

PAPER • OPEN ACCESS

Analysis of Power Requirements and Turning Circle of Amphibi Coach

To cite this article: V D Moganti *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1052** 012045

View the [article online](#) for updates and enhancements.

You may also like

- [Development of Mathematics Learning Tools Based on Coaching Technique to Create Accelerated Learning Revolution](#)
S P Tanjung and D Permana
- [Amphibian collapses increased malaria incidence in Central America](#)
Michael R Springborn, Joakim A Weill, Karen R Lips et al.
- [The Effect of Emotional Intelligence, Training Facilities, Self-Competence and Motivation toward Coaches' Performance of PPLP West Sumatra Province](#)
Donie



The Electrochemical Society
Advancing solid state & electrochemical science & technology

243rd ECS Meeting with SOFC-XVIII

More than 50 symposia are available!

Present your research and accelerate science

Boston, MA • May 28 – June 2, 2023

[Learn more and submit!](#)

Analysis of Power Requirements and Turning Circle of Amphibi Coach

V D Moganti¹, R E Garetno¹, R Irvana² and A Fadillah²

¹Student of Naval Architecture, Darma Persada University, Jl. Taman Malaka Selatan, Jakarta Timur 13450, Jakarta.

²Department of Naval Architecture, Darma Persada University, Jl. Taman Malaka Selatan, Jakarta Timur 13450, Jakarta.

Abstract. This research is a continuation of the previous one. It is an analysis to find the power requirements and turning circle of Amphibi Coach. In this analysis, the method used for calculating the propulsion power when in water uses the KR-Barge calculation method. In turning circle analysis using the Hovgaard method, this method is a simple method for estimating turning circle without field testing. The standard used for turning circles refers to the standard Resolution MSC 137 (76) (adopted on 4 December 2002) Standards For Ship Maneuverability. From the calculation of the driving power, the driving power needed when the Amphibi Coach is in the water is 126.99 HP while the Amphibi Coach driving power when on the ground is 420 HP. The final propulsion is determined based on the greatest propulsion, which is 420 HP. The results of the Amphibi Coach turning circle analysis showed that the Amphibi Coach turning circle without Fin Stabilizer was 25.96 m and had a tactical diameter of 51.92 m. For Amphibi Coach turning circle with Fin Stabilizer of 26.34 m and has a tactical diameter of 52.69 m. Amphibi Coach turning circle analysis using the approach formula shows that the results obtained have met the applicable criteria.

1. Introduction

North Sumatra province is one of the top 10 (ten) tourism destinations in Indonesia where there are 339 tourist attractions scattered throughout the region in 33 districts/cities in North Sumatra Province. Currently, only 120 attractions that have been marketed include natural potential, one of which is Lake Toba Area. Lake Toba is a mainstay tourism area, both provincial and national [1].

Amphibi Coach is a bus type vehicle that can be operated on land and water lines designed to support Lake Toba tourism. To support the operation of Amphibi Coach require power adequately. In determining power, it is necessary to determine the resistance elements and the efficiency of the thruster. The resistance elements that work on amphibious vehicles are frictional resistance, shape resistance, and wave-making resistance [2]. The sailing resistance of amphibious vehicles consists of friction drag, form drag and wave drag, friction drag related to water viscosity, water pressure related drag form, and wave drag related to car speed [3].

Increased resistance to shallow water compared to deep water at the same speed is seen as significant. The speed of flow under the hull in shallow waters is higher than in the deep waters because there is an increase in flow under the keel and a decrease in pressure in the region, as a result, the buoyancy decreases and results in sinkage and trim. As the ship sank, the wet surface area increased, as a result, the viscous resistance increased [4].

In general, one of the properties of the ship that needs to be known by the captain or officer of the ship is the ability to move when sailing and when going lean or going off the dock that is the response



speed of the steering wheel blade or the control lever of the aircraft engine on the moving platform and also the size or small turning circle of the rotating ship [5]. According to Jamaluddin, the IMO (International Maritime Organization) regulation called "Standard for Ship Maneuverability" should be met at the time of the ship's design and operation [6].

