USN | | | | | | | | | | |

Internal Assessment Test 3 –January 2023

Sub:	HIGHWAY ENGINEERING					Sub Code:	18CV56	Branch:	CIVIL
Date:	23.01.2023	Duration:	90 min's	Max marks:	50	Sem / sec:	5/A	OBE	

Answer all questions. Assume any missing data suitably.

	MARKS	CO	RBT
1. With a neat sketch, explain how the CBR test is conducted in the laboratory?	[10]	CO3	L2
2. Explain Rothfuch's Method of proportioning? Write briefly about Construction of Joints in CC Pavements.	[10]	CO4	L2
3. The properties of subgrade soil are given below. Passing 75 micron IS sieve =80%, Liquid limit :58%, Plasticity index :25% .Classify the soil by HRB system with group index value?	[10]	CO4	L3
4. Explain significance of Highway Drainage? What are the requirements of highway drainage?	[10]	CO5	L2
5. Compare the annual costs of two types of pavement structures (i) WBM with thin bituminous surface at a total cost of Rs. 2.2 lakhs per km, life of 5 years, interest at 10%, salvage value of Rs. 0.9 lakhs after 5 years; annual average maintenance cost of Rs.0.35 lakhs per km and (ii) Bituminous Macadam base and Bituminous concrete surface, total cost of Rs. 4.2 lakhs, life of 15 years interest at 8%, salvage value of 2.0 lakhs at the end of 15 years; annual average maintenance cost of Rs. 0.25 lakhs per km.	[10]	CO5	L3

Signature of CI Signature of CCI Signature of HoD

1. **With a neat sketch, explain how the CBR test is conducted in the laboratory?**

Ans:

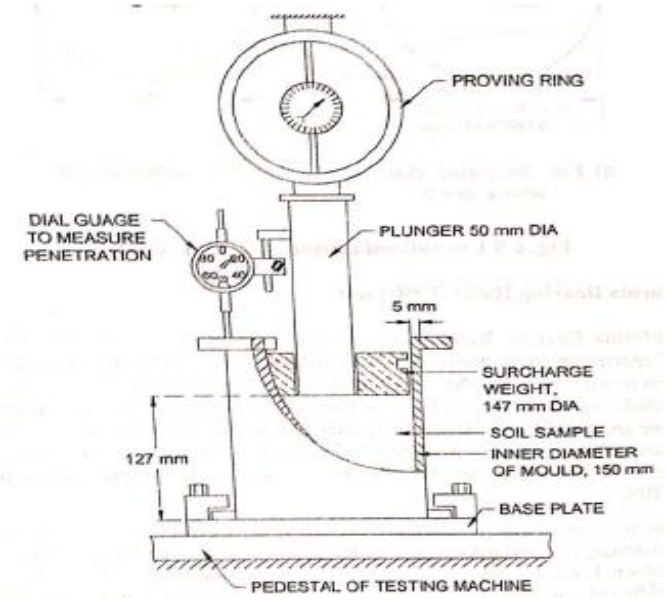
California Bearing Ratio (CBR) Test

Objective: CBR is the ratio expressed in percentage of force per unit area required to penetrate a soil mass with a standard circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material. The ratio is usually determined for penetration of 2.5 and 5 mm . When the ratio at 5 mm is consistently higher than that at 2.5 mm, the ratio at 5 mm is used. The following table gives the standard loads adopted for different penetrations for the standard material with a C.B.R. value of 100%.

Penetration of Plunger (mm)	Standard Load (kg)
2.5	1370
5	2055

Definition:

It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material.



$$CBR\ \% = \frac{\text{load carried by specimen at standard penetration}}{\text{load carried by standard crushed stone at standard penetration}} x$$

CBR value determined for 2.5 mm or 5mm penetration.

Apparatus **(As per IS:2720 (part 16))**

1. CBR mould – 150 mm diameter with base plate and collar
2. Loading frame – cylindrical plunger of 50 mm diameter (loading rate – 1.25 mm/min)
2. Dial gauge – for measurement of penetration value

Procedure –

1. Preparation of specimen and mould for the test
2. Surcharge weight of 2.5kg or 5 kg is placed on the specimen in the mould
3. The specimen is soaked for 4 days before testing.
4. Place this assembly in the loading frame such that the plunger is in contact with specimen. (seating load – 4 kg)
5. Cylindrical plunger of 50mm is allowed to penetrate into the specimen
6. Record the load values corresponding to the penetration of 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 7.5, 10, 12.5 mm.
7. Draw a graph for penetration in mm (X) vs load value in kg (Y)
8. Then the load values for 2.5mm and 5mm penetration are recorded from the graph and expressed in percentages of standard value to obtain CBR value.
9. The load values on standard crushed stones are 1370 kg and 2055 kg at 2.5 mm and 5.0 mm penetrations respectively.

