

case for which they are relevant comprised full lane loading and footpath loading on one side of the main span.

5.7.1 Longitudinal bending

The bending moment diagrams for the three 'structural' longitudinal grillage members are shown in Fig. 5.23. The diagrams have saw teeth with large jumps in moment at the joints because of the transfer of the torsion in the transverse members at each joint to bending moments and shear forces in the longitudinal member as was shown in Fig. 5.11. The 'true' bending moment diagrams can be assumed to pass through the average values of the bending moment on the two sides of each joint as shown by the dashed lines in Fig. 5.23.

The longitudinal bending stresses at a section are calculated from these 'true' moments using the section properties of the I-beam represented by the grillage member. Figure 5.24(a) and (b) show the bending stresses calculated in this way for sections a-a and b-b of the deck. The bending stresses are shown constant across each I-beam without smoothing out the impossible jumps in stress at the notional cuts between I-beams and without correction for shear lag as described in Chapter 8.

The shear force S_M due to bending is the slope of the 'true' dashed bending moment diagram in Fig. 5.23. The shear flows in the web and flanges of the 'I-beams' are calculated from S_M using equation (5.2). Figure 5.25 shows these bending shear flows at cross-section c-c.

Fig. 5.23 Longitudinal moments in part of grillage.

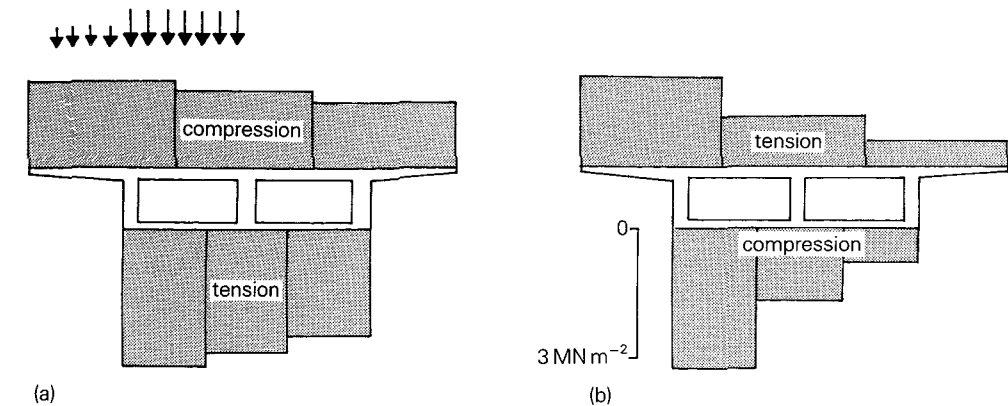
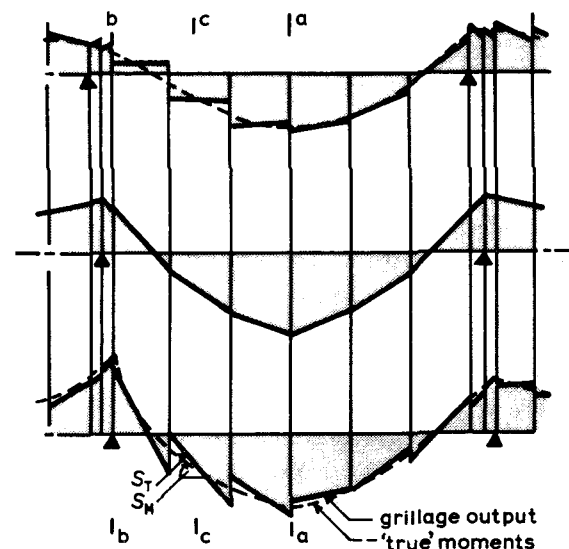


Fig. 5.24 Longitudinal bending stresses:
(a) sagging at midspan a-a and (b) hogging at support b-b.

