

APPENDIX B

Glossary

The material presented in this glossary constitutes a brief dictionary of words and terms frequently encountered in discussions of the design of building structures. Many of the words and terms have reasonably well-established meanings; in those cases we have tried to be consistent with the accepted usage. In some cases, however, words and terms are given different meanings by different authors or by groups that work in different fields, in which case the definition here is that used for the work in this book.

In some cases words and terms are commonly misused with regard to their precise meaning, an example being “unreinforced,” which would imply something from which reinforcing has been removed, whereas it is commonly used to refer to something that was never reinforced in the first place. Where such is the case, we have given the commonly used meaning here.

To be clear in its requirements, a legal document such as a building code often defines some words and terms. Care should be exercised when reading such documents to be sure of these precise meanings.

Abutment. Originally, the end support of an arch or vault. Now, any support that receives both vertical and lateral loading.

Acceleration. Rate of change of the velocity. Acceleration of the ground surface is more significant than its displacement in determining the dynamic earthquake effect on the building structure.

Accidental Torsion. Torsional effect on buildings, due to minimum accidental eccentricity required by codes, even when there is no actual computed eccentricity.

Active Lateral Soil Pressure (of Soil). See *Lateral Soil Pressure*.

Adequate. Just enough; sufficient. Indicates a quality of bracketed acceptability—on the one hand, not

insufficient, but on the other hand, not superlative or excessive.

Aggregate. Inert, loose material that makes up the largest part (typically two-thirds to three-fourths) of the concrete; what the water and cement paste holds together; ordinarily consists of stone—ranging in size from medium sand to coarse gravel.

Allowable Stress. See *Stress*.

Allowable Stress Design (ASD). Structural design method that employs limits based on allowable stresses and responses to service (actual usage) load conditions. See *Strength Design*.

Amplitude. See *Vibration*.

Analysis. Separation into constituent parts. In engineering, the investigative determination of the detail aspects of a particular phenomenon. May be qualitative, meaning a general evaluation of the nature of the phenomenon, or quantitative, meaning the numerical determination of the magnitude of the phenomenon. See also *Synthesis*.

Anchorage. Attachment for resistance to movement; usually opposing uplift, overturn, sliding, or horizontal separation. *Tiedown*, or *holddown*, refers to anchorage against uplift or overturn. *Positive anchorage* refers to fastening that does not easily loosen under a condition of repeated, reversing loading.

Aspect Ratio. Proportionate ratio of the dimensions of an object, such as height-to-width ratio of a shear wall.

Base. Level at which earthquake motions are considered to be delivered to a building.

Base Shear. Total design lateral force (horizontal shear) at the building base.

Beam. Structural element that sustains transverse loading and develops internal forces of bending and shear in resisting loads. Also called a *girder* if very large, a *joist* if small or in

closely spaced sets, a *rafter* if used for a roof, and a *header* or *lintel* if used over an opening in a wall.

Bearing Foundation. Foundation that transfers loads to soil by direct vertical contact pressure (bearing). Usually refers to a *shallow bearing foundation*, which is placed directly beneath the lowest part of the building and not very far from the ground surface. See also *Footing*.

Bending. Turning action that causes change in the curvature of linear elements; characterized by the development of opposed internal stresses of compression and tension. See also *Moment*.

Bent. Planar framework, or some defined portion of one, that is intended for resistance to both horizontal and vertical loads in the plane of the frame.

Box System. Lateral bracing system in which horizontal loads are resisted not by a column and beam system but rather by planar elements (shear walls and horizontal diaphragms) or braced frames (trusses).

Braced Frame. Building code term for a trussed frame used for lateral bracing.

Bracing. General term used for elements that provide support against sideways movements due to lateral loads or to the buckling of slender elements.

Brittle Fracture. Sudden failure, usually due to tension or shear; the usual failure of brittle materials, such as glass, plaster, and concrete.

Buckling. Collapse, in the form of sudden sideways deflection or of torsional rotation (twisting).

