWorks Flow Simulation. In addition, analysis can be further by using ANSYS FLUENT for dynamic analysis.

1.2 Objectives

The objective is to study a hull structure for the purpose of tugboat stability analysis, a skeg design (bottom of the hull structure to assist stability of tugboat) for the purpose of straight movement.

Design a hull structure and skeg using AutoCAD (2D) and SolidWorks (3D). Analysis the Bollard Pull Harbour Tug in static and dynamic force using SolidWorks Simulation Xpress, SolidWorks Flow Simulation and ANSYS FLUENT. Through this project, it will focus on the design of the tugboat by using AutoCAD and SolidWorks and it also involves in using analysis software using ANSYS to simulate a stability and straight movement.

1.3 Problem Statement

This study will cover the design and analysis of hull structure and skeg design. It is also to ensure the stability and straight movement of the tugboat. This study will thoroughly focus on analysis of the tugboat using the SolidWorks and ANSYS software. In addition, the physical analysis will perform as the test tugboat structure in small scale.

2.0. METHODOLOGY

Methodology of this project will explain about the flow to design and analysis bollard pull harbour tug. The planning of process and flow chart of the design and analysis can be easy to implement when the flow chart are drawn.

2.1 Research Methodology

Firstly, this project must have a drawing of bollard pull harbour tug. So that AutoCAD and SolidWorks software has been use as a method to design all drawing of bollard pull harbour tug. Secondly, stability analysis will be applied as a method to analyse the stability and the straight movement of the Bollard Pull Harbour Tug using a SolidWorks Simulation Xpress and SolidWorks Flow Simulation. Lastly ANSYS software is used to define the stability and straight movement to compare with the SolidWorks analysis.

2.2 Hull Construction

Figure 2 shows the existing design of skeg for Bollard Pull Harbour Tug.

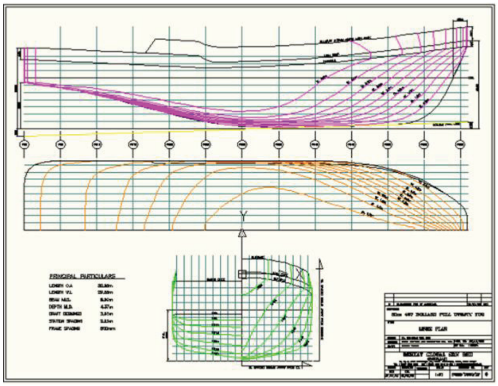


Figure 2: Existing Design of Skeg

2.3 Method of Analysis

Finite Element Analysis - Static analysis in this research is to define the Factor of Safety of both designs with the specific value of force applied on the old design and new design. Solid Works Simulation Xpress is the analysis software that is used to make the static analysis.

Dynamic Analysis - Dynamic analysis is the analysis of the properties of a running program. In contrast to static analysis, which examines a program text to define properties that hold all executions, dynamic analysis also derives properties that hold for one or more executions by examination of the running program usually through program instrumentation (Bell, 1999). SolidWorks Flow Simulation & ANSYS FLUENT is the analysis software that is used to make the dynamic analysis.

2.4 Analysis Comparison

The comparison of two different method of analysis is simple and easy. It is consists of comparison between SolidWorks Flow Simulation and ANSYS for the purpose of same analysis formation. To compare the analysis, each analysis method must meet the similarities of analysis method such as fluid flow configurations, speed of the fluid flow, and so on. The further information of this problem will be issue later at the Analysis topic.

