

Review Article

**PARAMETERS INVOLVED IN DESIGNING OF SUBMERGED LAND VEHICLE**

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Received: 17.11.2019

Revised: 15.12.2019

Accepted: 29.01.2020

**ABSTRACT**

A land and water capable vehicle floats at the water surface and its versatility is not confined by way of the depth of water channel. For maximum submerged land vehicle (SLV), water crossing are limited to fording. In this paper a contemporary SLV has been inspected as far as land and water capable capabilities are involved. This being a particularly new discipline, the behavior of the submerged land vehicle throughout amphibious operation is as yet little or no publicised. Eventually at some stage in underwater fording the dynamic forces that act up at the SLV are difficult to understand. Those forces legitimately impact and affect the power of the SLV submerged. In this manner there can be a want to examine the flow throughout the SLV. The CFD examination is generally used to test about the conduct of objects submerged in non-static fluids. It signifies to determine how proficiently a vehicle can tour through the medium and how liquid stream and automobile movement have an effect on each other concurrently. In the present scenario while the SLV is going under the stream, the liquid isn't confined among wall type conditions, for instance, pipes or bound circulation instances. The liquid is allowed to transport throughout the item and be a part of virtually with its outside "wet" layer. This indicates, it is the flow together with the frame shape that need to be considered. By way of comparing the load and velocity scattering across the SLV, made by way of the opposition of the fluid, we are able to select the diverse forces acting on the SLV in unique planes and concentrate the flow dynamic steadiness of the SLV whilst it is encountering deep fording.

**Keywords:** Component, Amphibious, Submerged Land Vehicle (SLV), Stream-crossing, Righting Moments, Buoyancy, Floatability, Stability, Dynamic Forces.

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DOI: <http://dx.doi.org/10.31838/jcr.07.02.26>

**INTRODUCTION**

A significant contemplations for improvement of army vehicles is the acknowledgment that to achieve cross-country versatility a vehicle should be able to cross internal rivers and lakes. This gives rise to another problem for those scientists who have or are working on the plan and advancement of new military vehicle ideas. So as to consolidate water capability into future plans, natural tendency is to approach the creators and engineers of land and/or water capable vehicles, who have for quite a while been confronted by comparable issues.

The information presented is relevant to land automobiles in standard; therefore, this could be taken as a guide for designing of vehicles which will have cross country capability along with water crossing capability.

Assessment can be carried out in following two ways:

1. Firstly the relationship between the vehicle and its surroundings has to be evaluated to determine its overall performance skills.
2. Second is to match these characteristics with the characteristics of the existing water bodies so as to find out the real capabilities of the designed vehicle. These two factors as brought out above present a difficult challenge to the designers of present in the existing knowledge available.

3 distinctive modes of locomotion are crucial in reference to the overall flow-crossing manoeuvre: floating types, land types, and amphibious types. Equally important are the related environmental features of the water bodies existing.

More attention has been paid to the resistance due to water, efficiency of the propulsion system used and effect caused due to waves. Quiet a lot of progress has been made in this field due to its employment in naval ships designs [1, 2], but still a lot has to be worked out for the design of submerged land vehicles or amphibious vehicles as the data available is very restricted and not freely available. With the passing time and more evolution it was found that the significant problem faced in the designing of submerged land vehicles or amphibious vehicles was the entering of the vehicle in a water body or the egress.

There is very little to no research on the various forces acting on a submerged land vehicle when it is crossing a water body. Calculation of forces acting on the body and its stability is a complex issue involving both the hydrodynamic forces and the surrounding conditions. It has been realised and experienced over a period of time that the motion of the submerged land vehicle under the water is very difficult and cannot be avoided while carrying out the designing of a vehicle for amphibious capabilities.

A lot of research has been carried out for designing of ground vehicles, its weight characteristics, body design features, drag forces and aerodynamic characteristics for the past many years [3-6]. This study which has been carried out in the past cannot be directly applied in case of amphibious vehicles. In other words the template for land vehicles cannot be used in designing of submerged land vehicles.

