Experimental Evaluation of Drag Force on Different Shapes of Pontoons at Different Water Stream Velocities at Specified Loads and Submergence

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Experimental Evaluation of Drag Force on Different Shapes of Pontoons at Different Water Stream Velocities at Specified Loads and Submergence

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Abstract: *The ability to cross both natural and man-made obstacles have always been crucial for good mobility and is vitally important for various operations. The series of Pontoons are used as floating bridge to allow the transport vehicles and personnel over water and marshy grounds. Floating bridges are cost-effective solutions for crossing large bodies of water with unusual depth. Friction drag is observed when relative motion exists between pontoon and fluid. In view of this drag force is required to be evaluated correctly so that arrangement to fix the pontoon can be accurately designed considering the load and safety factors. For this required to carry out experiment to measure drag forces acting on the pontoons due to water resistance at various weights and water velocities. To study and collect numerous data, three pontoons of various shapes and materials were chosen for experiments. The drag force of pontoons is measured at 0, 5 and 10 degrees by add on various loads and submergence levels. During the experiments, a pontoon freely suspended to Rating Trolley when towed at a predetermine speed in straight open water tank, the drag force induced is measured by precise load cell. Experimental outcomes of all three pontoons for drag forces at 0, 5 and 10 degrees at various submergences and velocities will limit its application in specific velocity range and weight applied on it. Experimental analysis indicates the drag force is directly proportional to the frontal resistive area, water velocity and depth of submergence.*

Keywords: *Drag force, Pontoon, Submergence, Rating Trolley.*

1. Introduction

Transport links between rivers, flooded areas and offshore areas are dependent on bridges. Large water bodies with unusual depths can be crossed with floating bridges. A floating bridge is a more economical and conspicuous alternative, as the self-weight of bridge and vehicle loads are supported by the buoyant forces from pontoons. Furthermore, a floating bridge made for vehicles, bicycles and pedestrians to travel can be easily removed when relocation is necessary. The design of pontoons should be lightweight in order to reduce buoyancy requirements but to sustain for weight of transportation over it.

When a pontoon travels through fluid, some resistances are exerted by the water body namely frictional resistance, eddy resistance and wave resistance. The drag force is the resistance offered by the flowing fluid to the floating body. Considering this drag force evaluation is required to find out the hydrodynamic forces acting on the pontoon, which in turn determines the power required to drive the floating object or resistive force required to hold the object under induced drag force. Various methods have been proposed to calculate frictional drag. The physical experimental tests under different conditions applied on the pontoons are proved to be the most reliable test for desired design consideration. This study aims to determine the drag force acting on the different shape, size and self-weight pontoons at various velocities with predefined loads and mounting angle. Based on the experiment results the design of pontoons can be finalize as per suitable application.

2. Experimental Setup, Methodology and Test Procedure

2.1. Experimental Setup

Central Water and Power Research Station (CWPRS), Pune established facility in 1955 for testing of ship models as well as for calibration of current meters. A rating tank having dimensions of 228 m long, 3.66 m wide and 2.13 m deep in which the Current Meter Rating Trolley (CMRT) is placed which is self-propelled type and runs on two parallel straight steel rails 4.267 m apart, accurately aligned over the length of tank. The Rating Trolley is equipped with servo motors and electronic drive and state of the art technology to achieve precise speed in the range of 0.01 m/s to 7.5 m/s. A customized dedicated software is provided to operate the Rating Trolley for predefined speed

profile and acquiring output of test device. Figure 1 shows the testing of ship model and current meter calibration facility at CWPRS. This infrastructure is used to conduct several experiments to evaluate the drag force on pontoons. [https:/www.cwprs.gov.in]

