Department of

CIVIL AND ENVIRONMENTAL ENGINEERING

CEE250L Transportation Engineering Lab

TRANSPORTATION ENGINEERING LABORATORY

NORTH SOUTH UNIVERSITY

Center of Excellence in Higher Education

The First Private University in Bangladesh

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North South University

Department of Civil and Environmental Engineering

CEE 250L

TRANSPORTATION ENGINEERING LABORATORY MANUAL

CEE 250L: Transportation Engineering Lab

COURSE DESCRIPTION

Laboratory experiments on highway materials (soil, aggregates and asphalt) and characterization of those materials.

COURSE OBJECTIVE

Provide the students a hands-on experience of conducting laboratory experiments on highway materials needed for the materials' characterization and conformation to the specifications.

LAB EXPERIMENTS

- Determination of Aggregate Impact Value
- Determination of Aggregate Crushing Value
- Determination of the Ten Percent Fines Value
- Determination of Flakiness Index
- Determination of Elongation Index
- Determination of Angularity Number
- Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact of the Los Angles Machine
- Specific Gravity Test on Bituminous Materials
- Softening Point of Bituminous Material (Ring and Ball Method)
- Determination of Viscosity of Asphalt By Rotational Viscometer
- Flash And Fire Points of Bituminous Material (Cleveland Open Cup Method)
- Penetration of Bituminous Material.

AVAILABILITY OF COURSE MATERIALS

The lab manual is available at the university common folder "Resource". You can print them from there. Students are advised to check the folders at regular intervals.

LAB INSTRUCTIONS

The course instructor or lab assistant/coordinator must be consulted before using any lab facility. Students are strongly advised to follow the general lab safety rules. Note that closed toe shoes are mandatory in all Civil Engineering laboratories. No sandals will be allowed in the lab. It is a student's responsibility to read the test procedures and text assignments before the scheduled labs. It is highly requested to maintain discipline in the lab like not to be late, refrain from making noise during lab time, not to leave the lab early.

EVALUATION

Participation and attendance	= 35%
Lab Report	= 35%
Lab Exam	= 30%

MAPPING OF COURSE OUTCOME-PROGRAM OUTCOME (CO-PO)

Sl.	Course Outcomes (COs)	Program Outcome[1]	Bloom's taxonomy Domain /level[2]	Delivery methods and activities	Assessment tools
CO1	Conduct common laboratory experiments on highway materials (soil, aggregates and asphalt) used in transportation projects and use the test data to characterize those materials in order to conform to standard specifications.	**PO-5**	P1, P2, P3	Lecture, Demonstration	Participation, Lab report, Exam

Notes:

1. BSCEE Program Outcomes (POs):

- PO - 1: Engineering Knowledge
- PO - 2: Problem analysis
- PO - 3: Design/development of solutions
- PO - 4: Investigation
- PO - 5: Modern tool usage
- PO - 6: The engineer and society
- PO - 7: Environment and sustainability
- PO - 8: Ethics
- PO - 9: Individual work and teamwork
- PO - 10: Communication
- PO - 11: Project management and finance
- PO - 12: Life-long learning
- PO - 13: Contemporary Issues.

2. Domains and Levels of Bloom's Taxonomy

- "Cognitive" Domain (C): C1 - Recall data, C2 - Understand, C3 - Apply, C4 - Analysis, C5 - Synthesize, and C6 - Evaluate.
- "Affective" Domain (A): A1 - Receive, A2 - Respond, A3 - Value, A4 - Organize personal value system, and A5 - Internalize value system.
- "Psychomotor" Domain (P): P1 - Imitation, P2 - Manipulation, P3 - Develop precision, P4 -Articulation, and P5 - Naturalization.

EXAM AND GRADING POLICY

Lab exam will be a written and/or viva based on the knowledge gained from experiments done in the lab. No makeup exam will be arranged unless an absolutely unavoidable valid reason for absence is found. For such unavoidable circumstances, written explanation must be submitted before the exam. Generally, NSU grading policy will be followed.

North South University
Department of Civil and Environmental Engineering

CEE 250L TRANSPORTATION ENGINEERING LAB

WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 01

DETERMINATION OF AGGREGATE IMPACT VALUE

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 01

DETERMINATION OF AGGREGATE IMPACT VALUE

OBJECTIVE

The aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shock or impact‖, which in some aggregates differs from its resistance to a slowly applied compressive load. With aggregate of aggregate impact value (AIV) higher than 30 the result may be anomalous. In addition, aggregate sizes larger than 15 mm are not appropriate to the aggregate impact test.

The standard aggregate impact test shall be made on aggregate passing a 15 mm BS test sieve and retained on a 10 mm BS test sieve. If required, or if the standard size is not available, smaller sizes may be tested but owing to the non-homogeneity of aggregates, the results are not likely to be the same as those obtained from the standard size. In general, the smaller sizes of aggregate will give a lower impact value but the relationship between the values obtained with different sizes may vary from one aggregate to another.

APPARATUS

An impact testing machine of the general form and complying with the followings-

Total mass not more than 60 kg or less than 45 kg. The machine shall have a circular metal base weighing between 22 kg and 30 kg., with a plane lower surface of not less than 300 mm diameter, and shall be supported on a level and plane concrete or stone block or floor at least 450 mm thick. The machine shall be prevented from rocking either by fixing it to the block or floor or by supporting it on a level and plane metal plate cost into the surface of the block or floor.

A cylinder steel cup having an internal diameter of 102 mm and an internal depth of 50 mm. The walls shall be not less than 6 mm thick and the inner surfaces shall be case hardened. The cup shall be rigidly fastened at the center of the base and be easily removed for emptying.

A metal hammer weighing 13.5 kg to 14.0 kg the lower end of which shall be cylindrical in shape, 100.00 mm diameter and 50 mm long, with a 1.5 mm chamfer at the lower edge, and case hardened. The hammer shall slide freely between vertical guides so arranged that the lower (cylindrical) part of the hammer is above and concentric with the cup.

Means or raising the hammer and allowing it to fall freely between the vertical guides from a height of 380±5 mm on to the test sample in the cup, and means for adjusting the height of fall within 5 mm.

1. Means for supporting the hammer whilst fastening or removing the cup.

2. A straight metal tamping rod of circular cross section, 10 mm diameter, 230 mm long, rounded at one edge.

3. A balance of capacity not less than 500 gm, and accurate to 0.1 gm.

PREPARATION OF THE TEST SAMPLE

The material for the standard test shall consist of aggregate passing a 15.0 mm BS test sieve and retained on a 10.00 mm BS test sieve, and shall be thoroughly separated on these sieves before testing. For smaller sizes, the aggregate shall be prepared in a similar manner using the appropriate sieves given in table 1. The quantity of aggregate sieved out shall be sufficient for two tests.

The aggregate shall be tested in a surface dry condition. If dried by heating, the period of drying shall not exceed 4 h, the temperature shall not exceed 110^0c and the samples shall be cooled to room temperature before testing.