5.7.2 Transverse bending

The transverse bending moment in the grillage member is equivalent to the opposed transverse compression of the top slab and tension of the bottom slab (or vice versa) due to transverse flexure without distortion. In narrow decks it is usually very small compared to the longitudinal bending moment (except in the diaphragms). However, in wide decks it can be large especially near skew supports. Since these moments interact with the torsions in longitudinal grillage members, a grillage output transverse moment diagram has a saw tooth shape like the longitudinal moment diagram, and in a similar way the top and bottom slab stresses are calculated from the average moments on the two sides of each joint.

5.7.3 Slab flexure from distortion

The stiffness of the cell against independent flexure of the slabs during distortion is represented by the shear stiffness of transverse grillage members. For this reason the slab bending moments are derived from the shear force in the transverse grillage members. Figure 5.26(a) shows the

Fig. 5.25 Longitudinal bending shear flow at section c-c.

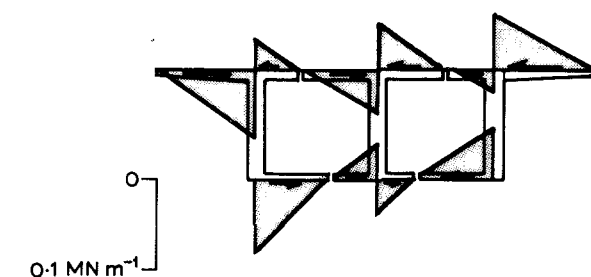


Fig. 5.26 Slab transverse moments at section a-a: (a) grillage transverse shear forces; (b) cell distortion moments; (c) cantilever and local moments; and (d) total moments.

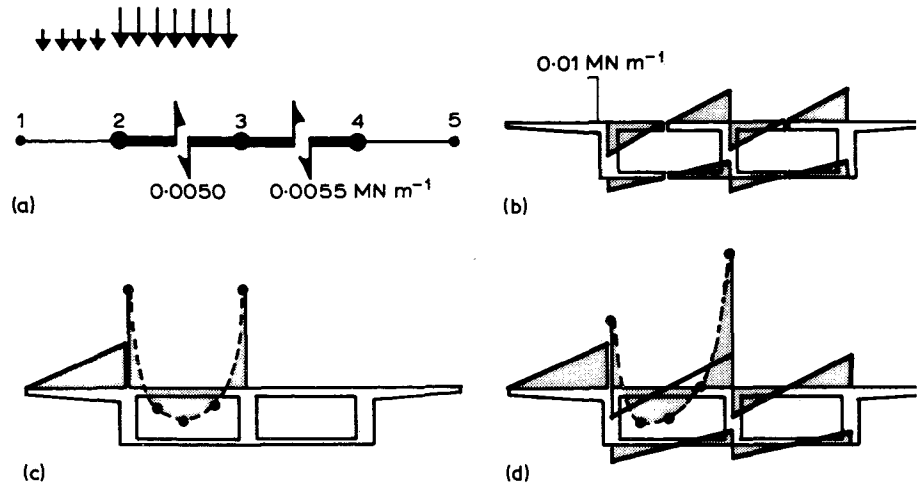
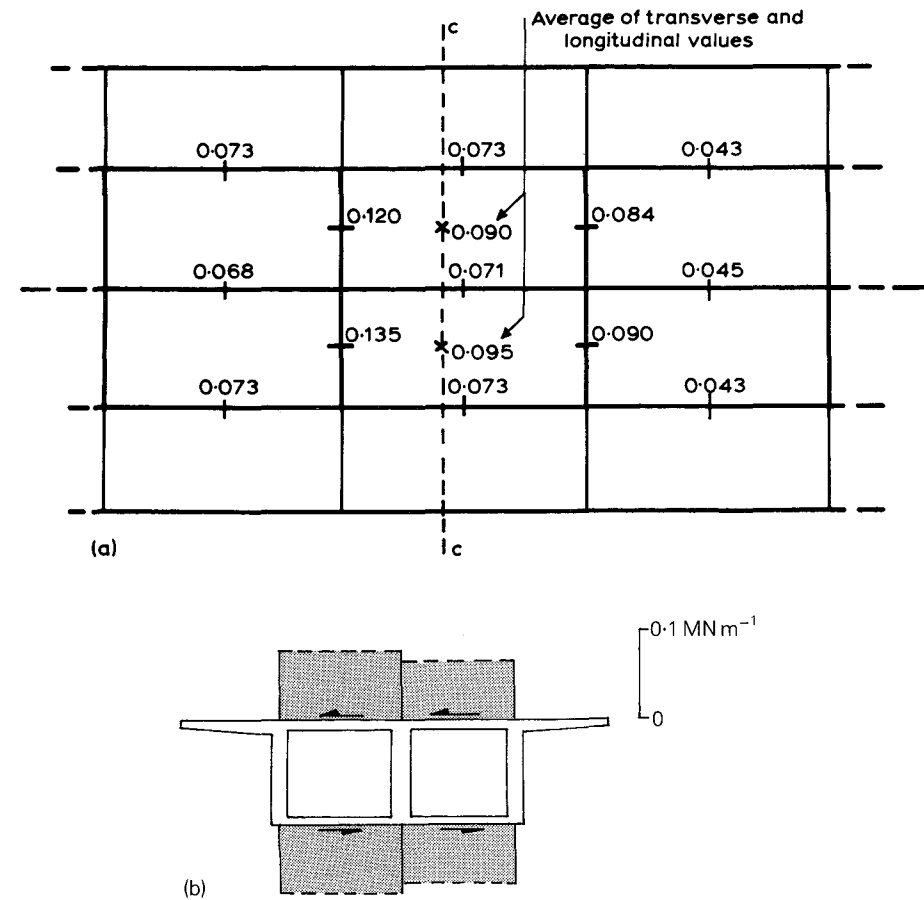