Building Code. Legal document for regulation of building form, features, and construction. Model codes are developed by recommending organizations; real codes are enacted as ordinances by some governmental unit (city, county, state).

Built-Up Member. Structural member assembled from two or more parts in a manner that results in the combined parts working as a single unit.

Calculation. Ordered, rational determination, usually by mathematical computations.

Centroid. Geometric center of an object, usually analogous to the center of gravity. The point at which the entire mass of the object may be considered to be concentrated when considering the moment of the mass.

Cold-Formed Element. Structural element produced from sheet steel by bending, rolling, or stamping without heating of the steel.

Collector. Force transfer element that functions to collect loads from a horizontal diaphragm and distribute them to the vertical elements of the lateral resistive system.

Composite Panel. Structural panel with wood veneer faces and a fiberboard core. In thick panels there is also a center wood veneer.

Compression. Force action that tends to press adjacent particles of a material together and to cause shortening of objects in the direction of the compressive force.

Concrete Masonry Unit (CMU). Precast concrete unit; or, good old concrete block.

Connection. Union or joining of two or more distinct elements. In a structural assemblage, a connection device itself becomes an entity, with interactions of the connected elements visualized in terms of their actions on the connecting device.

Continuity. Character of continuous, monolithic structural elements; wherein actions of adjacent elements are influenced by their continuous nature; such as with multistory columns, multispan beams, and multielement rigid frames.

Core Bracing. Concentration of the vertical elements of a lateral bracing system at a central location in the building; usually at the location of elevators, stairs, and vertical service elements.

Creep. Plastic deformation at constant stress levels that occurs over time (basically under dead load); a common effect in structures of concrete.

Critical Damping. Damping that will result in a return from initial deformation to the neutral position within one cycle of vibration.

Curtain Wall. Exterior wall of a building that is supported entirely by the building structure, rather than being self-supporting or a bearing wall.

Damping. See *Vibration*.

Dead Load. See *Load*.

Deflection. Lateral movement of a structure under loading, such as the sag of a beam.

Determinate Structure. Structure having the exact sufficiency for stability and therefore being subject to investigation by consideration of the equilibrium of simple static forces alone. See also *Indeterminate Structure*.

Diaphragm. Planar element (wall, floor deck, etc.) used to resist forces in its own plane by shear action. See also *Horizontal Diaphragm* and *Shear Wall*.

Doubly Reinforced. Concrete member with both tension and compression reinforcement, usually opposed in bending.

Drag. Refers to wind effect on surfaces parallel to the wind direction. *Ground drag* refers to the effect of the ground surface in slowing the wind velocity near ground level.

Drag Strut. Structural member that transfers load across a building and into some part of the vertical bracing system. See also *Collector*.

Drift. Lateral deflection. *Story drift* refers to lateral deflection of one level of a structure with respect to the level below.

Ductility. Stress–strain (load–deformation) behavior that results from the plastic yielding of materials. To be significant—qualifying a material as ductile—the plastic yield before failure should be several times the elastic strain up to the point of plastic yield.

Dynamic. Load effects or structural responses that are not static in nature. That is, they involve time-related considerations such as momentum, vibration, and energy effects, versus simple force.

