

Guide for Mechanistic-Empirical Design

OF NEW AND REHABILITATED
PAVEMENT STRUCTURES

FINAL REPORT
APPENDIX A



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APPENDIX A — GLOSSARY OF TERMS¹

aggregate base (AB) - A base course consisting of compacted mineral aggregates. Also, granular base (GB), unbound granular base.

aggregate interlock - A load transfer mechanism whereby the shear is carried by the aggregate-cement paste interface.

aggregate subbase (ASB) - A subbase course consisting of compacted mineral aggregates. Also, granular subbase, unbound granular subbase.

alligator cracking - Interconnected or interlaced cracks forming a pattern that resembles an alligator's hide. Also, map cracking.

alternatives - Differing paving or rehabilitation courses of action that will satisfy established pavement design and management objectives.

analysis period - The time period used for comparing design alternatives. An analysis period may contain several maintenance and rehabilitation activities during the life cycle of the pavement being evaluated.

annual average daily truck traffic (AADTT) - The estimate of typical truck traffic on a road segment for all days of the week over the period of a year.

a priori - Must be already known or self evident. Conceived or formulated before investigation.

asphalt concrete (AC) - A controlled mixture of asphalt cement and graded aggregate compacted to a dense mass. Also, hot-mixed asphalt (HMA), hot-mixed asphalt concrete (HMAC), bituminous concrete (BC), plant mix (PM).

asphalt concrete base (ACB) - Asphalt concrete used as a base course. Also, asphalt base course (ABC), asphalt-stabilized base - hot-mixed (ASB-HM), asphalt-treated base (ATB), bituminous aggregate base, bituminous concrete base (BCB), bituminous base (BB), hot-mixed asphalt base (HMAB).

asphalt concrete pavement (ACP) - A pavement structure placed above a subgrade or improved subgrade and consisting of one or more courses of asphalt concrete or a combination of asphalt concrete and stabilized or unstabilized aggregate courses.

asphalt concrete surface (ACS) - Asphalt concrete used as a surface course. Also, dense-graded asphalt concrete (DGAC).

asphalt-treated permeable base (ATPB) - A permeable base containing a small percentage of asphalt cement to enhance stability. Also, asphalt-treated open-graded base (ATOGB), asphalt-treated base - permeable (ATB-Perm).

¹ Includes materials from the 1986-93 AASHTO Guide, from NCHRP Project 1-32 Final Report, NCHRP Syntheses 135, 204 and 211, and from the applicable ASTM standards.

automatic vehicle classification (AVC) - A system for identification, summarization, and reporting of traffic volume by vehicle configuration.

average annual daily traffic (AADT) - The estimate of typical traffic on a road segment for all days of the week over the period of a year.

axle load - The sum of all tire loads on an axle.

axle load group - The sum of all tire loads on a group of adjacent axles.

axle load spectrum - The full spectrum (distribution) of single, dual, triple, and other axle loads applied to a pavement structure by a given traffic stream.

base - The layer or layers of specified or select material of designed thickness placed on a subbase or subgrade to support a surface course. The layer directly beneath the PCC slab is called the base layer.

base friction - The property of the PCC slab–base interface that resists movement of the slab over the base layer.

base year - The first year of traffic after construction, used as the basis for design computations.

backcalculation - A mathematical methodology for estimating mechanical properties of pavement materials and layers from the results of pavement deflection tests.

blowup - An upward eruption of a PCC pavement slab near a crack or joint.

bulk stress - The sum of the principal stresses a point

butt joint - A joint in which the structural units being joined abut each other (i.e., the joint faces are in intimate contact with zero designed clearance).

calibration factor - Factor used to adjust a model to fit measured performance data

cement-treated base (CTB) - A base course consisting of mineral aggregates blended in place or through a pugmill with a small percentage of portland cement to provide cementitious properties and strengthening. Also, aggregate cement, cement-stabilized graded aggregate (CSGA), cement-stabilized base (CSB).

cement-treated permeable base (CTPB) - An open-graded aggregate base treated with portland cement to provide enhanced base strength and reduce erosion potential.

chemically stabilized mixtures - subgrade materials whose plasticity characteristics have been modified using materials such as lime, flyash, or portland cement.

coefficient of thermal expansion - change in unit length per degree of temperature change.

cold mix asphalts - asphalt concrete mixtures composed of aggregate and asphalt emulsions or cut-back asphalts which do not require heating during mixing.

composite pavement - A pavement structure composed of an asphalt concrete wearing surface and portland cement concrete slab; an asphalt concrete overlay on a PCC slab is also referred to as a composite pavement.

