

AS 3600:2018 Concrete Column Design

Overview

This calculator is for the design of reinforced non-prestressed concrete columns as per AS 3600:2018. The following calculations are performed:

Column slenderness is determined in each direction depending on user inputs.

Design bending moments are calculated based on slenderness.

Moment capacities are derived from interaction diagrams, which are drawn based on the section properties of the column.

Shear capacities of the section are determined using the inclined strut truss model.

Detailing checks are performed on the section.

Assumptions

When calculating shear, the angle of the ligatures is assumed to be perpendicular to the longitudinal reinforcement and the longitudinal reinforcement is parallel with all faces of the concrete.

Aggregate size is assumed to be 20mm for calculations.

Section Analysis

Interaction Diagrams

The bending capacity of the concrete column is derived from interaction diagrams drawn for each axis. The interaction line is plotted by calculating values of 'M' and 'N' at varying depths of the neutral axis. This is done by determining the strains in the concrete and reinforcement bars for a given depth of the neutral axis. These strains can be converted into forces, which can then be used to calculate the maximum axial load and bending moment that the column can resist for that neutral axis depth.

Notes:

Moments are taken about the plastic centroid of the section.

The concrete block strength $\alpha_2 f_c$ is reduced by 5% for circular sections as per 10.6.2.5 NOTE 3.

The resultant concrete force is assumed to act at the centroid of the rectangular stress block.

For rectangular sections, this is taken as half the height of the block.

For circular sections, this is calculated by finding the centroid of the segment in compression, where the height of the segment is equal to $\gamma \cdot k_u \cdot d_0$.

Column Design

Axial Capacity

The ultimate compression strength of a column is defined as its squash load (N_{uo}). This is calculated assuming the section's reinforcement has reached its full yield stress (f_{sy}) in compression and the concrete is under a uniform compressive stress of $\alpha_1 f_c$ (10.6.2.2). The tensile capacity of the section is calculated as the strength of the reinforcement and ignores any contribution from the concrete.

Design Moments

The moments used to design a concrete column depend on the slenderness of the column in the considered axis. If the column is not slender (or 'short'), then the column only needs to be checked for first order moments. The column must be designed for second order moments for each axis about which it is slender.

Users have the option to directly provide second-order moments to be used in the calculation. This option is only available if the column is slender.

Column Moments:

$$M_1^* = \max [M_{min} ; \min [M_{top} ; M_{bottom}]]$$

$$M_2^* = \max [M_{min} ; \max [M_{top} ; M_{bottom}]]$$

Notes:

M_1 / M_2 is taken as negative when the column is bent in single curvature. In this calculator, this is when the moments have the same sign.

M_{min} is calculated as $N^* \times 0.05D$ (10.1.2).

Calculate Slenderness:

A column is deemed to not be slender if it is within the limits outlined below. A column's slenderness ratio (L_e / r) should not exceed 120. Note that radius of gyration is calculated as $(I / A)^{0.5}$.

Braced:

10.3.1(1)

$$\frac{L_e}{r} \leq \max \left[25 ; \alpha_c \left(38 - \frac{f'_c}{15} \right) \left(1 + \frac{M_1^*}{M_2^*} \right) \right]$$

$$\alpha_c = \sqrt{2.25 - 2.5 \frac{N^*}{\phi N_{uo}}} \quad \text{for } \frac{N^*}{\phi N_{uo}} \geq 0.15; \text{ or}$$

$$\alpha_c = \sqrt{\frac{1}{3.5 \frac{N^*}{\phi N_{uo}}}} \quad \text{for } \frac{N^*}{\phi N_{uo}} < 0.15$$

Unbraced:

10.3.1(2)

$$\frac{L_e}{r} \leq 22$$

Moment Magnification:

If a column is found to be slender, then the design moment is calculated as the first order moment multiplied by a magnification factor (δ). For braced columns, this factor is equal to the braced moment magnifier (δ_b). For unbraced columns it is the larger of the braced moment magnifier and the sway moment magnifier (δ_s). This tool does not offer a calculation for δ_s , so the user must calculate it separately as outlined in 10.4.3(b).

