Dry dock gate stability modelling

Oktoberty¹, Widiyanto²,* E J Sasono³, S Pramono⁴ and A T Wandono¹,⁴

¹Akademi Teknik Perkapalan Veteran, Semarang, Indonesia
²Universitas Negeri Semarang, Indonesia
³Teknik Perkapalan, Universitas Diponegoro, Semarang
⁴PT Jannata Marina Indah, Semarang, Indonesia

*Corresponding author : widiefree@gmail.com

Abstract. The development of marine transportation needs in Indonesia increasingly opens national shipyard business opportunities to provide shipbuilding services to the shipbuilding vessels. That emphasizes the stability of prime. The ship's decking door becomes an integral part of the efficient place and the specification of the use of the asset of its operational ease. This study aims to test the stability of Dry Dock gate with the length of 35.4 meters using Maxsurf and Hydromax in analyzing the calculation were in its assessment using interval per 500 mm length so that it can get detail data toward longitudinal and transverse such as studying Ship planning in general. The test result shows dry dock gate meets IMO standard with ballast construction containing 54% and 68% and using fix ballast can produce GMt 1,924 m, tide height 11,357m. The G Mt value indicates dry dock gate can be stable and firmly erect at the base of the mouth dry dock. When empty ballast produces GMt 0.996 which means dry dock date is stable, but can easily be torn down. The condition can be used during dry dock gate treatment.

1. Introduction

The construction of dry dock needs to design of the detail and thorough planning, including gate/door design. What distinguishes from other types of the dock is the door that can move freely. The door would close to separate the pool by the beach. After the ship goes into the dock, then the gate/door will be closed by withdrawal. Once the door is closed then the water inside the pond will be pumped out so that the pond dries. Water pressure from the beach will press the door/gate so it locks. After the pond dries up, it can be done work on the ship. Upon completion of the work, the pool will be filled with water again which causes the water pressure from the pool and the beach to be balanced. The balanced water pressure between the pool and the beach will release the lock so that the door/gate can move freely. The door can be pulled so that the open dock allows the ship to exit [1].

Dry dock gate has characteristics similar to the ship. Dry dock gate can float on water so it will be easy to move by attracted. To close the dry dock, the gate/door will be filled with water so it will sink to a certain depth. With these characteristics, it is necessary to take into account its stability in order to remain upright in various conditions and forces from the outside. Prior to the development of dry dock, gate needs to be modelled to ensure the gate can be stable, have the technical specifications according to the standard so it can work optimally (Figure 1 and Figure 2).
Dry dock gate has stability and hydrostatic characteristics similar to ships. The stability of the ship reflects the ability of the ship to return to its original position after experiencing tensile forces from the outside and from inside the vessel causing the ship to tilt. Floating bodies on the surface of the water are two main styles which are equal in magnitude and are in opposite directions on the vertical axis in the form of gravity G (centre of gravity) and buoyancy B (centre of buoyancy) [3–5]. There are three main points that determine the stability of the ship. The first point is the centre of gravity (G) which is the resultant point of gravity of all parts of the ship. The second point is the centre of buoyancy (B) which is the geometric point of the ship's sections buried in the water pressing upward. The third point is the meta centre (M) which is the height of the ship inclination angle and the centre point of the line that works in buoyancy and gravity. The force that causes stability is the gravity of G equal to the displacement and the floating force acting on B as large as the displacement of water in accordance with the law of Archimedes [6–8].

If point G is below the point M, then the righting moment, \( RM = \Delta GZ \), while \( GZ = GM \sin \theta \) is positive because the enforcement arm (GZ) is positive. This moment of enforcement is able to return the ship to its original upright position. Such stability is called positive (stable) stability. If the points G and M coincide, then the enforcement moment (RM) will be equal to zero since no enforcing arm \( GZ = 0 \) is formed so that \( RM = 0 \). This means that when the ship quickly ships the ship will still shake because there is no enforcement arm, this condition is called neutral stability. If point G is above the point M then the moment of enforcement (Righting moment, RM) is negative because GZ arm is negative. The moment of the peacekeeper is unable to return the ship to its original position, instead helping to tilt the ship and the possibility of the vessel being overturned, this condition is called negative stability (unstable).

