

Register of some important notions in structural mechanics

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Notions written in bold should be known!

Andrew-cross - X-shaped bracing, in which generally only the diagonal subjected to tension is working when loaded, the compressed diagonal buckles – due to its great slenderness ratio – at very little load level

Arch – a structural member with an upward-curved centre-line axis and a relatively small cross-section, supported so that the distance between the extremities can not change

Arm, moment – distance between line of action of a force and axis (or point) about which moments are being taken

Axial – in line with the axis. An axial force causes pure normal (tension or compression) stress over the cross-section of a member.

Axis – straight or curved line along the centre-line of a member

Neutral axis – centroid axis, transverse to longitudinal axis of a structural member, which is neither stretched nor shortened by bending of the member

Bay – the space between columns or walls, which is repeated as a structural modul

Beam, girder, joist – structural member loaded normal to its longitudinal axis, its cross-section usually deeper in the direction of loading and narrower in width.

Bracing – a kind of support, which impedes moving and rotation in all directions

Brick vault - one kind of horizontal loadbearing structure

Brickwork, brick wall – one kind of vertical loadbearing structure

Buckling – mode of failure under compression due to loss of stability. With very thin members, the buckling may be elastic, and the member will spring back to its original axis if the load is removed. The longitudinal axis of a prismatic member takes the shape approximately of a sine curve.

Building constructions – parts of building designed for different – but not loadbearing – functions, such as: windows, partition walls, false ceilings etc.

Cable – thin flexible member which takes only tensile forces usually made up of steel wires.

Cantilever – beam or column restrained at one end and free at the other end

Centre of gravity - point of application of gravity forces

Characteristic value - $f_k = f_m - ts$

where t is the so called Student factor, which, for $n=10$ and 5% risk is $t=1,79$ (5% threshold value: the probability of the occurrence of a strength value smaller than f_k is 5%)

Cinematic loads - loads applied through dislocation of a point or part of the structure, such as uneven settlement

Column – a usually vertical and prismatic member loaded generally in compression

Continuous beam – beam having more than two supports

Couple (of forces) – two equal and parallel forces of opposite direction

Cover – concrete cover on the surface of the elements of the reinforcement in reinforced concrete members

Component – one of two or more forces which acting together have the same effect as a single force, called the resultant.

Compression – the pushing together of one particle, element or portion of a structure toward the adjacent particle, element or portion.

Constructional units of buildings building constructions

Cornice - architectural façade construction unit of the façade, protruding from the vertical plane of the façade at top of the levels or the building

Couple - moment, produced by two parallel forces of equal magnitude and opposite direction

Cross-section – section of linear members (beams, columns) perpendicular to their axis

Curvature – specific change of the direction of curves, the second derivative function of deflections or reciprocal of the radius of curvature

Deflection – vertical displacement of points of axis of beams due to loading

Deformability – the capability to deform without rupture

Density – mass of unit volume of the material (its notation is ρ , its unit is kg/m^3)

Design requirements - the fundamental design requirements of buildings are that of functionality, safety, aesthetics, durability and economy

Design value of strength f -
$$f_d = \frac{f_k}{\gamma_m}$$
 where f_k is the characteristic strength and γ_m the safety factor of the material

Dilatation - structural detail at supports of a structure allowing relative movement of joining dilatation units due to temperature deformations

Dome – an arch rotated about a vertical axis passing through its crown, or highest point. Its trust can be resisted by horizontal forces from the ground or buttresses, or by a tension ring.

Durability - conserving the material characteristics during a long period of time on the course of the lifetime of the building (cca 50 years)

Dynamic loads - suddenly applied loads, such as earthquake, blasting, crane loads

Economic efficiency – acceptable price/performance rate

Elastic behaviour – if after removal of the load, the deformations disappear

Elastic material – material in which the specific deformation depends only from the actual value of the stress (does not depend from the process of loading or load removal)

Elasticity – property of a material to deform under load and return to its original dimensions when load is removed. Usually implies that material obeys Hooke's law.

Fatigue – rupture of the structural material due to a great number of loadings and down-loadings. The number depends from the stress level achieved at loading and can greatly be reduced when yield point is achieved by loading.

Flexural moment – internal force component producing curvature of the axis of the member.

