The Resistance and Self-propulsion Test Results for JBC in designed full load and ballast load conditions

by

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Abstract

The Japan Bulk Carrier (JBC) is the hull form of a bulk carrier designed in Japan to be used as a benchmark. Originally intended for validation studies on CFD calculations, the three-dimensional geometry of the hull below the water surface has already been published. However, the hull form was partly simplified for the validation studies, likely by omitting the bilge keel, as the JBC is not a real ship, and data for performance prediction such as self-propulsion factors have not been published.

To enhance the versatility of the JBC and contribute to validation studies on performance prediction methods, data was obtained from resistance tests and self-propulsion tests for the JBC in the designed full load condition and in the ballast load condition, the results of which are provided in this report.

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Contents

1. Introduction

The Japan Bulk Carrier (JBC) is the hull form of a bulk carrier designed in Japan to be used as a benchmark. Originally intended for validation studies on CFD calculations, the three-dimensional geometry of the hull below the water surface has already been published[1), and the geometry above the water surface and the wind tunnel test results have been published[2). However, the hull form was partly simplified for the validation studies, likely by omitting the bilge keel, as the JBC is not a real ship, and data for performance prediction such as self-propulsion factors have not been published.

To enhance the versatility of the JBC and contribute to validation studies on performance prediction methods, data obtained from resistance tests and self-propulsion tests are provided in this report.

2. Models and test conditions

The JBC is designed as a Capesize bulk carrier. Dimensions of JBC model for tank tests are shown in Table 1. The model is based on the public data. Bilge keels are not attached to the original hull of the JBC, but are added to the model for the tests. The bilge keel is with a length of 25% L_{pp} and installed with its center at the midship and with the angle of 45 deg. from the horizontal plane. The edge is shaped as ellipse, where the short diameter is equal to the breadth of the bilge keel and the long diameter is twice as the short diameter. The breadth of the bilge keel is set so as not to exceed the hull breadth. The appearance of the model ship is shown in Fig. 1.

Dimensions of the model propeller are shown in Table 2, and the appearance is shown in Fig. 2. The propeller open tests have been conducted in the same tank as the resistance and self-propulsion tests beforehand. The POC of the model propeller is shown in Fig. 3. Here, J is the advance coefficient, K_T is the thrust coefficient, K_Q is the torque coefficient, and J, K_T, K_Q are defined by Eqs. (1) ~ (3), respectively. Where, ρ is the fluid density, n_p is the propeller revolution, T is the propeller thrust, Q is the propeller torque, V_a is the advance speed.

$$K_T = \frac{T}{\rho\, n_P^2 D_p{}^4} \quad (1)$$

$$K_Q = \frac{Q}{\rho\, n_P^2 D_P^5} \quad (2)$$

$$J = \frac{V_a}{n_P D_P} \quad (3)$$

Fig.1 Ship model.

Table 1 Principal dimensions of JBC.

Condition	Design Full		Ballast	
Item	Ship	Model	Ship	Model
Length between perpendiculars L_{PP} [m]	280.0	7.000	280.0	7.000
Length at load waterline L_{WL} [m]	285.0	7.125	278.281	6.957
Ship breadth B [m]	45.0	1.125	45.0	1.125
Draft (aft) d_a [m]	16.500	0.4125	10.015	0.2504
Draft (mid) d_m [m]	16.500	0.4125	8.615	0.2154
Draft (fore) d_f [m]	16.500	0.4125	7.215	0.1804
Displacement *Disp.* [m^3]	178626.9	2.7910	89,222.8	1.3941
Wetted surface area S [m^2]	19929.3	12.4558	15,005.1	9.3782
Trim [m]	0	0	2.800	0.0700
Longitudinal centre of buoyancy lcb [%L_{PP}] (+aft)	-2.5475		-1.5589	
Length of the bilge keel L_{BK} [m]	70.000	1.7500	70.000	1.7500
Breadth of the bilge keel B_{BK} [m]	0.750	0.0188	0.750	0.0188
Thickness of the bilge keel t_{BK} [m]	0.080	0.0020	0.080	0.0020

Table 2 Dimensions of propeller model.

