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GLOSSARY OF TERMS RELATING TO SOIL DYNAMICS

(First Revision)

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Indian Standard

GLOSSARY OF TERMS RELATING TO SOIL DYNAMICS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 23 March 1979, after the draft finalized by the Soil Engineering and Rock Mechanics Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 A number of Indian Standards covering soil testing, site investigation for foundations, etc, has been either published or is under preparation; these include a large number of technical terms relating to soil engineering. The extensive use of these terms has necessitated the preparation of this glossary. This standard was originally published in 1964. This revision has been prepared so as to include a number of new terms besides making the existing terms up to date.

0.3 In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practice in the field in this country.

0.4 In the preparation of this standard, considerable assistance was given by the Civil Engineering Department of the University of Roorkee, Roorkee.

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1. SCOPE

1.1 This standard covers definitions of terms relating to soil dynamics. The symbols of some of the terms are also given.

2. DEFINITIONS

2.1 Accelerograph — An instrument for recording ground acceleration as picked up by the acceleration pick-up.

2.2 Accelerogram — A graphical record of acceleration *versus* time obtained from the accelerograph.

2.3 Acceleration Pick-Up — An instrument for measuring the absolute accelerations of vibrations.

2.4 Amplitude — Maximum displacement from mean position or position of static equilibrium.

2.4.1 *Double Amplitude* — Amplitude measured from peak to peak of the wave.

2.5 Anvil — A base block for a hammer on which material is forged into shape by repeated striking of the tup.

2.6 Attenuation — Decay or reduction of amplitude or change in waveform due to energy dissipation with distance and time.

2.7 Coefficient of Elastic Non-uniform Compression (C_ϕ) — It is the ratio of external non-uniform pressure to the elastic part of the settlement.

2.8 Coefficient of Elastic Uniform Compression (C_u) — It is the ratio of external uniform pressure to the elastic part of the settlement.

2.9 Coefficient of Elastic Non-uniform Shear (C_ψ) — It is the ratio of the external moment applied to the vertical axis to the product of polarmoment of inertia of contact area of base of foundation and the angle of rotation of the foundation.

2.10 Coefficient of Elastic Uniform Shear (C_τ) — It is the ratio of average shear stress at the foundation contact area to the elastic part of the displacement in sliding.

2.11 Coefficient of Subgrade Reaction (C_p) — It is the ratio of the pressure intensity to the corresponding settlement.

2.12 Critical Hydraulic Gradient (i) — It is the hydraulic gradient at which the seepage force balances the weight of the soil.

2.13 Cycle — The full sequence of a periodic quantity occurring during a period.

2.14 Damping Characteristics — Characteristics of the system by which the motion is retarded by energy dissipation.

2.14.1 *Critical Damping Coefficient* (C_c) — It is the value of damping coefficient which determines the case between periodic and aperiodic motion.

2.14.2 *Damping Coefficient* (C) — It is the ratio of the damping forces to the velocity.

2.14.3 *Damping Factor* (D) — It is the ratio of the damping coefficient (C) to the critical damping coefficient (C_c).

2.14.4 *Viscous Damping* — Where damping force is proportional to the velocity of the system.

2.15 Damage Potential — A measure of the damage causing capacity of a ground motion.

2.16 Degree of Freedom — Number of independent co-ordinates required to define a vibratory system.

2.17 Drop Hammer — A forge hammer used for die stamping where the side frame is mounted on the anvil.

2.18 Dynamic Compaction — Compaction produced by vibration or impact or blasting.

2.18.1 *Blasting* — Detonating small charges of explosive at predetermined points to increase the density of the soil.

2.18.2 *Impact* — Increasing the density of the soil by the application of pressure, by impact or falling of weights at predetermined points.

2.19 Dynamic Loading — A phenomenon giving rise to dynamic loading.

2.19.1 *Earthquake* — Soil samples are subjected to simplified load patterns taking into account the stress prior to and during the occurrence of earthquake.

2.19.2 *Transient* — Loading of short duration, generally applied on soil sample to simulate the condition of blast loading.

2.19.3 *Vibratory* — A load which repeats with time and has period comparable in relation to period of the system.

2.20 Dynamic Load Factor — Ratio of dynamic response to static response of the system.

2.21 Dynamic Shear Apparatus — An apparatus with provision for applying shear stresses (stress-controlled) or shear strains (strain-controlled) similar to one expected during a dynamic phenomenon.

2.21.1 *Oscillatory Shear Box* — A dynamic shear apparatus where soil samples are subjected to simple shear deformation under known shear stresses at known frequencies.

2.21.2 *Direct Shear* — A dynamic shear apparatus, where the normal and shear stresses can be cycled either independently or simultaneously.