Similarly it can be judged and appreciated that the water stream conditions, the soil features and their inter relation variev worldover and cannot be taken to be constant. It has become obvious that total evaluation of overall stream properties in

adequate detail for vehicle. Execution assessment can't in any way, shape or form be accomplished by direct estimation inside the extent of any sensible investigation, nor is the military truly intrigued by the attributes of each stream on the planet. In this manner, a methodology toward arranging conduits based on accessible climatic, topographical, and other existing ecological information has been started as a major aspect of the investigation, so that those of military premium might be considered.

A significant number of the connections which are exhibited ought to be considered as close to sensible theories which must be approved and, if fundamental, altered based on deliberately controlled tests. Much extra research in the different issue territories and a significant exertion to arrange the different aspects into a complete frameworks investigation is due.

**FLOATING FEATURES**

While designing any vehicle there are a number of tradeoffs that are resorted to. The length to width ratio is maintained in between 1.5 to 2 so as to achieve better control and driving features in addition to better manoeuvrability. Any shape which become too much long should be partitioned into a few segments, as in enunciated or prepared (coupled pair) vehicles. Bargains are no less present in land and/or water capable vehicle plan, for all the clashing issues intrinsic in the structure of land vehicles are available, in addition to extra issues emerging from the prerequisite for floating and satisfactory self-impetus in water. Many land vehicles will skim if the all-out fringe zone is fixed against water passage. Designing an amphibious vehicle is totally a different ball game and requires separate calculations.

For making a vehicle to float the following conditions are to be met

- a. Less density of the body
- b. Low weight to volume ratio.
- c. More displacement of water.

To achieve this objective scientist resorted to a number of features as brought out below

- a. Attaching hollow bodies to the main vehicle
- b. Separable floating gadgets

These methods however instead of being of help actually ended up restricting the movement of the vehicle. They also caused lot of inconvenience to the user as they had to carry all these gadgets along with whenever the vehicle had to be used. These gadgets could also not be carried separately as there was always a risk of them being not available whenever the need arises.

There are two main class of categorization of amphibious vehicles

- a. Amphibious
- b. Floaters

Amphibious vehicles are the vehicles which can operate both on land and in water. They don't have the risk of getting submerged in water in case of any technical failures. They have good speed both in water as well as on land. Whereas floaters can move on land but just float on water. They have very slow speed and are difficult to manoeuvre.

A submerged land vehicle can be compared to a floater. They are not too good in water and can be considered to be good only for a short period of time and basically as a military obstacle crossing vehicle. Their floating characteristics are achieved by resorting to a number of features as brought out below

- a. Attaching hollow bodies, foam bodies and air bags to the main vehicle
- b. Auxiliary water displacing bags

The submerged land vehicle moves using its own tractive power and very little attempt is made to give it more velocity. Common examples of amphibious American vehicles are as below

- a. M113,
- b. AAV-7
- c. Sherman DD
- d. M48A3 Patton

e. LCAC

**Buoyant Force**

Anybody floats because of the Buoyant force. Buoyant force was discovered by the great scientist Archimedes. Buoyant force is the upward and opposing force exerted by a fluid and equal to the weight of the fluid displaced.

$$F_B = \gamma V \tag{1}$$

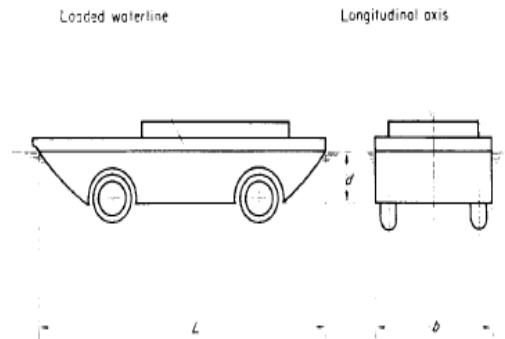
In case of boats displacement ( $\Delta$ ) term is mostly used.

