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Kingdom of Saudi Arabia
Ministry of Communications

Highway Materials Manual

Volume I
Part 1 General

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Foreword

Good materials control is a most important part of any construction project. Good materials control can only be maintained when the materials involved are properly sampled and accurately tested. It is an often repeated axiom that one test is worth a thousand opinions. The truth of this statement can only survive so long as that test is properly performed.

This materials manual has been prepared for the purpose of instructing and standardizing test methods and acceptance procedures for all materials used in construction which is under the supervision of the Ministry of Communications (MOC). It is intended that this manual be used in all project and MOC laboratories for guidance, reference, and instruction.

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Introduction

A. Background

The test methods presented in this Materials Manual were adapted from the latest edition of the Standard Specifications for Transportation Materials and Methods of Sampling and Testing of the American Association of State Highway and Transportation Officials (AASHTO), the American Society for Testing and Materials (ASTM), the Saudi Arabian Standards Organization (SASO), The Asphalt Institute, the Portland Cement Association, the American Concrete Institute and the British Standards Society. The adaptations were made as necessary to suit the specific needs of the Kingdom. Since all these sources are routinely revised and updated, it shall be necessary that this manual be periodically updated to reflect the latest methods. However, should discrepancies exist between the manual and the latest editions of the above referenced sources, the manual shall govern unless otherwise countermanded by the Ministry of Communications.

The loose leaf form was chosen because it facilitates revisions of the individual test methods and additions of new methods when developed, without reprinting the whole manual. While there are obvious advantages to this system, there is also one weakness that must be mentioned. That is the failure of some individuals in keeping all the manuals up to date. Additions and revisions will be distributed by the MOC; however, it shall be the responsibility of the individual holders of the manuals to see that their manuals are kept up to date. Each manual will be individually numbered and a record kept of the user and user's address so that any revisions may be properly distributed. Such revisions shall be dated in the upper right corner of each page.

Each test method is identified as a MRDTM, which stands for Materials and Research Department Test Method.

B. Content of Manual

This is Volume I of a series of three volumes comprising the Materials Manual.
The subjects of each volume are as follows:

Volume I

Part 1 Introduction
- List of Work Sheets (WS) and Report Sheets (RS)
- List of MRDTM's
- Glossary
- Sampling and testing frequency guide
- List of field laboratory equipment
- Table of conversion factors
- List of MRDTM's general to several test methods
- Test methods for general application

Part 2 A general discussion of soils and soil testing
- List of MRDTM's for soils
- Test methods for soils control

Volume II

Part 3 A general discussion of aggregates and aggregate testing
- List of MRDTM's for aggregates
- Test methods for aggregate control

Part 4 A general discussion of bituminous materials and mix properties
- List of MRDTM's for bituminous materials
- Test methods for bituminous materials and mix designs

Volume III

Part 5 A general discussion of portland cement concrete materials and design
- List of MRDTM's for concrete, steel and miscellaneous materials
- Test methods for portland cement concrete materials, concrete, steel, and miscellaneous materials

Part 6 Discussion of acceptance by certification
- Typical examples of mill certifications
- Procedure for laboratory standardization

Also included for each Test Method as applicable are examples of completed work sheets and test reports showing typical results. It is strongly recommended that the proper work sheets and test reports be used and that all data be carefully and accurately entered. These work sheets and test reports will constitute a valuable part of the documentation for all projects for which the Ministry of Communications is responsible.

C. Relations to Other Manuals and Specifications

This manual is one of a series of manuals distributed by the Ministry of Communications. Included are:

Highway Design Manual
Highway Construction Manual
Highway Maintenance Manual
Manual on Uniform Traffic Control Devices
General Specifications for Road and Bridge Construction

Briefly, the contents of these manuals include the following:

Highway Design Manual-Standard plans and details of standard highway features.

Highway Construction Manual-Contract administration, construction procedures and project control methods.

Highway Maintenance Manual-Administration of highway maintenance operations and a guide to good maintenance practices.

Manual on Uniform Traffic Control Devices-Signing and lighting standards for proper traffic control including signalization.

General Specifications for Road and Bridge Construction-General provisions, directions and requirements for the performance of the work.

It is expected that reference to these other manuals will be necessary for the successful accomplisment of the materials control program. Every effort has been made to coordinate the manuals, but should any discrepancies be found, they should be brought to the attention of the proper authorities for resolution.

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List of Report Sheets

List of Work Sheets

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List of Each Materials and Research Department Test Method (MRDTM)

Table 1 provides a list of test methods in numerical order, listing the Kingdom of Saudi Arabia, Ministry of Communications, Materials and Research Department, Standard Method of Test (MRDTM) and the MRDTM name.

Table 2 provides a list of MRDTM test numbers in numerical order, followed by the number of the appropriate test equivalent as published by the American Association of State Highway and Transportation Officials (AASHTO), the American Society for Testing and Materials (ASTM), or the Saudi Arabian Standards Organization (SASO).

Table 1
List of MRDTM Test Methods

MRDTM Number	MRDTM Test Name
Volume I-Part 1-General	
101	Sieves for Testing Purposes
102	Weights and Balances Used in Testing of Highway Materials
103	Terms Relating to Density and Specific Gravity of Solids, Liquids, and Gases
104	Verification of Testing Machines
Volume I-Part 2-Soils	
201	Dry Preparation of Disturbed Soil and Soil-Aggregate Samples
202	Wet Preparation of Disturbed Soil Samples for Test
203	Laboratory Determination of Moisture Content of Soils
204	Sieve Analysis of Fine and Coarse Aggregates
205	Particle Size Analysis of Soils
206	Amount of Material Finer than 0.075 mm Sieve in Aggregate
207	Specific Gravity of Soils
208	Determining the Plastic Limit and Plasticity Index of Soils
209	Determining the Liquid Limit of Soils
210	The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
211	Vacant
212	Moisture-Density Relations of Soils Using a 4.54 kg (10 lb) Rammer and a 457 mm (18 in.) Drop
213	The California Bearing Ratio
214	Relative Density of Cohesionless Soils
215	Density of Soil In-Place by the Sand Cone Method
216	Correction for Coarse Particles in the Soil Compaction Test
217	Determination of Moisture in Soils by Means of a Calcium Carbide Gas Pressure Moisture Tester
218	Density and Moisture Content of Soil and Soil-Aggregate in-Place by Nuclear Methods (Shallow Depth)
219	Vacant
220	Vacant
221	Vacant
222	Vacant
223	Soil Investigation and Sampling by Auger Borings
224	Penetration Test and Split-Barrel Sampling of Soils
225	Thin-Walled Tube Sampling of Soils
226	Diamond Core Drilling for Site Investigation
227	Field Vane Shear Test in Cohesive Soils
228	Determining Expansive Soils and Remedial Actions
229	Unconfined Compressive Strength of Cohesive Soils
230	One Dimensional Consolidation Properties of Soils
231	Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements

MRDTM Number **MRDTM Test Name**

List of MRDTM Test Methods (Continued)

232 ..... Strength Parameters of Soils by Triaxial Compression
233 ..... Direct Shear Test of Soils Under Consolidated Drained Conditions
234 ..... Bearing Capacity of Soil for Static Load on Spread Footings
235 ..... Measurements of Pore Pressure in Soils
236 ..... Installing, Monitoring, and Processing Data of the Travelling Type Slope Inclinometer
237 ..... Repetitive Static Plate Load Tests of Soils and Flexible Pavement Components for Use in Evaluation and Design of Highway Pavements
238 ..... Pavement Deflection Measurements
239 ..... Permeability of Granular Soils (Constant Head)
240 ..... Deep, Quasi-static, Cone and Friction Cone Penetration Tests of Soil

Volume 11-Part 3-Aggregates

301 ..... Sampling Stone, Gravel, and Sand for Use as Highway Materials
302 ..... Reducing Field Samples of Aggregate to Testing Size
303 ..... Total Moisture Content of Aggregate by Drying
304 ..... Specific Gravity and Absorption of Coarse Aggregate
305 ..... Specific Gravity and Absorption of Fine Aggregate
306 ..... Surface Moisture in Fine Aggregate
307 ..... Sieve Analysis of Mineral Filler
308 ..... Unit Mass and Voids in Aggregates
309 ..... Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
310 ..... Determination of Percentage of Crushed Aggregate
311 ..... Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
312 ..... Clay Lumps and Friable Particles in Aggregate
313 ..... Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
314 ..... Vacant
315 ..... Organic Impurities in Sands for Concrete
316 ..... Acid Insoluble Residue in Carbonate Aggregates
317 ..... Accelerated Polish Test for Coarse Aggregates
318 ..... Determination of Sulfate Content in Aggregates
319 ..... Chloride Determination in Aggregates
320 ..... Total Soluble Salt Content in Aggregates

Volume 11-Part 4-Bituminous Materials

401 .....Sampling Bituminous Materials
402 .....Solubility of Bituminous Materials in Organic Solvents
403 .....Flash and Fire Points by Cleveland Open Cup
404 .....Penetration of Asphalt Materials
405 .....Ductility of Asphalt Materials
406 .....Softening Point of Asphalt in Ethylene Glycol (Ring-and-Ball)
407 .....Specific Gravity of Semisolid Asphalt Materials
408 .....Kinematic Viscosity of Asphalts
409 .....Effect of Heat and Air on Asphalt Materials (Thin Film Oven Test)
410 .....Design of Asphalt Concrete Mixtures Using Marshall Procedures
411 .....Bulk Specific Gravity of Compacted Bituminous Mixtures
412 .....Maximum Specific Gravity of Bituminous Paving Mixtures
413 .....Coating and Stripping of Bitumen-Aggregate Mixtures
414 .....Compressive Strength of Bituminous Mixtures
415 .....Effect of Water on Cohesion of Compacted Bituminous Mixtures
416 .....Moisture or Volatile Distillates in Bituminous Paving Mixtures
417 .....Sampling Bituminous Paving Mixtures
418 .....Quantitative Extraction of Asphalt from Asphalt Paving Mixtures
419 .....Mechanical Analysis of Extracted Aggregate
420 .....Flash Point With Tag Open Cup Apparatus
421 .....Saybolt Viscosity
422 Distillation of Cutback Asphalt Materials

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MRDTM Number	MRDTM Test Name

List of MRDTM Test Methods (Continued)

Volume III-Part 5-Portland Cement Concrete Materials, Steel, and Miscellaneous Materials

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Table 2

Test Method Cross Reference
MRDTM-AASHTO-ASTM-SASO

Test Equivalent			
MRDTM	**AASHTO**	**ASTM**	**SASO**
101			227 and 228
102	M 231		
103	M 131		
104			211
201	T 87		
202	T 146		
203		D 2216	
204	T 27		
205	T 88		
206	T 11		
207	T 100		
208	T 90		
209	T 89		
210	M 145		
212	T 180		
213		D 1883	
214		D 2049	
215	T 191		
216	T 224		
217	T 217		
218	T 238 and T 239		
223	T 203		
224	T 206		
225	T 207		
226	T 225		
227	T 223		
228	T 258		
229	T 208		
230	T 216		
231	T 226		
232	T 234		
233	T 236		
234	T 235		
235	T 252		
236	T 254		
237	T 221		
238	T 256		
239	T 215		
240		D 3441	
301	T 2		
302	T 248		
303	T 255		
304	T 85		
305	T 84		
306	T 142		
307	T 37		
308	T 19 and T 20		
309	T 96		
311	T 104		
312	T 112		
313	T 176		
315	T 21		

Test Equivalent			
NIRDTM	**AASHTO**	**ASTNI**	**SASO**
316		D 3042	
319		D 1411	
401	T 40		
402	T 44		
403			25
404	T 49		
405	T 51		
406	T53		
407	T 228		
408			126
409	T 179		
410	T 245		
411	T 166		
412	T 209		
413	T 182		
414	T 167		
415	T 165		
416	T 110		
417	T 168		
418	T 164		
419	T 30		
420	T 79		
421	T 72		
422	T 78		
424	T 59		
427		D 3910	
501	T 127		
503	T 192		
504			142
505	T 105		
506	T 162		
508	T 186		
509	T 137		
511	T 154		
514	T 26		
516	T 141		
517	T 119		
518	T 121		
519	T 152		
521	T 199		
523	T 23 and T 126		
524	M 201		
525	T 24		
527	T 231		
528	T 22		
529	T 218		
530	T 133		
			107
			157
552			175
			189
			207
570	T 65		

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Glossary

A

Abrasion-Wearing away by friction.
Abrasive-Sharp granular material used to reduce or prevent slippery road surfaces.
Abscissa-The distance measure in the 'Y' or horizontal direction on a graph.
Absorption-The process by which a liquid is drawn into and tends to fill permeable pores in a porous solid body.
Accuracy-The degree of agreement between a measured value and a true value.
Acidity-The degree of strength of an acid. A liquid is said to be acid if it has a pH factor less than seven.
Active Pressure on Walls-The horizontal pressure exerted on the back of a retaining wall by earth loads and water, if present.
Adhesion-Molecular attraction exerted between the surfaces of two bodies; the force by which different substances cling to one another.
Admixture (Additive)-A substance added to a mixture to impart a specific characteristic, such as pozzolith in concrete, anti-stripping agents in bituminous mixes, calcium chloride or sodium chloride to clay, etc.
Addendum-A written amendment or revision to the Contract Documents or plans issued to bidders subsequent to the date of advertisement and prior to the final date and time for submission of Tenders indicated in the "Instructions to Tender."
Aeolian Deposits-Wind deposited material such as dune sands and loess deposits.
Aggregates-An aggregation of sand, gravel, crushed stone, or other material of mineral composition, used either alone or in combination with a binding medium to form bituminous and portland cement concrete, mortar, plaster,etc.
Aggregates (Coarse)-Aggregates predominantly retained on the 4.75 mm (No. 4) sieve.
Aggregates (Fine)-Aggregates passing the 9.5 mm (3/8 in.) sieve and almost entirely passing the 4.75 mm (No. 4) sieve, and predominantly retained on the 0.075 mm (No. 200) sieve.
Air-Dry Material-Materials dried by a natural method such as exposure under ambient atmospheric conditions or by an artificial method which simulates exposure to the atmosphere.
Air Entraining Agent-An admixture used in portland cement concrete to entrain air in the mixture.
Air-Voids-The space in a compacted mixture not filled with solids or liquids.
Aliquot-A portion of a known volume of liquid whose ratio to the total volume is the reciprocal of a whole number.
Alkalinity-The degree of strength of an alkali. A liquid is said to be alkaline if it has a pH factor greater than seven.
Alluvium-Soil, the constituents of which have been transported in suspension by flowing water and subsequently deposited by sedimentation.
AASHTO-Abbreviation for American Association of State Highway and Transportation Officials.
ASTM-Abbreviation for American Society for Testing and Materials.
Anhydrous-Free from water.
Angle of Internal Friction-The angle whose tangent is the ratio between the resistance offered to sliding along any plane in the soil and the component of the applied force acting normal to that plane. Values are given in degrees.
Angle of Repose-The angle between the horizontal and the maximum slope that a soil assumes through natural processes. For dry granular soils the effect of the height of slope is negligible; for cohesive soils the effect of height of slope is so great that the angle of repose is meaningless.
Aromatic Solvents-A chemical group of organic solvents which includes benzene, naptha, and xylene.
Asphalt-A dark brown to black cementitious material; solid, semisolid, or liquid in consistency; in which the predominating constituents are bitumens which occur in nature as such or which are obtained as residue in refining petroleum.
Asphaltenes-The components of the bitumen in petroleums, petroleum products, and asphalt cements which are soluble in paraffin napthas.
Asphalt Cement-A fluxed or unfluxed asphalt especially prepared as to quality and consistency for direct use in bituminous pavements, and having a penetration at 25 C of between 5 and 300 under a load of 100 g applied for 5 s.
Asphalt Concrete-See Bituminous Concrete.
Asphalt Emulsion-See Emulsified Asphalt.
Asphaltic Material-See Bituminous Material.
Asphalt Overlay-A bituminous paving course placed over an existing surface to provide smoothness and increase strength.
Aspirator-A device which uses flowing water to create a suction or vacuum.

