

Highway Engineering Laboratory

Introduction

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Laboratory tests and properties of asphalt

General

- ❑ The **purpose** of the laboratory tests is to
 - *Define its characteristic properties, so as to ascertain its suitability and predict its behaviour during the service life of the pavement.*
- ❑ The term characteristic properties include all properties, such as
 - *Technological*
 - ❖ Technological properties are those defined by **empirical and not fundamental tests**, unlike the mechanical and rheological properties
 - *Mechanical*
 - *Rheological*
 - *Physical*
 - *Chemical*

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Testing Standards

- ❑ ASTM
 - Stand for the American Society for Testing and Materials
- ❑ AASHTO
 - Stand for American Association of State Highway and Transportation Officials

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What is a laboratory testing standard ?

- ❑ ASTM's laboratory testing standards are
 - “*instrumental in specifying the standard dimensions, design, and make of the various equipments and instruments used in the laboratory for scientific experiments and procedures. These standards help laboratories, manufacturers, and other users and producers of such apparatuses in ensuring good quality and workmanship*”. (ASTM, 2020)

Astm., 2020Source <https://www.astm.org/Standards/laboratory-testing-standards.html#:~:text=ASTM's%20laboratory%20testing%20standards%20are,for%20scientific%20experiments%20and%20procedures.>

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Example

ASTM D5



Designation: D5/D5M – 13

Standard Test Method for Penetration of Bituminous Materials¹

This standard is issued under the fixed designation D5/D5M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers determination of the penetration of semi-solid and solid bituminous materials.

1.2 The needles, containers and other conditions described in this test method provide for the determinations of penetrations up to 500.

Note 1—For guidance in preparing and testing emulsion residue specimens for this test method, please refer to Section 35 of Test Method D244.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

E2251 Specification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids

2.2 ANSI Standard:

B46.1 Surface Texture³

2.3 ISO Standard:

ISO Standard 468 Surface Roughness—Parameters, Their Values and General Rules for Specifying Requirements³

3. Terminology

3.1 Definitions:

3.1.1 *penetration, n*—consistency of a bituminous material expressed as the distance in tenths of a millimetre that a standard needle vertically penetrates a sample of the material under known conditions of loading, time, and temperature.

4. Summary of Test Method

4.1 The sample is melted (if starting at ambient temperature) and cooled under controlled conditions. The penetration is measured with a penetrometer by means of which a standard needle is applied to the sample under specific conditions.

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Course description:

- The course is intended to teach the **civil engineering student** how to **conduct tests on materials** used in **highway pavement construction**.

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Pavement Materials

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Soil



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Aggregates



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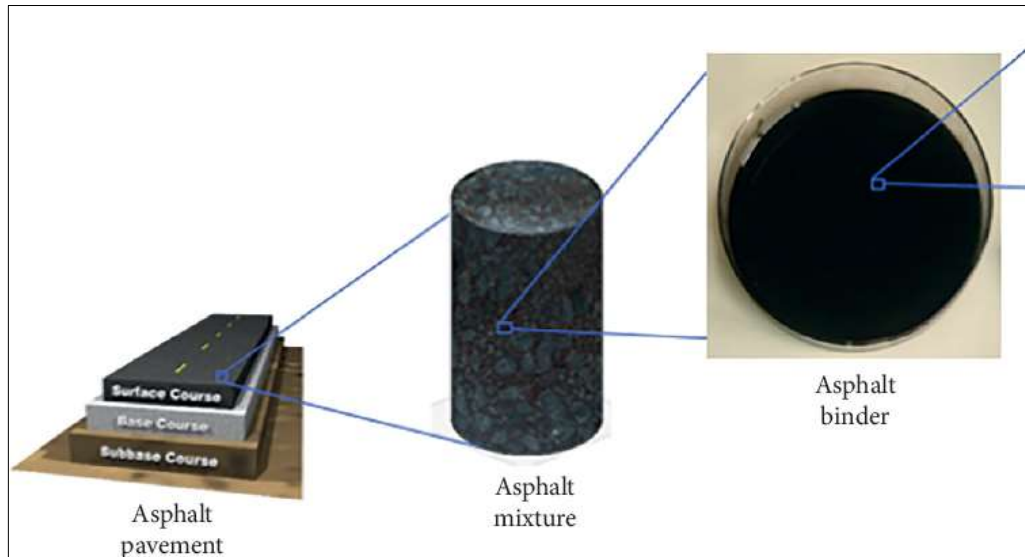
Concrete



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Asphalt



Qu, X., D. Wang, L. Wang, Y. Huang, Yue Hou and M. Deser. "The State of the Art Review on Molecular Dynamics Simulation of Asphalt Binder." (2018).