construction joint - For rigid pavements, a joint made necessary by a prolonged interruption in the placing of concrete. For a flexible pavement, a longitudinal joint between adjoining lanes paved separately or a transverse joint separating layers of different ages or paved at different times.

continuously reinforced concrete pavement (CRCP) - Portland cement concrete pavement containing longitudinal reinforcement at or above mid-depth designed to hold shrinkage cracks tightly closed. Transverse joints exist only for construction purposes and on-grade structures. Transverse reinforcement may or may not exist. Longitudinal joints exist similar to other types of concrete pavements.

contraction joint - A joint normally placed at recurrent intervals in a rigid slab to control transverse cracking.

crack - A fissure or discontinuity in the pavement surface not necessarily extending through the entire thickness of the pavement.

crushed stone base - A base course of designed thickness and constructed of graded and mechanically crushed mineral aggregate compacted above a subbase course or subgrade. Also, aggregate base (AB), graded aggregate base (GAB), crushed aggregate (CA).

crushed stone subbase - A subbase course of designed thickness and constructed of graded and mechanically crushed mineral aggregate compacted above a subgrade.

curling - Deformation of a PCC slab caused by a temperature difference between the upper and lower surfaces.

deflection - Vertical deformation of a pavement under an applied load.

deformed bar - A reinforcing bar for rigid slabs conforming to "Requirements for Deformations," in AASHTO Designations M31, M42, or M53.

dense-graded aggregate (DGA) - A mechanically crushed aggregate having a particle size distribution such that when it is compacted, the resulting voids between the aggregate particles, expressed as a percentage of the total space occupied by the material, are relatively small.

design life - The length of time for which a pavement structure is being designed, including the time from construction until major programmed rehabilitation.

deviator stress - In triaxial testing the difference between the axial stress applied by the testing apparatus and the confining stress (pressure).

direction distribution factor - A factor describing the percentage of truck traffic traveling in a given direction on a roadway.

discount rate - The time value of money used as the means of comparing the alternative uses for funds by reducing the future expected costs or benefits to present-day terms. Discount rates are used to reduce various costs or benefits to their present worth or to uniform annual costs so that the economics of the various alternatives can be compared (approximately equals interest minus inflation).

dowel - A load transfer device across a joint (usually transverse joint) in a rigid slab, usually consisting of a plain cylindrical steel bar.

drainable granular subbase - A subbase constructed of compacted and crushed open-graded aggregate.

dynamic modulus (E^*) - The relationship between stress and strain under continuous sinusoidal loading used to evaluate the elastic-viscoelastic response parameters of a material. The dynamic modulus of a material is typically defined as the absolute value of the complex modulus E^* .

elastic layer theory - A mathematical process wherein the layers of a pavement structure are all assumed to behave elastically.

equivalent single axle load (ESAL) - A numerical factor that expresses the relationship of a given axle load to another axle load in terms of the relative effects of the two loads on the serviceability of a pavement structure. Often expressed in terms of 18,000-pound single axle loads.

expansion joint - A joint located to provide for expansion of a rigid slab, without damage to itself, adjacent slabs, or structures.

fatigue cracking - Cracking of the pavement surface as a result of repetitive loading; may be manifested as longitudinal or alligator cracking in the wheel paths for flexible pavement and transverse cracking (and sometimes longitudinal cracking) for jointed concrete pavement.

faulting - Elevation or depression of a PCC slab in relation to an adjoining slab, usually at transverse joints and cracks.

finite element analysis - The finite element method is one wherein rigorous mathematical solution, often employing complex differential equations, of an engineering problem is approximated algebraically. The geometry of the problem is described by discrete elements of finite dimensions that are analyzed through the application of engineering mechanics principles. Results of the finite element analyses are aggregated to approximate the exact mathematical solution.

flexible pavement - A pavement structure that maintains intimate contact with and distributes loads to the subgrade and depends on aggregate interlock, particle friction, and cohesion for stability.

friction number - The number that is used to report the results of pavement friction tests conducted in accordance with ASTM Standard E-274. Also, skid number.

gear load - loading applied to the pavement by a combination of tire loads

geosynthetics - a planar material manufactured from a polymeric material used with soil, rock, earth or other geotechnical-related materials and serve six primary functions: filtration, drainage, separation, reinforcement, fluid blockage, and protection. Typical geosynthetics include geotextiles, geomembranes, and geogrids.

geotextiles - Permeable fabric made of textile materials used as filters to prevent soil migration, separators to prevent soil mixing and as reinforcement to add shear strength to a soil

geomembranes - Impermeable polymer sheeting used as fluid barriers to prevent migration of liquid pollutants in soil.

