

GLOSSARY OF SEISMIC TERMINOLOGY

Acceleration – The time rate of velocity change, commonly measured in “g” (an acceleration of 32 ft/sec/sec or 980 cm/sec/sec = gravity constant on earth).

Accelerogram – The record from an accelerograph showing acceleration as a function of time.

Accelerograph – A strong motion earthquake instrument recording ground (or base) acceleration.

Aftershock – One of a series of smaller quakes following the main shock of the earthquake.

Amplification - The period (or frequency) of the ground motion coinciding with the period of the building causing significant increase of acceleration and damage.

Amplitude – Maximum deviation from mean of centerline of a wave.

Attenuation – Reduction of amplitude or change in wave due to energy dissipation over distance within time.

Axial Load – Force coincident with primary axis of a member.

Base Isolation – A method using flexible bearings, whereby a building superstructure is detached from its foundation in order to reduce earthquake forces.

Base Shear or Equivalent Lateral Force (ELF)– Total shear force acting at the base of a structure.

Brittle Failure – Failure in material due to limited plastic range; material subject to sudden failure without warning signs.

Center of Mass – Point in the building plan at which the building would be exactly balanced.

Center of Resistance – Resultant of resistance provided by walls and frames.

Configuration Terms:

Building Configuration – Size, shape and proportions of the building; size, shape and location of structural elements; and the type, size and location of nonstructural elements.

Regular Configuration – Building configurations resisting lateral forces with shear walls, moment resistant frames or braced frames - all in simple and near symmetrical layout.

Irregular Configuration – Deviation from simple symmetrical building configurations with repetitive plan and volume. (See WBDG Seismic Design Principles resource page for examples).

Structural Configuration – The size, shape and arrangement of the vertical load carrying the lateral force resistance components of a building.

Core – The central part of the earth below a depth of 2,900 kilometers. It is thought to be composed of iron and nickel and to be molten on the outside with a central solid inner core.

Creep (along a fault) - Very slow periodic or episodic movement along a fault trace without earthquakes.

Crust - The lithosphere, the outer 80 kilometers of the earth's surface made up of crustal rocks, sediment and basalt. The general composition is silicon-aluminum-iron.

Damping – The rate at which natural vibration decays as a result of the absorption of energy. In buildings it is an inherent nature to resonate inefficiently to vibration depending on structural connections, kinds of materials and nonstructural elements used. “Damping” design measures can reduce the magnitude of seismic forces.

Critical Damping – The minimum damping that will allow a displaced system to return to its initial position without oscillation.

Deflection – The horizontal or vertical displacement of a member due to the application of external force.

Deformation – Permanent distortion due to seismic forces.

Depth of Focus – the depth of the focus or hypocenter beneath the earth’s surface commonly classes Earthquakes: Shallow (0-70 kilometers), intermediate (70-300 kilometers), and deep (300-700 kilometers).

Design Earthquake – Generally defined as 2/3 of the maximum considered earthquake.

Diaphragm – Generally a horizontal member, such as a floor or roof slab, which distributes lateral forces to vertical resisting elements.

Displacement - Lateral movement of the structure caused by lateral force.

Drift - Horizontal displacement of basic building elements due to lateral earthquake forces.

Ductility – Ability to withstand inelastic strain without fracturing. Ductility is a material property to fail only after considerable inelastic (permanent) deformation which process dissipates the energy from the earthquake by design.

Duration – The period of time within which ground acceleration occurs.

Dynamic - The opposite of “static”, when a body (building) is in motion.

Eccentric Braced Frame – A steel frame in which diagonal bracing is arranged eccentric to column/beam joints.

Effective Peak Acceleration – A coefficient shown on NEHRP maps used to determine seismic forces.

Elasticity – The ability of a material to return to its original form or condition after a displacing force is removed. Materials have an elastic range.

Elastoplastic – The total range of stress (deformation), including expansion beyond elastic limit into the plastic range. In the plastic range deformation is permanent.

Energy Dissipation – Reduction in intensity of earthquake shock waves with time and distance, or by transmission through discontinuous materials with different absorption capabilities.

