SECTION 5. SLENDERNESS RATIO

Slenderness ratio is the measure of height or length of a wall or pier divided by the thickness, sometimes multiplied by a ratio to account for fixity of the ends, lateral restraint etc. It provides a means of calculating the robustness of a structural member, and it is used in calculations to adjust the capacity of a structural member to account for the possibility of buckling causing a premature mode of failure.

AS 3700 stipulates the following:

- maximum slenderness for robustness,
- maximum slenderness for various FRL's depending on whether the structural member is reinforced or not, and
- maximum slenderness for compression members and the relationship between compression capacity and slenderness.

All structural members should be proportioned to satisfy the most stringent requirement for slenderness.

5.1 Requirement for robustness

Stocky structural members are more robust than slender structural members and therefore as the slenderness ratio of a structural member increases the robustness of the member decreases. AS 3700 Clause 4.6 requires that all masonry members and their connections have an adequate degree of robustness and it sets out the minimum requirements for a **deemed to comply** situation. These are as follows:

a) Walls

Clause 4.6.2 simply requires all walls to be proportioned to resist an unfactored out-of-plane horizontal load of 0.5kPa whether they be designed as reinforced or unreinforced. When the walls are being designed to carry axial compression loads those loads are to be disregarded when checking for the 0.5kPa lateral loading. In contrast to AS 3700:2001slenderness ratio limits are no longer given.

b) Isolated piers

Clause 4.6.3 requires isolated piers to be proportioned such that

$$\frac{H}{t_r} \leq C_v$$

Where: H = the clear height of the pier between horizontal lateral supports,

t_r = the minimum thickness of the pier,

C_v = robustness coefficient
= 13.5 for piers that are not reinforced vertically
= 30 for piers that are reinforced vertically and where the reinforcement complies with the requirements of AS 3700 Clause 8.6 for members in bending.

5.2 Requirement for fire resistance – structural adequacy

Mortarless masonry must always be fully grouted, however it can be designed as reinforced or unreinforced as required.

In terms of fire resistance, if ***mortarless*** masonry is not reinforced to the minimum requirements of AS 3700 then it must be considered unreinforced masonry and it must comply with slenderness ratio limitations provided in the table below (taken from AS 3700 Table 6.1) for unreinforced masonry. These decrease as the fire resistance period increases.

Reinforced ***mortarless*** masonry must also comply with slenderness ratio limitations provided in the table below, but these are constantly 36.0 regardless of the fire resistance period.

Table SR3: Maximum slenderness ratios for structural adequacy

	Maximum slenderness ratio					
Fire resistance period - minutes	30	60	90	120	180	240
Unreinforced mortarless	19.5	18.0	17.0	16.0	15.5	15.0
Reinforced mortarless	36.0	36.0	36.0	36.0	36.0	36.0

Note that **'**reinforced ***mortarless'*** refers to ***mortarless*** masonry that is reinforced for bending but not necessarily for compression.

Refer to AS 3700 Clause 6.3.2.2 for actual calculation of the slenderness ratio.

If the slenderness limit for reinforced masonry is adopted, the minimum horizontal or vertical reinforcement must be sufficient to withstand a lateral load of 0.5kPa depending on whether the wall is spanning horizontally or vertically, and in the situation of the wall spanning vertically, the vertical reinforcement must also be adequate to resist a flexural moment equivalent to the vertical load times the height of the wall divided by 36, but not acting simultaneously with the lateral load of 0.5kPa. (AS 3700 Clause 6.3.5).

5.3 Requirement for compression members designed by refined calculation

AS 3700 Clause 7.3.4.3 requires the slenderness ratio for a wall designed using refined calculations to be calculated as follows:

- For a wall that is laterally supported along one or both of its vertical edges and subject to a design compressive force $F_d \leq 0.20 F_0$ the lesser of

$$S_r = \frac{a_v H}{k_t t} \quad \text{or}$$

$$S_r = \frac{0.7}{t}\sqrt{a_v H a_h L}$$

Where: S_r = the slenderness ratio

a_v = a slenderness coefficient

= 0.75 for a member laterally supported and partially rotationally restrained at both top and bottom

= 0.85 for a member laterally supported at top and bottom and partially rotationally restrained at one of them

= 1.0 for a member laterally supported at both top and bottom

= 1.5 for a member laterally supported and partially rotationally restrained at the bottom and partially laterally supported at the top

= 2.5 for a free standing wall.

H = the clear height of a member between horizontal lateral supports, or for a member without top horizontal support, the overall height from the bottom lateral support.

k_t = a thickness coefficient derived from Table 7.2. (note that any engaged piers that are not fully monolithic as described in Clause 4.11 are not to be considered)

a_h = a slenderness coefficient

= 1.0 if the member is laterally supported along both of its vertical edges (regardless of any rotational restraint along these edges)

= 2.5 if the member is laterally supported along one of its vertical edges, and unsupported along its other vertical edge

L = the clear length of a wall between vertical edge lateral supports

= the length from a vertical edge lateral support at one end to a free end or a control joint

t = the overall thickness of the wall, or the overall thickness or length of an isolated pier (for cavity wall construction each leaf must be assessed individually)

- For the masonry between any two consecutive openings in a wall which by definition is an isolated pier, the slenderness of that isolated pier is to be the lesser of the following:

$$\boldsymbol{S_r = \frac{2 H_1}{t}}$$ and the value of S_r calculated as given below.

Where: S_r = the slenderness ratio

H_v = the height of the taller opening

t = the design thickness of the wall

- For all other cases

$$S_r = \frac{a_v H}{k_t t}$$

Where: S_r = the slenderness ratio

a_v = a slenderness coefficient

= 0.75 for a member laterally supported and partially rotationally restrained at both top and bottom

= 0.85 for a member laterally supported at top and bottom and partially rotationally restrained at one of them

= 1.0 for a member laterally supported at both top and bottom

= 1.5 for a member laterally supported and partially rotationally restrained at the bottom and partially laterally supported at the top

= 2.5 for a free standing wall.

H = the clear height of a member between horizontal lateral supports, or for a member without top horizontal support, the overall height from the bottom lateral support.

k_t = a thickness coefficient derived from Table 7.2. (note that any engaged piers that are not fully monolithic as described in Clause 4.11 are not to be considered)

t = the overall thickness of the member's cross section perpendicular to the principal axis under consideration

Engineers should note the following:

- The requirements of AS 3700 Clause 2.6.3 must be met if an edge is to be considered laterally supported. This stipulates that the horizontal design load to be resisted by the lateral support must be the larger of the static reaction from all horizontal forces applied plus 2.5% of the vertical load, and a horizontal load equal to 0.5kPa times the tributary area.

- A control joint or an edge to an opening is to be regarded as an unsupported edge unless specifically detailed otherwise (refer Clause 4.6.2).