AS 3700 'MASONRY STRUCTURES'
REINFORCED MASONRY UNDER COMPRESSION

UPDATE

The **Concrete Masonry Association of Australia (CMAA)** identified that due to some impractical reinforcement detailing requirements the current design method for compression in AS 3700 'Masonry Structures' for reinforced masonry (RM) walls severely limits the design compressive capacity of RM walls.

SITUATION

Recent research funded by the CMAA at the Queensland University of Technology (QUT) is being accepted by the BD-004 Standards Australia committee to revise the AS 3700 design method by:

- Relaxing stringency on the detailing of the vertical steel
- Recognising the true contribution of grout to the walls compressive strength, and
- Remove the current limitation on the allowable grout strength (being 1.3 x the masonry unit's strength)

RESEARCH AIMS

The research aimed to investigate the effectiveness of the vertical steel in contributing to the compressive strength of the wall, **despite being laterally unrestrained.**

HYPOTHESIS

It was hypothesised the grout should provide **some degree of lateral restraint** to prevent the vertical steel from buckling when compressed.

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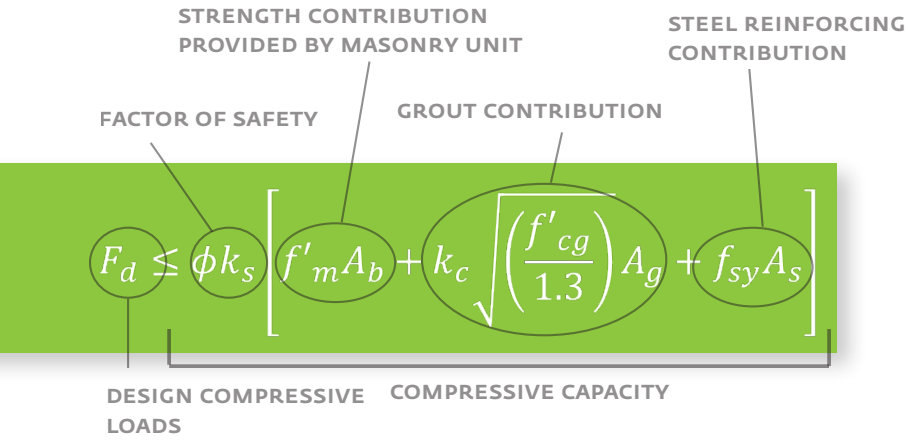
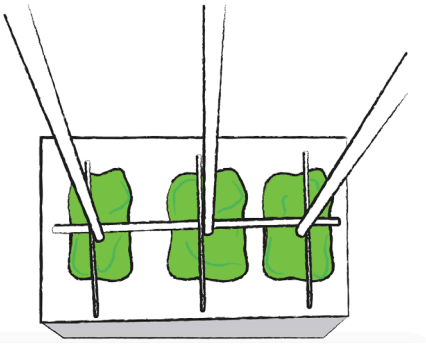
CURRENT SITUATION



Equation 8.5 (left) is used to calculate whether the compressive capacity provided by a RM wall (RH side of equation) is enough to satisfy the design compressive forces (F_d) acting vertically through the walls cross section.



Where:

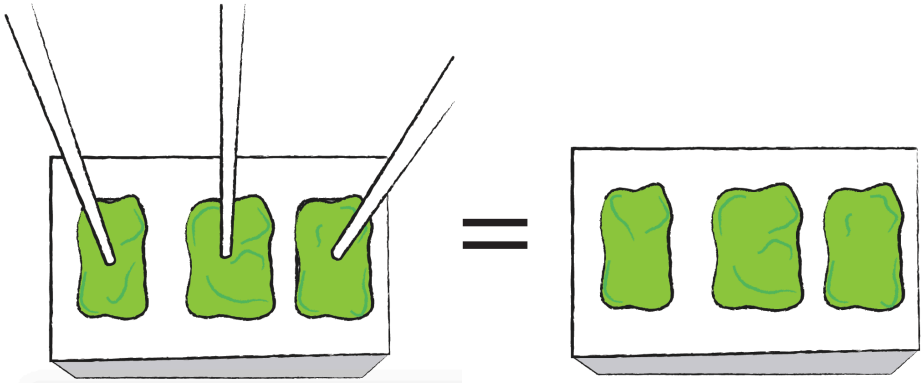
Φ = capacity reduction factor=0.75 (Table 4.1 AS 3700 (2011))