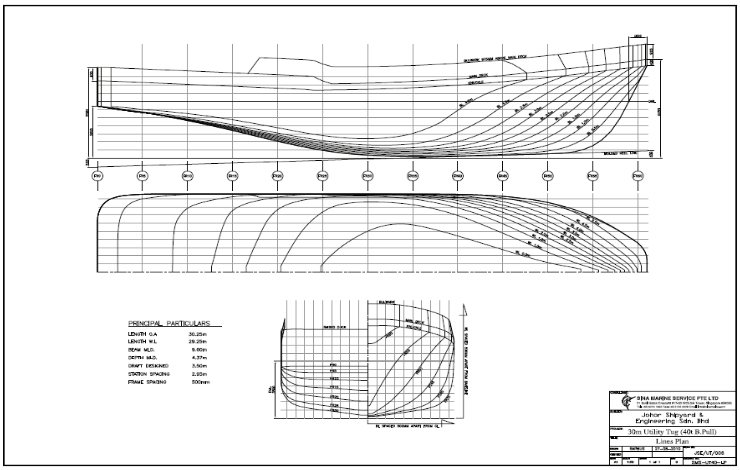
3.0 DESIGN & FINITE ELEMENT ANALYSIS

The design is form in AutoCAD for 2-dimensional structural system and SolidWorks for 3-dimensional structural system. The method of

3-dimenional structural system will discuss in 3.2 sub-topics which is Design Methodology. The guidelines of a design are based on the 40ton Bollard Pull Utility Tug's Offset Table. Other guideline used to design the 3D drawing is AutoCAD drawing which shows the dimensional characteristics of each frame for assisting in visualisation of the shape of hull design.

3.1 2-Dimensional Structural Systems

The method of designing hull of the tugboat is based on the frames which is each of the frame have its own characteristics and dimensional based on the curvature and height of buttocks and lines plan. The frames consists of 61 frames had been drawn using a 3D sketch and continue with a 2D sketch which the curve lines. Figure 3 shows the 2D structural system of Bollard Pull Harbour Tug.



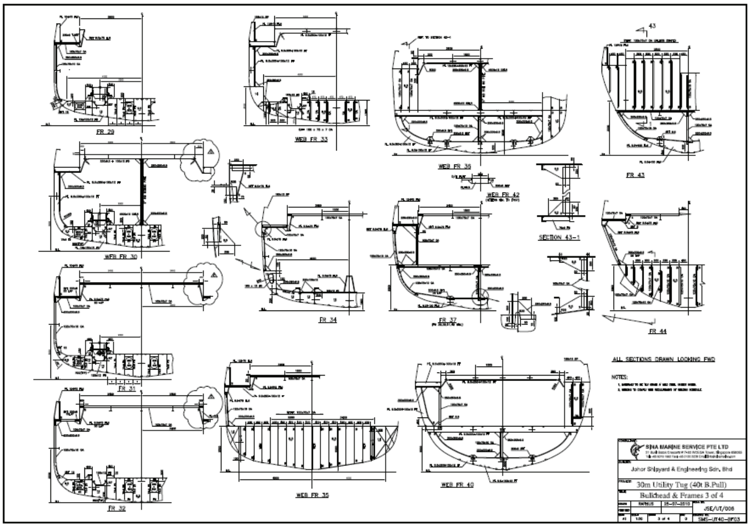


Figure 3: 2D Structural System of Bollard Pull Harbour Tug

3.2 3-Dimensional Structural Systems.

Before carrying out the design process, the scale needs to be considered first. It is because the actual size of the tugboat is too large and is would be take a time to do an analysis mostly during dynamic analysis. According to the previous study, it will take about one to two days to construct a meshing geometry and run analysis. With downsize the tugboat; it will take two or three hours to do a mesh and run analysis. Instead of that the force requirement also need to scale down due to downsize the tugboat design. The decision making was carried out and the result found that the suitable dimension is scale down to 1:100 in milimetre. Figure 4 shows the 3D structural system of Bollard Pull Harbour Tug.

