SOLUTION- IMPROVEMENT TEST

HIGHWAY ENGINEERING (15CV63)

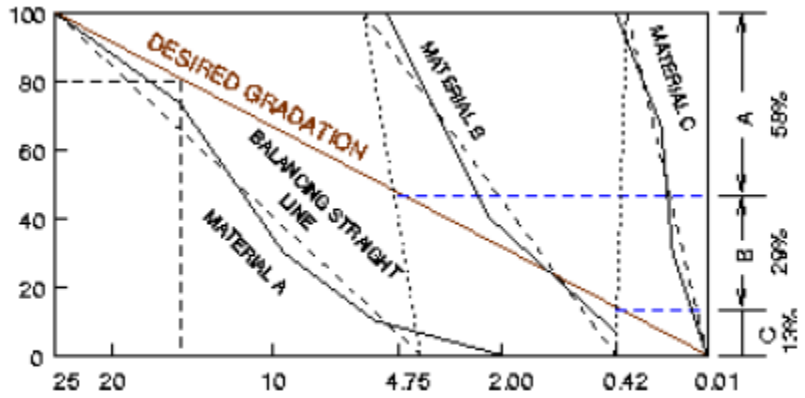
1. (a). Explain briefly the proportioning of soil aggregate by Rothfutch's method.

Ans:- 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.

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



Proportioning of materials

1(b). Explain the construction steps for WBM layer.

Ans:- Preparation of Foundation for Receiving the WBM course:- The foundation for receiving the new layer of WBM may be either the sub grade ors ub-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(a). With neat sketches, explain the different methods of subsurface drainage

Ans:- The methods of sub surface drainage are lowering of water table, control of seepage and control of capillary rise.

Lowering of water table:-

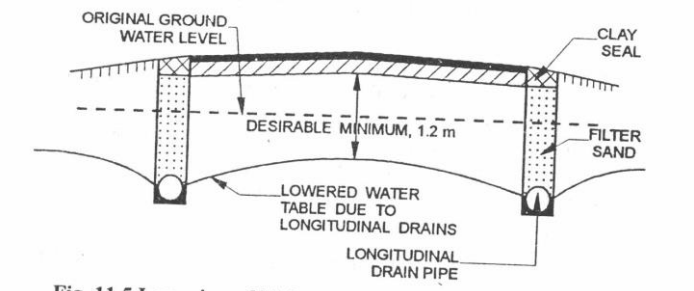
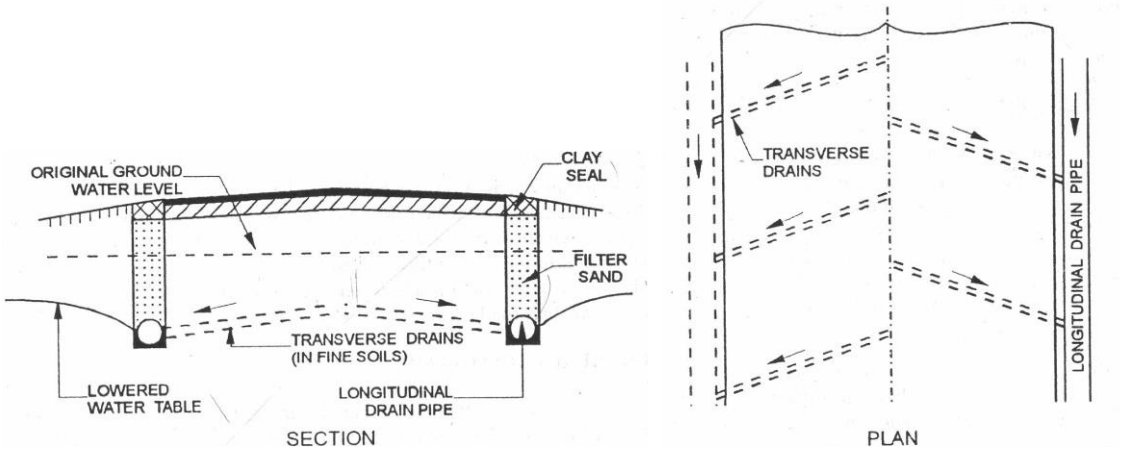