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B

Backfill-Material used to replace, or the act of replacing, material removed during construction; also denotes material placed, or the act of placing, material adjacent to structures.
Backslope-In cuts, the slope from the bottom of the ditch to the top of cut.
Balance-(I) An instrument used for weighing; (2) To design a section of highway such that the volume of earth necessary for embankment equals the volume of excavation.
Ballast-(I) Gravel, broken stone, granular materials, etc., used to provide added stability. (2) A device used with an electric discharge lamp to obtain the necessary circuit conditions (voltage, current, and waveform) for starting and operating the lamp.
Base Course-The layer, or layers, of specified or selected material of designed thickness placed on a subbase or a subgrade to support a surface course.
Beaker-A flat bottomed, cylindrical vessel usually with a pouring lip used especially for testing purposes.
Bedrock-Rock of relatively great thickness and extent in its native location.
Binder-Material used to stabilize or bind together loose soil or aggregates.
Binder Course-A plant mix of graded aggregate and bituminous material which is placed between the base course and a bituminous surface course.
Biodegradable-A substance, which will rot or decay under the action of weather, bacteria, or other natural agents.
Bitumen-(I) A hydrocarbon material, obtained from natural asphalts or refined petroleum, which is completely soluble in carbon disulfide. (2) Bitumen is a common synonym for asphalt cement.
Bituminous Concrete-A combination of mineral aggregates and asphalt cement, mixed in a central plant which is usually mixed, laid, and compacted while hot.
Bituminous Material-(I) Material containing bitumen. (2) A general term encompassing asphalt cements, cutbacks, and emulsified asphalts.
Bituminous Pavement-A pavement composed of crushed rock or other aggregate cemented together with bitumen.
Bituminous Plant Mix Friction Course-A combination of mineral aggregate and bituminous material mixed in a central plant, laid and compacted while hot. This type of course is usually laid in very thin layers.
Bituminous Surface Treatment-The application of liquified bituminous material and aggregate to an existing road surface.
Bleeding (Asphalt)-The flushing to the surface of excess bitumen in bituminous pavement caused by heat or the use of excessive quantities of bituminous material in construction, patching, or resurfacing.
Bleeding (Concrete)-The flow of water toward the surface of freshly placed concrete or mortar.
Bond (Tack Coat)-The application of a liquid bitumen to cause a new surface to adhere to an existing hard surface.
Borrow-That material necessary to construct the embankment which is not available from the design excavation.
Boulder-A rock fragment, usually rounded by weathering or abrasion, with an average diameter of 75 mm or more.
Bulking-(I) The increase in volume of a material due to manipulation. Rock bulks upon being excavated; damp sand bulks if loosely deposited, as by dumping, because the apparent cohesion prevents movement of the soil particles to form a reduced volume. (2) The act of fine material solidifying in a plant bin so as not to discharge freely when the gates are open.

C

Calcareous-Material containing or like calcium carbonate or lime.
Calcium Chloride-A white salt, in the form of flakes, pellets, or granules which are soluble in water and are used to lay dust, or to stabilize gravel surfaces.
Calcium Magnesium Chloride Solution (Brine)-Calcium chloride, either alone or in combination with magnesium or sodium chloride, in a liquid state, and obtained from natural or concentrated brine, used to stabilize gravel surfaces and as an aid in dust control.
Calibrate-(I) To determine settings of the plant which will provide correct proportions of the components of plant-mixed materials. (2) To compare with a standard or check the graduations of a gauge or other measuring devices.
California Bearing Ratio (CBR)-The ratio of the force required to penetrate a soil mass with a circular piston of 5 cm diameter to the force required to penetrate a mass of high quality crushed stone with the same piston. The rate of penetration in both cases is 1.27 mm per minute.
Capillary Moisture-Moisture which clings to soil particles by surface tension and reaches the particles by surface tension either when free water passes through the soil or by capillary attraction from a wetter stratum. Within limits, it can move in any direction.
Cationic Emulsion-An asphalt emulsion which contains positively charged particles which are attracted to a negative electrode (cathode).
Centipoise-A unit of absolute viscosity.

Centistoke-A unit of kinematic viscosity.

Certificate of Guarantee-A signed statement by a person having legal authority to bind a company or supplier to its product. Such certificate shall state that the material specifications and test results are in compliance with the specified requirements of the pertinent MOC, AASHTO, ASTM, and/or other designations.

Chips-Small angular fragments of aggregate containing no dust.

Classification-The grouping of highways, materials, soils, etc., according to similar traffic or physical characteristics.

Clay-A fine-textured soil, usually plastic and sticky when wet, which usually breaks into hard lumps when dry. When the moist soil is pinched between the thumb and finger, it will form a long, flexible ribbon.

Clay Sized-That portion of the soil finer than 0.002 mm.

Coagulate-To unite into a coherent mass.

Cohesion-That property of material that tends to make its particles stick together.

Cohesionless Soil-A soil that, when unconfined, has little or no strength when air dried, and little or no cohesion when submerged. Sand is an example of cohesionless soil.

Cohesive Soil-A soil that when unconfined has considerable strength when air dried and that has significant cohesion when submerged.

Cold Patch-A mixture of bituminous material and aggregate used for general maintenance pavement patching and applied at ambient temperatures.

Colloids-That portion of the soil finer than 0.001 mm.

Compaction-The artificial densification of a mass by rolling, tamping, vibrating, or other means.

Compressibility-The property of a material which enables it to remain compressed after compaction.

Compressive Stress-The stress produced in a member when the forces acting on it tend to push the particles together.

Concrete (Bituminous)-See Bituminous Concrete.

Concrete (Portland Cement)-A mixture of portland cement, water, fine aggregate, and coarse aggregate with or without an admixture.

Consistency-The degree of cohesiveness or resistance to movement of constituent particles in a mass of material. Some of the terms used to express consistency are: firm, hard, friable (easily crumbled), sticky, or soft.

Consolidate-To densify by compaction or natural means.

Consolidation Test-A test in which a saturated soil specimen is laterally confined in a ring and is compressed between porous plates.

Constraint-Any restriction to the deformation of a body.

Contract and Contract Documents-The written agreement between the MOC and the Contractor setting forth the obligations of the parties thereunder, including, but not limited to, the performance of the work, the furnishing of labor and materials, and the basis of payment. The contract documents include the invitation for tenders, instructions to tenderers, the tender, notice of award, form of contract, contract bond, general conditions and special conditions, general specifications, supplemental specifications, special specifications, plans, addenda, directives, change orders and supplemental agreements that are required to complete the work, all of which constitute one instrument.

Correlation-A comparison of the relationship between two properties.

Corrugated Metal-A sheet of metal that has been formed into a series of small regular parallel undulations.

Course-A layer of road material separately compacted, used as a wearing surface or as base for a wearing surface. (2) One element of the pavement structure of finite depth, e.g. bituminous wearing course.

Crack Filler-Asphalt material used to fill and sealcracks.

Crash Cushion (Impact Attenuator)-A device placed before a fixed roadside object to absorb and dissipate collision energy, thus reducing the severity of injuries and property damage.

Creep-The slow movement of a material under stress usually imperceptible except to observations of long duration.

Crushed Gravel-The product resulting from the crushing of ordinary gravel with substantially all fragments having one or more faces resulting from fracture.

Crushed Stone-The product resulting from the crushing of fragments of bedrock or large stones with all fragments having all faces resulting from fracture.

Curing Material-A material, such as saturated burlap, polyethelene sheets, or a sprayable compound, that prevents the evaporation of mixing water from portland cement concrete.

Cutback Asphalt-A mixture of asphalt cement and a diluent blended to provide viscosities suitable for spraying at relatively low temperatures. The diluents vary from naphtha and gasoline for rapid curing cutbacks, to kerosene for medium curing cutbacks to low volatile oils for slow curing mixtures.

Cut Section-That part of the roadway which, when constructed, is lower in elevation than the original ground.

D

Decant-To pour liquid from one vessel to another without disturbing the sediment or lower liquid level.
Degree of Saturation-The ratio of the volume of water to the volume of voids. It is usually expressed as a percentage.
Dehydrate-To remove water from a solid.
Deleterious-Harmful.
Delineator-A visual device for defining the alignment of a roadway.
Dense Graded-A well graded aggregate with sufficient fine material to nearly fill all voids.
Density-(I) The mass per unit volume of a material, usually expressed in kg per cubic m or g per cubic cm. (2) The number of vehicles per kilometer on the traveled way at a given instant.
Design Subgrade Value-The subgrade strength value that is equal to or less than approximately 90% of all test values in the section.
Design Thickness-The total thickness of asphalt concrete determined from the thickness design chart as adequate for a given Design Traffic Number and subgrade strength value.
Desiccator-A glass jar fitted with an airtight cover and containing a drying agent (desiccant).
Direct Shear Test-A shear test in which soil under an applied normal load is stressed to failure by moving one section of the soil container relative to the other section.
Dry Masonry-Stone laid without mortar.
Ductility (Bituminous)-The measured distance which a bituminous briquet of standard dimensions will elongate before breaking when pulled apart at specified conditions of temperature and speed.
Ductility (Steel)-The ability of a material to deform plastically under tensile forces before fracturing.
Durability-That property which enables a material to resist disruptive forces of nature and those applied in service over an extended period of time.
Dust Palliative-Any material used to control dust.

E

Elasticity-That property of a material which permits it to return approximately to its original dimensions upon the removal of an applied load.
Elastic Limit-The greatest stress which a material is capable of sustaining without any permanent deformation remaining upon complete release of the stress.
Elongation-The increase in gauge length of a tension test specimen, usually expressed as a percentage of the original gauge length.
Embankment-A raised earth structure on which the roadway pavement structure is placed.
Embankment Foundation-The material below the original ground surface, the physical characteristics of which affect the support of the embankment.
Empirical-Developed from experience or observations without regard to science and theory.
Emulsified Asphalt-A mixture of asphalt cement and water mixed with an emulsifying agent.
Emulsified Asphalt Break-Coalescence (uniting) of asphalt globules. The time required for asphalt to separate from the water phase is called breaking or setting time.
Emulsified Asphalt Treated Base-A base consisting of a mixture of mineral aggregate and emulsified asphalt spread on a prepared surface to support a surface course.
Emulsion-A suspension of small droplets of one liquid material in another, the two liquids being mutually insoluble, in the presence of an emulsifying agent.
Encroachment-Unauthorized use of the right-of-way or easements as for signs; fences, buildings, etc.
Engineer-The duly authorized representative of the Ministry of Communications at the project site, acting directly or through his duly authorized representatives, who is responsible for engineering supervision of the work.
Entrained Air-Air bubbles of extremely small size in diameter ranging from about 0.02 to 0.08 mm which are usually incorporated into a portland cement concrete mix through the use of an air entraining agent.
Erosion-A slow wearing away of the surface by natural action of wind or water.
Excavation-(1) The act of taking out material. (2) The materials taken out. (3) The cavity remaining after materials have been removed.
Expansion-The increase in volume of a material due to increase in temperature.
Expansion Joint-A narrow space left between two parts of a concrete structure to allow for expansion and contraction of the concrete with changes in temperature and loading.
Extensometer-A device for measuring linear strain.

F

Factor of Safety (Safety Factor, Cut and Fill Slopes)-That factor by which the shear strength may be reduced in order to bring the slope into a state of limiting equilibrium along a given slip surface.
Fabricating Plant-A plant where component parts are formed, welded, or bolted together to form assembled units, such as beams, trusses, or other parts of metal structures.
False Set-The rapid development of rigidity in a mixed portland cement paste, mortar, or concrete which can be dispelled by further mixing without the addition of water.
Family of Curves-A group of similar moisture-density curves assuming a characteristic shape. The higher unit mass soil or soilaggregate materials assume steep slopes, while the lower unit mass soil, or soil aggregate materials assume a conical shape of curve with higher optimum moisture contents. Usually a "Family of Curves" is derived from one source of supply.
Filtrate-Liquid which has passed through a filter.
Fill Section-See Embankment.
Fill Slope-In fills, the slope from the top of the subgrade to the toe of fill.
Fineness Modulus-An index of the fineness or coarseness of an aggregate; the summation of the cumulative percentages of the material retained on a specified series of sieves divided by 100. It is not an indication of grading. Sizes range from 0.15 mm (No. 100) to 37.5 mm (1 ½ in.), and larger, increasing in the ratio of 2 to 1.
Fines-(1) Aggregates-Portion finer than the 4.75 mm (No. 4) sieve. (2) Soils-Portion of a soil finer than a 0.075 mm (No. 200) sieve.
Flash Point-That temperature at which a material gives off a flammable vapor in sufficient quantity to cause fire immediately when a flame or spark comes near.
Flexible Base-A base with low resistance to bending enabling it to stay in contact with the underlying structure. This type of base distributes loads to the subbase. Examples are dense graded aggregate bases and asphalt treated bases.
Flexible Pavement-A pavement structure which maintains intimate contact with and distributes loads to the subgrade and depends on aggregate intergranular particle friction, and cohesion for stability.
Floc-Loose open-structured mass formed in a liquid suspension by the aggregation of minute particles.
Flushing-See Bleeding (Asphalt).
Fog Seal-A thin application of bituminous material without cover aggregate.
Footing-Portion of the foundation of a structure that transmits loads directly to the soil.
Foundation-Lower part of a structure that transmits loads directly to the soil.
Friable Soil-A soil that can be easily broken and crushed by moderate finger pressure.
Fuel Oil-A light oil, similar to kerosene, used as a solvent for asphalt cutbacks of type MC.

G

Gap-Graded-An aggregate gradation of predominately two types with little or no in between sizes.
Gasoline-An inflammable liquid produced from petroleum, which is used as a motor fuel and as a solvent for asphalt cutbacks of type RC.
Gauge Length-The original length of that portion of a test specimen over which strain or change of length is determined.
Geotechnical Engineering-The application of scientific methods and engineering principles to the acquisition, interpretation, and evaluation of subsurface data to predict the behavior of the materials of the earth's crust. It encompasses the fields of soil mechanics, rock mechanics, geological engineering, geophysics, and related fields, such as pavement design.
Gradation-A general term used to describe the composition of an aggregate, soil, or other granular materials. Gradation is usually expressed as the proportions (percents) of the aggregate that will pass each of several sieves of different sizes.
Grade-(l) The profile of the center of the roadway, or its rate of ascent or descent. (2) To shape or reshape an earth road by means of cutting or filling. (3) To arrange according to size. (4) Elevation.
Grading-(I) Construction of the earthwork portion of the highway. (2) Planing or smoothing the surface of various parts of the road by means of a motor-driven adjustable steel blade.
Gravel-Aggregate composed of hard, durable stones or pebbles, crushed or uncrushed, often intermixed with sand.
Ground Water-Free water contained in the zone below the water table.
Grout-Mortar, composed of sand, cement ' and water, of such consistency that it can be easily worked.
Gunite (Shoterete)-A type of portland cement mortar blown into place by compressed air. The materials are mixed while being forced through a nozzle.

H

Hardpan-Layer of extremely dense soil.
Heterogeneous-Composed of parts of different kinds; having widely dissimilar elements or constituents.
Homogeneous-Having a uniform composition throughout.
Horizon (Soils)-One of the layers of the soil profile, distinguished principally by its texture, color, structure, and chemical contents.
Hot Mix-A general term used for hot plantmixed bituminous concrete and sheet asphalt mixtures which are manufactured and laid at temperatures ranging from 120 to 190 Celsius.
Humidity (Relative)-The amount of moisture in the air compared with the amount that the air could hold if saturated at that temperature.
Humus-A brown or black material formed by the partial decomposition of vegetable or animal matter; the organic portion of soil.
Hveem Stabilometer-A laboratory instrument used to measure the lateral pressure transmitted by a soil or aggregate subjected to a vertical load. The pressure thus obtained is used to compute the "R" value of that material.
Hydrated Lime-A dry powder obtained by treating quick-lime with enough water to satisfy its chemical affinity for water under the conditions of its hydration.
Hydrometer-A floating instrument used for determining the specific gravity of liquids and solutions.
Hydrophilic-Tending to attract water.
Hydrophobic-Tending to repel water.
Hydrostatic Pressure-The pressure in a liquid under static conditions; the product of the unit weight of the liquid and the difference in elevation between the given point and the free water elevation.
Hygroscopic Moisture (Water)-Water retained by soil after gravitational and capillary moisture are removed. It is held by each soil grain in the form of a very thin film and has both a physical and chemical affinity for the soil grain. Also, it is spoken of as the air dry moisture content. This film is in equilibrium with the moisture content of the air and increases or decreases as the moisture content (humidity) of the air increases or decreases. The hygroscopic moisture content of a soil also varies with the grain size. As the grain size decreases, the hygroscopic moisture content increases.

I

Igneous Rock-Those rocks formed by the cooling and consolidation of complex silicious solutions (magmas) newly risen from some deeperlevel.
Impervious-Resistant to the penetration of a liquid or gas.
Improved Material-A material whose engineering properties have been enhanced by processing, blending, or additives.
Infiltration-The ability of the soil of a drainage area to absorb water, expressed in centimeters per hour.
Insoluble-Incapable of being dissolved.
Inspector-The Engineer's authorized representative assigned to make detailed inspections of the Work.
Internal Friction-The resistance to sliding within the soil mass.

J

Job Mix-The exact proportions of all components of a bituminous or other type mix, determined by laboratory tests.

K

Kinematic Viscosity-A measure of the time for a fixed volume of liquid to flow through a calibrated capillary tube at a specified temperature.

L

Laboratory-The field testing laboratories or any other testing laboratories which may be designated by the Engineer.
Ledge Rock-A layer of stone in a quarry.
Leveling Course-The layer of material placed on an existing surface to eliminate irregularities prior to placing an overlaying course.
Lime-A general term which includes the various chemical and physical forms of quicklime, hydrated lime, and hydraulic lime used for any purpose.

Liquid Asphalt-Cutbacks or emulsified asphalts.
Lithology-A geological term dealing with the physical properties of rocks and their structure.
Loam-A mixture of sand, silt or clay, or a combination of any of these, with organic matter. It is sometimes called topsoil in contrast to the subsoils that contain little or no organic matter.
Loess-A uniform wind-blown deposit of silty material having an open structure and relatively high cohesion due to cementation of clay or calcareous material at grain contacts.
Log, Drilling-A record of underground conditions discovered by drilling test holes. A drilling log documents the thickness and composition of underground geological formations.
Longitudinal-Running or placed lengthwise.
Longitudinal Joint-A joint which extends lengthwise of the roadway.
Lot-A finite quantity of material produced more or less continuously from a single production process.