Fig. 5.27 Torsion shear flows at c-c calculated from average of transverse and longitudinal torques output by grillage: (a) torques in grillage members per unit width and (b) shear flows.



shear force in the transverse members on section a-a of Fig. 5.20(d). The fractions of this shear force carried by each of the top and bottom slabs are assumed to be proportional to the flexural stiffnesses of the slabs (here 0.7:0.3). Assuming also that points of contraflexure lie midway between the webs, the moment at each end of a slab is simply the shear force it carries times half the distance between webs. Hence we obtain the transverse moment diagram of Fig. 5.26(b) from the shear forces of (a). The transverse slab moment in the cantilever can be taken directly from the grillage output since this member is not representing a cell. Figure 5.26(c) shows the cantilever moment and the local moments under the knife-edge load above section a-a, while (d) shows the total moments obtained by adding (b) and (c). The local moments are derived from a local grillage analysis as described in Section 4.6.

5.7.4 Torsion shear flow

The torsion shear flows in the slabs must be calculated from the average torque per unit width of transverse and longitudinal grillage member as described in Section 5.4.4. Figure 5.27(a) shows the torques in grillage members per unit width of cell; the averages of the values in the two directions are also shown. By dividing these average torques per unit width of cell by the distance *h* between slab midplanes, we obtain the shear flows in the slabs shown in Fig. 5.27(b). On adding these to the bending shear flows in Fig. 5.25, we obtain the total shear flows shown in Fig. 5.28.

The shear forces output from the grillage for longitudinal members are the slopes of the saw teeth of the output moment diagram of Fig. 5.23. These shear forces combine the components *S_M* due to bending (the slope of the dashed ‘true’ moment diagram) and the components *S_T* due to torsion (the additional slope of the teeth caused by transverse torsion). Consequently, the grillage output shear force represents the total shear force in each web of the deck.

Fig. 5.28 Combined shear flow from torsion and bending.

