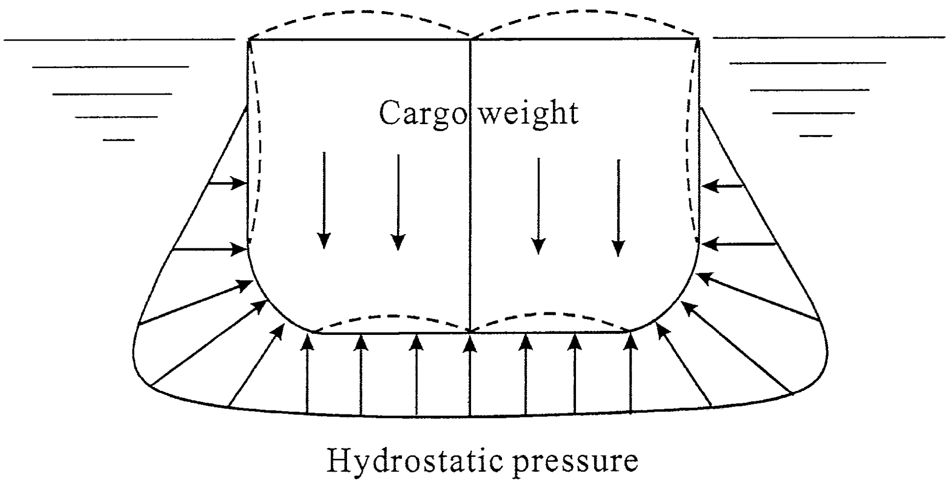
CHAPTER 5 TRANSVERSE STRENGTH OF SHIPS

5.1 Transverse Loads

Transverse loads tend to change the shape of a vessel's cross section and introduce transverse stresses, Figure 5.1. These transverse loads are:

1. Static and dynamic pressure loads.
2. Structural weights and cargos.
3. Reaction of weights and cargo due to motion.
4. Impact of storm seas.

These loads may cause cross-sectional deformation as shown by the dotted lines.



Transverse Loads on Ship Hulls

Fig. 5.1

5.1.1 Hydrostatic Loading

A transversely framed ship consists of a bottom floor, a side frame and one or more deck beams forming a "ring". The bottom and side frames resist principally the water pressure and the deck beams support the sides and the deck loads. Hence a section of the structure having a length equal to one frame space is considered under equilibrium under its own weight, the weight of all cargo and the hydrostatic loads.

Hydrostatic head – It can be determined from classification society rules or by assuming a head to the full load-draft plus one half the height of a $1.1\sqrt{L}$ wave or the head obtained by rolling the vessel 30 deg. in stillwater.
If it is possible, it is more accurate to calculate the dynamic head due to waves and ship motions and add it to the hydrostatic head.

