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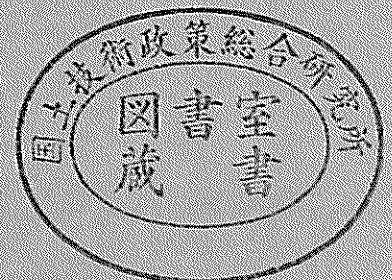
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Ship Dimensions of Design Ship under Given Confidence Limits

信頼度を与条件とした船舶諸元

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Ship Dimensions of Design Ship
under Given Confidence Limits

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Synopsis

In designing port facilities, the dimensions of Design Ship are one of the most important conditions. Design Ship is the largest ship among ships that are expected to use the facility. If Design Ship has been specified previously, the dimensions of the specified ship are used. In another case, the dimensions are calculated by the ship type and DWT / GT of Design Ship. The confidence limits of those dimensions shall be determined in considering the function, the way of use, the environmental condition, etc. of the facility.

This paper proposes the procedure to determine the dimensions of Design Ship under given confidence limits. The ship dimensions such as displacement, length over all, length between perpendicular, breadth, depth, maximum draft, wind projected front area (full load condition / ballast condition) and wind projected lateral area (full load condition / ballast condition) are calculated in proportion to confidence limits. The ship data used in this paper are mainly Lloyd's Register of Ships (1995.6).

Key Words: Port Facility, Design Ship, Ship Dimensions, Confidence Limits, Lloyd's Register of Ships

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信頼度を与条件とした船舶諸元

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要　　旨

　港湾施設の設計において，対象船舶の諸元は大きな条件の一つである．対象船舶とは，当該施設を利用すると想定される船舶のうち最大のものである．対象船舶が事前に特定される場合には，その諸元を用いて設計すればよい．対象船舶が事前に特定されない場合，対象船舶の船種と規模（DWT / GT）から船舶諸元を算定しなければならない．その際，船舶規模に対して，信頼度をどこに設定するかは，その港湾施設の性格，使用される状況，自然環境等により決定されるべきである．

　本研究は，対象船舶の船種と規模から任意の信頼度による船舶諸元を算定する方法を提案し，信頼度を与条件として排水トン，全長，垂線間長，型幅，型深，満載喫水，風圧投影正面積（満載状態／バラスト状態），風圧投影側面積（満載状態／バラスト状態）を算定したものである．なお，本研究で用いた船舶データは主にLloyd's Register of Ships (1995.6)である．

キーワード：港湾施設，対象船舶，船舶諸元，信頼度，Lloyd's Register of Ships

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1. INTRODUCTION

Various conditions such as natural, economic, social, technical etc. must be taken into account in the design of port facilities to ensure a sufficient level of function and safety. The dimensions of the ship that is expected to use these facilities are one of the most important conditions to determine the design of these facilities. For example, the area of turning basin is the circle with the radius of multiple of the length of the ship and the depth of berth is expressed as a multiple of maximum draft of the ship. If the ship has been specified previously, the ship dimensions that are needed in the design are definitely decided. But, this case is not often, so the concept of "Design Ship" is used. This paper proposes the way to decide the dimensions of Design Ship and shows the results of the procedure under various conditions.

A previous study[1)-6)] on ship dimensions of Design Ship was done at the Port and Harbour Research Institute (P.H.R.I.). But, these study's philosophies were based on the Japanese guideline[7)], because these study focused on Japanese port facilities. This study can be applied to port facilities all over the world.

2. DESIGN SHIP

Design Ship is the object of design of port facility. The following points need to be considered in determining of Design Ship:

- Design Ship has the largest gross tonnage (GT) / dead weight tonnage (DWT) among vessels expected to use the port facilities[7)]
- All other ships likely to use the port facilities must do so safely[8)]

Furthermore, other factors may need to be considered:

- If ships having dimensions larger than that of Design Ship are expected to call[7)]
- If ships carrying dangerous articles are expected to call[7)]
- If very large ships in the context of port

operations are expected to call[8)]
- If ships having poor inherent maneuverability are expected to call[8)]

Example of Design Ship expressed as ship type and DWT / GT:

　　　Bulk carrier, 150,000 DWT
　　　Container ship, 9,000 DWT
　　　Passenger ship, 80,000 GT

Ship dimensions of Design Ship should be decided after Design Ship is decided. There are difficulties to decide ship dimensions from the ship type and DWT / GT, because more than one ship corresponds to the decided Design Ship. The ship dimensions of Design Ship should be decided considering the sufficient level of function and safety of designed facility.

3. OBJECT OF ANALYSIS

3. 1 PROCESSED DATA

The processed data is Lloyd's Register of Ships 1995.6 (Lloyd's Maritime Information Services) to determine the ship dimensions of Design Ship. This database of ship dimensions is one of the most reliable in the world. Lloyd's Maritime Information Service has collected ship data by sending a questionnaire to shipping companies. The data is divided into many ship types.

Lloyd's Register of Ships, however, does not provide the projected wind areas of ships. Therefore, P.H.R.I. and Port and Harbor Bureau of M.O.T. of Japan had collected the projected wind areas of ships using the results of questionnaires sent to Japanese shipyards and Nippon Kaiji Kyokai. It must be care that the reliability of analysis result of projected wind areas is not the same as that of the other ship dimensions' because the number of wind areas' data is much smaller than that of the other dimensions'.

3. 2 SHIP TYPE

Ship dimensions vary according to ship type. The ship type of Design Ship shall be determined adequately. In this paper, Design Ship is divided into 8 ship types based on the classification of Lloyd's Register of Ships, as follows:

- General Cargo Ship
- Bulk Carrier
- Container Ship
- Oil Tanker
- Ro/Ro Ship
- Passenger Ship
- Ferry
- Gas Carrier

The Combination Carriers such as Ore/Oil Carrier, Ore/Bulk/Oil Carrier are excluded from the analysis, because it is difficult to classify the Combination Carriers into the above ship types and the number of such ships is very small.

3. 3 VALID DATA

Only the data of ships that were built after 1980 are utilized because the data becomes invalid after 15 years. It is said that the life span of a ship is generally 20 to 30 years and that time span of revising guidelines on port facilities may be 10 years (Ex. Technical Standards for Port and Harbour Facilities in Japan[7]). Fig. 1 shows the year of built of all ships in Lloyd's Register of Ships 1995. The number of ships built in the first half of the 1990's is equal to that of the second half of the 1960's. This implies that the ship begin to retire at the age of 25. Limiting the data to recent 15 years at the revision of the guidelines is equal to limiting the data to recent 25 years at the end of the guidelines.
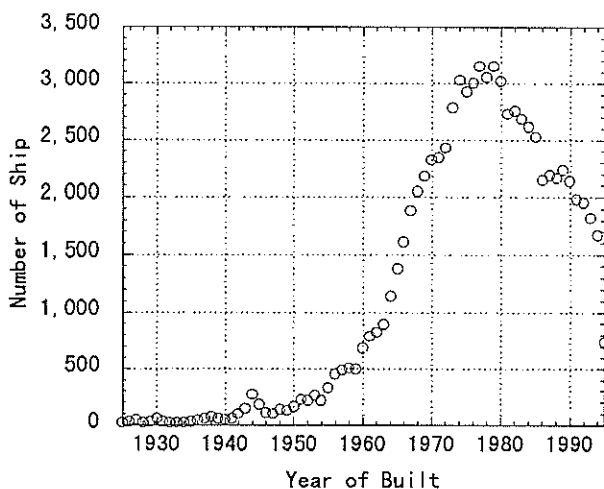
For example, the dimensions of Oil Tanker had been getting larger in the 1960's and 70's as follows[9]:

1959	114 ('000 DWT)	Universal Apollo
1965	151 ('000 DWT)	Tokyo Maru
1966	209 ('000 DWT)	Idemitsu Maru
1971	372 ('000 DWT)	Nisseki Maru
1975	484 ('000 DWT)	Nissei Maru

But since the beginning of the 1980's, U.L.C.C. (Ultra Large Crude Carrier) which is larger than 310,000 DWT has not been built. Some such vessels are now in service but they will retire in these 10 years. By this reason, the guideline used in these 10 years may not consider these U.L.C.C.

Passenger ship is not the same as the other ship in terms of life span. The life span of a passenger ship is generally 40 years as shown in Fig. 2. The valid term of data of passenger ship is 30 years.
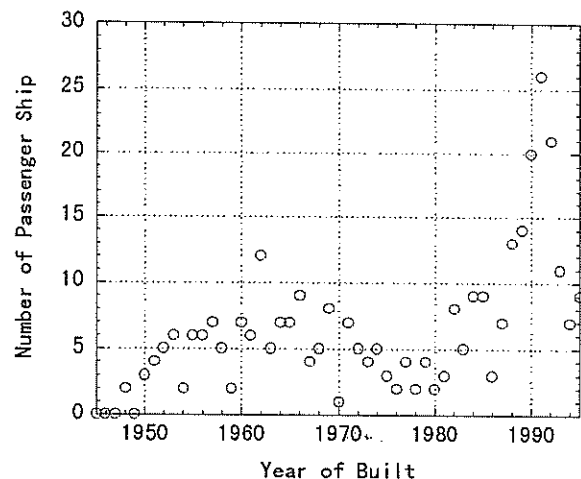
Fig. 2   Year of Built of Passenger Ship

4. ANALYTICAL PROCEDURES

4. 1   CONCEPT OF ANALYSIS

This analysis is to determine the dimensions of Design Ship. The explanatory variable of this analysis is GT or DWT and objective variable are various dimensions of Design Ship. The choice of GT or DWT for explanatory variable depends upon the ship type of Design Ship. The ship carrying heavy cargo is adequately expressed by DWT, while the

Fig. 1   Year of Built of All Ships

ship carrying light cargo is adequately expressed by GT. Because DWT is the measure signifying weight, while GT is the measure signifying volume. The relation between ship type and explanatory variable defined in this paper is:

- DWT: General Cargo Ship, Bulk Carrier, Container Ship, Oil Tanker and Ro/Ro Ship
- GT : Passenger Ship, Ferry and Gas Carrier

The relations between DWT and GT of each ship type are as follows:

General Cargo Ship	GT = 0.712 DWT
Bulk Carrier	GT = 0.538 DWT
Container Ship	GT = 0.880 DWT
Oil Tanker	GT = 0.553 DWT
Ro/Ro Ship	GT = 1.217 DWT
Passenger Ship	GT = 7.657 DWT
Ferry	GT = 4.490 DWT
Gas Carrier	GT = 1.185 DWT

Objective variables are selected in consideration of various guidelines of port facilities such as:

Displacement (D_{SP}), Length Over All (L_{OA}), Length between Perpendicular (L_{PP}), Breadth Moulded (B), Depth (D), Maximum draft (d), Wind Lateral Area (full load condition: A_{LF}, ballast condition: A_{LB}), Wind Front Area (full load condition: A_{FF}, ballast condition: A_{FB})

4. 2 REGRESSION ANALYSIS

An objective variable Y is expressed by an explanatory variable X in form of power function as:

$$Y = \alpha X^{\beta} \qquad (1)$$

Where α, β : regression coefficient

The reason for adapting power function is that the coefficient β is nearly equal 1/3, 2/3 and 1. Because, objective variables such as L_{OA}, B, d etc. are one-dimensional figures, A_{LF}, A_{LB} etc. are two-dimensional figures and D_{SP} is three-dimensional figures, while explanatory variables are three-dimensional figures. The other reason is that power function is very easy of regression analysis. To take logarithms of both members, formula (1) changes into formula (2).

$$\log Y = a + b \log X \qquad (2)$$

Where $a = \log(\alpha)$, $b = \beta$

Formula (2) represents liner relation between $\log Y$ and $\log X$. That is to say, relation of power function is changed into relation of liner function by taking logarithms and regression analysis becomes to be liner regression of $\log Y$ on $\log X$ by least-squares method.

