SECTION 3. REINFORCEMENT

The reinforcement in ***mortarless*** walls designed for the Indian market will need to comply with the requirements outlined in IS 456:2000. This may be reviewed when an Indian Standard for reinforced masonry is published.

IS 456:2000 Section 32 is for reinforced concrete walls. Clause 32.1 states that walls subjected to direct compression or combined flexure and direct compression should be designed in accordance with Section 5 or Annex B provided the vertical reinforcement is provided in each face. For strict compliance with Clause 32.1 therefore all walls subject to combined flexure and direct compression should have reinforcement on both sides. Note that IS 456:2000 Section 5 Structural Design (Limit State Method) and Annex B is Structural Design (Working Stress Method).

Clause 32.1 further states that braced walls subjected only to vertical compression may be designed as per the empirical procedure given in 32.2 provided the walls are not thinner than 100mm. Clause 32.1.1 states further that guidelines for the design of walls subjected to horizontal and vertical loads are given in 32.3.

Clause 32.2.1 lists the requirements for walls to be considered braced. The requirements are:

- The walls or braced elements must be arranged in two directions so as to provide lateral stability to the structure as a whole
- Lateral forces are to be resisted by shear in the planes of the walls or braced elements
- Floor and roof systems are to be designed to transfer lateral forces
- Connections between the walls and the lateral supports are to be designed to resist a horizontal force of not less than the simple static reactions to the total applied horizontal forces at the level of the lateral support, and 2.5% of the total vertical load that the wall is designed to carry at the level of the lateral support. It is the larger of these two forces that is the design force.

In view of the all the above, and as ***mortarless*** walls are designed as unreinforced for compression loads, that ***mortarless*** walls can generally be designed in accordance with Section 32.

In preparing the design aids in this manual walls designed for out-of-plane lateral loads in addition to axial compression have been designed to IS 456 Part 32 for axial load and Parts 38 and 39 for the combined action. When designed for the combined action it is essential to ensure that the vertical reinforcement is installed in the tension side of the wall and this might alternate throughout the height of the wall.

3.1 Mechanical properties

Reinforcement for ***mortarless*** masonry will generally be Grade 500 deformed bars.

3.2 Main reinforcement

Reinforcement can be accurately positioned by means of the plastic connectors that are perform the dual role of bar chairs, and whilst main reinforcement is generally vertical it can also be horizontal in certain circumstances.

See below for minimum reinforcement requirements.

3.3 Secondary reinforcement

Reinforcement can be accurately positioned by means of the plastic connectors that are perform the dual role of bar chairs, and whilst secondary reinforcement is generally horizontal it can also be vertical in certain circumstances.

See below for minimum reinforcement requirements.

3.4 Minimum reinforcement

IS 456:2000 Clause 32.5 outlines the minimum reinforcement requirements for walls.

3.4.1 Minimum main reinforcement

The minimum ratio of vertical reinforcement to gross concrete area of walls is 0.12% for deformed bars not greater than 16mm in diameter and with a characteristic strength not less than 415Mpa.

This means that minimum the vertical reinforcement is as shown in Table 3.4-1. Note that the maximum spacing of vertical bars is the lesser of 3 times the wall thickness and 450mm (Clause 32.5 b))

When designing walls for out-of-plane lateral loads consideration should also be given to the provisions of Clause 26.3.3

3.4.2 Minimum secondary reinforcement

The minimum ratio of horizontal reinforcement to gross concrete area of walls is 0.20% for deformed bars not greater than 16mm in diameter and with a characteristic strength not less than 415Mpa.

This means that minimum the horizontal reinforcement is as shown in the table below. Note that the maximum spacing of horizontal bars is the lesser of 3 times the wall thickness and 450mm (Clause 32.5 d))

As with the main reinforcement when designing walls for out-of-plane lateral loads consideration should also be given to the provisions of Clause 26.3.3

TABLE 3.4-1

	Design Thickness t_d (mm)	**Minimum Vertical Reinf't** 0.12%	**Minimum Horiz. Reinf't** 0.20%	**Maximum Spacing** 450 or 3*t* (mm)
140 *Mortarless*	114	T12-400	T12-400	400
200 *Mortarless* Chamfered	164	T12-400	T12-300 (T12-200&400 Alternating)	450
200 *Mortarless* Unchamfered	174	T12-400	T12-300 (T12-200&400 Alternating)	450

Note: This table is for walls designed for axial load, not flexure.

Note that in IS 456:2000 Clause 32.5 attention is drawn to the fact that minimum reinforcement as per Table 3.4-1 might not always be sufficient to provide adequate resistance to the effects of shrinkage and temperature.

In walls of thickness greater than 200mm the reinforcement is to be installed in two grids, one near each face of the wall. (IS 456:2000 Clause 32.5.1). This Clause does not apply to 140 and 200 ***mortarless*** walls.

3.5 Laps in reinforcement

IS 456:2000 Clause 26.2.5 requires that lap splices in reinforcement be as far away as possible from sections of maximum stress. This is not an issue in walls being designed for axial load however it needs to be considered when designing walls for lateral (out-of-plane) loads. It is also recommended in this clause that splices in flexural members should not be at sections where the bending moment is more than 50% of the moment of resistance, and that not more than 50% of the bars be spliced at a section.

This is ideal and it should certainly be followed where possible but it is not the normal practice with reinforced ***mortarless*** walls. In these walls splice locations are more or less determined by maximum lifts of the wall prior to grouting.

Clause 26.2.5 states that where more than 50% of the bars are spliced at a section or where splices are made at points of maximum stress, special precautions shall be taken such as increasing the length of the lap and/or confining the concrete around the splice.

IS 456:2000 Clause 26.2.5.1 adds the following with respect to lap splices:

- Lap splices shall be considered staggered if the center to center distance of the splices is not less than 1.3 times the lap length

- Lap length for bars in flexural tension shall be L_d or 30 bar diameters whichever is the greater, and for members in direct tension shall be 2 L_d of 30 bar diameters where L_d is the development length of the bar which is calculated as follows:

  L_d = (Bar Dia x the stress in the bar at the splice)/(4 times the design bond stress)

The design bond stress for deformed bars in concrete is as follows:

1.92Mpa for M20 concrete
2.24Mpa for M25 concrete
2.40MPa for M30 concrete

Based on these provisions it is recommended that the minimum lap lengths be as follows:

450min for T12 bars
600min for T16 bars

In walls that are subjected to out-of-plane lateral loads it is often necessary to lap bars in regions of high flexural tensile stress and in view of the provisions of Clause 26.2.5 it is recommended that the lap lengths in such regions be increased accordingly by at least 50%.