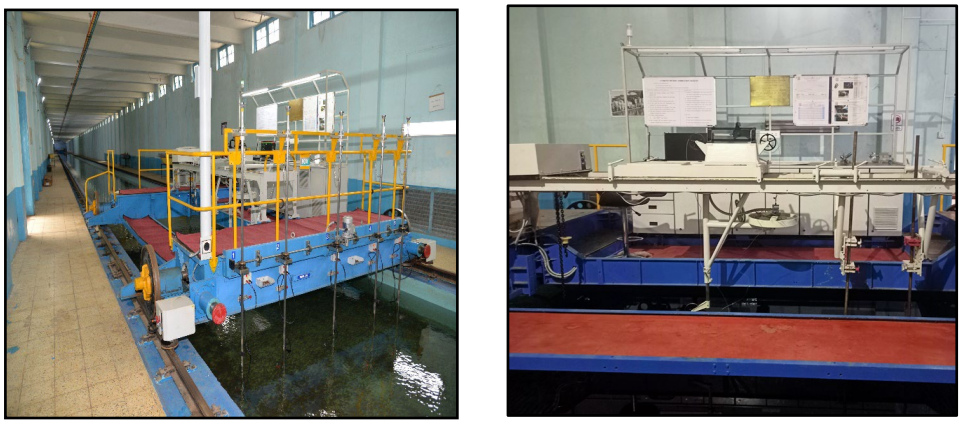


Figure 1. Ship model testing and current meter calibration facility at CWPRS

The drag force evaluation study was carried out on three types of pontoons. Table 1 describes the details of pontoons like overall dimensions of pontoons, self-weight of pontoons and velocity under which the drag of pontoons observed during this experiment. [CWPRS Technical Report No. 5999, February 2022]

Table 1. Details of Pontoons

Parameter	Pontoon-I	Pontoon-II	Pontoon-III
Length (m)	2.25	2.0	2.0
Width (m)	1.0	1.0	1.0
Depth (m)	0.245	0.3	0.28
Self-Weight (kg)	49.8	36.18	41.76
Velocity Range (m/s)	0.5 - 1.5	0.5 - 3.0	0.5 - 3.0

To conduct various experiments, the pontoons freely suspended on Rating Trolley with the help of compatible brackets for different angle as desired for 0°, 5° and 10°. Due to supporting brackets for mounting, the overall weight of pontoons increased. On pontoon-I, five different weights were selected for experiments and on each weight condition, six velocity profile were selected for only 0° angle condition to measure the drag force. On pontoon-II and pontoon-III, five and six different weights were selected respectively for experiments under 0°, 5° and 10° angle condition and on each weight and angle condition six velocity profiles were selected to measure the drag force. This is described briefly in Table 2.

Table 2. Detail Experiments profile for drag force measurement on Pontoons

Pontoon-I: Mounting Angle at 0°		
Sr. No.	weights of pontoon (kg)	Submergence of pontoon in water (m)
1	60.1 (Self-weight + bracket)	0.027
2	185.1 (60.1 + 125)	0.083
3	263.5 (60.1 + 203.4)	0.105
4	280.1 (60.1 + 220)	0.130
5	396.4 (60.1 + 336.3)	0.175

Pontoon-II:				
	Mounting Angle at 0°	Mounting Angle at 5°	Mounting Angle at 10°	
Sr. No.	weights of pontoon (kg)	weights of pontoon (kg)	weights of pontoon (kg)	Submergence of pontoon in water (m)
1	46.78 (Self-weight + bracket weight)	46.78 (Self-weight + bracket weight)	56.6 (Self-weight + bracket weight)	0.026, 0.026, 0.035 for 0°, 5° &10°respectively
2	51 (46.78 + 4.22)	51 (46.78 + 4.22)	--	0.041(for 0° & 5°)
3	117.45 (46.78 + 70.67)	117.45 (46.78 + 70.67)	117.45 (46.78 + 70.67)	0.080
4	182.14(46.78 + 135.36)	182.14(46.78 + 135.36)	182.14(46.78 + 135.36)	0.110
5	250.18 (46.78 + 203.4)	250.18 (46.78 + 203.4)	250.18 (46.78 + 203.4)	0.160
6	333.3 (46.78 + 286.52)	333.3 (46.78 + 286.52)	333.3 (46.78 + 286.52)	0.200
Pontoon-III:				
	Mounting Angle at 0°	Mounting Angle at 5°	Mounting Angle at 10°	
Sr. No.	weights of pontoon (kg)	weights of pontoon (kg)	weights of pontoon (kg)	Submergence of pontoon in water (m)
1	53.88 (Self-weight + bracket weight)	60. (Self-weight + bracket weight)	62.09 (Self-weight + bracket weight)	0.032, 0.036, 0.040 for 0°, 5° &10°respectively
2	76.2 (53.88 + 22.32)	76.2 (60.82 + 15.38)	76.2 (62.09 + 14.11)	0.045
3	117.45(53.88 + 63.57)	117.45 (60.82 + 56.63)	117.45 (62.09 + 55.36)	0.080
4	182.14(53.88 + 128.26)	182.14(60.82 + 121.32)	182.11(62.09 + 120.02)	0.110
5	250.18 (53.88 + 196.3)	250.18(60.82 + 189.36)	250.23(62.09 + 188.14)	0.160
6	339.36(53.88 + 285.48)	339.3(60.82 + 278.48)	339.41(62.09 + 277.32)	0.200

During the experiment concentrated weights were used as huge load over a small flat surface area of the pontoons. Hence flat steel plates and blocks with a higher density were chosen. After weighing all the pontoons, the Centre of Gravity (C.G.) of each pontoon was marked on the respective pontoon. Figure 2(a) shows dimensional details of three pontoons. All dimensions shown are in mm. The frontal resistive area in case of pontoon- I being rectangular in shape, longer side as 2250 mm was selected and for pontoon -II and pontoon-III nose end was selected for towing pontoons while conducting experiments.