A, B, estimated values of a, b, are obtained by formula (3) and (4).

$$A = \frac{\sum_{i=1}^{n} \log y_i - \frac{S_{xy}}{S_x} \sum_{i=1}^{n} \log x_i}{n} \qquad (3)$$

$$B = \frac{S_{xy}}{S_x}$$
$$= \frac{n \sum_{i=1}^{n} \log x_i \log y_i - \sum_{i=1}^{n} \log x_i \sum_{i=1}^{n} \log y_i}{n \sum_{i=1}^{n} (\log x_i)^2 - \left(\sum_{i=1}^{n} \log x_i \right)^2} \qquad (4)$$

Where S_{xy} : covariance of x and y

S_x : variance of x

n : number of data

Conditional standard deviation $\hat{\sigma}$ is given by

$$\hat{\sigma} = \sqrt{\frac{S_{y,x}}{n-2}} = \sqrt{\frac{1}{n-2} \left(S_y - \frac{S_{xy}^2}{S_x} \right)} \qquad (5)$$

Where $S_{y,x}$: conditional variance

S_y : variance of y

To confirm whether linear regression is adequate or not, correlation coefficient R is calculated by formula (6).

$$R = \sqrt{\frac{S_{xy}}{S_x S_y}} \qquad (6)$$

4. 3 RESULT OF ANALYSIS

To give an example of regression analysis, Fig. 3 shows the relation between DWT and d of Oil Tanker. It is difficult to tell the fittest curve from Fig. 3.

Fig. 4 is the same relation of Fig. 3 on a log scale. It is easy to tell the fittest curve is a strait line. Therefor, d is expressed by power function of DWT accurately.
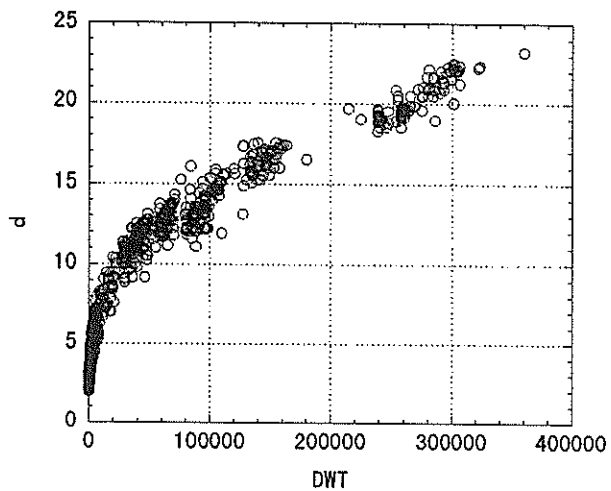
Fig. 3   DWT-d of Oil Tanker

All the results of regression analysis are shown in Table 1. There are some cases in which dimensions and ship types that can not be expressed by the analysis result directly. These will be indicated later in section 6.

Table 1   Results of Regression Analysis

Type	Dimension	N of data	α	β	R	A	B	σ
General Cargo Ship	Dsp	1,256	2.371	0.942	0.995	0.375	0.942	0.0414
	L_{OA}	5,361	7.411	0.310	0.962	0.870	0.310	0.0434
	L_{PP}	5,562	6.435	0.318	0.957	0.809	0.318	0.0474
	B	2,849	1.506	0.278	0.970	0.178	0.278	0.0343
	D	5,929	0.647	0.301	0.923	-0.189	0.301	0.0762
	d	5,645	0.378	0.326	0.966	-0.423	0.326	0.0538
	A_{LF}	67	3.213	0.616	0.908	0.507	0.616	0.1302
	A_{LB}	67	3.014	0.662	0.952	0.479	0.662	0.1007
	A_{FF}	21	0.592	0.666	0.964	-0.228	0.666	0.0451
	A_{FB}	21	1.256	0.615	0.967	0.099	0.615	0.0365
Bulk Carrier	Dsp	881	2.137	0.946	0.998	0.330	0.946	0.0167
	L_{OA}	2,290	9.302	0.285	0.980	0.969	0.285	0.0179
	L_{PP}	2,376	7.643	0.299	0.978	0.883	0.299	0.0195
	B	1,512	1.062	0.311	0.973	0.026	0.311	0.0223
	D	2,362	0.661	0.299	0.991	-0.180	0.299	0.0121
	d	2,366	0.487	0.297	0.984	-0.313	0.297	0.0171
	A_{LF}	72	16.518	0.425	0.917	1.218	0.425	0.0729
	A_{LB}	72	9.334	0.530	0.978	0.970	0.530	0.0460
	A_{FF}	57	8.787	0.370	0.907	0.944	0.370	0.0497
	A_{FB}	57	4.254	0.469	0.967	0.629	0.469	0.0376
Container Ship	Dsp	602	2.203	0.953	0.991	0.343	0.953	0.0325
	L_{OA}	1,069	3.542	0.394	0.958	0.549	0.394	0.0350
	L_{PP}	1,111	3.098	0.401	0.957	0.491	0.401	0.0375
	B	742	1.762	0.272	0.954	0.246	0.272	0.0243
	D	1,098	0.279	0.396	0.954	-0.554	0.396	0.0361
	d	1,099	0.474	0.303	0.969	-0.324	0.303	0.0241
	A_{LF}	55	2.614	0.703	0.974	0.417	0.703	0.0675
	A_{LB}	63	5.388	0.625	0.905	0.731	0.625	0.1016
	A_{FF}	24	1.369	0.609	0.901	0.136	0.609	0.0598
	A_{FB}	26	3.752	0.526	0.834	0.574	0.526	0.0741

Type	Dimension	N of data	α	β	R	A	B	σ
Oil Tanker	Dsp	983	1.968	0.956	0.999	0.294	0.956	0.0570
	L_{OA}	2,299	6.637	0.315	0.994	0.822	0.315	0.0310
	L_{PP}	2,539	5.859	0.322	0.993	0.768	0.322	0.0379
	B	1,298	1.140	0.310	0.991	0.057	0.310	0.0292
	D	2,550	0.378	0.351	0.994	-0.422	0.351	0.0320
	d	2,470	0.510	0.291	0.991	-0.293	0.291	0.0349
	A_{LF}	57	3.598	0.558	0.965	0.556	0.558	0.0708
	A_{LB}	57	4.468	0.592	0.992	0.650	0.592	0.0333
	A_{FF}	46	2.946	0.474	0.949	0.469	0.474	0.0625
	A_{FB}	46	1.784	0.551	0.981	0.251	0.551	0.0408
Ro/Ro Ship	Dsp	159	3.335	0.924	0.991	0.523	0.924	0.0674
	L_{OA}	424	5.255	0.366	0.953	0.721	0.366	0.0614
	L_{PP}	437	4.665	0.370	0.950	0.669	0.370	0.0640
	B	270	2.415	0.245	0.964	0.383	0.245	0.0390
	D	442	0.248	0.439	0.880	-0.605	0.439	0.1173
	d	435	0.244	0.372	0.965	-0.613	0.372	0.0625
	A_{LF}	25	28.411	0.464	0.848	1.453	0.464	0.1453
	A_{LB}	25	34.790	0.456	0.890	1.541	0.456	0.1123
	A_{FF}	8	10.697	0.435	0.949	1.029	0.435	0.0469
	A_{FB}	8	8.266	0.473	0.954	0.917	0.473	0.0453
Passenger Ship	Dsp	48	1.818	0.891	0.959	-0.050	0.891	0.1205
	L_{OA}	210	5.464	0.346	0.990	-0.461	0.346	0.0434
	L_{PP}	220	5.555	0.330	0.979	0.745	0.330	0.0626
	B	179	2.030	0.250	0.980	-0.601	0.250	0.0380
	D	219	0.292	0.382	0.906	-0.418	0.382	0.1132
	d	211	0.126	0.395	0.859	-0.900	0.395	0.1855
	A_{LF}	14	3.888	0.680	0.999	0.590	0.680	0.0552
	A_{LB}	11	4.532	0.666	0.998	0.656	0.666	0.0466
	A_{FF}	6	8.842	0.426	0.978	0.947	0.426	0.0715
	A_{FB}	6	9.680	0.419	0.976	0.986	0.419	0.0746
Ferry	Dsp	408	0.929	0.981	0.898	-0.032	0.981	0.2681
	L_{OA}	1,664	4.889	0.361	0.954	0.689	0.361	0.0776
	L_{PP}	1,601	4.192	0.369	0.948	0.622	0.369	0.0790
	B	1,027	2.272	0.249	0.925	0.356	0.249	0.0766
	D	1,747	0.550	0.309	0.868	-0.259	0.309	0.1029
	d	1,521	0.355	0.294	0.907	-0.450	0.294	0.1556
	A_{LF}	14	3.666	0.674	0.987	0.564	0.674	0.0391
	A_{LB}	14	3.707	0.679	0.988	0.569	0.679	0.0377
	A_{FF}	8	5.340	0.473	0.944	0.728	0.473	0.0578
	A_{FB}	8	5.124	0.484	0.949	0.710	0.484	0.0557
Gas Carrier	Dsp	211	5.001	0.882	0.952	0.699	0.882	0.0727
	L_{OA}	488	8.045	0.309	0.994	0.906	0.309	0.0280
	L_{PP}	500	7.050	0.316	0.994	0.848	0.316	0.0295
	B	248	1.428	0.297	0.992	0.155	0.297	0.0303
	D	505	0.450	0.357	0.984	-0.347	0.357	0.0442
	d	500	0.584	0.287	0.927	-0.233	0.287	0.0574
	A_{LF}	12	5.074	0.613	0.969	0.705	0.613	0.0706
	A_{LB}	12	6.725	0.604	0.988	0.828	0.604	0.0420
	A_{FF}	12	2.649	0.553	0.980	0.423	0.553	0.0593
	A_{FB}	12	3.181	0.547	0.990	0.503	0.547	0.0468
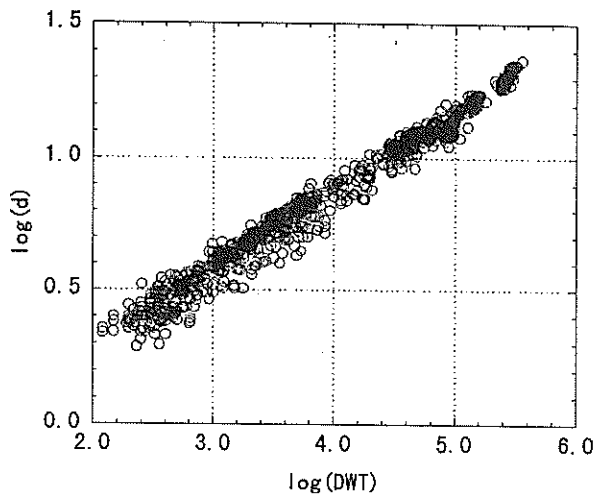
Fig. 4　log(DWT)-log(d) of Oil Tanker