Floor – horizontal loadbearing structure subdividing buildings in the vertical direction

Floor construction – floor structure together with all thermal insulation, acoustic insulation and pavement layers

Floor thickness – generally the thickness of the (total) construction

Force – Resultant of distributed load, units: N, kN. According to Newton's 2nd law: $F = ma$ that is force is equal to mass times acceleration. The vector character of forces means that beside magnitude, forces are characterized by their line of action, direction (sense) and point of application.

Foundations - underground part of a building designed for safe transmission of loads to the subsoil

Functional units of buildings - spaces of a building (rooms) **Installations of buildings** - parts of buildings designed for electric, water, gas supply, rain and waste water canalization, heating, informatics (in general: tubing an electric network)

Ground plan - horizontal section of a building at 1 m height above pavement level

Functionality – the way of serving the function(s) for which spaces of a building were designed

Footing – the part of a foundation which transmits the weight of the building to the part of the foundation under the ground level, should be frost resistant under our climatic conditions and therefore it is usually made of concrete or natural stone.

Girder – a heavily loaded beam, usually supported by other beams.

Heat deformation – deformations and displacements due to temperature changes

Hinge – a joint fixing the relative position of the ends of two or more structural members, but permitting their relative rotation. A pin or bolt passed through drilled holes is a hinge for a plane structure. For a three-dimensional joint some kind of spherical hinge is required. A hinged joint transmits shears and axial forces but no moments.

Horizontal loadbearing structures - floor structures, beams and lintels

I-beam – beam or column with I-shaped cross-section

Hook's law – the law which states the straight-line proportionality between stress and strain for a specimen of material under load. $\sigma = E \varepsilon$, where σ is stress, E the modulus of elasticity for the material, and ε the strain.

Hyperbolic paraboloid – doubly curved surface of negative Gaussian curvature which can be generated by sliding a straight line along two other lines which are skew to each other but lie in parallel planes. Alternatively, a parabola can be slid along another parabola, with successive positions of the first parabola always lying in parallel planes which are normal to the plane of the second parabola.

Internal forces – resultant forces of stresses developing in cross-sections of structural members when loaded.

Inflection point - on a curve, a point at which the curvature is zero. On the elastic curve it is the point of zero moment.

Isotropic material - its mechanical characteristics (for example modulus of elasticity, strength) are constant in all directions of the space

Jet-grouting – underground soil strengthening technology: pressing at very high pressure cement paste through drilled down steel tube

Joint – the point of connection between structural members. A joint is idealized as (1) a roller, (2) a hinge, or (3) fixed (built-in or restrained). The reaction between two members may, therefore, be (1) a single force acting normal to the surface on which the roller rolls, (2) a single force acting in any direction but passing through the hinge, or (3) a force acting in any direction through the joint plus a moment acting in any direction through the joint.

Joist – a small beam or a series of beams which are closely spaced, implying that they are relatively lightly loaded.

Layout plan - ground plan of the construction site and the neighbourhood

Level – units of buildings placed upon each other (for example a building with ground floor level, two storeys and cellar has four levels)

Storey height

Linear member – structural member that can be characterized by its axis and cross-section perpendicular to its axis, and the length of the axis is significantly greater than the cross-sectional dimensions

Linear (elastic) calculation – calculation based on the supposition that deformations and stresses are proportional to the load intensity

Link – short, straight supporting member, hinged at both ends so that it is a two-force member. It is used to ensure or define precisely the line of action (the axis of the link) and the nature (pure compression or pure tension) of the reactive force.

Load – a force, usually external, acting on a structure or a structural element.

Permanent load – loads that are constantly acting during the whole life of the structure

Variable load – load that may act or not during the life of the structure

Live load – variable load acting on floor structures. Intensity of live loads depends on the function of the building

Characteristic load – load given with the characteristic value of the load intensity.

Design load – Design value of loads: characteristic value times the safety factor

Self-weight - $G = m \times g$, originated by the attraction of the Earth. It is a kind of permanent load.

Meteorological loads - wind load, snow load, temperature effect

Uneven settlement - cinematic loading, caused by uneven load distribution and/or uneven subsoil capacity distribution under the foundations of a building

Aging – corrosion, loss of strength due to aging, fatigue, (loss of colour due to aging)

Earth pressure - pressure acting on the foundations of buildings due to the weight of the wet soil

Ground water pressure - the same as earth pressure but due to underground water

Earthquake - dynamic loading caused by horizontal shocks produced by motions of the surface of the Earth

Loadbearing capacity – the maximum load intensity (or internal force, for example moment or shear force) that the structure can resist by taking into consideration safety levels as given by standard prescriptions.