Item	Value
Diameter D_p [m]	0.203
Pitch ratio P/D_p [-]	0.750
Expanded area ratio a_E [-]	0.500
Blade's number Z [-]	5
Boss ratio $B.R.$ [-]	0.18

Fig. 2 Propeller model.

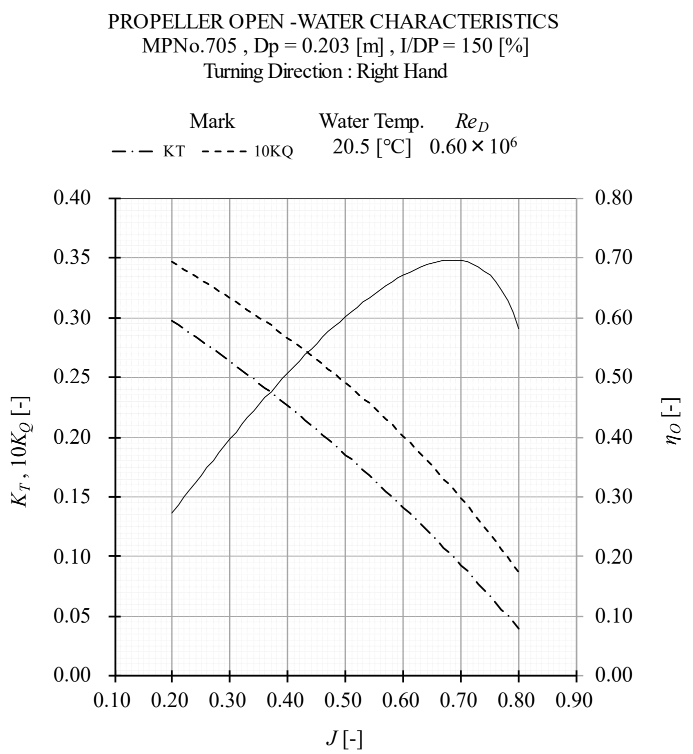

Fig.3 Propeller open-water characteristics.

3. Test results

Tank tests were conducted in Mitaka No.2 Ship Model Experiment Tank at National Maritime Research Institute. In this chapter, the facility, the measurement system and test results are shown.

3.1 Towing tank and measurement system

The outline of Mitaka No.2 Ship Model Basin is illustrated in Fig. 5. The carriage shown in Fig.4 was used for towing the model ship, which enables heave and pitch motion and fixes surge motion. Measured items are ship speed through water, resistance, sinkage at A.P. and F.P., propeller revolution, propeller thrust and propeller torque (latter three items are measured for self-propulsion tests only).

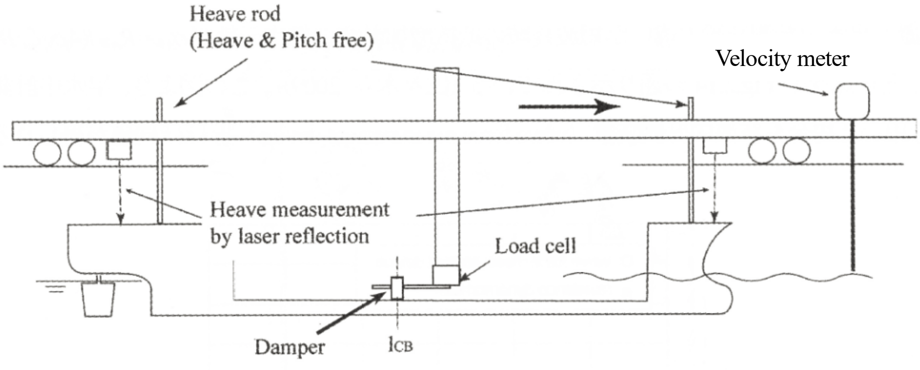

Fig.4 Measurement system.