Transverse stability is one of the major factors in ship stability. Ship stability lines include KM lines, KB lines, BM lines, GZ lines, GM lines, KG lines. The KM and KB Line values are obtained from the ship's static hydro curve, whereas the BM, GZ, GM, KG line values are obtained from the slope experiment. Conventionally, a slope experiment is performed using a pendulum on the centre line of the ship, CL (Center of Line). The slope of the vessel is measured from the pendulum pendant against the CL line when the trim vessel conditions [9,10].

Inclining experiments aim to investigate stability in completing shipbuilding by testing objects called centres of gravity. The main purpose of testing is to know the highest value of the metacentric point. A centre of gravity position with accurate value is required to keep the vessel steady in operation. Inclining experiments are shown to obtain a vertical distance from point G above the K point accurately when the ship is stable.

Parameters to assess ship quality are the ratio of main dimension, hydrostatic parameter and ship stability condition. The main condition ratio is used to determine the strength of construction, movement resistance, and ship movement. The hydrostatic parameter is used to determine the technical performance of the vessel at a certain load limit. The stability of the vessel aims to ensure the safety and goodness of the ship. Displacement \( Aw \), LCF and shape coefficient will increase with draft increase, while LCB, KMI and KMt will decrease with increasing draft [11]. The stability of the vessel is also influenced by natural conditions in the form of waves, waves, currents, so that ship planning must meet the requirements of shipbuilding construction is strong and resistant to the worst sea conditions.
conditions. The tilt experiment using the pendulum is not practical because it uses a lot of equipment and equipment. Conventional convoluted convolutional calculations require a high degree of accuracy in reading the slope of the ship from the pendulum pendants against the CL line. In the design of the ship, at this time there are various software that can be used to be used to simplify the design of the ship and have more precise and detailed results [12,13]. Maxsurf is a software that can be used to analyze the hydrostatic vessel [14–16]. By entering the vessel data, maxsurf will process and generate hydrostatic parameter values in the form of data tabulation and hydristatic curve. Maxsurf is a software that can be used for modeling stability and seakeeping analysis. Maxsurf software provides ship resilience data. Maxsurf is one of CASD with Design reuse method with design process which in development of design result begins by using old design example (abundant knowledge) about old design directly, then modify old design to produce new design [17,18].

2. Methods
This research uses computer modelling method with maxsurf and hydromax software. Maxsurf is used to determine the hydrostatic characteristics of ships. Testing includes sounding tank, hydrostatic, simulation of three constructions. The first condition uses fixed ballast and without ballast. The second construction uses fixed ballasts and ballasts. The third construction without a fixed ballast, without ballast. In addition, simulation of leaks in the tank so filled with sea water. Stability criteria use International Marine Organization (IMO) standard.

3. Result and Discussion
The modelling was done on dry dock gate with length 35.4m, width 3m with four water tank as ballast. High gate and fix ballasts 7.2m with an estimated receded water of 8.5m and an estimated tidal of 10.5m. High water fixed bottom ballasts 2.25m and high fix upper ballasts 1.32m. Weight fixed bottom ballast 325.2 ton and fix upper ballast 120 ton with SG Concrete 2 ton / m$^3$. The design of dry dock gate can be seen in Figure 3.

![Figure 3. Design of Dry Dock Gate](Image)

3.1 Tank Sounding
The data tank show in tank 1 shows the empty condition. The longitudinal gravity centre (LCG) is at 5.6m, the Gravity Transversal Center (TCG) is in the 0m position, the 2,296m Vertical Center of
Gravity (VCG) and the FSM 11.676ton.m. When fully charged, water capacity is 214.193m³ or 219.590ton, LCG is at position 5,529m, TCG remain at position 0m, VCG shifted at position 6,892m, and FSM 0ton.m.