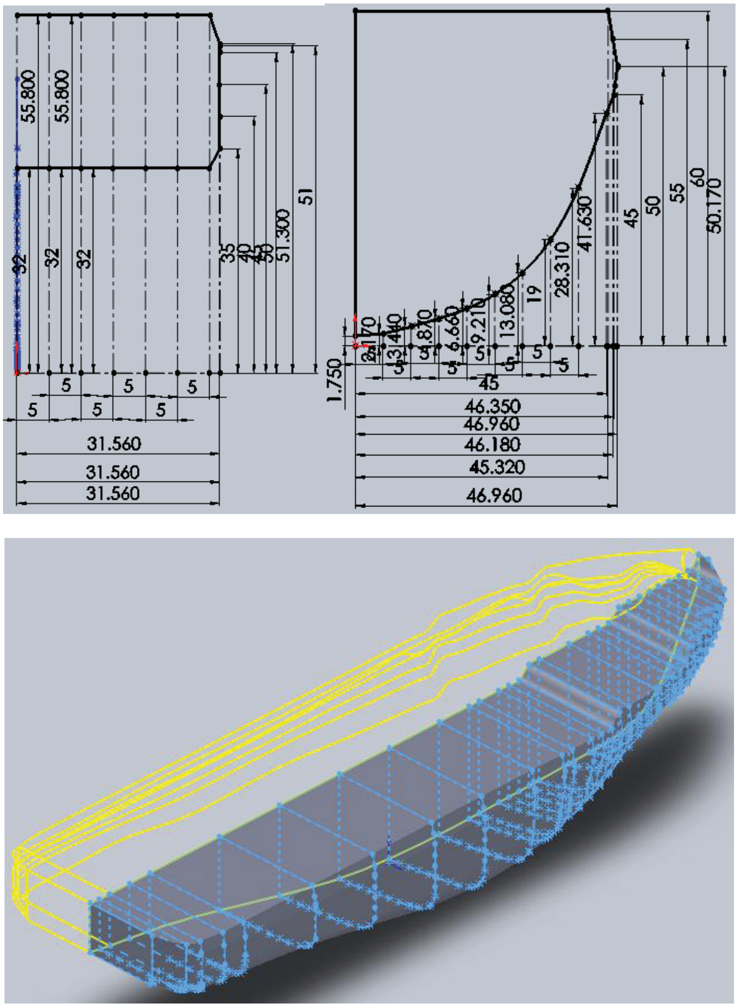


Figure 4: 3D Structural System of Bollard Pull Harbour Tug

3.3 Static Analysis for Tugboat Hull

Linear Static analysis is used to generate the stress distribution on the tugboat hull as that mention in Chapter 3. Static analysis can analyzed the SolidWorks parts and determine the safety factor of the certain part. These analyses also show a result on stress, strain, displacement and Von Mises. The analysis is done by using SolidWorks SimulationXpress. Firstly, the fixtures are set on the upper surface of the tugboat. The reason is there is no load or pressure on the surface and for the purpose of this study is only analysis on the hull, not the upper surface of the tugboat. Figure 5 shows where the fixture had been put.

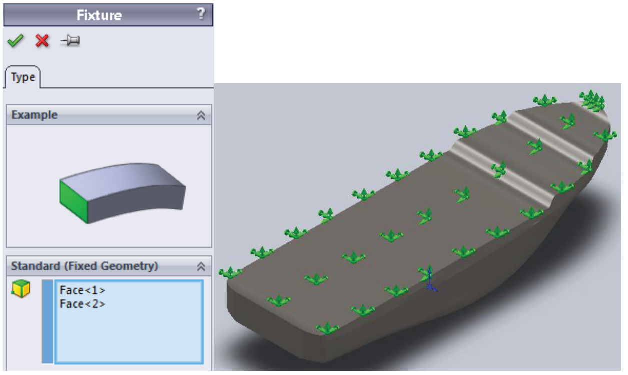


Figure 5: Fixture Setup on the Upper Surface

Then, to simulate the loading in the hull, need to apply forces. The load apply is 121000 N/m2. For the real situation, the load apply on the hull is 12.1 MPa but after scale down to 1:10 so the load apply is 0.121MPa.