*See final page for a full list of all notation used

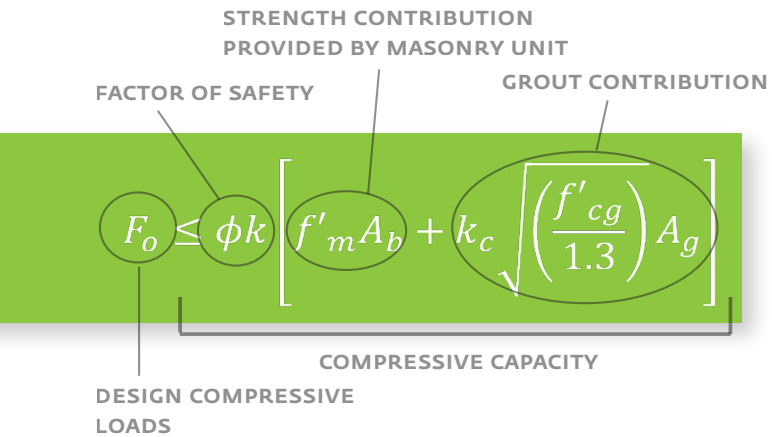
Currently, clause 8.5 (b) requires the vertical steel in RM to be laterally restrained by horizontal ties, in both directions, or else the contribution provided by the steel (f_{sy} A_s) is taken as zero and the wall designed as URM.

This is fine, however this detailing requirement is impractical, time consuming, costly and is rarely adhered to onsite.

In fact, if you do comply with clause 8.5 (b) you will find it difficult to comply with other areas of AS 3700, such as ensuring the grout flows into all the voids.



The **left detail** is what ends up occurring, and is still considered as RM for satisfying wind and earthquake lateral loads, but in compression, it is considered as URM.



The URM equation 7.3.3.2 is at left, where:

Φ = 0.5 (Table 4.1 AS 3700 (2011)

*See final page for a full list of all notation used

When applying each of these equations, there are significant differences in capacity provided.

EXAMPLE: For a commonly constructed reinforced concrete block wall on the ground floor of a common office building, with the wall being 2.7m high, 6m long, 190mm thick, 15MPa blocks with 20MPa grout and N16 bars @ 200 centres:

- Equation 8.5 for RM provides a capacity of **978 KN/m (allowing approximately 8-9 stories on top)**
- Equation 7.3.3.2 for URM will provide a capacity of **364.4KNm (allowing approximately 3-4 stories on top)**

Because of the impracticality of clause 8.5(b), designers are forced to use the capacity of URM walls when designing RM, which presents a significant disadvantage to RM's design compressive capacity compared to other materials, and thus research by the CMAA was sought.

RESEARCH FINDINGS

- No benefit provided by laterally retraining the steel via ties
- The contribution of the grout to the overall compressive capacity of the wall was significantly higher than suggested by AS 3700 (2011)
- The magnitude of the contribution provided by the grout increased with increased grout strengths
- The strength of the grout is currently limited to 1.3 x the strength of the masonry unit, yet grout strengths of up to 3 times higher than that of the masonry were used in this testing without any adversity in the results

From this testing and subsequent analysis, equation 8.5 AS 3700 (2011) will be amended to:

$$F_d \leq \phi k_{es} \left[f'_m A_b + k_c \left(\frac{f'_{cg}}{1.3} \right)^{0.55+0.055 f'_c} A_g + \alpha_r f_{sy} A_s \right]$$

Where:

k_{es} = (1.0-0.025S_r)(1-2 e/t)

$e < 0.05t\_w$

Φ = 0.75 (as per RM in table 4.1)

α_r = reinforcement contribution factor
= 0.4 (for RM walls)
= 1 (for RM piers/columns)

$f'_{cg} \geq f'_m$

It is proposed equation 7.3.3.2 for the purposes of grouted URM be altered to:

$$F_d \leq \phi k \left[f'_m A_b + k_c \left(\frac{f'_{cg}}{1.3} \right)^{0.55+0.055 f'_c} A_g \right]$$

Where:

Φ = 0.5 (as per URM in table 4.1)