Fig. 11.5 Lowering of high water table in permeable soils

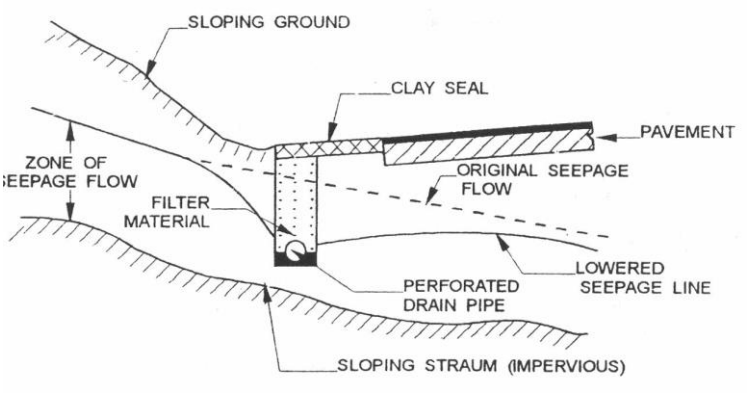
- Highest level of WT should be 1.0 to 1.20 m below the sub grade in order to avoid excessive moisture content in the pavement layers.
- In places of high WT, embankment height should be 1.2 to 1.50m above ground level.
- In cases of permeable soil, construct longitudinal drainage trenches with drain pipe and filter sand.
- Wherever soil is less permeable, in addition to longitudinal trench drains, transverse



Surface drainage system with transverse drains

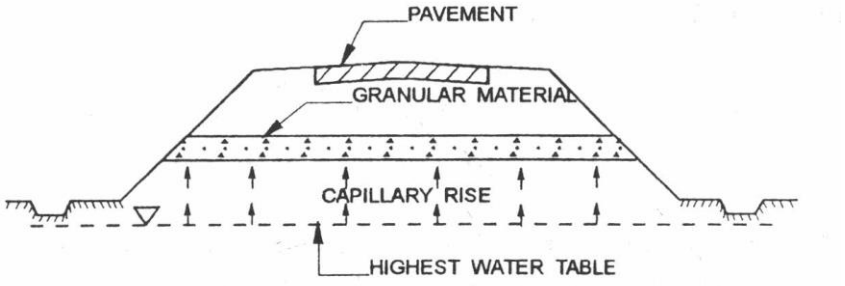
Control of Seepage flow

- Occurs when ground level as well as the impervious strata below are sloping.
- If the seepage zone depth < (0.6 to 0.9 m) from sub grade level, longitudinal drain in trench filled with filter material and clay seal may be provided to intercept the seepage flow.

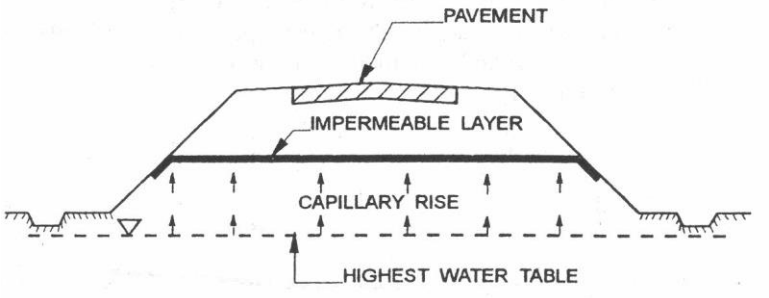


Control of capillary rise

- The capillary rise may be checked by providing a suitable capillary cut-off by granular capillary cut-off and by impermeable capillary cut-off.
- Granular Capillary cut-off:- A layer of granular material is provided during the construction of embankment as shown in fig below. The thickness of this layer should be higher than the anticipated capillary rise within the granular layer.



- Impermeable capillary cut-off:- In this case, an impermeable membrane or a bituminous layer is inserted in the place of granular blanket during the construction of embankment.



2(b). The maximum quantity of water expected in one of the open longitudinal drains on the clayey soil is 0.625 m^3/sec. design the cross section and longitudinal slope of trapezoidal drain assuming the bottom width of trapezoidal section to be 0.5 m & cross slope to be 1V:1.5H. The allowable velocity of flow in the drain is 0.8 m/sec & n= 0.022.

Ans:-

Cross section design:-

Given, Q = 0.625 m^3/sec, V= 0.8 m/sec.