Figure 2(b) shows a schematic diagram of experimental setup of drag force evaluation of pontoons. The mounting brackets were fixed such that, they should not be displaced under the induced water force during the experiment. The pontoon is freely suspended between two rods of Rating Trolley and the string is tied between C.G of the pontoon position and the load cell. The load cell is equipped with a spring to absorb the shocks developed while change in movement or velocity of water body transmitted to load cell through string.

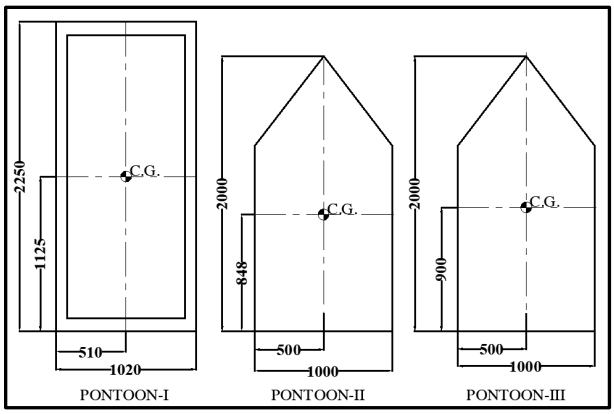
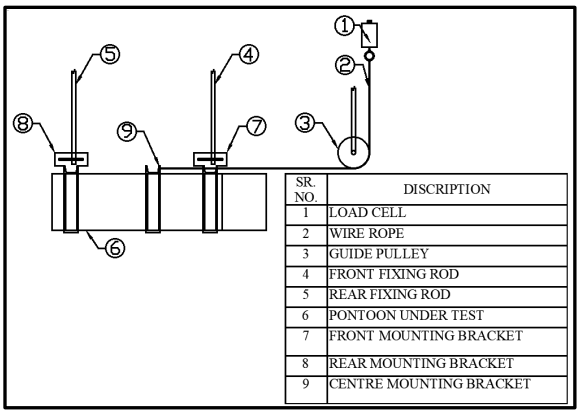


Figure 2. (a) Location of Centre of Gravity (C.G.) of Pontoons (All dimensions are in mm.)



SR. NO.	DISCRIPTION
1	LOAD CELL
2	WIRE ROPE
3	GUIDE PULLEY
4	FRONT FIXING ROD
5	REAR FIXING ROD
6	PONTOON UNDER TEST
7	FRONT MOUNTING BRACKET
8	REAR MOUNTING BRACKET
9	CENTRE MOUNTING BRACKET

Figure 2. (b) Experimental Setup of Drag Force Evaluation

In Figure 3(a) the pontoon-III is mounted on Rating Trolley for 5° with self-weight condition and Figure 3(b) the pontoon-II under test for 5° with 250 kg total load condition.

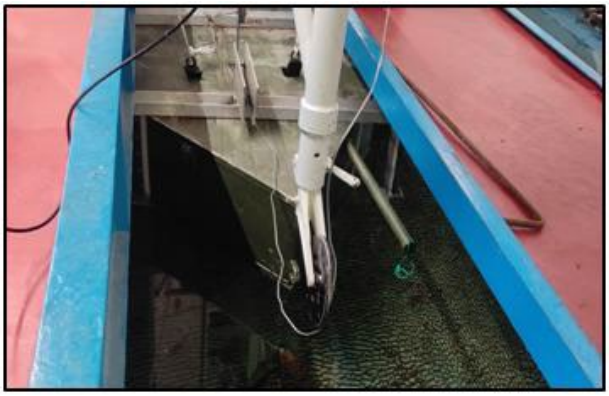


Figure 3. (a) Pontoon-III on CMRT at 5° with Self-weight

Figure 3. (b) Pontoon-II on CMRT at 5° with 250 kg

2.2. Experimental Methods and Test Procedure

During the experiment the following procedure was adopted for all pontoons at different depth of submergences, velocities and various angles as specified in the Table 2

1. The pontoon under test was freely suspended on the Rating Trolley with the help two rods and the string is connected between pontoon and load cell. The output cable of the load cell was connected to the Real Time Data Acquisition System (RTDAS) for acquiring the data. Figure 4 shows experimental set up along with load cell and data acquisition system.
2. Pontoon was immersed in the rating tank and the corresponding submergence of the pontoon was measured.
3. As the Rating Trolley was towed in the forward direction, the pontoon experiences backward drag force due to the relative motion of the water and the pontoon. The exerted drag can be directly measured by the load cell whenever stable movement of the pontoon is achieved. The Rating Trolley is move at different pre-defined velocities and corresponding drag is acquired.