$$\Delta = \gamma V \tag{2}$$

The volume of a rectangular body can be easily calculated by multiplying the length, width and height. The same cannot hold true for an automobile because the shape of the vehicle is not classically rectangular but consists of a combination of a number of shapes. This forces us to introduce a factor called as the block coefficient  $C_B$  to calculate the volume of fluid displaced by the submerged part of the vehicle. The formula for calculating the volume of fluid displaced by the submerged part of the vehicle then reduces to

$$V = C_B L b d \tag{3}$$

For different vehicles the value of  $C_B$  varies however for submerged land vehicles as shown in figure 1 the value of  $C_B$  can be assumed to be in between 0.7 to 0.85.



**FIG. 1: Submerged Land Vehicle**

where,

L = Length of the vehicle at the water level

b = width of the vehicle at the water level

d = depth of the vehicle at the water level

The proportions of length to width brings out the resistance to movement and increases with the ratio decreasing. The proportions of width to depth brings out the stability of the submerged land vehicle and decreases as the ratio decreases.

**Center of buoyancy**

For any submerged body the centre of buoyancy is given by the following formula and acts along the centre of the volume of fluid displaced

$$\bar{x} = \frac{1}{V} \int x dV \tag{4}$$

in which

$\bar{x}$  = axial distance

x = axial distance to  $dV$

$dV$  = differential displaced volume.

On a basic level, conditions (1) and (4) are very basic. However when the equations are applied to actual vehicle bodies the solving becomes very complicated. Easy method is to divide the body into a number of small simple shapes and then evaluate for each shape. Example of a simple automobile is shown in Fig 2.

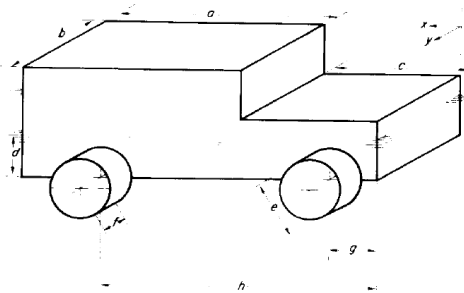


Fig. 2: Calculating Buoyant Force

The total displaced volume after summing up the two regions is  $F_B = C_B \gamma V \approx 0.775.62.4(abd + cbd + \pi f e^2) 1b$  (5)

The buoyant force will act at

$$\bar{x} = \frac{1}{V} \sum x_i v_i \approx \frac{\frac{c}{2}(dbc) + (\frac{a}{2} + c)(abd) + g(\frac{\pi f e^2}{2}) + h(\frac{\pi f e^2}{2})}{abd + dbc + \pi f e^2}$$

**Righting Moments and Stability**

When a boat remains stable in water inspite of external disturbances and comes back to its stable state after being dislodged from its original position, then the feature is called as Stability. Righting moment is the moment which makes the boat stable.

At the point when the center of gravity of any floating article is beneath its center of buoyancy, the item glides in stable harmony. Certain floating items be that as it may, are likewise steady when their center of gravity is over the center of buoyancy. The stability and righting moments for such bodies might be controlled by utilizing the conditions created beneath.

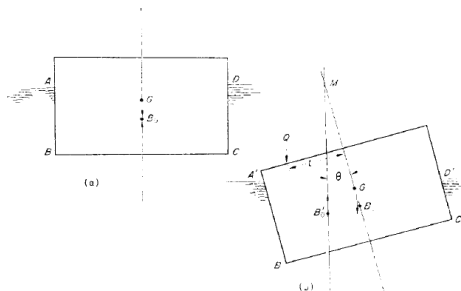


Fig. 3: Floating Body Stability

The restoring couple, or righting moment, might be determined from

$$\beta = W \overline{GM} \sin \theta \quad (7)$$

The metacentric height is given by

$$\overline{GM} = \frac{I}{V} \pm \overline{GB} \quad (8)$$

I = moment of inertia of the water-plane area about the fore and aft axis of the

body =  $\int_A x^2 dA$  (see Fig. 4).