The measure shall be filled about one third full with the aggregate by means of a scoop, the aggregate being discharged from a height not exceeding 50mm above the top of the container. The aggregate shall then be tamped with 25 blows of the rounded end of the tamping rod, each blows being given by allowing the tamping rod to fall freely from a height of about 50 mm above the surface of the aggregate and the blows being evenly distributed over the surface. A further similar quantity of aggregate shall be added in the same manner and a further tamping of 25 times and the surplus aggregate removed by rolling the tamping rod across, and in contact with, the top of the container, any aggregate which impedes its progress being removed by hand and aggregate being added to fill any obvious depressions. The net mass of aggregates in the measure shall be recorded (mass A) and the same mass used for the second test.

TEST PROCEDURE

Rest the impact machine, without wedging or packing, upon the level plate, black or floor, so that it is rigid and the hammer guide columns are vertical.

Fix the cup firmly in position on the base of the machine and place the whole of the test sample in it and compact by a single tamping of 25 strokes of the tamping rod as above.

Adjust the height of the hammer so that its lower face is 380±5 mm above the upper surface of the aggregate in the cup and then allow it to fall freely on to the aggregate. Subject the test sample to a total of 15 such blows, each being delivered act an interval of not less than 1 s. No adjustment for hammer height is required after the first blow.

Then remove the crushed aggregate by holding the cup over a clean tray and hammering on the outside with a suitable rubber mallet until the sample particle s are sufficiently disturbed to enable the mass of the sample to fall freely on to the tray. Transfer fine particles adhering to the inside of the cup and the underside of the hammer to the tray by means of a stiff bristle brush. Sieve the whole of the sample in the tray, for the standard test, on the 2.5 mm BS test sieve until no further significant amount in 1 min.

Weigh the fraction passing and retained on the sieve to an accurately of 0.1 gm (mass B and mass C respectively) and if the total mass B+C is less than the initial mass (mass A) by more than 1 gm, discard the result and make afresh test.

Repeat the whole procedure starting from the beginning using a second sample of the same mass as the first sample.

CALCULATIONS

The ratio of the mass of fines formed to the total sample mass in each test shall be expressed as a percentage, the result being recorded to the first decimal place.

$$\text{Percentage fines: } B/A \times 100$$

Where,

A is the a mass of surface dry sample, gm

B is the fraction passing the sieve for separating the fines, gm

REPORTING OF RESULTS

The means of the two results shall be reported to the nearest whole number as the aggregate impact value.

DISCUSSION

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Signature of the Faculty

North South University
Department of Civil and Environmental Engineering

CEE 250L TRANSPORTATION ENGINEERING LAB
WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 02

DETERMINATION OF AGGREGATE CRUSHING VALUE

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 02

DETERMINATION OF AGGREGATE CRUSHING VALUE

GENERAL

Aggregate used in road construction, should be strong enough to resist crushing under traffic wheel load. If the aggregate are weak, the stability of the pavement structure is likely to be adversely affected. The strength of coarse aggregate is assessed by aggregate crushing test. The aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied compressive load. To achieve a high quality of pavement, aggregate possessing low aggregate crushing value should be preferred.

With aggregate of an aggregate crushing value higher than 30 the result may be anomalous and in such as the ten percent fines value should be determined instead

SAMPLING

The standard aggregate crushing test shall be made on aggregate passing a 14.0 mm BS test and retained on a 10.0 m BS test sieve

APPARATUS

The following apparatus is required for the standard test.

An open ended steel cylinder of nominal 150 mm internal diameter with plunger and base plate, of the general from and diameter shown in the figure. The surfaces in contact with the aggregate shall be machined and case hardened, and shall be maintained in a smooth condition.

A straight metal tamping rod of circular cross section, 16 mm diameter and 450 mm to 600 mm long. One end shall be rounded.

A balance of at least 3 kg capacity and accurate to 1 gm.

BS test sieves of sizes 14.0 mm, 10.0 mm and 2.36 mm.

A compression testing machine capable of applying a force of 400 KN and which can be operated to give a uniform rate of loading so that this force is reached in 10 minute.

A cylindrical metal measure (optional) for measuring the sample, of sufficient rigidity to remain its form under rough usage and having an internal diameter of 115 mm and an internal depth of 180 mm.

PREPARATION OF TEST SAMPLE

The material for the standard test shall consist of aggregate passing the 14.0 mm BS test sieve and retained on the 10.0 mm BS test sieve and shall be thoroughly separated on these sieves before testing. The quality of aggregate shall be cooled to room temperature before testing.

The aggregate shall be tested in a surface-dry condition. If dried by heating the period of drying shall not exceed 4 h, the temperature shall not exceed 110^0 c and the aggregate shall be cooled to room temperature before testing.

The quantity of aggregate for one test shall be such that the depth of the material in the cylinder shall be 100 mm after tamping.

TEST PROCEDURE

Put the cylinder of the test apparatus in position on the base plate, and add the test sample in thirds, each third being subjected to 25 strikes from the tamping rod distributed evenly over the surface of the layer and dropping from a height approximately 50 mm above the surface of the aggregate. Carefully level the surface of the aggregate and insert the plunger so that it rests horizontally on this surface, taking care to ensure that the plunger does not jam in the cylinder.

Place the Apparatus, with the test sample and plunger in position, between the plates of the testing machine and load it at as uniform a rate as possible so that the required force is reached in 10 minutes. The required force shall be 400 kN.

Release the load and remove the crushed material by holding the cylinder over a clean tray and hammering on the outside with a suitable rubber mallet until the sample particles are sufficiently disturbed to enable the mass of the sample to fall freely on to the tray. Transfer fine particles adhering to the inside of the cylinder, to the base-plate and the underside of the plunger to the tray by means of a stiff bristle brush. Sieve the whole of the sample on the tray on the 2.36 mm BS test sieve until no further significant amount passes in 1 minute. Weight the fraction passing the sieve (mass B). Take care in all of these operations to avoid loose of the fines.

Repeat the whole procedure, starting from the beginning of 2.5, using a second sample of the same mass as the first sample.

CALCULATION

The ratio of the mass of fines formed to the total mass of the sample in each test shall be expressed as a percentage, the result being recorded to the first decimal place.

Percentage Fines: B/A x 100

Where,

A is the mass of surface dry sample (gm)

B is the mass of the fraction passing the 2.36 mm BS test sieve (gm)

EXPERIMENT NO: 02

DETERMINATION OF AGGREGATE CRUSHING VALUE

Name: Student No:

Type of material: Brick Chips/ Stone Chips/ Gravels/ Boulder/

Rock Sample Size: 14 mm to 10 mm

Test Method: BS 812 (part 3) 1975

Test No	1	2
Wt. of Sample (Surface Dry), A gm		
Wt. of materials passing 2.36 mm sieve, B gm		
Aggregate Crushing Value (%) = B/A x 100% (to the first decimal place)		
Average Aggregate Crushing Value (ACV) = (to the nearest whole number)		

Calculation:

DISCUSSION

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WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 03

DETERMINATION OF THE TEN PERCENT FINES VALUE

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 03

DETERMINATION OF THE TEN PERCENT FINES VALUE

OBJECTIVE

The ten percent fines value gives a measure of the resistance of an aggregate to crushing which is applicable to both weak and strong aggregate.