geogrids - Polymeric grid material having relatively high tensile strength and a uniformly distributed array of large apertures (openings). The apertures allow soil particles on either side to come in direct contact, thereby increasing the interaction between the geogrid and surrounding soils. Used primarily for reinforcement.

gravel - Coarse aggregate resulting from natural disintegration and abrasion of rock or processing of weakly bound conglomerate.

gravel base - A base course constructed of compacted gravel. May or may not be graded and/or crushed.

gravel subbase - A subbase course constructed of compacted gravel. May or may not be graded and/or crushed.

gravel subgrade - A subgrade where a natural gravel has been used as the roadbed surface or where the native soil has been blended with a gravel additive.

hourly distribution factor - A factor used to describe the proportion of traffic on a given roadway for a given hour of the day.

international roughness index (IRI) - A pavement roughness index computed from a longitudinal profile measurement using a quarter-car simulation at a simulation speed of 50 mph (80 km/h).

jointed plain concrete pavement (JPCP) - Jointed portland cement concrete pavement containing transverse joints spaced to accommodate temperature gradient and drying shrinkage stresses to avoid cracking. This pavement contains no distributed steel to control random cracking and may or may not contain joint load transfer devices.

jointed reinforced concrete pavement (JRCP) - Jointed portland cement concrete paving containing distributed steel reinforcement to control random cracking and usually containing transverse joint load transfer devices.

lane distribution factor - A factor describing the percentage (of traffic in one direction) of a given vehicle class using a given lane.

lean concrete base (LCB) - A base course constructed of mineral aggregates plant mixed with a sufficient quantity of portland cement to provide a strong platform for additional pavement layers and placed with a paver.

life cycle costing analysis (LCCA) - An economic assessment of an item, area, system, or facility and competing design alternatives considering all significant costs of ownership over the economic life, expressed in equivalent dollars.

lime-stabilized subgrade - A prepared and mechanically compacted mixture of hydrated lime, water, and soil supporting the pavement system that has been engineered to provide structural support.

lime-flyash base - A blend of mineral aggregate, lime, flyash and water, combined in proper proportions and producing a dense mass when compacted.

load transfer device - A mechanical means designed to carry loads across a joint in a rigid slab.

load transfer efficiency (LTE) - The ability of a joint to transfer load from one side to another. LTE is defined as the deflection of the unloaded side divided by the loaded side times 100.

longitudinal cracking - Pavement cracking predominantly parallel to the direction of traffic.

longitudinal joint - A joint normally placed between traffic lanes in rigid pavements to control longitudinal cracking.

longitudinal profile - The perpendicular deviations of the pavement surface from an established reference parallel to the lane direction, usually measured in the wheel tracks.

low-volume road - A roadway generally subjected to low levels of traffic; in this Guide, structural design is based on a range of 18-kip ESALs from 50,000 to 1,000,000 for flexible and rigid pavements, and from 10,000 to 100,000 for aggregate-surfaced roads.

maintenance - The preservation of the entire roadway, including surface, shoulders, roadsides, structures, and such traffic control devices as are necessary for its safe and efficient utilization.

mechanistic-empirical - A design philosophy or approach wherein classical mechanics of solids is used in conjunction with empirically derived relationships to accomplish the design objectives.

modulus of elasticity (E) - The ratio of stress to strain in the elastic portion of a stress strain curve.

modulus of rupture (MR) - Indicator of flexural bending strength of concrete, is the maximum tensile stress at the bottom of a simply supported concrete beam, loaded at the third points at failure.

modulus of subgrade reaction (k) - Westergaard's modulus of subgrade reaction for use in rigid pavement design (the load in pounds per square inch on a loaded area of the roadbed soil or subbase divided by the deflection in inches of the roadbed soil or subbase, psi/ in). The value used in design is the dynamic modulus of subgrade reaction as directly backcalculated from FWD deflections or backcalculated from deflections obtained from the elastic layered program where resilient moduli values are assigned to each layer. The traditional modulus of subgrade reaction is the static value which is approximately ½ that of the dynamic value.

monthly distribution factor (MAF) - A factor describing the proportion of total roadway traffic or of a given class of traffic using a roadway during a given month of the year.

nonlinear material - A pavement material having properties such that the relationship between stress and strain is nonlinear.

open-graded aggregate base (OGAB) - A crushed mineral aggregate base having a particle size distribution such that when compacted the interstices will provide enhanced drainage properties. Also, granular drainable layer, untreated permeable base (UPB).