5. CONFIDENCE LIMITS FOR ANALYSIS RESULTS

5.1 SERVICE ABILITY OF PORT FACILITIES

The result of regression analysis is the mean value of processing data. If the port facility is designed using this analysis result directly, the probability not to meet the function of the facility for Design Ship is 50%. (This probability decrease for ships smaller than Design Ship) There are three means to decrease this probability:

(1) enlarge the Design Ship
(2) enlarge the ship dimensions across the board, multiplying ship dimensions by the invariable number such as 1.2, 1.3
(3) enlarge the confidence limits of analysis result

The first doesn't make sense of Design Ship. To apply the second, invariable number (safety factor) would have to be decided reasonably. It is difficult, however, to find a theory which explains this invariable number. In this paper, the third, which sets the safety factor in considering the analysis result of each ship type and dimension is applied.

5.2 EVALUATION OF CONFIDENCE LIMITS

This sub section is about enlarging the confidence limits of analysis result. For example, L is in direct proportion to DWT on log scales as shown in Fig. 5,

but the real points are distributed around the straight line. The enlarged ship dimensions are calculated depending on supposed distribution around the straight line. Fig. 5 shows the 85% confidence limits for L.
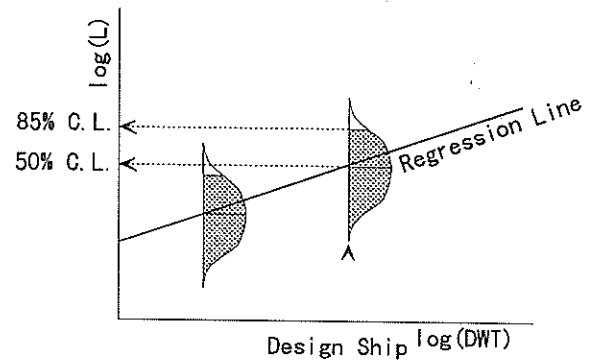
Fig. 5　Distribution around the Regression Analysis of DWT and L

Normal distribution is supposed in this paper. The enlarged ship dimensions are also straight line parallel with regression line. The line of P% confidence limits is translated the line of 50% confidence to σ multiplied by k as shown in Fig. 6. The σ is standard deviation of normal distribution and the k is coefficient of P% in Table 2.
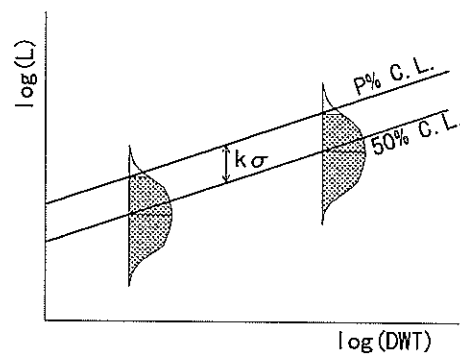
Fig. 6　Line of P% Confidence Limits

Table 2　Relation between Confidence Limits and k

P	50%	60%	75%	90%	95%	99%
k	0.000	0.253	0.674	1.282	1.645	2.326

Fig. 7 shows the 75% confidence limits and analysis result of d about Oil Tanker.
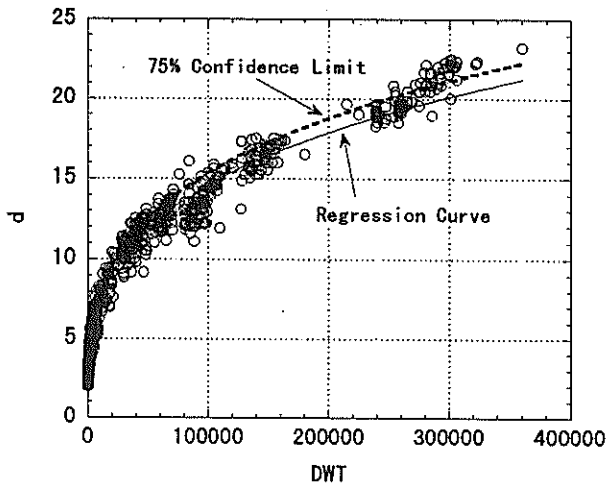
Fig. 7   75% Confidence Limits and Analysis Result
of d about Oil Tanker

Panamax type also exists for Oil Tanker. Analysis
results of these three ship types of B are modified.
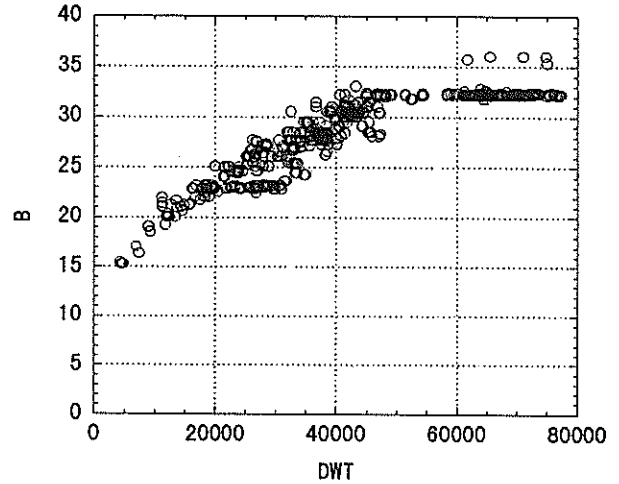
Fig. 8 DWT-B of Bulk Carrier

6. LIMIT OF SHIP DIMENSIONS

6. 1   LIMIT OF BREADTH BY THE PANAMA
CANAL

In the case of a ship passing through the lock of
canal, the ship dimensions are limited by the size of
the lock. Therefore, it must be decided at the design
of ship whether it will pass the lock or not. The most
noted canal of this type is the Panama Canal. Pedro
Miguel Lock is the smallest lock in this canal, and
ships passing through this lock are limited to the
following dimensions[10]:

- maximum length is 274.3m

    (289.5m for Container Ship and Passenger Ship)

- maximum breadth is 32.30m

- maximum draft is 11.28m

    (depending on season and the amount of rain)

Ships with dimensions exceeding the limits of
Pedro Miguel Lock can not pass through the Panama
Canal and are forced to go around Cape Horn
crossing the American continent. Fig. 8 and Fig. 9
show the relation between DWT and B of Bulk
Carrier and Container Ship. There is a mass around
32m of B in both figures. 32m is the maximum
breadth of the Panama Canal as stated previously
and ships of this types are called Panamax.
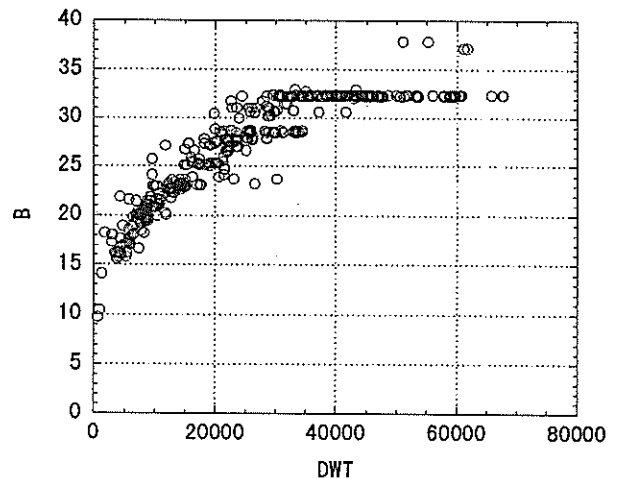
Fig. 9 DWT-B of Container Ship

There is also a mass around 23m of B in Fig. 8.
23m is limit for passing through the St. Lawrence
River, which located between United States and
Canada. This mass is smaller than that of the
Panama Canal because the St. Lawrence River is
more local than the Panama Canal. Therefore,
analysis result is not modified due to the limits of the
St. Lawrence River.

There are also limits to the ships that pass
through the Suez Canal and the Strait of Malacca.
Oil Tanker is divided into U.L.C.C., V.L.C.C and
Suezmax by those limits[11]. But, no masses appear

due to those limits.