- Eccentric Bracing.** Braced frame in which the diagonal members do not connect to the joints of the beam-and-column frame, thus resulting in bending and shear in the frame members.
- Elastic Behavior.** Used to describe two aspects of stress-strain behavior. The first is a constant stress-strain proportionality, or constant modulus of elasticity, as represented by a straight-line form of the stress-strain graph. The second is the stress level limit within which all strain is recoverable; that is, there is no permanent deformation. The latter phenomenon may occur even though the stress-strain relationship is nonlinear (as it is for wood, for example).
- Engineered Wood.** General term for products produced from wood other than single pieces of sawn wood.
- Equilibrium.** Balanced state or condition, usually used to describe a situation in which opposed force effects neutralize each other to produce a net effect of zero.
- Equivalent Static Force Analysis.** Technique by which a dynamic effect is translated into a hypothetical (equivalent) static effect that produces a similar result.
- Factored Load.** Service load multiplied by a factor to produce an adjusted load for strength design.
- Field Assemblage.** Construction work performed at the construction site (the field). Refers mostly to production and erection of steel frames.
- Flexible.** See *Stiffness*.
- Footing.** Shallow bearing-type foundation element consisting of a concrete pad cast directly into an excavation.
- Freestanding Wall.** See *Wall*.
- Function.** Capability; intended use.
- Fundamental Period.** See *Period*.
- Grade.** 1. Level of the ground surface. 2. Rated quality (capability, capacity, refinement, etc.) of material.
- Grade Beam.** Foundation element at or near the finished ground level that acts as a footing, a tie, or a spanning element.
- Grain.** 1. Discrete particle of material that constitutes a loose material, such as soil. 2. Fibrous orientation of wood.
- Grout.** Lean concrete (predominantly water, cement, and sand) used as a filler in the voids of masonry units, under steel bearing plates, and so on.
- Gust.** Increase, or surge, of short duration in a sustained wind velocity.
- Header.** Beam at the edge of an opening in a roof or floor or at the top of an opening in a wall.
- Horizontal Bracing System.** Diaphragm or truss in a horizontal plane that collects lateral loads and distributes them to vertical bracing elements.
- Horizontal Diaphragm.** Usually a roof or floor deck used as part of a lateral bracing system. See *Diaphragm*.
- Hot Rolling.** Industrial process in which an ingot (lump) of steel is heated to the softening point and then repeatedly squeezed between rollers to produce a linear element with a constant cross section.
- Indeterminate Structure.** In general, any structure whose load-resisting behavior cannot be determined by simple consideration of static equilibrium.
- Inelastic.** See *Stress-Strain Behavior*.
- Inertia.** See *Mass*.
- Irregular Structure.** See *Regular Structure*.
- Joist.** See *Beam*.
- Kern Limit.** Limiting dimension for the eccentricity (off-center condition) of a compression force if tension stress is to be avoided.
- Lateral.** Sideways. Used to describe something that is perpendicular to a major axis or direction. With respect to the vertical direction of gravity forces, primary effects of wind, earthquakes, and horizontal soil pressures are called *lateral effects*. Horizontal buckling of beams is called lateral buckling.
- Lateral Resistive System.** Combination of elements of a structure that contributes to the general bracing against lateral forces.
- Lateral Soil Pressure.** Horizontal soil pressure of two kinds: 1. *Active* pressure is that exerted by a retained soil on a restraining structure. 2. *Passive* pressure is that exerted by soil against an object that is attempting to move sideways.
- Lateral Unsupported Length.** For a linear structural element (beam, column), the distance between points of assured lateral bracing.
- Liquefaction.** Action in which a soil deposit temporarily loses its shear resistance and takes on the character of a liquid; usually resulting from some dynamic vibration, such as that occurring during an earthquake.
- Live Load.** See *Load*.
- Load.** Active force (or combination of forces) exerted on a structure. *Dead load* is permanent gravity load, including the weight of the structure itself. *Live load* is literally any load which is not permanent, although the term is ordinarily applied to distributed surface loads on roofs and floors. *Service load* is that to which the structure is expected to be subjected. *Factored load* is the service load modified by amplification factors for use in strength design.
- Load and Resistance Factor Design (LRFD).** See *Strength Design*.
- Mass.** Dynamic property of an object that causes it to resist change in its state of motion; this resistance is called *inertia*. The magnitude of the mass per unit volume of the object is called *density*. Dynamic force is defined as $F = ma$, or force equals mass times acceleration. Weight is defined as the force produced by the acceleration of gravity; thus, $W = mg$.
- Member.** One of the distinct elements of an assemblage.
- Moment.** Action tending to produce turning or rotation. Product of a force and a distance (lever arm); yields a measurement unit of force times distance: foot-pounds, kilonewton-meters, and so on. Bending moment causes curvature of linear elements; torsional moment causes twisting rotation.