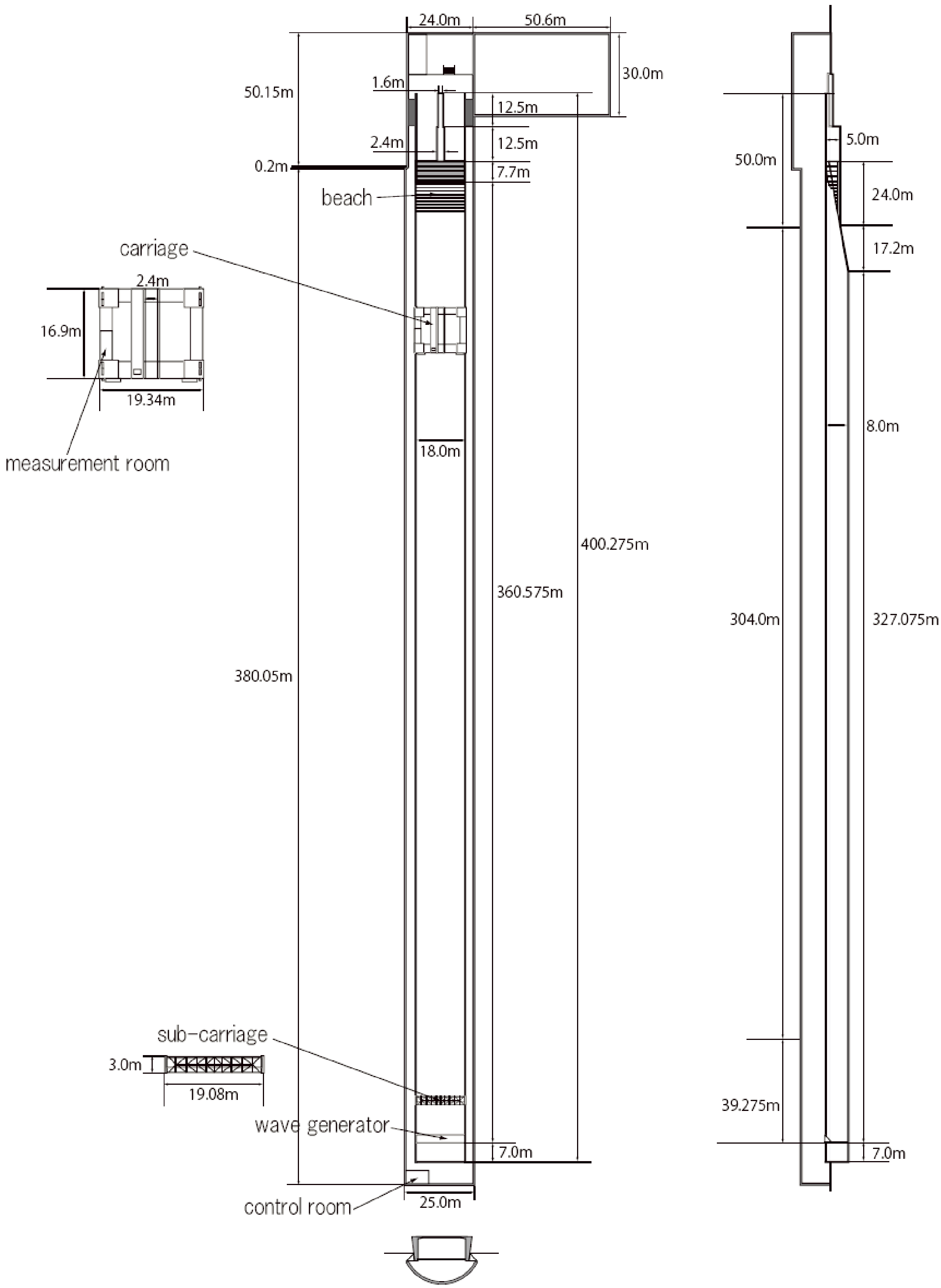

Fig.5 Mitaka No.2 Ship Model Experiment Tank.