octahedral stress - stresses acting on the octahedral plane which cuts through the corners of a stress cube and is equal to 1/3 the stresses on the x, y, and z faces (i.e. $\sigma_{oct} = 1/3(\sigma_1 + \sigma_2 + \sigma_3)$)

panel length -The distance between adjacent transverse joints in concrete pavement.

pavement condition - A quantitative representation of pavement distress at a given point in time.

pavement management - The effective and efficient direction of the various activities involved in providing and sustaining pavements at a condition acceptable to the travelling public at the lowest life cycle cost.

pavement performance - Measure of accumulated service provided by a pavement (i.e., the adequacy with which it fulfills its purpose). Often referred to the record of pavement condition or serviceability over time or with accumulated traffic.

pavement rehabilitation - Work undertaken to extend the service life of an existing facility. This includes placement of additional surfacing material and/or other work necessary to return an existing roadway, including shoulders, to a condition of structural or functional adequacy. This could include the complete removal and replacement of a portion of the pavement structure.

pavement structure - A combination of subbase, 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 condition when rehabilitation is performed. This is also referred to as the design period.

permeable base (PB) - A base course constructed of treated or untreated open-graded aggregate. Also, free-draining base.

plain concrete - PCC without reinforcing steel.

plastic strain - non-recoverable strain after removing the load from a specimen under high strain.

portland cement concrete (PCC) - A composite material consisting of a portland or hydraulic cement, water, and embedded particles or fragments of aggregate. The portland cement and water react chemically to form a solid which binds the aggregates into a rocklike mass.

pozzolan - a finely divided material that reacts with calcium hydroxide and alkalis to form compounds with cementitious properties

prepared roadbed - In-place roadbed soils compacted or stabilized according to provisions of applicable specifications.

present serviceability index (PSI) - An index derived by formula for estimating the serviceability rating from measurements of physical features of the pavement.

present serviceability rating (PSR) - A mean rating of the serviceability of a pavement (traveled surface) established by a panel rating under controlled conditions. The usual scale for highways is 0 to 5, with 5 being excellent.

pumping - The ejection of foundation material, either wet or dry, through joints or cracks, or along edges of rigid slabs resulting from vertical movements of the slab under traffic, or from cracks in semi-rigid pavements.

punchouts - A broken area of a CRCP bounded by closely spaced cracks usually spaced less than 3 ft.

quad axle load - Four axles whose centers may be included between two parallel transverse vertical planes more than 120 inches (3m) but not more than 160 inches (4m) apart, extending across the full width of the vehicle.

random cracking - Uncontrolled and irregular fracturing of a pavement layer.

rankine temperature - Temperature scale having the same degree size as that used in the Fahrenheit scale. Zero degrees Rankine is the temperature at which molecular energy is a minimum and corresponds to -459.67°F . The freezing point of water and the boiling point of water correspond to 491.67 and 671.67 degrees Rankine

raveling - A pavement distress characterized by the loss of surface material involving the dislodgment of aggregate particles and degradation of the binder material.

reliability - The probability that a given pavement design will last for the anticipated design life.

reflective cracking - Cracks in asphalt or concrete surfaces of pavements, occurring over joints or cracks in the underlying layers.

rehabilitation - The act of restoring a pavement to a former condition.

reinforcement - Steel embedded in a rigid slab to resist tensile stresses and detrimental opening of cracks.

resilient modulus (M_r) - A standardized measurement of the modulus of elasticity of roadbed soil or other pavement material.

resilient strain - Recoverable strain in a material when a load is removed.

rideability - A subjective judgment of the comparative discomfort induced by traveling over a specific section of highway pavement in a vehicle.

rigid pavement - A pavement structure that distributes loads to the subgrade, having as one course a portland cement concrete slab of relatively high-bending resistance.

roadbed - The graded portion of a highway between top and side slopes, prepared as a foundation for the pavement structure and shoulder.

roadbed material - The material below the subgrade in cuts and embankments and in embankment foundations, extending to such depth as affects the support of the pavement structure.

rutting - Longitudinal depression or wearing away of the pavement in wheel paths under load.

salvage value - The value (positive if a residual economic value is realized and negative if demolition costs are accrued) of competing alternatives at the end of the life cycle or analysis period.

select material - A suitable native material obtained from a specified source, such as a particular roadway cut or borrow area, having specified characteristics to be used for a specific purpose.

serviceability - The ability at time of observation of a pavement to serve traffic (autos and trucks) that uses the facility.

single axle load - The total load transmitted by all wheels whose centers may be included between two parallel transverse vertical planes 40 inches (1m) apart, extending across the full width of the vehicle.