4. During experiments, stilling of water was observed so that water in the rating tank will be tranquil before starting each run of a Rating Trolley.

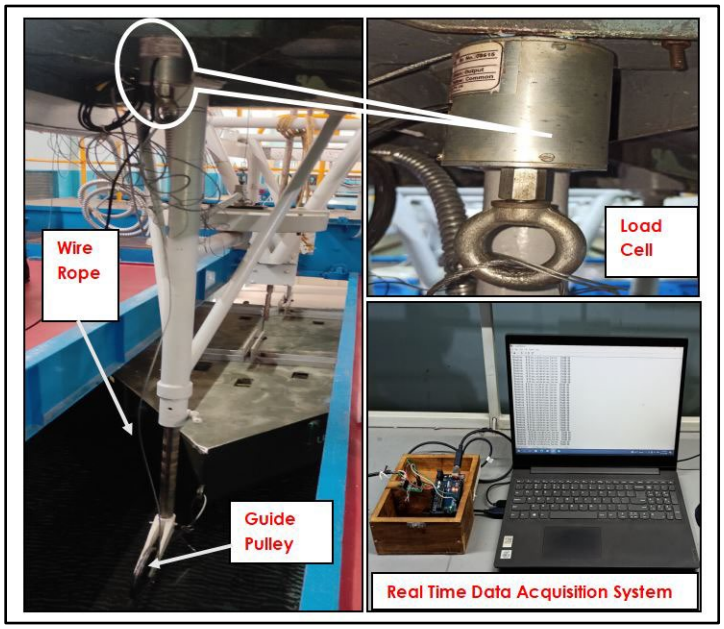


Figure 4. Experimental setup along with load cell and data acquisition system

5. For addition of weights, the suitable pre-decided weights were placed on the pontoon. Considering C.G. of the pontoons, weights were added on the pontoon to keep it in balance condition.
6. The above procedure as mentioned in 1 to 5 was followed for all the specified weights when the pontoon axis was at 0º, 5º and 10º with the towing direction of the Rating Trolley and corresponding drag forces were measured for specified velocities.

3. Results and Discussion

Table 3 shows drag forces induced on pontoon-I at various submergence levels, velocities and its graphical representation is shown in Figure 5.

Table 3. Drag force observed at various conditions on the pontoon-I

Total Weight on Pontoon Including Self-weight in kg	Submergence in m	Rating Trolley Velocity in m/s					
		0.5	0.6	0.8	1	1.2	1.5
		Drag Force in kg					
60.1 (Self-weight + bracket)	0.027	0.75	1.28	3.07	4.04	4.96	10.13
185.1 (60.1 + 125)	0.083	2.31	3.78	4.87	8.08	11.89	25.79
263.5 (60.1 + 203.4)	0.105	3.87	4.80	5.93	9.19	12.80	27.83
280.1 (60.1 + 220)	0.130	5.90	6.58	7.84	11.48	17.19	41.37
396.4 (60.1 + 336.3)	0.175	6.47	8.11	11.79	20.08	33.51	*
Maximum Drag Force		6.47	8.11	11.79	20.08	33.51	**41.37**
Minimum Drag Force		**0.75**	1.28	3.07	4.04	4.96	10.13

*It was observed during the experiment that for the speed of Rating Trolley 1.5 m/s and add-on weight on pontoon was approximately 396 kg, instability was noticed resulting in the tilting of the pontoon.