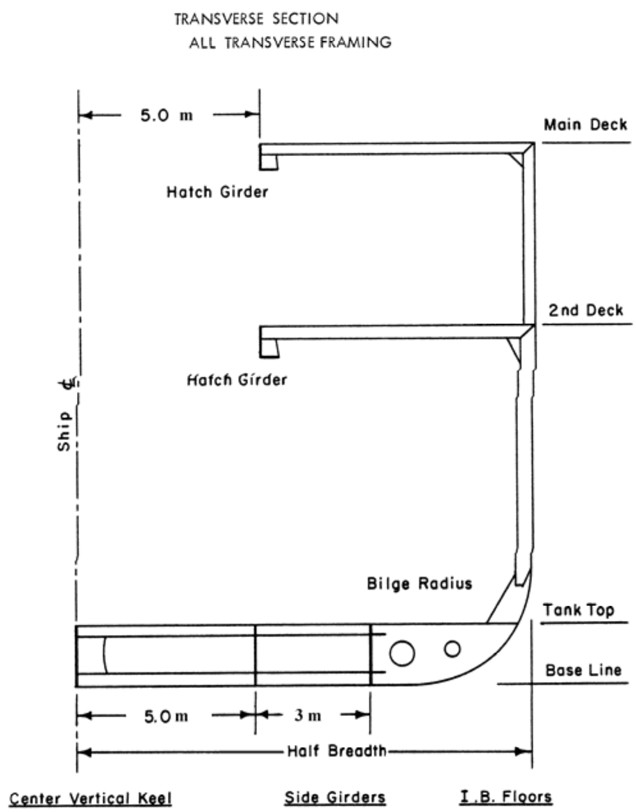
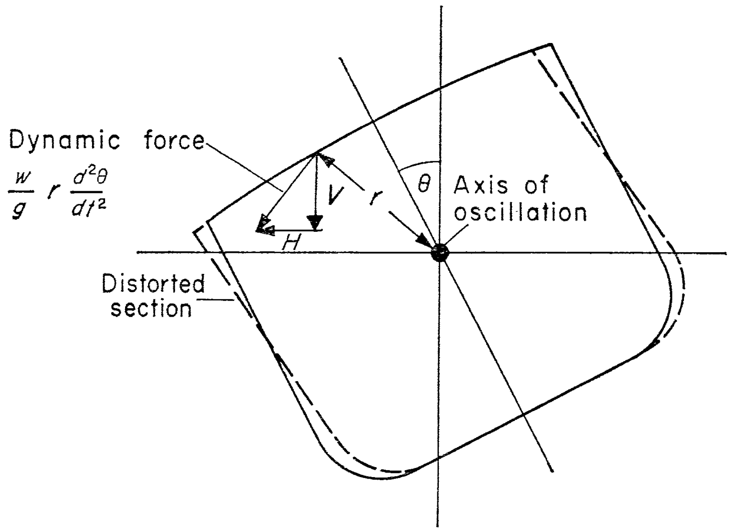


Fig. 5.2

Racking – When a ship rolls, the deck moves laterally relative to the bottom. This type of deformation is called "racking", Figure 5.3. Transverse bulkheads resist racking.



Distortion of transverse section due to rolling

Fig. 5.3

5.1.2 Impact of storm seas (slamming)

The impact of the bottom bow as it hits the water during a severe storm is called "slamming". Slamming causes increased pressure.

5.2 Transverse Strength

Figure 5.4 shows the transverse ring of material for a single deck ship. This structure is idealized by representing it by the dotted line drawn through the centroids of the individual members.

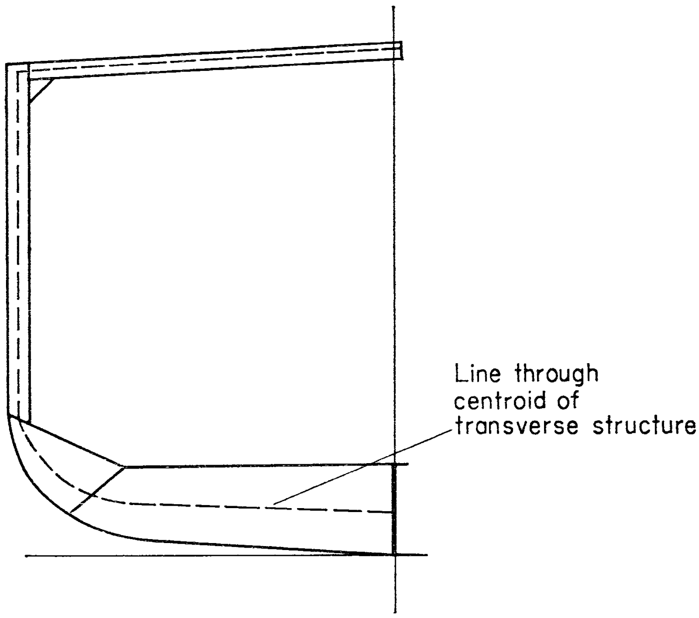


Fig. 5.4

The bilge area may be transformed into a rigid joint formed by the intersection of the line representing the bottom structure and that representing the side structure. For each of the members forming the structure, the moment of inertia is to be calculated.