M

Mandrel-A tool used in making bend tests by applying the bending force to the inside surface of the bend.
Marshall Stability-The maximum load sustained by a Marshall briquette when tested at 60 C.
Material Direct Cost-A monetary value which is the sum of expenditures for purchases from suppliers, and services from outside processors and/or haulers, plus direct costs for highway department labor and equipment involved in processing, handling, and/or hauling a specific lot or class of material.
Materials-Any substance specified for use in the construction of the project and its appurtenances.
Mechanical Analysis (Soils)-Finding the gradation of a soil by the use of specified sieves and a hydrometer.
Mesh-The square opening of a sieve.
Mineral Filler-A fine inert mineral matter such as limestone dust or portland cement, used in bituminous concrete mixtures.
Miscible-Capable of being mixed.
Modulus of Elasticity-The ratio of stress to strain for a material under given loading conditions.
Modulus of Rupture-A measure of the strength of concrete when it is broken by bending.
Moisture Content-The percentage, by mass, of water contained in soil or other material, usually based on the dry weight.
Mortar-A mixture of cement, sand, lime, and water.
Muck-An organic soil of very soft consistency.

N

Naptha-An inflammable liquid produced from petroleum. Solvent Naptha is used in the production of RC cutback asphalts.

0

Oiling-The application of a cutback asphalt material to a surface.
Open-Graded Aggregate-A graded aggregate, containing little or no fines, with a high percentage of aggregate voids.
Optimum-The best quantity, number, or condition.
Ordinate-The distance measured in the "y" or vertical direction on a graph.
Overburden-The mass of soil which overlies a source of rock, gravel, or other road material. This material is removed before the materials are quarried to avoid contamination.
Overlaying Course (Overlay)-A bituminous surface course, either plant mixed or road mixed.

P

Passive Pressure on Walls-The horizontal pressure exerted on the front of a wall by the earth load, or water, if present. Passive pressure opposes active pressure.
Patching-Mending; repairing; especially to repair a road surface.
Pavement Design-The arrangement of materials in depth to best accommodate the anticipated loading.
Pavement Structure-The combination of subbase, base course, and surface course placed on a subgrade to support the traffic load and distribute it to the roadbed.
Penetration-(I) The consistency of a bituminous material expressed as the distance that a standard needle vertically penetrates a sample of the material under known conditions of loading, time, and temperature. (2) A method of applying bituminous binder to gravel or crushed stone roadbeds by spreading liquid bitumen over the surface and allowing it to seep into, or penetrate, the surface.

Permeability-The property of soils which permits the passage of any fluid and depends on grain size, void ratio, shape, and arrangement of pores.
Pervious-A layer of material, through which water will move under ordinary hydrostatic pressure.
pH-A scale of numbers from 0-14 which indicate the acidity or alkalinity of a solution. Numbers below 7 indicate acidity and numbers above 7 alkalinity.
Pipet-A small calibrated glass tube used to measure and transfer an exact volume of liquid.
Plant Mix-A term describing the mixing of mineral aggregate and asphaltic products in a mechanical mixer, after which the finished mix is transported and laid on the road. The proportioning of aggregate constituents and asphalt is closely controlled, and the aggregate is usually dried and heated before mixing.
Plant Mixed Bituminous Base-A base consisting of mineral aggregate and bituminous material, mixed in a central plant, laid and compacted while hot, on subbase or subgrade, to support a surface course.
Plant Mixed Bituminous Surface Course-A combination of mineral aggregate and bituminous material mixed in a central plant, laid, and compacted while hot, on a previously prepared base.
Plastic-A material which exhibits no recovery when molded or compressed.
Plating-The covering or confining of unstable fills with a suitable, stable material.
Plumb-Vertical.
Porous-Having many small openings, through which liquids may pass.
Portland Cement-A hydraulic cement consisting of compounds of silica, lime, and alumina; so called from its resemblance in color, when set, to the Portland stone of England.
Portland-Pozzolan Cement-An intimate and uniform blend of portland cement and fine pozzolan, produced by either intergrinding portland cement clinker and pozzolan or by blending portland cement and finely divided pozzolan.
Precipitate-Material that drops out of solution as a solid.
Precision-The variance of repeated measurements of a characteristic from their average.
Premix-(I) To mix in a central mixing plant, or elsewhere, previous to placing. (2) Any prepared bituminous or surfacing material that can be applied either hot or cold.
Prestressed Concrete (Pre-Tensioned)-Reinforced concrete in which bars, wires, or cables are held in a stretched condition during placing of the plastic concrete until the concrete has hardened. Then as the tension on the reinforcing steel is released, it compresses the concrete.
Prestressed Concrete (Post-Tensioned)-Reinforced concrete in which the pre-stressing wires or tendons are placed in tubes before the concrete is cast. After the concrete has hardened the wires or tendons are stretched to a pre-determined tension by jacking and are wedged in this position. The tubes may also be pressure-grouted.
Prime Coat-The application of a low viscosity liquid bituminous material to an absorbent surface, preparatory to any subsequent treatment, for the purpose of hardening or toughening the surface and promoting adhesion between it and the superimposed construction.
Pugmill-A type of paddle mixer used for mixing bituminous paving materials.

Q

Quality Standard-A formally established criterion for a specific activity which: (a) describes a deficiency, condition, or schedule that establishes the need for work; (b) outlines the work involved; (c) tells how to achieve good workmanship; and (d) lists expected end results.
Quarry-A place from which stone is excavated, as by blasting, for construction purposes.
Quartering-Dividing into four equal parts so that each part is truly representative of the whole. Applied generally to obtain representative samples.
Quicklime-A calcined material, the major part of which is calcium oxide or calcium oxide in natural association with a lesser amount of magnesium oxide, capable of slaking with water.

R

Random-Without bias or regularity.
Ravelling-The progressive loosening of the aggregate in the surface course of a road.
Rebars or Reinforcing Bars-Steel bars used as reinforcement in concrete.
Recycling-The reuse, usually after some processing, of a material that has already served its first intended purpose.
Reduction of Area-The difference between the original cross sectional area of a tension test specimen and the area of the smallest cross section after testing.
Referee Test-A test of definite procedure to be used in case of dispute.

Reflection Crack-A crack appearing in a resurface or overlay caused by movement at joints or cracks in underlying base or surface.
Reflux-To boil under a condenser so that the condensed vapors return to the original container.
Reinforced Concrete-Concrete in which steel reinforcement is embedded so that the steel and concrete act together in resisting stress.
Repeatability-The degree to which the same operator can duplicate the results of a test or measurement in a laboratory.
Representative-Typical of a larger number of items or quantity.
Reprocessing-The working of an existing surface or shoulder material by scarifying and/or remixing with additional materials, then reshaping to proper contour.
Reproducibility-The degree to which different operators or different laboratories can duplicate the results of a test.
Resilient Modulus-A measure of the resilient character of an untreated fine-grained soil when tested for conditions that represent stress in pavements subjected to moving wheel loads.
Resurfacing-The placing of one or more new courses on an existing surface.
Riprap-A protective covering of graded stones, with or without mortar, to prevent erosion.
Roadbed-The graded portion of a road or highway, usually considered as the area between the intersection of top and side slopes, upon which the base course, surface course, shoulders, and median are constructed. The top of the subgrade.
Road Mix-A method of combining surfacing materials, such as mineral aggregate combined with liquid bituminous material, in which the materials are mixed on the road by means of discs, harrows, blades, or other approved means.
Rockwell Hardness Test-An indentation hardness test using a calibrated machine to force a diamond penetrator or a hard steel ball under specified conditions, into the surface of the material under test in two operations, and to measure the difference in depth of the impression under the specified conditions of minor and major loads.

S

Safety Factor (Soils)-That factor by which the shear strength may be reduced in order to bring the slope into a state of limiting equilibrium along a given slip surface.
Sand-A fine granular material, that results from the natural disintegration of rock.
Sand Seal-An application of asphaltic material covered with fine aggregate.
Sample-A portion of material or a group of units taken in such a way as to represent a material.
Sample Splitter-A device used to reduce a sample proportionally to an amount suitable for testing.
Saybolt Furol Viscosity-The efflux time in seconds of 60 milliliters of sample flowing through a calibrated furol orifice under specified conditions.
Seal Coat-A bituminous coating with aggregate applied to the surface of a pavement for the purpose of waterproofing and preserving the surface, relivening a previous bituminous surface, altering the surface texture of the pavement, or providing resistance to traffic abrasion.
Sedimentation-The action or process of depositing particles of waterborne or windborne soil, rock, or other materials.
Segregation-Separation of portions of a mixture from the mass. The localization of sizes or portions within a mixture or mass.
Selected Material-Native material obtained from a specified source such as a particular roadway cut or borrow area, and having specified characteristics.
Set-(I) The strain remaining after complete release of the load producing the deformation. (2) The initial hardening of portland cement concrete.
Sieve-In laboratory work an apparatus, with definite openings for separating sizes of soils or aggregates.
Significant Digit-That digit in a calculated number which represents the highest acceptable level of accuracy obtainable from the numbers used in the calculation.
Silt-Material passing the 0.075 mm (No. 200) sieve that is nonplastic or very slightly plastic, and exhibits little or no strength when air dried.
Silt Size-That portion of the soil finer than the 0.075 mm (No. 200) sieve and larger than 0.0005 mm.
Skip-Graded Aggregate-An aggregate which lacks one or more sizes of material.
Slaking-The treatment of calcium oxide (lime) with water to make calcium hydroxide.
Slump-The measure of the consistency of portland cement concrete by consolidating in a slump cone, removing the cone, and allowing the concrete to settle under its own mass.
Slurry-A suspension of solids in water.
Slurry Seal-A seal coat consisting of semifluid mixture of asphaltic emulsion and fine aggregate.
Soil-Sediments or other unconsolidated accumulation of solid particles produced by the natural physical and chemical disintegration of rocks, and which may or may not contain organic matter.
Soil Classification-The arrangement of soils into classes according to their physical properties. There are several systems of soil classifications.

Soil Stabilization-Measures taken to eliminate or minimize the erosion of soil, or to improve its supporting capacity.
Soil Strength-The ability of a soil to resist displacement during cyclic or repetitive loading as compared to static loading.
Soil Support Value-A number which expresses the relative ability of a soil aggregate mixture to support traffic loads through the pavement structure.
Solids-The portion of a liquid sample remaining after evaporation of the liquid, usually expressed as percent of the original sample.
Solubility-The amount of a substance which will dissolve in a liquid, usually expressed as a percent.
Solute-A dissolved substance.
Solvent-A liquid used for dissolving another substance.
Spalling-Chipping along the edges, as at joints in concrete pavement and structures.
Specific Gravity-The ratio of the mass of a solid to the mass of an equal volume of water at a standard temperature. (1) (Apparent)- The specific gravity in which only those voids or pores which cannot be penetrated by water are included in the volume. (2) (Bulk)-The specific gravity in which the voids or pores in the material that can be penetrated by water are included in the volume.
Special Specifications-Additions and revisions to the General and Supplemental Specifications covering conditions peculiar to an individual project.
Specifications-The formal directions, provisions, and requirements which outline the work to be done, the way in which it is to be done, the character of materials and mixtures to be used, or the results to be obtained.
Stability-That property of a material which determines its resistance to deformation when subjected to external loading.
Stability (Marshall)-The maximum load sustained by a Marshall briquette when tested at 60 C.
Stabilization-Modification of soils or aggregates by incorporating materials that will increase load-bearing capacity, firmness, and resistance to weathering or displacement.
Standard-Something having recognized and usually permanent values and established as a model or criteria.
Standard Sand-A sand used in making a standard mortar for testing cement.
Stockpiles-Piles of material stored for later use.
Stone-Rock material produced from a quarry, i.e., non-gravel material.
Strain-The change in length per unit of length in a given direction.
Stratigraphy-The study of rock strata, generally by analyzing rock outcrops or drill cores.
Strength Coefficient-A factor used for expressing the relative strength, or substitution value, of layers, one to the other, for conversion purposes in a pavement structure.
Stress-The force per unit area acting within a mass.
Stress-Strain Diagram-A diagram in which corresponding values of the stress and strain are plotted.
Stripped-Peeled off, as asphalt from aggregate or forms from concrete.
Structural Section-The planned layers of specified materials, normally consisting of subbase, base, and surface course placed over the subgrade.
Subbase-The layer or layers of specified or selected material of designed thickness placed on a subgrade to support a base course.
Subgrade-(I) The top layer of specified thickness of embankments or excavated areas on which the pavement structure including shoulders is constructed. (2) The top of a roadbed upon which the pavement structure and shoulders are constructed.
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 is sometimes called Wearing Course.
Surface Treatment-An application of bituminous material and cover aggregate.

T

Tack Coat-An application of bituminous material to an existing surface to provide bond with a superimposed course.
Tamp-To compact material by a succession of light or medium blows.
Texture-Surface appearance of a material such as smooth, rough, etc.
Titration-The volumetric addition of a solution to another solution to determine the endpoint of a reaction.
Topsoil-Surface soil, usually containing organic matter.
Toxic-Poisonous.
Triaxial Shear Test-A test in which a cylindrical specimen of soil, encased in an impervious membrane, is subjected to a confining pressure and then loaded axially to failure.

U

Undisturbed Sample-A sample that has been obtained by methods in which every precaution has been taken to minimize disturbances to the sample.
Uniformly Graded-Material with a uniform gradation from coarse to fine.
Unstable-Natural or processed materials which readily yield to relatively small loads.
Untreated Base Course-The layer or layers of base course without mineral filler or asphaltic binder.

V

Viscosity-The property of a fluid to resist flow.
Visual Inspection-Inspection for defects which can be seen.
Vitrified Clay-Clay that has been fired to produce a glassy or glasslike surface, usually used in pipe and tile.
Voids-The empty spaces between particles in a substance or mixture.

W

Warehouse Stock-Materials stored by a producer or supplier for anticipated use on highway projects.
Waste-Excess earth, rock, vegetation, or other materials resulting from highway construction.
Waterbound-Bonded with the aid of water.
Water-Cement Ratio-The ratio of the amount of water, exclusive only of that absorbed by the aggregates, to the amount of cement in a concrete or mortar mixture; preferably stated as a decimal by mass.
Wearing Course (Surface Course)-The top layer of a pavement.
Weathering-The decomposition of rock, shale, etc., because of the action of the weather.
Well Graded-Aggregate material of varying particle sizes which produce maximum density when mixed.
Windrow-Material deposited or manipulated into a continuous uniform row.
Wire Mesh-A network of wires used as distributed reinforcement in concrete.

Y

Yield (Concrete)-The ratio of the volume of a mixture produced to that which theoretically should be produced.
Yield Strength-The stress at which a material exhibits a specified limiting deviation from the proportionality of stress to strain.

Sampling and Testing

A. Field Quality Control and Documentation

1. Responsibility of the Engineer

The plans and specifications define the minimum requirements for the quality of materials and work to be furnished under the contract.

The objectives of the sampling, testing, and inspection performed on construction projects are to insure that materials used and work done will conform with the plans and specifications and to alert the Engineer and the contractor to the need for corrective action in case of nonconformity.

The Engineer is responsible to verify that the required sampling and testing is accomplished according to standard procedures and that the materials used and work done on the project, whether produced on the project or delivered to the project from an outside source, comply with the contract specifications. Control of the quality of the materials used is accomplished in one of the following ways:

a. The material is inspected or sampled and tested on the project.
b. The material is sampled on the project and the sample is sent to the Materials and Research Department for testing. The material is sampled and tested on the project, but a part of the sample is sent to the Materials and Research Department for check testing. This is to check the equipment and the testing procedure used at the project site.
d. A representative of the Materials and Research Department samples the materials at the source or observes the taking of the samples and the sample is tested either at the site or at the Materials and Research Department laboratory. The test results are sent to the Engineer.
e. The material is accepted on the basis of a certification or guarantee furnished by the manufacturer or supplier.

The Engineer and Inspectors on the project must know which of the methods of control are to be used for each material. Sufficient samples must be taken to represent the material that is delivered to the project for assurance that it complies with specification requirements.

The Engineer and Inspectors must know where, when, and how to take the samples; what size they must be; what tests are required; how they are to be performed; and which reports and records are to be used to document the results. Reports on all materials must be kept in the project files for necessary documentation.

As an aid and guide to the Inspector and other personnel involved in the various inspection programs, the schedules for sampling and testing in Sec B have been prepared. These schedules show the minimum number of samples to be taken; however, a nonuniform product will require more samples than indicated in the schedule for assurance of its quality.