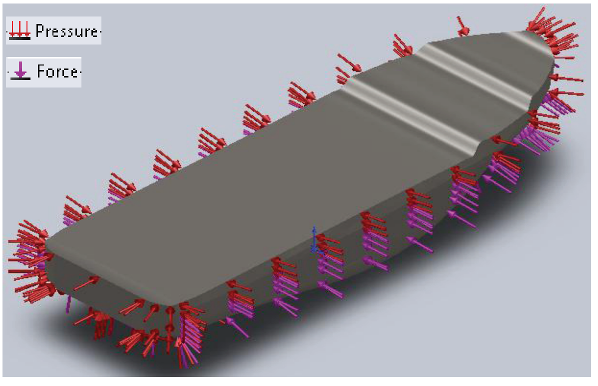


Figure 6: Pressure and Force Applied on Required Faces

After that, the material is selected. In this part, material selection is important because it affect the results of the analysis. The study on material properties of the hull is crucial to ensure the requirement to manufacture the tugboat is on optimum level such as material cost, manufacturing cost, maintenance cost, etc. In the purpose of this study, the material applied is 1023 Carbon Steel Sheet. The material properties of this material are shown in Figure 7.

Mechanical Properties

Properties		Conditions	
		T (°C)	Treatment
Density (×1000 kg/m^3)	7.858	25	
Poisson's Ratio	0.27-0.30	25	
Elastic Modulus (GPa)	190-210	25	
Tensile Strength (Mpa)	425	25	cold drawn (round bar (19-32 mm)) more
Yield Strength (Mpa)	360		
Elongation (%)	15		
Reduction in Area (%)	40		
Hardness (HB)	121	25	cold drawn (round bar (19-32 mm)) more

Figure 7: Material Properties of 1023 Carbon Steel

Lastly, run the simulation and obtain the results. During this time, simulation can be done and the result can be shows. The results von Mises stress, displacement, deformation and factor of safety.

3.4 Fluid Flow Analysis for Tugboat Hull

They are the fluid dynamic analyses which consist of more than one fluid type. The fluid types could either exist in the analysis from the beginning or appear at later stages. Multi phase flows are more complex analyses than the single phase analyses due to its theory and numerical solution methods. Therefore the duration for the solution is much longer and they require expertise in perspective of solution techniques. Multi phase flow is very important especially for ship hydrodynamics and offshore structures.

Firstly, setup geometry. Before proceeds setup geometry, the SolidWorks drawing need to change its format to IGES file (.IGS). This is because ANSYS software is compatible with the IGES format. After finished converting file format, the drawing of tugboat that been converted is import into the geometry.

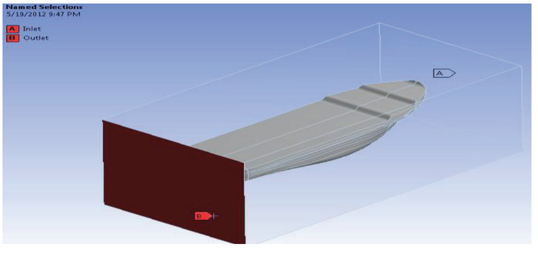


Figure 8: Geometry of Tugboat Hull after generated

Then, meshing the tugboat hull to make the subsidiaries of the geometry.

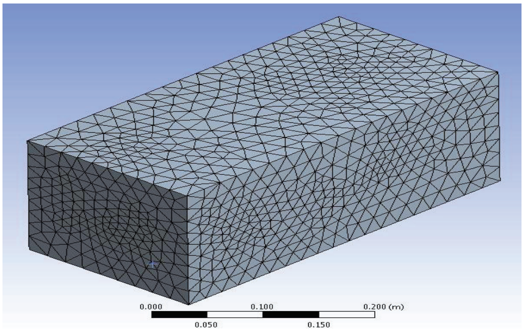


Figure 9: Meshing the Tugboat Hull

After that, setup all the information needed to make the fluid flow of Tugboat Hull.

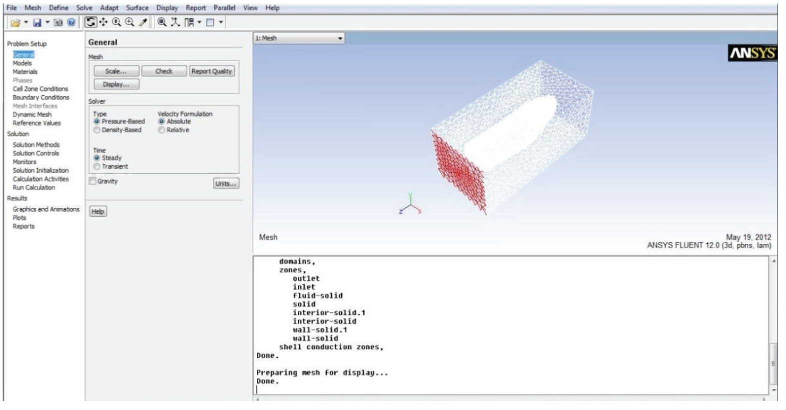


Figure 10: Fluid setup of Tugboat Hull

Finally, run the fluid flow analysis and obtain a result. During this step, the graph iteration versus velocity is obtained.