The tank sounding data on tank 2 shows the empty condition of the Longitudinal Center of Gravity (LCG) at 13.913m, the Transverse Center of Gravity (TCG) is in the position 0m, Vertical Center of Gravity (VCG) 5.215m and FSM 17.27 ton.m. When fully charged, the water capacity is of 66.795m³ or 68.478ton, LCG is at 13.913m, TCG remains at 0m, VCG shifts at position 5.215m, and FSM 0ton.m.

The tank sounding data on tank 3 shows the empty condition of the Longitudinal Center of Gravity (LCG) at 21.499m, the Transverse Center of Gravity (TCG) is in the position 0m, Vertical Center of Gravity (VCG) 5.215m and FSM 17.519ton.m. When fully charged, the water capacity of 66.795m³ or 67.117ton, LCG is in position 21.499m, TCG remain at position 0m, VCG shifted at position 6.673m, and FSM 0ton.m.

From the sounding tank data shows the LCG each tank is in the middle of each tank, it is due to the box-shaped tank, so the LCG has no effect on the filling of water in the tank. Likewise, the TCG remains in position 0m or remains in full or empty tank condition. While VCG will decrease if the tank is filled with water, the more water filled, the lower the VCG, so the gate will be more stable. Sounding tank data shows no trim on the tank. The trim caused by leaks in the tank. Trim causes dry dock gate tilting, it can be overcome by adding or reducing water in one of the tanks.

3.2 Hydrostatic
Modeling is done every 0.25m, starting from draft at midship 1m to 12m. The data shows that in each AP and FP height the same or no trim, it shows the gate in an upright position, or not tilted or can be seen from heel to starboard degrees is 0o. When draft at midship 12m, displacement equal to 1.009 ton with the coefficient block is 1,449 and LCB location is 0,031 from a midship gate. Displacement, AP, FP, coefficient block and LCB decreased according to the height of draft at midship up to 1m displacement position of 368.7 tonnes, FP and AP 4.5m, the coefficient of 0.753 and LCB 0,030 m from the midship gate.

The highest GMt value of 2.741m at the time of the gate is buried as high as 12m, the condition is the most stable condition. The GMt value decreases according to the draft height. GMt is 0,004m when draft at height 5,750m, condition G and M value almost coincide so gate in still upright position, but easy to tear down. By the time the draft reaches 5.5m, GMt is already negative, ie -0.118m it indicates the gate is unstable. The lowest GMt value is in the 1m draft with a value of -2.489m.

The amount of load used to change the draft value of the ship by 1cm (TPC) at each draft height is different. At the time of draft 12m, TPC is worth 0.581 tonne/cm and is worth 0.608 tonne/cm at the time of draft 1m. The maximum value of TPC is 0.950 tonne/ m at the time of draft in the position of 3.00 m - 7.50 m.

Modelling is done in three tank conditions. The first condition of the gate using fixed ballast and without ballast. The second gate conditions use fixed ballast and ballast, the third condition, gate without fixed ballast and without ballast. Fixed Ballasts are filled with concrete with 2ton / m³ period. While the ballast in the form of tanks that can be filled with sea water. If the ballast filled with sea water, then the gate will go down.

3.3 Tank Condition with Fixed Ballast or without Ballast
First modelling with tank condition using fixed ballast and without ballast. The condition without ballast means the tank is not filled with water. The weight of door and fittings of 193 tons, Fixed
ballasts over 120 tons, fixed ballasts under 325.2 tons, so the total weight is 638 tons. LCG door and fitting bearings at 17.7 m position, as well as the upper and lower fixed ballasts are at position 17.7m, while Tank 1 5.529m, tank 2 13.913m, tank 3 21.499 and tank 4 29.844m. VCG doors and constructions are at 6.5m, the fixed ballast of 2.92m, Fixed ballasts below 1.06m, while VCG Tank 1 6.892m, Tank 2 6.673m, tank 3 6.673m and tank 4 at 6.844m. LCG gate is in position 17.7m or in the middle with VCG 3.055m and VCG water 3,055 and TCG and FSM 0m.