- Moment of Inertia.** Second moment of an area about a fixed line (axis) in the plane of the area. A purely mathematical property, not subject to direct physical measurement. Has significance in that it can be quantified for any geometric shape and is a measurement of certain structural responses, such as deflection of beams.
- Natural Period.** See *Period*.
- Net Section.** Cross-sectional area of a structural member reduced by holes, notches, and so on. Most significant in determination of tension response.
- Normal.** 1. Ordinary, usual, unmodified state of something. 2. Perpendicular, such as pressure on a surface.
- Occupancy Importance Factor, *I*.** Code term used in basic equations for lateral force. Expresses potential for increased concern for certain building occupancies.
- Open Web Joist.** Light steel truss, usually with parallel chords, commonly used in closely spaced sets, as with wood floor joists. A manufactured product.
- Optimal.** Best; most satisfying. The best solution to a set of criteria is the optimal one. When the criteria have opposed values, there may be no single optimal solution, except by the superiority of a single criterion, such as the lightest, the strongest, the cheapest, and so on.
- Overturn.** Rotational effect consisting of toppling or tipping over; an effect of lateral loads on vertical elements.
- Passive Soil Pressure.** See *Lateral Soil Pressure*.
- P-delta Effect.** Secondary bending effect on vertical members of a frame, induced by the vertical loads acting on the laterally displaced (deflected) members.
- Pedestal.** Short pier or upright compression member. A column qualified by a ratio of unsupported (unbraced) height to least lateral dimension of 3 or less.
- Perimeter Bracing.** Vertical elements of a lateral bracing system located at the building perimeter.
- Period (of Vibration).** Elapsed time for one full cycle of vibration. For an elastic structure in simple vibration, the period is a constant (called the *natural* or *fundamental period*) and is independent of the magnitude of the amplitude of the vibration, of the number of cycles, and of most damping or resonance effects. See also *Vibration*.
- Pier.** 1. Short, stocky column with a height not greater than three times its least lateral dimension. 2. Deep foundation element that is placed in an excavation rather than being forcefully driven as a pile. Although it actually refers to a particular method of excavation, the term *caisson* is commonly used to describe a pier foundation.
- Pile.** Deep foundation element, consisting of a linear, shaftlike member, that is placed by being driven dynamically into the ground. *Friction piles* develop resistance to both downward load and upward load (pullout) through friction between the soil and the pile surface. *End-bearing piles* are driven so that their ends are seated in low-lying strata of rock or very hard soil.
- Plain Concrete.** Concrete cast without reinforcement or prestressing.
- Plastic.** In structural investigation, the type of stress-strain response that occurs in ductile behavior, beyond the yield stress point; usually results in permanent deformation.
- Plastic Hinge.** Rotational effect that occurs in steel members when the entire cross section is subjected to yield stress.
- Plastic Moment.** Resisting moment produced at the point of development of a plastic hinge.
- Positive Anchorage.** See *Anchorage*.
- Poured-in-Place Concrete.** Concrete cast where it is intended to stay; also called *sitecast*.
- Precast Concrete.** Concrete members cast at a location other than that at which they are to be used.
- Preconsolidation.** Condition of a highly compressed soil, usually referring to a condition produced by the weight of soil above on some lower soil strata. May also refer to a condition produced by other than natural causes—piling up of soil on the site, vibration, or saturation that dissolves soil bonding, for example.
- Presumptive Soil Pressure.** Value for allowable vertical soil pressure that is used in the absence of intensive investigation and testing. Requires a minimum of soil sampling and identification and is usually quite conservative.
- Principal Axes.** Set of mutually perpendicular axes through the centroid of an area, about which the moments of inertia will be maximum and minimum. Called individually the *major axis* and the *minor axis*.
- Radius of Gyration.** Defined mathematical property: the square root of the moment of inertia divided by the area of a section.
- Reaction.** Response. In structural investigation, the response of the structure to the loads, or the response of the supports to the loaded structure. Mostly used to describe the latter.
- Redundancy (in Structures).** Refers to the existence of multiple load paths or to multistage response to loads.
- Reentrant Corner.** Exterior corner in a building plan having a form that is indented.
- Reference Design Values.** Values for allowable stress and modulus of elasticity for wood with no modification for usage conditions.
- Regular Structure.** With reference to lateral loading, a structure that is symmetrical and has an ordered regular form without abrupt changes affecting dynamic response.
- Reinforce.** To strengthen, usually by adding something.
- Relative Stiffness.** See *Rigidity*.
- Resistance Factor.** Reduction factor for adjustment of the ultimate resistance of a structural element to a force action: bending, compression, shear, and so on.
- Restoring Moment.** Resistance to overturn due to the weight of the laterally loaded element.
- Rigid Bent.** See *Rigid Frame*.
- Rigid Frame.** Common term for a framework in which members are connected by joints that are capable of transmitting bending moments to the ends of the members. The term “rigid” derives not so much from