Resistance and maneuvering characteristics are required to predict the speed, acceleration, stop, turn, yaw inspection, and track keeping ability of amphibious ships [7]. In the research journal Renaldi, Amphibi Water School Bus has frictional resistance of 0.176 tons, wave-making resistance is 1.737 tons, and air resistance 0.026 tons so it has a total resistance of 1.939 tons [8]. For the determination of the vehicle's engine while on the ground, the total force of the vehicle is calculated at the desired speed. Traction style is derived from the calculation of total aerodynamic inhibition force, rolling inhibition force, gradient resistance [9].

In the research journal Moganti, Amphibi Coach design has a length size of 13.115 m, width 2.5 m, height 3.8 m equipped with fin stabilizer has met rolling criteria standards according to IMO Level 2 but in this design barrier analysis and turning circle, Amphibi Coach has not been done [10].

From the design analyzed by Moganti, the idea of calculating power requirements and estimates turning circle Amphibi Coach. This research will be conducted to analyze the power requirements and turning circle Amphibi Coach equipped with the addition of fin stabilizer on Amphibi Coach.

2. Methodology

In this study, the object used was the Amphibi Coach of literature [10]. Here is the Amphibi Coach data shown in Table 1.

Table 1. Amphibi coach main size data

LWL	13.115 m
Draft	1 m
Height	3.8 m
Beam Hull	2.5 m
Displacement	27.21 ton
Service Speed	8.2 knot
Fin Stabilizer	Aquarius A25
Fin Length	1.26 m
Fin Wide	0.67 m

Amphibi Coach lines plan is designed using Maxsurf software with a similar shape to the bus in general. Amphibi Coach parts are made almost ship-like to provide good stability. Amphibi Coach is designed using fin stabilizer to provide comfort to its users and equipped with jet ski as supporting recreational rides and at the top of the vehicle is used as a rooftop as a place to relax or sunbathe enjoying the view of Lake Toba. For fin stabilizers use active fin stabilizers that are used only when in water. Fin stabilizer data using fin data from Kongsberg company with type fin designated in Table 1 [11]. Amphibi Coach's design concept and lines plan can be seen in Figure 1.

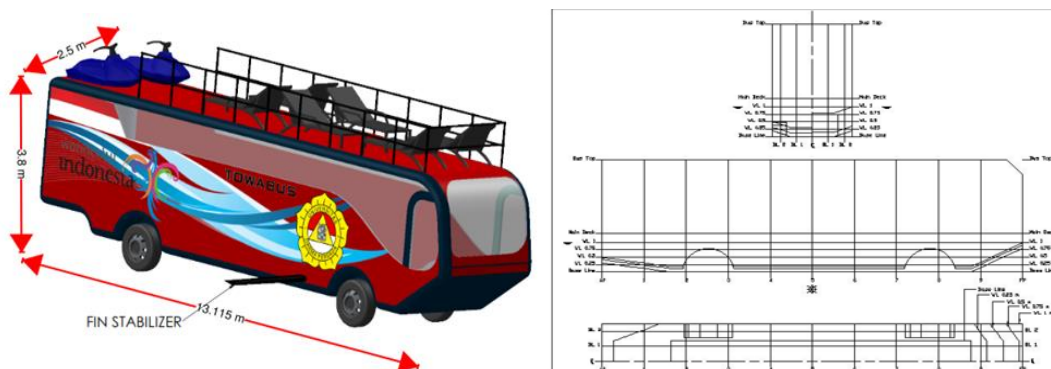


Figure 1. Model amphibi coach

Amphibi Coach drive power analysis is an analysis of the calculation of power while on land and in water. The method of calculating the drive power when in the water is the KR Barge method [12]. This method is used because it sees the shape of the Amphibi Coach that almost resembles a barge.

$$R_t = R_f + R_w + R_a \quad (1)$$

Where

R_t = total resistance (ton).
 R_f = frictional resistance (ton).
 R_w = wave-making resistance (ton).
 R_a = air resistance (ton).

For analysis of power while on land used the calculation formula as follows [13].

$$F_{tot} = F_{Ro} + F_{Ae} = F_{Cl} \quad (2)$$

Where

F_{Ro} = Rolling resistance (N).
 F_{Ae} = Aerodynamic Resistance (N).
 F_{Cl} = Climbing Resistance (N).

$$T_{aw} = F_{tot} \times \text{rolling radius (m)} \quad (3)$$

Where

T_{aw} = Torque at the wheel (N m).

$$b.p. = \frac{2\pi TN}{60000} \quad (4)$$

Where

b.p. = brake power (kW).
 π = 3.142.
 T = engine torque (N m).
 N = crankshaft speed (rev/min).

