IAT-3-SOLUTIONS

HIGHWAY ENGINEERING (17CV63)

1.

Preparation of Foundation for Receiving the WBM course:- The foundation for receiving the new layer of WBM may be either the sub grade or sub-base or base course. This foundation layer is prepared to the required grade and camber and the dust and either loose materials are cleaned. On existing road surface, the depressions and pot-holes are filled and the corrugations are removed by scarifying and reshaping the surface to the required grade and camber as necessary.
Provision of Lateral confinement:-Lateral confinement is to be provided before starting WBM construction. This may be done by constructing the shoulders to advance, to a thickness equal to that of the compacted WBM layer and by trimming the inner sides vertically
Spreading of Coarse Aggregates:- The coarse aggregates are spread uniformly to proper profile to even thickness upon the prepared foundation and checked by templates. The WBM course is normally constructed to compacted thickness of 7.5 cm except in the case of WBM sub-base course using coarse aggregate grading no.1 which is of 10.0 cm compacted thickness.

Rolling:-After spreading the coarse aggregates properly, compaction is done by a three wheeled power roller of capacity 6 to 10 tons or alternatively by an equivalent vibratoryroI1q the weight of the roller depends on the type of coarse aggregates.
Application of Screenings:- After the coarse aggregates are rolled adequately, the dry screenings are gradually over the surface to fill the interstices in three or more applications. Dry rolling is continued as the screenings are being spread and brooming carried out.
Sprinkling and Grouting:- After the application of screenings, the surface is sprinkled with water, swept rolled. Wet screenings are swept into the voids using hand brooms. Ad• screenings are applied and rolled till the coarse aggregates are well bonded and firmly set.
Application of Binding Material:- After the application of screening and rolling, binding material is applied at a uniform and slow rate at two or more successive thin layers. After each application of binding material, the surface is copiously sprinkled with water and wet slurry swept with brooms to fill the voids.
Setting and Drying:- After final compaction, the WBM course is allowed to set over-night. On the next day the ‘hungry’ spots are located and are filled with screenings or binding material, lightly sprinkled with water if necessary and rolled. No traffic is allowed till the WBM layer sets and dries out.

2.b.

Quality Control Tests

A) Quality control tests for materials used –

1	Cement	Physical & Chemical Tests	One for each source of supply and occasionally
2	Coarse aggregates & fine aggregates	(i) Gradation (ii) Deleterious constituents	One test for every day work of each fraction of coarse aggregate and fine aggregate.

B) Quality control tests for levels, alignment and texture -

1	Level Tolerance	+5mm
2	Width of pavement & position of paving edges	-6mm +-10mm
3	Alignment of joints, widths, depths of dowel	To be checked @ one joint per 400m
	groves	length
4	Surface regularity both transversely	Once a day or one day's work
5	Alignment of dowel bars and tie bars	To be checked in trail length.

3.a.

Given: Q= 0.9 m^3/s, B = 1 m, V = 1.2 m/s, n = 0.02

Design of cross section

$$Q = AV \cdots\cdots\cdots 1$$

A= Q/V = 0.9/ 1.2 = 0.75 m^2

Area of trapezium = 0.5 *d * (B + 1.5 d+ B+1.5 d)

= 0.5 * d* (2B+ 3d)

Given B = 1

Area of trapezium =$d + 1.5d^2 \cdots\cdots\cdots 2$

Equating 1 & 2 and solving for d,

$$1.5d^2 + d - 0.75 = 0$$

Solving this quadratic equation for d, we get

$$d = \frac{-1 \pm \sqrt{1^2 - 4 \times 1.5 \times (-.75)}}{2 \times 1.5} = 0.45\ m$$

Assume a free board of 0.15 m.
Hence depth of side drain = 0.45 + 0.15 = 0.60 m

Design of Longitudinal slope

(ii) Slope

The longitudinal slope may be found using Manning's formula

$$V = \frac{1}{n} . R^{2/3} . S^{1/2}$$

$$Hydraulic\ radius, R = \frac{area}{wetted\ perimeter}$$

Wetted perimeter $= B + 2d\sqrt{(1+n^2)}$

Wetted perimeter $= 1 + 2 \times 0.45\sqrt{(1+1.5^2)} = 2.62\ m$

$$Hydraulic\ radius, R = \frac{0.75}{2.62} = 0.286\ m$$

$$S^{1/2} = \frac{Vn}{R^{2/3}}$$

$$S^{1/2} = \frac{1.2 \times 0.02}{0.286^{2/3}} = 0.0553$$

Slope S = 0.0031 OR 1 in 322.5

Hence provide a longitudinal slope of 1 in 320.