- the character of the frame as from that of the rigid joints. Now more accurately described as a *moment-resisting space frame*—a mouthful, but more accurate.
- Rigidity.** Degree of resistance to deformation; highly resistive elements are *stiff* or *rigid*, elements with low resistance are *flexible*.
- Risk.** Degree of probability of loss due to some potential hazard.
- Rolled Shape.** Steel member with cross section produced by *hot rolling*.
- Safety.** Relative unlikelihood of failure; absence of danger. The *safety factor* is the ratio of the structure's ultimate resistance to the actual demand (service load) on the structure.
- Section.** Two-dimensional area or profile obtained by passing a plane through a form. *Cross section* usually implies a section at right angles to another section or to the linear axis of an object (such as a vertical cross section of a horizontal beam).
- Sense.** See *Sign*.
- Separation Joint.** Joint between adjacent parts of a building that allows for independent movement of the parts.
- Service Conditions.** Situations arising from the usage of a structure. See *Load*.
- Service Load.** See *Load*.
- Shear.** Force effect that is lateral (perpendicular) to a structure, or one that involves a slipping effect, as opposed to a push-pull effect on a cross section.
- Shear Wall.** Vertical diaphragm; acts as a bracing element for horizontal force (shear) by developing shear stress in the plane of the wall.
- Shop Assemblage.** Refers to construction work performed at a production facility (the shop), as opposed to work done at the construction site (the field). Refers mostly to production and erection of steel frames.
- Sign.** Algebraic notation of sense: positive, negative, or neutral. Relates to direction of forces—if up is positive, down is negative; to stress—if tension is positive, compression is negative; to rotation—if clockwise is positive, counterclockwise is negative.
- Sitecast Concrete.** See *Poured-in-Place Concrete*.
- Slab.** Horizontal, planar element of concrete. Occurs as a roof or floor deck in a framed structure (called a *supported slab*) or as a pavement poured directly on the ground surface (called a *slab on grade*).
- Slenderness.** Relative thinness; a measurement of resistance to buckling.
- Soft Story.** In a multistory structure, a story level whose lateral stiffness is significantly less than that of stories above or below it.
- Stability.** Refers to the inherent capability of a structure to develop force resistance as a result of its form, orientation, articulation of its parts, type of connections, methods of support, and so on. Is not related to quantified strength or stiffness, except when actions involve buckling of slender elements.
- Static.** State that exists when acceleration is zero; thus the state of motion is unchanging. Generally refers to conditions in which no motion is occurring.
- Stiffness.** See *Rigidity*.
- Strain.** Deformation resulting from stress; measured as a percentage change and thus dimensionless.
- Strength.** Capacity to resist force.
- Strength Design.** One of two fundamental design methods for assuring a margin of structural safety. *Allowable stress design* (ASD) is performed by analyzing stresses produced by *service loads* and comparing them to established limits. *Strength design*, also called *ultimate strength design*, is performed by using a design ultimate load (a magnification of the service load) and comparing it to the ultimate resistance of the structure. When strength design is performed with both factored loads and factored resistances, it is called *load and resistance factor design* (LRFD).
- Stress.** Mechanism of force within a material of a structure, visualized as a pressure effect (tension or compression) or a shear effect on the surface of a unit of material and quantified as force per unit area. *Allowable stress* is a limit established for design by stress methods; *ultimate stress* is that developed at a failure condition.
- Stress Design.** See *Strength Design*.
- Stress-Strain Behavior.** Relation of stress to strain in a material or structure; usually visualized by a stress-strain graph covering the range from no load to failure. Various aspects of the form of the graph define particular behavior characteristics of the material. A straight line indicates an *elastic* relationship; a curve indicates *inelastic* behavior. A sudden bend in the graph usually indicates a plastic strain or *yield* that results in some permanent deformation. The slope of the graph (if straight), or of a tangent to the curve, indicates the relative stiffness of the material; measured by the tangent of the angle (stress/strain) and called the *modulus of elasticity*.
- Structure.** That which gives form to something and works to resist changes in the form due to the actions of various forces.
- Stud.** One of a set of closely spaced columns used to produce a framed wall.
- Synthesis.** Process of combining a set of components into a whole; opposite of analysis.
- System.** Set of interrelated elements; an ordered assemblage; an organized procedure or method.
- Tension.** Force action that tends to separate adjacent particles of a material or pull elements apart. Produces straightening effects and elongation.
- Tiedown.** See *Anchorage*.
- Torsion.** Rotational (moment) effect involving twisting in a plane perpendicular to the linear axis of an element.
- Truss.** Framework of linear elements that achieves stability through triangular formations of the elements.
- Unreinforced.** Grammatically incorrect but commonly used term referring to concrete or masonry structures without