For turning circle calculations Amphibi Coach is done when Amphibi Coach uses fin and without using fin. This calculation uses a formula from Teguh Sastrodiwongso which is the development of the Hovgaard formula[5]. This formula is a simple way of estimating turning circles. Turning circle calculation stipulated by equation (5) :

$$\rho = K_3 \frac{V}{C_n \cdot A \cos a} \quad (5)$$

K_3 is a coefficient obtained from Table 2.

Table 2. Coefficient K_3

$\nabla/S.L$	K_3	$\nabla/S.L$	K_3
0.050	1.140	0.10	0.460
0.055	1.285	0.11	0.400
0.060	1.100	0.12	0.370
0.065	0.960	0.13	0.355
0.070	0.845	0.14	0.345
0.080	0.670	0.15	0.340
0.090	0.550		

The formula for calculating the normal style coefficient (C_n) is shown in equations (6) using the Joessel formula.

$$C_n = \frac{0.811 \sin \alpha^0}{0.195 + 0.305 \sin \alpha^0} \quad (6)$$

Where

∇ = volume displacement (m^3).

A = rudder area (m^2).

S = the area of the middle field extends the ship (m^2).

L = ship waterline length (m).

α = maximum steering leaf angle ($35^\circ \sim 37^\circ$).

Advance calculation as in equation (7) or distance traveled by ship in its original direction, measured from the point when the rudder was first applied at the turn and Transfer as in equation (8) is the distance of the ship's center of gravity from the original trajectory line when the ship's header is 90° . It can be calculated using the formula contained in the journal Vessel Maneuverability American Bureau of Shipping (ABS).

$$\frac{Ad}{L} = 0.519 \frac{Td}{L} + 1.33 \quad (7)$$

$$\frac{Tr}{L} = 0.497 \frac{Td}{L} + 0.065 \quad (8)$$

Where

Ad = Advance distance (m).

Td = Tactical Diameter distance (m).

Tr = Transfer distance (m).

L = ship waterline length (m).

3. Result And Discussion

In this study, the power analyzed is the power while in the water at a speed of 8 knots with 60% efficiency and on the 1 m draft with 2 models and power on land with a maximum speed of 100 km/hour. For water power, it is analyzed on 2 models, namely Amphibi Coach without fin stabilizer and Amphibi Coach using Fin Stabilizer.

3.1. Amphibi coach power analysis

Following the data in the methodology, the results of the power analysis when in the water using the Maxsurf Resistance for both models are shown in Table 3.

Table 3. Results of analysis of the power of each model when in water

Model	Speed (knot)	Resist. (kN)	Power (HP)
No Fin	8	11.9	112.653
With Fin	8	13.5	126.992

The results obtained according to Table 3 shows that at the same speed for both models require different power, Amphibi Coach without fin has less power than Amphibi Coach with the fin.

For analysis of onshore power at a constant speed of 100 km/h obtained results as shown in Table 4.

Table 4. Results of calculation of power while on land

Model	Speed (km/jam)	Resist. (N)	Torque (Nm)	Power (HP)
Amphibi Coach	100	5570.25	2935.52	419.06

From the analysis of the above driving power obtained for power in water and on land has a considerable difference in yield. This is due to the difference in the size of resistance while in the water and on land. Therefore, the power determination for Amphibi Coach is taken the most power which is 419.06 HP, and determined to be 420 HP according to the existing catalog [14]. The results of the power

obtained do not have a very cyclical difference with the power of Mercedes-Benz Tourismo L bus [15] with a total weight of 24.750 tons which has a drive power of 388.89 HP while amphibibi coach weighing 27.21 tons has a power of 420 HP.

From the catalog, the engine size is obtained and is used as a consideration for the shape of the engine room and the transmission line of the Amphibi Coach.