6. 2 LIMIT OF MAXIMUM DRAFT OF PASSENGER SHIP AND GAS CARRIER

The relation between GT and d of Passenger Ship is shown in Fig. 10. There seems to be no problem about regression curve but the curve of 75% confidence limits overestimates d by more than 40,000 GT. This is why the real point is up to around 8.5m of d except the point (70,327GT, 9.945m) There are two reasons for this limitation.
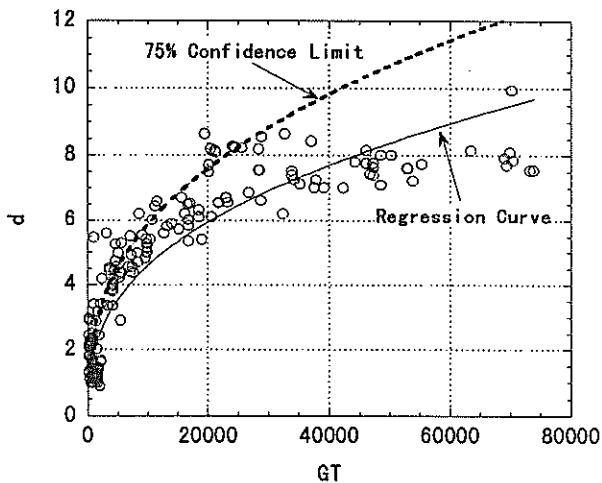
Fig. 10   GT-d of Passenger Ship

The first is that a Passenger Ship carries very light cargoes i.e. people. Generally speaking, in order to enlarge the capacity of carrying cargo, it is necessary to increase the maximum draft of ship because the weight of cargo also increases. But it is not necessary to increase the maximum draft of a Passenger Ship in order to increase the number of passengers. An increase in passengers is negligible in terms of weight and can be accommodated by enlarging the length and breadth of ship. Large Passenger Ship, called Cruise Ship, keeps her balance of weight above and under water around 20,000GT. Therefore, it is not necessary to enlarge maximum draft over 20,000GT of Passenger Ship.

The other reason is the water depth of a Passenger Ship berth. A Passenger Ship berth is used for a long time and it may be difficult to move to another place because it needs to be located near the center of city.

There are some berths where depth is not increased for a long time. Then the maximum draft of Passenger Ship is limited.

The only example of d exceeding 9.0m is the Queen Elizabeth 2, which was built 1969. Other ships in excess of 40,000GT were built from the later half of the 1980's onword. It can be said that Q.E.2 is an exception in large Passenger Ship.

To solve the problem of overestimating, usual analysis is done only for Passenger Ships less than 20,000GT, while a constant value is set for Passenger Ships greater than 20,000GT as shown Fig. 11.
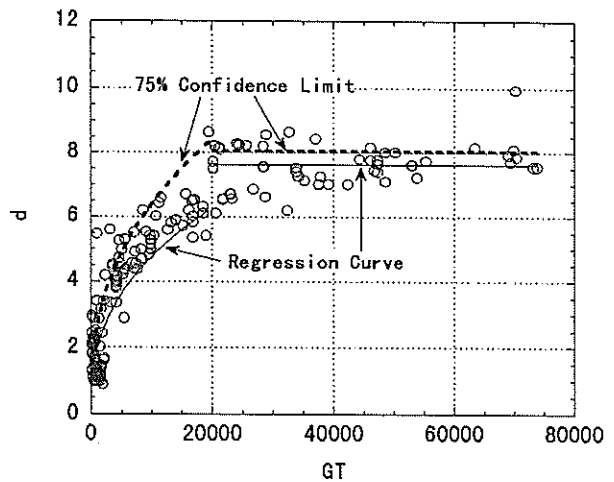
Fig. 11   GT-d of Ferry Analyzed by Another Way

Gas Carriers also carry very light cargo. It may not be necessary to enlarge maximum draft over 30,000GT.

6. 3 DEPTH OF FERRY

Care needs to be taken when using data on D of Ferry. D is defined as the height from keel to deck. Large Ferry has plural deck which means measuring D can be confusing as shown in Fig. 12. This relation can not be fitted by a regression curve adequately. But as there are not any other data on D of Ferry, regression analysis is done normally.
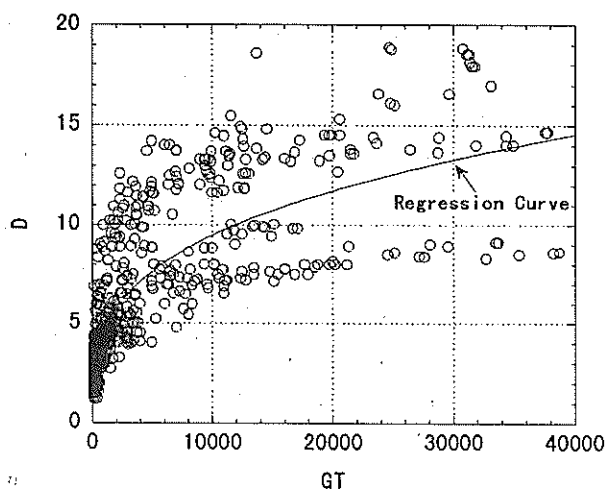
Fig. 12 GT-D of Ferry

7. SUMMARY

This paper presents the procedure to determine the ship dimensions of Design Ship. All results of this procedure are shown in Table 3, adopted confidence limits are 50%, 60%, 75%, 90%, and 95%.

The following conclusions are obtained from this paper;

(1) The ship dimensions, such as D_{SP}, L_{OA}, L_{PP}, B, D, d, A_{LF}, A_{LB}, A_{FF} and A_{FB} are regressed by DWT or GT accurately.

(2) The analysis results are expressed in proportion to confidence limits.

(3) When ship dimensions are restricted by lock of canal, port facility shall be considered apart from results of regression analysis.

This study has been performed at the request from working group 33 of PIANC (Permanent International Association of Congress) for fendering guidelines[6]. But study results can be used as guidelines for other port facilities as well.

The trend of ship dimensions change by time. They are greatly affected by the economic, social, etc. environment. There may be an innovation in handling cargo such as with the appearance of containers.

It is necessary to revise the ship dimensions of Design Ship at the time of revision of the guidelines, to cope with changes on ship dimensions etc.

ACKNOWLEDGEMENTS

REFERENCES

1) Takeo KATAYAMA, Kenichi FURUHATA, Koji MOTO, Yoshinobu HAYAFUJI: Study on the Interrelations among the Several Dimensions of Ships Technical Note of P.H.R.I., No.101, pp.1-130, 1970.6 (in Japanese)

2) Kiyoshi TERAUCHI, Yukihide YOSHIDA, Yasuhide OKUYAMA: Analysis on the Interrelations among the Several Dimensions of Ships Report of the P.H.R.I., Vol.17, No.4, pp.265-328, 1978.12 (in Japanese)

3) Kiyoshi TERAUCHI, Yukihide YOSHIDA: Analysis on the Interrelations among the Several Dimensions of Ships Technical Note of P.H.R.I., No.348, pp.1-115, 1980.6 (in Japanese)

4) Kunihiro AJIKI, Takashi NEGI, Toshiharu MURATA: Statistical Analysis on Staple Dimensions of Ship Technical Note of P.H.R.I., No.652, pp.1-43, 1989.6 (in Japanese)

5) Keiji HAMADA, Hideo MATSUMOTO, Yuich KURODA, Yoshinobu HAYAFUJI: Analysis on

External Forces Acting on Ships, Technical Note of P.H.R.I., No.714, pp.1-63, 1991.6 (in Japanese)

6) Yasuhiro AKAKURA, Hironao TAKAHASHI, Takashi NAKAMOTO: Statistical Analysis of Ship Dimensions for Standard Size of Design Ship (in Japanese), Technical Note of P.H.R.I., 1998.6 (now printing, in Japanese)

7) Ports and Harbours Bureau and Port and Harbour Research Institute: Technical Standards for Port and Harbour Facilities in Japan 1991

8) Joint Working Group PIANC and IAPH, in cooperation with IMPA and IALA: Approach Channels A Guide for Design, June 1997

9) Takeshi OGAWA: Tramper and Specialized Carrier, Seizando-Shoten, September 1997 (in Japanese)

10) Ports of the world 1995, Lloyd's of London Press

11) Muneo IKEDA, Yasushi SAKAI: The ABC of Shipping Seizando-Shoten, July 1991 (in Japanese)

Table 3 Ship Dimensions

・Confidence Limit : 50%

Type	Dead Weight Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Ballast Condition	Wind Front Area (m²) Full Load Condition	Ballast Condition
General Cargo Ship	1,000	1,580	63	58	10.3	5.2	3.6	227	292	59	88
	2,000	3,040	78	72	12.4	6.4	4.5	348	463	94	134
	3,000	4,460	88	82	13.9	7.2	5.1	447	605	123	172
	5,000	7,210	104	96	16.0	8.4	6.1	612	849	173	236
	7,000	9,900	115	107	17.6	9.3	6.8	754	1,060	216	290
	10,000	13,900	128	120	19.5	10.3	7.6	940	1,340	274	361
	15,000	20,300	146	136	21.8	11.7	8.7	1,210	1,760	359	463
	20,000	26,600	159	149	23.6	12.7	9.6	1,440	2,130	435	552
	30,000	39,000	181	170	26.4	14.4	10.9	1,850	2,780	569	709
	40,000	51,100	197	186	28.6	15.7	12.0	2,210	3,370	690	846
Bulk Carrier*	5,000	6,740	106	98	15.0	8.4	6.1	615	850	205	231
	7,000	9,270	116	108	16.6	9.3	6.7	710	1,010	232	271
	10,000	13,000	129	120	18.5	10.4	7.5	830	1,230	264	320
	15,000	19,100	145	135	21.0	11.7	8.4	980	1,520	307	387
	20,000	25,000	157	148	23.0	12.8	9.2	1,110	1,770	341	443
	30,000	36,700	176	167	26.1	14.4	10.3	1,320	2,190	397	536
	50,000	59,600	204	194	32.3	16.8	12.0	1,640	2,870	479	682
	70,000	81,900	224	215	32.3	18.6	13.3	1,890	3,440	542	798
	100,000	115,000	248	239	37.9	20.7	14.8	2,200	4,150	619	940
	150,000	168,000	279	270	43.0	23.3	16.7	2,610	5,140	719	1,140
	200,000	221,000	303	294	47.0	25.4	18.2	2,950	5,990	800	1,310
	250,000	273,000	322	314	50.4	27.2	19.4	3,240	6,740	868	1,450
Container Ship**	7,000	10,200	116	108	19.6	9.3	6.9	1,320	1,360	300	396
	10,000	14,300	134	125	21.6	10.7	7.7	1,690	1,700	373	477
	15,000	21,100	157	147	24.1	12.6	8.7	2,250	2,190	478	591
	20,000	27,800	176	165	26.1	14.1	9.5	2,750	2,620	569	687
	25,000	34,300	192	180	27.7	15.4	10.2	3,220	3,010	652	770
	30,000	40,800	206	194	29.1	16.5	10.7	3,660	3,370	729	850
	40,000	53,700	231	218	32.3	18.5	11.7	4,480	4,040	870	990
	50,000	66,500	252	238	32.3	20.2	12.5	5,230	4,640	990	1,110
	60,000	79,100	271	256	35.2	21.7	13.2	5,950	5,200	1,110	1,220
Oil Tanker	1,000	1,450	59	54	9.7	4.3	3.8	170	266	78	80
	2,000	2,810	73	68	12.1	5.4	4.7	251	401	108	117
	3,000	4,140	83	77	13.7	6.3	5.3	315	509	131	146
	5,000	6,740	97	91	16.0	7.5	6.1	419	689	167	194
	7,000	9,300	108	102	17.8	8.4	6.7	505	841	196	233
	10,000	13,100	121	114	19.9	9.5	7.5	617	1,040	232	284
	15,000	19,200	138	130	22.5	11.0	8.4	770	1,320	281	355
	20,000	25,300	151	143	24.6	12.2	9.1	910	1,560	322	416
	30,000	37,300	171	163	27.9	14.0	10.3	1,140	1,990	390	520
	50,000	60,800	201	192	32.3	16.8	11.9	1,510	2,690	497	689
	70,000	83,900	224	214	36.3	18.9	13.2	1,830	3,280	583	829
	100,000	118,000	250	240	40.6	21.4	14.6	2,230	4,050	690	1,010
	150,000	174,000	284	273	46.0	24.7	16.4	2,800	5,150	840	1,260
	200,000	229,000	311	300	50.3	27.3	17.9	3,290	6,110	960	1,480
	300,000	337,000	354	342	57.0	31.5	20.1	4,120	7,770	1,160	1,850

