

SECTION 3. REINFORCEMENT

The reinforcement in **mortarless** walls designed to AS 3600:2009 needs to comply with the minimum requirements outlined in Clause 11.7. When calculating the minimum reinforcement requirements the thickness of the **mortarless** wall should be taken as the design thickness given in the Properties Table in Section 1 of the subsequent parts of this manual.

3.1 Vertical reinforcement

The vertical reinforcement is not considered as contributing the compression load capacity of a **mortarless** wall and that is because it cannot be tied in the way that prevents premature buckling of the bars (refer Clauses 10.7.2 and 10.7.4). Note however that Clause 11.7.4 states that it is not necessary to restrain the vertical reinforcement if:

$$N^* \leq 0.5 \Phi N_u, \text{ or}$$

the vertical reinforcement is not used as compressive reinforcement, **or**

the vertical reinforcement ratio is not greater than 0.01 and a minimum horizontal reinforcement ratio of 0.0025 is provided.

This means that generally, in terms of compliance with AS 3600, the vertical reinforcement could be considered to contribute to the axial load capacity of a **mortarless** wall and therefore the values in the load tables are generally a little conservative.

Clause 11.7.1 requires a minimum reinforcement ratio of 0.0015, i.e. 0.15% of the cross sectional area (refer first paragraph above). The area of reinforcement however must be adequate to satisfy the strength requirements.

3.2 Horizontal reinforcement

Clause 11.7.1 requires a minimum reinforcement ratio of 0.0025, i.e. 0.25% of the cross sectional area (refer first paragraph above). As for the vertical reinforcement however the area of reinforcement must also be adequate to satisfy the strength requirements.

It is noted in 11.7.1 that the minimum ratio may be reduced to 0.0015 if the wall is being designed for one-way buckling using Clause 11.4(a). It further states that the minimum reinforcement ratio may be reduced to zero when there is no restraint to horizontal shrinkage or thermal movements and the length of the wall is less than 2.5m, or 0.0015 when there is no restraint against horizontal shrinkage or thermal movements and the length of the wall is equal to or greater than 2.5m.

Clause 11.7.2 provides further requirements for minimum reinforcement ratios in terms of exposure classifications and crack control. The requirements are as follows:

Reinf't Ratio	Exposure Classification	Degree of control over cracking
0.0025	A1 & A2	Minor
0.0035	A1 & A2	Moderate and where cracks are inconsequential or hidden from view
0.006	A1 & A2	Strong – for appearance and where cracks may reflect through finishes
0.006	B1, B2, C1, C2	All

It is also noted in Clause 11.7.2 that additional horizontal crack control reinforcement may be needed at the base of the wall to control thermal cracking during hydration for walls longer than 8m. The author is of the opinion that this is not applicable to **mortarless** walls.

3.3 Spacing of reinforcement

Clause 11.7.3 gives guidance on the maximum spacing of reinforcement. The maximum clear spacing is given as the lesser of $2.5t_w$ and 350mm. As mentioned above the design thickness of a **mortarless** wall (t_d) is the value given in the section properties tables in the subsequent Parts of this manual and for the purposes of this calculation t_d should be substituted for t_w .

With **mortarless** construction the spacing of vertical and horizontal reinforcement can only be in increments of 200mm, i.e. 200, 400, 600 etc. This is something the designer needs to come to terms with and decide whether the maximum spacing provisions of AS 3600 will be stretched a little. It is the opinion of the author that due to the unique nature of **mortarless** construction for concrete walls, the maximum spacing of reinforcement can readily be increased to 400mm without detriment to the wall.

In view of all of the above the minimum reinforcement requirements of **mortarless** walls can be summarized as follows:

TABLE 3.3-1

Mortarless	Design Thickness t_d (mm)	Minimum Vertical Reinforcement 0.15%		Minimum Horizontal Reinforcement 0.25%		Maximum Spacing (mm) 350 or $2.5t$
		AS 3600	Suggested	AS 3600	Suggested	AS 3600
140 Unchamfered	114	N12-640	N12-600	N12-310	N12-400	285
200 Chamfered	164	N12-450	N12-400	N12-270	N12-300	350
200 Unchamfered	174	N12-420	N12-400	N12-250	N12-300	350

As can be seen in Table 3.3-1 above, the maximum spacing provisions will control the selection of vertical reinforcement for all walls being designed for axial compression loads only, and it is the author's recommendation that N12-400 be adopted as the minimum vertical reinforcement despite this slightly exceeding the literal interpretation of the maximum spacing provisions of AS 3600.

It is the author's opinion that N12-300 (N12 at alternating 400mm and 200mm centres) should also be adopted as the minimum horizontal reinforcement and this is because the design thickness of a **mortarless** wall is more than 20% greater than the actual average thickness of the grout (i.e. the fresh concrete). The minimum reinforcement ratios given in AS 3600 should arguably be applied to this thickness rather than the design thickness, and if so the minimum horizontal reinforcement in a 200 **mortarless** wall would be N12-330 rather than N12-250 as tabulated above. Note that it is the Author's experience also that N12-400 horizontal is generally adequate for all walls as minimum horizontal reinforcement.

The options for the design engineer are:

1. be conservative and adopt N12-200 horizontal reinforcement
2. be less conservative and adopt alternating N12-200 and 400 horizontal reinforcement
3. Take into consideration the provisions of AS3700 and adopt N12-400 or even greater

Over and above this of course the engineer should give consideration to the degree of crack control required and therefore to the provisions of Clause 11.7.2.

An alternative for any engineer of course is to design **mortarless** walls to the provisions of AS 3700 in lieu of AS 3600 but this will result in reduced load capacities.

3.4 Position of reinforcement

Clause 11.7.3 states that reinforcement must be provided in both faces of a wall if:

1. the wall is greater than 200mm thick
2. if the tension in the wall exceeds the tensile capacity of the concrete under the design ultimate loads
3. the walls are designed for two way buckling (Clauses 11.4(b) and 11.4(c))

3.5 Laps in reinforcement

The lap length for splicing bars in tension is given in Clause 13.2.2 as follows:

$$L_{sy.t.lap} = k_7 L_{sy.t} \geq 29k_1 d_b$$

Where:

$L_{sy.t}$ is calculated in accordance with Clause 13.1.2.1, and

k_7 is to be taken as 1.25 unless the area of steel provided is at least twice the area required and no more than half of the reinforcement at the section is spliced in which case it can be taken as 1.

Accordingly a minimum lap length of 36.25 bar diameters applies and for N12 bars this is 435mm but say 450mm.

When calculating the basic development length in accordance with Clause 13.1.2.2 the following values result:

Development length $L_{sy.tb}$ calculated in accordance with Clause 13.1.2.2		
	20MPa concrete	25MPa concrete
N12 vertical bars	390	350
N12 horizontal bars	510	455
N16 vertical bars	540	485

Assuming $k_7 = 1.25$ as is normally the case, the minimum lap lengths are as follows:

Lap length $L_{sy.tb.lap}$ calculated in accordance with Clause 13.2.2 (mm)		
	20MPa concrete	25MPa concrete
N12 vertical bars	490	440
N12 horizontal bars	640	570
N16 vertical bars	675	605

Clause 13.2.2 states that the tabulated lap lengths apply to both contact and non-contact splices. Note that Clause 13.2.1 states that lap splices shall not be used in tension tie members; in these members splices must be made only by welding or mechanical means.