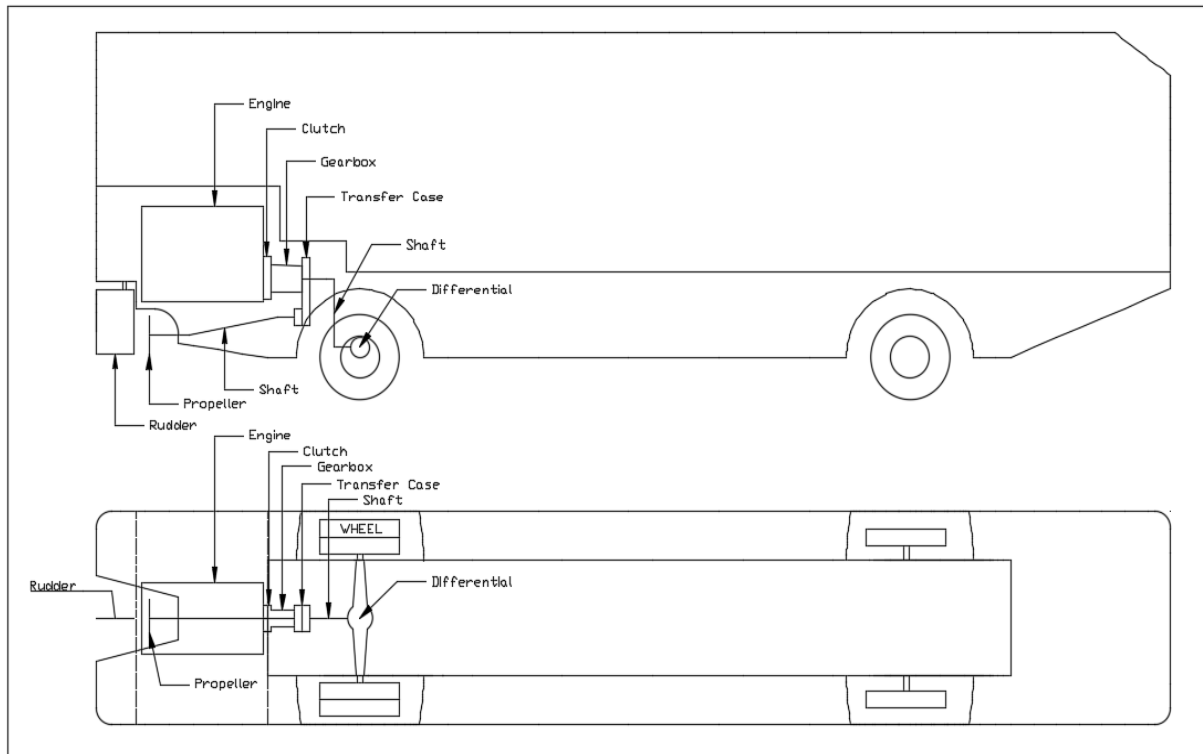


Figure 2. Transmission sketch

For the process of getting into the water, Amphibi Coach uses the ground with a slope of ten degrees.