SAMPLING

The standard aggregate crushing test shall be made on aggregate passing a 15.0 mm BS test and retained on a 10.0 m BS test sieve.

APPARATUS

Same as the Aggregate Crushing Value.

PREPARATION OF THE TEST SAMPLE

Same as the previous except in case of weak materials, particular care shall be taken not to break the particles when filling the measure and the cylinder.

TEST PROCEDURE

Put the cylinder of the test apparatus in position on the base-plate and add the test sample in thirds, each third being subjected to 25 strokes from the tamping rod distributed evenly over the surface of the layer and dropping from a height approximately 50 mm above the surface of the aggregate, particular care being taken in the case of weak materials not to break the particles. Carefully level the surface of the aggregate and insert the plunger so that it rests horizontally on this surface, taking care to ensure that the plunger does not jam in the cylinder.

Then place the apparatus, with the test sample and plunger in position, between the plates of the testing machine. Apply forces at as uniform a rate as possible to cause a total penetration of the plunger in 10 min of about:

a) 15 mm for rounded or partially rounded aggregate (e.g. uncrushed gravels)

b) 20 mm for normal crushed aggregate

c) 24 mm for honeycombed aggregate (e.g. some slags)

The figures may be varied according to the extent of the rounding or honeycombing.

NOTE: When an aggregate impact value is available, the force required for the first ten percent fines test can be estimated by means of the following more conveniently than by the use of the dial gauge.

Required force (KN) = 4000/ Aggregate Impact Value

This value of force will nearly always gives a percentage fines within the required range of 7.5 to 12.5.

Record the maximum force applied to produce the required penetration. Release the force and remove the crushed material by holding the cylinder over a clean tray and hammering on the outside with a suitable rubber mallet until the sample particles are sufficiently disturbed to enable the mass of the sample to fall freely on to the tray. Transfer fine particles adhering to the inside of the cylinder and the underside of the plunger to the tray by means of a steel bristle brush. Sieve the whole of the sample in the tray on the 2.5 mm BS test sieve until no further significant amount passes in 1 minute. Weight the fraction passing the sieve, and express this mass as percentage of the mass of the test sample. Normally this percentage of fines will fall within the range 7.5 to 12.5, but if it does not, make a further test loading to a maximum value adjusted as seems appropriate to bring the percentage fines within the range of 7.5 to 12.5. The formula given which may be used for calculating the force required.

In all of these operations take care to avoid loss of the fines. Make a repeat test at the maximum force that gives a percentage fines within the range 7.5 to 12.5.

The mean percentage fines from the two tests at this maximum force shall be used in the following to calculate the force required to produce ten percentage fines.

Force required to produce ten percent fines = 14 x / (y+4)

Where,

x is the maximum force (kN)

y is the mean percentage fines from two tests at –x kN forces.

DISCUSSION

EXPERIMENT NO: 03

DETERMINATION OF THE TEN PERCENT FINES VALUE

Name: Student No:

Type of material:

Rock Sample Size : 15 mm to 10 mm

Force required to produce T.F.V = 4000kN / A.I.V = kN.

Used Force x = kN

Test No Data	1	2	3 (if required)
Wt. of Sample (Surface Dry), A gm			
Wt. of materials retained on 2.5 mm sieve, C gm			
Wt. of materials passing 2.5 mm sieve, B gm			
Percent Fines = B/A x 100% (to the first decimal place)			
Mean percentage fines (y), at x = kN force			

CALCULATION:

Ten Percent Fines Value (T.F.V) = 14x / (y+4) =

(to the nearest 5 kN, if < 100 kN & 10kN, if ≥ 100 kN)

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WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 04

DETERMINATION OF FLAKINESS INDEX

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 04

DETERMINATION OF FLAKINESS INDEX

OBJECTIVE

Aggregate particle may have three types of shapes, namely rounded, angular and flaky. Round shape is good for use in cement concrete as it produces more workable concrete with comparatively less quantity of water. Angular particles are good for bituminous pavements as they have better interlocking property.

Flaky particles are comparatively thin as compared to their length. Flakiness Index is the percentage by weight of particle in it, whose least dimension is less than three fifth of its mean dimension. Those particles whose least dimension is less than 0.6 of their mean size and whose greatest dimension is more than 1.8 times their mean size, are respectively termed as flaky and elongated particles. The shape of the particles is evaluated in terms of flakiness index.

FLAKINESS INDEX

This test is carried on aggregate of having particles larger than 6.3mm. Let a particle of aggregate passes through 20mm sieve but retained on 10mm sieve. The mean size of this particles is (20+10)/2 = 15mm. When this mean size multiplied by 0.6, 9mm size is obtained. Hence for this aggregate if thickness of the particles is less than 9mm it is said to be flaky.

APPARATUS

The following apparatus is required,

a. A metal thickness gauge.
b. A balance accurate to 0.5% of the mass to the test sample.

SAMPLE FOR TEST

Aggregate passing through 63.0mm BS test sieve and retained on the 6.30mm BS test sieve.

PROCEDURE

1. A sample of aggregate to be tested is sieved through set of sieves (63.0mm, 50.0mm, 37.5mm, 28.0mm, 20.0mm, 14.0mm, 10.0mm, 6.3mm) and separated into specified size ranges.
2. The particles retained on each sieve are then made to pass through appropriate slot, (0.6 time of the mean size) of standard thickness gauge.
3. The material that passes through the appropriate slot of the gauge is said to be flaky. The flaky material that has passed through the appropriate slots of standard gauge, for each size of range of the test aggregate, are added up and weighted.

DATA TABLE

Sieve Size, mm		Wt. of the material retained, gm	Wt. of the flaky particles (amount passed), gm
Passing	Retained		
63.0	50.0		
50.0	37.5		
37.5	28.0		
28.0	20.0		
20.0	14.0		
14.0	10.0		
10.0	6.30		
x	x	W=	W1=

CALCULATIONS

Flakiness Index is determined as follows,

- W1/W x 100%

Where, W1= Weight of flaky material from whole test sample
W= Total weight of sample

DISCUSSION

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WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 05

DETERMINATION OF ELONGATION INDEX

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 05

DETERMINATION OF ELONGATION INDEX

OBJECTIVE

Aggregate particle may have three types of shapes, namely rounded, angular and flaky. Round shape is good for use in cement concrete as it produces more workable concrete with comparatively less quantity water. Angular particles are good for bituminous pavements as they have better interlocking property.

Flaky and elongated particles may have adverse effects on concrete and bituminous mix. For instance, flaky and elongated particles tend to lower the workability of concrete mix that may impair the long-term durability. For bituminous mix, flaky particles are liable to break up and disintegrate during the pavement rolling process.