Note :-

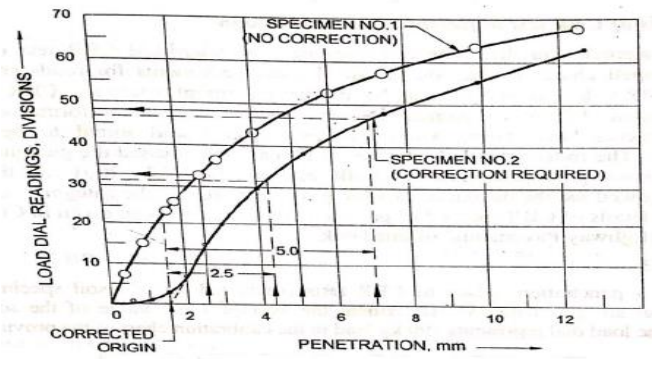
Value for 2.5 mm > for 5.0 mm penetration - the former is adopted.

Value for 5.0 mm penetration > for 2.5 mm - then the test is to be repeated for checking.

similar results after retest - 5.0 mm penetration is reported as the CBR value.

The average CBR value of three test specimens is reported as the CBR value of the sample.

IS : 2720 (Part 16) - 1987



2. **Explain Rothfuch's Method of proportioning? Write briefly about Construction of Joints in CC Pavements.**

Ans:

Rothfutch's method of proportioning

This method is used when a number of materials have to be mixed together for obtaining appropriate gradation. The gradation may be decided either based upon recommended grain size distribution charts or by any equation like Fuller's gradation. It is done to proportionate materials for Marshall Mix design. I S sieves of sizes 63, 50, 40, 31.5, 25, 20, 16, 12.5, 10, and 6.3mm are required.

Procedure:

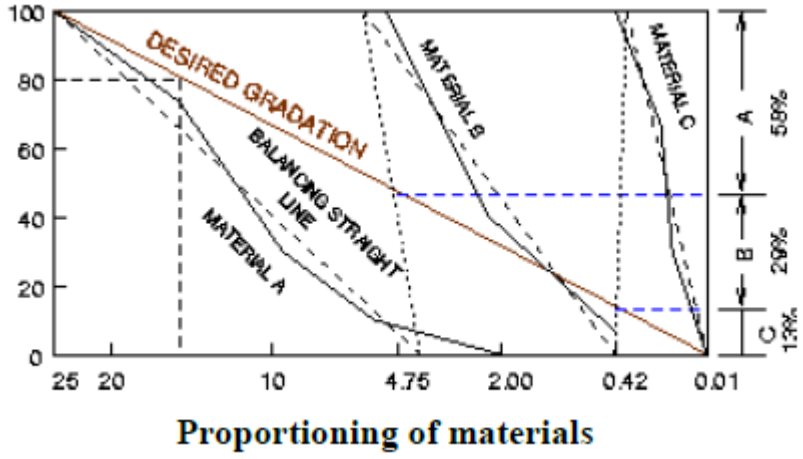
1. On a graph paper when Y-axis represents percent passing and X-axis representing particle size a diagonal line is drawn from point corresponding to 100 percent particles passing i.e maximum particle size passing to a point corresponding to zero percentage passing i.e smallest particle size.

2. For different material say A, B and C sieve analysis has to be done and percentage finer has to be calculated at each range of particle size for all the materials.

3. The balancing straight lines of A, B and C are obtained by allowing only minimum of the areas on the center sides of the balancing lines.

4. The opposite ends of the balancing line of A and B are joined (i.e zero point passing of material A is pointed with 100 percent passing B). Similarly the opposite ends of the balancing lines of B and C are joined.

5. The points where these lines meet the desired gradation line represent the proportions in which type materials A, B and C are to be mixed. These values may be read from the Y axis by projecting the Points of intersection, as shown in the figure below.



Proportioning of materials

Thus Proportion of materials A, B and C to be mixed for preparing Marshall mix design test specimen are obtained.

Construction of Joints in CC Pavements.

Provisions of joints are necessitated due to:

- Expansion, contraction and warping of concrete slabs resulting from temperature and moisture changes;
- Facilitate a break in the construction at the end of day's work or for any unexpected interruption to work progress; and
- Construction of pavements in lanes of convenient width.

Joints are the discontinuities in the concrete pavement slab, and help to release stresses due to temperature variation, subgrade moisture variation, shrinkage of concrete etc.
There are various types of joints in concrete pavement, e.g. contraction joint, **construction joint, expansion joint and warping joint**

▶ The functions of these joints are as follows:

Contraction joint: Contraction joints are provided along the transverse direction to take care of the contraction of concrete slab due to its natural shrinkage

Construction joint: Construction joints are provided whenever the construction work stops temporarily. The joint direction could be either along the transverse or longitudinal direction.

Expansion joint: Expansion joints are provided along the transverse direction to allow movement (expansion/ contraction) of the concrete slab due to temperature and subgrade moisture variation.