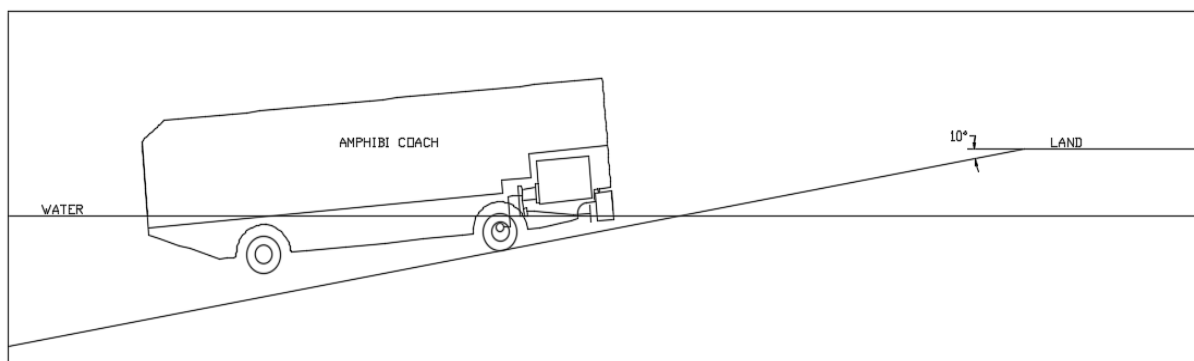


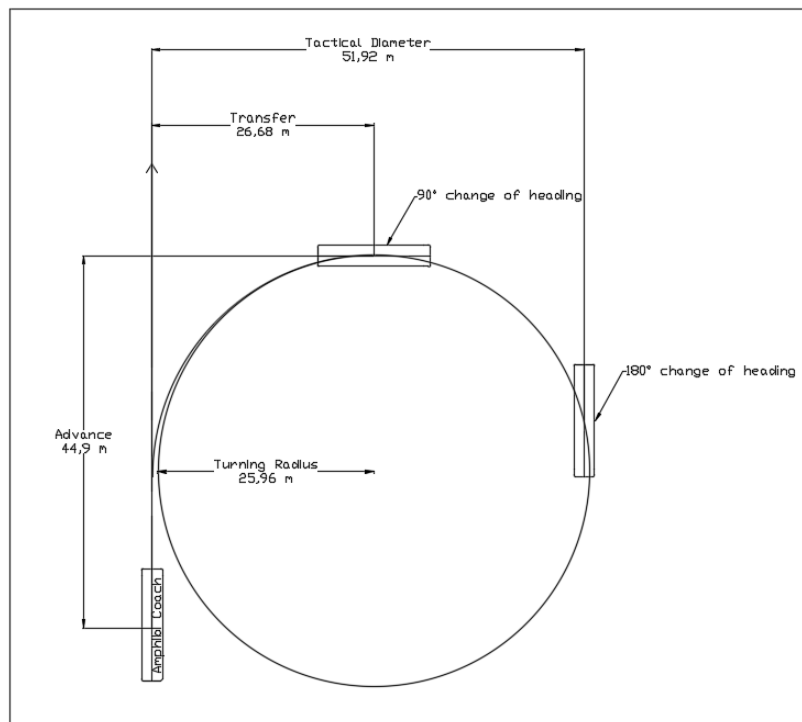
Figure 3. Water entry process

3.2. Turning circle amphibibi coach analysis

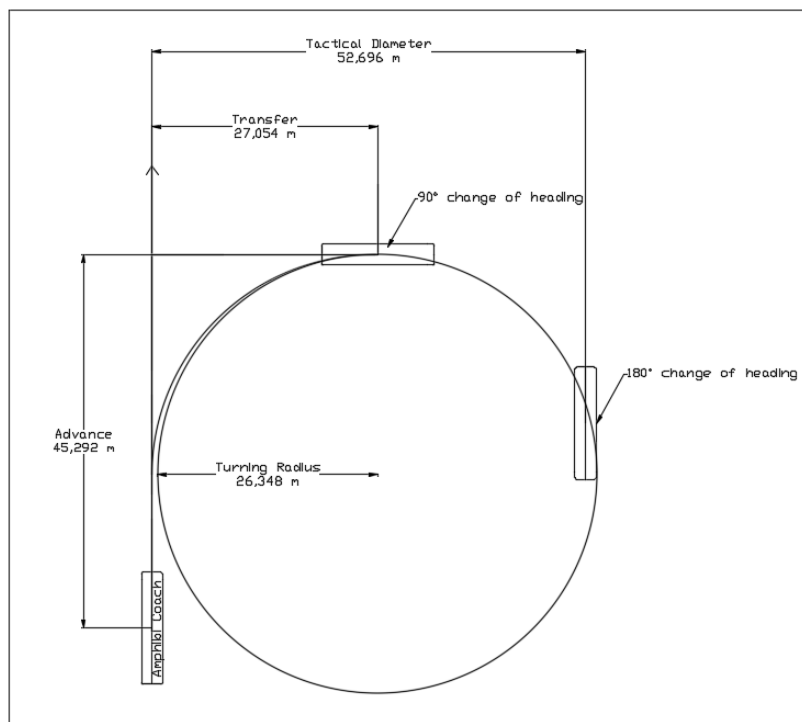
Amphibi Coach turning circle analysis is carried out on 2 different models namely model 1 without fin stabilizer and model 2 with fin stabilizer. This analysis using a rudder which has an area of 0.534 m^2 with a size of 0.8 m high and 0.47 m wide. For the standard that is the reference calculation turning circle Amphibi Coach refers to resolution standard MSC 137(76) (adopted on 4 December 2002) Standards For Ship Manoeuvrability which in this standard explains that the advance distance of the ship should not be more than 4.5 ship length and tactical diameter distance should not be more than 5 times the length of the ship.