Loadbearing structures - structures, designed for transmission of loads to the underground, such like foundations, vertical loadbearing structures (columns and walls), horizontal loadbearing structures (floor constructions), roof structures

Mean value of strength f :
$$f_m = \frac{\sum f_i}{n}$$
 n : number of test data

Modulus of elasticity – (also called Young's modulus) the constant relating stress and strain (see Hook's law). It has the (usually imaginary) magnitude of a stress which would cause an elastic stretch in a loaded bar equal to the original length.

Moment – of a force with respect to an axis is the product of the force F times the distance d , called the moment arm, between the line of action of the force and the axis. It is a turning or a twisting effect. $M = Fd$. Moment of a couple = Fa , where a is the distance between the lines of action of two parallel and opposite forces of equal magnitude F . Clockwise positive. Unit: kNm. Nm etc.

Moment connection, rigid connection – a joint which is rigid and which can transmit a moment between the members it connects

Moment diagram – a graph or curve whose ordinates measure the magnitude of the moment acting on the section at the corresponding point of the structural member

Moment of inertia – or second moment of area, with respect to a y axis is equal to $\int x^2 dA$. The term usually refers to its centroid axis and is given the symbol I .

Neutral axis – see axis

Nonlinear calculation – structural calculations respecting that the relationship between loads and deformations and stresses respectively is nonlinear

Normal – at right angles, perpendicular

Normal force – internal force component acting perpendicular to the cross-section

One-way slab – in reinforced concrete, a slab supported principally on only two of its four edges. The supports are usually beams or girders but may be walls too.

Orthogonal – at right angles.

Pavement - the top surface layer of the floor construction frost-proof

Profile – cross-section of laminated linear members, mainly of steel or of other metals

Permit project – project of a building submitted to the building authority for authorization (to receive the building permit)

Planar structure, planar frame – Loadbearing structure consisting of structural members lying in the same plane and loaded by loads acting in this plane.

Plastic behaviour – deformation increases without increasing the load intensity

Brittle behaviour – sudden rupture of the material occurring without deformation

Plastic hinge – in rigid joints of frames a plastic hinge can develop by increasing the moment beyond the elastic limit, by plasticising of the structural material. Unlike a real hinge, it transmits a moment, a plasticised section can resist. In a plastic hinge a plastic rotation can develop.

Plasticity – property of a material to deform under load and to retain the deformation after the load is removed;

Plasticising (or yield) – the property of a material that after reaching a certain stress level, deformation takes place without increase of the stress level

Plate – thin structural member with planar middle-surface, loaded generally perpendicular to its plane

Plinth - façade construction at ground level, which should be hit-proof and - under continental climate – also frost-proof

Poisson's ratio – when an element of a structure is elongated, its cross-section is slightly diminished. The ratio of this lateral strain to the lengthwise strain is called the Poisson's ratio, designated by the greek letter $\nu = \epsilon_{\text{transverse}} / \epsilon_{\text{lengthwise}}$

Prismatic – of constant cross-section

Purlin – beam of the roof structure running horizontally and usually of timber

Rafter – beam of a roof structure running perpendicular to the eaves in a sloping plane, usually of timber

Reaction force – force which supports a structure or structural element holding in equilibrium the actual external loads.

Reinforced concrete – composite structural material consisting of concrete and steel reinforcement. Generally concrete resists compression, steel resists tension.

Resistance moment – value of the flexural moment that a cross-section can resist by respecting the prescriptions of the related standard

Restraint – a kind of support of structures, by which transfer of moment can also take place.

Resultant force – a single force which has the same effect as all the forces to be added.

Rigid frame – structure made up of columns and beams, jointed by rigid joints.

Roof cover – waterproof top layer of the roof, designed for rainwater canalisation

Roof structures (pitched roof construction, close couple roof, couple roof, collar roof, purlin roof) – structure holding the roof cover, usually constructed of timber.

Safety (of load-bearing structures) – the probability rate of not becoming unfit for use through rupture, loss of stability, overturning or sliding of the load-bearing structures

Safety factor – rate of the design and characteristic values of loads or rate of characteristic and design values of strengths of structural materials (also called *partial factors of safety*)

Safety requirements - safety against rupture and collapse, safety against overturning and sliding, safety against corrosion (durability), safety against fire - adequate fire resistance

Scatter of strength values $f_i, i=1,2, \dots, n$:
$$s = \sqrt{\frac{\sum (f_i - f_m)^2}{n-1}}$$

Sense – direction along a line.

