

Glossary of Terms Used in the Production, Design, Construction and Testing of Interlocking Concrete Pavement

Concrete Paver Products and Production Terms

Admixture: Prepared chemicals added to the concrete mix immediately before or during mixing water, cement and aggregate to improve properties such as density, durability and strength.

Like other pavements, interlocking concrete pavement has a broad range of terms. Many are unique to the design and construction of this system. Some are common to other pavement systems.

Aspect Ratio: The overall length of a paver divided by its thickness. Example: A 4 in. (100 mm) wide by 8 in. (200 mm) long by $3\frac{1}{8}$ in. (80 mm) thick paver has an aspect ratio of 2.5. **Plan Ratio:** The over-

all length of a paver divided by its width.

ASTM C 936: American Society for Testing and Materials, Standard Specification for Solid Concrete Interlocking Paving Units. This product standard defines dimensions, dimensional tolerances, maximum absorption, minimum compressive strength, maximum abrasion and freeze-thaw durability through various test methods.

CSA-A231.2: Canadian Standards Association product standard for Precast Concrete Pavers (interlocking units) that defines standards for dimensions, minimum compressive strength, and durability under freeze-thaw cycles with deicing salt through various test methods.

Cement-Aggregate Ratio: The proportional weight of cement to fine and coarse aggregate in concrete.

Cement, Portland: A hydraulic cement produced by pulverizing clinker consisting essentially of hydraulic calcium silicates, and usually containing one or more forms of calcium sulfate.

Chamfer: A 45° beveled edge around the top of a paver unit usually $\frac{1}{16}$ to $\frac{1}{4}$ in. (2-6 mm) wide. It allows water to drain from the surface, facilitates snow removal, helps prevent edge chipping, and delineates the paving individual units.

Concrete Grid Pavers: Concrete units (generally small slabs) that have up to 50 percent open

area. The units are generally no larger than 16 in. (400 mm) by 24 in. (600 mm). Aggregate or grass can be placed in the openings to promote infiltration of storm water. Grids are generally used for intermittent parking, access lanes, abating runoff and/or controlling erosion. See ASTM C 1319, Standard Specification for Concrete Grid Paving Units for product standards.

Cube(s): Pavers stacked at the factory, strapped or wrapped, with or without a wooden pallet, for shipping and for transfer around the site. The cube has several layers of pavers. The number of layers and pavers on a cube varies with their thickness and shape. The term bundle can refer to the entire cube or a portion.

Dentated Paver: A unit that is not rectangular or square in shape.

Dummy Grooves: False joints in concrete pavers that contribute to the installed joint pattern. Dummy grooves can enhance the appearance of the pattern and speed installation when compared to placing separate (sub)units.

Efflorescence: A white deposit of calcium carbonate on concrete surfaces. It results from the reaction of calcium hydroxide with carbon dioxide from the air. The calcium hydroxide is a byproduct when cement hydrates. It is slightly soluble in water and migrates to the surface through capillary action. The calcium hydroxide remains on the surface, reacts with carbon dioxide, which forms calcium carbonate and water. This conversion, depending on weather conditions, will dissipate over time.

Face Mix or Hard Facing: The application of a thin layer of fine aggregate and cement to the top surface of a concrete paver. The layer is often colored and is used to provide a more intense appearance, greater abrasion resistance, or provide a base for a textured finish.

Half Stone: A half of a paver.

Multi-Colored Paver (Color Blend): A paver with two or more colors. The appearance is usually variegated.

Paving Slab (or Flag): A paving unit with a surface area over 100 in.² (0.065 m²) and with maximum length and width dimensions of 36 in. by 36 in. (915 mm x 915 mm). Paving slabs do not rely on interlock as the principal means of load distribution.

Permeable Interlocking Pavement: Concrete pavers with wide joints (10 mm to 30 mm) or a pattern that creates openings in which rainfall can infiltrate. The openings can be filled with aggregate or topsoil and grass. The pavers are typically placed on an open-graded aggregate base which stores runoff.

Pozzolanic Materials: Flyash, pozzolan, silica fume, or blast furnace slag used as substitutes for cement. They are generally used in the concrete mix to increase density and durability of concrete pavers.

Slump: A measure of consistency and water content of freshly mixed concrete. Slump is the subsidence measured from a specimen immediately after removal of a cone shaped mold. See ASTM C 143. Unlike ready-mixed concrete, pavers are zero slump concrete because of low water content. They are not tested for slump.

Solid Color Paver: A paver with one color created by adding iron oxide, metal oxide, or other mixed metal oxide pigment to the concrete mix.

