INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

TRANSPORTATION ENGINEERING LABORATORY								
VI Semester: CE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
ACEC33	Core	L	T	P	C	CIA	SEE	Total
		0	0	3	1.5	30	70	100
Contact Classes: Nil	Total Tutorials: Nil	Total Practical Classes: 45				Total Classes: 45		
Prerequisite: Concrete Technology Laboratory								

I. COURSE OVERVIEW:
The Transportation Engineering Laboratory intends to train the students in the field of testing of aggregates to determine their physical, index and engineering properties. This course enables the students to perform the most important tests including: crushing strength, specific gravity, abrasion, and attrition test, based on ductility and penetration. Each experiment of aggregate and bituminous testing is presented with brief introduction covering the important details of the experiment. the theory and the purpose for which it is to be performed, has greater emphasis is placed on shape strength, size ductility, temperature and time and other properties. Followed by the detailed explanation of apparatus required, procedure and specimen calculations.

II. COURSE OBJECTIVES:
The students will try to learn:

I. Properties and inherent behaviour of highway material for different loading patterns
II. Testing procedures of transportation materials like aggregate, bitumen, sand etc. and check their suitability.
III. The properties of cement by conducting setting time, specific gravity, and compressive strength tests.
IV. Techniques to characterize various pavement materials through relevant tests.

III. COURSE OUTCOMES:
After successful completion of the course, students should be able to:

CO 1 Explain the basic properties of cement and aggregates for determining their suitability through various laboratory tests.
CO 2 Identify the problems associated with roads based on the properties to suggest the appropriate remedy.
CO 3 Determine mechanical properties of aggregates in laboratory for deciding its suitability in construction practice.
CO 4 Examine the physical and chemical properties of cement for producing the good quality of concrete.
CO 5 Outline the various properties of bitumen material to obtain the grade of bitumen mix.
CO 6 Make use of the concept on properties of aggregates and binding materials for design of roads.

IV. COURSE CONTENT

EXCERCISES ON TRANSPORTATION ENGINEERING LABORATORY

Note: Students are encouraged to wear shoes for laboratory practice sessions.

INTRODUCTION

This lab is mainly focuses on different material properties of cement aggregates and bituminous. The main of aim of this lab is to find the strength characteristic of pavement materials and desirable aggregates. The students will get a brief discussion on highway material properties for different projects.

1. STRENGTH CHARACTERIZATION OF AGGREGATE:

1.1 Influence of aggregate particle size on crushing strength

IS Standards: IS-2386 Part- 4 and BS: 2009

Determine the influence of aggregate particle sizes on the quality of aggregates, specifically their resistance to crushing. The Testing apparatus shown in Fig 1.

Fig:1 Aggregate Crushing test.

Try:

1. How does the crushing content of aggregates affect its strength characteristics
2. What methods are employed to determine the crushing of light weight aggregates
3. What is the specific standard size of aggregates? How the aggregate crushing value of non-standard size aggregate is evaluated?

1.2 Aggregate Crushing Value

Determine the aggregate crushing value that provides a relative measure of resistance to crushing under a gradually applied compressive load. The Testing apparatus shown in Fig 2

Try:

1. How can crushing measurements be used to assess the compaction and strength of aggregates?

2. What are the recommended maximum values of aggregate crushing value for the aggregates to be used in base and surface courses of cement concrete?
3. Aggregate crushing value of material A is 40 and that of B is 25. Which one is better and why?

2. IMPACT STRENGTH OF AGGREGATE:

2.1 Aggregate Impact Strength

IS Standards: IS: 2386(Part-4)-1963

Determine the aggregate impact strength and resistance of aggregates due to sudden impacts or shock.The Testing apparatus shown in Fig 2

Fig:2 Aggregate Impact Test

Try:

1. How does the particle size of aggregates affects its impact characteristics.
2. What mechanisms explain the relationship between wear and tear in coarse aggregates

2.2 Aggregate Impact Value

Determine the aggregate impact value relative which is a measure of the resistance of an aggregate to sudden shock or impact, which in some aggregates differs from its resistance to a slow compressive load. The Testing apparatus shown in Fig 2.

Try:

1. What factors contribute to the impact of aggregates on the behaviour of coarse aggregates?
2. Aggregate impact value material A is 20 and that of B is 45. Which one is better surface course and why?
3. Which test simulates the field conditions better, aggregate crushing value test or impact value test?

3. SPECIFIC GRAVITY AND WATER ABSORPTION TEST:

3.1 Specific Gravity of Coarse Aggregate

IS Standards: IS 2386(Part 3):1963 (Reaffirmed 2016)

Determine the Specific gravity as a measure of the density of a substance in comparison to the density of water or solids. The Testing apparatus shown in Fig 3(a) and 3(b)

Fig: 3(a) Specific garvity and water absorption test

Try:

1. What methods are used to determine the specific gravity and absorption of different grade of aggregates?
2. How does the specific gravity of aggregates influence the strength of aggregates?