3.b.

(a) The surface water from the carriageway and shoulder should effectively be drained off without allowing it to percolate to subgrade and weaken the soil

(b) The surface water from the adjoining land should be prevented from entering the roadway

(c) The side drain should have sufficient capacity and longitudinal slope to carry away all the surface water collected from the roadway

(d) Flow of surface water across the road and shoulders and along slopes should not cause erosion or form cross ruts

(e) Seepage and other sources of under-ground water should be effectively intercepted and drained off by the suitable subsurface drainage system.

(f) Highest level of ground water-table should be kept well below the level of subgrade, preferably by at least 1.2 m. If the highest level of ground water level is closer than 1.2 m, it is desirable to lower the same with a well planned and laid subsurface drainage system.

(g) In water-logged areas special precautions should be taken, especially if detrimental salts are present or if flooding is likely to occur.

4.

(i) Annual cost of land $= 35 \times \dfrac{0.06(1+0.06)^{100}}{(1+0.06)^{100}-1}$

$= 35 \times CRF_{(i=6\% \text{ or } 0.06,\, n=100)} = 35 \times 0.06018$

$=$ Rs. 2.1063 lakhs

(ii) Annual cost of earthwork $= 40 \times CRF_{(i=0.08,\, n=40)} = 40 \times 0.08386$

$=$ Rs. 3.3544 lakhs

(iii) Annual cost of bridges $= 50 \times CRF_{(i=0.08,\, n=60)} = 50 \times 0.08080$

$=$ Rs. 4.04 lakhs

(iv) Annual cost of pavement $= 100 \times CRF_{(i=0.1,\, n=15)} = 100 \times 0.13147$

$=$ Rs. 13.147 lakhs

(iv) Annual cost of Traffic Signs $= 15 \times CRF_{(i=0.1,\, n=5)} = 15 \times 0.26380$

$=$ Rs. 3.9570 lakhs

(v) Average annual maintenance cost $=$ Rs. 1.5 lakhs

(vi) Total annual highway cost $= 2.1063 + 3.3544 + 4.0399 + 13.1474 + 3.9570 + 1.50 =$ Rs. 26.6049 lakhs

5.a

Net Present Value Method: This method is based on the discounted cash flow technique (DCF). In this method, the stream of costs and benefits associated with the project over its time horizon is calculated and is discounted at a selected discount rate to give the present value. Benefits are treated as positive and costs are treated as negative. Any project with a positive NPV is treated as acceptable. In comparing more than one project, a project with the highest NPV is selected.

$$NPV_0 = (B_0-C_0) + B_1-C_1/(1+i) + B_2-C_2/(1+i)^2 + \ldots + B_n-C_n/(1+i)^n$$

Where NPV_0 = Net present value in the year 0

B_t = Value of benefits which occur in

the year t C_t = Value of costs that occur

in the year T

i = discount rate per annum

n = no: of years considered for the analysis.

Benefit Cost Ratio Method:-The principle of this method is to assess the merit of a particular scheme by comparing the annual benefits with the increase in annual cost.

Benefit cost ratio = Annual benefits from improvement / Annual cost of the improvement

= (R-R1)/total annual cost of the

project Where, R = Total annual road user cost for

existing highway

R1 = Total annual road user cost for proposed highway improvement

The benefit-cost ratios are determined between alternate proposals and those plans which are not attractive are discarded. Then the benefit cost ratios for various increments of added investment are computed to arrive at the best proposal. In order to justify the investment, the ratio should be greater than 1.0.

5.b.

Annual cost of pavement type B:-

$$Cr = (6.2 - 3.0)*[(0.09*(1+0.09)^{12})/(1+0.09)^{12} - 1)] + (0.09 * 3) + 0.2$$

= Rs. 0.916 lakhs.

Pavement type B with the lowest annual cost is more economical when compared with the other.