*) Full load wind lateral / front areas of log carrier don't include the areas of logs on deck

**) Full load wind lateral / front areas of container ships include the areas of containers on deck

Type	Dead Weight Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Wind Lateral Area (m²) Ballast Condition	Wind Front Area (m²) Full Load Condition	Wind Front Area (m²) Ballast Condition
Ro/Ro	1,000	1,970	66	60	13.2	5.2	3.2	700	810	216	217
Ship	2,000	3,730	85	78	15.6	7.0	4.1	970	1,110	292	301
	3,000	5,430	99	90	17.2	8.4	4.8	1,170	1,340	348	364
	5,000	8,710	119	109	19.5	10.5	5.8	1,480	1,690	435	464
	7,000	11,900	135	123	21.2	12.1	6.6	1,730	1,970	503	544
	10,000	16,500	153	141	23.1	14.2	7.5	2,040	2,320	587	643
	15,000	24,000	178	163	25.6	16.9	8.7	2,460	2,790	701	779
	20,000	31,300	198	182	27.4	19.2	9.7	2,810	3,180	794	890
	30,000	45,600	229	211	30.3	23.0	11.3	3,400	3,820	950	1,080

Type	Gross Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Wind Lateral Area (m²) Ballast Condition	Wind Front Area (m²) Full Load Condition	Wind Front Area (m²) Ballast Condition
Passenger	1,000	850	60	54	11.4	4.1	1.9	426	452	167	175
Ship	2,000	1,580	76	68	13.6	5.3	2.5	683	717	225	234
	3,000	2,270	87	78	15.1	6.2	3.0	900	940	267	277
	5,000	3,580	104	92	17.1	7.5	3.6	1,270	1,320	332	344
	7,000	4,830	117	103	18.6	8.6	4.1	1,600	1,650	383	396
	10,000	6,640	133	116	20.4	9.8	4.8	2,040	2,090	446	459
	15,000	9,530	153	132	22.5	11.5	5.6	2,690	2,740	530	545
	20,000	12,300	169	146	24.2	12.8	7.6	3,270	3,320	599	614
	30,000	17,700	194	166	26.8	14.9	7.6	4,310	4,350	712	728
	50,000	27,900	231	197	30.5	18.2	7.6	6,090	6,120	880	900
	70,000	37,600	260	220	33.1	20.7	7.6	7,660	7,660	1,020	1,040
Ferry	1,000	810	59	54	12.7	4.6	2.7	387	404	141	145
	2,000	1,600	76	69	15.1	5.8	3.3	617	646	196	203
	3,000	2,390	88	80	16.7	6.5	3.7	811	851	237	247
	5,000	3,940	106	97	19.0	7.6	4.3	1,150	1,200	302	316
	7,000	5,480	119	110	20.6	8.5	4.8	1,440	1,510	354	372
	10,000	7,770	135	125	22.6	9.5	5.3	1,830	1,930	419	442
	15,000	11,600	157	145	25.0	10.7	6.0	2,400	2,540	508	537
	20,000	15,300	174	162	26.8	11.7	6.5	2,920	3,090	582	618
	30,000	22,800	201	188	29.7	13.3	7.4	3,830	4,070	705	752
	40,000	30,300	223	209	31.9	14.5	8.0	4,660	4,940	810	860
Gas	1,000	2,210	68	63	11.1	5.3	4.3	350	436	121	139
Carrier	2,000	4,080	84	78	13.7	6.8	5.2	535	662	177	203
	3,000	5,830	95	89	15.4	7.8	5.8	686	846	222	254
	5,000	9,100	112	104	17.9	9.4	6.7	940	1,150	295	335
	7,000	12,300	124	116	19.8	10.6	7.4	1,150	1,410	355	403
	10,000	16,900	138	130	22.0	12.0	8.2	1,430	1,750	432	490
	15,000	24,100	157	147	24.8	13.9	9.3	1,840	2,240	541	612
	20,000	31,100	171	161	27.1	15.4	10.0	2,190	2,660	634	716
	30,000	44,400	194	183	30.5	17.8	11.7	2,810	3,400	794	894
	50,000	69,700	227	216	35.5	21.3	11.7	3,850	4,630	1,050	1,180
	70,000	94,000	252	240	39.3	24.0	11.7	4,730	5,670	1,270	1,420
	100,000	128,000	282	268	43.7	27.3	11.7	5,880	7,030	1,550	1,730

• Confidence Limit : 60%

Type	Dead Weight Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²)		Wind Front Area (m²)	
								Full Load Condition	Ballast Condition	Full Load Condition	Ballast Condition
General Cargo Ship	1,000	1,620	65	59	10.5	5.4	3.7	245	310	61	90
	2,000	3,120	80	74	12.7	6.7	4.7	376	491	96	137
	3,000	4,570	91	84	14.2	7.5	5.3	482	642	126	176
	5,000	7,390	106	99	16.4	8.8	6.3	661	900	177	241
	7,000	10,100	118	110	18.0	9.7	7.0	813	1,130	222	296
	10,000	14,200	132	123	19.8	10.8	7.9	1,010	1,420	281	369
	15,000	20,800	149	140	22.2	12.2	9.0	1,300	1,860	368	473
	20,000	27,300	163	154	24.1	13.3	9.9	1,550	2,260	446	564
	30,000	39,900	185	175	26.9	15.0	11.3	1,990	2,950	585	724
	40,000	52,400	202	191	29.2	16.4	12.4	2,380	3,570	708	864
Bulk Carrier*	5,000	6,810	107	99	15.2	8.5	6.1	642	870	211	237
	7,000	9,360	117	109	16.8	9.4	6.8	741	1,040	238	277
	10,000	13,100	130	121	18.8	10.5	7.5	860	1,260	272	327
	15,000	19,300	146	137	21.3	11.8	8.5	1,020	1,560	316	396
	20,000	25,300	159	149	23.3	12.9	9.3	1,160	1,820	351	453
	30,000	37,100	178	169	26.4	14.5	10.4	1,370	2,250	408	548
	50,000	60,100	206	196	32.3	16.9	12.2	1,710	2,950	493	697
	70,000	82,700	227	217	32.3	18.7	13.4	1,970	3,530	558	816
	100,000	116,000	251	242	38.4	20.8	14.9	2,290	4,260	637	960
	150,000	170,000	282	273	43.6	23.5	16.8	2,720	5,280	740	1,170
	200,000	223,000	306	297	47.6	25.6	18.3	3,080	6,150	823	1,340
	250,000	276,000	326	318	51.0	27.4	19.6	3,380	6,920	894	1,480
Container Ship**	7,000	10,400	119	110	19.9	9.5	7.0	1,370	1,440	311	413
	10,000	14,600	137	127	21.9	10.9	7.8	1,760	1,800	387	498
	15,000	21,500	160	150	24.5	12.8	8.8	2,340	2,320	495	617
	20,000	28,300	179	168	26.4	14.4	9.6	2,860	2,780	589	718
	25,000	35,000	196	184	28.1	15.7	10.3	3,350	3,190	675	810
	30,000	41,600	211	198	29.5	16.9	10.9	3,800	3,580	755	890
	40,000	54,800	236	222	32.3	18.9	11.9	4,650	4,280	900	1,033
	50,000	67,800	258	243	32.3	20.7	12.7	5,440	4,920	1,030	1,160
	60,000	80,600	277	262	35.7	22.2	13.4	6,190	5,520	1,150	1,280
Oil Tanker	1,000	1,500	60	56	9.9	4.3	3.9	178	271	81	82
	2,000	2,900	74	69	12.3	5.5	4.8	262	409	112	120
	3,000	4,280	84	79	13.9	6.4	5.4	328	519	136	150
	5,000	6,970	99	93	16.3	7.6	6.2	436	703	173	199
	7,000	9,600	110	104	18.1	8.6	6.9	527	857	203	239
	10,000	13,500	123	117	20.2	9.7	7.6	643	1,060	240	291
	15,000	19,900	140	133	22.9	11.2	8.6	810	1,350	291	364
	20,000	26,200	153	146	25.0	12.4	9.3	950	1,600	334	426
	30,000	38,600	174	166	28.4	14.3	10.5	1,190	2,030	405	533
	50,000	62,900	205	196	32.3	17.1	12.2	1,580	2,740	515	706
	70,000	86,700	228	219	36.9	19.2	13.4	1,910	3,350	604	849
	100,000	122,000	255	245	41.3	21.8	14.9	2,330	4,130	716	1,030
	150,000	180,000	290	280	46.8	25.1	16.8	2,920	5,250	870	1,290
	200,000	236,000	317	307	51.2	27.8	18.2	3,420	6,230	990	1,510
	300,000	348,000	360	350	58.0	32.1	20.5	4,290	7,920	1,200	1,890