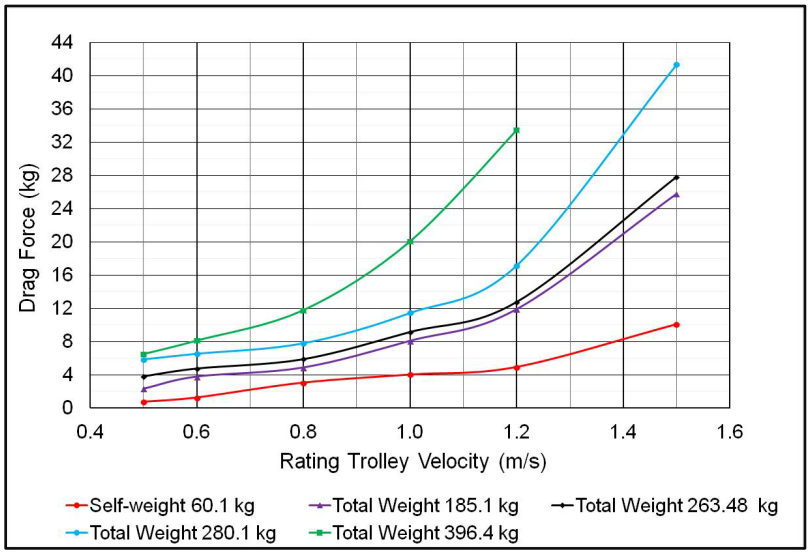


Figure 5. Drag force vs. Rating trolley velocity at various loads on pontoon I

From this experiments it was observed that the maximum drag force is induced 41.47 kg at 1.5 m/s velocity of the Rating Trolley for 280.1 kg load and 0.130 m submergence level, and the minimum drag force is induced 0.75 kg at 0.5 m/s velocity of the Rating Trolley for 60.1 kg load and 0.027 m submergence level on the pontoon-I at 0°.

Table 4, Table 5 and Table 6 show drag forces induced on pontoon-II when its axis was 0°, 5° and 10° with towing direction respectively. The graphical representation of the same are shown in Figure 6(a), Figure 6(b) and Figure 6(c) respectively.

Table 4. Drag force observed under various load on pontoon II when pontoon axis is at 0° with towing direction

Total Weight on Pontoon Including Self-weight in kg	Submergence in m	Rating Trolley Velocity in m/s					
		0.5	1	1.5	2	2.5	3
		Drag Force in kg					
46.78 (Self-weight + bracket)	0.026	0.500	1.703	4.280	9.542	19.270	34.098
51 (46.78 + 4.22)	0.041	0.710	1.907	4.311	9.640	20.146	35.379
117.45 (46.78 + 70.67)	0.080	0.839	1.949	6.539	13.427	29.399	52.579
182.14 (46.78 + 135.36)	0.110	0.957	3.860	11.759	23.388	46.161	63.829
250.18 (46.78 + 203.4)	0.160	1.387	5.589	12.925	32.064	63.559	81.392
333.3 (46.78 + 286.52)	0.200	1.877	6.498	20.204	47.055	82.981	108.696
Maximum Drag Force		1.877	6.498	20.204	47.055	82.981	**108.696**
Minimum Drag Force		**0.500**	1.703	4.280	9.542	19.270	34.098

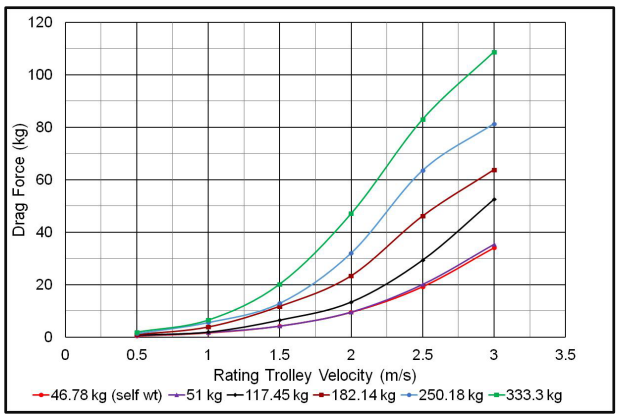


Figure 6. (a) Drag force vs. Rating trolley velocity at various loads on pontoon-II at 0°

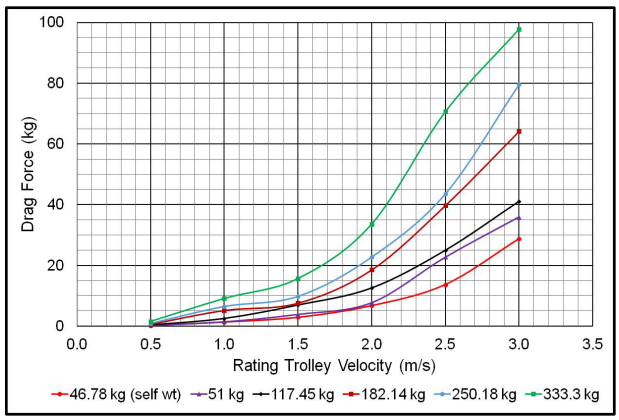


Figure 6. (b) Drag force vs. Rating trolley velocity at various loads on pontoon-II at 5°