Epicenter – The point of the earth’s surface directly above the focus or hypocenter of an earthquake.

Equivalent Lateral Force (ELF) – The representation of earthquake forces on a building by a single static force applied at the base of a building; also referred as Base Shear (V).

Failure Mode – The manner in which a structure fails (column buckling, overturning of structure, etc).

Fault Terms:

Fault – A fracture plane in the earth’s crust across which relative displacement has occurred. (Location of slippage between the earth’s plates).

Normal Fault – A fault under tension where the overlying block moves down the dip or slope of the fault plane.

Strike-Slip Fault (or lateral slip) – A fault whose relative displacement is purely horizontal.

Thrust (Reverse) Fault – A fault under compression where the overlying block moves up the dip or slope of the fault plane.

Oblique-Slip Fault – A combination of normal and slip or thrust and slip faults whose movement is diagonal along the dip of the fault plane.

Faulting – The movement which produces relative displacement of adjacent rock masses along a fracture.

Fault Zones – The zone surrounding a major fault, consisting of numerous interlacing small faults.

FEMA – Federal Emergency Management Agency. Free publications available at: <http://www.fema.gov/>

Flexible System – A structural system that will sustain relatively large displacements without failure.

Focal Depth – Depth of the earthquake (or hypocenter) below the ground surface.

Focus (of an earthquake) or Hypocenter – The point at which the rupture occurs; (It marks the origin of the kinetic waves of an earthquake).

Frame Terms:

Braced Frame – One having diagonal braces for stability and capacity to resist lateral forces.

Concentric Braced Frame – The centerlines of brace, supporting beam and column coincide.

Eccentric Bracing – The centerlines of brace, beam and of column and do not coincide allowing deformation, thereby utilizing ductility.

Moment Frame – Frames in which structural members and joints resist lateral forces by bending. There are “ordinary”, “intermediate” and “special” moment frames. The latter provide the most resistance.

Frequency - The number of wave peaks or cycles per second. The inverse of Period.

Fundamental or Natural Period – The elapsed time, in seconds, of a single cycle of oscillation. The inverse of Frequency.

“g” - see Acceleration.

Graben (rift valley) - Long, narrow trough bounded by one or more parallel normal faults. These down-dropped fault blocks are caused by tensional crustal forces.

Ground Acceleration - Acceleration of the ground due to earthquake forces.

Ground Displacement - The distance that ground moves from its original position during an earthquake.

Ground Failure - A situation in which the ground does not hold together such as land sliding, mud flows and liquefaction.

Ground Movement - A general term; includes all aspects of motion: acceleration, particle velocity and displacement. (The plates of the earth's crust move slowly relative to one-another accumulating pressure or strain resulting in slippage and complex vibration inducing forces in a building.)

Ground Velocity - Velocity of the ground during an earthquake.

Hypocenter or Focus - The point below the epicenter at which an earthquake actually begins; the focus.

Input Motion - A term representing seismic forces applied to a structure.

Inelastic - Behavior of an element beyond its elastic limit, having permanent deformation.

Inertial forces - Earthquake generated vibration of the building's mass causing internally generated inertial forces and building damage. Inertial forces are the product of mass times acceleration ($F = m a$).

Intensity - A subjective measure of the force of an earthquake at a particular place as determined by its effects on persons, structures and earth materials. Intensity is a measure of energy. The principal scale used in the United States today is the Modified Mercalli, 1956 version. MM (or Modified Mercalli) scale is based on observation of the effects of the earthquake MM-I thru MM-XII (MM-I = not felt, MM-XII = damage nearly total).

Isoseismals - Map contours drawn to define limits of estimated intensity of shaking for a given earthquake.

Jacketing - Encasement of existing columns with steel or Kevlar to increase resistance.

Landslide - Earthquake triggering land disturbance on a hillside where one land mass slides over the other.

Lateral Force Coefficients - Factors applied to the weight of a structure or its parts to determine lateral force for seismic structural design.