*) Full load wind lateral / front areas of log carrier don't include the areas of logs on deck

**) Full load wind lateral / front areas of container ships include the areas of containers on deck

Type	Dead Weight Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Ballast Condition	Wind Front Area (m²) Full Load Condition	Ballast Condition
Ro/Ro Ship	1,000	2,050	68	62	13.5	5.5	3.3	760	870	222	222
	2,000	3,880	88	80	15.9	7.5	4.3	1,050	1,190	300	309
	3,000	5,650	102	93	17.6	8.9	5.0	1,270	1,430	358	374
	5,000	9,060	123	113	20.0	11.2	6.0	1,610	1,800	447	476
	7,000	12,400	140	128	21.7	13.0	6.8	1,880	2,100	517	558
	10,000	17,200	159	146	23.7	15.2	7.8	2,220	2,470	604	661
	15,000	25,000	185	170	26.1	18.1	9.0	2,680	2,980	720	800
	20,000	32,600	205	189	28.1	20.6	10.0	3,060	3,390	816	920
	30,000	47,400	238	219	31.0	24.6	11.7	3,700	4,080	970	1,110

Type	Gross Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Ballast Condition	Wind Front Area (m²) Full Load Condition	Ballast Condition
Passenger Ship	1,000	920	61	56	11.7	4.4	2.1	440	464	174	183
	2,000	1,700	78	71	13.9	5.7	2.8	705	736	234	244
	3,000	2,440	90	81	15.4	6.6	3.3	930	960	278	290
	5,000	3,840	107	96	17.5	8.1	4.0	1,310	1,360	346	359
	7,000	5,190	120	107	19.0	9.2	4.6	1,650	1,700	399	413
	10,000	7,130	136	120	20.8	10.5	5.3	2,110	2,150	465	480
	15,000	10,200	156	137	23.0	12.3	6.2	2,780	2,820	552	569
	20,000	13,200	173	151	24.8	13.7	7.8	3,370	3,410	624	642
	30,000	19,000	199	173	27.4	16.0	7.8	4,450	4,470	742	760
	50,000	29,900	237	204	31.2	19.4	7.8	6,290	6,290	920	940
	70,000	40,300	267	228	33.9	22.1	7.8	7,910	7,870	1,060	1,080
Ferry	1,000	950	62	56	13.3	4.9	3.0	396	413	146	150
	2,000	1,880	79	72	15.8	6.1	3.6	632	661	202	209
	3,000	2,790	92	84	17.5	6.9	4.1	830	870	245	255
	5,000	4,610	110	102	19.8	8.1	4.8	1,170	1,230	312	326
	7,000	6,410	125	115	21.6	9.0	5.3	1,470	1,550	366	384
	10,000	9,090	142	131	23.6	10.1	5.8	1,870	1,970	433	456
	15,000	13,500	164	152	26.1	11.4	6.6	2,460	2,600	525	555
	20,000	17,900	182	169	28.0	12.5	7.2	2,980	3,160	602	638
	30,000	26,700	211	197	31.0	14.1	8.1	3,920	4,160	729	776
	40,000	35,400	234	219	33.3	15.4	8.8	4,760	5,050	840	890
Gas Carrier	1,000	2,310	69	64	11.3	5.4	4.4	365	447	125	143
	2,000	4,250	86	79	13.9	6.9	5.4	557	679	184	209
	3,000	6,080	97	90	15.7	8.0	6.0	715	867	230	261
	5,000	9,500	113	106	18.2	9.6	7.0	980	1,180	305	345
	7,000	12,800	126	118	20.2	10.9	7.7	1,200	1,450	367	414
	10,000	17,600	141	132	22.4	12.3	8.5	1,490	1,790	448	504
	15,000	25,200	159	150	25.3	14.2	9.6	1,920	2,290	560	629
	20,000	32,400	174	164	27.5	15.8	10.4	2,290	2,730	657	736
	30,000	46,300	197	187	31.1	18.2	11.9	2,930	3,480	822	919
	50,000	72,700	231	219	36.2	21.9	11.9	4,010	4,740	1,090	1,210
	70,000	98,000	256	244	40.0	24.7	11.9	4,930	5,810	1,310	1,460
	100,000	134,000	286	273	44.4	28.0	11.9	6,130	7,210	1,600	1,770

• Confidence Limit : 75%

Type	Dead Weight Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Wind Lateral Area (m²) Ballast Condition	Wind Front Area (m²) Full Load Condition	Wind Front Area (m²) Ballast Condition
General Cargo Ship	1,000	1,690	67	62	10.8	5.8	3.9	278	342	63	93
	2,000	3,250	83	77	13.1	7.2	4.9	426	541	101	142
	3,000	4,750	95	88	14.7	8.1	5.6	547	708	132	182
	5,000	7,690	111	104	16.9	9.4	6.6	750	993	185	249
	7,000	10,600	123	115	18.6	10.4	7.4	922	1,240	232	307
	10,000	14,800	137	129	20.5	11.6	8.3	1,150	1,570	294	382
	15,000	21,600	156	147	23.0	13.1	9.5	1,480	2,060	385	490
	20,000	28,400	170	161	24.9	14.3	10.4	1,760	2,490	466	585
	30,000	41,600	193	183	27.8	16.2	11.9	2,260	3,250	611	750
	40,000	54,500	211	200	30.2	17.6	13.0	2,700	3,940	740	895
Bulk Carrier*	5,000	6,920	109	101	15.5	8.6	6.2	689	910	221	245
	7,000	9,520	120	111	17.2	9.5	6.9	795	1,090	250	287
	10,000	13,300	132	124	19.2	10.6	7.7	930	1,320	286	340
	15,000	19,600	149	140	21.8	11.9	8.6	1,100	1,630	332	411
	20,000	25,700	161	152	23.8	13.0	9.4	1,240	1,900	369	470
	30,000	37,700	181	172	27.0	14.7	10.6	1,480	2,360	428	569
	50,000	61,100	209	200	32.3	17.1	12.4	1,830	3,090	518	723
	70,000	84,000	231	221	32.3	18.9	13.7	2,110	3,690	586	846
	100,000	118,000	255	246	39.2	21.1	15.2	2,460	4,460	669	1,000
	150,000	173,000	287	278	44.5	23.8	17.1	2,920	5,520	777	1,210
	200,000	227,000	311	303	48.7	25.9	18.6	3,300	6,430	864	1,380
	250,000	280,000	332	324	52.2	27.7	19.9	3,630	7,240	938	1,540
Container Ship**	7,000	10,700	123	115	20.3	9.8	7.2	1,460	1,590	330	444
	10,000	15,100	141	132	22.4	11.3	8.0	1,880	1,990	410	535
	15,000	22,200	166	156	25.0	13.3	9.0	2,490	2,560	524	663
	20,000	29,200	186	175	27.1	14.9	9.9	3,050	3,070	625	771
	25,000	36,100	203	191	28.8	16.3	10.6	3,570	3,520	716	870
	30,000	43,000	218	205	30.2	17.5	11.1	4,060	3,950	800	950
	40,000	56,500	244	231	32.3	19.6	12.2	4,970	4,730	950	1,110
	50,000	69,900	266	252	32.3	21.4	13.0	5,810	5,430	1,090	1,250
	60,000	83,200	286	271	36.5	23.0	13.8	6,610	6,090	1,220	1,370
Oil Tanker	1,000	1,580	61	58	10.2	4.5	4.0	190	280	86	85
	2,000	3,070	76	72	12.6	5.7	4.9	280	422	119	125
	3,000	4,520	87	82	14.3	6.6	5.5	351	536	144	156
	5,000	7,360	102	97	16.8	7.9	6.4	467	726	184	207
	7,000	10,200	114	108	18.6	8.9	7.1	564	885	216	249
	10,000	14,300	127	121	20.8	10.0	7.9	688	1,090	255	303
	15,000	21,000	144	138	23.6	11.6	8.9	860	1,390	309	378
	20,000	27,700	158	151	25.8	12.8	9.6	1,010	1,650	355	443
	30,000	40,800	180	173	29.2	14.8	10.9	1,270	2,090	430	554
	50,000	66,400	211	204	32.3	17.6	12.6	1,690	2,830	548	734
	70,000	91,600	235	227	38.0	19.9	13.9	2,040	3,460	642	884
	100,000	129,000	263	254	42.5	22.5	15.4	2,490	4,270	761	1,080
	150,000	190,000	298	290	48.1	25.9	17.4	3,120	5,430	920	1,340
	200,000	250,000	327	318	52.6	28.7	18.9	3,670	6,430	1,060	1,570
	300,000	368,000	371	363	59.7	33.1	21.2	4,600	8,180	1,280	1,970

*) Full load wind lateral / front areas of log carrier don't include the areas of logs on deck

**) Full load wind lateral / front areas of container ships include the areas of containers on deck

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Type	Dead Weight Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Wind Lateral Area (m²) Ballast Condition	Wind Front Area (m²) Full Load Condition	Wind Front Area (m²) Ballast Condition
Ro/Ro Ship	1,000	2,190	73	66	14.0	6.2	3.5	880	970	232	232
	2,000	4,150	94	86	16.6	8.4	4.5	1,210	1,320	314	323
	3,000	6,030	109	99	18.3	10.0	5.3	1,460	1,590	374	391
	5,000	9,670	131	120	20.7	12.5	6.4	1,850	2,010	467	497
	7,000	13,200	148	136	22.5	14.5	7.2	2,170	2,350	541	583
	10,000	18,300	169	155	24.6	17.0	8.2	2,560	2,760	632	690
	15,000	26,700	196	180	27.2	20.3	9.6	3,090	3,320	754	836
	20,000	34,800	218	201	29.1	23.1	10.7	3,530	3,780	854	960
	30,000	50,600	252	233	32.2	27.6	12.4	4,260	4,550	1,020	1,160