Stability criteria based on standard A.749 (18) Ch3 Design criteria applicable to all ships. Criteria include Area 0 to 30 from the greater, Area 30 to 40 from the greater, Max GZ at 30 or greater in the range, Angle of maximum GZ, Initial GMt spec. heel angle. Of all these criteria, the results indicate the value meets the predefined standard criteria. This construction has GZ 0.083m, initial GMt at 0° 0.966, and Max GZ 2.918 m at 90° angle with heel to starboard 4.910° and area 0.2024m.deg. With these conditions can be said gate in a stable position.

3.4 Tank Condition with Fixed Ballast & Ballast
Second modelling with tank condition using fixed ballast and ballast. The weight of doors and fittings of 193 tons, Fixed ballasts of 120 tons, fixed ballasts under 325.2 tons, Tank weight 1 118.6 tons, tanks 2 46.56 tons, tanks 3 46.79 tons, tanks 4 119.9 tons, so the total weight is 970 ton. LCG door and fitting are at 17.7 m position, as well as fixed upper and lower fixed ballast at position 17.7m, while Tank 1 5.529m, tank 2 13.913m, tank 3 21.499 and tank 4 29.759m. VCG doors and construction are at 6.5m, fixed ballast over 2.92m, Fixed ballasts below 1.06m, while VCG Tank 1 6.892m, Tank 2 6.673m, tank 3 6.673m and tank 4 are at 6.884m. LCG gate is in position 17.7m or in the middle with VCG 3.767m and VCG water 3.282 and TCG and FSM 0m. This condition causes FS correction of 0.061.

Data Large Angle Stability shows Max GZ 2,159 m at 90° angle, Gz 0.963 m with the heel to starboard of 30°. Initial GMt GM 1.924 at an angle of 0° it meets the criterion standard 3.1.24 with Initial GMt no smaller 0.150m. At gate with fix ballast and ballast filled with water as much as 54% produce GMt 1.924 with water level 11,357. With these conditions, the gate can stand upright stable and sturdy at the bottom of the floor dry dock. The condition is used when in the process of closing the gate to the dry dock.

3.5 Tank Condition without Fixed Ballast & without Ballast
Third modelling with tank condition is without fixed ballast and without ballast. The weight of the doors and fittings of 193 tons. LCG doors and fittings are at 17.7m, while Tank 1 5.529m, tank 2 13.913m, tank 3 21.499 and tank 4 29.844m. VCG doors and constructions are at 6.5m, the fixed ballast of 2.92m, Fixed ballasts below 1.06m, while VCG Tank 1 6.892m, Tank 2 6.673m, tank 3 6.673m and tank 4 at 6.884m. LCG gate is at 17.7m or centre position with VCG 6.5m and VCG water 6.5 and TCG and FSM 0m, and FS correction is 0.

Data Large Angle Stability shows an angle of vanishing stability at area 0-30 is to -36,133m.deg or far below threshold criterion that is 3.151m.deg. In the area 0-40 of -62,920m.deg with a minimum criterion threshold of 5.157. In a 30-40 area of -26,787m.deg with a minimum threshold of 1.719m.deg. Max GZ on area 30 or more equal to -0.861m with the lower limit of 0.2m. And Initial GMt of -4.727m with a minimum threshold of 0.15m. From the data can be stated dry dock without fixed ballast and without unstable ballast. If gate without fix ballast and ballast or not filled with water, the result is GMt value worth -4.727 with water level 2,649m. The condition of the gate is in an unstable position.