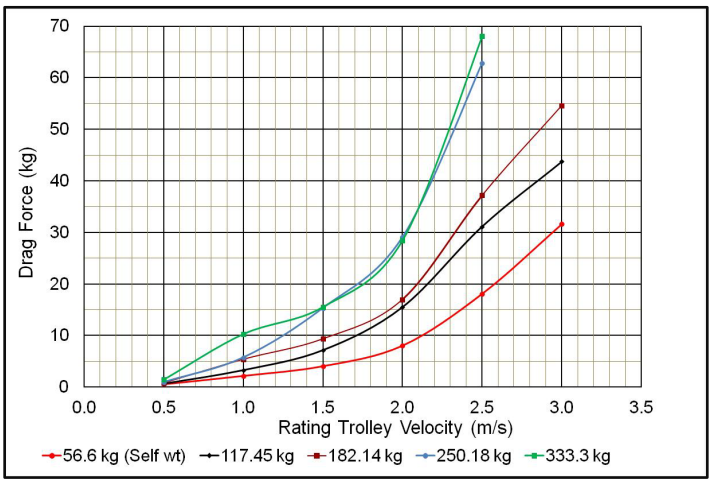


Figure 6. (c) Drag force vs. Rating trolley velocity at various loads on pontoon-II at 10°

Table 5. Drag force observed under various loads on pontoon-II when pontoon axis at 5° with towing direction

Total Weight on Pontoon Including Self-weight in kg	Submergence in m	Rating Trolley Velocity in m/s					
		0.5	1	1.5	2	2.5	3
		Drag Force in kg					
46.78 (Self-weight + bracket)	0.026	0.258	1.374	2.937	6.784	13.707	28.773
51 (46.78 + 4.22)	0.041	0.284	1.457	3.910	7.758	22.736	35.965
117.45 (46.78 + 70.67)	0.080	0.373	2.519	6.954	12.567	25.012	41.156
182.14 (46.78 + 135.36)	0.110	0.670	5.239	7.628	18.560	39.748	64.110
250.18 (46.78 + 203.4)	0.160	0.875	6.463	9.784	22.743	43.595	79.637
333.3 (46.78 + 286.52)	0.200	1.512	9.078	15.641	33.585	70.602	97.826
Maximum Drag Force		1.512	9.078	15.641	33.585	70.602	**97.826**
Minimum Drag Force		**0.258**	1.374	2.937	6.784	13.707	28.773

Table 6. Drag force observed under various loads on pontoon-II when pontoon axis at 10° with towing direction

Total Weight on Pontoon Including Self-weight in kg	Submergence in m	Rating Trolley Velocity in m/s					
		0.5	1	1.5	2	2.5	3
		Drag Force in kg					
56.6 (Self-weight + bracket)	0.035	0.548	2.190	4.067	8.054	18.110	31.616
117.45 (56.6 + 60.85)	0.080	0.593	3.243	7.126	15.490	31.142	43.734
182.14 (56.6 + 125.54)	0.110	0.798	5.403	9.365	17.008	37.175	54.561
250.18 (56.6 + 193.58)	0.160	0.938	5.723	15.323	29.093	62.870	*
333.3 (56.6 + 276.7)	0.200	1.434	10.287	15.548	28.464	68.054	*
Maximum Drag Force		1.434	10.287	15.548	29.093	**68.054**	54.561
Minimum Drag Force		**0.548**	2.190	4.067	8.054	18.110	31.616

*In case of pontoon- II, for the condition of experiment at higher loads and Rating Trolley velocity of 3 m/s, the water overtopped on the pontoon and the pontoon get tilted drastically which results in falling of weights even when tied properly. In view of this, beyond 250.18 kg at 3 m/s speed, it is not feasible to conduct experiments hence no data is obtained.

From the experiments it was observed that (i) the maximum drag force is induced 108.696 kg at 3 m/s velocity of the Rating Trolley for 333.3 kg load and 0.200 m submergence level and the minimum drag force is induced 0.500 kg at 0.5 m/s velocity of the Rating Trolley for 46.78 kg load 0.026 m submergence level on a pontoon-II at 0° (ii) The maximum drag force is induced 97.826 kg at 3 m/s velocity of the Rating Trolley for 333.3 kg load and 0.200 m submergence level and the minimum drag force is induced 0.258 kg at 0.5 m/s velocity of the Rating Trolley for 47.78 kg load and 0.026m submergence level on a pontoon-II at 5°. (iii) The maximum drag force is induced 68.054 kg at 2.5 m/s velocity of the Rating Trolley for 333.3 kg load and 0.2 m submergence level and the minimum drag force is induced 0.548 kg at 0.5 m/s velocity of the Rating Trolley for 56.6 kg load and 0.035 m submergence level on a pontoon-II at 10°. Table 7, Table 8 and Table 9 show drag forces induced on pontoon-III when its axis is 0°, 5° and 10° with towing direction respectively. The graphical representation of the same are shown in Figure 7(a), Figure 7(b) and Figure 7(c) respectively.