Elongation Index is the percentage by weight of particles in it, where the largest dimension (i.e. length) is greater than one and four-fifths times its mean dimension. Those particle whose least dimension is less than 0.6 of their mean size and whose greatest dimension is more than 1.8 times their mean size, are respectively termed as flaky and elongated particles. The shape of the particles is evaluated in terms of flakiness index, elongation index and angularity number.

ELONGATION INDEX

This test is carried on aggregate of having particles larger than 6.3mm. Let a particle of aggregate passes through 20 mm sieve but retained on 10mm sieve. The mean size of this particles is (20+10)/2 = 15mm. When mean size (15 mm) is multiplied by 1.8, 27.00 mm size is obtained. Hence, a particle that is longer than 27 mm, for this particular range of size, is termed as elongated particle.

APPARATUS

The following apparatus is required,

c. A metal length gauge.
d. A balance accurate to 0.5% of the mass to the test sample.

SAMPLE FOR TEST

Aggregate passing through 63.0mm BS test sieve and retained on the 6.30mm BS test sieve.

PROCEDURE

1. A sample of aggregate to be tested is sieved through set of sieves (63.0mm, 50.0mm,

37.5mm, 28.0mm, 20.0mm, 14.0mm, 10.0mm, 6.3mm) and separated into specified size ranges.

2. The particles retained on each sieve are then made to pass through appropriate slot, (1.8 times the mean size) of standard length gauge.
3. The material that does not pass through the appropriate slot of the gauge is said to be elongated. The elongated material that has not passed through the appropriate slots of standard length gauge, for each size range of the test aggregate, are added up and weighted.

DATA TABLE

Sieve Size, mm		Wt. of the material retained, gm	Wt. of the elongated particles (amount retained), gm
Passing	Retained		
63.0	50.0		
50.0	37.5		
37.5	28.0		
28.0	20.0		
20.0	14.0		
14.0	10.0		
10.0	6.30		
x	x	W=	W1=

CALCULATIONS

Elongation Index is determined as follows,

W1/W x 100%

Where, W1= Weight of elongation material from whole test sample

W= Total weight of the sample

DISCUSSION

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WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 06

DETERMINATION OF ANGULARITY NUMBER

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 06

DETERMINATION OF ANGULARITY NUMBER

OBJECTIVE

The angularity number is determined from the proportion of voids in a sample of aggregate after compaction in the specified manner. This property is used mainly in the design of mix proportions and in research. Angularity or absence of rounding of the particles of an aggregate is a property which is of importance because it affects the ease of handling of a mixture of aggregate and binder (e.g. the workability of concrete) or the stability of mixtures that rely on the interlocking of the particles. The least angular (most rounded) aggregates are found to have about 33% voids and the angularity number is defined as the amount by which the percentage of voids exceeds 33. The angularity number ranges from 0 to about 12. The angularity number indicates the voids in excess of the voids in perfectly rounded gravel (33%). More angular is the aggregate the higher will be its angularity number.

SAMPLE FOR TEST

Aggregate passing through 20.00 mm BS test sieve and retained on the 5.00 mm BS test sieve.

APPARATUS

The following apparatus is required:

1. A metal cylinder closed at one end of about 0.003 m^3 volume, the diameter and height of which should be approximately equal (e.g. 150 mm and 150 mm). The cylinder shall be made from metal of a thickness not less than 3 mm and shall be of sufficient rigidity to retain its shape under rough usage.
2. Metal Tamping Rod: 16 mm in dia and 600 mm long with of circular cross section.
3. A balance or scale of capacity 10 kg, accurate to 1.
4. A metal scoop.
5. BS test sieves: 20.0 mm, 14.00mm, 10.00mm, 6.30mm, 5.0 mm.

PREPARATION OF THE TEST SAMPLE

The aggregate to be tested shall be dried for at least 24 hr in shallow trays in a well-ventilated oven at a temperature of 105 ±5^0C, cooled in an airtight container and tested.

TEST PROCEDURE

1. The aggregate sample is now filed in the metal cylinder in the three layers. Each layer being tamped 100 times with tamping rod 50 mm above the surface of the aggregate

before the next layer is put.

2. The excess material is struck off at level with top of the cylinder.
3. The weight of the aggregate in the cylinder is determined.
4. Now cylinder is emptied and filled with water and weight of the water is determined.
5. The specific gravity of the Aggregate may be separately determined (Here, assume 2.7)

CALCULATIONS

Angularity Number is determined as follows,

$$\text{Angularity Number: } 67 - W \times 100/wG$$

Where, W = Weight of the aggregate filled in the cylinder.

w = Weight of the water filled in the cylinder.

G = Specific Gravity of the aggregate.

The angularity number shall be reported to the nearest whole number.

DISCUSSIONS

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CEE 250L TRANSPORTATION ENGINEERING LAB
WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 07

RESISTANCE TO DEGRADATION OF SMALL SIZE COARSE AGGREGATE BY ABRASION AND IMPACT OF THE

LOS ANGLES MACHINE

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 07

RESISTANCE TO DEGRADATION OF SMALL SIZE COARSE AGGREGATE BY ABRASION AND IMPACT OF THE LOS ANGLES MACHINE

RELATED THEORY

Apart from testing aggregate with respect to its resistance to wear or degradation (hardness) is an important test for aggregate to be used for roads, and in floor surfaces subjected to heavy traffic. This test method covers a procedure for testing sizes of coarse aggregate smaller than 1.5in (37.5 mm) for resistance to degradation using the Los Angeles testing machine. This test has been widely used as an indicator of the relative quality or competence of various source of aggregate having similar mineral compositions. The test method conforms to the ASTM standard requirements of specification C131.

OBJECTIVE

Resistance to Degradation of small size course Aggregate by Abrasion and Impact of the Los Angeles Machine.

MATERIAL & EQUIPMENT

a) Los Angeles Machine: The machine shall consist of a hollow a steel cylinder, closed at both ends having an inside diameter of 28#0.2in(711#5 mm),and an inside length of 20#0.2in.(508#5 mm).The cylinder shall be mounted on stub shafts attached to the ends of the cylinder but not entering it, and shall be mounted in such a manner that it may be rotated with the axis in a horizontal position within a tolerance in slope of in 100.An opening in the cylinder shall be provided for the introduction of the test sample .A suitable, dust-tight cover shell be provided for the opening with means for bolting the cover in place. The cover shall be so designed as to maintain the cylindrical contour of the interior surface of the cylinder, in such a way that a plane centered between the large faces coincides with the axial plane .The shelf shall be not of such `thickness and so mounted, by bolts or other suitable means, as to be firm and rigid. The position of the shelf shall be such that cylinder in the direction of rotation, shall be not less than 50 in (1.27m). The machine shall be so driven and so counterbalanced as to maintain a uniform peripheral speed.

b) Sieves: conforming to the specifications for sieves for testing purposes.

c) Balance: Accurate within 0.1% of test load over the range required for the test.

d) Charge: The charge shall consist of steel spheres averaging approximately 1-27/32 in (46.8mm) in diameter and each weighing between 390 and 445g.

