Structural Engineering

Structures can be classified based on deformation and type of primary load carried (i.e. Axial (tensile, compressive), flexure, shear and torsion) and their combinations. In order to determine the type of the structure we need to strip it down to its basic skeleton.

The human skeleton is a structure which maintains the shape of the body, keeps the various organs and muscles in the right place and transmits loads down to the ground.

Various components carry different types of loads. The material of the bough is stretched near its upper surface and compressed or contracted near its lower surface by the weight of the monkey.

A building structure safely transmits loads down to Earth.

The spider’s web is a good example of a tension structure. The weight of the spider and its prey is supported by tensile strength of the web.

All materials and structures deflect, to greatly varying extents, when they are loaded. The science of elasticity is about the interactions between forces and deflections. The material of the bough is stretched near its upper surface and compressed or contracted near its lower surface by the weight of the monkey.

Maintain / shape / transmit / ground

Spider web / tension structure / tensile strength

Ground level / foundation / soil / rock

Defact / elasticity / interaction between forces and deflections / stretch / compress / contract
Some Types of Structures

- Arch
- Planar Truss
- Beam/Girder
- Braced Frame
- Rigid Frame
- Space Truss
- Cable Suspended Structure
Collapse or failure may take place under applied extreme loads such as earthquake, wind or blast. Failure may take place in various modes: plastic deformation (ductile, yielding), brittle fracture, buckling (elastic or inelastic), fatigue, vibration (resonance), foundation settlement and failure.

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- Plastic deformation (ductile, yielding)
- Brittle fracture
- Buckling (elastic or inelastic)
- Fatigue
- Vibration (resonance)
- Foundation settlement
- Failure

A structure damaged during Northridge (CA) Earthquake

Unexpected load scenario (for instance fire damage) and unwise design like inadequate sealing and paint protection that cause leakage and subsequent corrosion may also lead the structure to a case where it becomes out of service.

Some loading types such as blasts cannot be beared. No matter how strong your design is damage may sometimes become just unavoidable as a result of the severity of loading unless your structure is built underground.

A structure with blown off roof under strong winds

Damaged facade cladding during a hurricane

blown off / roof / facade cladding / hurricane

The blast damage on A. F. Murrah Federal Building in Oklahoma City

The nuclear blast damage in Hiroshima

An underground shelter

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A buckled column due to excessive axial load during earthquake

Buckling of a thin-shell cylinder

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Brittle vs. Ductile Fracture

- Ductile materials: extensive plastic deformation and energy absorption ("hinge") before fracture
- Brittle materials: little plastic deformation and low energy absorption before fracture

Fracture behavior:
- Very ductile
- Ductile
- Moderate
- Brittle
- Very brittle

Toughness / fracture

plastic hinge / sway / non-ductile / energy absorption / toughness / fracture
The Narrows Bridge collapsed as result of resonance in torsional mode of vibration.

https://www.youtube.com/watch?v=JUVgouE_sg0

Collapse of a silo structure (The Transcona Grain Elevator) as a result of foundation failure (a) before collapse, and (b) after collapse

Sealing a gap at the door-wall interface to prevent water infiltration using silicon type sealing material.

Complete deterioration of prefabricated reinforced concrete driven pile as a result of corrosion that took place in sea water that triggers chlorine attack on concrete cover leading to the corrosion of rebar and spalling of the concrete. The rust accumulates on steel expanding the rebar diameter generating large pressures at micro scale.

Build-up / cracking / march on / extensive / break away / spalling / stain

Bridges

approach embankment / abutment / back wall / longitudinal girder / cross girders / pier / slab / road level / approach slab / deck slab / kerb / handrail / parapet bearing / effective span / bed level / foundation
Steel Buildings

purlin / eave / ridge / roof system / rafter / haunch / wall girt / post / gable / anchor bolt / rigid frame / bay spacing

Steel Connection Details

transition plate / assembly support angle / weld / provisional / leveling mortar / lock nut / anchorage plate / bevel

Reinforced Concrete Building Details

slab / beam / column / spread footing / pedestal / slab on grade / basement floor / column capital / drop panel / bracket / roof / flat plate / upturned beam

Reinforced Concrete Retaining Wall Details

stem / toe slab / counterfort / heel slab / distribution bar / hardcore / rubble / filtering material / weep hole / shrinkage crack / drainage channel / main bar / binders to beam / lean concrete / rebar / bending tendency / heel / toe

weathering course / parapet / roof slab / brick masonry / lintel / damp proof course / plinth / floor finish / floor concrete / sand filling / foundation / step
Reinforcement Cage of a Simply Supported Beam

hanger bar / restrain / stirrup / dislocation / hook / longitudinal bar / tension reinforcement / support / shear / steel wire / precut and prebent bar / cage

stirrup hanger / primary beam / secondary beam / support bar / construction joint / mud slab / mesh spacer / perimeter beam bottom reinforcement