

# Structural Analysis of Masonry Buildings

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Key concepts, typical procedures, and practical guidelines

### 1. Introduction to Masonry Structures

| Aspect                  | Description                                                                                                                                                                       |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Definition              | Assemblies of units (bricks, blocks, stone) bonded with mortar, often reinforced with steel or fibers.                                                                            |
| Common Types            | – <b>Solid masonry</b> (load-bearing walls)                                                                                                                                       |
|                         | – <b>Cavity masonry</b> (inner/outer leaves)                                                                                                                                      |
|                         | – <b>Reinforced masonry</b> (RM) – steel bars or mesh embedded in mortar.                                                                                                         |
| Typical Uses            | Residential, commercial, industrial, heritage structures, low-rise high-rise, seismic retrofits. <ul style="list-style-type: none"><li>• Eurocode 6 (EN 1996) – Masonry</li></ul> |
| Design Codes (selected) | <ul style="list-style-type: none"><li>• ACI 530/ASCE 5 – Masonry Design</li><li>• IBC Chapter 22 – Masonry</li><li>• BS 5628 – Structural Use of Masonry</li></ul>                |

### 2. Fundamental Mechanical Behaviour

| Property                     | Typical Range                                  | Influencing Factors                          |
|------------------------------|------------------------------------------------|----------------------------------------------|
| Compressive strength, $f_c$  | 5–40 MPa (brick)<br>10–80 MPa (concrete block) | Unit material, mortar type, curing, density. |
| Tensile strength, $f_t$      | 0.2–1.5 MPa                                    | Very low; governs cracking and shear.        |
| Modulus of elasticity, $E_c$ | 5–15 GPa                                       | Unit stiffness, mortar, confinement.         |
| Poisson’s ratio, $\nu$       | 0.15–0.25                                      | Material composition.                        |
| Shear strength, $V_c$        | 0.5–1.0 $f_c$ (MPa)                            | Mortar bond, unit interlock.                 |

Key points

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- Masonry behaves **linearly elastic** up to ~30% of its compressive strength; thereafter it softens and crushes.
  - **Anisotropy**: properties differ in the direction of the mortar joints (weak) vs. the direction of the units (strong).
  - **Cracking** occurs when tensile stresses exceed  $f_t$ ; cracks localise along mortar joints.
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## 3. Load Path & Structural System

1. **Vertical Loads** – gravity (dead + live) → transferred through **load-bearing walls** to foundations.
2. **Lateral Loads** – wind, seismic → resisted by **shear walls, diaphragms, and boundary elements** (corners, openings).
3. **Out-of-Plane Bending** – walls act as vertical plates; critical for openings and wall slenderness.

### Typical wall classifications

| Wall Type          | Height-to-Thickness Ratio (h/t) | Typical Use                           |
|--------------------|---------------------------------|---------------------------------------|
| Stiff (shear) wall | $\leq 10$                       | Core of high-rise, seismic zones      |
| Partition wall     | $> 10$                          | Interior partitions, non-load-bearing |
| Boundary wall      | $\approx 8$                     | Corners, perimeters, openings support |

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## 4. Analytical Models

| Model                                | Applicability                         | Governing Equations                          |
|--------------------------------------|---------------------------------------|----------------------------------------------|
| Linear Elastic Analysis              | Small stresses, serviceability checks | $\sigma = E\epsilon$ , shear flow $q = VQ/I$ |
| Elastic-Plastic (Limit State) Method | Design for ultimate loads             | $\sigma \leq f_c/\gamma_c$ , $V \leq V_c$    |