Table 7. Drag force observed under various loads on pontoon-III when pontoon axis at 0° with towing direction

Total Weight on Pontoon Including Self-weight in kg	Submergence in m	Rating Trolley Velocity in m/s					
		0.5	1	1.5	2	2.5	3
		Drag Force in kg					
53.88 (Self-weight + bracket)	0.032	0.300	1.582	4.817	9.289	19.861	23.364
76.2 (53.88 + 22.32)	0.045	0.450	2.100	5.544	14.338	21.867	37.902
117.45 (53.88 + 63.57)	0.080	0.618	3.200	10.122	23.719	33.018	53.432
182.14 (53.88 + 128.26)	0.110	0.678	5.836	11.152	22.879	45.368	65.556
250.18 (53.88 + 196.3)	0.160	1.287	6.339	16.621	28.747	53.977	81.150
339.36 (53.88 + 285.48)	0.200	1.632	6.665	18.669	49.535	121.231	128.479
Maximum Drag Force		1.632	6.665	18.669	49.535	121.231	**128.479**
Minimum Drag Force		**0.300**	1.582	4.817	9.289	19.861	23.364

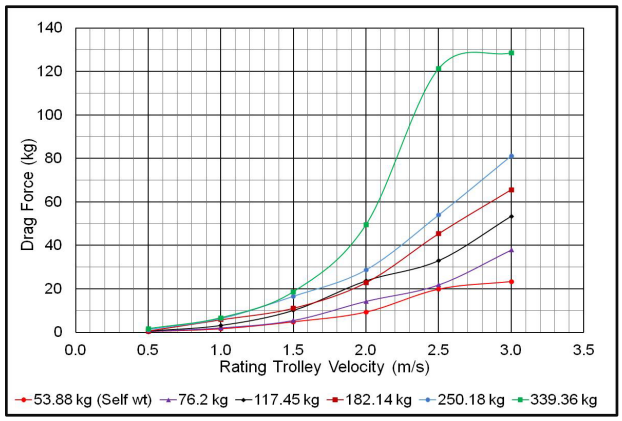


Figure 7. (a) Drag force vs. Rating trolley velocity at various loads on pontoon-III at 0°

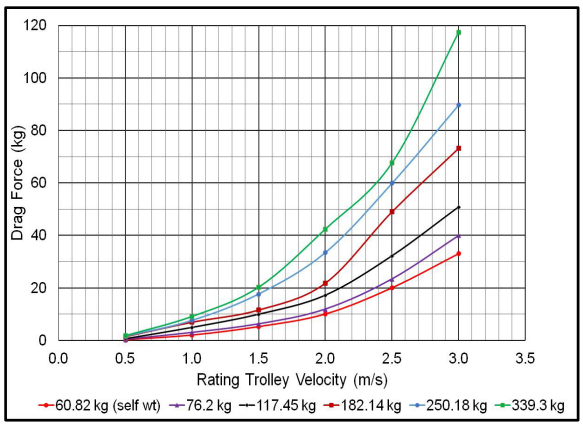


Figure 7. (b) Drag force vs. Rating trolley velocity at various loads on pontoon-III at 5°

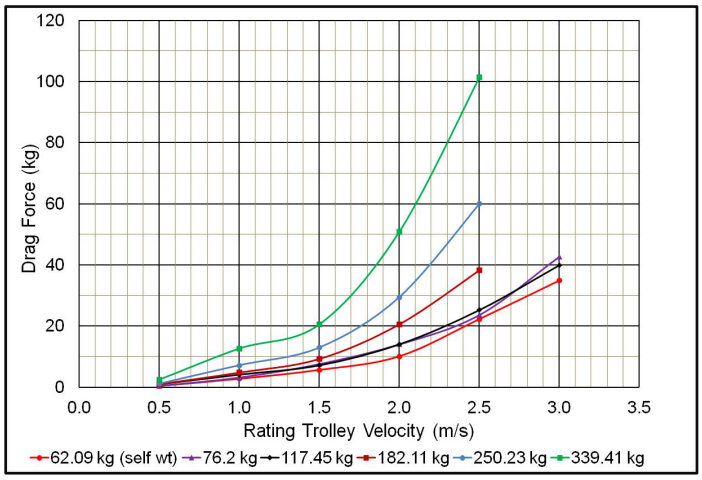


Figure 7. (c) Drag force vs. Rating trolley velocity at various loads on pontoon-III at 10°

Table 8. Drag force observed under various cases on pontoon-III when pontoon axis at 5° with towing direction