Type	Gross Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Wind Lateral Area (m²) Ballast Condition	Wind Front Area (m²) Full Load Condition	Wind Front Area (m²) Ballast Condition
Passenger Ship	1,000	1,030	64	60	12.1	4.9	2.6	464	486	187	197
	2,000	1,910	81	75	14.4	6.3	3.4	744	770	251	263
	3,000	2,740	93	86	16.0	7.4	4.0	980	1,010	298	311
	5,000	4,320	112	102	18.2	9.0	4.8	1,390	1,420	371	386
	7,000	5,830	125	114	19.8	10.2	5.5	1,740	1,780	428	444
	10,000	8,010	142	128	21.6	11.7	6.4	2,220	2,250	498	516
	15,000	11,500	163	146	23.9	13.7	7.5	2,930	2,950	592	611
	20,000	14,900	180	160	25.7	15.3	8.0	3,560	3,570	669	690
	30,000	21,300	207	183	28.4	17.8	8.0	4,690	4,680	795	818
	50,000	33,600	248	217	32.3	21.7	8.0	6,640	6,580	990	1,010
	70,000	45,300	278	243	35.2	24.6	8.0	8,350	8,230	1,140	1,170
Ferry	1,000	1,230	67	61	14.3	5.5	3.4	411	428	154	158
	2,000	2,430	86	78	17.0	6.8	4.2	656	685	214	221
	3,000	3,620	99	91	18.8	7.7	4.8	862	903	259	269
	5,000	5,970	119	110	21.4	9.0	5.5	1,220	1,280	330	344
	7,000	8,310	134	124	23.2	10.0	6.1	1,530	1,600	387	405
	10,000	11,800	153	142	25.4	11.1	6.8	1,940	2,040	458	482
	15,000	17,500	177	164	28.1	12.6	7.6	2,550	2,690	555	586
	20,000	23,300	196	183	30.2	13.8	8.3	3,100	3,270	636	673
	30,000	34,600	227	212	33.4	15.6	9.4	4,070	4,310	771	819
	40,000	45,900	252	236	35.9	17.1	10.2	4,950	5,240	880	940
Gas Carrier	1,000	2,480	71	66	11.7	5.7	4.6	390	465	133	150
	2,000	4,560	88	82	14.3	7.2	5.7	597	707	195	219
	3,000	6,530	100	93	16.1	8.4	6.4	765	903	244	273
	5,000	10,200	117	109	18.8	10.0	7.4	1,050	1,230	323	361
	7,000	13,800	129	121	20.8	11.3	8.1	1,290	1,510	389	434
	10,000	18,900	144	136	23.1	12.9	9.0	1,600	1,870	474	527
	15,000	27,000	164	154	26.0	14.9	10.1	2,050	2,390	593	658
	20,000	34,800	179	169	28.4	16.5	11.0	2,450	2,840	696	770
	30,000	49,700	203	192	32.0	19.0	12.3	3,140	3,630	870	961
	50,000	78,000	237	226	37.2	22.8	12.3	4,290	4,940	1,150	1,270
	70,000	105,000	263	251	41.2	25.7	12.3	5,270	6,050	1,390	1,530
	100,000	144,000	294	281	45.8	29.2	12.3	6,560	7,510	1,690	1,860

• Confidence Limit : 90%

Type	Dead Weight Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Wind Lateral Area (m²) Ballast Condition	Wind Front Area (m²) Full Load Condition	Wind Front Area (m²) Ballast Condition
General Cargo Ship	1,000	1,790	72	66	11.4	6.5	4.2	333	394	67	98
	2,000	3,440	89	83	13.8	8.0	5.3	511	623	107	149
	3,000	5,040	101	94	15.4	9.0	6.0	656	815	140	192
	5,000	8,150	118	111	17.8	10.5	7.1	899	1,143	197	262
	7,000	11,200	131	123	19.5	11.6	8.0	1,106	1,430	247	323
	10,000	15,700	146	138	21.5	12.9	8.9	1,380	1,810	313	402
	15,000	22,900	166	157	24.1	14.6	10.2	1,770	2,370	410	516
	20,000	30,100	181	172	26.1	15.9	11.2	2,110	2,860	496	615
	30,000	44,000	205	195	29.2	18.0	12.8	2,710	3,740	650	789
	40,000	57,700	224	214	31.6	19.6	14.0	3,240	4,530	788	942
Bulk Carrier*	5,000	7,090	111	103	16.0	8.7	6.4	763	970	237	259
	7,000	9,740	123	114	17.7	9.7	7.1	880	1,160	268	303
	10,000	13,700	136	127	19.8	10.8	7.9	1,020	1,400	306	358
	15,000	20,000	152	143	22.5	12.1	8.9	1,220	1,740	356	433
	20,000	26,300	165	156	24.6	13.2	9.6	1,370	2,030	395	495
	30,000	38,600	186	176	27.9	14.9	10.9	1,630	2,510	459	599
	50,000	62,600	215	206	32.3	17.4	12.7	2,030	3,290	555	761
	70,000	86,000	236	227	32.3	19.3	14.0	2,340	3,930	628	892
	100,000	121,000	262	253	40.5	21.4	15.5	2,720	4,750	717	1,050
	150,000	177,000	294	286	45.9	24.2	17.5	3,240	5,890	833	1,280
	200,000	232,000	319	311	50.2	26.4	19.1	3,660	6,860	926	1,460
	250,000	287,000	340	333	53.8	28.2	20.4	4,020	7,720	1,006	1,620
Container Ship**	7,000	11,200	129	121	21.1	10.3	7.4	1,600	1,830	358	492
	10,000	15,800	148	139	23.2	11.9	8.3	2,060	2,290	445	594
	15,000	23,200	174	164	25.9	14.0	9.3	2,740	2,950	570	735
	20,000	30,500	195	184	28.0	15.7	10.2	3,360	3,530	679	855
	25,000	37,800	213	201	29.8	17.1	10.9	3,930	4,060	778	960
	30,000	45,000	229	216	31.3	18.4	11.5	4,460	4,550	869	1,060
	40,000	59,100	256	243	32.3	20.6	12.6	5,460	5,450	1,040	1,232
	50,000	73,200	280	266	32.3	22.5	13.5	6,390	6,260	1,190	1,380
	60,000	87,100	301	286	37.8	24.2	14.2	7,260	7,020	1,330	1,520
Oil Tanker	1,000	1,710	64	61	10.6	4.7	4.2	210	293	94	90
	2,000	3,320	80	76	13.1	6.0	5.2	309	442	130	132
	3,000	4,890	91	87	14.9	6.9	5.8	388	562	158	165
	5,000	7,970	107	102	17.5	8.2	6.8	516	760	201	219
	7,000	11,000	119	114	19.4	9.3	7.5	623	928	235	263
	10,000	15,500	133	128	21.6	10.5	8.3	760	1,150	279	320
	15,000	22,800	151	146	24.5	12.1	9.3	950	1,460	338	401
	20,000	30,000	165	160	26.8	13.4	10.1	1,120	1,730	387	469
	30,000	44,200	188	182	30.4	15.4	11.4	1,400	2,190	469	587
	50,000	72,000	220	215	32.3	18.5	13.2	1,870	2,970	598	777
	70,000	99,200	245	239	39.6	20.8	14.6	2,250	3,620	701	935
	100,000	140,000	274	268	44.2	23.5	16.2	2,750	4,470	830	1,140
	150,000	206,000	312	306	50.2	27.1	18.2	3,450	5,690	1,010	1,420
	200,000	271,000	341	336	54.8	30.0	19.8	4,050	6,740	1,150	1,670
	300,000	399,000	388	382	62.2	34.6	22.3	5,080	8,570	1,400	2,080

*) Full load wind lateral / front areas of log carrier don't include the areas of logs on deck

**) Full load wind lateral / front areas of container ships include the areas of containers on deck

Type	Dead Weight Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Ballast Condition	Wind Front Area (m²) Full Load Condition	Ballast Condition
Ro/Ro Ship	1,000	2,400	79	72	14.8	7.3	3.8	1,080	1,130	248	248
	2,000	4,560	102	94	17.5	9.9	4.9	1,480	1,550	335	344
	3,000	6,630	118	109	19.3	11.8	5.8	1,790	1,860	400	416
	5,000	10,620	143	131	21.9	14.8	7.0	2,270	2,350	499	530
	7,000	14,500	161	149	23.8	17.1	7.9	2,650	2,740	578	621
	10,000	20,200	184	170	26.0	20.0	9.0	3,130	3,230	675	736
	15,000	29,300	213	197	28.7	23.9	10.5	3,780	3,880	805	891
	20,000	38,200	237	219	30.8	27.2	11.6	4,320	4,430	912	1,020
	30,000	55,600	275	255	34.0	32.5	13.5	5,210	5,330	1,090	1,240

Type	Gross Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Ballast Condition	Wind Front Area (m²) Full Load Condition	Ballast Condition
Passenger Ship	1,000	1,220	68	65	12.8	5.7	3.3	502	518	207	218
	2,000	2,260	86	82	15.2	7.4	4.4	804	822	278	292
	3,000	3,240	99	94	16.9	8.7	5.1	1,060	1,080	330	346
	5,000	5,110	119	111	19.2	10.5	6.3	1,500	1,510	410	428
	7,000	6,900	133	124	20.8	12.0	7.2	1,880	1,890	473	493
	10,000	9,480	151	139	22.8	13.7	8.2	2,400	2,400	551	573
	15,000	13,600	173	159	25.2	16.0	8.4	3,160	3,150	654	679
	20,000	17,600	192	175	27.1	17.9	8.4	3,850	3,810	740	766
	30,000	25,200	220	200	30.0	20.9	8.4	5,070	4,990	879	907
	50,000	39,700	263	237	34.1	25.4	8.4	7,170	7,020	1,090	1,120
	70,000	53,600	296	265	37.1	28.9	8.4	9,020	8,780	1,260	1,290
Ferry	1,000	1,790	74	68	15.9	6.3	4.3	434	451	167	171
	2,000	3,540	95	87	18.9	7.8	5.3	693	722	232	239
	3,000	5,260	110	101	20.9	8.8	5.9	911	951	281	291
	5,000	8,690	133	122	23.8	10.4	6.9	1,290	1,350	358	372
	7,000	12,100	150	139	25.9	11.5	7.6	1,610	1,690	420	438
	10,000	17,100	170	158	28.3	12.8	8.4	2,050	2,150	497	521
	15,000	25,500	197	184	31.3	14.5	9.5	2,700	2,840	602	633
	20,000	33,800	219	204	33.6	15.9	10.3	3,270	3,450	690	728
	30,000	50,300	253	237	37.2	18.0	11.7	4,300	4,540	836	886
	40,000	66,800	281	264	39.9	19.7	12.7	5,230	5,520	960	1,020
Gas Carrier	1,000	2,740	74	68	12.2	6.0	5.0	431	493	144	160
	2,000	5,050	91	85	14.9	7.7	6.1	659	750	211	233
	3,000	7,230	104	97	16.8	8.9	6.9	845	958	265	291
	5,000	11,300	121	114	19.6	10.7	8.0	1,160	1,300	351	385
	7,000	15,300	135	126	21.7	12.0	8.8	1,420	1,600	423	463
	10,000	20,900	150	141	24.1	13.7	9.8	1,770	1,980	515	563
	15,000	29,900	170	161	27.2	15.8	11.0	2,260	2,530	645	702
	20,000	38,500	186	176	29.6	17.5	11.9	2,700	3,010	756	822
	30,000	55,100	211	200	33.4	20.2	12.8	3,460	3,850	946	1,026
	50,000	86,400	247	235	38.9	24.3	12.8	4,740	5,240	1,250	1,360
	70,000	116,000	274	262	42.9	27.4	12.8	5,820	6,420	1,510	1,630
	100,000	159,000	306	293	47.7	31.1	12.8	7,240	7,960	1,840	1,980