2. Types of Samples

Depending upon the information required on a material, the type of sample to be taken may be one of the following:

Qualifying samples
Job control samples
Split samples
Laboratory check samples
Information samples
Acceptance samples

It is important that the distinction between the six types be understood and applied by all personnel involved with sampling and testing. A description of each is given below.

a. Qualifying Samples

Qualifying samples are taken and tested to determine the quality of a given product or general source of material. Qualifying tests are those such as soundness, wear and deleterious substances for aggregates, and those to determine the acceptability of an asphalt or portland cement concrete, etc. Quality and source approval tests generally have a lesser frequency than job control tests and a substantial quantity of material may be utilized between sampling periods. While in many instances only one test is indicated on a composite sample, it is imperative that the composite sample as prepared

be truly representative of the source. If obvious visual differences exist, the minimum number of samples should be increased and, if necessary due to failing tests, either the source shall be rejected, or those portions represented by failing tests properly marked and placed off limits. The frequency of testing quality or source approval samples presumes continued uniformity. At any time a change in the characteristics of the source is observed or suspected, additional samples should be taken. Where a previously tested and approved source subsequently produces failing results, use of that source shall immediately cease and the Engineer shall determine the corrective action to be taken.

b. Job Control Samples

Job control samples are tested at the project site, or at the site of production for the purpose of quality control of all materials used in construction. Material samples shall be taken at the location where the material is required to meet specification requirements. This should be at a point immediately prior to mixing the product with other materials or so processed that its characteristics are changed, unless otherwise indicated. A minimum number of test samples are required to represent a definite and identified lot of material presumed by the producer or contractor to be acceptable for use. The quantity represented by each sample must be recorded as well as the test results and the test report must be signed by the Inspector. It is important that a definite numbering system be used to identify each sample tested with a given quantity of material inspected.

c. Split Samples

Split samples are a split part of a job control sample taken by the project personnel and sent to the Materials and Research Department laboratory to check the results of the field control tests. The sample data sheet accompanying the split sample shall show the job control sample number and the project test results for comparing the results obtained by both laboratories.

d. Check Samples

Check samples are taken of materials that are used in construction work. They are similar to job control samples except that they are taken and tested by, or in the presence of the Engineer or his designated representative. The purpose is to check the equipment and procedures used in sampling and testing materials and to verify the reliability of the job control test results. The results from check samples and tests do not in themselves form a basis for determining if a material or process is in compliance with the specifications but serves to augment job control results for this purpose. This sampling and testing is in addition to job control sampling and testing.

The personnel performing the check sampling and testing are MOC personnel other than those involved in the routine job control sampling and testing, and may make visits to the project sites and perform one or several of the following functions as appropriate:

1. Obtain check samples for testing at the Materials and Research Department laboratory. If possible, samples will be taken near the location of the job control sampling.
2. Perform tests at the site.
3. Observe sampling and testing procedures and equipment utilized by site personnel.
4. Review results from job control sampling and testing.
5. Obtain occasional split samples for cooperative testing by Materials and Research Department and site laboratories.

It is the responsibility of the Engineer to review results of laboratory check testing as to compliance with governing specifications and also to compare the results of laboratory check samples with results from job control tests. Significant or major differences should be cause for evaluation of testing procedures or equipment.

e. Information Samples

Information samples may be any type of samples not mentioned above. These may be samples taken during production of materials and prior to the point at which acceptance is made, gradation samples to determine the type of material available, samples taken during the calibration of hot mix plants, and the like. The reason for taking information samples should be clearly stated on the test report and/or sample transmittal.

f. Acceptance Samples

Acceptance samples are taken at random locations for the purpose of determining compliance with specifications and final acceptance of the material prior to provisional handover.

3. Sampling and Testing Requirements

It is the responsibility of the project personnel to sample and test all materials as frequently as is necessary to assure that all materials being used conform to the specifications. The minimum requirements set forth in Sec B are based on experience and/or research which has shown that, in general, reasonably uniform materials when sampled at these frequencies will assure that the materials being used are adequately represented by the tests. Where materials exhibit nonconformity, as shown by either visual inspection or tests, it is necessary that the frequency of sampling and testing be substantially increased.

These frequencies are intended for average size projects. Typically, high production may result in more uniform materials and a reduced testing frequency may be permitted so long as satisfactory results are being obtained. However, low production rates often result in more variability of the materials and more frequent sampling and testing may be required to ensure quality. Increased sampling and testing frequencies may be ordered by the Engineer at any time. Reduced frequencies must be approved by the MOC and documented in the files.

Samples are considered to represent not more than a maximum quantity. The inspector must use judgement in determining and recording the information on the quantity represented by a sample. The important item is to obtain sufficient tests to properly represent all the materials being used.

The size of the sample will vary depending on the type of material and the tests required. It should be large enough to provide sufficient material to conduct all of the required tests and to make check tests as desired. The information contained in Sec B is a guide to the size of sample to submit for testing.

4. Locations for Taking Samples

The location for taking samples will vary depending on the type of material and the information desired. An information sample will be taken at a location where the given information is needed. For example, during the production of aggregate, material should be sampled at several intervals for proper control of the operation. Samples taken for assurance of the quality of a material to determine its acceptability shall be taken at the location where it is required to meet the specifications. Job control samples shall be taken at a location prior to the material being mixed with other materials or so processed that its characteristics are changed.

5. Acceptance of Materials

The Engineer is responsible to ensure that all materials incorporated into the work meet or exceed the specifications requirements. Where job control samples or laboratory check samples indicate failing materials, that quantity of material as represented shall be either removed and/or reworked and retested to ensure its compliance with specifications.

Numerous instances of passing density tests taken in the field immediately after compaction have failed to meet specifications when tested during Handover. Engineers need to be cognizant that loss of moisture in a compacted layer will not in and of itself result in a loss in density, however, loss of moisture together with subsequent traffic or vibration may result in a loss of density in cohesionless materials. Therefore not only frequency, sample size and location, but also timeliness are all important to ensure the end result specifications are achieved.

Minimum Sampling and Testing Schedule

General Specifications	Test	Reference	Test Frequency: Quality/Source	Test Frequency: Project Control	Test Frequency: Check	Sample Size and Location: Quality/Source	Sample Size and Location: Project Control/Check
Section 2.02 Roadway and Borrow Excavation	Classification	MRDTM 210(1)	One per source	–	–	Fifty (50) kilogram sample from borrow pit	–
	California bearing Ratio (CBR)	MRDTM 213(1)	or material type	–	–	or roadway excavation for source approval	–
	Moisture Density or	MRDTM 212 or	"	–	–	Use same sample	–
	Relative Density	MRDTM 214	"	–	–	"	–
Embankment	Moisture Density or	MRDTM 212	See Roadway and		One per layer per	–	In place immediately
	Relative Density	MRDTM 214	Borrow Excavation	–	50,000 sq. meters	–	prior to placement
	Field Density	MRDTM 215 or	"	One per layer	"		of next layer
		MRDTM 218		per 5,000 sq. meters	"		
Subgrade	Classification	MRDTM 210	"	One per 5,000 square meters of completed subgrade	One per 50,000 square meters of completed subgrade	–	Fifty (50) kilogram sample from roadway
	California bearing Ratio (CBR)	MRDTM 213	"	–	One per 5,000 meters of completed subgrade	–	Use same sample
	Moisture Density	MRDTM 212	See Roadway and Borrow Excavation	–	One per layer per 20,000 square meters	–	"
	Field Density	MRDTM 215 or	"	One per layer	"	–	In place immediately
		MRDTM 218	"	per 2,000 square meters	"	–	prior to placement of next layer
Section 2.04 Lime Treated Subgrade	Source Approval	Specifications(5)	One per source or combination of sources	Certificates of Guarantee for lime	–	–	–
	Moisture Density	MRDTM 212	"	–	–	–	Same as subgrade
	Field Density	MRDTM 215 or	–	One per layer	One per layer	–	In place
		MRDTM 218		per 2,000 square meters	per 20,000 square meters		after final compacting
Section 2.05 Backfill for Structures	Classification	MRDTM 210(1)	See Roadway and Borrow Excavation	One per layer per 5,000 square meters	–	–	–
	Moisture Density	MRDTM 212	"	–	–	–	–
	Field Density	MRDTM 215 or	–	One per layer	One per layer	–	In place immediately
		MRDTM 218		per 2,000 square meters	per 20,000 square meters		prior to placement of next layer

For explanation of notes in parentheses see last sheet.

B. Minimum Sampling and Testing Schedule (Continued)

General Specifications	Test	Reference	Test Frequency			Sample Size and Location	
			Quality/Source	Project Control	Check	Quality/Source	Project Control/Cbeck
Section 3.02 Untreated Granular Sub-base and Base Courses	Sieve Analysis	MRDTM 204	One per source	One per 1,000 cubic meters	One per 10,000 cubic meters	Seventy-five (75) kilogram sample from pit or crusher	Tbirty-five (35) kilogram sample from central mix plant
	Plasticity Index	MRDTM 209	"	"	"	Use same sample	Use same sample
	Loss by Abrasion	MRDTM 309	"	–	"	"	"
	Moisture Density	MRDTM 212	"	–	"	"	"
	California Bearing Ratio (CBR)	MRDTM 213	"	–	"	"	–
	Field Density	MRDTM 215 or	–	One per layer	One per layer	–	In place immediately
		MRDTM 218	–	per 2,000 square meters	per 20,000 square meters	–	prior to placement of next layer
	Thickness	Specifications	–	One per completed 2,000 square meters	–	–	In place
	Fractured Faces	MRDTM 310(1)	One per source	–	One per 10,000 cubic meters	Use same sample	Use same sample
	Thin and Elongated Pieces	Specifications(1)	"	–	"	"	"
	Soundness	MRDTM 311(1)		–	"	"	"
Section 3.03 Aggregates for Cement Treated Base Course	Sieve Analysis	MRDTM 204	One per source	One per 1,000 cubic meters	One per 10,000 cubic meters	Seventy-five (75) kilogram sample from pit or crusher	Tbirty-five (35) kilogram sample from central mix plant
	Plasticity Index	MRDTM 208	"	One per 5,000 cubic meters	One per 10,000 cubic meters	Use same sample	Use same sample
	Loss by Abrasion	MRDTM 309	"	–	"	"	"
	Soluable Sulfates and Chlorides	MRDTM 318(2) MRDTM 319(2)	"	–	One per 50,000 cubic meters	"	"
Cement for Cement TreAted Base Courses	Quality	Specifications	"	Certificates of Guarantee	One per 50,000 cubic meters of base course	Five (5) kilogram sample from several bags or silo	Five (5) kilogram sample from several bags or silo
Water for Cement Treated Base Courses	Quality	MRDTM 514(2)	"	–	"	One (1) liter sample from source	One (1) liter sample from source

For explanation of notes in parentheses see last sheet.

B. Minimum Sampling and Testing Schedule (Continued)

General Specifications	Test	Reference	Test Frequency			Sample Size and Location	
			Quality/Source	Project Control	Check	Quality/Source	Project Control/Check
Section 3.03 Aggregates for Cement Treated Base Courses	Mix Verification	Specifications(,)	One per source or Combination of Sources	–	One per 5,000 cubic meters	Use same sample	Use same sample
	Moisture Density	MRDTM 212	"	–	"	"	"
	Field Density	MRDTM 215 or MRDTM 218	–	One per layer per 2,000 square meters	One per layer per 20,000 square meters	"	"
	Thickness	Specifications		One per completed 2,000 square meters	–		In place
Section 4.01 Asphalt Cement	Quality	Specifications(2)	–	Certificates of Guarantee	–	–	–
	Penetration	MRDTM 404	–	"	One per plant per production week	–	One liter sample from plant line
Liquid Asphalts	Quality	Specifications(2)	–	"		–	–
Section 4.03 Aggregates For Bituminous Surface Treatments And Seal Coats	Sieve Analysis	MRDTM 204	One per source	One per production day	One per production week	Fifty (50) kilogram sample from crusher or pit	Twenty-five (25) kilogram sample from stockpile
	Flakiness	MRDTM 423	"	–	"	Use same sample	Use same sample
	Loss by Abrasion	MRDTM 309	"		"	Fifty (50) kilogram sample from crusher or pit	Fifty (50) kilogram sample from crusher or pit
	Soundness	MRDTM 311	"	–	–	Use same sample	–
	Stripping	MRDTM 413	"	–	–	"	–
Section 4.04 Aggregates for Sand Subbase Courses and Open Graded Subbase Course (Stockpiled)	Sieve Analysis	MRDTM 204	One per source	One per week during production and stockpiling	–	Twenty-five (25) kilogram sample	Twenty-five (25) kilogram sample from stockpile

For explanation of notes in parentheses see last sheet.

B. Minimum Sampling and Testing Schedule (Continued)

General Specifications	Test	Reference	Test Frequency			Sample Size and Location	
			Quality/Source	Project Control	Check	Quality/Source	Project Control/Check
Section 4.04 Aggregates for Sand Subbase Courses and Open Graded Subbase Course (Stockpiled)	Liquid Limit(3)	MRDTM 208	One per source	One per week during production and stockpiling	One per week from the cold feed during mix production	Use same sample	Use same sample
	Plasticity Index(3)	MRDTM 209	"		"	"	"
	Sand Equivalent(3)	MRDTM 313	"	"	"	"	"
	Loss by Abrasion	MRDTM 309	"	"		"	"
	Stripping	MRDTM 413	"	"		–	
Aggregates for Bituminous Sand Subbase Courses and Open Graded Subbase Course (Hot bins)	Sieve Analysis	MRDTM 204	–	One set per plant per production day	"	–	Ten (10) Kilogram sample from each bin
Bituminous Sand Subbase Courses	Marshall Mix Design	MRDTM 410	One per source	–	–	Fifty (50) kilogram plus ten (10) liters asphalt cement	–
	Marshall Stability	MRDTM 410	–	One per plant per production day	–		Ten (10) kilogram sample from plant
	Effect of Water	MRDTM 415	"	–	One per plant production week	–	Fifteen (15) kilogram sample from plant
	Extracted Asphalt	MRDTM 418	–	One per 500 cubic meters (not less than one per production day)	One per 5,000 cubic meters	–	Ten (10) kilogram sample from roadway behind paver
	Gradation of Extracted Aggregate	MRDTM 419	–	"	"	–	Use same sample
	Thickness	MRDTM 417	–	One core per 1,000 square meters of completed course	–	–	Roadway
	Field Density	MRDTM 411	–	"	–	–	Use roadway sample
Section 4.05 Aggregates for Bituminous Base Course (Stockpiled)	Sieve Analysis	MRDTM 204	One per source	–	One per week during production and stockpiling	Twenty-five (25) kilogram sample from pit or crusher	Twenty-five (25) kilogram sample from pit or crusher

For explanation of notes in parentheses see last sheet.

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B. Minimum Sampling and Testing Schedule (Continued)

General Specifications	Test	Reference	Test Frequency			Sample Size and Location	
			Quality/Source	Project Control	Check	Quality/Source	Project Control/Check
Section 4.05				–			
Aggregates for Bituminous Base Course (Stockpiled)	Fractured Faces	MRDTM 310	One per source	One per week during production and stockpiling	One per week from the cold feed during mix production	Use same sample	Use same sample
	Sand Equivalent(3)	MRDTM 313				"	"
	Plasticity Index(3)	MRDTM 208	"	"	"	"	"
	Soundness	MRDTM 311	"	–	–	"	–
	Loss by Abrasion	MRDTM 309	"	–	One per week during production and stockpiling	"	
	Thin and Elongated Pieces	Specifications	"	–	"	"	"
Aggregates for Bituminous Base Course (Hot Bins)	Stripping	MRDTM 413	"	–	–	Ten (10) kilogram sample from bins	–
	Sieve Analysis	MRDTM 204	–	–	One set per plant per production day	–	Ten (10) kilogram sample from each bin
Mineral Filler	Sieve Analysis	MRDTM 307	One per source	One per 500 tons of filler		Five (5) kilogram sample	–
Bituminous Base Course	Marshall Mix Design	MRDTM 410	"	–		Fifty (50) kilogram each size aggregate and ten (10) liters asphalt cement	–
	Marshall Stability	MRDTM 410	–	One per plant per production day		–	Fifteen (15) kilogram sample from roadway behind paver
	Effect of Water	MRDTM 415	One per source	–	One per plant per production week	–	Use same sample
	Extracted Asphalt Content	MRDTM 418	–	One per 500 cubic meters (not less than one per production day	One per 5,000 cubic meters	–	Ten (10) kilogram sample from roadway behind paver
	Gradation of Extracted Aggregate	MRDTM 419	–	"	"	–	Use same sample

For explanation of notes in parentheses see last sheet.

B. Minimum sampling and Testing Schedule (Continued)

General Specifications	Test	Reference	Test Frequency			Sample Size and Location	
			Quality/Source	Project Control	Check	Quality/Source	Project Control/Check
Section 4.05 Aggregates for Bituminous Base Course	Thickness	MRDTM 417	–	One core per 1,000 square meters of completed course	–	–	Roadway
	Field Density	MRDTM 411	–	One core per 1,000 square meters of each layer	–	–	Use roadway Sample
Section 4.06	Same as Section 4.05						
Section 4.07	Same as Section 4.05						
Section 4.08	Same as Section 4.05						
Section 5.01 Coarse Aggregate for Concrete	Sieve Analysis	MRDTM 204	One per source	One per 1,000 cubic meters of concrete	One per 10,000 cubic meters of concrete	Fifty (50) kilogram sample from source	Twenty-five (25) kilogram sample from stockpile
	Loss by Abrasion	MRDTM 309	"	–	"	Use same sample	Use same sample
	Soundness	MRDTM 311	"	–	"	"	"
	Friable particles	MRDTM 312	"	–	"	"	"
	Specific Gravity and Absorption	MRDTM 304	"	–	"	"	"
	Soft Fragments and Shale	AASHTO TI 13-80	"	–	"	"	"
	Thin and Elongated Pieces	Specifications		–	"	"	"
	Soluable Sulfates and Chlorides	MRDTM 318(2) MRDTM 319(2)	"		"	"	"
	Moisture	MRDTM 303	–	One per production day	–	–	Use same sample
Fine Aggregate for Concrete	Sieve Analysis (Including Fineness Modulus)	MRDTM 204	One per source	One per 1,000 cubic meters of concrete	One per 10,000 cubic meters of concrete	Twenty-five (25) kilogram sample from stockpile	Five (5) Kilogram sample from stockpile
	Soundness	MRDTM 311	"	–	"	Use same sample	Use same sample
	Friable Particles	MRDTM 312	"	–	"	"	"
	Organic Impurities	MRDTM 315	"	–	"	"	"
	Sand Equivalent	MRDTM 313	"	One per 1,000 cubic meters of concrete	One per 10,000 cubic meters of concrete	"	"

For explanation of notes in parentheses see last sheet.