3.2 Test results for designed full load condition

Results of resistance tests in still water are shown in Fig. 6. The form factor k was determined by the Prohaska's method as k = 0.331. Here, F_r is the Froude number based on the ship length at water line, C_{TM}, C_{FM}, C_{VM}, C_W are the total resistance coefficient for a ship model, the frictional resistance coefficient of a corresponding plate for a ship model, the viscous resistance coefficient for a ship model, the wave making resistance, respectively. C_{TM}, C_{FM}, C_{VM}, C_W are non-dimensionalized by ($0.5\rho S V_w^2$), where S is the wetted surface area with all appendages, V_w is the speed through the water. C_{FM} is calculated by the Schoenherr's formula.

The sinkage at A.P. and F.P is shown in Fig. 7. Here, DF is the sinkage at F.P., and DA is the sinkage at A.P.

Results of self-propulsion tests in still water are shown in Fig. 8. Here, (1-w) is the wake coefficient of a ship model, (1-t) is the thrust deduction coefficient, η_R is the relative rotative efficiency.

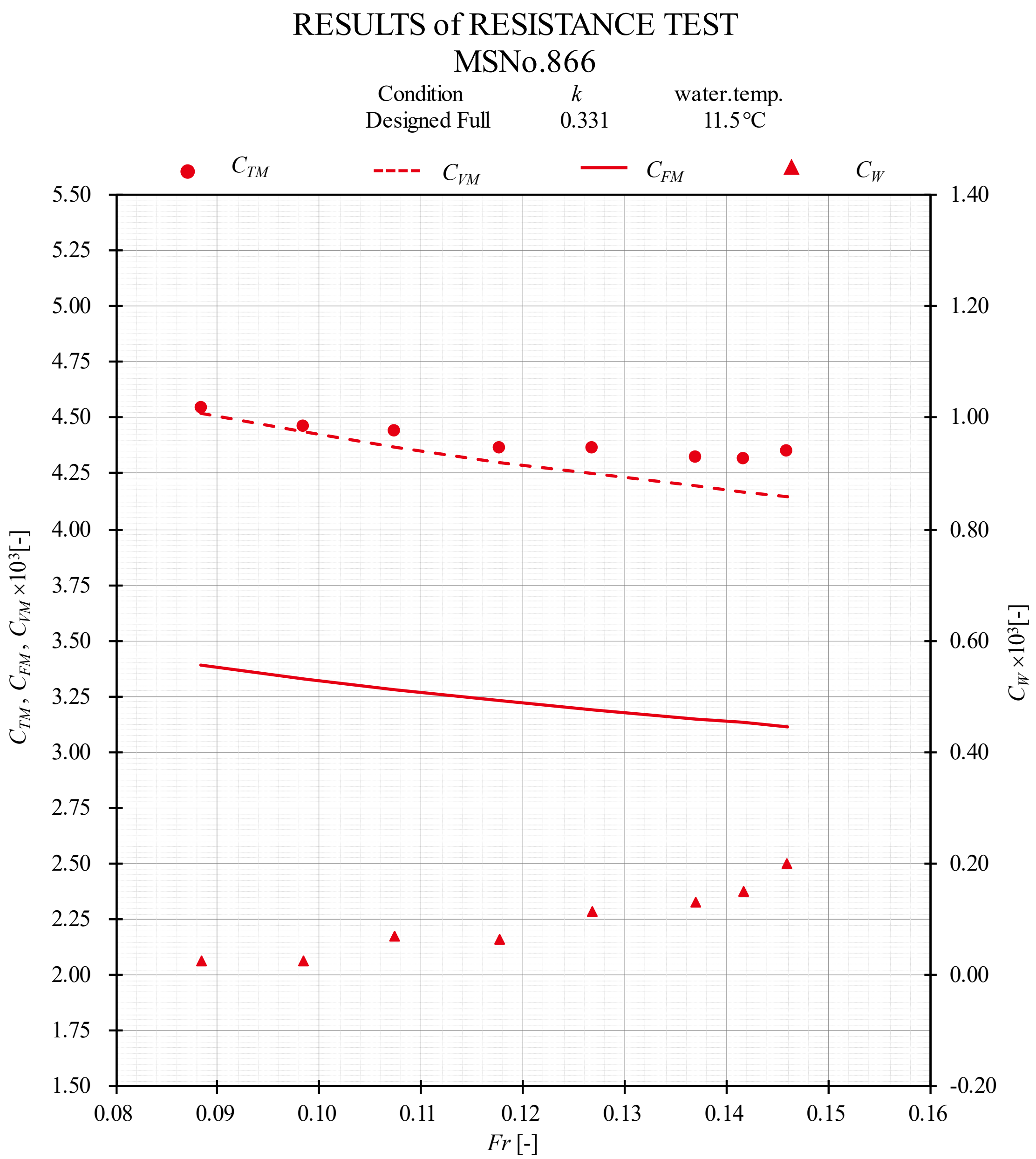

Fig.6 Results of resistance tests in designed full load condition.

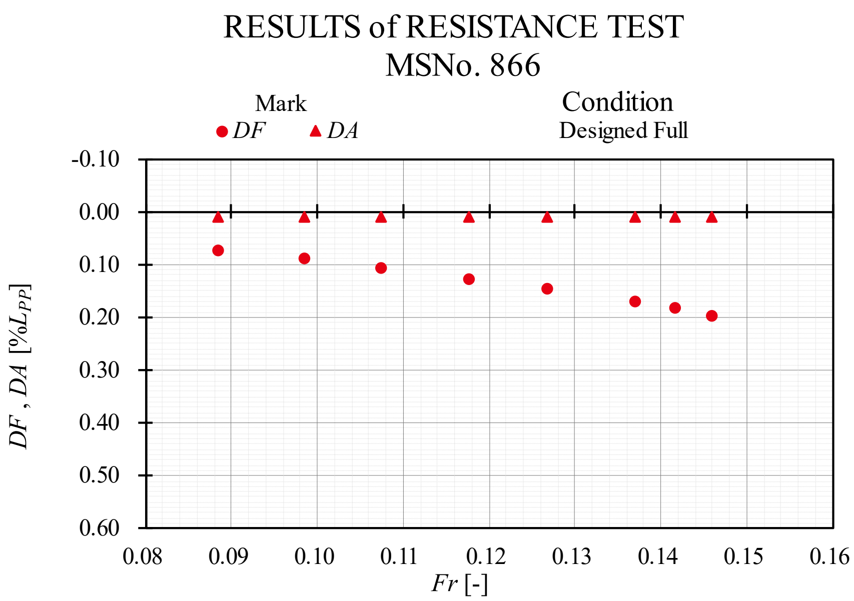

Fig.7 Sinkage results from resistance tests in designed full load condition.