Spacer Bars, Spacers or Nibs: Small protrusions on each side of the paver used to keep them uniformly spaced so that sand can fill into the joints. Spacer bars help prevent edge chipping and spalling. Some spacer bars stop short of the top surface, and are known as “blind spacers.” They can not be seen once the pavers have been installed.

Spall: A fragment, usually in the shape of a flake, detached from the edge or surface of a paver by a blow or sudden force, the action of weather, or pressure from adjacent pavers.

Textured or Architectural Finish: Paver surfaces altered by the manufacturing mold or mechanical means, such as shot blasting, bush hammering, tumbling, grinding, polishing, flame treated, or washing. The purpose of such treatments is often to simulate the appearance of stone.

Water-Cement Ratio: The weight of water divided by the weight of cement in a concrete mixture. Concrete pavers typically have a water-cement ratio of 0.27 to 0.33, lower than ordinary concrete, which contributes to strength and durability.

Engineering Terms Used in Design of Interlocking Concrete Pavement

California Bearing Ratio (CBR): The ratio of: (1) the force per unit area required to penetrate a soil mass with a 3 in.² (19 cm²) circular piston (approximately 2 in. (51 mm) diameter) at the rate of 0.05 in. (1.3 mm)/min, to (2) that required for corresponding penetration of a standard material. The ratio is

usually determined at 0.1 in. (2.5 mm) penetration, although other penetrations are sometimes used. See ASTM D 1883.

Creep: Slow lateral movement of pavers from horizontal forces such as braking tires. The movement is usually imperceptible except to observations over a long duration.

Crown: The slightly convex shape of a road cross section. It is beneficial to surface drainage and interlock.

Deflection: The temporary movement of a pavement structure due to traffic loads.

Deformation: A change in the shape of the pavement.

Drainage Coefficient: Factor used to modify layer coefficient of pavements. It expresses how well the pavement structure can handle the adverse effect of water infiltration. (*See Layer Coefficient.*)

Equivalent Single Axle Loads (ESALs): Summation of equivalent 18,000 pound-force (80 kN) single axle loads used to combine mixed traffic to a design traffic load for the design period.

Failure: The point at which a pavement does not adequately service its intended use. For flexible pavements, rut depth is often a criteria for failure.

Flexible Pavement: A pavement structure which maintains intimate contact with and distributes loads to the subgrade. The base course materials rely on aggregate interlock, particle friction, and cohesion for stability.

Frost Action: Freezing and thawing of moisture in pavement materials and the resultant effects on them.

Frost Heave: The raising of a pavement surface due to the accumulation and expansion of ice in the underlying soil or rock.

Gradation: Soil or aggregate distributed by mass in specified particle-size ranges. Gradation is typically expressed in percent of mass of sample passing a range of sieve sizes. See ASTM C 136.

Interlock: The three kinds transfer of loads in a segmental pavement. They include *vertical interlock*, *horizontal interlock* and *rotational interlock*. Vertical interlock is achieved by shear transfer of loads to surrounding units through sand in the joints. Horizontal interlock is primarily achieved through the use of laying patterns that disperse forces from braking and accelerating vehicles. The most effective laying patterns for maintaining horizontal interlock are herringbone patterns. Rotational interlock is maintained by the pavers being of sufficient thickness, placed closely together, and being restrained by a stationary edge such as a curb.

Layer Coefficient: From the American Association of State Highway and Transportation Officials (AASHTO) pavement design procedure, it is a dimensionless number that expresses the material strength per inch (25 mm) of thickness of a pavement layer (surface, base, or sub-base). Example:

The layer coefficient of $3\frac{1}{8}$ in. (80 mm) thick pavers and 1 in. (25 mm) bedding sand is 0.44 per in. (25 mm), therefore, the structural Number (SN) = $4\frac{1}{8} \times 0.44 = 1.82$

Life-cycle cost: An analysis tool to calculate all costs anticipated over the life of the pavement. Discounted cash-flow methods are generally used, typically with calculation of present worth and annualized cost. Factors that influence the results include the initial costs, assumptions about maintenance and periodic rehabilitation, pavement user and delay costs, salvage value, inflation, discount rate, and the analysis period. A sensitivity analysis is often performed to determine which variables have the most influence on costs.

Modulus of Elasticity: The ratio of stress to strain for a material under given loading conditions.

Pavement Performance: The trend of serviceability under repetitive loads.

Pavement Rehabilitation: Work undertaken to extend the service life of an existing pavement. This includes placement of additional surfacing material and/or other work necessary to return an existing roadway to a condition of structural or functional adequacy. This could include the complete removal and replacement of the pavement structure.