Liquefaction - Transformation of a granular material (soil) from a solid state into a liquefied state as a consequence of increased pore-water pressure induced by vibration. Normally solid soil suddenly changes to liquid state (usually sand or granular soil in proximity to water) due to vibration.

Macrozones - Large zones of earthquake activity such as zones designated by the International Building Code map.

Machine Isolators - Calibrated mountings with springs used to attenuate vibration generated by machines. For seismic locations they are modified in order to absorb lateral movement and to keep the machine or equipment upright. These devices are available commercially.

Magnification Factor - An increase in lateral forces at a specific site for a specific factor.

Magnitude - A measure of earthquake size which describes the amount of energy released. See Richter Scale.

Mantle - The main bulk of the earth between the crust and the core.

Mass - A constant quantity or aggregate of matter.

MCE: Maximum Credible Earthquake, about 50% higher than the Design Base Earthquake (DBE).

Mercalli Scale - See "Intensity".

Microzonation - Seismic zoning, generally by use of maps, for land areas smaller than regions shown in typical seismic code maps, but larger than individual building sites.

Modal Analysis - Determination of seismic design forces based upon the theoretical response of a structure in its several modes of vibration to excitation.

Mode - The shape of the vibration curve.

Modified Mercalli - See "Intensity".

Moment Magnitude is the measure of total energy released by an earthquake. It is based on the area of the fault that ruptured in the quake. It is calculated in part by multiplying the area of the fault's rupture surface by the distance the earth moves along the fault.

Mud Flow - Mass movement of material finer than sand, lubricated with large amounts of water.

Natural or Fundamental Frequency - The constant frequency of a vibrating system in the state of natural oscillation.

NEHERP – National Earthquake Hazard Reduction Program (FEMA).

Nonstructural Components - Those building components, which are not intended primarily for the structural support and bracing of the building.

Oscillation- Mechanism capable to vibrate.

Out of Phases - The state where a structure in motion is not at the same frequency as the ground motion; or where equipment in a building is at a different frequency from the structure.

Period - The elapsed time in seconds of a single cycle of oscillation. The inverse of frequency.

Performance Based Design – New concept of designing a project for optimum performance within a given life cycle (usually 50 years for institutional use). By definition the building program is to include the careful analysis of all physical, economical, environmental, aesthetic, and sociological factors that will result in the desirable functioning of the project. This, of course, includes hazard mitigation (natural or man-made) and the agreed upon level thereof.

Plate Tectonics - The theory and study of plate formation, movement, interaction and destruction; the theory which explains seismicity, volcanism, mountain building and paleomagnetic evidence in terms of plate motions.

P-Wave – See “Waves”.

Relative Rigidity - The comparative stiffness of interconnected structural members in view of relative distribution of the horizontal force. (Only identical stiffness of interconnected members can share the total load equally.)

Resonance - Induced oscillations of maximum amplitude produced in a physical spectrum when applied oscillatory motion and the natural oscillatory frequency of the system are the same. When the site and building periods coincide, the buildings resonate with the ground. Then the amplitude of building vibration gradually approaches infinity by time, resulting in structural failure. The ground may vibrate at a period of 0.5 to 1.0 sec. Structures may vibrate at a period of 0.1 to 6 sec. depending on the type of structure.

Examples:

1 story structure = 0.1 sec.

Up to 4 story structure = 0.5 sec.

10-20 story structure = 1 - 2 sec.

Water tank structure = 2.5 - 6 sec.

Large suspension bridge = 6 sec.

Response Spectrum - maximum response (generally acceleration) of a site plotted against increasing periods.

Return Period of Earthquakes - The time period (years) in which probability is 63 percent that an earthquake of a certain magnitude will recur.

Richter Magnitude Scale - A measure of earthquake size which describes the amount of energy released. The measure is determined by taking the common logarithm (base 10) of the largest ground motion observed during the arrival of a P-wave or seismic surface wave and applying a standard correction for distance to the epicenter. (Each unit of the Richter Scale represents a 10 times increase in wave amplitude. This corresponds to approx. 31 times increase of energy discharge for each unit on the Richter Scale.) – See Moment Magnitude Scale an alternative.