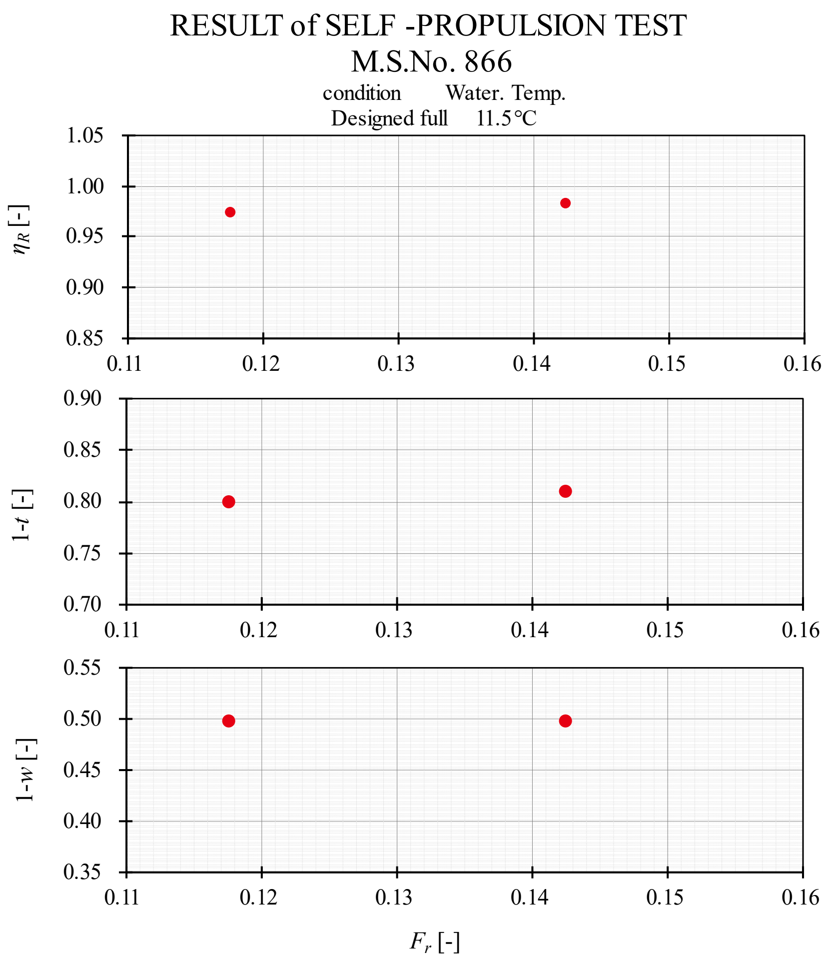

Fig.8 Results of self-propulsion tests in designed full load condition.

3.3 Test results for ballast load condition

Results of resistance tests in still water are shown in Fig. 9. The form factor k was determined by the Prohaska's method as $k = 0.327$.

The sinkage at A.P. and F.P is shown in Fig. 10.

Results of self-propulsion tests in still water are shown in Fig. 11.