Total Weight on Pontoon Including Self-weight in kg	Submergence in m	Rating Trolley Velocity in m/s					
		0.5	1	1.5	2	2.5	3
		Drag Force in kg					
60.82 (Self-weight + bracket)	0.036	0.215	2.011	5.242	10.054	20.074	33.161
76.2 (60.82 + 15.38)	0.045	0.412	3.034	6.300	11.935	23.451	40.002
117.45 (60.82 + 56.63)	0.080	0.646	4.961	9.974	17.223	32.238	50.870
182.14 (60.82 + 121.32)	0.110	1.482	6.976	11.617	21.846	49.023	73.206
250.18 (60.82 + 189.36)	0.160	1.561	7.585	17.672	33.469	59.936	89.799
339.3 (60.82 + 278.48)	0.200	1.841	9.169	20.293	42.434	67.665	117.482
Maximum Drag Force		1.841	9.169	20.293	42.434	67.665	**117.482**
Minimum Drag Force		**0.215**	2.011	5.242	10.054	20.074	33.161

Table 9. Drag force observed under various loads on pontoon-III when pontoon axis at 10° with towing direction

Total Weight on Pontoon Including Self-weight in kg	Submergence in m	Rating Trolley Velocity in m/s					
		0.5	1	1.5	2	2.5	3
		Drag Force in kg					
62.09 (Self-weight + bracket)	0.040	0.381	2.730	5.636	10.086	22.266	34.913
76.2 (62.09 + 14.11)	0.045	0.479	3.217	7.607	14.014	23.590	42.616
117.45 (62.09 + 55.36)	0.080	1.026	4.169	7.198	14.081	25.265	39.937
182.11 (62.09 + 120.02)	0.110	1.030	4.832	9.298	20.626	38.315	*
250.23 (62.09 + 188.14)	0.160	1.068	7.131	12.916	29.420	60.001	*
339.41 (62.09 + 277.32)	0.200	2.352	12.560	20.444	50.781	101.339	*
Maximum Drag Force		2.352	12.560	20.444	50.781	**101.339**	42.616
Minimum Drag Force		**0.381**	2.730	5.636	10.086	22.266	34.913

*- In case of pontoon-III, at higher loads and 3 m/s speed, the water overtopped on the pontoon and it tilted drastically which resulted in falling of weights even when tied properly. Hence under 182.11 kg, 250.23 kg, and 339.41 kg at 3 m/s speed no data was obtained.

From the experiments it was observed that (i) the maximum drag force is induced 128.479 kg at 3 m/s velocity of the Rating Trolley velocity for 339.36 kg load and 0.200 m submergence level and the minimum drag force is induced 0.3 kg at 0.5 m/s velocity of the Rating Trolley for 53.88 kg load and 0.032 m submergence level on a pontoon-III at 0°.(ii) The maximum drag force is induced 117.482 kg at 3 m/s velocity of the Rating Trolley for at 339.3 kg load and 0.200 m submergence level and the minimum drag force is induced 0.215 kg at 0.5 m/s velocity of the Rating Trolley for 60.82 kg load and 0.036 m submergence level on a pontoon-III at 5° (iii) The maximum drag force is induced 101.339 kg at 2.5 m/s velocity of the Rating Trolley for the 339.41 kg load and 0.02 m submergence level and the minimum drag force is induced 0.381 kg at 0.5 m/s velocity of the Rating Trolley for 62.09 kg and 0.040 m submergence level on a pontoon-III at 10°

4. Conclusion

- The drag force measurement is varied in direct relation with the water stream velocity, load carrying and submergence level at 0 degree angle of pontoons.
- Recommendation for the design of the Pontoon I for the maximum permissible weight is approximately 396 kg for the velocity 1.2 m/s and 280kg for 1.5 m/s the velocity.
- Considering the results of experiments while designing of Pontoon II, at 0 degree the maximum permissible weight is approximately 333 kg for the velocity 3.0 m/s, at 5 degree the maximum permissible weight is approximately 333 kg for the velocity 3.0 m/s, and at 10 degree the maximum permissible weight is approximately 182 kg for velocity 3.0 m/s or 333 kg for velocity 2.5 m/s. These values are more important while designing pontoons and selecting during its site application.
- Considering the results of experiments while designing of Pontoon III, at 0 degree the maximum permissible weight is approximately 339 kg for the velocity 3.0 m/s, pontoon II at 5 degree the maximum permissible weight is approximately 339 kg for the velocity 3.0 m/s, and Pontoon II at 10 degree the maximum permissible weight is approximately 182 kg for velocity 3.0 m/s or 101 kg for velocity 2.5 m/s. These values are more important while designing pontoons and selecting during its site application.

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6. REFERENCES

https:/www.cwprs.gov.in and CWPRS Technical Report No. 5999, February 2022