STRUCTURAL ENGINEERING

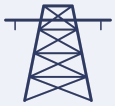
Everything you need to know on two sides. Read it · cover it · test yourself · check.

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01 FORMS OF STRUCTURE



MASS
Strong because it is heavy — stone, brick or concrete. e.g. dam, pyramid, drystone dyke.



FRAME
A skeleton of members carries the load. e.g. pylon, bicycle, steel-framed skyscraper.



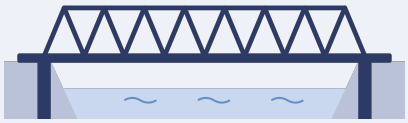
SHELL
A thin outer skin carries the load. e.g. egg, drinks can, car body, helmet.

Biomimicry = copying nature to solve human problems (e.g. a building cooled like a termite mound).

02 SIX TYPES OF BRIDGE



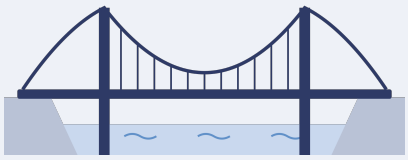
BEAM — A straight deck rests on piers. Simple and cheap — short spans.



TRUSS — A frame of triangles makes a light, stiff structure.



ARCH — A curve pushes the load outwards into the ground — all in compression.



SUSPENSION — The deck hangs from main cables slung between towers. Longest spans.



CABLE-STAYED — Straight cables run from the towers directly to the deck.



CANTILEVER — Arms reach out from the piers and carry a central span.

03 CHOOSING A BRIDGE

Engineers consider: **span** (distance to cross) · **cost** · **volume of traffic** · **weight of traffic** · **environment and weather** · **lifespan**.

Bridges affect the **economy** (jobs, trade, tourism, travel time) and the **environment** (wildlife, habitats, pollution).

Scottish examples: Forth Bridge (cantilever, 1890) · Forth Road Bridge (suspension, 1964) · Queensferry Crossing (cable-stayed, 2017) · Glenfinnan Viaduct (concrete arches, 1901).

04 WHO BUILDS STRUCTURES?

- **Structural engineer** — calculates forces so structures are safe
- **Architect** — designs how buildings look and work
- **Civil engineer** — roads, railways, bridges, dams, water
- **Quantity surveyor** — controls the costs
- **CAD technician** — 2D drawings and 3D models
- **Site manager** — runs the construction site

Routes in: **university**, **college** or an **apprenticeship**.

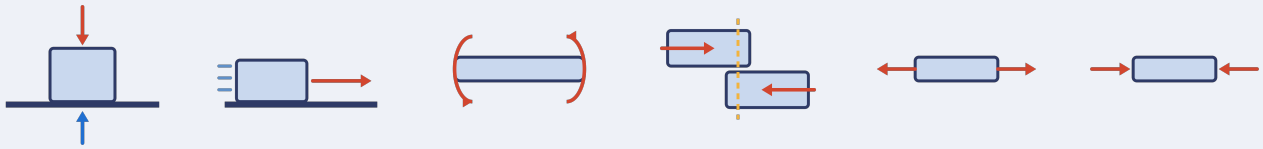
FORCES, FRAMES & MOMENTS

Mass and force · types of force · tension and compression · beams · frames · moments.

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05 FORCES

Mass = amount of matter, in **kilograms (kg)**. **Force** = a push or a pull, in **newtons (N)**. **Strength-to-weight ratio** = load held ÷ mass of structure.



Static constant, does not change

Dynamic changes in size or direction

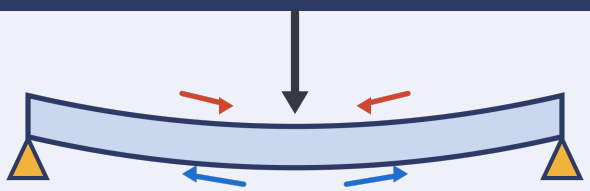
Torsion twisting about an axis

Shear pushed opposite ways, like scissors

Tension pulls apart — makes longer

Compression squeezes — makes shorter

06 SQUASH AND STRETCH



A loaded beam bends: the **top** is in **compression**, the **bottom** is in **tension**. Concrete is strong in compression but weak in tension, so steel bars go near the bottom (**reinforced concrete**).

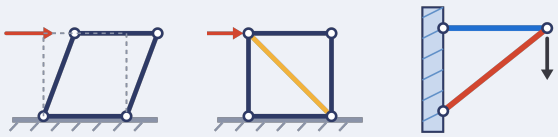
07 BEAM SECTIONS



I-beam · Channel · Angle · T-section · Box · Tube

A length of metal is a **beam**. Its cut-through shape is the **section**. Most of an I-beam's material is at the top and bottom, where it is squashed and stretched most — so it is stiff but light.

08 FRAMES



Racking — a frame deforms out of square. **Cross-bracing** joins opposite corners to make **triangles**, which cannot rack. **Tie** = member in tension (blue). **Strut** = member in compression (red).

09 MOMENTS

moment (Nm) = force (N) × distance (m)
Distance is measured from the **pivot** (fulcrum).
Balanced: **clockwise moments = anticlockwise moments**.
Example: 100 N at 2 m (clockwise) balances F at 1 m (anticlockwise): 100 × 2 = F × 1, so **F = 200 N**.
cm to m: divide by 100.

10 KEY WORDS

Structure — something built to carry loads safely

Load — a force acting on a structure

Span — the distance a bridge crosses

Pier — a support under a bridge

Member — one part of a frame

Truss — a frame made of triangles

Pivot / fulcrum — the point something turns about

Buckling — a long thin strut bending sideways

Gusset — a plate that strengthens a joint

TEST YOURSELF

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Cover the organiser. Answer from memory. Then check and correct in a different colour.

1. What is the difference between a mass, a frame and a shell structure?
2. What is biomimicry? Give an example.
3. Name the six types of bridge.
4. Which two bridge types can span the longest distances?
5. Name four things engineers consider when choosing a bridge.
6. What units are mass and force measured in?
7. What is the difference between tension and compression?
8. Name the six types of force.
9. What is racking, and how do you stop it?
10. What is the difference between a strut and a tie?
11. Write the formula for a moment, with units.
12. A 60 N force acts 3 m clockwise from the pivot. What force at 2 m anticlockwise balances it?