3.2 Water Absorption Test of Coarse Aggregate

Determine the percentage of absorption of coarse aggregates immersed in water for a period of 24 ± 4 hours.

Fig:3(b) Aggregate sample

Try:

1. How does the water absorption of aggregates impact the workability and strength of concrete mixture
2. How does the aggregate absorb the temperature conditions of different materials.

4. ABRASION OF COARSE AGGREGATES:

4.1 Abrasion Resistance of Coarse Aggregate

IS Standards: I.S.-2386 part-IV, ASTM C131.

Determine the Los Angeles (L.A.) abrasion to indicate aggregate toughness and abrasion characteristics. The Testing apparatus shown in Fig 4.

Fig: 4 Los Angles Abrasion test.

Try:

1. How do different sample preparation techniques for the abrasion of aggregates.
2. What variations exist in wear of aggregates how does this knowledge inform geotechnical engineering and construction practices?

4.2 Abrasion Test of Coarse Aggregate

Determine the Los Angeles (L.A.) abrasion to indicate aggregate toughness and abrasion characteristics. The Testing apparatus shown in Fig 4.

Try:

1. How does aggregates properties are used for the different samples.

5. ATTRITION TEST OF COARSE AGGREGATES:

5.1 Attrition Loss of Coarse aggregate:

IS Standards: IS 2386 (Part IV):1963

Determine the Attrition of aggregates to indicate aggregate wear and tear characteristics. The Testing apparatus shown in Fig 5.


Fig: 5 Deval Attrition Test

Try:

1. What variations exist of aggregates how does this knowledge inform geotechnical engineering and construction practices?
2. How does aggregates properties are use for the different samples.

5.2 Grading of Aggregates before and after test:

Determine the gradation of aggregates by sieve analysis before and after Attrition test of aggregates to indicate aggregate wear and tear characteristics. The Testing apparatus shown in Fig 4.2.

Try:

1. How do different sample preparation techniques for the attrition of aggregates.
2. What variations exist of aggregates how does this knowledge inform geotechnical engineering and construction practices?
3. How does aggregates properties are used for the different samples.

6. SHAPE TEST OF COARSE AGGREGATES:

6.1 Flakiness Index of Coarse aggregate:

IS Standards: IS 2386(Part-I)-1963 (Reaffirmed 2007)

Determined the particle shape of aggregates by the percentages of flaky and elongated particles contained. The Testing apparatus shown in Fig 6(a) and 6(b)

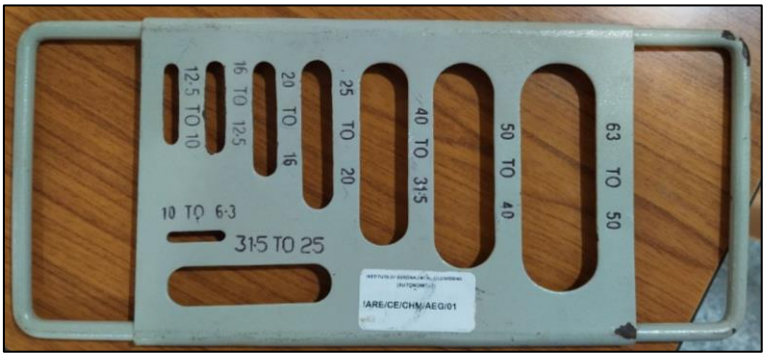

Fig:6(a) Thickness Gauge for Flakiness Index.

Try:

1. How does the shape of aggregates are used for the different grades
2. Compare of flakiness and elongation index for different materials.

6.2 Elongation Index of Coarse aggregate:

Determine the elongation index of an aggregate sample by sieving the sample of aggregates through specified sieves to separate the aggregates into fractions of different sizes.

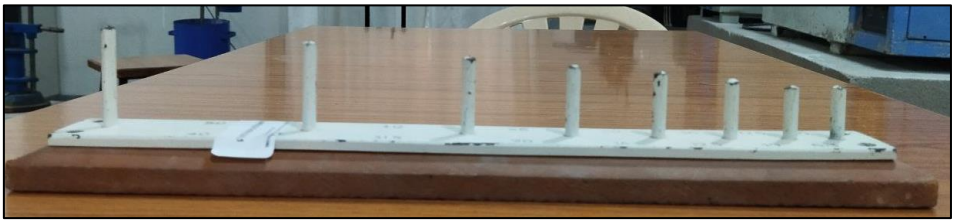

Fig:6(b) Length Gauge for Elongation Index

Try:

1. Discuss the specific dimensions and criteria for identifying flaky particles in aggregates.
2. What the elongation index limit for pavement construction and flakiness index limit suitable for road construction?

