|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Type of Ship. | Number of Screws. | Propulsive Coefficient,  *p.* | Wake Value, *w.* | Thrust Deduction, *. t.* | Hull  Efficiency. | Remarks. |
| Battleship (turbine driven) | 4 | ·47@@1 | *s* ∙15  ? ·2Ο | •12 •16 | 1∙o1 1∙oι | Inner screws Outer screws |
| Battleship (older types) | 2 | \* ‘47 | •14 | •17 | •95 |
| First-ciass cruiser | 2 | •53 | ∙1O | •10 | •99 |  |
| Second „ ... | 2 | .48 | •06 | •10 | •95 |  |
| Third „ . . . | 2 | .48 | •05 | •08 | .97 |  |
| Torpedo-boat destroyer | 2 | •62 | •Οί | •02 | •97 |  |
| Mail steamer (turbine) | √ι | •4.6 | J -30 | •17 | 1∙o8 | Inner screws |
| Cargo vessel | 4 | 40 | ? ∙22 | •20 | •98 | Outer screws |
| 2 | .. | •20 | •14 | I-03 |  |
| Sloop  Submarine (on surface) | 1 | •45  • · » | •21 | •17 | ι∙oo |  |
| 2 | •16 | •10 | I-04 |  |
| „ (diving) . | 2 |  | •20 | •12 | I-05 |  |
| The above figures refer to full speed and are affected by alteration of speed. | | | | | | |

Strength.

The forces tending to strain a ship’s structure include (1) the static forces arising from the distribution of the weight and buoyancy when afloat, and the weight and supporting forces when in dock or ashore; (2) the dynamic forces arising from the inertia of the ship and its lading under the accelerations experi- enced in the various motions to which the ship is liable, such as rolling and pitching in a sea way; and (3) local forces and water pressures incidental to (*a*) propulsion and steering, and (*b*) the operation of the various mechanical contrivances which it carries.

The straining actions of the forces, due to the distribution of the weight and buoyancy of the ship at rest and to the inertia of the ship in motion, constitute the only part of the problem of the strength of the structure which can be considered theoretically with any generality; the character of the internal reactions arising in the structure is so complex, that simplifying assumptions have always to be made in order to enable them to be calculated.

The results of theoretical calculations as to the general structural strength of ships are therefore of value for comparative purposes and to some extent for the approximate estimation of stresses actually liable to occur in the structure. The comparison of the theoretical calculations with the results of experience forms an invaluable guide to the proper distribution of material. In making such a comparison the necessity of providing sufficient strength, on the one hand, and of keeping down the weight, on the other hand, has to be borne in mind; the latter point being especially important in a ship, since its economical performance is roughly dependent on the difference between the weight of the structure and the total available displacement.

The greatest straining actions, to which vessels of ordinary forms and proportions are subject, are due to inequalities in the longitudinal distribution of the weight and the buoyancy. Let WWW (fig. 54) represent the weight, and BBB. . . the buoyancy per foot run of a ship plotted along the length AC ; over the lengths Aα, *bc, de. fC* the weight is in excess of the buoy­ancy ; while from *a* to *b, c* to *d, e* to *f,* it is in defect. A curve LLL, whose ordinates are equal to the differences between those of WWW and BBB, is termed a curve of loads, and represents the net load of the ship regarded as a beam subject to longitudinal bending. Shearing forces are produced whose resultant at any trans­verse section is equal to the total net load on either side of the section ; they are represented by the “ shearing force" curve FFF ..., whose ordinate at any trans- verse section is pro­portional to the area of the “ loads ” curve LLL . .uρ to that section. Similarly, on plotting the areas of the shearing force curve as ordinates, a "bending moment ” curve sure that the end ordinates of the shearing force and bending moment curves are zero.

@@@1 Higher values have been obtained for the propulsive coefficients of the most recent turbine-driven ships.

These curves are usually constructed for three standard conditions of a ship, viz. (i.) in still water; (ii.) on a trochoidal wave of length equal to that of the ship and height 1/20th of the length, with the crest amidships; and (iii.) on a similar wave with the trough amidships. The curve of weight is obtained by distributing each item of weight over the length of the ship occupied by it and sum­ming for the whole ship. Such a condition of the ship as regards stores, coal, cargo, &c., is select­ed, which will produce the greatest bending moment in each case. The ordinates of the curve of buoyancy are calculated from the areas of the immersed sections, the ship being balanced longitudinally on the wave in the second and third conditions. The shearing force and bending moment curves are then drawn by successive in­tegration of the curve of loads. Typical curves are shown in figs. 55 to 59 for a first-class cruiser on wave crest, a torpedo- boat destroyer on wave crest (bunkers empty) and in trough (bunkers full), and a cargo vessel on wave crest (hold and bunkers empty) and in trough (hold and bunkers full). From these curves it is seen that the maxi­mum bending moment occurs near amidships; its effect in figs. 55, 56 and 58 is to cause the ends to fall relatively to the middle, such a moment being termed “ hogging ”; the reverse or a “ sagging ” moment is illustrated in figs. 57 and 59. Curves of a similar character are obtained in the still-water condition, but the bending moments and shearing forces are then generally reduced in amount.

The maximum bending moment is frequently expressed as a ratio of the product of the ship’s length and the displacement; average values for various types of ships are tabulated below:—

ΜΜM is obtained which gives the bending moment at any section. Symbolically, if *w,* F, M represent the load, shearing force, and bending moment, and *x* the co-ordinate of length,

*dF* . „ dM w"3≡ a∏d F = -^-.

The conditions of equilibrium, viz. (*a*) that the . total weight and buoyancy are equal, and *(b)* that the centre of gravity and the centre of buoyancy are in the same vertical transverse section, eπ-

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| --- | --- | --- |
| Class of Ship. | W×L  Maximum B.M. | Whether Hogging (on Wave Crest) or Sagging  (in Wave Hollow). |
| Mail steamer .... | From 25 to 30 | H |
| Cargo vessel | From 30 to 35 | H |
| Battleship (modern) | About 30 | H |
| Battleship (older types) | About 40 | H |
| First-class cruiser | About 32 | H |
| Second-class cruiser | About 25 | S |
| Scout | About 22 | H |
| Torpedo-boat destroyer | ( About 22  ( From 17 to 25 | H  S |
| Torpedo boat .... | 5 About 23 | H |
|  | ( About 23 | S |