The charge depending upon the grading of the test sample shall be as follows.

Grading	Number of spheres	Weight of Charge, g
A	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 20
D	6	2500 ± 15

SAMPLING

The test sample shall be washed and oven- dried at 221 to 230 ---F (105 to 110 C) to substantially constant weight separated into individual size fractions, and recombined to the grading of Table-1 most nearly corresponding to the range of the aggregate as furnished for the work. The weight of the sample prior to test shall be recorded to the nearest 1g.

Table-1 Grading of Test Samples

Sieve Size (Square Openings)		Weight of Indicated Size, g			
Passing	Retained on	Grading			
		A	B	C	D
37.5mm(1.5in)	25.0mm(1in)	1250±25	……..	…….	……….
25.0mm(1in)	19.0mm(3/4in)	1250±25	………	……	……….
19.0mm(3/4in)	12.5mm(1/2in)	1250±10	2500±10	………..	………
12.5mm(0.5in)	09.5mm(3/8in)	1250±10	2500±10	……….	……..
09.5mm(3/8in)	06.3mm(1/4in)	…….	……..	2500±10	…….
06.3mm(1/4in)	04.75mm(No-4)	…..	……..	2500±10	5000±10
04.75mm(No-4)	02.36mm(No-8)	……..	……	……..	……
Total		5000±10	5000±10	5000±10	5000±10

EXPERIMENTAL PROCEDURE

Place the test sample and the charge in Los Angeles testing machine and rotate the machine at a speed of 30 to 33 rpm for 500 revolutions. After the prescribed number of revolutions, discharge the material from the machine and make a preliminary separation of the sample on a sieve coarser than the 1.70mm (NO.12). Sieve the finer portion on a 1.70mm sieve in a manner conforming to Method C 136. Wash the material coarser then the 1.70mm sieve, oven-dry at 221 to 230 F (105to110 C) to a substantially constant weight, and weight to the nearest 1g.

SAMPLE CALCULATION

Express the loss (difference between the original weight and the final weight) of the test sample. Report this value as the percent loss.

DATA SHEET

Sieve Size Passing	Sieve Size Retained	Wt. of Material, W_1	Grading of material	No of Steel Balls Used	Wt. Retained on No 12 Sieve, W_2(gm)	Total Wear (gm) W_1-W_2

CALCULATION

$$\text{Abrasion Value} = \frac{W_1 - W_2}{W_1} \times 100$$

RESULT

Abrasion Value =

DISCUSSION

Signature of the Faculty

North South University
Department of Civil and Environmental Engineering

CEE 250L TRANSPORTATION ENGINEERING LAB
WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 08

SPECIFIC GRAVITY TEST ON BITUMINOUS MATERIALS

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 08

SPECIFIC GRAVITY TEST ON BITUMINOUS MATERIALS

OBJECTIVE

This method covers the determination of the specific gravity of semi-solid bituminous materials, asphalt cements, and soil tar pitches by use of a pycnometer.

The specific gravity of semi-solid bituminous materials, asphalt cements, and soft tar pitches shall be expressed as the ratio of the mass of a given volume of the material at 25^0 C(77^0 F) or at 15.6°C (60°F) to that of an equal volume of water at the same temperature, and shall be expressed thus:

Specific gravity, 25/25°C (77/770F) or 15.6/15.6°C (60/60°F)

APPARATUS

Pycnometer, glass, consisting of a cylindrical or conical vessel carefully ground to receive an accurately fitting glass stopper 22 to 26 mm in diameter. The stopper shall be provided with a hole 1.0 to 2.0 mm in diameter, centrally located in reference to the vertical axis. The top surface of the stopper shall be smooth and substantially plane and the lower surface shall be concave in order to allow all air to escape through the bore. The height of the concave section shall be 4.0 to 18.0 mm at the center. The stoppered pycnometer shall have a capacity of 24 to 30 ml, and shall weigh not more than 40 g.

Water Bath- Constant temperature, capable of maintaining the temperature within 0.1^0C (0.2^0F) of the test temperature.

Thermometers- Calibrated liquid-in-glass of suitable range with graduations at least every 0.2°F (0.1°C) and a maximum scale error of 0.2°F (0.1°C) as prescribed in ASTM specification on El. Thermometers commonly used are 63°F or 63°C. Any other thermometer of equal accuracy may be used.

Balance - a balance conforming to the requirements of M 231, Class B.

Materials- Distilled Water - Freshly boiled and cooled distilled water shall be used to fill the pycnometer and the beaker.

PREPARATION OF EQUIPMENT

Partially fill a 600 ml or larger Griffin low-form beaker with freshly boiled and cooled distilled water to a level that will allow the top of the pycnometer to be immersed to a depth of not less than 40 mm.

Partially immerse the beaker in the water bath to a depth sufficient to allow the bottom of the beaker to be immersed to a depth of not less than 100 mm, while the top of the beaker is above the water level of the bath. Clamp the beaker in place. Maintain the temperature of the water bath within 0.1°C (0.2°F) of the test temperature.

PROCEDURE

1. Thoroughly clean, dry, and weigh the pycnometer to the nearest 1 mg. Designate this mass as A.

2. Fill the pycnometer with freshly boiled distilled water at test temperature and place the stopper in the pycnometer. Do not allow any air bubbles to remain in the pycnometer.

3. Allow the pycnometer to remain in the water for a period of not less than 30 min. Remove the pycnometer, immediately dry the top of the stopper with one stroke of a dry towel (Note 1), then quickly dry the remaining outside area of the pycnometer and weigh to the nearest 1 mg. Designate the mass of the pycnometer plus water as B.

Note-1: Do not re-dry the top of the stopper even if a small droplet of water forms due to expansion. If the top is dried at the instant of removing the pycnometer from the water, the proper mass of the contents at the test temperature will be recorded. If moisture condenses on the pycnometer during weighing, quickly re-dry the outside of the pycnometer (excluding the top) before recording the mass.

Note-2: Calibration should be done at the specific temperature. A pycnometer calibrated at one temperature cannot be used at a different temperature without recalibration, at that temperature.

4. Preparation of Sample - Heat the sample with care, stirring to prevent local overheating, until the sample has become sufficiently fluid to pour. In no case should the temperature be raised to more than 56^{0}C (100°F) above the expected softening point for tar, or to more than 111°C (200°F) above the expected softening point for asphalt. Do not heat for more than 30 minutes over a flame or hot plate or for more than 2 hours in an oven, and avoid incorporating air bubbles in the sample.

5. Pour enough sample into the clean, dry, warmed pycnometer to fill it about three-fourth to its capacity. Take precautions to keep the material from touching the sides of the

pycnometer above the final level, and to prevent the inclusion of air bubbles (Note 3). Allow the pycnometer and its contents to cool to ambient temperature for a period of not less than 40 minutes, and weigh with the stopper to the nearest 1 mg. designate the mass of the pycnometer plus sample as C.