Pavement Structure: A combination of sub-base, base course, and surface course placed on a subgrade to support the traffic load and distribute it to the roadbed.

Performance Period: The period of time that an initially constructed or rehabilitated pavement structure will last (perform) before reaching its terminal serviceability. This is also referred to as the design period or life, expressed in years. Twenty years is normally used in North America.

Plastic Limit: (1) The water content corresponding to an arbitrary limit between the plastic and the semisolid states of consistency of a soil. (2) Water content at which a soil will just begin to crumble when rolled into a thread approximately $\frac{1}{8}$ in. (3.2 mm) in diameter.

Poisson's Ratio: The ratio of transverse (lateral) strain to the corresponding axial (longitudinal) strain resulting from uniformly distributed axial stress below the proportional limit of the material; the value will average about 0.2 for concrete.

Present Serviceability Index (PSI): A rating, usually between 0 (completely non-functional) and 5 (new/perfect), that generalizes several measurements of the condition of pavement. It is a convenient method of rating the overall condition and usefulness of a pavement over time.

Progressive Stiffening: The tendency of pavements to stiffen over time. Interlocking concrete pavement stiffens as it receives increasing traffic loads. Also referred to as "lock-up."

Rutting: Permanent deformation from repetitive traffic loading that exceeds the ability of the

pavement structure to maintain its original profile.

Skid Resistance: A measure of the frictional characteristics of a surface with respect to tires.

Structural Number (SN): The basis of the flexible pavement design method developed by the American Association of State Highway and Transportation Officials (AASHTO). It is a dimensionless number expressing the relative strength of a pavement structure. The SN is calculated from an analysis of traffic, roadbed soil conditions, and environment. The SN equals the sum of layer coefficients, with each coefficient quantifying the material strength and thickness of each pavement layer.

Sub-base: The layer or layers of specified or selected material of designed thickness placed on a subgrade to support a base course.

Subgrade: The soil upon which the pavement structure and shoulders are constructed.

Strain: The change in length per unit of length in a given direction.

Stress: The force per unit area.

Terms Used in Architectural Design and Detailing of Interlocking Concrete Pavement

Basket Weave or Parquet: A laying pattern where two or more pavers are placed side-by-side. Adjacent pavers are placed side-by-side, but turned 90° and alternated 90° throughout the pattern.

Engraved Pavers: Pavers that have been engraved with letters or images by molding during or after manufacture, shot blasting, wet cutting or that have a cast metal plate set into the surface.

Hard Edges: A field of pavers that is restrained against a visible edge restraint or curb, thus visually reinforcing the edge of pavement.

Herringbone Pattern: A pattern where joints are no longer than the length of one and one-half pavers. Herringbone patterns can be 45° or 90° depending on the orientation of the joints with respect to the direction of the traffic.

Human Scale: Using paver sizes, patterns, colors and textures next to large buildings or open areas with the intent of reducing the user perception of being overwhelmed by the large scale of these spaces.

Markers: Marking underground utilities, traffic direction, parking stalls, lanes, pedestrian/vehicular areas, etc., with pavers of different colors, textures or shapes.

Mosaics: Pavers used as pictorial maps, murals, or geometric patterns as a landmark, to emphasize an area, or suggest movement.

Reflecting: Using pavers to mirror geometric patterns, shapes, colors or textures in the surrounding site.

Running Bond Course: A paver course or two where lengths abut against the edge restraint. Also known as a "sailor course."

Running or Stretcher Bond: A laying pattern with continuous joint lines in one direction and

pavers are staggered from one row to the next.

Slip Resistance: Resistance against pedestrian slipping, defined as the ratio of a minimum tangential force necessary to initiate sliding of a pedestrian's shoe or related device over a surface. Non-mobility impaired persons require minimum coefficient of friction values ranging from 0.2-0.3. Wheelchair users require friction values ranging from 0.5-0.7. Crutch users and those with artificial limbs require values from 0.7 to 1.0. Clean concrete pavers generally have values exceeding 0.7.

Stack Bond: A laying pattern in which the joints in both directions are continuous.

Soft Edges: A field of pavers with no visible edge restraint that meets grass or other vegetation, thus giving a soft appearance to the edge.

Soldier Course: A paver course where widths abut against the edge restraint.

Tactile Pavers: A paver detectable by sight impaired persons due to change in color or texture from surrounding surfaces. Changes in texture are achieved with detectable warnings.