B. Minimum Sampling and Testing Schedule (Continued)

General Specifications	Test	Reference	Test Frequency			Sample Size and Location	
			Quality/Source	Project Control	Check	Quality/Source	Project Control/Check
Section 5.01							
Fine Aggregate for Concrete	Moisture	MRDTM 303	One per source	One per production day	–	Use same sample	–
	Soluable Sulfates	MRDTM 318(2)	"	–	One per 10,000 cubic meters	"	Use same sample
Water for Portland Cement Concrete	Quality	MRDTM 514	"	–	One per 10,000 cubic meters	One (1) liter sample from source	One (1) liter sample from source
Portland Cement	Quality	MRDTM 504(2)	"	Certificates of Guarantee	One per 10,000 cubic meters of concrete	Five (5) kilogram sample from several bags or silo	Five (5) kilogram sample from several bags or silo
	Time of set (Vicat)	MRDTM 504	–	One test per shipment	–	Use same sample	–
Portland Cement Concrete	Mix Design	MRDTM 515	One per mix design	–	–	Two hundred (200) kilogram sample of aggregate	–
	Compressive Strength	MRDTM 523	One set of cylinders per mix design	One set of cylinders per 50 cubic meters. Not less than one per production day	One set of cylinders per 500 cubic meters	Three (3) cylinders from mixer or truck	Three (3) cylinders from mixer or truck
	Air Content	MRDTM 519 or MRDTM 520	See mix design	One test per 50 cubic meters. Not less than one per production day	–	0. 1 cubic meter from mixer or truck	–
	Unit Weight/ Cement Factor	MRDTM 518	"	One test per 50 cubic meters. Not less than one per production day	–	0.1 cubic meter from mixer or truck	–
	Slump	MRDTM 517		One test per 20 cubic meters	–	0.5 cubic meter from mixer or truck	–
Mortar		Same requirements as cement, fine aggregate, and water for concrete.					
Section 5.02							
Reinforcing Steel	Quality	Specification(2)	–	Certificates of Guarantee	One sample for each size bar for each 50 tons or fraction of that size.(4)	–	One-1.5 meter bar each size

For explanation of notes in parentheses see last sheet.

B. Minimum Sampling and Testing Schedule (Continued)

General Specifications	Test	Reference	Test Frequency: Quality/Source	Test Frequency: Project Control	Test Frequency: Check	Sample Size and Location: Quality/Source	Sample Size and Location: Project Control/Check
Section 5.04 Prestressing Steel	"	"	–	"	One sample from each spool (4)	–	One-2 meter strand each spool
Section 6.09 Paint	"	"	–	"	One sample from each lot.(4)	–	Ten (10) liter sample from project storage
Section 6. 10 Thermoplastic Traffic Markings	Quality	Specifications(2)	–	Certificates of Guarantee	One sample from each lot.(4)	–	Ten (10) kilogram sample from project storage
All other manufactured items	Manufacturers certificates and/or test reports covering all material. Additional tests or samples may be ordered by the Engineer.						
All other contractor produced materials	Sampling and testing as ordered by the Engineer and required by the specifications.						

NOTES:

(1) Not required unless the test is specifically included in the specifications.

(2) Contractor not required to furnish facilities to perform test. Tests may be performed in an independent laboratory approved by the Ministry.

(3) If lime is added, acceptance samples shall be taken after the addition of the slurry but before the drier. In this case, minimum acceptance sampling frequency shall be one per production day.

(4) Physical tests required on all samples. Chemical tests required on occasional samples selected by the Engineer.

(5) If used for roadway structural improvement, additional design testing will be required.

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Field Laboratory Equipment

A. Introduction

The quality control of materials used in roadway construction projects requires specialized test equipment. Each field laboratory shall be equipped with all necessary test equipment to control the materials to be used on the project. The test equipment shall be in good condition and calibrated in accordance with the requirements of Part 6, of this manual.

The following listing of both general and specific test equipment is given as a check list of required items and is keyed to the type of construction control expected on the project. The equipment listed and the number of individual items is a minimum requirement. Many of the items are easily broken or otherwise rendered unusable and replacement should be readily available so that control testing of critical construction is not interrupted.

No attempt is made to fully describe the various items listed; however, references are given to a MRD Test Method in which the specific requirements of each item are given.

The list is organized to present first those items of general testing equipment which every field laboratory is expected to have. They are items that are used in a number of different test areas. Following the list of general testing equipment are lists of additional test equipment required in specific areas of control testing including soils analysis and compaction, aggregate quality, bituminous materials and portland cement concrete. There may be some duplication of equipment where one field laboratory has responsibility for two or more areas of testing, such as asphalt concrete and aggregate testing.

In addition to the items listed it is expected that each project laboratory will be supplied with necessary paper and drawing materials, as well as rudimentary tools such as hammers, saws, pliers, screwdrivers, gloves, etc.

B. General Testing Equipment

Number Required	Description			MRDTM Reference
2	Sets of Sieves, 203 mm (8 in.) diameter including the following sieve sizes:			101
	75 mm (3 in.)	12.5 mm (1/2 in.)	0.60 mm (No. 30)	
	63 mm (2 1/2 in.)	9.5 mm (3/8 in.)	0.425 mm (No. 40)	
	50 mm (2 in.)	4.75 mm (No. 4)	0.30 mm (No. 50)	
	3 7.5 mm (1 1/2 in.)	2.36 mm (No. 8)	0.18 mm (No. 80)	
	25.0 mm (1 in.)	2.00 mm (No.10)	0.15 mm (No. 100)	
	19.0 mm 3/4 in.)	1. 18 mm (No. 16)	0.075 mm (No. 200)	
	pan and cover.			
1	Set of Sieves, 305 mm (12 in.) diameter including the following sieve sizes:			101
	75 mm (3 in.)	37.5 mm (1/2 in.)	12.5 mm (1/2 in.)	
	63 mm (2 1/2 in.)	25.0 mm (1 in.)	9.5 mm (3/8in.)	
	50 mm (2 in.)	19.0 mm (3/4 in.)	4.75 mm (No. 4)	
	pan and cover.			
1	Motorized, Dynamic Sieve Shaker for 203 mm (8 in.) sieves			204
1	Timer for Motorized Sieve Shaker			204
1	Brass Wire Brush			204
1	Stiff Bristle Brush			204
2	Small Paint Brush			204
1	Sample Splitter, coarse			302
1	Sample Splitter, fine .			302
1	Quartering Canvas 2 x 2 m (approximately)			302
2	Laboratory Oven, 50 x 50 x 50 cm minimum, 110 C minimum,			
2	Hot Plate, 150 mm square, 400 C,			
1	Platform Scale, 115 kg capacity, sensitivity ±50 g			214
1	Balance, Class E			102
2	Balance, Class D			102
1	Balance, Class B			102

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1	Stop Watch, 60 minutes, graduated in one-fifth second increments.	
2	Calculator, scientific,	
4	Thermometer, general lab, 0-200 C, ±0.5 C	205
6	Pans, metal, 50 x 30 x 10 cm (approximately),	
2	Drying Pans, 60 x 90 x 10 cm (approximately),	
3(ea)	Beaker, glass, 250 ml, 500 ml, 1000 ml,	
24(ea)	Metal Tins with lids, 150 ml and 75 ml capacity	209
1 (ea)	Metal Straightedge, 30 cm and I m, with beveled edge	517 & 212
1	Micrometer Calipers, 25 mm	
2(ea)	Volumetric Flask, 500 ml and 1000 ml	305
1	Desiccator, 200 mm (minimum) diameter	207
1	Aspirator	412 & 207
1	Testing Machine, 1375 kN, (125,000 kg) capacity	528 & 213
12	Metal Can, 4 liter (approximately), with lids	215
48	Sample Sack, canvas, 50 kg capacity,	
2	Wash Bottle, 1000 ml, complete,	
2	Graduated Cylinder, 100 ml capacity,	
2	Tamping Rod, 16 x 6 10 mm	308 & 517
3	Thermometer, armored, 250 C,	
20	Distilled Water, 1 liter bottle,	
10	Standard Weights, 25.0 kg,	
I	Calipers, 40 cm opening,	
4	Mixing Bowls, stainless steel, 1 1/2 to 2 1/2 liter	
2(ea)	Tongs, Beaker and Crucible	
2	Scoop, grain,	
2	Shovel, square,	
2	Brush,bench,	
2	Bucket, 12 liter (approximately)	
2(ea)	Trowel, large and small,	
3	Spoons, heavy mixing,	
2	Ruler, folding or retractable, 1 m,	
I	Rubber Mallet, approximately 1 kg,	
I	Mikrotest Gauge (for galvanized coating),	
I	Feeler Gauge, 0.25 mm,	

C. Soils Testing Equipment

Number Required	Description	MRDTM Reference
1	Mortar, porcelain, 200 mrn diameter, with rubber-covered pestle	203
1	Stirring Apparatus	205
1	Hydrometer, 152H	205
2	Graduated Cylinder, 1000 ml	205
1	Water Bath, thermostatically controlled	205
1	Porcelain Dish, 115 mm diameter (approximately) with handle	209
1	Liquid Limit Device, complete	209
1	Spatula, 75 mm long x 20 mm wide (approximately)	209
1	Vibratory Table	214
1	Mold, metal cylindrical, 2830 cm^3 capacity	214
1	Mold, metal cylindrical, 14160 cm^3 capacity	214
	(above molds to be accompanied by guide sleeves, base plates, surcharge mass, dial indicators, calibration bar and pouring devices),	
1	Hoist, 136 kg capacity (minimum)	214
2	Pycnometer Jar with top, 500 ml capacity	207
2	Pycnometer Bottle, 100 ml capacity	207
4	Mold, Proctor	212
1	Hammer, Proctor, 4.54 kg with 457 mm drop	212
1	Sample Extruder	212

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3	Mold, CBR, with plate, collar, penetration piston and expansion measuring device,	213
1	Water Tank, 1 x 2 x 1 m (approximately)	213
4	Sand Cone Density Apparatus	215
1	Speedy Moisture Tester, complete (optional)	217
1	Nuclear Moisture Density Gauge (optional)	218

D. Aggregate Testing Equipment

Number Required	Description	MRDTM Reference
1	Sand Equivalent Test Set, complete	313
4	Graduated Sand Equivalent Plastic Cylinders	313
1	Sand Equivalent Shaker, manual or mechanical	313
12	Stock Solution, Sand Equivalent, 240 ml bottle	313
1	Unit Mass Measure, 30 liter capacity, with glass cover plate	308
1	Set, Organic Impurities Test	315
1	Sand Moisture Test Mold and Tamper	305
1	Wire Mesh Basket, 3500 cm^3 volume (approximately)	304
1	Los Angeles Abrasion Machine	309
1	Sieve, 203 mm (8 in.) diameter 4.00 mm (No. 5)	311
1	Set Brass Baskets	311
1	Glazed Porcelain Crock, 20 liter (approximately)	311
1	Pycnometer, glass	305
1	Aggregate Accelerated Polishing Machine (when specified)	317
1	British Portable Pendulum Tester (when specified)	317

E. Bituminous Test Equipment

Number Required	Description	MRDTM Reference
48	Sample Can, 1 liter, with screw caps	401
6	Marshall Specimen Mold Assembly	410
1	Marshall Specimen Extractor	410
1	Marshall Compaction Hammer	410
1	Marshall Specimen Mold Holder	410
1	Marshall Breaking Head	410
1	Marshall Ring Dynamometer Assembly	410
1	Marshall Flowmeter	410
1	Mechanical Mixing Apparatus	410
1	Water Bath, thermostatically controlled to 60 ±1 C	410
6	Glass Plates, 15 x 15 x 0.5 cm	415
1	Bituminous Extraction Apparatus, complete	418
1	Specific Gravity Apparatus for compacted bituminous mixtures	411
1	Laboratory Oven, 50 x 50 x 50 cm (approximately), to 200 C	414
48	Sample Box, 30 x 30 x 10 cm, cardboard	
3	Mixing Pan, rounded corners, 500 ml capacity	413
3	Glass Pycnometer with top, 1000 ml capacity	412
2	Specific Gravity Bottle, 24 to 30 ml capacity	407
2	Thermometer, -8 to 32 C, ASTM E I No. 63 C	407
1	Test Set for Penetration of Bituminous Materials	404
1	pH Meter	424
1	Core Drilling Apparatus with bits	411
6	10 1. 6 mm (4 in.) Compression Molds with top and bottom plungers	414 & 415

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F. Portland Cement Concrete Test Equipment

Number Required	Description	MRDTM Reference
12	Cylinder Molds, 150 x 300 mm, reusable	522
2	Slump Cone, complete	517
1	Air Meter, complete	519
1	Cylinder Capping Apparatus	527
2	Concrete Capping Compound, 23 kg bag	527
1	Mixing Pan, heavy gauge metal, 0.1 m^3 (approximately)	523
1	Core Drilling Apparatus	525
2	Evaporating Dish, 200 ml capacity	514
1	pH Meter	514
1	Conductivity Meter	514
1	Unit Mass Measure, 0.014 ml with cover plate	518
1	Tube Sampler	501
1	Melting Pot for cylinder capping compound	527
2	Cube Molds, Set of Three, 50 x 50 x 50 mm	513
1	Tamper, 13 x 25 x 150 mm	513
1	Chace Air Indicator	521
1	Quality of Water Test Set	
1	Schmidt Concrete Test Hammer	
1	Vicat Apparatus	504
1	Steel Straightedge, 46 cm	523
1	Curing Tank, with temperature control	
1	Gilmore Apparatus	511
1	No. 325 Sieve	503
1	Mechanical Mixer for PCC pastes and mortars	506

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Table of Conversion Factors
U.S. Customary Units to International System (SI) of Units

To Convert From	to	Multiply by
acre	meter ^{2} (m^2)	$1.233\ 489 \times 10^3$
atmosphere (1 kgf/cm^2)	pascal (Pa)	$9.806\ 650 \times 10^4$
fluid ounce	meter^3 (m^3)	$2.957\ 353 \times 10^{-5}$
foot	meter (m)	$3.048\ 006 \times 10^{-1}$
ft^2	meter ^{2} (m^2)	$9.290\ 304 \times 10^{-2}$
f^3	meter^3 (m^3)	2.831685×10^{-2}
gallon (U.S . liquid)	meter^3 (m^3)	$3.785\ 412 \times 10^{-3}$
gram-force/cm^2	pascal(Pa)	$9.806\ 650 \times 10$
inch	meter (m)	$2.540000\ X\ 10^{-2}$
in^2	meter^2 (m^2)	6.451600×10^{-4}
in^3	meter^3 (m^3)	$1.638\ 706 \times 10^{-5}$
kilogram-force (kgf)	newton (N)	9.806650
kgf•m	newton meter (N • m)	9.806650
kg f/cm^2	pascal (Pa)	$9.806\ 650 \times 10^4$
kgf/m^2	pascal(Pa)	9.806650
km/h	meter per second (m/s)	$2.777\ 778 \times 10^{-1}$
kip (1000 lbf)	newton (N)	$4.448\ 222 \times 10^3$
kip/in^2 (ksi)	pascal (Pa)	$6.894\ 757 \times 10^6$
knot	meter per second (m/s)	$5.144\ 444 \times 10^{-1}$
liter	meter^3 (m^3)	$1.\ 000\ 000\ X\ 10^{-3}$
microinch	meter (m)	$2.540\ 000 \times 10^{-8}$
micron	meter (m)	$1.000000\ X\ 10^{-6}$
mil	meter (m)	$2.540\ 000 \times 10^{-5}$
mile	meter (m)	$1.609\ 344 \times 10^3$
mile (U.S. nautical)	meter (m)	$1.852\ 000 \times 10^3$
mi/h	meter per second (m/s)	$4.470\ 400 \times 10^{-1}$
mi/h	kilometer per hour (km/h)	1.609344
ounce (avoirdupois)	kilogram (kg)	$2.834\ 952 \times 10^{-2}$
ounce (troy)	kilogram (kg)	$3.110\ 348 \times 10^{-2}$
ounce (U.S. fluid)	meter' (M3)	$2.957\ 353 \times 10^{-5}$
poise (absolute viscosity)	pascal second (Pa • s)	$1.000\ 000 \times 10^{-1}$
pound (avoirdupois)	kilogram (kg)	$4.535\ 924 \times 10^{-1}$
pound (troy)	kilogram (kg)	$3.732\ 417 \times 10^{-1}$
lb•ft^2 (moment of inertia)	kilogram meter^2 (kg • m^2)	$4.214\ 011 \times 10^{-2}$
lb/ft^2	kilogram per meter^2 (kg/m^2)	4.882428
lb/ft^3	kilogram per meter^3 (kg/m^3)	1.601 846 x 10
lb/gal(U.S . liquid)	kilogram per meter^3 (kg/m^3)	$1.\ 198\ 264 \times 10^2$
lb/in^3	kilogram per meter^3 (kg/m^3)	$2.767\ 990 \times 10^4$
lb/yd^3	kilogram per meter^3 (kg/m^3)	$5.932\ 764 \times 10^{-1}$
poundal	newton (N)	$1.382\ 550 \times 10^{-1}$
poundal/ft^2	pascal(Pa)	1.488 164
pound-force (lbf)	newton (N)	4.448222
lbf•ft	newton meter (N • m)	1.355 818
lbf/ft	newton per meter (N/m)	1.459 390 x 10
lbf/ft^2	pascal(Pa)	4.788 026 x 10
lbf/in^2 (psi)	pascal (Pa)	$6.894\ 757 \times 10^3$
quart (U.S. liquid)	meter^3 (m^3)	$9.463\ 529 \times 10^{-4}$
stokes (kinematic viscosity)	meter^2 per second (m^2/s)	$1.\ 000000\ X\ 10^{-4}$
ton (long, 2240 lb)	kilogram (kg)	$1.016\ 047 \times 10^3$
ton (metric, tonne)	kilogram (kg)	$1.000000\ x10^3$
ton (short, 2000 lb)	kilogram (kg)	$9.071\ 847 \times 10^2$
ton-force (2000 lbf)	newton (N)	$8.896444\ X\ 10^3$
ton (short)/yd^3	kilogram per meter^3 (kg/m^3)	$1.186\ 553 \times 10^3$
yard	meter (m)	$9.144\ 000 \times 10^{-1}$
yd^2	meter ^{2}(m^2)	$8.361\ 274 \times 10^{-1}$
yd^3	meter ^{3}(m^3)	$7.645\ 549 \times 10^{-1}$

General

Several items are required for good quality control testing. They include representative sampling, proper test procedures and adequate testing equipment. Sampling and test procedures are more directly related to the training and abilities of the Engineer or technician; however, his efforts are wasted if the equipment he is using is not in good condition and accurately calibrated in accordance with the test procedure involved. This section presents several specifications and methods used to insure that the testing equipment described will provide consistent and accurate test results. Further information on insuring adequate test equipment is described in Part 6 of this Materials Manual.