Shear – the sliding of one particle, element or portion of a structure with respect to the adjacent particle, element or portion. See also *stress* and *strain*.

Shear force – at any point along the axis of a linear structural member refers to the total force acting transversally (normal) to the axis at a point, causing shear stresses on the cross-section of the member.

Separated structure – the whole structure or any part of it should be in equilibrium by the effect of the applied external loads and the support reaction forces or internal force components that are acting on the separated sections of the structure.

Simple supported beam – Linear structure supported in two points along its axis by one hinged and one roller support, and loaded generally perpendicular to its axis. The axis can be straight, curved or polygonal.

Simple supported beam with cantilever – simple supported beam with at least one of the supports positioned at an internal point of its axis and thus having a cantilever part beyond this support.

Slab – Structural member, having two major dimensions, the third one – the thickness – being by more than an order of magnitude smaller. The most common planar slabs lay generally in horizontal plane, are loaded vertically, and have constant thickness.

Specific weight – weight of a unit volume of a material (designated by γ , measured in kN/m^{34})

Span – distance between supports of horizontal loadbearing structures

theoretical span or effective span – distance between theoretical support points in the

clear span – distance between internal faces of adjacent supports

Stability – state of equilibrium, in which the body will return to its original position if displaced a very small amount when the force causing this displacement is removed.

Static – motionless, at rest;

Static loads - slowly applied loads, such as live loads, earth pressure, self-weight

Static model *Simple supported beam* – simplified model of the structure (so for example bars are substituted by their axis, connections are supposed to be rigid or hinged, supports are point-like).

Strain - change of length per unit of length of an element in tension or in compression. In shear, strain is measured as the change in angle at the corner of an element. Note that strains are dimensionless.

Strength – capacity force per unit area (the maximal value of the stress the material can bear respecting safety principles of the standard prescriptions concerned)

Strength of materials – branch of mechanics and experimental physics dealing with stresses, strains and the general behaviour of materials and structural elements under the action of forces and moments.

Stress – average force acting per unit area in a plane between elemental particles of the structural material (measured in units: kN/cm^2 , N/mm^2)

Normal stress – stress acting in perpendicular direction with respect to the plane considered (designated by σ)

Shear stress – stress acting in the plane under consideration (designated by τ)

Stress-strain relationship – diagram, characterizing the mechanical behaviour of a structural material

Structural materials - materials used for the construction of loadbearing structures, such as: natural stone, timber, concrete, steel, bricks, reinforced concrete

Strut – a compression member, a prop, a column, usually implying that it can be placed at any angle, not just vertically. The compression members in the web of a truss could be called struts.

Support – idealized support of a structure (here are treated only planar supports)

Hinged support – kind of support impeding motion in all directions but allowing rotation in the support plane

Roller support – kind of support also called simple support, equilibrating a force component in direction of the support, allowing rotation and motion perpendicular to the direction of the support

Torsion – or **torsional moment**, also called torque, moment turning around the axis of the member

Total net area - the sum of useful ground plan areas of different levels of a building, with subtraction of the area occupied by walls

Truss – structure, whose static model, constructed generally of straight linear members connected by hinged joints following the so called triangulation rule, having generally two parallel chords (compression chord and tension chord), interconnected by vertical columns and/or diagonal struts.

Twist – subject to torsional moment

Ultimate deformation – deformation at rupture

Ultimate strength or rupture strength - strength obtained by testing

Unity of form and functions - basic aesthetical design requirement

Units, conversion of units: measurement units of different physical quantities such as N, kN, m, mm, s, h etc.

Vault – curved surface structure working in compression made of brickwork, natural stone or concrete

Vector –**force vector**, mechanical quantity determined by its point of application, line of action, direction and magnitude.

Vector diagram – or vector polygon, used for addition or equilibration of force vectors

Vertical loadbearing structures - loadbearing walls and columns of a building

Wall – vertical loadbearing planar structure, whose in-plane dimensions are significantly greater than its thickness

Wind bracing – stiffening structural members against horizontal actions lying in vertical plane (diagonals or walls)

Yield – process of development of plastic deformations