7. PENETRATION AND DUCTILITY TEST OF BITUMINOUS MATERIALS

7.1 Penetration of bituminous material

IS Standards: IS 1203 – 1978

Determined the penetration of bituminous materials to specify the appropriate grade of bitumen for different climatic and traffic conditions. The Testing apparatus shown in Fig 7(a).

Fig:7(a) Standard Penetrometer.

Try:

1. How does bitumen type after penetrating characteristics including compaction factor.
2. How is the penetration value calculated, and what does it indicate about the bitumen's consistency.
3. What are the key differences in penetration test procedures, how do they affect results on using different samples.

7.2 Ductility Test of bituminous material

Determined the ductility of bitumen to evaluate the flexibility and deformation resistance, particularly under varying temperature conditions. The Testing apparatus shown in Fig 7.2.

Fig:7(b) Ductility of Bitumen

Try:

1. Compare bitumen of ductility and penetration for different sample mixing.
2. How is the ductility value calculated, and what does it indicate about the bitumen's consistency.
3. What are the key differences in ductility test procedures, how do they affect results on using different samples.

8. SOFTENING POINT AND VISCOSITY OF BITUMEN

8.1 Softening Point of Bitumen

IS Standards: IS 1203 – 1978

Determine the softening point of bitumen that helps to know the temperature up to which a bituminous binder should be heated for various road use applications. The Testing apparatus shown in Fig8.

Fig:8 Ring Ball Apparatus

Try:

1. How does bitumen type affect temperature characteristics for the different points of grades?
2. How does Ring Ball apparatus is used for the softening point at what degree of softening will be occur?

8.2 Viscosity of Bitumen

Determine the viscosity of bitumen at various temperatures to measure the degree of fluidity at the application temperature or ability of bituminous material to spread, penetrate into the voids. The Testing apparatus shown in Fig 8.

Try:

1. How does bitumen type affect temperature characteristics for the different points of grades?
2. How is strength of bituminous road affected by the viscosity of binder?

9. FLASH AND FIRE POINT OF BITUMEN MATERIAL:

9.1 Flash Point

IS Standards: IS: 1209-1978

Determine the flash point of a material which is the lowest temperature at which the vapour of the substance momentarily takes fire in flashes. The Testing apparatus shown in Fig 8.

Fig: 9 Flash and Fire Point, IS Standards used: IS: 1209-1978.

Try:

1. What is the utility of determination of flash point and should a good binder possess higher flash point?
2. What is the impact of flashing on form of bitumen temperatures?

9.2 Fire Point

Determine fire point which is the lowest temperature at which the material gets ignited and burns under specified condition of test. The Testing apparatus shown in Fig 8.

Try:

1. What are the main advantages on using bitumen for flash and fire point test?
2. What is the softening point and fire point of bitumen?

10. NORMAL CONSISTENCY OF CEMENT

10.1 Normal Consistency of Ordinary Portland Cement (OPC)

IS Standards: IS 4031 (Part 4) 1988

Determine the consistency of Ordinary Portland Cement (OPC) using the Vicat test apparatus and measure normal consistency of cement paste. The Testing apparatus shown in Fig 10.

Try:

1. What is the significance of establishing the normal consistency, and how is it related to the workability and setting properties of cement paste.

2. What is the impact of consistency factor in various grade of cement types?

Fig:10 Vicat apparatus for Normal Consistency of cement.

10.2 Normal Consistency of Portland Pozzolana Cement (PPC)

Determine the consistency of Portland Pozzolana Cement (PPC) using the Vicat test apparatus and measure normal consistency of cement paste. The Testing apparatus shown in Fig 10.

Try:

1. How does the apparatus and equipment used to determine the normal consistency of cement.
2. What is the significance of establishing the normal consistency, and how is it related to the workability and setting properties of cement paste.

11: INITIAL AND FINAL SETTING TIME OF CEMENT

11.1 Initial Setting Time of Cement

IS Standards: IS 4031-Part 5-1988, IS 269-1975

Determine the Initial setting time of cement measured by the time elapsed between the moments that the water is added to the cement, to the time that the paste starts losing its plasticity. The Testing apparatus shown in Fig 11.

Fig:11 Vicat Apparatus for setting time of cement.

Try:

1. What are the key methods used for setting time of cement for different grades of cement
2. How does the temperature, water-cement ratio, and cement type influence the initial setting time of cement.

11.2 Final Setting Time of Cement

Determine the final setting time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity.

Try:

1. How does the final setting time affect the strength development and durability of concrete structures.
2. What size needle is used for initial and final setting time of cement?

12: SPECIFIC GRAVITY AND SOUNDNESS OF CEMENT

12.1 Specific Gravity of Cement

IS Standards: IS 4031 Part-11 (1988)

Determine the specific gravity of mass of cement of a specified volume to the mass of kerosene of the same volume of cement. As kerosene does not react with cement. The Testing apparatus shown in Fig 12(a).