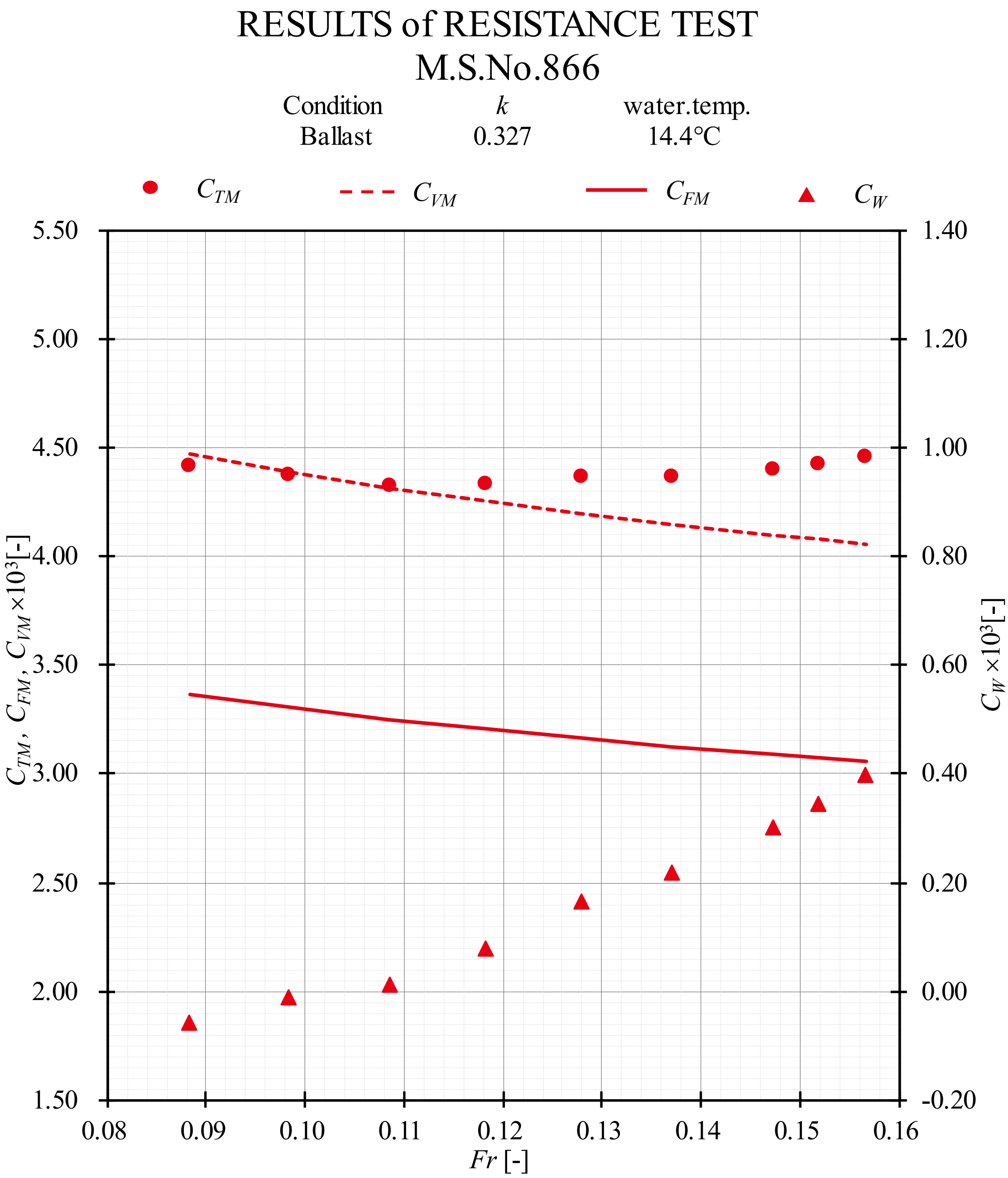

Fig.9 Results of resistance tests in ballast load condition.

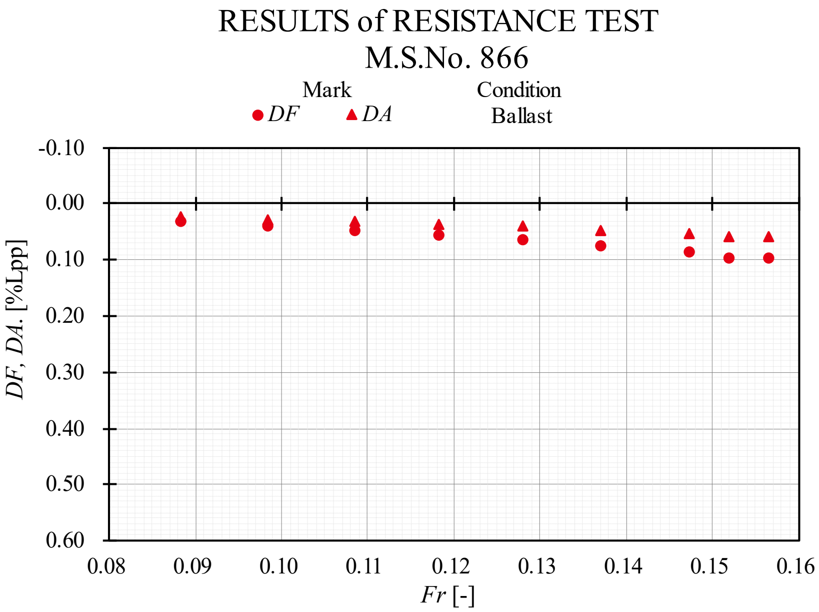

Fig. 10 Sinkage results from resistance tests in ballast load condition.