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List of Each Materials and Research Department Test Method for General Tests

The following list provides a summary of test methods by numerical order, listing the Kingdom of Saudi Arabia, Ministry of Communications, Materials and Research Department, Standard Method of Test (MRDTM) and the MRDTM name.

MRDTM Number	MRDTM Test Name
101	Sieves for Testing Purposes
102	Weights and Balances Used in Testing of Highway Materials
103	Terms Relating to Density and Specific Gravity of Solids, Liquids, and Gases
104	Verification of Testing Machines

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Kingdom of Saudi Arabia
Ministry of Communications
Materials and Research Department

Standard Method of Test for

Sieves For Testing Purposes

MRD Test Method 101
(SSA 227/1981 and SSA 228/1981)

This specification consists of two parts. Part I is Saudi Arabian Standards Organization (SASO) SSA 227/1981 Methods of Testing of "Test Sieves" and Part 11 is SSA 228/1981 "Wire Cloth Test Sieves".

Part I
Methods of Testing of "Test Sieves"

1. Scope

1.1 This standard is concerned with methods of testing and calibration of test sieves of metal wire cloth or perforated plate sieving mediums.

2. Definitions

2.1 Particle-A discrete part of the material regardless of its size.

2.2 Sieving Medium-A surface containing regularly arranged apertures of uniform shape and size.

2.3 Certified Test Sieve-A test sieve that has been examined and certified, by an authority accredited for the purpose, as complying with agreed specifications.

3. Instruments

3.1 A suitable projector with magnification lenses.

3.2 A set of graduated scales specially made for test purposes.

3.3 Inside and outside vernier calipers (of an accuracy 0.02 mm).

3.4 Micrometer (of an accuracy 0.001 mm).

3.5 Limited-tapered plate gauges (flat or round).

3.6 Graduated ruler-to 0.5 mm.

4. Methods of Testing and Calibration of Wire Cloth Sieves

4.1 Visual examination of general condition of wire cloth.

4. 1.1 If an obvious defect in the screening medium or the construction of the sieve is visually apparent, to include bends, creases, wrinkles, tears, punctures, plugged apertures, or other deficiencies such as obvious deviation from specified measurement, the sieves shall be rejected.

4.2 Examination of the regularity of the weaving of the wire cloth (apertures).

4.2.1 Sieves with apertures greater than 9.5 mm shall be tested using vernier calipers, micrometer or flat or round limit-tapered plate gauges. Sieves with measurements nonconforming to the values and tolerances mentioned in Saudi Standard No. 228 "Wire Cloth Test Sieves" shall be rejected.

4.2.2 Sieves with apertures up to 9.5 mm shall be tested using a projector forming an illuminated background on a screen to show a clear picture of the apertures of the wire cloth of the tested sieve as follows:

4.2.2.1 The sieve to be tested shall be placed on the sieve holder and held rigidly in a position with its bottom toward the light source. The beam of light shall be perpendicular on the screen. The projected image shall be uniformly illuminated and of constant magnification at all points within a tolerance of $\pm$ 0.1%.

4.2.2.2 The linear magnification of the image on the screen shall be 100 times for fine sieves with apertures up to 1.0 mm, and 50 times for medium sieves with apertures more than I mm up to 9.5 mm.

4.2.2.3 The aperture widths and wire diameters shall be checked by measuring the image projected on the screen with the appropriate graduated scale (Fig. 1). Sieves which do not conform to the dimensions and tolerances mentioned in Saudi Standard No. 228 "Wire Cloth Test Sieves" shall be rejected.

5. Methods of Testing and Calibration of Perforated Plate Sieves

5.1 Visual examination of general condition of the perforated plate.

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5.1.1 If obvious defects in the screening medium or the construction of the sieve is visually apparent, to include creases, wrinkles, tears, punctures, bends, plugged apertures and obvious deviation from specified measurements, the sieve shall be rejected.

5.2 Examination of Measurement of apertures size.

5.2.1 Dimensions of individual apertures shall be checked over any selected area of the sieve plate along two straight lines of different directions, each of 100 mm length at least and shall include five apertures.

In case of round apertures, the angle between the two selected straight lines shall be 60°. In case of square apertures the angle between the lines shall be 90°. This test may be carried out along a straight diametrical line not less than 150 mm in length which includes eight apertures at least.

5.2.2 Apertures of 9.5 mm or greater shall be measured by using vernier calipers, micrometer or flat or round limit-tapered plate gauges. Apertures less than 9.5 mm shall be measured by using the projector method mentioned in 4.2.2. Sieves which do not conform to the dimensions and tolerances mentioned in Saudi Standard No. 229 "Perforated Plate Test Sieves," shall be rejected.

5.3 Examination of perforated plate thickness.

5.3.1 Vernier calipers or any other instrument with a suitable vernier shall be used to measure the perforated plate thickness to ensure conformity of its dimensions to the values and tolerances mentioned in Saudi Standard No. 229 "Perforated Plate Test Sieves."

6. References

6.1 Main Reference

6.1.1 International Standard ISO 3310 "Test Sieves: Part 1/1975 "Metal Wire Cloth" Part 11/1975 "Metal Perforated Plate."

6.2 Other References

6.2.1 American National Standards:

6.2.1.1 ANSI E 11/1977 "Wire-Cloth Sieves for Testing Purposes."

6.2.1.2 ANSI E 323/1977 "Perforated Plate Sieves for Testing Purposes."

6.2.2 British Standard BS 410/1976 "Specificatons for Test Sieves."

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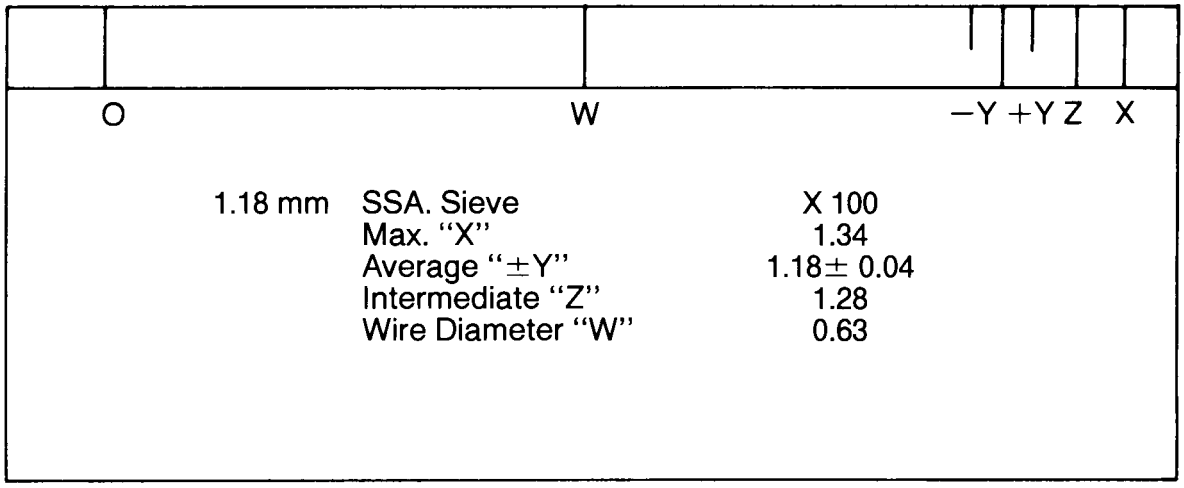

Fig. 1 (a) Graduated Scale for Checking of Wire Cloth Test Sieves

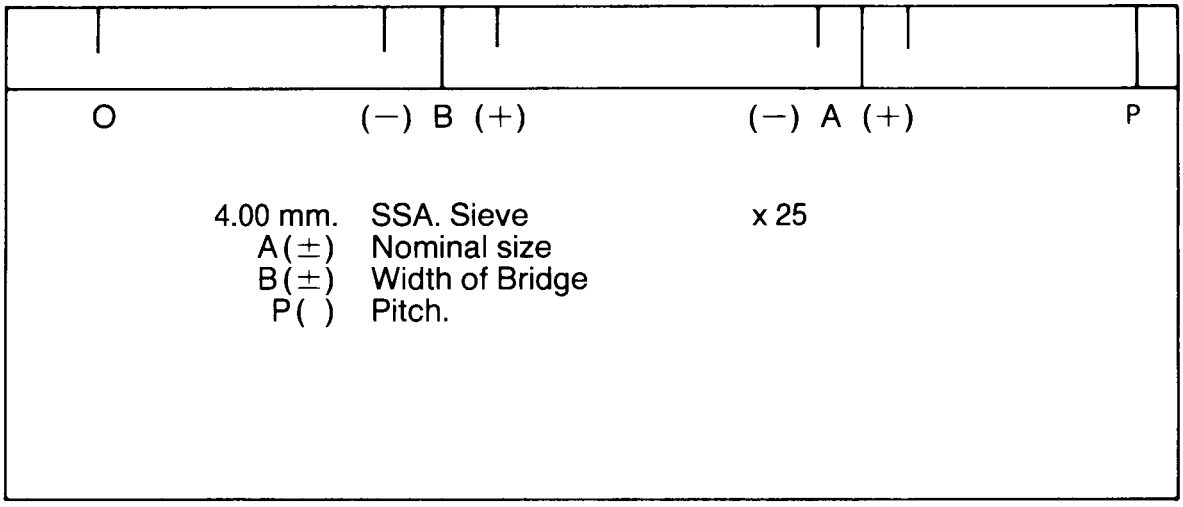

Fig. 1 (b) Graduated Scale for Checking of Perforated Plate Test Sieves

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Part II
Wire Cloth Test Sieves

1. Scope

1. 1 This standard is concerned with test sieves with metal wire cloth as sieving medium mounted in a frame.

2. Definitions

2.1 Sieving Medium-A surface of wire cloth containing regularly arranged square apertures of uniform shape and size.
2.2 Wire Cloth-A sieving medium made of metal wires interlaced with each other to form the apertures.
2.3 Sieve-An apparatus for the purpose of sieving, consisting of a sieving medium mounted in a frame.
2.4 Test Sieve-A sieve intended for the particle size analysis of the material to be sieved.
2.5 Certified Test Sieve-A test sieve that has been examined and certified, by an authority accredited for the purpose, as complying with agreed specifications.
2.6 Matched Test Sieve-A test sieve that reproduces the results of a master test sieve within defined tolerance limits of a given material.
2.7 Full set of Test Sieves-A set of test sieves of a given type of sieving medium contained in a standard specification.
2.8 Regular set of Test Sieves-A number of sieves taken in regular order from a full set of test sieves, for particle size analysis of the material.
2.9 Irregular Set of Test Sieves-A number of sieves taken in irregular order from a full set of test sieves, for particle size analysis of the material.
2. 10 Nest of Test Sieves-A set (regular or irregular) of test sieves assembled together with a cover and receiver.
2.11 Frame-A rigid framework which supports the sieving medium and limits the spread of the material being sieved.
2.12 Cover-A lid which fits snugly over a sieve to prevent escape of the material being sieved.
2.13 Receiver-A pan which fits snugly beneath a sieve to receive the whole of the passing fraction.
2.14 Aperture Size-Dimension defining the length of an opening side.
2.15 Percentage of Sieving Area-Ratio of the area of the apertures to the total area of sieving medium, as a percentage.
2.16 Wire Diameter-Diameter of the wire in the woven cloth.
2.17 Warp-All wires running lengthwise of the cloth as woven.
2.18 Weft-All wires running crosswise of the cloth as woven.
2.19 Type of Weave-The way in which warp and weft wires cross each other.
2.19.1 Plain Weave-A weave in which every warp wire crosses alternately above and below every weft wire and vice versa (see Fig. 1).
2.19.2 Twilled Weave-A weave in which every warp wire crosses alternately above and below every second weft wire and vice versa (See Fig. 2).

3. Requirements

3.1 The following requirements shall be met in test sieves:
3. 1.1 Sieving medium
3. 1. 1.1 Wire cloth shall be woven from brass, phosphor bronze, steel or from any other suitable material according to the aperture size (see Table 1). The wire shall not be coated or plated.

Table 1

Materials for Wire Cloth

Aperture size	Material
Less than 250 Micrometer	Phosphor bronze
250 micrometer to 850 micrometer	Phosphor bronze or brass
1.00 to 3.5 mm	Phosphor bronze, brass or steel
4.00 mm and above	Brass or steel.

3.1.1.2 The wire cloth shall be woven to produce uniform square apertures.
3.1.1.3 Wire cloth shall be plain woven except in the case of 63 micrometer opening and finer where it can be twilled.
3.1.1.4 The full set of standard sieves shall be one of the sets mentioned in Table 2.
3.1.1.5 The wire cloth shall be so mounted in the frame as to be held firmly and equally taut in all directions.

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3.1.1.6 Both the warp and weft wires shall be crimped before weaving so as to be rigid when in use.

3.1.1.7 There shall be no punctures or other obvious defects in the wire cloth.

3.2 Aperture Size

3.2.1 The measured aperture size before the sieve is used shall comply with the nominal size within the tolerances given in Table 2. Aperture size is measured on the center lines of the aperture (Fig. 3). The tolerances shall apply both to the warp and weft directions separately.

3.2.2 No aperture size shall exceed the nominal value by more than the tolerance “X"

3.2.3 The average size shall not be greater or smaller than the nominal value by more than the tolerance "Y"

3.2.4 Not more than 6 percent of the measured apertures shall depart from the nominal size by more than the tolerance "Z."

where $Z = \frac{X + Y}{2}$

3.3 Frame

3.3.1 The frame of a test sieve shall be made of brass, stainless steel or other suitable material. It shall be cylindrical in shape and shall conform to dimensions given in Table 3.

Table 3
Frame Dimensions

Nominal Diameter D. (mm)	Depth from Top Edge to Sieving Surface C_1 (mm)	Depth from Bottom Edge to Sieving Surface C_2 (mm)	Minimum Effective Diameter of Sieving Surface (mm)	Aperture Size
100	40	15	62	Up to 125 µm
200	50	15	175	From 150 µm to 3.6 mm
300	75	15	275	More than 3.6 mm

3.4 Receiver

3.4.1 The receiver shall be constructed of the same metal and of the same thickness as that of the frame of the corresponding test sieve.

3.5 Cover

3.5.1 A fitting flat cover shall be provided with the test sieve upon the purchaser's request.

3.5.2 The cover shall be constructed of the same metal and thickness of the frame of the corresponding test sieve.

3.5.3 The cover may be fitted with a handle or knob.

3.6 Sieves, receivers and covers shall be smoothly finished. The seal between frame and sieving medium shall be formed so as to prevent lodging of the material to be sieved. There shall be no lacquer on surfaces which come into contact with the sieved sample.

4. Marking

4.1 Each sieve shall bear a permanent metallic label attached to the frame, legibly marked with the following information, in Arabic and/or English:

4. 1.1 The manufacturer's name or trade mark.