The effect of longitudinal members such as deck girders, center girder and side girders in the double bottom are usually considered by assuming these members do not deflect under load (knife-edge support). If the bottom structure is of considerable stiffness relative to the side structure, the side structure may be assumed to end at the bottom structure with a fixed support.

Transverse strength calculations may be carried out by one of the methods previously discussed: Castigliano's theorem, slope deflection method or moment distribution method. Two dimensional (2-D) Finite Element analysis is the method of choice at present. Transverse strength calculations enable us to compute shear and bending stresses and to show where the maximum bending action takes place. It helps us to check the structural arrangement and scantlings of the different structural members.

5.3 Example Ring Frame Analysis

Figure 5.5 gives the moments of inertia of the structural members, the span lengths, the loadings on the decks and inner bottom and the water pressure.

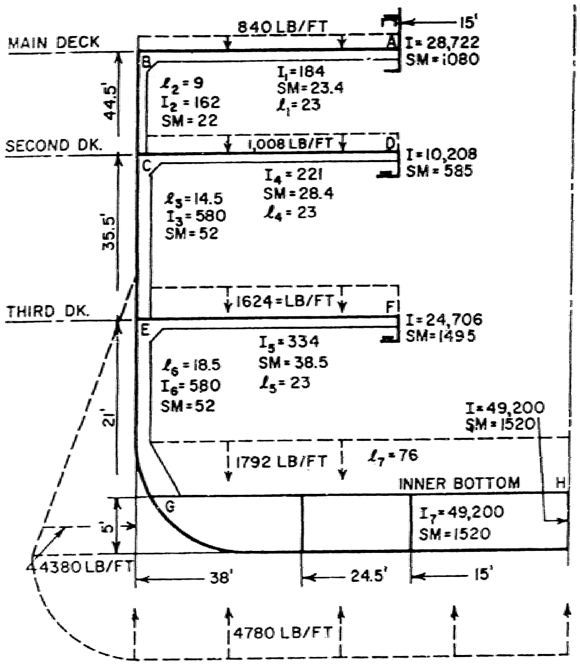


Fig. 5.5

Figures 5.6 and 5.7 show the moment distribution and bending stresses calculated using the moment distribution method.