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Major Topics To Be Covered



TOPICS	No. of Weeks	Contact Hours*
Tests on asphalt binders: penetration, softening and flash points, ductility, viscosity, and specific gravity.	6	9
Test on subgrade soils or granular materials: CBR	2	3
Tests on aggregates: Specific gravity, absorption, and sieve analysis (gradation)	2	3
Design of hot mix asphalt using Marshall design method	2	3
Tests on bituminous mixtures: Extraction and skid resistance	2	3
TOTAL	14	21

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Laboratory tests and properties of asphalt

Consistency tests

- ❖ *Absolute (dynamic) viscosity (ASTM D2171, D4402)*
- ❖ *Kinematic viscosity (ASTM D445 and D2170)*
- ❖ *Penetration test (ASTM D5)*
- ❖ *Softening point (ASTM D36)*
- ❖ *Ductility test (ASTM D113)*

Durability tests

- ❖ *Thin Film Oven test (ASTM D 1754)*
- ❖ *Rolling Thin Film Oven Test (ASTM D 2872)*
- ❖ *Distillation of Cutback Asphalt (ASTM D402)*
- ❖ *Loss on heating (ASTM D6)*

Purity tests

- ❖ *Solubility in Trichloroethylene (ASTM D2042)*
- ❖ *Presence of water (ASTM D95)*
- ❖ *Water content (ASTM D95)*

Safety tests

- ❖ *Flash and fire point test (ASTM D1310)*

Other tests

- ❖ *Specific Gravity (S.G) (ASTM D70)*

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Laboratory tests and properties of asphalt

Aggregates and Soil

- Specific Gravity and Absorption of Coarse Aggregate Test
- Specific Gravity and Absorption of Fine Aggregate Test
- Los Angeles (LA) Abrasion Test
- Coarse Aggregate Angularity (CAA) Test
- Fine Aggregate Angularity (FAA) Test
- Flat and Elongated (F&E) Particles Test
- Sand Equivalent (SE) Test
- California Bearing Ratio (CBR) Test

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Laboratory tests

Asphalt Mixture Design

☐ Marshall Mixture Design Method:

- Aggregate and Asphalt Preparation and Evaluation.
- Preparation of Marshall Specimens.
- Bulk Specific Gravity of Compacted Asphalt Mixtures (Gmb).
- Theoretical Maximum Specific Gravity of Asphalt Mixtures (Gmm).
- Marshall Stability and Flow Test.
- Volumetric (Density and Voids) Analysis.
- Selection of Design Asphalt Content.

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JORDAN PETROLEUM REFINERY CO. LTD

Specifications of Asphalt 60-70

S.N	Characteristics		Test Method	Control Limits
1	Ductility @ 25 °C, 5cm / min.	cm	ASTM D113	Min. 100
2	Flash Point	°C	ASTM D92	Min. 232
3	Penetration @ 25 °C, 100g, 5 sec.	0.1 mm	ASTM D5	60 - 70
4	Solubility in Trichloroethylene	Mass %	ASTM D2042	Min. 99.0
5	Performance after Thin-film Oven Test_ ASTM D1754			
5.1	Retained Penetration.	%	ASTM D5	Min. 52+
5.2	Ductility at 25°C, 5 cm/min.	cm	ASTM D113	Min. 50

¹ This specification is based on Jordanian Technical Regulation # JS 612:1989, and ASTM D946/D946M-15 for Asphalt- Penetration Graded Asphalt Cement for Use in Pavement Construction.

² The asphalt binder shall be homogeneous, free from water and foreign matter, and shall not foam when heated to 175°C.

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Lab Instructions

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Lab Grading Plan

- Mid term Exam (30 Points)
- Lab work & Reports (30 Points)
- Final Exam (40 Points)

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Report Structure

REPORT STRUCTURE

The report should be scientifically prepared, neat, and well organized. It should include the following main parts:

Cover Page: Shows the University name, course name, lab number and title, student name and student I.D. number.

Abstract: Very short statement about the experiment, its final results and your conclusions.

Introduction: General importance of the experiment and particular importance of the findings, location of the study if any and the specific statement of the studied problem.