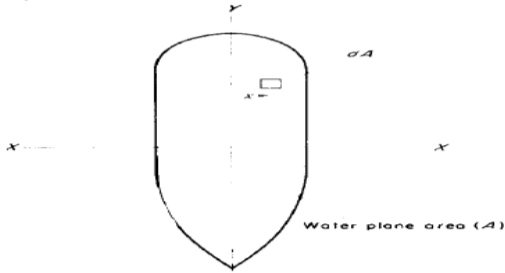


Fig. 4: Hull Cross Section

Greater metacentric heights will cause an enormous load on the ship structure and is not suitable while designing an amphibious vehicle.

The quick moving likewise makes inconvenience both group and travelers. Likewise, a high metacentric height will in general produce more prominent amplitudes of move from synchronous waves. Hence submerged land vehicles will have lower metacentric height.

**Rolling and pitching motions**

The period of roll is very important for the following reasons

- a. If it is small then the ride will be very jerky.
- b. If it is large then it will give rise to motion sickness.
- c. If it is equal to the wave then there is a risk of the vehicle submerging under water.

The forces acting on a vehicle actually cause the oscillatory motion of the vehicle which is floating on the water body. This oscillatory motion is produced because of the buoyant forces generated. The motion of the vehicle is greatly affected by its shape.

**RESISTANCE TO CAPSIZIN**

Fig 8 depicts a graph which predicts the point when the vehicle will get submerged. It can be seen that as the tilt angle increases the vehicle becomes more and more unstable and will finally capsize when the angle crosses seventy degrees.

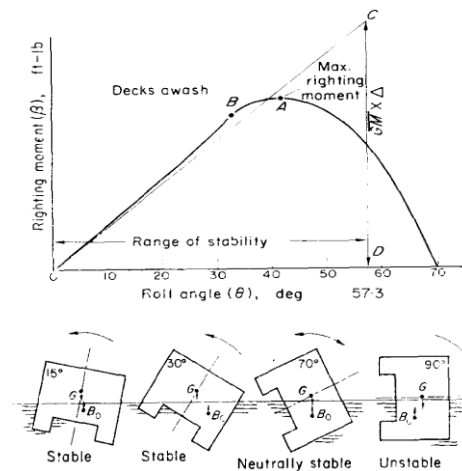


Fig. 8: Diagram of Static Stability

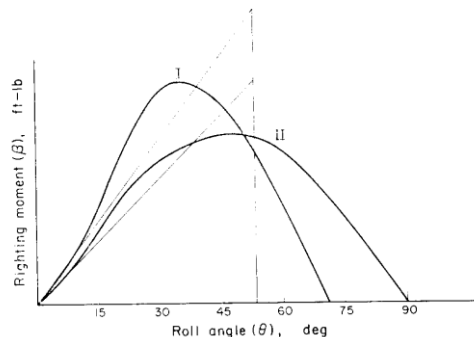


Fig. 9: Static Stability for different Type of Vehicles

Figure 9 depicts stability graphs for two different vehicles. It can be clearly seen that the vehicle I loses its stability at a much lower angle then the vehicle II. Hence it can be said that the design of vehicle II is much more stable then the design of vehicle I for floatation.

## CONCLUSION

Designing an submerged land vehicle is a very difficult task in the absence of varied study material available on the issue. Since the designing involves combining the features of both amphibious vehicles and land terrain vehicles, the dynamic forces acting at varied stages are to be studied in depth. With the advances in technology and availability of accurate Computational Fluid Dynamics software, the calculation of the drag forces will be easier in the times to come.

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