skewed joints - A variation of transverse contraction joint often used in plain undoweled pavements and placed at an angle (such as 2 to 12) such that no two wheels of a vehicle traverse the joint simultaneously.

soil aggregate - Natural or prepared mixtures consisting predominantly of stone, gravel, or sand that contain a significant amount of minus 75- μm (No. 200) silt-clay material.

soil cement - A mechanically compacted mixture of soil, portland cement, and water, used as a layer in a pavement system to reinforce and protect the subgrade or subbase. Also, cement-treated subgrade (CTS).

spalling - The cracking, breaking, or chipping of pavement edges in the vicinity of a joint or crack.

stabilized granular base - A base course with an unspecified stabilizing material, usually asphalt cement or portland cement.

stabilized permeable base - A permeable base with an unspecified stabilizing material, usually asphalt cement or portland cement. Also, bound drainable base.

subbase - The layer or layers of specified or selected materials of designed thickness placed on a subgrade to support a base course. Note that the layer directly below the PCC slab is now called a base layer, not a subbase layer.

subgrade - The top surface of a roadbed upon which the pavement structure and shoulders are constructed.

subgrade, improved - Any course or courses of select or improved materials between the subgrade soil and the pavement structure.

surface course - One or more layers of a pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion, and the disintegrating effects of climate. The top layer of flexible pavements is sometimes called the "wearing" course.

tandem axle load - The total load transmitted to the pavement by two consecutive axles whose centers may be included between parallel vertical planes more than 40 inches (1m) but not more than 8 feet (2400mm) apart, extending across the full width of the vehicle.

temperature difference – The difference between temperature at the top and bottom of a concrete slab.

thermal cracking - Cracks in an asphalt pavement surface, usually full width transverse, as a result of seasonal or diurnal volume changes of the pavement restrained by friction with an underlying layer.

thermal gradient – change in temperature through a concrete slab per unit length.

tie bar - A deformed steel bar or connector embedded across a longitudinal joint in a rigid slab to prevent separation of abutting slabs.

tire load - The portion of the gross-vehicle load imposed on the static tire at the time of weighing, expressed in units of mass, pounds, (kilograms) due only to the vertically downward force of gravity acting on the mass of the static vehicle.

traffic growth factor - A factor used to describe the annual growth rate of traffic volume on a roadway.

Traffic Monitoring Guide - Federal Highway Administration document providing guidance on the development of traffic monitoring programs for highway agencies.

transfer function - A factor that relates the theoretical calculation of damage to actual measured distress.

transverse cracking - Pavement cracking predominantly perpendicular to the direction of traffic.

transverse profile - The vertical deviations of the pavement surface from a horizontal reference perpendicular to the lane direction.

tridem axle load (triple axle load) - The total load transmitted to the road by three consecutive axles whose centers may be included between parallel vertical planes spaced more than 40 inches (1m) and not more than 96 inches (2400mm) apart, extending across the full width of the vehicle.

truck traffic classification (TTC) (truck class distribution factor) - A factor describing the proportion of trucks in a given class on a given roadway.

user costs - Those costs realized by the users of a facility. In life cycle-cost analysis, user costs could take the form of delay costs or of changes in vehicle operating costs associated with various alternatives.

vehicle classification - The identification, summarization and reporting of traffic volume by vehicle classification.

vehicle miles traveled - The average Sunday through Saturday vehicle movement on a specific road segment multiplied by the length of the road segment.

viscoelastic - Used to describe asphalt and many polymers that exhibit both viscous and elastic properties when deformed.

warping - Deformation of a PCC slab caused by a moisture differential between the upper and lower surfaces.

weigh-in-motion (WIM) - The process of estimating a moving vehicle's gross weight and the portion of that weight that is carried by each wheel, axle, or axle group, or combination thereof, by measurement and analysis of dynamic forces.

welded wire fabric (WWF) - A two-way reinforcement system for rigid slabs, fabricated from cold drawn steel wire, having parallel longitudinal wires welded at regular intervals to parallel transverse wires. The wires may be either smooth or deformed. Deformed wire (used in deformed wire fabric, DWF) is that which has uniformly spaced deformations which inhibit longitudinal movement of the wire and which conform to "Specifications for Welded Deformed Steel Wire Fabric for Concrete Reinforcement," AASHTO Designation - M221.

wheel load - The sum of the tire loads on all tires included in the wheel assembly comprising a half axle.

zero-stress temperature - temperature (after placement and during curing) at which the concrete layer exhibits zero thermal stress (at temperatures less than this, concrete exhibits tensile stress).