reinforcement. Unreinforced concrete is also called *plain concrete*.

Uplift. Net upward (lifting) force effect; may be due to wind, overturning moment, or an upward seismic acceleration.

Vector. Mathematical quantity having direction as well as magnitude and sense (sign). Comparison is made to *scalar* quantities having only magnitude and sense, such as time and temperature. A vector may be represented by an arrow with its length proportional to the magnitude, the angle of its line indicating the direction, and the arrowhead representing the sign.

Velocity. Time rate of motion; also commonly called *speed*.

Vertical Diaphragm. See *Shear Wall*.

Vibration. Cyclic, rhythmic motion of an object. Occurs when the object is displaced from some neutral position and seeks to restore itself to a state of equilibrium when released. In its pure form it occurs as a harmonic motion with a characteristic behavior described by the cosine form of the displacement–time graph of the motion. The magnitude of the displacement from the neutral position is called the *amplitude*. The time elapsed for one full cycle of vibration is called the *period*. The number of cycles occurring in 1 second is called the *frequency*. Effects that

tend to reduce the amplitude of succeeding cycles are called *damping*. The increase of amplitude in successive cycles is called a *resonant effect*.

Void Ratio. Term commonly used to indicate the amount of void in a soil, expressed as the ratio of the volume of the void to the volume of the solids.

Wall. Vertical, usually planar building element. *Foundation walls* are those partly or totally below ground. *Bearing walls* are used to carry vertical loads. *Shear walls* are used as bracing elements for horizontal forces in the plane of the wall. *Freestanding walls* are walls whose tops are not laterally braced. *Retaining walls* resist horizontal soil pressures perpendicular to the wall plane. *Curtain walls* are nonstructural exterior walls. *Partition walls* are nonstructural interior walls.

Weak Story. In a multistory structure, a story level whose lateral strength is significantly less than stories above or below.

Wet Concrete. Freshly mixed concrete before hardening.

Wind Stagnation Pressure. Reference wind pressure established by the basic wind speed for the region; used in determining design wind pressures.

Yield. See *Stress–Strain Behavior*.