Zoning: Using different paver colors, textures, shapes, laying patterns, and surface elevations to delineate pedestrian and vehicular areas or districts.

Terms Used in Interlocking Concrete Pavement Construction

Aggregate: Sand, gravel, shell, slag, or crushed stone used in base materials or mixed with cement to make concrete.

Base Course: A material of a designed thickness placed on a sub-base or a subgrade to support a surface course. A base course can be compacted aggregate, cement or asphalt stabilized aggregate, asphalt or concrete.

Bedding Sand: A layer of coarse, clean sand that is screeded smooth for bedding the pavers. The sand can be natural or manufactured, i.e., crushed from larger rocks, and should conform to the grading requirements of ASTM C 33. This layer is 1 to 1½ in. (25 to 40 mm) thick.

Bentonite Clay: A clay with a high content of the mineral montmorillonite, usually characterized by high swelling on wetting that can be used to help seal paver joints.

Bishop's Hat: A five-sided paver often used as an edge paver with a 45° herringbone pattern.

Bitumen: A class of asphalts combined with neoprene and used as an adhesive under unit paving.

Blending Pavers: Mixing of colored concrete pavers from three or four cubes to insure even color distribution.

Clay: Fine-grained soil or the fine-grained portion of soil that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. The term can designate soil particles finer than 0.002 mm (0.005 mm in some cases).

Coarse Aggregate: Aggregate predominantly retained on the U.S. Standard No. 4 (4.75 mm) sieve; or that portion of an aggregate retained on the No. 4 (4.75 mm) sieve.

Course: A row of pavers.

Crushed Stone: A product used for pavement bases made from mechanical crushing of rocks, boulders, or large cobblestones at a quarry. All faces of each aggregate have well-defined edges resulting from the crushing operation.

Crusher Run: The total unscreened product of a stone crusher.

Dense-Graded Aggregate: An aggregate that has a gradation that, when compacted, yields very small voids between the particles.

Dry Mix Joint Sand Stabilizer: Joint sand treated with chemicals that when placed in contact with water, activates them to bind together the sand particles. This stabilizes the joint sand and reduces permeability.

Edge Paver: A paving unit that is made with a straight, flush side, or cut straight for placement against an edge restraint.

Edge Restraint: A curb, edging, building or other stationary object that contains the sand and pavers so they do not spread and lose interlock. It can be exposed or hidden from view.

Fineness Modulus: A factor obtained by adding the total percentages by weight of an aggregate sample retained on each of a specified series of sieves, and dividing the sum by 100; in the United States the standard sieve sizes are No. 100 (0.150 mm), No. 50 (0.300 mm), No. 30 (0.600 mm), No. 16 (1.18 mm), No. 8 (2.36 mm) and No. 4 (4.75 mm), and ¾ in. (9.5 mm), 1½ in. (37.5 mm), 3 in. (75 mm), and 6 in. (150 mm).

Flowable Fill: A low strength concrete mix used to fill utility trenches and other excavated pavement openings. Also known as unshrinkable fill.

Geogrids: Geogrids are two dimensional or three dimensional. The two dimensional type are flat and have small, "TV screen" shaped openings. The material is generally placed between the soil and the base to reduce rutting. Three dimensional geogrids are 4 to 8 in. (100 to 200 mm) high and provide stability under loads for cohesionless soils.

Geotextiles: Woven or non-woven fabrics made from plastic fibers used for separation, reinforcement, or drainage between pavement layers.

Gravel: Rounded or semirounded particles of rock that will pass a 3 in. (75 mm) and be retained on a No. 4 (4.75 mm) U.S. standard sieve.

Joint Sand: Sand swept into the openings between the pavers.

Joint Sand Stabilizer: Liquid penetrating or dry mix applied or materials that provide early stabilization of joint sand.

Joint Spacing: The distance between pavers subsequently filled with joint sand.

Layer or Cluster: A group of pavers manufactured in a laying pattern, generally placed by mechanical equipment.

Laying Face: The exposed, vertical face of a row of pavers on bedding sand.

Laying Pattern: The sequence of placing pavers such that a repetitive geometry is created by the installed units. Laying patterns may be selected for their visual or structural benefits.

Lean Concrete: Concrete of low cement content used as a structural base material or as flowable fill in utility trenches.

Liquid Penetrating Joint Sand Stabilizer: Polymer liquid spread over the surface of pavers and allowed to penetrate the joint sand. After curing, the material stabilizes the joint sand and reduces permeability.

Mechanical Installation: The use of machines to lift and place layers of pavers on screeded sand in their final laying pattern. It is used to increase the rate of paving.