4.1.2 The material of the wire cloth.

4.1.3 The material of the sieve frame.

4.1.4 The nominal size of the aperture (in micrometer or mm).

5. Testing Methods

5.1 Wire cloth test sieves shall be tested according to Saudi Standard No. 227 "Methods of Testing of Test Sieves".

5.2 Tests

5.2.1 Visual inspection to examine the general condition of wire cloth.

5.2.2 Examination of the regularity of weaving of wire cloth.

6. Packaging

6.1 After testing, sieves shall be packed in polyethylene bags, then put into carton boxes to ensure that they have adequate protection before reaching the user.

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Table 2
Standard Test Sieves

Values in millimetres

Nominal Sizes of Aperture W			Aperture Tolerances			Wire Diameters		
Principal Sizes R 20/3	Supplementary Sizes R 20	Supplementary Sizes R 40/3	Maximum Tolerance For Any One Aperture + X	Tolerance For Average Aperture Size ± Y	Intermediate Tolerance + Z	Preferred Size d	Permissible Range of Choice	
							d max	d min
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
125	125	125	4.51	3.66	4.09	8	9.2	6.8
	112		4.15	3.29	3.72	8	9.2	5.8
		106	3.99	3.12	3.55	6.3	7.2	5.4
	100		3.82	2.94	3.38	6.3	7.2	5.4
90.0	90.0	90.0	3.53	2.66	3.09	6.3	7.2	5.4
	80.0		3.24	2.37	2.80	6.3	7.2	5.4
		75.0	3.09	2.22	2.65	6.3	7.2	5.4
	71.0		2.97	2.10	2.54	5.6	6.4	4.8
63.0	63.0	63.0	2.71	1.87	2.29	5.6	6.4	4.8
	56.0		2.49	1.67	2.08	5	5.8	4.3
		53.0	2.39	1.58	1.99	5	5.8	4.3
	50.0		2.29	1.49	1.89	5	5.8	4.3
45.0	45.0	45.0	2.12	1.35	1.73	4.5	5.2	3.8
	40.0		1.94	1.20	1.57	4.5	5.2	3.8
		37.5	1.85	1.13	1.49	4.5	5.2	3.8
	35.5		1.78	1.07	1.42	4	4.6	3.4
31.5	31.5	31.5	1.63	0.95	1.29	4	4.6	3.4
	28.0		1.50	0.85	1.17	3.55	4.1	3
		26.5	1.44	0.80	1.12	3.55	4.1	3
	25.0		1.38	0.76	1.07	3.55	4.1	3
22.4	22.4	22.4	1.27	0.68	0.98	3.55	4.1	3
	20.0		1.17	0.61	0.89	3.15	3.6	2.7
		19.0	1.13	0.58	0.85	3.15	3.6	2.7
	18.0		1.08	0.55	0.82	3.15	3.6	2.7
16.0	16.0	16.0	0.99	0.49	0.74	3.15	3.6	2.7
	14.0		0.90	0.43	0.67	2.8	3.2	2.4
		13.2	0.86	0.41	0.64	2.8	3.2	2.4
	12.5		0.83	0.39	0.61	2.5	2.9	2.1

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Table 2 (contd.)

Values in millimetres

Nominal Sizes of Aperture W			Aperture Tolerances (see 4.1)			Wire Diameters (see 4.2)		
Principal Sizes R 20/3	Supplemen-tary Sizes R 20	Supplemen-Tary Sizes R 40/3	Maximum Tolerance For AnyOne Aperture + X	Tolerance For Average Aperture Size ± Y	Intermediate Tolerance + Z	Preferred Size d	Permissible Range of Choice	
							d_{max}	d_{min}
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
11.2	11.2	11.2	0.77	0.35	0.56	2.5	2.9	2.1
	10.0		0.71	0.31	0.51	2.5	2.9	2.1
		9.50	0.68	0.30	0.49	2.24	2.6	1.9
	9.00		0.65	0.28	0.47	2.24	2.6	1.9
8.00	8.00	8.00	0.60	0.25	0.43	2	2.3	1.7
	7.10		0.55	0.22	0.38	1.8	2.1	1.5
		6.70	0.53	0.21	0.37	1.8	2.1	1.5
	6.30		0.51	0.20	0.35	1.8	2.1	1.5
5.60	5.60	5.60	0.47	0.18	0.32	1.6	1.9	1.3
	5.00		0.43	0.16	0.29	1.6	1.9	1.3
		4.75	0.41	0.15	0.28	1.6	1.9	1.3
	4.50		0.40	0.14	0.27	1.4	1.7	1 2
4.00	4.00	4.00	0.37	0.13	0.25	1.4	1.7	1.2
	3.55		0.34	0.11	0.23	1.25	1.5	1.06
		3.35	0.32	0.11	0.22	1.25	1.5	1.06
	3.15		0.31	0.10	0.21	1.25	1.5	1.06
2.80	2.80	2.80	0.29	0.09	0.19	1.12	1.3	0.95
	2.50		0.26	0.08	0.17	1	1.15	0.85
		2.36	0.25	0.08	0.17	1	1.15	0.85
	2.24		0.24	0.07	0.16	0.9	1.04	0.77
2.00	2.00	2.00	0.23	0.07	0.15	0.9	1.04	0.77
	1.80		0.21	0.06	0.14	0.8	0.92	0.68
		1.70	0.20	0.06	0.13	0.8	0.92	0.68
	1.60		0.19	0.05	0.12	0.8	0.92	0.68
1.40	1.40	1.40	0.18	0.05	0.11	0.71	0.82	0.6
	1.25		0.16	0.04	0.10	0.63	0.72	0.54
		1.18	0.16	0.04	0.10	0.63	0.72	0.54
	1.12		0.15	0.04	0.10	0.56	0.64	0.48
1.00	1.00	1.00	0.14	0.03	0~09	0.56	0.64	0.48

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Table 2 (contd.)

Values in micrometres

Nominal Sizes of Aperture W			Aperture Tolerances			Wire Diameters		
Principal Sizes R 20/3	Supplementary Sizes R 20	Supplementary Sizes R 40/3	Maximum Tolerance ForAnyOne Aperture + X	Tolerance forAverage Aperture Size ±Y	Intermediate Tolerance + Z	Preferred Size d	Permissible Range of Choice	
							d max	d min
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	900		131	31	81	500	580	430
		850	127	29	78	500	580	430
	800		122	28	75	450	520	380
710	710	710	112	25	69	450	520	380
	630		104	22	63	400	460	340
		600	101	21	61	400	460	340
	560		96	20	58	355	410	300
500	500	500	89	18	54	315	360	270
	450		84	16	50	280	320	240
		425	81	16	48	280	320	240
	400		78	15	47	250	290	210
355	355	355	72	13	43	224	260	190
	315		67	12	40	200	230	170
		300	65	12	38	200	230	170
	280		62	11	37	180	210	150
250	250	250	58	9.9	34	160	190	130
	224		54	9.0	32	160	190	130
		212	52	8.7	30	140	170	120
	200		50	8.3	29	140	170	120
180	180	180	47	7.6	27	125	150	106
	160		44	6.9	25	112	130	95
		150	43	6.6	25	100	130	95
	140		41	6.3	24	100	115	85
125	125	125	38	5.8	22	90	104	77
	112		36	5.4	21	80	92	68
		106	35	5.2	20	71	82	60
	100		34	5.0	19	71	82	60
90	90	90	32	4.6	18	63	72	54
	80		30	4.3	17	56	64	48
		75	29	4.1	17	50	58	43
	71		28	4.0	16	50	58	43
63	63	63	26	3.7	15	45	52	38
	56		25	3.5	14	40	46	34
		53	24	3.4	14	36	41	31
	50		23	3.3	13	36	41	31
45	45	45	22	3.1	13	32	37	27
	40		-	-	-	32	37	27
		38	-	-	-	30	35	24
	36		-	-	-	30	35	24
	32	32	-	-	-	28	33	23
	28		-	-	-	25	-	-
		26	-	-	-	25	-	-
	25		-	-	-	25	-	-
	22	22	-	-	-	22	-	-
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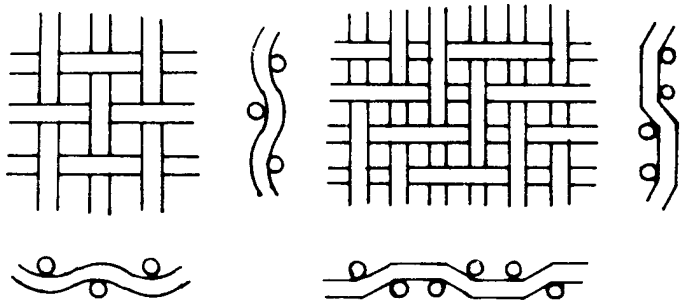

Fig. 1. Plain Weave

Fig. 2. Twilled Weave

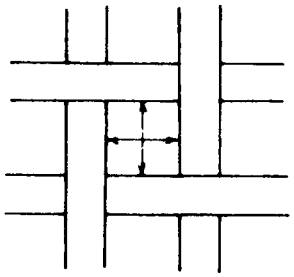

Fig. 3. Measurement of Woven Wire Aperture Size

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7. References

7.1 Main References

7.1.1 International Standard ISO 33101/1975 "Test Sieves-Technical Requirements and Testing-Part 1: Metal Wire Cloth."

7.1.2 ISO 2395/1972 "Test Sieves and Test Sieving Vocabulary."

7.2 Other References

7.2.2 British Standard BS 410/1976 "Specifications for Test Sieves."

7.2.3 ANSI/ASTM E 11-70/1977 "Standard Specifications for Wire Cloth Sieves for Testing Purposes."

7.2.4 Deutsche Normen

7.2.4.1 DIN 4188/1977 "Screening Surfaces; Wire Screens for Test Sieves; Dimensions."

7.2.4.2 DIN 4189/1968 "Screening Surfaces Woven Wire Cloth Made of Steel, Stainless Steel, and Nonferrous Metals; Dimensions."

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Kingdom of Saudi Arabia
Ministry of Communications
Materials and Research Department

Standard Method of Test for

Weights and Balances Used in Testing of Highway Materials

MRD Test Method 102
(Adaptation of AASHTO M 231-77)

1. Scope

1. 1 This specification covers requirements for weights and balances used in the testing of highway materials.

2. Definitions

2.1 Definitions applicable to weights are as follows:

2.1.1 Analytical Weights-Weights used for analytical work.

2.1.2 General Purpose Weights-Weights used for general laboratory weighings.

2.2 Definitions applicable to balances are as follows:

2.2.1 Readability-The smallest fraction of a division at which the index scale can be read with ease either by estimation or by use of a vernier on a direct reading balance.

2.2.2 Sensitivity-Ability of a balance to respond to an applied load at any test point within the rated capacity.

2.2.3 Accuracy-Conformance of the indications or deliveries of a balance within applicable tolerances as determined by tests made with suitable standards.

2.2.4 Simple Balance-A balance designed primarily for use in conjunction with a set of weights. There may or may not be a weighbeam.

2.2.5 Direct Reading Balance-A balance on which the weights of applied loads of various magnitudes are either automatically indicated throughout all or a portion of the weighing range of the balance measured by means of a weighbeam.

2.2.6 Weighbeam-An element comprising one or more bars, equipped with movable poises or means for applying counterpoise weights or both.

3. Basis of Purchase

3.1 Weights-The purchaser should specify the type of weights desired.

3.2 Balances-The purchaser should specify the type and class of balance desired.

4. Requirements

4.1 Weights shall conform to the following requirements:

4. 1.1 Analytical weights shall conform to Class S-1 requirements as described in the United States' National Bureau of Standards Handbook 77, Part 111, and the applicable tolerances shown in Table I of this specification.

4.1.2 General purpose weights shall conform to the requirements for metric weights as described in the third edition of the United States' National Bureau of Standards Handbook 44 and the applicable tolerances shown in Table 2 of this specification.

4.2 Balances shall conform to the requirements of Table 3 for the type and class specified. Whenever a particular class of balance is specified in a Test Method, any (alphabetically) higher class of balance may be substituted, provided the balance has sufficient capacity for the weighings normally required by the Test Method.

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Table 1
Tolerances of Analytical Weights

Weights	Tolerances of Weights in Use, ± mg*
Grams	
100	1.0
50	0.6
30	0.45
20	0.35
10	0.25
5	0.18
2	0.13
1	0.10
Milligrams	
500	0.080
300	0.070
200	0.060
100	0.050
50	0.042
30	0.038
20	0.035
10	0.030

**Two thirds of the weights in a new set must be within one half the individual tolerances.*

Table 2
Tolerances of General Purpose Weights

Weights, g	Tolerances on Weights in Use, ± mg*
2000	0.40
1000	0.25
500	0.20
300	0.15
200	0.10
100	0.07
50	0.04
30	0.03
20	0.02
10	0.02
5	0.01
3	0.01
2	0.01
1	0.01

**The permissible tolerances of new weights shall be one half the permissible tolerances on used weights.*

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Table 3
Requirements for Balances

Class	Type 1 Simple Balances		Type 1 Direct Reading Balances			Recommended Maximum Range of Use,[1] g
	Sensitivity, g	Accuracy, g	Readability, g	Sensitivity, g	Accuracy, g	
A	0.0001	0.0002	0.0001	0.0001	0.0002	200
B	0.001	0.002	0.001	0.001	0.002	200
C	0.01	0.02	0.01	0.01	0.02	1200
D	0.1	0.2	0.1	0.1	0.2	2000
E	0.5	1.0	1.0	0.5	1.0	5000
F	5.0	0.2%*	5.0	5.0	0.2%*	-

**0.2 percent of total sample mass.*
[1]Or maximum range of use as recommended by manufacturer.

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Kingdom of Saudi Arabia
Ministry of Communications
Materials and Research Department

Standard Method of Test for

Terms Relating to Density and Specific Gravity of Solids, Liquids, and Gases

MRD Test Method 103
(Adaptation of AASHTO M 132-78)

Introduction

In scientific terminology, mass is a measure of the quantity of material in a body, and is constant regardless of geographical location, altitude, or atmospheric conditions, so long as no material is added or taken away. Weight is the force with which a body is attracted to the earth, and varies from place to place with the acceleration of gravity.
Density (of solids and liquids) is the mass of a unit volume of a material at a specified temperature. The units shall be stated, such as grams per milliliter, grams per cubic centimeter, or other. If the material is a solid, the volume shall be that of the impermeable portion. The form of expression shall be:

Density at x ....

where:
x = the temperature of the material.
Density (of gases) is the mass of a unit volume of a gas at a stated temperature and pressure. The units shall be stated. The form of expression shall be:

Density at x, y ....

where:
x = temperature of the gas, and
y = pressure of the gas.
Apparent density (of solids and liquids) is the mass in air of a unit volume of a material at a specified temperature. The units shall be stated. If the material is a solid, the volume shall be that of the impermeable portion. The form of expression shall be:

Apparent density at x ....

where:
x = the temperature of the material.
Bulk density (of solids) is the mass in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature. The units shall be stated. The form of expression shall be:

Bulk density at x ....

where:
x = temperature of the material.
Specific gravity (of solids and liquids) is the ratio of the mass of a unit volume of a material at a stated temperature to the same volume of gas free distilled water at a stated temperature. If the material is a solid, the volume shall be that of the impermeable portion. The form of expression shall be:

Specific gravity x/y, C ....

where:
x = temperature of the material, and
y = temperature of the water.

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Specific gravity (of gases) is the ratio of the density of a gas, under the observed conditions of temperature and pressure to the density of dry air of normal carbon dioxide content, at the same temperature and pressure. The units shall be stated. The form of expression shall be:

Specific gravity at x, y ....

where:
x = temperature of gas, and
y = pressure of the gas.

Apparent specific gravity, (of solids and liquids) is the ratio of the mass in air of a unit volume of a material at a stated temperature to the mass in air of equal density of an equal volume of gas free distilled water at a stated temperature. If the material is a solid, the volume shall be that of the impermeable portion. The form of expression shall be:

Apparent specific gravity x/y, C ....

where:
x = temperature of the material, and
y = temperature of the water.

Bulk specific gravity, (of solids) is the ratio of the mass in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the mass in air of equal density of an equal volume of gas free distilled water at a stated temperature. The form of expression shall be:

Bulk specific gravity x/y, C ....

where:
x =temperature of the material, and
y = temperature of the water.

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Kingdom of Saudi Arabia
Ministry of Communications
Materials and Research Department

Standard Method for

Load Verification of Tensile Testing Machines

MRD Test Method 104
(SSA 211/1981)

1. Scope

1.1 This standard is concerned with the methods used for load verification of tensile testing machines by one of the following means:

Standard weights.
Standardized proving levers.
Elastic proving devices.

2. Definitions

2.1 Verification-The process of testing an instrument for the purpose of assessing the indication errors, to determine whether the instrument complies with a prescribed specification.

2.2 Indicated Value-The value read on the graduated scale of the testing machine for the measured quantity.

2.3 True Value-The value obtained by the verification device for the measured quantity.

2.4 Error-The value obtained by subtracting the true value from the indicated value.

2.5 Percentage of Error-The ratio expressed as percentage of the error to the true value of the quantity measured.

2.6 Correction-The value obtained by subtracting the indicated value from the true value of the quantity measured, (i.e. correction has the same magnitude as the error, but with opposite sign).