Table 5. Turning circle amphibi coach calculation results

Model	ρ (m)	Td (m)	Ad (m)	Tr (m)	Criteria
No Fin	25.96	51.92	44.90	26.68	PASS
With Fin	26.348	52.69	45.29	27.05	PASS

**Figure 4.** Turning circle amphibi coach without fin stabilizer

From the analysis turning circle, Amphibi Coach obtained the turning circle Amphibi Coach without fin stabilizer of 25.96 m and has a tactical diameter of 51.92 m.

**Figure 5.** Turning circle amphibi coach with fin stabilizer

Turning circle Amphibi Coach with fin stabilizer of 26.348 m and tactical diameter of 52.696 m. The results obtained show that Amphibi Coach with fin stabilizer has a turning circle larger 0.388 m than Amphibi Coach without fin stabilizer.

4. Conclusion

From the results of the resistance, analysis shows that Amphibi Coach with fin stabilizer requires a power of 126.992 HP while Amphibi Coach without fin stabilizer requires a power of 112.653 HP. The power needed on the ground is 420 HP. The determination of power is taken based on the larger power needs of 420 HP. The analysis of these resistance shows that the effect of using fin stabilizer on Amphibi Coach produces a large resistance that affects the power needs of Amphibi Coach that require the drive power even while from the analysis turning circle Amphibi Coach is obtained turning circle Amphibi Coach without Fin Stabilizer of 25.96 m and has a tactical diameter of 51.92 m. For turning circle Amphibi Coach with fin stabilizer of 26.348 m and tactical diameter 52.696 m. Analysis of turning circle Amphibi Coach using approach formula shows that the results obtained have met the applicable criteria. For further research, It is advisable to check the transmission line of the vehicle along with the engine type, construction and actual model testing.

5. References

- [1] K. PUPR 2015 *Profil Kawasan Danau Toba* (Jakarta: Kementrian PUPR)
- [2] L. Duan 2015 Study on force characteristics and resistance for water by amphibious vehicle *ICMEIS*. **III** 553-557
- [3] Z. Guo 2013 Numerical simulation of an amphibious vehicle sailing resistance *IJCSI*. **10** 33-36
- [4] M. Nakisa 2017 Numerical estimation of shallow water effect on multipurpose amphibious vehicle resistance *JNAME*. **14** 1-8
- [5] T. Sastrodiwongso 2002 *Kemudi dan Olah Gerak Kapal* (Jakarta: FTK UNSADA)
- [6] A. Jamaluddin 2013 Analisa dan evaluasi faktor-faktor yang mempengaruhi karakteristik olah-gerak (maneuver) kapal *Warlit*. **23** 17-26
- [7] H. U. A. M. Command 1971 *Engineering Design Handbook Wheeled Amphibians* (Virginia: University Of Virginia Library)
- [8] R. R. R. Rinaldi 2018 Desain kapal amfibi water school bus sebagai sarana transportasi pelajar untuk rute pelayaran Kepulauan Seribu - Jakarta Utara *Jurnal Teknik ITS*. **7** G65-69
- [9] R. F. Rahman 2018 Perancangan dan analisis karakteristik traksi ada mobil pedesaan serbaguna WAPRODES *Jurnal Teknik ITS*. **VII** 21-26
- [10] V. D. Y. Moganti 2020 A study of the effectiveness fin stabilizer on unsada water tour bus to comfort the rolling period to support Toba lake tourism *IOP Conf. Ser.: Earth Environ. Sci.* **557** 012012
- [11] Kongsberg 2019 *Marine Products and Systems* (Norway: Kongsberg)
- [12] K. Register 2014 *Rules for The Towing Survey of Barges and Tugboats* (Busan: Korean Register)
- [13] E. b. D. A. Crolla 2009 *Automotive Engineering Powertrain Chassis System and Vehicle Body* (Burlington: Elsevier's Science & Technology Rights)
- [14] MAN 2020 *On-Road Engine and Components* (Vogelweiherstr: MAN Truck & Bus)
- [15] Mercedes-Benz 2019 *The Turismo right-hand drive Technical Information* (Stuttgart: Mercedes-Benz)

Acknowledgments

We would like to thank Darma Persada University who has supported this research and the supervisors who have provided input and suggestions in this research.