Note-3: If any air bubbles are inadvertently included, remove by brushing the surface of the asphalt in the pycnometer with a high "soft" flame of a Bunsen burner. In order to avoid overheating, do not allow the flame to remain in contact with the asphalt more than a few seconds at any one time.

6. Fill the pycnometer with freshly boiled distilled water at test temperature and place the stopper in the pycnometer. Do not allow any air bubbles to remain in the pycnometer.

7. Allow the pycnometer to remain in the water bath for a period of not less than 30 minutes. Remove the pycnometer from the bath. Dry and weigh using the same technique as that employed in Procedure No.3. Designate this mass of pycnometer plus sample plus water as D.

DATA TABLE

Weight of Pycnometer, M_1

Weight of Pycnometer + Bitumen, M_2

Weight of Pycnometer + Bitumen + Water, M_3

Weight of Pycnometer + Water, M_4

Specific gravity of distilled water, G_T

CALCULATION

$$G_S = \frac{(M2-M1)}{(M4-M1)-(M3-M2)} G_T$$

DISCUSSION

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North South University
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CEE 250L TRANSPORTATION ENGINEERING LAB
WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 09
SOFTENING POINT OF BITUMINOUS MATERIAL
(RING AND BALL METHOD)

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 09

SOFTENING POINT OF BITUMINOUS MATERIAL

(RING AND BALL METHOD)

GENERAL

The ring and ball softening point is extensively used to evaluate the consistency of bituminous binders. It is a very simple one, consisting of placing a 3/8 in diameter steel ball on a binder sample placed in a steel ring and immersed in a water bath. Heat is applied to the water and its temperature is raised until a value is reached when the test sample has become sufficiently soft to allow the ball, enveloped in binder to fall down. The water temperature at which this occurs is called the ring and ball softening point.

The softening point is not a melting point; bituminous binders do not melt but instead gradually change from semi-solids to liquids on the application of heat. It is useful for determining the temperature susceptibilities of bitumen, which are to be used in thick films, such as in crack fillers. When two bitumen's have the same penetration value, the one with the higher softening point is normally less susceptible to temperature changes.

STANDARDS

C 670 Practices for Preparing Precision Statements for Test Methods for Construction materials.

- E 1 Specification for ASTM Thermometers.
- T 40 Methods of Sampling Bituminous Materials.

OBJECTIVE

Determine the Softening Point of Bituminous Material by Ring and Ball Method.

APPARATUS AND MATERIALS

Ring- A brass ring of 15.875 mm (5/8 in) inside diameter, 6.35 mm (1/4 in) depth and thickness of wall is 2.38 mm (3/32 in). This ring shall be attached in a convenient manner to a brass with (diameter 1.85 mm = 0.072 in).

Ball- A steel ball 9.53 mm (3/8 in) in diameter having a mass of 3.50 ± 0.05 g.

Container- A glass vessel, not less than 8.5 cm (3.34 in) in diameter and measuring 10.5 cm (4.13 in.) in depth from the bottom of the flare (a 600 ml beaker, low form, meets this requirement).

Thermometer- ASTM Low softening point Thermometer having a range of -2 to +80°C or 30° to 180°F is specified.

Reagent- Freshly boiled distilled water, USP Glycerin or Ethyl Glycol, with a boiling point between 195 and 197°C (383 and 387°F).

PREPARATION OF SAMPLE

Melt and thoroughly stir the sample avoiding incorporating air bubbles in the mass and then pour it into the ring. The ring, while being filled, should rest on a brass plate, which has been amalgamated to prevent the bituminous material from adhering to it. Allow the excess material to cool for 1 hr then cut it off cleanly with a slightly heated knife.

PROCEDURE FOR MATERIALS HAVING SOFTENING POINTS 80^{0}C (176^{0}F) OR BELOW

- Fill the glass vessel to a depth of substantially 8.25 cm (3.25 in) with freshly boiled, distilled water at 5°C (41°F).

- Suspend the ring containing the sample in the water so that the lower surface of the filled ring is exactly 2.54 cm (1 in) above the bottom of the glass vessel and its upper surface is 5.08 cm (2 in) below the surface of the water.

- Place the ball in the water but not on the specimen.

- Suspend the thermometer so that the bottom of the bulb is level with the bottom of the ring and within 0.635 cm (3/4 in) but not touching the ring. Maintain the temperature of the water at 5°C (41°F) for 15 min.

- With suitable force, place the ball in the center of the upper surface of the bitumen in the ring, thus completing the assembly.

- Apply the heat in such a manner that the temperature of the water is raised 5°C (9°F) each minute.

SOFTENING POINT

Report the temperature recorded by the thermometer at the instant the bituminous material touches the bottom of the glass vessel as the softening point. No correction shall be made for emergent stem of the thermometer.

PROCEDURE FOR MATERIALS HAVING SOFTENING POINTS ABOVE 80^{0}C (176^{0}F)

Thermometer- an ASTM high softening point Thermometer having a range of 30 to 200 °C or 85 to 392 °F is specified Modifications for Hard Materials.

Employ the same procedure as described above except that U.S.P., Glycerin shall be used

instead of water, and the starting point of the Glycerin bath shall be 32 °C (89.6 °F). Bring the bath to this temperature and thoroughly agitate it, then place the apparatus and specimens in the bath, which shall be maintained, under agitation at the starting temperature for 15 min. In applying the heat, place the ring apparatus of the center of the container and place the burner midway between the center and edge of the beaker away from the specimen.

RESULT

Temperature when the ball touches bottom, ^{o}C =

Average =

Softening Point of Bituminous material =

DISCUSSION

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Department of Civil and Environmental Engineering

CEE 250L TRANSPORTATION ENGINEERING LAB WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 10

DETERMINATION OF VISCOSITY OF ASPHALT BY ROTATIONAL VISCOMETER

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 10

DETERMINATION OF VISCOSITY OF ASPHALT BY ROTATIONAL VISCOMETER

GENERAL

This test method is used to measure the apparent viscosity of asphalts at handling, mixing, or application temperatures. The Rotational Viscometer (RV) is used to determine the viscosity of asphalt binders in the high temperature range of manufacturing and construction. This measurement is used in the Superpave performance grade asphalt binder specification. The RV test can be conducted at various temperatures, but since manufacturing and construction temperatures are fairly similar regardless of the environment, the test for Superpave performance grade asphalt binder specification is always conducted at 275°F (135°C).

The basic RV test measures the torque required to maintain a constant rotational speed (20 RPM) of a cylindrical spindle while submerged in an asphalt binder at a constant temperature. This torque is then converted to a viscosity and displayed automatically by the RV.

STANDARDS

The standard Rotational Viscometer procedure is found in:

- AASHTO T 316 and ASTM D 4402

OBJECTIVE

Viscosity Determination of Asphalt Binder Using Rotational Viscometer.