2.7 Permissible Variation (Tolerance)-The allowable error in the value of the indicated quantity expressed in terms of percentage of error.

2.8 Capacity Range-The load range or ranges for which the testing machine is designed, (some testing machines have more than one capacity range).

2.9 Loading Range-The range of indicated loads for each capacity range for which the testing machine gives results within the permissible variations specified.

2.10 Proving Levers-Devices with known mechanical properties, for applying axial loads to the testing machine by means of standard weights.

2.11 Elastic Proving Device-A device used for load verification of testing machines. It consists of an elastic member or members to which loads may be applied, combined with a mechanism or device for indicating the magnitude of deformation under load.

2.12 Calibration Factor-The load per unit deflection of the elastic member of the elastic proving device. It is determined from the curve (or Table) attached to the device.

3. Requirements

3.1 The following shall be observed:

3. 1.1 Before a tensile testing machine is verified, it shall be examined to ensure that:

3. 1. 1. 1 The least graduation value of the machine scale shall permit the indicated loads to be read with the specified accuracy.

3.1.1.2 The pointer indicates the load without lag, independent of the rate of loading specified, and returns to zero when the machine is unloaded.

3.1.1.3 A free pointer is provided to indicate the maximum load.

3.1.1.4 Provision is made for counter balancing the weight of grips, test pieces, elastic proving devices, etc.

3.1.2 For each loading range, verify the testing machine at maximum and minimum loads and at three other test loads, at least, approximately equally spaced on the graduated scale. The difference between any two successive test loads shall not exceed one third of the difference between the maximum and minimum test loads.

3.1.3 If it is required to verify the lower limit of a loading range when the lower limit is less than 10 percent of the capacity range, apply five approximately equal test loads, none of which shall differ from the smallest one by more than 5 percent.

3.1.4 All test loads shall be applied so that the resultant load is as nearly along the loading axis of the testing machine as possible.

3.1.5 For hydraulic tensile testing machines, the position of the ram shall be changed for each series of tests if practicable.

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3.1.6 The machine to be verified shall be in its normal operating condition with all attachments and recording mechanisms in operation.

4. Verification Methods

4.1 Verification by Standard Weights

4.1.1 Verification by standard weights is the most accurate method, but it is not usually used for loads greater than 10 kN (1 ton f), and it is not applicable to horizontal testing machines.

4.1.2 Standard Weights

4.1.2.1 Standard weights used for verification tests shall be masses of suitable design and finish which have been adjusted and certified to ensure that they are correct to within ±0.02 percent of their nominal value. Ten-kg weights are usually convenient for use. Weights certified within less than five years shall be used.

4.1.3 Procedure

4.1.3.1 Place standard weights equal to the lowest test load on a suitable support suspended from the cross-head of the machine in place of the test piece, so that the centre of gravity of the resulting load shall lie on the loading axis of the machine.

4.1.3.2 Add weights in increments to obtain the test loads required for verification, as in 3.1.3. For each test load applied, record the applied load and the corresponding indicated load (reading of the graduated scale of the machine).

4.1.3.3 Repeat the step in 4.1.3.2 by removing the weights in the same increments to obtain the testing loads in a descending order.

4.2 Verification by Proving Levers.

4.2.1 This method involves the use of a pair of standardized proving levers together with standard weights for the verification of mainly vertical testing machines up to 250 kN (25 ton f). (Note 1).

Note 1: The use of proving levers on horizontal testing machines involves the use of bellcrank levers. Such levers require special methods of determination of lever ratio.

4.2. 1.1 Proving Levers-The common arrangement of proving levers is shown in Fig. I where the two levers rest on supports on the platform of the testing machine. The supports shall move easily in a horizontal direction, which ensures that the forces at each of the knife edges or other bearings, shall be very nearly vertical. The inner knife edges in each lever shall bear against a suitable block in the cross-head of the testing machine. A weight hanger is suspended from each of the outer knife edges. Proving levers and their associated weights shall be periodically calibrated at intervals not exceeding two years or prior to any repair or adjustment. Standard weights used shall be correct to within ±O.02 percent of their nominal value.

4.2.1.2 The load applied on the testing machine by the standard weights is the load exerted by the standard weights multiplied by the lever ratio m/n Fig. I (Note 2).

Note 2: In testing machines having a hydraulic support where the load during a test is pressing upward against the cross-head instead of downward to the platform, the lever ratio is (m-n)/n.

4.2.2 Procedure Conduct the test by applying loads in increments, first in increasing order to the maximum load, then in decreasing order from the maximum to the minimum load as follows:

4.2.2.1 Place the proving levers in the testing machine to be verified so that the resultant load line coincides with the vertical line through the centre of the platform.

4.2.2.2 Balance the testing machine at zero reading with the levers in place and the weight hanger empty.

4.2.2.3 Apply standard weights in increments, half an increment on each tray. Place the weights symmetrically on the trays with the centre of gravity of the whole weights (test load) as nearly over the centre of the tray as possible.

4.2.2.4 Record the applied load, and the indicated load for each test load applied.

4.2.2.5 Before adding or subtracting weights to obtain subsequent test loads, reset levers as near to a horizontal position as is feasible by means of the movable head of the testing machine.

4.3 Verification by Elastic Proving Devices-This method of verification involves measurement of the elastic strain or deflection under test load of an elastic proving device. Elastic proving devices shall be calibrated at intervals not exceeding two years.

4.3.1 Elastic Proving Devices-Proving devices shall be supported and loaded in the testing machine, in accordance with the instructions for use of these devices, taking care that devices are not subjected, in use, to loads in excess of their maximum rated capacity. The true loads can be calculated from the product of the respective deflections and the calibration factor (2.11). Proving devices shall be of such a design that they permit axial application of load, either in tension or in compression, or both. The most generally used types of elastic proving devices are as follows:

4.3.1.1 "Steel proving bar" (solid or hollow) together with an attached strainometer is suitable principally for use in tension for the verification of large capacity testing machines up to 2000 kN (200 ton f).

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4.3.1.2 "Proving ring" is used either in tension or in compression, and is made to operate in either vertical or horizontal positions. It is used for the verification of large capacity testing machines up to 2000 kN (200 ton f). Fig. 2 shows a proving ring while it is used for the verification of a vertical testing machine.

4.3.1.3 In order to obtain the reading under load, the central reed is set vibrating. While the reed is vibrating, the micrometer head is rotated slowly and carefully until a very faint buzzing is produced as the micrometer tip just touches the weight at the end of the reed. The reed should not be suddenly stopped by the contact, rather it should continue to vibrate for two or three seconds after the buzzing starts then take the reading of the micrometer. Repeat this operation several times to obtain the average of readings.

4.3.1.4 Standardizing Box-Standardizing boxes are used in compression for the verification of testing machines of capacities up to 500 kN (50 ton f). The general construction of the standardizing box is shown in Fig. 3.

4.3.1.5 If the hollow cylinder (which is filled with mercury) is subjected to a purely axial compression, its volume shall decrease forcing an amount of mercury, equal to the decrease in volume, into the capillary tube and then into the glass bulb. Before the test is carried out, the micrometer is adjusted at zero load to bring the mercury in the capillary to a calibrated mark. After the load is applied, the micrometer is turned to bring the mercury back to the calibrated line. Thus, the movement of the micrometer screw (i.e. the difference between the micrometer reading under load and at no-load) is the measure of decrease in volume of the cylinder and therefore, is proportional to the load. Each box shall be calibrated by the makers with dead-weight loading.

4.3.2 Procedure

4.3.2.1 Allow the elastic proving device to remain on the platform of the testing machine a sufficient length of time before verification test, so that the device and the machine become very nearly of the same temperature.

4.3.2.2 Immediately before test, preload the device to the maximum test load, then unload the device.

4.3.2.3 Place the proving device in the machine so that its center line coincides with the loading axis of the machine. If proving devices are used in multiple, such as standardizing boxes, to provide a convenient means of measuring greater loads, they shall be arranged so that the resultant applied load shall be along the loading axis of the machine.

4.3.2.4 Balance the machine with no load on the proving device and take a zero reading of the device.

4.3.2.5 Apply test loads in increasing order by adding suitable increments until the max. load is reached, and record the indicated load of the testing machine and the applied load computed from the readings of the elastic device.

4.3.2.6 Continue the test, applying test loads in diminishing order by subtracting suitable increments till zero load. Record the results as in 4.3.2.5.

5. Calculations and Results

5.1 Calculations

5.1.1 Calculate the average values of the indicated loads for each test load, to obtain their mean indicated load.

5.1.2 Calculate the load percentage error for each test load as follows:

$$\text{Percentage error} = \frac{F_i - F}{F} \times 100$$

where:

F = test load

F_i = mean indicated load.

5.2 Basis of Verification

5.2.1 The percentage error for loads within the loading range of the testing machine shall not exceed ±1%. (The loading range within which the testing machine can be used, shall be defined from the permissable tolerance)

5.2.2 In establishing the lower limit of a loading range, where the lower limit is less than 10 percent of the capacity range (where five applications of load are required as in 3.4), the algebraic difference between the highest and lowest percentage of error shall not exceed 1. (This means that the errors for these five readings shall not be only less than 1.0 per cent, but also no two errors shall differ by more than 1.0 percent. Thus if the minimum error in this series is -1.0 percent, the maximum error shall not exceed +0.0 percent, and if the minimum error is -0.5 percent, the maximum error shall not exceed +0.5 percent, etc.).

5.2.3 In no case shall the loading range be stated as including loads below the value which is 100 times the smallest change of load which can be estimated on the load indicating device of the testing machine. (This means that if estimations of load can be made to 1/10 graduation division, the loading range could not extend downward to a load less than that corresponding to 10 graduation divisions).

5.2.4 In no case shall the loading range be stated as including loads outside the range of the loads applied during the verification test.

5.3 Report

5.3.1 The test report shall include the following data:

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5.3. 1.1 The verification method used.

5.3.1.2 Manufacturer's name and serial numbers of all proving devices employed in carrying out the verification.

5.3.1.3 Calibration method, name of calibrator and date of calibrating devices used in verification of the testing machine.

5.3.1.4 The loading range of the proving device.

5.3.1.5 The loading range of the testing machine, based upon the verification test.

6. References

6.1 Main Reference

6.1.1 International Standard ISO/R 147/1960 "Load Calibration of Testing Machines for Tensile Testing of Steel."

6.2 Other References

6.2.1 ASTM E4-72/1978 "Standard Methods of Verification of Testing Machines."

6.2.2 British Standard BS 1610/1964 "Methods for the Load Verification of Tensile Testing Machines."

6.2.3 Indian Standard IS 1828/1975 "Method for Load Verification of Tensile Testing Machines."

6.2.4 Iraqi Standard IOS 46/1970 "Methods for Load Verification of Testing Machines."

6.2.5 Egyptian Standard ES 1128/1972 "Load Calibration of Testing Machines for Tensile Testing of Steel."

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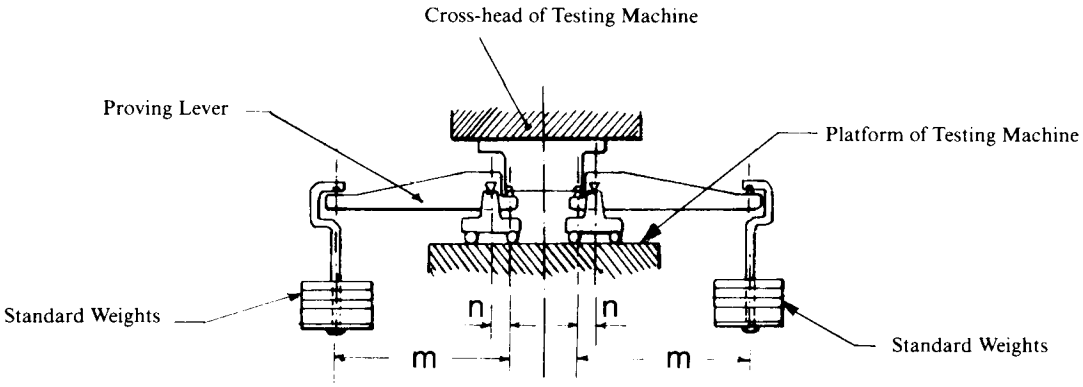

Fig. 1. Verification of a Tensile Testing Machine Using Proving Levers

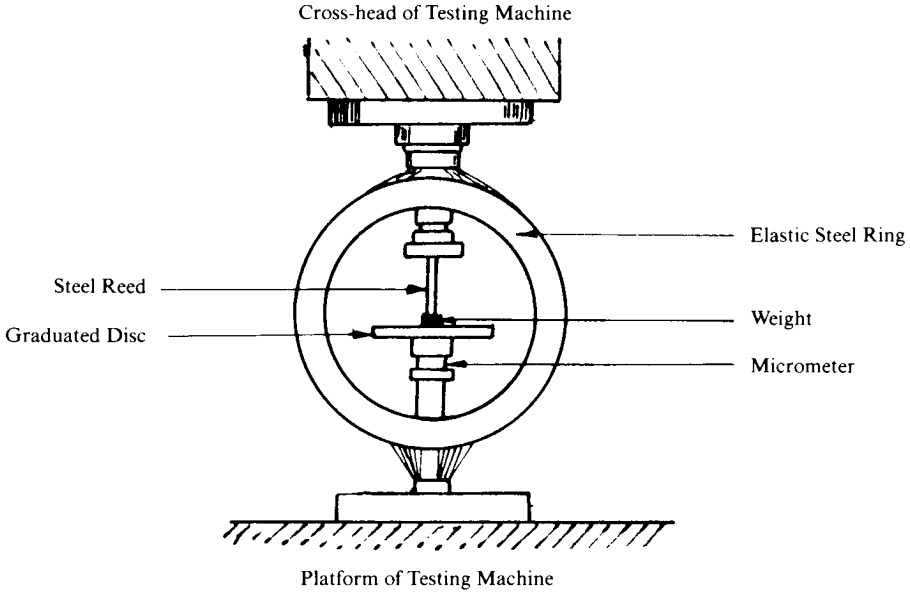

Fig. 2. Verification of a Tensile Testing Maching Using a Proving Ring

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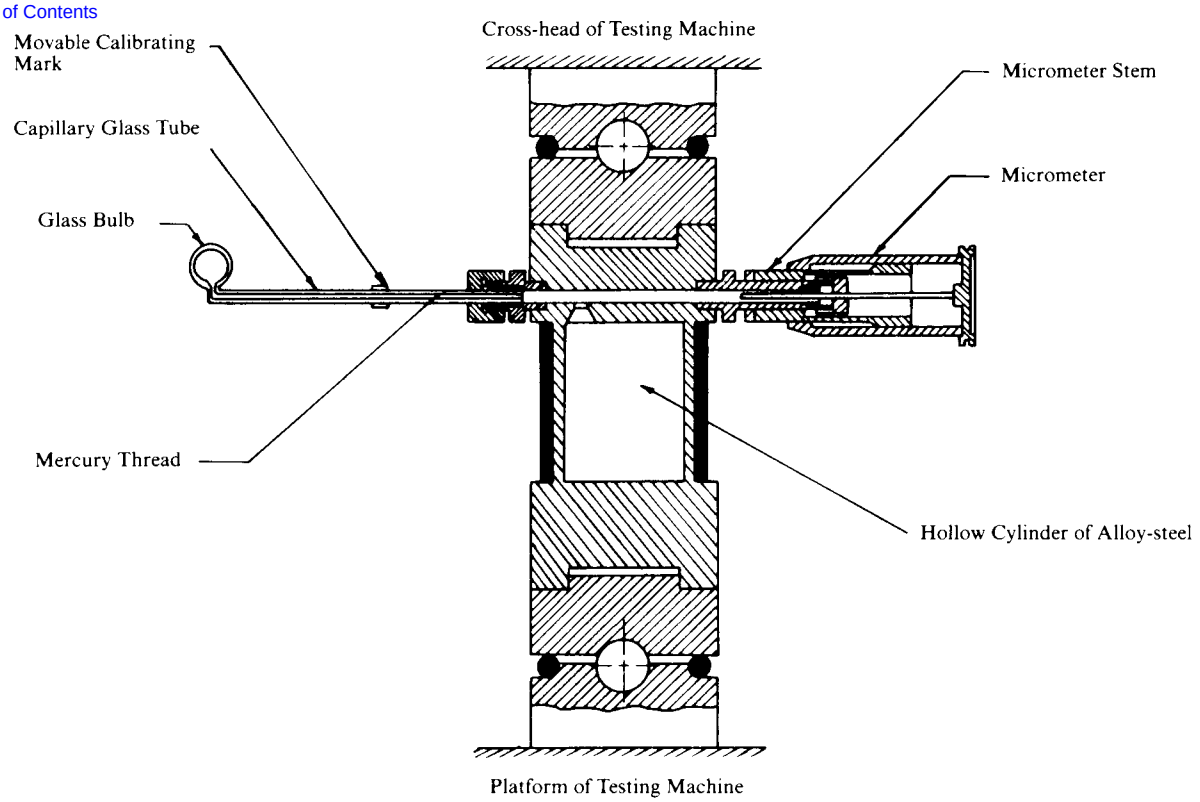

Fig. 3. Standardizing Box