Warping joint: Warping joints are provided along the longitudinal direction to prevent warping of the concrete slab due to temperature and subgrade moisture variation.

3. The properties of subgrade soil are given below. Passing 75 micron IS sieve =80%, Liquid limit :58%, Plasticity index :25% .Classify the soil by HRB system with group index value?

Ans:

Given data
Passing 75micron IS sieve=80%
Liquid limit= 58%
Plasticity index=25%
To classify it by HRB system

Soln: we know that
GI(Group Index)= 0.2a+0.005ac+0.01bd……..(1)
To determine the constants
a= P-35%> 40%
a= 80%-35%
=45%> 40%
b= P-15% > 40%
=80%-15%
= 65% >40%
C= L.L-40%> 20%
= 80%-40%
= 18% < 20%
d= P.L-10% > 20%
= 25%-10%
=15% > 20%
Now put the constants value in eqn(1)
G.I = (0.2*45)+(0.005(45*18))+(0.01(65*15))
G.I = 22.8%

4. Explain significance of Highway Drainage? What are the requirements of highway drainage?

Ans:

Significance of Drainage

An increase in moisture content causes decrease in strength or stability of a soil mass the variation in soil strength with moisture content also depends on the soil type and the mode of stress application.

Highway drainage is important because of the following reasons: -

- Excess moisture in soil subgrade causes considerable lowering of its stability the pavement is likely to fail due to subgrade failure.
- Increase in moisture cause reduction in strength of many pavement materials like stabilized soil and water bound macadam.
- In some clayey soils variation in moisture content causes considerable variation in flume of subgrade. This sometimes contributes to pavement failure.
- One of the most important causes of pavement failure by the formation of waves and corrugations in flexible pavements is due to poor drainage.
- Sustained contact of water with bituminous pavements causes failures due to stripping of bitumen from aggregates like loosening or detachment of some of the bituminous pavement layers and formation of pot holes.
- TIE- prime cause of failures in rigid pavements by mud pumping is due to the presence of water in fine subgrade soil.
- Excess water on shoulders and pavement edge causes considerable damage.
- Excess moisture causes increase in weight and thus increase in stress and simultaneous reduction in strength of the soil mass. This is one of the main reasons of failure of earth slopes and embankment foundations.
- In places where freezing temperatures are prevalent in winter, the presence of water in the subgrade and a continuous supply of water from the ground water can cause considerable damage to the pavement due in frost action.

Requirements of Highway Drainage System

- The surface water from the carriageway and shoulder should effectively be drained off without allowing it to percolate to subgrade.
- The surface water from the adjoining land should be prevented from entering the roadway.
- The side drain should have sufficient capacity and longitudinal slope to carry away all the surface water collected.
- Flow of surface water across the road and shoulders and along slopes should not cause formation of cress ruts or erosion.
- Seepage and other sources of underground water should be drained off by the subsurface drainage system.
- Highest level of ground water table should be kept well below the level of subgrade, preferably by at least 1.2 m.

- In waterlogged areas special precautions should be taken, especially if detrimental salts are present or if flooding is likely to occur.

5. Compare the annual costs of two types of pavement structures

(i) WBM with thin bituminous surface at a total cost of Rs. 2.2 lakhs per km, life of 5 years, interest at 10%, salvage value of Rs. 0.9 lakhs after 5 years; annual average maintenance cost of Rs.0.35 lakhs per km and

(ii) Bituminous Macadam base and Bituminous concrete surface, total cost of Rs. 4.2 lakhs, life of 15 years interest at 8%, salvage value of 2.0 lakhs at the end of 15 years; annual average maintenance cost of Rs. 0.25 lakhs per km.

Ans:

5)	WBM	Bitumen
1. Total cost [lakhs/km]	2.2	4.2
2. Design life (n)	5	15
3. Annual rate of interest (%)	10%	8%
4. Salvage value after design life (years)	0.9	2
5. Avg maintenance cost (lakhs/km)	0.35	0.25

Soln:

$$C_R = \frac{Pi(1+i)^n}{(1+i)^n - 1} + (i \times P) + \text{maintenance} = P(CRF)$$

P = total cost/km − Salvage value

WBM $\Rightarrow$ P = 2.2 − 0.9 = 1.3 lakh/km

$$C_R = \frac{1.3 \times 0.1 (1+0.1)^5}{(1+0.1)^5 - 1} + (0.1 \times 1.3) + 0.35$$

$$= 0.823 \text{ lakh/km}$$

Bitumen

P = 4.2 − 2 = 2.2 lakh/km

$$C_R = \frac{2.2 \times 0.08 (1+0.08)^{15}}{(1+0.08)^{15} - 1} + (0.08 \times 2.2) + 0.25$$

$$= 0.68 \text{ lakh/km}$$

Bitumen is lower than WBM Hence Bitumen is adopted.