2.21.3 *Dynamic Triaxial* — A dynamic shear apparatus where the deviator stress and the confining pressure can be cycled at known frequency, either independently or simultaneously.

2.21.4 *Resonance Column Apparatus* — An apparatus in which a cylindrical (solid and hollow) sample of soil can be excited at different frequencies for determination of dynamic soil properties (dynamic shear modulus).

2.22 Excursion — Variation of dependent of variables from mean value or variation of wave from centre line.

2.23 Flow Slides Due to Vibration — The flow of loose soil mass because of earthquake loading.

2.24 Forced Vibration — Motion of a system, when an external periodic force is impressed on the system.

2.25 Free Vibration — Vibrations of a system when displaced from its equilibrium position and left free to vibrate.

2.26 Frequency — The rate at which a motion is repeated in a vibrating system, expressed in radians/second, cycles/second or rev/min.

2.26.1 *Damped Natural Frequency* — The natural frequency considering damping in the system.

2.26.2 *Natural Frequency* — The frequency at which a system vibrates under the effect of forces inherent in the system.

2.26.3 *Operating Frequency* — The frequency at which the machine is operating.

2.26.4 *Resonant Frequency* — The frequency at which the maximum response occurs in a system subjected to forced vibrations.

2.26.5 *Undamped Natural Frequency* — Natural frequency without considering damping.

2.27 Frequency Ratio — The ratio of the forcing frequency to the natural frequency of a system.

2.28 Inertia Force — The product of the mass of a system and the acceleration.

2.29 Liquefaction — The phenomenon by which a submerged cohesionless soil loses its strength.

2.30 Logarithmic Decrement — The natural logarithm of the ratio of any two successive amplitudes of same sign in decay curve obtained in free vibration.

2.31 Loading — *See* **2.19.**

2.32 Magnification Factor — It is the ratio of the dynamic amplitude to the static displacement.

2.33 Mass Ratio (*b*) — It is the ratio of the mass of machine foundation to the product of mass density and cube of the equivalent radius of the base.

2.34 Mode of Vibration — A characteristic pattern assumed by a system in which the motion of every particle is simple harmonic with same frequency.

2.35 Modulus of Deformation — It is the secant modulus of a soil between the pressure range of zero and half yield stress.

2.36 Modulus of Subgrade Reaction — It is the ratio of the pressure intensity to the corresponding total settlement.

2.37 Motion

2.37.1 *Aperiodic* — When there is non-regularity of the system in crossing its equilibrium position during motion.

2.37.2 *Periodic* — When the system in motion crosses the equilibrium position at definite intervals of time.

2.37.3 *Steady State* — When a system is under a sinusoidal forced vibration and the response of the system is also sinusoidal.

2.37.4 *Transient* — When a system is subjected to a sudden displacement.

2.38 Natural Frequency — *See* **2.26.2.**

2.39 Node — Point, line or surface of standing wave system at which amplitude is zero.

2.40 Oscillator

2.40.1 *Electromagnetic* — Electromagnetic unit to produce oscillation. Dynamic load is constant and independent of frequency.

2.40.2 *Mechanical* — Mechanical unit to produce sinusoidal, unidirectional force with action line through centre of oscillator by means of two unbalanced rotating masses. Dynamic load of a mechanical oscillator is frequency dependent.

2.41 Period — Time interval at which the cycle repeats.

2.42 Periodic Motion — *See* **2.37.2.**

2.43 Phase Angle (Phase Difference) — Difference between phase angles of two waves of same frequency.

2.44 Pitching — Rotational vibration motion of the foundation block about the shorter horizontal axis.

2.45 Pressure Cell — A transducer to transform pressure into another physical quantity (usually electrical) whose magnitude can be more easily or conveniently measured.

2.46 Pseudostatic Analysis — Analysis in which dynamic action is replaced by an inertia force assumed to remain static.

2.47 Pulsating Stress — Stress which varies with time.

2.48 Resonance Characteristics — Quantitative expression of input *versus* output. Variables, such as force, displacement, velocity, acceleration, or power input are functions of frequency.

2.49 Resonance — A condition of maximum increase in amplitude of a vibrating system.

2.50 Resonant Frequency — *See* **2.26**.

2.51 Resonant Tamping — Compaction by impact with blows at critical frequency.

2.52 Response Spectrum — The dynamic response of an idealized structure to an earthquake motion. The response can be expressed in terms of the maximum relative velocity S_v.