Braced Moment Magnification Factor, δ_b

10.4.2

$$\delta_b = \frac{k_m}{\left(1 - \frac{N^*}{N_c} \right)} \geq 1$$

$$k_m = \left(0.6 - 0.4 \frac{M_1^*}{M_2^*} \right) \geq 0.4$$

Buckling Load, N_c

10.4.4

$$N_c = \left(\frac{\pi^2}{L_e^2} \right) \left[\frac{182d_o(\phi M_c)}{1 + \beta_d} \right] \quad \text{where } M_c \text{ is the balance moment, } M_{ub} \text{ when } k_u = 0.545$$

$$\beta_d = \frac{G}{G + Q}$$

Bending Capacity

The bending moment capacity is calculated in each axis by plotting the coordinates of the design forces (axial load and bending moment) on the interaction diagrams. A line is drawn parallel to the x-axis, which intersects this coordinate ($N =$ design axial load). The moment capacity is taken at the point where this line intersects the interaction line.

Biaxial Bending Check

10.6.4

$$\left(\frac{M_x^*}{\phi M_{ux}} \right)^{a_n} + \left(\frac{M_y^*}{\phi M_{uy}} \right)^{a_n} \leq 1.0$$

$$\alpha_n = 0.7 + 1.7 \frac{N^*}{\phi N_{uo}}, \quad \text{with } 1 \leq \alpha_n \leq 2$$

Shear Capacity

The total shear capacity of the column is calculated as the capacity of the concrete combined with the capacity of the shear reinforcement. This value is limited to the crushing strength of the shear web.

$$V_u = \min [V_{uc} + V_{us}; V_{u,max}] \quad 10.4.2$$

Shear Strength Limited By Web Crushing 8.2.3.3

$$V_{u,max} = 0.55 \left[0.9 f'_c b_v d_v \left(\frac{\cot \theta_v + \cot \alpha_v}{1 + \cot^2 \theta_v} \right) \right]$$

$$d_v = \max [0.72D; 0.9d] \quad 8.2.1.9$$

$$\theta_v = (29 + 7000 \varepsilon_x) \quad 8.2.4.2(1)$$

Mid-Height Strain, ε_x 8.2.4.2.2

$$\varepsilon_x = \frac{\left| \frac{M^*}{d_v} \right| + |V^*| + 0.5N^*}{2(E_s A_{st})} \leq 3.0 \times 10^{-3}$$

Note: Mid-height strain calculation excludes the contribution of steel on the mid-height line.

If ε_x is found to be negative (in compression), then the value should be further modified using the equation below:

$$\varepsilon_x = -2.0 \times 10^{-3} \leq \frac{\left| \frac{M^*}{d_v} \right| + |V^*| + 0.5N^*}{2(E_s A_{st} + E_c A_{ct})} \leq 0$$

Concrete Contribution To Shear Strength, V_{uc} 8.2.4.1

$$V_{uc} = k_v b_v d_v \sqrt{f'_c}$$

Calculation of k_v

$$\text{when } \frac{A_{sv}}{s} < \frac{A_{sv,min}}{s}, \quad k_v = \left[\frac{0.4}{1 + 1500 \varepsilon_x} \right] \left[\frac{1300}{1000 + k_{dg} d_v} \right] \quad 8.2.4.2(2)$$

$$\text{when } \frac{A_{sv}}{s} \geq \frac{A_{sv,min}}{s}, \quad k_v = \left[\frac{0.4}{1 + 1500 \varepsilon_x} \right] \quad 8.2.4.2(5)$$

Shear Reinforcement Contribution To Shear Strength k_v 8.2.5.2

$$V_{us} = \left(\frac{A_{sv} f_{sy,f} d_v}{s} \right) \cot(\theta_v)$$

Biaxial Shear Capacity

This calculator includes a value for 'Biaxial Shear', which is calculated as the resultant of the mono-axial shear utilisations in the 'Y' and 'Z' axes. AS3600 does not provide specific guidance on how to consider a concrete section for biaxial shear, so this value is provided as a conservative safeguard.

Change Log

1) Initial deployment 05/09/2025.

Feedback

We're constantly looking to expand and improve our product offering!

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