Strength Assessment of Ore Carrier Cross-Deck Structures

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ABSTRACT

A simple, first-principle-based calculation method has been developed to assess, at a global level, the transverse compression strength of cross-deck structures in ore carriers. The concept of cross-deck and associated structures is introduced in which the cross-deck and other structures attached to it make contribution to resist transverse compressive loads. The effects of cargo holds and hatches arrangement, cargo profile, cargo inertia loads, still water and wave head pressures have been taken into account. The developed calculation procedure, which is written to make a straight-forward assessment possible, links the general particulars of a ship, its hatches and hold dimensions directly to the safety factors. A damage case was investigated and the strength assessment made using this method. Strength studies provide important information about the possible hazards on the ore carriers.

KEY WORDS: Strength; ore carrier; cross-deck; buckling; damage.

NOMENCLATURE

- \(A_i\) [\(\text{mm}^2\)] area of structural element
- \(B\) [\(\text{m}\)] moulded breadth
- \(B_{bd}\) [\(\text{m}\)] inner bottom semi-width of hold
- \(B_s\) [\(\text{m}\)] distance from the centre of gravity of cargo at one side to the centre line
- \(B_{hd}\) [\(\text{m}\)] maximum hold breadth
- \(B_k\) [\(\text{m}\)] distance from the centre of gravity of light weight at one side to centre line
- \(B_{wt}\) [\(\text{m}\)] average width of wing tank
- \(C_{CLB}\) coefficient of calibration against FE and FSM (Full Scale Measurement)
- \(C_g\) coefficient of inertia
- \(C_w\) [\(\text{m}\)] wave elevation (Eqn. 3)
- \(D\) [\(\text{m}\)] moulded depth
- \(F_i\) [\(\text{tonnes-f}\)] transverse force acting on structural element \(i\) (see Eqn. 10)
- \(F_{cd}\) [\(\text{tonnes-f}\)] transverse force acting on the cross-deck structure of interest
- \(g\) [\(\text{m/s}^2\)] acceleration of gravity
- \(H_{bd}\) [\(\text{m}\)] hold height
- \(H_{hp}\) [\(\text{m}\)] height of hopper sloping plate
- \(K\) [\(1/\text{m}\)] wave number (Eqn. 5)
- \(L\) [\(\text{m}\)] Rule length
- \(L_{cd}\) [\(\text{m}\)] length of the cross-deck of interest (Fig. 2)
- \(L_{hdave}\) [\(\text{m}\)] average hold length of 2 adjoining holds (Fig. 2)
- \(L_{td}\) [\(\text{m}\)] total length of cross-deck strips (Eqn. 8)
- \(L_{td}\) [\(\text{m}\)] total hold length (Fig. 2)
- \(N_{hd}\) total number of holds
- \(N_{hat}\) total number of hatches
- \(p_{dw}\) [\(\text{tonnes-f/ mm}^2\)] wave head pressure at ship bottom (Eqn. 4)
- \(p_{sw}\) [\(\text{tonnes-f/ mm}^2\)] maximum still water pressure (Eqn. 2)
- \(Q_{c1}\) [\(\text{tonnes}\)] cargo weight over the length \(L_{hdave}\) (Eqn. 1)
- \(Q_s\) [\(\text{tonnes/m}\)] cargo weight per unit length
- \(T_d\) [\(\text{m}\)] design draught
- \(W_{s1}\) [\(\text{tonnes}\)] light weight over the length \(L_{hdave}\)
- \(W_s\) [\(\text{tonnes/m}\)] light weight per unit length
- \(Z\) [\(\text{m}\)] depth below the still water level (Eqn. 4)
- \(Z_i\) [\(\text{mm}\)] distance from centre of area of structural element \(i\) to mid-depth line (see Fig. 1)
- \(\rho\) [\(\text{tonnes/ m}^3\)] density of sea water
- \(\rho_c\) [\(\text{tonnes/ m}^3\)] density of cargo
- \(\sigma_i\) [\(\text{N/ mm}^2\)] compressive stress for structural element \(I\) (Eqn. 9)
- \(\theta_i\) [\(\text{deg}\)] height coefficient for the neutral axis
- \(\theta_c\) [\(\text{deg}\)] cargo repose angle (Fig. 3)