Modified Proctor Test: A variation of the Standard Proctor Test used in compaction testing which measures the density-moisture relationship under a higher compaction effort. See ASTM D 1557.

Moisture Content: The percentage by weight of water contained in the pore space of soil, sand or base, with respect to the weight of the solid material.

Mortar: A mixture of cement paste and fine aggregate.

Open-Graded Aggregate: An aggregate that has a gradation that, when compacted, has relatively large spaces between the particles. It can be used as a drainage course in base design, or as a medium for storing storm water in permeable pavements.

Optimum Moisture Content: The water content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.

Organic Soil: Spongy, compressible soils usually consisting of peat humus or vegetative matter that have undesirable construction characteristics.

Paver Extractor: A tool used to grab a paver and remove it from the laying pattern.

Paver Splitter: (Also called a guillotine splitter.) A hand operated machine, sometimes hydraulically assisted, for cutting concrete pavers.

Plate Compactor: Also known as a plate vibrator, which is used to compact pavers into bedding sand in order to promote interlock among the individual units.

Prepared Roadbed: In-place roadbed soils compacted or stabilized according to provisions of applicable specifications.

Proctor Compaction Test: A test which measures the relationship of soil density with respect to soil moisture content under a standard compaction effort. This test identifies the maximum density obtainable at an optimum moisture content. See ASTM D 698.

Pumping: The ejection of saturated bedding and

joint sand, through joints or cracks or along edges of pavers when a load is applied.

Sand: Granular material passing the $\frac{3}{8}$ in. (5 mm) and retained on the No. 200 (0.075 mm) sieve, made from the natural erosion of rocks, and consisting of subangular or rounded particles. Sands made by crushing of coarse aggregates are called *manufactured sands*.

Screed Board or Strike Board: A rigid, straight piece of wood or metal used to level bedding sand to proper grade by pulling across guides or rails set on the base course or edge restraints.

Screed Guides or Bars: Grade strips such as pipe that will guide the screed in producing the desired elevation of the bedding sand.

Screenings: A residual product not suitable for bedding sand. It is a by-product from the crushing of rock, boulders, cobble, gravel, blast-furnace slag or concrete. Most of the aggregate passes the No. 4 (4.75 mm) sieve.

Sealer: A material usually applied as a liquid that is used to waterproof, enhance color, and reduce abrasion of interlocking concrete pavements.

Silt: Soil finer than 0.02 mm and coarser than 0.002 mm (0.5 mm and 0.005 mm in some cases)

Soil Separation Fabric: A layer of fabric typically placed between the subgrade and the base reduce rutting, also called a geotextile.

Soil Stabilization: Chemical or mechanical treatment designed to increase or maintain the stability of a mass of soil or otherwise to improve its engineering properties. Lime, flyash or cement are typical chemical stabilization materials. Geotextiles and geogrids are typical mechanical materials for soil stabilization.

Stabilized Base: An aggregate base where either cement, asphalt or other material is added to increase its structural capacity. The soil subgrade can be stabilized with cement, lime, flyash or other materials.

Topsoil: Surface soil, usually containing organic matter.

Terms Used in Concrete Paver Testing

Abrasion: The mechanical wearing, grinding scraping or rubbing away (or down) of paver surface by friction or impact, or both.

Absorption: Weight of water incorporated by a concrete paver unit during immersion under prescribed conditions, typically expressed as a percentage relating to the dry weight of the unit.

Bedding Sand Degradation Tests: Evaluation of the degree of attrition of sand. Tests are conducted with steel balls or other abrading devices agitated with a sand sample in a container. Pre- and post-testing sieve analysis are conducted to determine the increase in fines. The tests are used to evaluate the durability of bedding sand under heavy loads or channelized traffic.

Compressive Strength: The measured maximum

resistance of a concrete paver to loading; expressed as force per unit cross-sectional area (in pounds per square inch or megapascals).

Density: The mass per unit volume.

Flexural Strength: A property of a paver or slab that indicates its ability to resist failure in bending.

Freeze-Thaw Durability Testing: Tests in which pavers are exposed to cycles of freeze and thaw, partially or totally immersed in water, and with or without salt water.

Macro Texture: The deviations of a pavement surface from a true planar surface with dimensions generally 0.5 mm or greater or those that no longer affect tire-pavement interaction.

Micro Texture: The deviations of a pavement surface from a true planar surface with dimensions generally less than 0.5 mm.

Tensile Strength: Maximum unit stress which a paver is capable of resisting under axial tensile loading, based on the cross-sectional area of the specimen before loading.

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