Cross sectional area of the drain, A = Q/V = 0.78 m^2

Let "d" be the depth of flow in trapezoidal drain.

Top width of the drain = 1.5d + 0.5 + 1.5d = 0.5 + 3d

Cross sectional area of the drain = 0.5d + $1.5d^2$

On equating both cross sectional areas, we get, d = 0.573 m.

Allowing a free board of 0.13 m, depth of side drain = 0.57 + 0.13 = 0.70 m.

Longitudinal slope:-

$V = (1/n)*(R^{2/3})*(S^{1/2})$

R = 0.78 / (0.5+ 1.032 + 1.032) = 0.304 m.

$S = [(0.8 * 0.022) / (0.304^{2/3})]^2 = 0.0015$ OR 1 in 660.

Provide a longitudinal slope of 1 in 660.

3(a). Write short notes on BOOT and Benefit-Cost Ratio methods.

Ans:-

BOOT(Build Own Operate & Transfer).

- BOOT (build, own, operate, transfer) is a public-private partnership (PPP) project model in which a private organization conducts a large development project under contract to a public-sector partner, such as a government agency.
- It is often seen as a way to develop a large public infrastructure project with private funding.
- The public-sector partner contracts with a private developer - typically a large corporation or consortium of businesses with specific expertise - to design and implement a large project.
- The public-sector partner may provide limited funding or some other benefit (such as tax exempt status) but the private-sector partner assumes the risks associated with planning, constructing, operating and maintaining the project for a specified time period. During that time, the developer charges customers who use the infrastructure that's been built to realize a profit.
- At the end of the specified period, the private-sector partner transfers ownership to the funding organization, either freely or for an amount stipulated in the original contract. Such contracts are typically long-term and may extend to 40 or more years.

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)/(H1-H)

Where, R = Total annual road user cost for existing highway

R1 = Total annual road user cost for proposed highway improvement

H = Total annual cost of existing road

H1 = Total annual cost of 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.

3(b). Briefly explain the various highway user benefits.

Ans:-

Quantifiable Benefits:- Various benefits which can be quantified include benefits to road users such as reduction in the vehicle operation cost, time cost and accident cost. Also it enhances the land value. These are briefly explained below:

1. Saving in vehicle operation cost is due to the reduction in the fuel and oil consumption and reduction in wear and tear of tyre and other maintenance costs. A road with sharp curves and steep grades require frequent speed changes, vehicle operation on road stretches with high traffic volume or congestion necessitate speed changes; all these factors result in an increase in every component of vehicle operation cost.
2. Saving in travel time is of direct consequence to commercial vehicles due to possible increase in their trip length and earning per unit time.
3. Value may also be assigned for the saving in travel time of passengers. A part of the time saved by the passengers or commuters may be used for some useful purpose and a value can be assigned for the saving in the travel time.
4. The reduction in the accident rate due to improvements in the highway facilities causes considerable benefits to the road users and others. The component of the accident costs may include cost of damages to vehicles and other properties, cost for investigations, legal proceedings etc.
5. The benefits to other than road users include the enhancement in land value, increase in the employment opportunities and related economic uplift.

Non- Quantifiable Benefits:- The non- quantifiable benefits due to improvements in highway facilities include reduction in fatigue and discomfort during travel, increase in comfort and conveniences and improvement in general amenities, social and educational aspects, development of recreational and medical services, improved mobility of essential services and defense forces, aesthetic values, etc. Yet another important intangible road user benefit is the reduced suffering and pain of those involved in highway accidents.

3(c). Determine the relative economics of 2 types of pavements by annual cost method from the following data:

Details	**Pavement type A**	**Pavement type B**
Total cost per Km, Rs (lakhs)	**3.3**	**6.20**
Design life, years	**5.0**	**12.0**
Annual rate of interest, %	**10.0**	**9.0**
Salvage value after design life, Rs.(lakhs)	**2.10**	**3.0**
Avg annual maintenance cost per Km, Rs(lakhs)	**0.40**	**0.20**

Ans:-

Annual cost of pavement type A:-

$Cr = (3.3 – 2.10)*[(0.1*(1+0.1)^5)/ (1+0.1)^5 - 1)] + (0.1 * 2.10) + 0.4$

= Rs. 0.926 lakhs.

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.