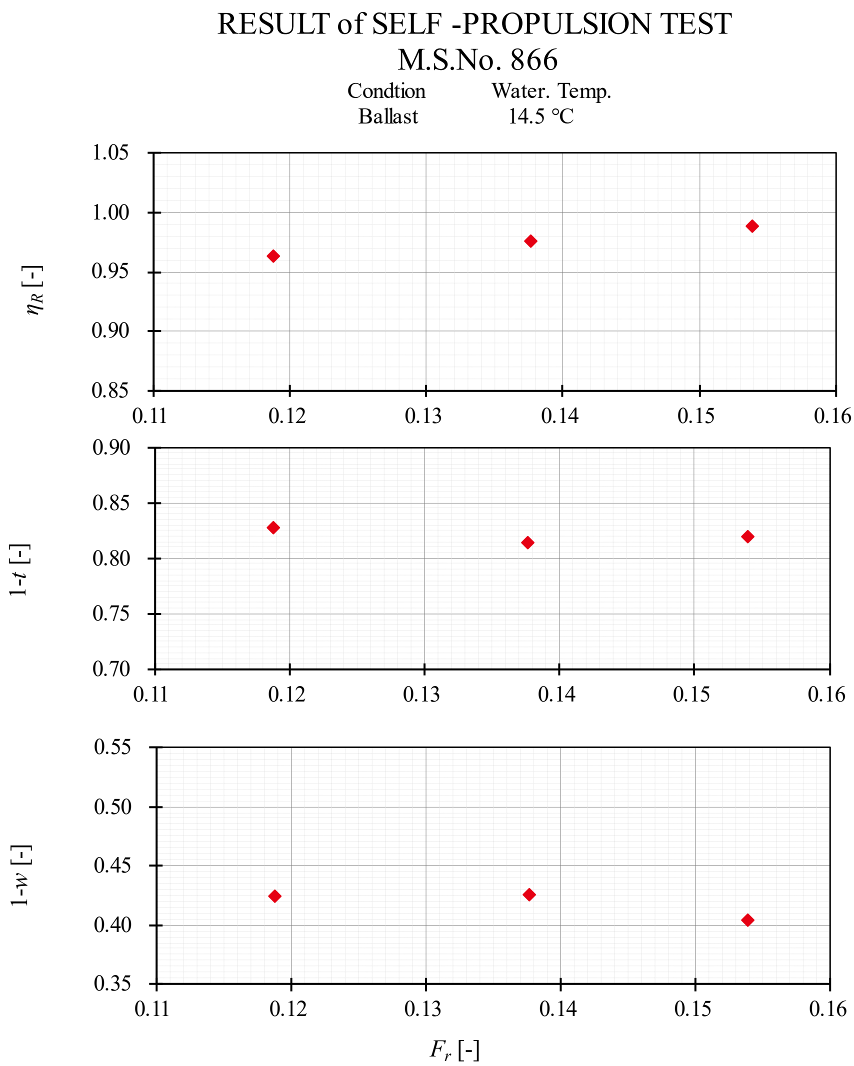

Fig.11 Results of self-propulsion tests in ballast load condition.

3.4 Test results data

Results of resistance tests and self-propulsion tests in still water for designed full load condition and for ballast load condition are also stored in the “NMRI DB” at the URL below.

URL for getting results of resistance tests and self-propulsion tests in still water:
https://www.nmri.go.jp/study/intellectual/db/jbc2/

4. Conclusions

This paper shows results of the resistance test and the self propulsion test for JBC in designed full load condition and in ballast load condition. The JBC is a benchmark hull form whose underwater geometry has been published and has been used mainly to validate CFD calculations. The presentation of the results of resistance data and self propulsion factors in still water will enable comparative verification of not only CFD calculations but also tank test results or full scale predictions. It is hoped that the enhanced data will increase its value as a benchmark ship and be widely used in this field.

Acknowledgements

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References

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2) KUME, Kenichi, The Geometry of JBC Above Water Surface and the Wind Tunnel Test Results, Papers of National Maritime Research Institute, Vol. 22-3 (2022).