3.6 Damage Condition
The last modelling is the leak in the tank. The tank is assumed to have the worst condition, a leak in one of the big tanks so that it is fully charged. The modelling results show that if one large tank (tank 1 or tank 4) has leakage, the gate will be inclined at 33.5° and still float. Although in a state of leaking and drowning gate dry dock remains in stable condition. It can be seen from the data of large stability.
Max GZ at point 1.926m at the 90° angle with minimum criterion threshold at 0.2m. Initial GMt GM at point 1.769m at an angle of 0° with a minimum threshold of 0.15 m. Heel to starboard at corner 30° has GZ 0.764m.

4. Conclusion
Gate dry dock when opened can float like a ship, so the characteristics of stability resemble with the ship. Gate dry dock has ballast to balance. Ballast gate dry dock usually uses concrete located at the bottom of the gate that makes a standing position. To close the dry dock gate is pulled and filled with sea water so it sinks and closes the dry dock.

The result of modelling on a gate dry dock that has a width of 35.4 m and has four tanks with a capacity of 21.193 m³, 66.795, 67.117m³, 216,628m³ satisfies the stability standard A.749 (18) Ch3 on construction using fixed ballasts, without ballasts, and construction using fixed ballast and ballast. Gate graving dock is unstable in construction without fixed ballast and without ballast. In a leaky condition, the gate dry dock remains in a condition stable although one large tank leaked and filled full water. If one large tank is full of water, then the gate dry dock will experience a slope of 33.5°. Tanks that use fixed ballast and without ballast have GZ 0.083m, initial GMt at 0° 0.966, and Max GZ 2.918 m at 90° angle with the heel to starboard 4.910° and area of 0.2024 m.deg.

References
[1] Hanley T, Sowder A M, Palmer C A and Weiss R L 2016 Acad. Pathol. 3 1
[2] Zucca M, Crespi P G and Longarini N 2017 Case Stud. Struct. Eng. 7 1
[3] Acanfora M and Cirillo A 2017 J. Mar. Sci. Technol. 22 734
[4] Sun H and Faltinsen O M 2011 J. Mar. Sci. Technol. 16 270
[5] Masumi Y and Nikseresht A H 2017 Appl. Ocean Res. 68 228
[6] Ueng S K 2013 J. Mar. Sci. Technol. 21 674
[7] Eduart W, Baruadi A S, Fachruzyah Z and Junus S 2017 J. Eng. Appl. Sci. 12 2879
[8] Hafez K A and El-Kot A A 2012 Alexandria Eng. J. 51 153
[9] Koh K K, Ibrahim I H M, Kader A S A, Agoes P, Rahimuddin R, Arib M N, Zan U I, Lok K B, Wira J Y, Mohd Noor A B and Maimun A 2015 J. Teknol. 74 33
[10] Yaakob O, Hashim F E, Jalal M R and Mustapa M A 2015 J. Sustain. Sci. Manag. 10 50
[11] Maimun A, Nakima S, Tarmiza A, Ahmed Y M and Behrouzi F 2014 Appl. Mech. Mater. 663 522
[12] Maki A, Umeda N, Renilson M and Ueta T 2010 J. Mar. Sci. Technol. 15 218
[13] Nakisaa M, Maimun A, Ahmed Y M, Behrouzia F, Steene S and Tarmizia A 2015 J. Teknol. 74 73
[14] Rusmilyansari, Rosadi E and Iriansyah 2017 IOP Conf. Ser. Earth Environ. Sci. 89 12007
[15] Ahmed A M E and Duan W 2016 World J. Eng. Technol. 4 235
[16] Hussain N A A, Sathyamoorthy D, Md Nasuddin N, Nawi N M, Mansor M N, Sulaiman N E S, Yaacob R, Ramli R, Mohd Rashid M R, Ramli I, Ismail A S, Louisnaden E and Ibrahim N A 2013 Def. S T Tech. Bull. 6 1
[17] Sun H and Faltinsen O M 2011 J. Mar. Sci. Technol. 16 168
[18] Rahman S 2017 Procedia Eng. 194 323