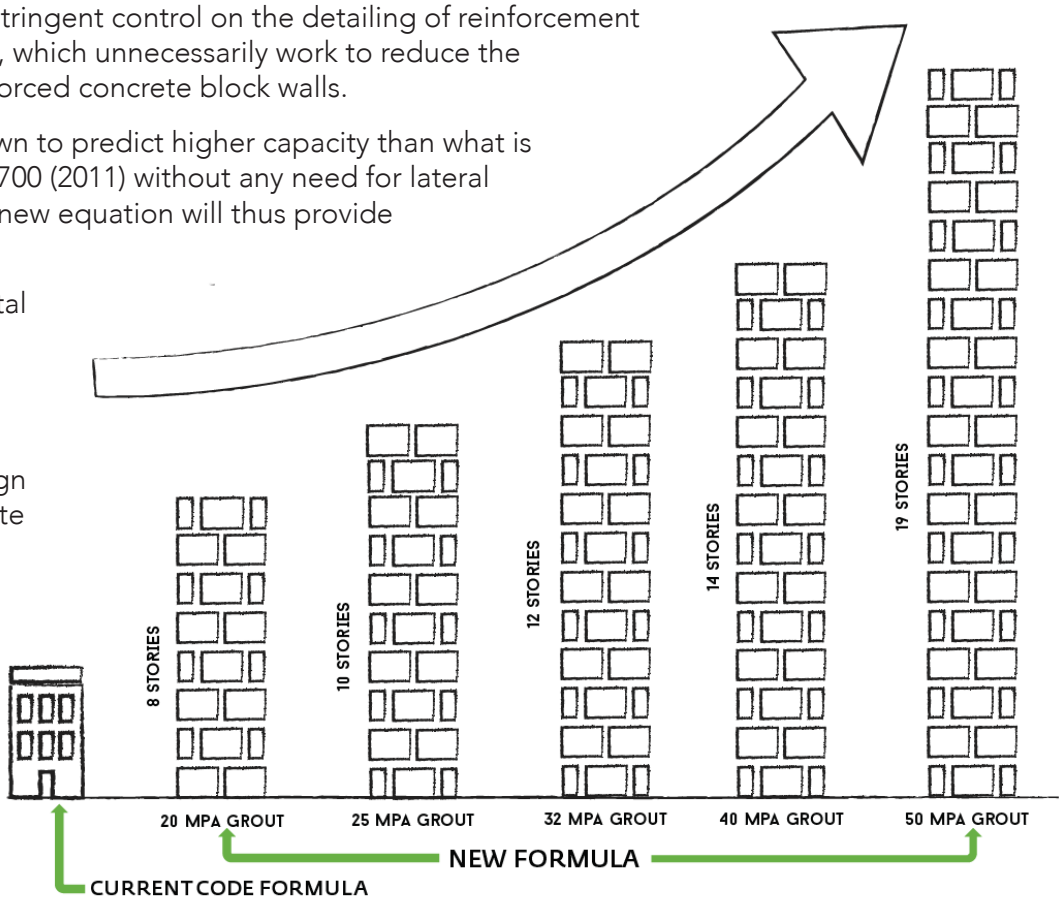
$f'_{cg} \geq f'_m$

CHANGES TO THE AS3700 DESIGN METHOD

These formulas are evidence based, self-consistent and easy to use. Once implemented in the AS 3700 revision, designers could design RM walls under compression with ease, rationally allowing for slenderness and eccentricity without the stringent control on the detailing of reinforcement and the strength of the grout, which unnecessarily work to reduce the compressive capacity of reinforced concrete block walls.

The proposed formula is shown to predict higher capacity than what is currently represented in AS 3700 (2011) without any need for lateral reinforcement detailing. The new equation will thus provide more competitive designs.

In conclusion, the experimental research has uncovered data and knowledge hitherto not well understood and has provided a strong basis to develop a more rational design formula for reinforced concrete masonry walls.



NOTATION:

F_d = Design compressive force acting on the member's cross section

k_s = 1.18-0.03S_r

S_r = Slenderness ratio

k = Reduction factor for slenderness and eccentricity

f'_m = Characteristic compressive strength (Cl 3.3.2)

A_b = Bedded area of a masonry member cross-section

k_c = Strength factor for grout in compression (Cl 7.3.2)

f'_{cg} = Design compressive strength of grout (Cl 3.5)

$f'_{cg} < 1.3f'_{uc}$ (Cl 3.5)

A_g = Design cross section area of grout

f'_{sy} = Design yield strength of reinforcement

A_s = Total cross sectional area of main reinforcement

The **Concrete Masonry Association of Australia (CMAA)** is the peak body representing the concrete masonry manufacturers of Australia, including bricks, blocks, pavers & retaining walls.

We support the concrete masonry industry by providing technical information and advice to architects, engineers, specifiers and educators.

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