Rift - A fault trough formed in a divergence zone or in other areas in tension. (See Graben)

Rigidity - Relative stiffness of a structure or element. In numerical terms, equal to the reciprocal of displacement caused by a unit force.

Scarp - A cliff, escarpment, or steep slope of some extent formed by a fault or a cliff or steep slope along the margin of a plateau, mesa or terrace.

Seiche - A standing wave on the surface of water in an enclosed or semi-enclosed basin (lake, bay or harbor).

Seismic - Pertaining to earthquake activities.

Seismic Zone – Areas defined on a map within which seismic design requirements are constant.

Seismicity - The worldwide or local distribution of earthquakes in space and time; a general term for the number of earthquakes in a unit of time, or for relative earthquake activity.

Seismograph - A device, which writes or tapes a permanent, continuous record of earth motion, a seismogram.

Shear Distribution - Distribution of lateral forces along the height or width of a building.

Shear Strain - The ratio obtained by dividing shear displacement by the thickness of the rubber layer in shear.

Shear Strength - The stress at which a material fails in shear.

Shear Wall - A wall designed to resist lateral forces parallel to the wall. A shear wall is normally vertical, although not necessarily so.

Simple Harmonic Motion - Oscillatory motion of a wave, single frequency. Essentially a vibratory displacement such as that described by a weight, which is attached to one end of a spring and allowed to vibrate freely.

Soil Structure Interaction - The effects of the properties of both soil and structure upon response of the structure.

Spectra - A plot indicating maximum earthquake response with respect to natural period or frequency of the structure or element. Response can show acceleration, velocity, displacement, shear or other properties of response.

Stability - Resistance to displacement or overturning.

Stiffness - Rigidity, or resistance to deflection or drift. A measure of deflection or of staying in alignment within a certain stress.

Strain – Deformation per unit of material of the original dimension.

Strain Release - Movement along a fault plane; can be gradual or abrupt.

Strength - A measure of load bearing without exceeding a certain stress.

Stress – Internal resistance within a material opposing a force to deform it.

Subduction - The sinking of a plate under an overriding plate in a convergence zone.

S-Wave – See “Waves”.

Time Dependent Response Analysis - Study of the behavior of a structure as it responds to a specific ground motion.

Torque – The action of a force that tends to produce torsion. The product of a force and a lever arm.

Torsion - Twisting around an axis. (The center of the mass does not coincide with the center of resultant force of the resisting building elements causing rotation or twisting action in plans and stress concentrations. Symmetry in general reduces torsion.)

Trench - A long and narrow deep trough in the sea floor; interpreted as marking the line along which a plate bends down into a subduction zone.

Tsunami - A sea wave produced by large area displacements of the ocean bottom, the result of earthquakes or volcanic activity. (Tidal wave caused by ground motion.)

Tuning - To modify the period of the building beyond the range of the site period to avoid resonance. Examples of "tuning" include lowering the height of a building; lowering the position of weight in a building; changing materials; changing fixity of base, etc. The longer the period, the less inertial forces can be expected. Short periods close to the fault and long periods far from the fault are usual.

Velocity – Rate of change of distance traveled with time in a given direction in centimeters/second.

Vibration - A periodic motion that repeats itself after a definite interval of time.

Wave Terms:

Body Wave – Seismic waves within the earth.

Longitudinal Wave - Pure compressional wave with volume changes.

Love Wave – Surface waves that produce a sideways motion.

Rayleigh Wave - Forward and elliptical vertical seismic surface waves.

P-Wave - The primary or fastest waves traveling away from a seismic event

through the earth's crust, and consisting of a train of compressions and dilatations of the material (push and pull).

S-Wave - Shear wave, produced essentially by the shearing or tearing motions of earthquakes at right angles to the direction of wave propagation.

Seismic Surface Wave - A seismic wave that follows the earth's surface only, with a speed less than that of S-waves.

Wave Length - The distance between successive similar points on two wave cycles.