Fig:12(a) Specific gravity of cement

Try:

1. How is the specific gravity of cement calculated, and what does it indicate about the density of cement particles.
2. How does the influence of specific gravity on the workability and strength of concrete mixtures.

12.2 Soundness of Cement

Determine the soundness of cement which indicates the stability of any cement during the volume change in the process of setting and hardening. The Testing apparatus shown in Fig The Testing apparatus shown in Fig 12(b).

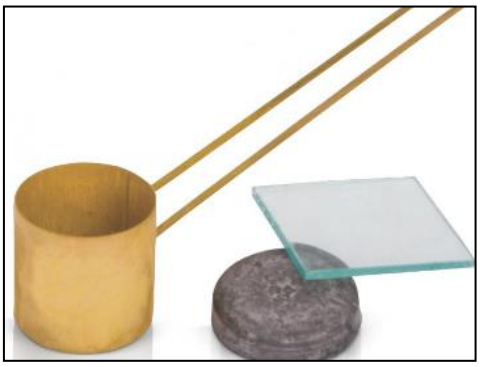

Fig:12(b) Soundness of cement

Try:

1. How is the soundness test used to evaluate the resistance of cement to expansion and cracking during the setting and hardening process
2. If L1=Measurement taken after 24 hours of immersion in water at a temp. of 27 ± 20oC and L2=Measurement taken after 3 hours of immersion in water at boiling temperature. Then what is soundness of cement?

13. COMPRESSIVE STRENGTH OF CEMENT

13.1 Compressive Strength of Cement

IS Standards: IS 5513 (1996)

Determine the Compressive strength of concrete is by the ability of the material to resist failure in the form of cracks and fissure. The Testing apparatus shown in Fig 13

Fig:13. Compressive strength of cement

Try:

1. How does the cement types affect strength characteristics including compaction loading?
2. What are the key practical implications of compressive strength of cement in construction projects, particularly in concrete mix design.

13.2 Compressive Strength of Flyash Blended Cement

Determine the Compressive strength of Flyash Blended Cement is by the ability of the material to resist failure in the form of cracks and fissure. The Testing apparatus shown in Fig 13.

Try:

1. How does the flyash cement affect strength characteristics including compaction loading?
2. How does the compressive strength of flyash based cement effected?

14. Bulking of Fine aggregates

14.1 Bulking Test

IS Standards: IS 2386 (Part III)-1963 (Reaffirmed 2002)

Determine the Bulking of Fine aggregates by the increase in volume of sand due to presence of moisture. The Testing apparatus shown in Fig 14.

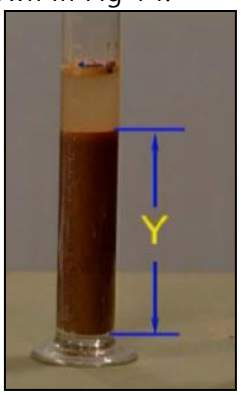

Fig:14.Bulking of sand

Try:

1. How does the soil moisture content affect bulking nature. What is the maximum limit of bulking of sand?
2. Compare fineness of moisture content of soil with different admixtures?

14.2 Moisture Absorbed by Fine aggregates

Determine the moisture content absorbed by aggregates due to increase in volume of sand. The Testing apparatus shown in Fig 14.

Try:

1. What are the differences in bulking factor results when applied to cohesive and non-cohesive soils?
2. How is bulking related to moisture content? What happens if bulking is not accounted for while preparing concrete?

V. TEXT BOOKS

1. Khanna, S.K., and Justo, C.E.G, "Highway Engineering", Nem Chand & Bros, Revised 10th edition, 2017.
2. Shetty, M.S., "Concrete Technology, Theory & Practice", S. Chand and Co, 8th edition, 2018.
3. Gambhir, M.L., "Concrete Technology", Tata McGraw Hill, 5th edition 2013.

VI. REFERENCE BOOKS:

1. Hemanth Sood and LN Mittal, "Laboratory Manual on Concrete Technology", CBS Publishers Pvt. Ltd., New Delhi, 2016.
2. Khanna S.K & Justo C.E.G. "Pavement Materials and Testing", Tata McGraw Hill Education10th Edition, 2018.

VII. WEB REFERENCE BOOKS

1. https://www.iare.ac.in/sites/default/files/lab1/IARE Transportation Engineering laboratory.pdf
2. https://www.nitw.ac.in/ce/syllabus/material testing-lab.pdf
3. https:/www.studocu.com/in/course/indian-institute-of-technology-kharagpur/transportation-engineering-lab-i/5026141

VIII. MATERIAL ONLINE

1. Course description
2. Lab Manual