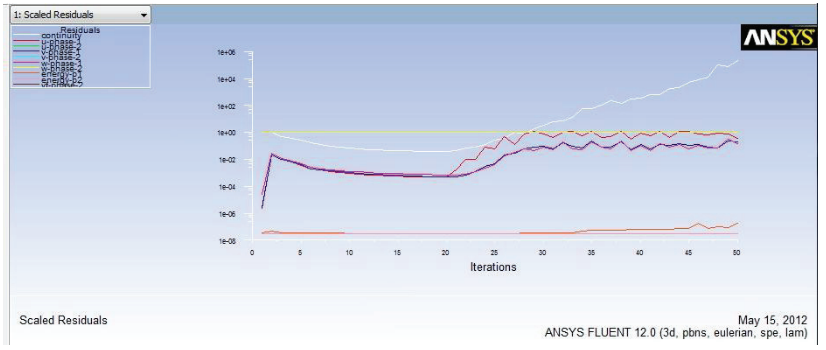


Figure 11: Graph Iteration vs. Velocity

4.0 RESULT AND DISCUSSION

4.1 Static Analysis

The results von Mises stress, displacement, deformation and factor of safety are obtained from the SolidWorks SimulationXpress.

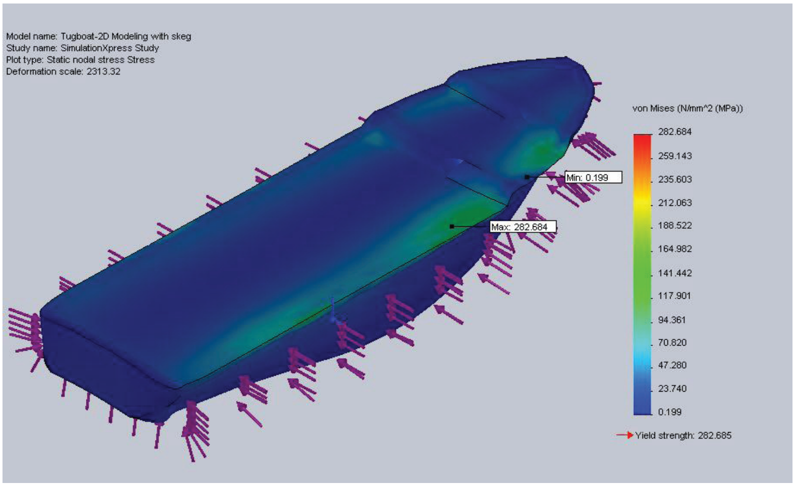


Figure 12: Result of Von Mises Stress (Equivalent Stress)