Objectives: The precise statement of the purposes of the experiment.

Methodology: Describe the methodology of the study and the specific steps (procedure) of your work. Include illustrative maps, sketches, .. etc., if needed.

Data Collection and Analysis:

Present the collected data in an easily interpreted forms (tables, figures, ..) and carry out the needed calculations and analysis so that you are able to draw clear results.

Result: State your final results directly, clearly, and precisely.

Discussion and Conclusions:

Discuss your results and draw clear conclusions.

Recommendations:

List any recommendations about the practical use of the results and how can they be applied.

References: Written in a formal way and in an alphabetical order.

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General Notes

- Notes:
1. Absolutely no late reports are accepted.
 2. Bonus is expected for a well prepared report and for any extra put effort.
 3. Failure to attend the lab meeting implies missing the chance to submit the report required for this session.

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Laboratory instructions

- No Food or Drink
- Students should enter the lab wearing a Lab coat. It should be worn at all times in the lab.
- Don't forget to bring Lab manual/standards, small **NOTEBOOK**, calculator, and other accessories when you come to lab
- Your phone should be Turned off
- Follow all written and verbal instructions carefully
- No foolish behavior allowed (e.g, running, playing games, throwing objects).
 - *Disciplinary actions will be taken against offenders*
- Don't try to repair any faulty instruments.
- Always keep work areas clean and tidy.
- Place tools and equipment in proper place after use

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Fundamental Statistical Concepts

Descriptive statistics

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Fundamental Statistical Concepts

General Definitions

- ❑ In order for a highway engineer to understand the role of statistics in the field of pavement design and construction, he must get good knowledge of the basic statistical concepts
- ❑ In any project like construction of a highway or an airport, to judge the quality of the work, you have to measure more than one parameter like moisture content of the subgrade, degree of compaction of any layer, CBR value, ... etc.
- ❑ Statistics should be used to decide the number of samples to be tested and to decide whether to accept the work if there are some sample results that are outside the required limit.

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Fundamental Statistical Concepts

Average Value (\bar{X})

- ❑ This \bar{X} value is called the sample mean and is the best estimate of the true population mean, μ .

- ❑
$$\bar{X} = \frac{\sum_{i=1}^n x_i}{n}$$

Averages

Find the mean of the following data set:

4, 9, 12, 1, 20, 35, 5, 3, 2

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Variability Parameters

The Variance (s²):

- ❑ The variance (s²):

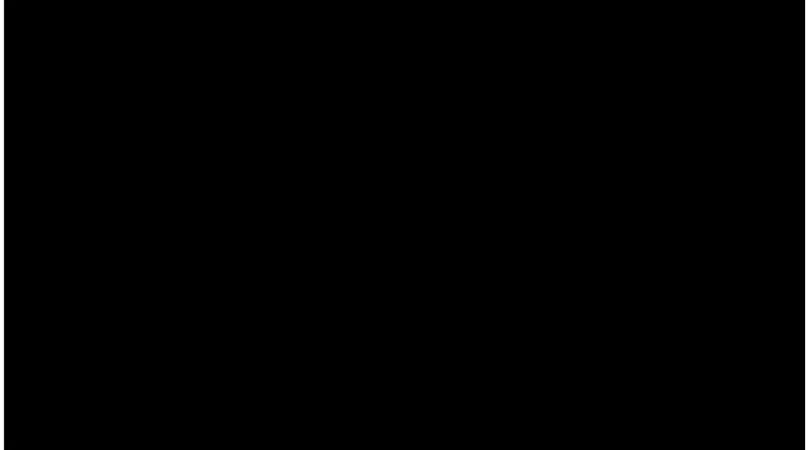
- $s^2 = \sum_{i=1}^n \frac{(x_i - \bar{X})^2}{n-1}$

- ❑ A more convenient computational form of the previous equation can be written as:

- $s^2 = \frac{\sum_{i=1}^n x_i^2 - (\sum_{i=1}^n x_i)^2/n}{n-1}$

- ❑ The standard deviation is the square root of the variance.

- $s = \sqrt{s^2}$



<https://www.youtube.com/watch?v=x0msW0558>

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Variability Parameters

The coefficient of variation (C.V.) or (COV):

- ❑ The general expression is usually given in percent as:

$$C.V. = \left(\frac{s}{\bar{X}} \right) \times 100$$

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