# Highway Materials

Highway materials are the materials used for the construction of roads and bridges. Different highway materials, like aggregate, bitumen, concrete, steel, etc., can be used to construct various highways. These materials have different properties based on their constituents. These are used for the construction of highways based on the nature of highways and their strength characteristics.

For the construction of rigid pavements, reinforced concrete material is based on its strength characteristics, and water-bound macadam materials, bitumen mix macadam, etc., are used for the construction of flexible pavements. Before selecting any highway materials for construction, different tests on these materials are required to ensure the Geometric design of highways and the design strength of the pavements.

## Properties of Highway Materials

The properties of highway materials are to be known before their use for the construction of roads. These properties can be determined with the help of different tests on these materials. Different properties of the highway materials are listed in the GATE CE syllabus, which includes Strength, Hardness, soundness, Group index value, Specific gravity, etc.

**Group Index of Soils (G.I)**

To classify the fine-grained soils within one group and to judge their suitability as subgrade material, an indexing system has been introduced in HRB classification, termed a group index. Soils are thus assigned arbitrary numerical numbers known as group index (GI). The group index is a percentage function given by the equation G.I = 0.2a + 0.005ac + 0.01bd.

Where

$$a = (P - 35) < 40$$

$$b = (P - 15) < 40$$

$$c = (W_L - 40) < 20$$

$$d = (I_P - 10) < 20$$

Where

- $W_L$ = Liquid limit,
- $I_P$ = Plasticity Index.
- P = Percentage fines passing from 0.074 mm sieve.

# Tests on Highway Materials

Tests on highway materials are required to know the different characteristics of the materials. Tests on highway materials are required before the construction of the roads. These tests depend on the type of materials also. For example viscosity test is required to know the strength of bitumen, etc. These tests are important for the GATE exam. Here a few types of tests on highway materials are described below.

**Plate Bearing Test**

(i) $k = P/0.125\ kg/cm^3$

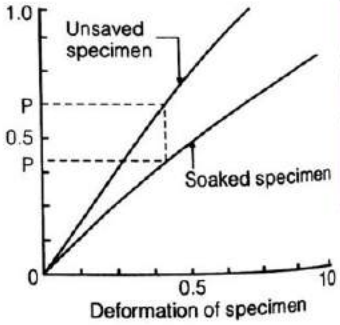
Here,

- k = Modulus of subgrade reaction
- P = Pressure Corresponding to a settlement of 0.125 cm.

(ii) $k_s = k.(P_s/P)$

Where,

- $k_s$ = Modulus of subgrade reaction for soaked condition.
- $P_s$ = Pressure required in the soaked condition to produce the same deformation as deformation Produced by pressure 'P' in consolidated condition.
- k = Modulus of subgrade reaction for the consolidated stage.




$\Delta = 1.18\ Pa/E$

$\Delta$ = Deformation in 'cm'.

a = Radius of the rigid plate in 'cm'.

$k = P/\Delta = E/1.18a$

E = Modulus of elasticity of soil subgrade in $kg/cm^2$.

k.a = constant

$a_1$ = Radius of the smaller plate (another plate)

$k = k_1.(a_1/a)$

$k_1$ = Modulus of subgrade reaction of another plate of radius '$a_1$' cm.

**California Bearing Ratio (CBR) Test**

CBR (%) = [ Load or pressure sustained by the specimen at 2.5 or 5.0 mm penetration ] × 100 / [ Load or pressure sustained by standard aggregates at the corresponding penetration level ]

**Test for Road Aggregate**

| | Machine | Base Course | Surface Course |
|---|---|---|---|
| (i) Aggregate Abrasion value | Los Angeles | $\not>$ 50% | $\not>$ 30% |
| (ii) Aggregate crushing value | UTH | $\not>$ 45% | $\not>$ 30% |
| (iii) Aggregate Impact value | Impact Testing Machine | $\not>$ 40% (for Bitcemine machine)<br>$\not>$ 35% (for WBM) | $\not>$ 30% |

| Indicator | Respective Test Result |
|---|---|
| 1. Flakiness Index | $\not>$ 15% |
| 2. Elongation | $\not>$ 15% |
| 3. Angularity | 0-11 |
| 4. Soundness index | $\not>$ 18% ($MgSO_4$),<br>$\not>$ 12% ($Na_2SO_4$) |
| 5. Water absorption value | $\not>$ 0.6% |
| 6. Stipping value | $\not>$ 25% |

(i) Aggregate crushing test

Aggregate crushing value = 100 $w_2/w_1$ %

Where

- $w_1$ = Weight of the test sample in 'gm'
- $w_2$ = weight of the crushed material in 'gm' passed through a 2.36 mm sieve.

(ii) Shape Tests

Angularity number = 67 - ($100w/CG_a$)

Where

- $G_a$ = specific gravity of aggregate
- W = mass of mould containing aggregate
- C = mass of mould containing water

(iii) Abrasion Test

(a) Los Angeles Abrasion Test

Coefficient of hardness = 20 - [ Loss in weight in 'gm' /3 ]

# Bitumen as a Highway Material

Bitumen is one of the highway materials used in construction as a binding material. It is mixed with aggregate and other ingredients for the construction of flexible pavements. Bitumen properties and different types of bitumen mix are explained below.

1. Product of fractional distillation of Petroleum: Gasoline, Naptha, Kerosene, Lubricating oil and Residue – Petroleum Bitumen.
2. Cutback Bitumen: Reduced Viscosity Bitumen

| | Types | Volatile Diluent Used |
|---|---|---|
| 1 | RC-N | Gasoline / Naptha |
| 2 | MC-N | Kerosene |
| 3 | SC-N | High boiling point gas |

N – Numeral [0, 1, 2, 3, 4, 5]

Show progressive thickening from 0 to 5

3. Specific Gravity:

Bituminous → 0.97 – 1.02

Tar → 1.1 – 1.5

**Bituminous Mixes**

(i) **Determination of Specific Gravity**

$G_a = 100/[(w_1/G_1)+(w_2/G_2)+(w_3/G_3)+(w_4/G_4)]$

Where $G_a$ = Average specific gravity of blended aggregate mix.

$w_1$, $w_2$, $w_3$, $w_4$ are % by weight of aggregate 1, 2, 3 & 4 respectively. $G_1$, $G_2$, $G_3$ & $G_4$ are specific gravities of the aggregate 1, 2, 3 & 4, respectively.

(ii) **Specific Gravity of Compacted Specimen**

(a) $G_t = 100/[(100-w_b/G_a)+(w_b/G_b)]$

Where

- $G_t$ = Theoretical maximum specific gravity of the mix.
- $W_b$ = % by weight of bitumen.
- $G_b$ = Specific gravity of bitumen.
- $G_a$ = Average specific gravity of aggregates.

(b) Theoretical density $\gamma_t$, per-cent solids by volume

$\gamma_t = 100\ G / G_t$

Where

- G = Actual specific gravity of test specimen
- $G_t$ = Theoretical maximum specific gravity.

$VMA - (V_v + V_b) = 100 -(G/W_a)$

(c) Voids in the Mineral Aggregate (VMA)

Where,

- $V_b$ = % of bitumen
- $W_a$ = Aggregate content per cent by weight
- $V_v$ = % air voids in the specimen.

$Vv = 100 - \gamma_t = 100(G_t - G)/G_t$

(d) % Voids Filled with Bitumen (VFB)

$VFB = 100V_b/VMA$