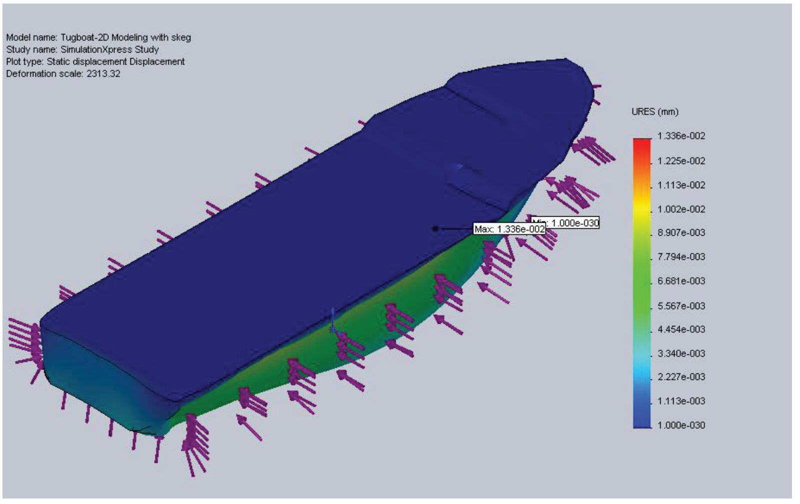


Figure 13: Result of displacement

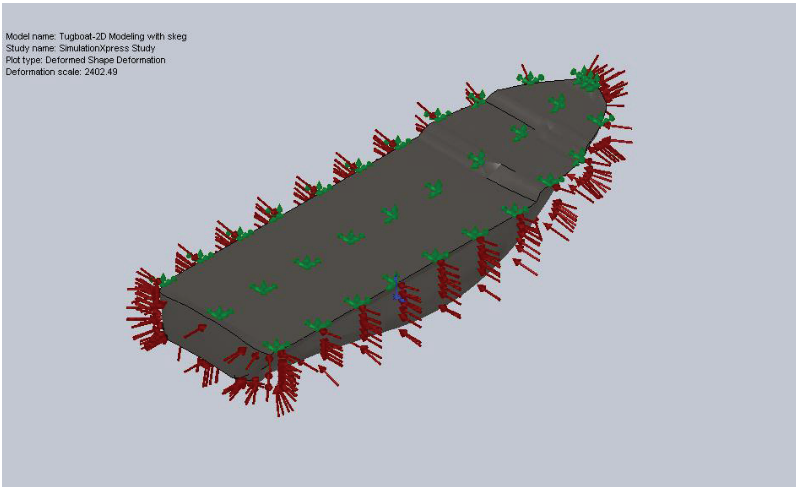


Figure 14: Result of deformation

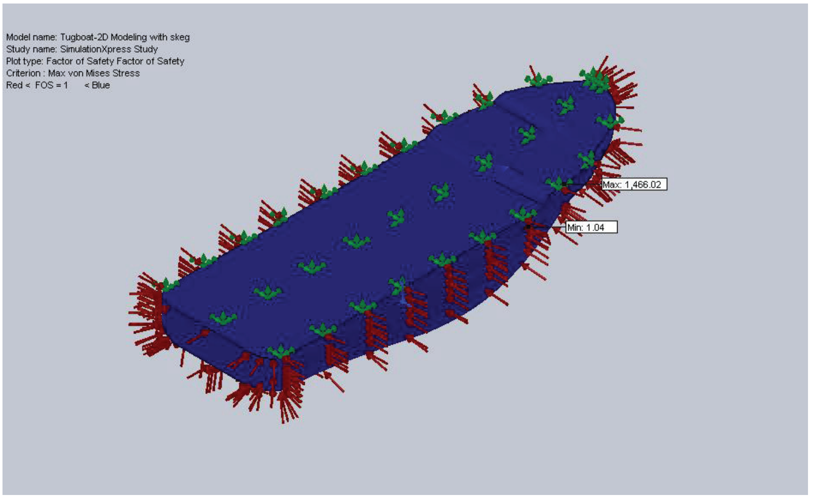


Figure 15: Result of Factor of Safety

4.2 Fluid Flow Analysis

The results for fluid flow analysis are air phase contour, water phase contour, air phase streamline, and water phase streamline.