APPARATUS AND MATERIALS

1. Rotational Viscometer

2. Temperature-Controlled Thermal Chamber Heater

BASIC PROCEDURE

1. Preheat spindle, sample chamber, and viscometer environmental chamber (Thermosel) to 275°F (135°C).
2. Heat asphalt binder until fluid enough to pour. Stir the sample, being careful not to entrap air bubbles.
3. Pour appropriate amount of asphalt binder into sample chamber (Figure 8). The sample size varies according to the selected spindle (Figure 9) and equipment manufacturer.

4. Insert sample chamber into RV temperature controller unit and carefully lower spindle into sample
5. Bring sample to the desired test temperature (typically 275°F (135°C)) within approximately 30 minutes and allow it to equilibrate at test temperature for 10 minutes.
6. Rotate spindle at 20 RPM, making sure the percent torque as indicated by the RV readout remains between 2 and 98 percent
7. Once the sample has reached temperature and equilibrated, take 3 viscosity readings from RV display, allowing 1 minute between each reading. Viscosity is reported as the average of 3 readings.
8.

DATA SHEET

Spindle No.	Temperature ^{0}C	RPM	cP	log cP

GRAPH

Draw a graph log cP vs. Temperature.

RESULT

- Kinematic Viscosity =
- Compaction Temperature (log280) =
- Mixing Temperature (log170) =

DISCUSSION

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WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 11

FLASH AND FIRE POINTS OF BITUMINOUS MATERIAL

(CLEVELAND OPEN CUP METHOD)

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 11

FLASH AND FIRE POINTS OF BITUMINOUS MATERIAL

(CLEVELAND OPEN CUP METHOD)

OBJECTIVE

This method describes a test procedure for determining the flash and fire points (Cleveland Open Cup Tester) of all petroleum products except fuel oils and those having an open cup flash below 175^0F. The flash point is the temperature at which a bituminous material, during heating, will evolve vapors that will temporarily ignites or flash when a small flame is brought in contact with them. The fire point is the temperature at which the evolved vapors will ignite and continue to burn.

To make the test, the material is heated in an open cup, and at intervals a small flame is applied near its surface. The lowest temperature at which application of the test flame causes the vapors to ignite is recorded as the flash point while the temperature at which the vapors ignited and burn for at least 5 seconds is recorded as the fire point. The flash and fire point test is purely a safety test. It indicates the maximum temperature to which the material can be safely heated.

APPARATUS

Cleveland Open Tester - The apparatus consists of the test cup, heating plate, test flame applicator, heater, and support.

Shield - A shield 18 inch (46 cm) square and 24 in, (61 cm) high, is recommended but not essential.

Thermometer - ASTM thermometer having a range of 20^0F to 760^0F (-6°C to + 400°C).

PROCEDURE

1. Clean the cup with an appropriate solvent and remove all gums, carbon deposit, and oxide coating from the inside of the cup with fine steel wool until a bright metallic surface is presented.

2. Support the thermometer in a vertical position with the bottom of the bulb 1/4 inch (0.635 cm) from the bottom of the cup and above a point halfway between the center and back of the cup.

3. Fill the cup at any convenient temperature so that the top of the meniscus is exactly at the filling line. When too much sample has been added to the cup, remove the excess, using a spoon or other suitable device; however, if there is sample on the outside of the apparatus, empty, clean. Destroy any air bubbles appear on the surface of the sample.

4. Light the test flame and adjust it to a diameter of 1/8 to 3/16 in. (0.08 cm).

5. Apply heat initially so that the rate of temperature rise of the sample is 25 to 30^0F (13.9 to 16.7°C) per minute. When the sample temperature is approximately 100°F (56^0C) below the anticipated flash point, decrease the heat so that the rate of temperature rise for the last 50^0F (27.8°C) before the flash point is 10 + 1°F (5.5 + 0.6°C) per minute.

6. Record as the flash point the temperature read on the thermometer when a flash appear at any point on the surface of the sample but do not confuse the true flash with the bluish halo that sometimes surrounds the test flame.

7. To determine the fire point, continue heating so that the sample temperature increases at rate of 10 ± 1°F (5.5 ± 0.6^0C) per minute. Continue the application of the test flame at 5^0F (2.8°C) intervals until the vapor ignites and continues to burn for at least 5 sec. Record the temperature at this point as the fire point.

CALCULATION AND REPORT

Observe and record the barometric pressure at the time of the test. When the pressure differs from 760 mm Hg, correct the flash or fire point, or both, by means of the following equations:

- Corrected flash or fire point, or both = F + 0.06(760-P) or
- Corrected flash or fire point, or both = C + 0.03(760-P) Where:

F = observed flash or fire point, or both, to the nearest 5°F

C = observed flash or fire point, or both, to the nearest 2°C.

P = barometric pressure, mm Hg.

Observe Flash Point

Observe Fire Point

DISCUSSION

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CEE 250L TRANSPORTATION ENGINEERING LAB

WORKBOOKS FOR LABORATORY PRACTICE

EXPERIMENT NO: 12

PENETRATION OF BITUMINOUS MATERIAL

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 12

PENETRATION OF BITUMINOUS MATERIAL

OBJECTIVE

This test method covers determination of the penetration of semi-solid and solid bituminous materials. Materials having penetrations below 350 can be tested by the standard apparatus and procedure described. Materials having penetrations between 350 and 500 can be determined using the special apparatus and modifications. This is the most widely used method of measuring the consistency of a bituminous material at a given temperature. It is a means of classification rather than a measure of quality. The engineering term consistency is an empirical measure of the resistance offered by a fluid to continuous deformation when it is subjected to shearing stress.

The penetration test is used as a measure of consistency. Higher values of penetration indicate softer consistency.

APPARATUS

Penetration Apparatus - Any apparatus permitting movements of the spindle without appreciable friction and which is accurately calibrated to yield results in accordance with the description of the term penetration will be acceptable. The surface on which the sample container rests shall be flat and the axis of the plunger shall be at approximately 90 degrees to this surface. The spindle shall be detachable without the use of special toots, for checking its mass. When the needle is mounted in a ferrule, the mass of the moving spindle shall be 47.5 ± 0.05 g. Regardless of the type of mounting of the needle, the total mass of the needle and spindle assembly shall be 50.0 ± g. Weights of 50.0 ± 0.05 g and 100.0 ± 0.05 g shall be provided for total loads of 100 g and 200 g (0.9 N and 2 N), depending upon the conditions of test to be applied.

Needle- The needle shall be made from fully hardened and tempered stainless steel, grade 440 C or equal HRC 54 to 60. It shall be approximately 50 mm (2 in.) in length and 1.00 to 1.02 mm (0.039 to 0.040 in) in diameter.