Type	Dead Weight Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²)		Wind Front Area (m²)	
								Full Load Condition	Ballast Condition	Full Load Condition	Ballast Condition
General Cargo Ship	1,000	1,850	74	69	11.7	6.9	4.4	372	428	70	101
	2,000	3,560	92	86	14.2	8.5	5.5	570	678	111	154
	3,000	5,210	104	98	15.9	9.6	6.3	732	887	146	198
	5,000	8,440	122	115	18.3	11.2	7.5	1,000	1,240	205	271
	7,000	11,600	136	128	20.1	12.4	8.3	1,230	1,550	256	333
	10,000	16,200	151	143	22.2	13.8	9.3	1,540	1,970	325	414
	15,000	23,700	172	163	24.8	15.6	10.7	1,970	2,570	426	532
	20,000	31,100	188	179	26.9	17.0	11.7	2,360	3,110	516	634
	30,000	45,600	213	203	30.1	19.2	13.4	3,030	4,070	675	814
	40,000	59,800	233	223	32.6	20.9	14.7	3,610	4,930	818	971
Bulk Carrier*	5,000	7,190	113	105	16.3	8.8	6.5	811	1,010	247	267
	7,000	9,880	124	116	18.1	9.8	7.2	936	1,210	280	312
	10,000	13,800	138	129	20.2	10.9	8.0	1,090	1,460	319	369
	15,000	20,300	155	146	22.9	12.3	9.0	1,290	1,810	371	447
	20,000	26,700	168	159	25.0	13.4	9.8	1,460	2,110	412	511
	30,000	39,100	188	179	28.4	15.1	11.0	1,740	2,610	479	618
	50,000	63,500	218	209	32.3	17.6	12.8	2,160	3,420	578	786
	70,000	87,200	240	231	32.3	19.5	14.2	2,490	4,090	655	920
	100,000	122,000	266	257	41.2	21.6	15.8	2,890	4,940	747	1,090
	150,000	179,000	298	290	46.8	24.4	17.8	3,440	6,120	868	1,320
	200,000	236,000	324	316	51.1	26.6	19.4	3,890	7,130	965	1,510
	250,000	291,000	345	338	54.8	28.5	20.7	4,270	8,020	1,050	1,670
Container Ship**	7,000	11,500	133	125	21.5	10.6	7.6	1,700	2,000	377	524
	10,000	16,200	153	144	23.7	12.3	8.4	2,180	2,490	468	632
	15,000	23,900	179	169	26.4	14.4	9.5	2,900	3,210	599	782
	20,000	31,400	201	190	28.6	16.1	10.4	3,550	3,850	714	910
	25,000	38,800	219	208	30.4	17.6	11.1	4,150	4,420	818	1,020
	30,000	46,200	236	223	31.9	18.9	11.8	4,720	4,950	914	1,130
	40,000	60,800	264	251	32.3	21.2	12.8	5,780	5,930	1,090	1,310
	50,000	75,200	288	274	32.3	23.2	13.7	6,760	6,820	1,250	1,470
	60,000	89,400	310	295	38.5	24.9	14.5	7,680	7,640	1,390	1,620
Oil Tanker	1,000	1,800	66	63	10.9	4.8	4.4	223	302	99	93
	2,000	3,480	82	78	13.5	6.1	5.3	328	455	137	137
	3,000	5,130	93	89	15.3	7.1	6.0	412	578	166	171
	5,000	8,360	109	105	17.9	8.5	7.0	548	782	211	226
	7,000	11,500	122	118	19.9	9.5	7.7	661	954	248	272
	10,000	16,200	136	132	22.2	10.8	8.5	806	1,180	294	332
	15,000	23,900	155	150	25.2	12.4	9.6	1,010	1,500	356	414
	20,000	31,400	169	165	27.5	13.7	10.4	1,190	1,770	408	486
	30,000	46,300	192	188	31.2	15.8	11.7	1,490	2,260	494	607
	50,000	75,500	226	222	32.3	19.0	13.6	1,980	3,050	630	804
	70,000	104,000	251	247	40.6	21.3	15.0	2,390	3,720	739	968
	100,000	146,000	281	277	45.3	24.2	16.7	2,920	4,600	875	1,180
	150,000	216,000	320	316	51.4	27.9	18.8	3,660	5,850	1,060	1,470
	200,000	284,000	350	346	56.2	30.8	20.4	4,300	6,930	1,210	1,730
	300,000	418,000	398	395	63.7	35.5	23.0	5,390	8,810	1,470	2,160

*) Full load wind lateral / front areas of log carrier don't include the areas of logs on deck

**) Full load wind lateral / front areas of container ships include the areas of containers on deck

Type	Dead Weight Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Ballast Condition	Wind Front Area (m²) Full Load Condition	Ballast Condition
Ro/Ro Ship	1,000	2,540	83	76	15.2	8.0	4.0	1,210	1,240	258	257
	2,000	4,820	107	99	18.1	10.9	5.2	1,680	1,700	348	357
	3,000	7,010	125	115	20.0	13.0	6.1	2,020	2,050	416	432
	5,000	11,200	150	139	22.6	16.3	7.3	2,560	2,590	519	551
	7,000	15,300	170	157	24.6	18.9	8.3	3,000	3,010	601	645
	10,000	21,300	194	179	26.8	22.1	9.5	3,540	3,550	702	764
	15,000	31,000	225	208	29.6	26.4	11.0	4,270	4,270	837	925
	20,000	40,400	250	231	31.8	30.0	12.3	4,880	4,860	949	1,060
	30,000	58,800	290	269	35.1	35.8	14.3	5,890	5,850	1,130	1,280

Type	Gross Tonnage (t)	Displacement (t)	Length Overall (m)	Length P.P. (m)	Breadth (m)	Depth (m)	Maximum Draft (m)	Wind Lateral Area (m²) Full Load Condition	Ballast Condition	Wind Front Area (m²) Full Load Condition	Ballast Condition
Passenger Ship	1,000	1,350	70	69	13.2	6.3	3.9	525	539	219	232
	2,000	2,500	90	86	15.7	8.2	5.1	842	855	295	310
	3,000	3,590	103	99	17.4	9.5	6.0	1,110	1,120	350	368
	5,000	5,650	123	117	19.8	11.6	7.3	1,570	1,570	435	456
	7,000	7,630	138	131	21.5	13.2	8.4	1,970	1,970	502	525
	10,000	10,500	156	147	23.5	15.1	8.7	2,510	2,500	585	609
	15,000	15,000	180	168	26.0	17.6	8.7	3,310	3,270	695	722
	20,000	19,400	199	185	28.0	19.7	8.7	4,030	3,960	785	815
	30,000	27,900	229	211	31.0	23.0	8.7	5,310	5,190	933	966
	50,000	44,000	273	250	35.2	27.9	8.7	7,510	7,300	1,160	1,200
	70,000	59,300	307	279	38.3	31.8	8.7	9,440	9,130	1,340	1,380
Ferry	1,000	2,240	79	72	17.0	6.9	4.9	449	466	175	179
	2,000	4,430	102	93	20.2	8.5	6.0	716	746	243	250
	3,000	6,590	118	108	22.3	9.6	6.7	941	982	295	305
	5,000	10,900	142	131	25.4	11.3	7.8	1,330	1,390	376	390
	7,000	15,100	160	148	27.6	12.5	8.7	1,670	1,750	441	459
	10,000	21,500	182	169	30.1	14.0	9.6	2,120	2,220	522	545
	15,000	31,900	210	196	33.4	15.8	10.8	2,790	2,930	632	664
	20,000	42,300	233	218	35.8	17.3	11.8	3,380	3,560	724	763
	30,000	63,000	270	253	39.6	19.6	13.3	4,450	4,690	877	928
	40,000	83,500	300	282	42.6	21.5	14.5	5,400	5,700	1,010	1,070
Gas Carrier	1,000	2,910	75	70	12.5	6.2	5.3	457	511	151	166
	2,000	5,370	94	87	15.3	8.0	6.4	699	777	222	243
	3,000	7,680	106	99	17.3	9.2	7.2	896	992	278	303
	5,000	12,000	124	116	20.1	11.1	8.4	1,230	1,350	369	401
	7,000	16,200	138	129	22.2	12.5	9.2	1,510	1,660	444	481
	10,000	22,200	154	145	24.7	14.2	10.2	1,870	2,050	541	585
	15,000	31,700	174	165	27.9	16.4	11.5	2,400	2,620	677	730
	20,000	40,900	190	180	30.4	18.2	12.5	2,870	3,120	794	855
	30,000	58,500	216	205	34.2	21.0	13.1	3,670	3,990	994	1,070
	50,000	91,800	253	241	39.9	25.2	13.1	5,030	5,430	1,320	1,410
	70,000	124,000	280	268	44.0	28.4	13.1	6,180	6,650	1,590	1,700
	100,000	169,000	313	300	49.0	32.3	13.1	7,680	8,250	1,930	2,060