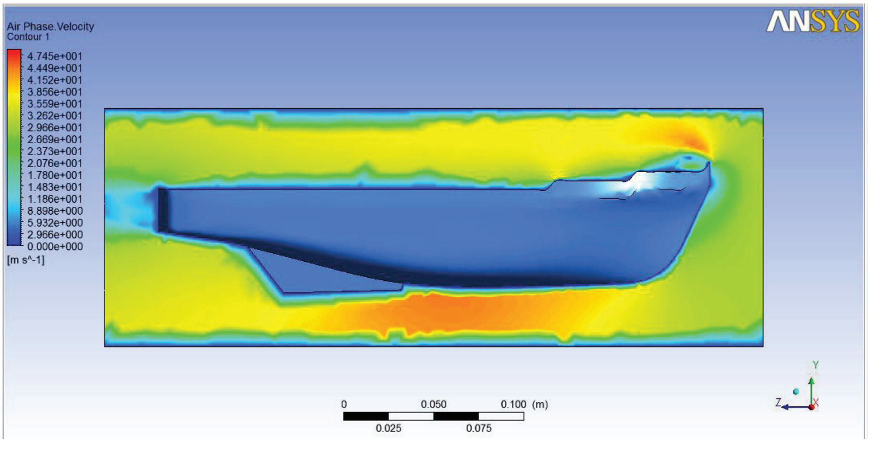


Figure 16: Air Phase Contour

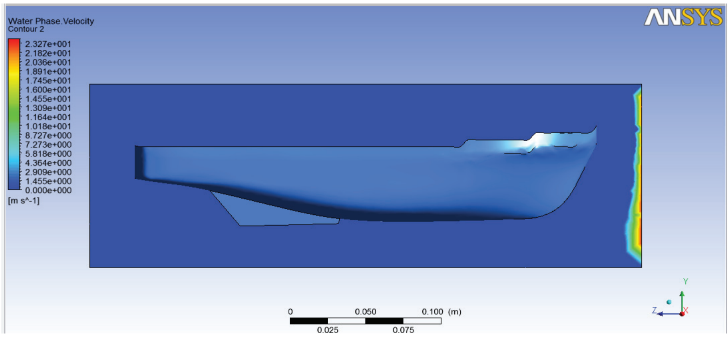


Figure 17: Water Phase Contour

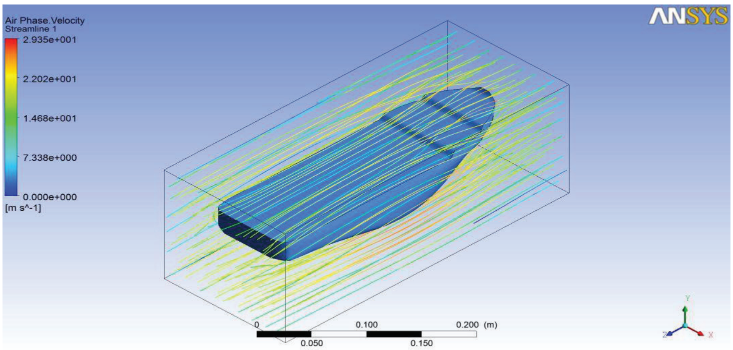


Figure 18: Air Phase Streamline Figure 19: Water Phase Streamline

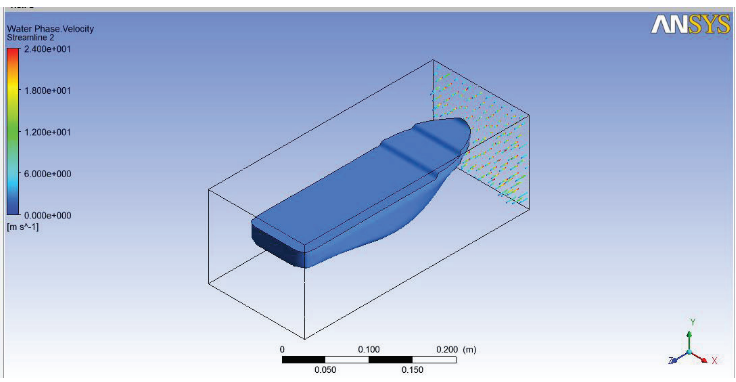


Figure 19: Water Phase Streamline

5.0 CONCLUSION

This study has demonstrated the ease to make an analysis of fluid flow by using ANSYS FLUENT. Relatively low velocity from inlet or outlet interface of fluid flow analysis can affect the flow of water or air in a certain period of time. The shape of Tugboat Hull also can affect the flow of water or air this could prove to be problematic if not disastrous. Hence, the designing steps of Tugboat Hull should be given emphasis including fluid flow analysis to enhance the quality and factor of safety for the Bollard Pull Harbour Tug.

6.0 ACKNOWLEDGEMENT

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