Container- A container, in which the sample is tested, made of metal or glass cylindrical in shape, and having a flat bottom. The container to be used for materials having a penetration of 200 or less shall have a nominal capacity of 3 oz (90 ml). Its inside dimensions shall be essentially as follows: 55 mm (2.17 in) in diameter and 35 mm (1.38 in) in depth. The container to be used for materials having a penetration over 200 shall have a nominal capacity of 6 oz (175 ml). Its inside dimensions shall be essentially as follows: 70 mm (2.75 in) in diameter and 45 mm (1.77 in) in depth.

Water Bath - A water bath maintained at a temperature varying not more than 0.1°C (0.2°F) from the temperature of the test. The volume of water shall not be less than 10 liters. The bath shall have a perforated shelf supported in a position not less than 50 mm from the bottom of the bath and not less than 100 mm below the liquid level in the bath. The water in the bath shall be substantially free from oil and slime or other organic growth. Brine may be used in the water bath for determinations at low temperatures. If penetration tests are to be made without removing the sample from the bath, a shelf strong enough to support the penetration apparatus shall be provided.

NOTE 1- The use of distilled, dematerialized or demonized water is recommended for the bath. Care should be taken to avoid contamination of the bath water by surface active agents, release agents or other chemicals as their presence may affect the penetration values obtained.

Transfer Dish for Container- When used; the transfer dish for the container shall be a cylinder with a flat bottom made of glass, metal or plastic. It shall be provided with some means, which will ensure a firm bearing and prevent rocking of the container. It shall have a minimum inside diameter of 90 mm (3.5 in) and a minimum depth above the bottom bearing of 55 mm (2.17 in).

Thermometers for Water Bath- Calibrated Liquid-in-glass thermometers of suitable range with subdivisions and maximum scale error of 0.1°C (0.2°F) or any other thermometric device of equal accuracy, precision, and sensitivity shall be used.

Timing Device- For hand-operated penetrometers any convenient timing device such as an electric timer, a stopwatch, or other spring-activated device may be used provided it is graduated in 0.1 second or less and is accurate to within ± 0.1 second for a 60 second interval. An audible second counter adjusted to provide 1 beat each 0.5 second may also be used. The time for a count interval must be 5±0.1 second. Any automatic timing device attached to a penetrometer must be accurately calibrated to provide the desired test interval within ± 0.1 second.

Heater- An oven or hot plate, heated by electricity or gas, shall be provided for heating samples.

PREPARATION OF SAMPLE

Heat the sample with care to prevent local overheating until it has become fluid. Then with constant stirring, raise the temperature of the asphalt sample not more than 100°C or l80°F above its expected softening point or the tar pitch sample not more than 56°C or 100°F above its softening point determined in accordance with the Method of test for Softening Point of Bituminous Materials (Ring and Ball Method), T 53. Avoid the inclusion of air bubbles. To reach the pouring temperature, do not heat the softened sample more than 30 minutes.

Then pour it into the sample container to a depth such that, when cooled to the temperature of test the depth of the sample is at least 10 mm greater than the depth to which the needle is expected to penetrate. Pour separate samples for each variation in test conditions.

Loosely cover each container and its contents as a protection against dust and allow to cool in an atmosphere at a temperature not higher than 30°C or 86°F and not lower than 20°C or 68°F for not less than 1-1/2 hours nor more than 2 hours when the sample is in a 175 ml (6 oz) container and for not less than 1 nor more than 1-1/2 hours when the sample is in a 90 ml (3 oz) container. Then place the sample in the water bath maintained at the prescribed temperature of test, along with the transfer dish if used, and allow it to remain for not less than 1-1/2 hours nor more than 2 hours when the sample is in the 175 ml (6 oz) container, and for not less than 1 nor more than 1-1/2hours when the sample is in a 90 ml (3 oz) container.

TEST CONDITIONS

Where the conditions of test are not specifically mentioned, the temperature, load, and time are understood to be 25°C (77°F), 100 g, 5 second, respectively. Other conditions of temperature, load and time may be used for special testing, such as:

Temperature	Load, g	Time, Sec
0^0C/(32°F)	200	60
4^0C/(39.2°F)	200	60
46.1^0C/(115F)	50	5

In such cases, the specific conditions of test shall be reported.

PROCEDURE

Examine the needle holder and guide to establish the absence of water and other extraneous matter. Clean a penetration needle with toluene or other suitable solvent, dry with a clean cloth, and insert the needle in the penetrometer. Unless otherwise specified, place the 50 g weight above the needle, making the total load of 100 g ± 0.1g for the needle and attachment. If tests are made with the penetration apparatus mounted in the bath, place the sample container directly on the submerged stand of the penetration apparatus. If tests are made with the sample in the bath and the penetration apparatus outside the bath, place the containers on the shelf provided in the bath. In the above procedures the container shall be kept completely submerged during the complete test. If tests are made using the transfer dish with the penetration apparatus outside the bath, place the sample in a dish filled with water from the bath to a depth to cover completely the sample container. Then place the transfer dish containing the sample on the stand on the penetration apparatus and penetrate immediately. In each case, adjust the needle loaded with the specified weight to just making contact with the surface of the sample. Accomplish this by making contact of the actual needle point with its image reflected by the surface of the sample from a properly placed source of light (Note 2). Either note the reading of the dial or bring the pointer to zero. Then quickly release the needle for the specified period of time and adjust the instrument to measure the distance penetrated. Observe the sample container as the needle is applied, and if any movement of the container is noted, ignore the result.

NOTE 2- The positioning of the needle can be materially aided by using an illuminated methyl methacrylate rod.

Make at least three penetrations at points on the surface of the sample not less than 10 mm (3/8 in) from the side of the container and not less than 10 mm (3/8 in) apart. If the transfer dish is used, return the dish and sample to the water bath after each penetration. Before each test, clean the needle with a clean cloth moistened with toluene or other suitable solvent to remove all adhering bitumen, and then wipe with a clean dry cloth. For penetration values greater than 200, use at least three needles, leaving them in the sample until completion of the penetrations.

The needles, containers, and other conditions described in this method provide for determinations of penetrations up to 350. However, the method may be used for direct determinations up to 500 provided special containers and needles are used. The container shall be at least 60 mm in depth. The overall volume of material in the container should not exceed 125 ml to permit proper temperature adjustment of the sample.

Specially made needles for such determination shall meet all the requirements of Section

6.2 for dimensions and weight except that the minimum exposed length of the needle shall be 50 mm.

An approximation of the penetration of such high penetration materials may also be obtained by determining the penetration using the standard needle and 6 oz container but with a 50 g loading. The penetration is then calculated by multiplying the result for the 50 g load by the square root of 2. That is:

Penetration under 100g load = (Penetration under 50g load) x 1.414

The report of results obtained by this procedure shall indicate the basis of the test.

REPORT

Report to the nearest whole unit the average of at least three penetrations whose values do not differ by more than the amount shown:

Penetration	0-49	50-149	150-249	≥ 250
Maximum difference between highest and lowest determinations	2	4	6	8

If the appropriate tolerance is exceeded, ignore all results and repeat the test.

DATA SHEET

No. of Observation	Penetration	Average Penetration

DISCUSSION

Signature of the Faculty