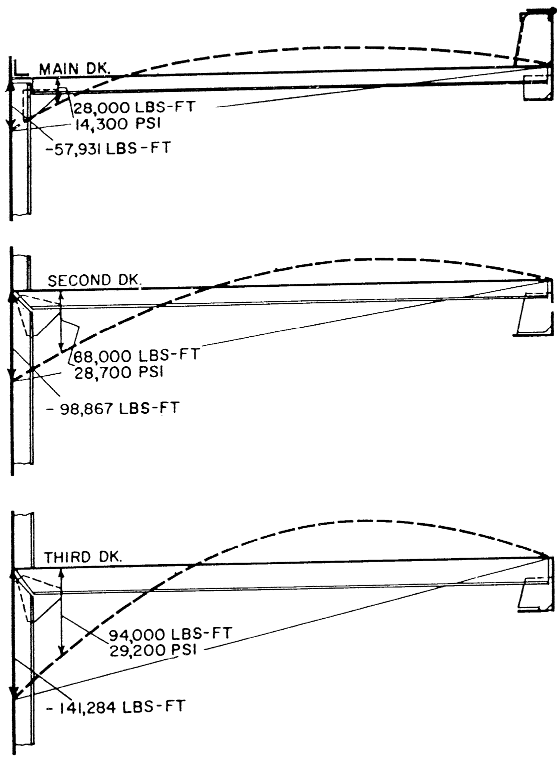


Fig. 5.6

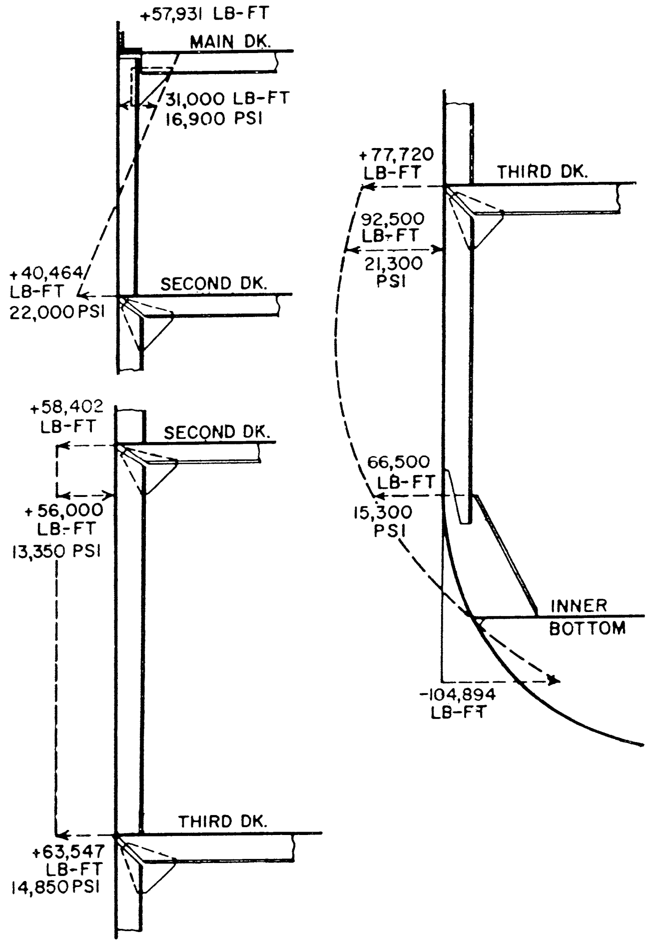


Fig. 5.7

5.4 Sagging and Hogging Loads

When the midship section is to be analyzed, the loading considered will depend on whether the ship is in a sagging or a hogging condition. The maximum draft will occur during hogging, since the wave crest will occur at amidship while in the sagging condition the wave trough will occur at amidship, see Figures 5.8 and 5.9 for an example ship.

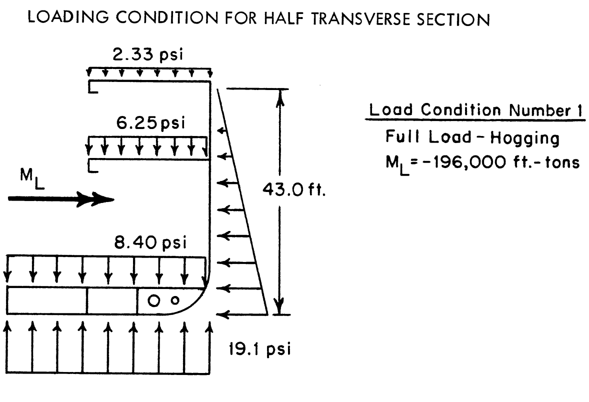


Fig. 5.8

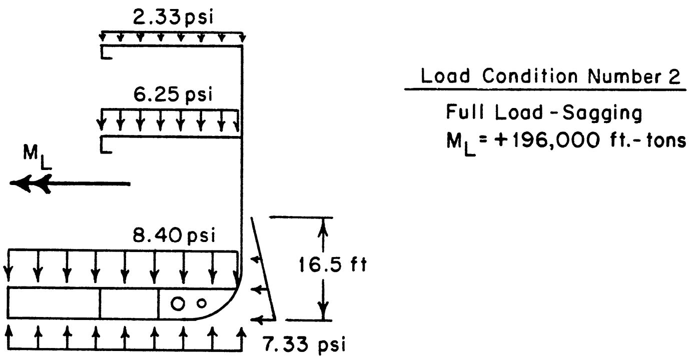

2.33 psi
6.25 psi
M_L
8.40 psi
16.5 ft
7.33 psi
Load Condition Number 2
Full Load - Sagging
M_L = +196,000 ft.-tons

Fig. 5.9