2.53 Rigid Body Response — Response of a system treating it as a rigid body.

2.54 Rocking — Rotational motion of the foundation block about the longer horizontal axis.

2.55 Screening of Vibrations — Protecting structure from influence of energy of elastic waves propagative in soils.

2.56 Seismic Coefficient — The rates of the design acceleration due to earthquake and the acceleration due to gravity.

2.57 Seismic Wave — Waves produced by any seismic activity.

2.58 Simple Harmonic — Simple harmonic motion defined as the motion of a point in a straight line, such that acceleration of the point is proportional to the distance of the point from the mean position, and is always directed towards it.

2.59 Simulitude — The technique of representing one system with another system with respect to force, time and length such that the result of one can be accurately predicted by the observations from the other.

2.60 Sinusoidal — Quantity varying according to sine law with line.

2.61 Spectral Response — *See* **2.52**.

2.61.1 *Spectral Acceleration* — Spectral response expressed in terms of the maximum relative acceleration.

2.61.2 *Spectral Displacement* — Spectral response expressed in terms of the maximum relative displacement.

2.61.3 *Spectral Velocity* — Spectral response expressed in terms of the maximum relative velocity.

2.62 Strain Amplitude — The maximum strain from its position of rest, to extreme position of the vibrating particle.

2.63 Strain Gauge — Gauge for measuring strains in an elastic element of vibration.

2.64 Synchronous — Two rotating machines having identical frequency.

2.65 Time of Loading — It is the time from the application of stress to the time of reaching the maximum stress.

2.66 Time Period — *See* 2.41.

2.67 Torsional Vibrations — Vibrations in torsional mode.

2.68 Transducer — Pick-up unit to transform mechanical input into electrical output.

2.69 Transient Strength — Strength of soil under transient loading.

2.70 Transmissibility

2.70.1 *Force* — Force transmitted by a vibrating system to its support.

2.70.2 *Motion* — Motion transmitted by a vibrating system to its support.

2.71 Tuning Factor — Ratio of exciter frequency to natural frequency.

2.72 Tup — Falling part of the hammer.

2.73 Vibrations Absorber — Pad of an elastic material introduced to reduce transmissibility of vibrations.

2.74 Vibrometer — Instrument which measures the phase, velocity and acceleration of vibrations.

2.75 Wave — Disturbance propagated in medium in such a manner that at any point in medium the amplitude is a function of time, while at any instant the displacement at point is function of position of point.

2.76 Wave Front — The surface which is the locus of all points having motion in identical phase propagating in a wave, the direction of propagation being perpendicular to the wave front.

2.77 Wavelength — Normal distances between two wave fronts with periodic characteristics in which amplitudes have phase difference of one complete cycle.

2.78 Wave Types

2.78.1 *Longitudinal Wave or Primary Wave* — Wave in which direction of displacement at each point of medium is normal to wave front with propagation velocity, calculated as follows:

$$v_l \text{ or } v_p = \sqrt{\frac{E(1-\nu)}{\rho(1+\nu)(1-2\nu)}} = \sqrt{\frac{\lambda+2\mu}{\rho}}$$

where

v_l, v_p = velocity of longitudinal wave,
ρ = mass density,
E = Young's modulus,
λ, μ = Lame's constants, and
ν = Poisson's ratio.

2.78.2 *Rayleigh Wave* — Dispersive surface wave in which element has retrograding elliptic orbit with one major vertical and one minor horizontal component both in plane of propagation velocity.

v_R = velocity of Rayleigh wave = $\alpha\, v_t$ with $0{\cdot}910 < \alpha < 0{\cdot}995$ for $0{\cdot}25 < \nu < 0{\cdot}50$

where

α = angle of obliquity, and
v_t = propagation velocity of transverse waves.

2.78.3 *Reflected (or Refracted) Wave* — Components of wave incident upon second medium and reflected into first medium (or refracted into second medium).

2.78.4 *Shear Wave (Rotational Equivoluminal)* — Wave in which medium changes shape without change of volume (shear plane wave in isotropic medium is transverse wave).

2.78.5 *Transverse Wave* — Wave in which the direction of displacement of element of medium is parallel to wave front. The propagation velocity v_t is calculated as follows:

$$v_t = \sqrt{\frac{G}{\rho}} = \sqrt{\frac{\mu}{\rho}} = \sqrt{\frac{E}{2\rho(1+\nu)}}$$

where

G = shear modulus,
ρ = mass density,
ν = Poisson's ratio,
E = Young's modulus, and
μ = Lame's constant.

2.79 Yawing — Rotational motion of the foundation block about its vertical axis.

2.80 Yield Acceleration — The acceleration at which yielding of a slope of material occurs.

2.81 Zoning — The various zones into which a country may be divided for design of structures, etc, based upon the seismic coefficient.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg. m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002

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