SECTION 9. DESIGN FOR COMBINED AXIAL COMPRESSION AND BENDING

Section 7 of this design manual deals with the design of ***mortarless*** walls for axial compression and this also takes into account the design eccentricities of the vertical load at the point of application and the design eccentricities at about mid height of any wall due to the effects of slenderness (buckling deflection). Walls can also be subjected to out-of-plane lateral loads however in addition to axial compression loads. A typical example of such a wall is a perimeter load-bearing wall in a building that is also a retaining wall.

In walls subjected to both compression and bending, compressive stress in the concrete can govern the design in situations where the compression stress due to axial load is high and the applied bending moment is sufficient to increase the compressive stress in the concrete (at the extreme fibre) beyond that which is allowed. In such circumstance the entire section can still be in compression and tensile reinforcement plays no direct role in the strength of the wall.

The other extreme is where the axial compression load is low and the wall fails in flexure through excessive tension in the reinforcement. In this circumstance the wall is essentially a vertical slab and can be designed as a slab (refer Sections 7 and 8).

9.1 Axial compression and in-plane bending

IS 456:2000 Clause 32.3.1 addresses the situation in which the bending results from in-plane lateral loads e.g. load-bearing shear walls in buildings. It states that where the entire horizontal cross section of the wall remains in compression then the in-plane bending in the wall can be ignored and the wall simply designed for axial compression as outlined in Section 7 of this manual and for in-plane shear as outlined in Section 11 of this manual.

Although not stated, if the in-plane bending is such that parts of the wall horizontal cross section are in tension then reinforcement must be provided to accommodate the tensile forces. The masonry and the grout cannot be designed for such tensile forces.

9.2 Axial compression and out-of-plane bending

IS 456:2000 Clause 32.3.2 states that when walls are subject to axial compression plus out-of-plane bending they can be designed as slabs provided the axial compressive stress does not exceed $\mathbf{0.04}f_{ck}$.

When the axial compression load is larger than that which produces a compressive stress of $\mathbf{0.04}f_{ck}$ then it is necessary to consider the combined effect to ensure that neither the concrete in compression nor the steel reinforcement in tension is overstressed. This is referred to in Clause 39.5 in which it is stated that the compression member shall be designed on the basis of Clauses 39.1 and 39.2.

Clause 39.1 outlines the basic assumptions for limit state design of a section, viz that plane sections remain plane and that the maximum strains are 0.002 for concrete when subjected to axial compression and varying up to 0.0035 in the extreme compression fibre when subjected to compression plus bending.

Clause 39.2 states that minimum eccentricity is to be in accordance with Clause 25.4, and this is the clause that deals with the minimum eccentricity for columns. (Refer 7.1.2 in this design manual)

The footnote to Clause 39.5 states that *"the design of member subject to combined axial load and uniaxial bending will involve length calculation by trial and error."* To overcome this issue interaction diagrams for ***mortarless*** walls have been prepared and these are included in the subsequent Parts of this manual. The values in the interaction diagrams have been calculated in accordance with the provisions of IS 456:2000 for limit state design (Section 39).