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Laboratory Studies on Granular Sub Base Grade-I

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Abstract—*Sub base is the layer that lies over the subgrade and consist of crushed aggregate or gravel mixed with fine aggregate. The main function of the sub base layer is to provide adequate drainage and stability to achieve longer life of the pavement. For proper drainage, granular sub base (GSB) layer should have sufficient permeability which allows the flow of water through it. There are six grading of GSB that have been recommended by MORTH specifications[1]. In this paper results of a laboratory study conducted on GSB Grade-1 material are given. GSB material used in the study consisted of crushed coarse aggregate of various sizes mixed with fine aggregate (stone dust) in the proportion decided by granular mix design by trial and error method. The granular mix thus obtained was tested for strength and permeability characteristics of GSB.*

Keywords*: Permeability, Granular sub base, natural coarse aggregate*

1. INTRODUCTION

Water plays badly with all structures and is equally true in case of highways. As it is impossible to provide a road with water tight surfacing, the water, therefore, must be removed from the roadway. The intensity of rainfall and road drainage problems are different from place to place in India. Drainage is very important factor in pavement design. One illusion is that good drainage is not necessary, if the thickness design is based on saturated condition. This concept may have been true during old days when traffic volume and weight of traffic was low.

As weight and number of axle load increases, water causes damage of pavement, such as pumping and degradation of pavement material. Hence permeability along with strength of material in the sub base layer is the important parameter which should be considered in the design of pavement. The granular sub base layer are used as a pavement layer to provide proper drainage and stress transmitting medium to spread the surface load to a larger area so as to prevent load concentration, shear and consolidation deformations. Granular sub base layer also acts as drainage layer so that excess water can flow through it towards edge of pavement and finally removed from pavement structure The un-drained water in the pavement sub base is a major contributor to distress and failure of pavements. Some of the detrimental effects of water are-

- Water reduce the strength of granular material and subgrade soil.
- Water causes pumping of concrete pavement with subsequent faulting, cracking, and general shoulder deterioration.
- With the high hydrodynamic pressure generated by moving traffic, pumping of fines in the base coarse of flexible pavement may also occur.Water causes differential heaving.
- Continuous contact with water causes stripping of asphalt mixture.

Latest MORTH specifications [1] have given six grading of GSB with minimum CBR of 30% for each of them. However, the specifications are silent over the permeability requirement of these gradings. Grading-1 out of the six gradings has been tested in the lab for its strength and permeability characteristics the results of which are presented in the paper.

2. MORTH SPECIFICATIONS

As per MORTH [1] the material used in GSB layer shall be crushed stone, gravel, natural sand or the combination. Material like kankar, crushed slag, and brick matel may be used with proper quality control. The material used in GSB shall be free from the organic or other deleterious material and conform to one of the grading requirements given in Table 1.

TABLE 1: Grading for GSB Material

IS SIEVE SIZE(mm)	Percentage by weight passing The IS Sieve		
	GRADE-1	GRADE-II	GRADE-III
75.00	100	100	100
53.00	80-100	100	100
26.50	55-90	70-100	55-75
9.50	35-65	50-80	-
4.75	25-55	40-65	10-30

2.36	20-40	30-50	-
0.425	10-15	10-15	-
0.075	<5	<5	<5

IS SIEVE SIZE(mm)	Percentage by weight passing The IS Sieve		
	GRADE-IV	GRADE-V	GRADE-VI
75.00	100	100	100
53.00	100	80-100	100
26.50	50-80	55-90	75-100
9.50	-	35-65	55-75
4.75	15-35	25-50	30-55
2.36	-	10-20	10-25
0.425	-	2-10	0-8
0.075	<5	<5	0-3

Strength of GSB It is recommended by MORTH that minimum CBR for each of the six gradingsis 30%. The material used should conform to this requirement alongwith requirement of water absorption (max 2.0%) and plasticity index less than 6.0%.

3. EXPERIMENTAL PROGRAM

Non-plastic granular materials of sizes and sieve analysis as shown in Table 2 were used as GSB material. The proportions of these materials were first decided by granular mix design by trial and error method. The granular mix so obtained was then tested for strength and permeability characteristics.

TABLE-2: Sieve analysis of different size particles

IS sieve size (mm)	Percentage by weight passing the IS Sieve				
	53mm	40mm	20mm	10mm	Stone Dust
75.00	100	100	100	100	100
53.00	78.8	100	100	100	100
26.50	1	25.5	100	100	100
9.50	0	0	5.1	92.9	100
4.75	0	0	0	9.3	100
2.36	0	0	0	2	87
0.425	0	0	0	0	52.5
.075	0	0	0	0	9

The gradation obtained by blending aggregatesof size 53mm, 40mm, 20mm, 10mm and stone dust in proportion 15%:15%:20%:20%:30%is given in table-3

TABLE-3: Obtained gradation of GSB Grade-I

IS SIEVE SIZE(mm)	Percentage by weight passing The IS Sieve
	GRADE-I
75.00	100
53.00	96.8
26.50	74.0
9.50	49.6
4.75	31.9
2.36	26.5
0.425	15.8
.075	2.7

Maximum Dry Density and Optimum Moisture Content: To know the maximum dry density (MDD) and optimum moisture content (OMC) test is conducted as per IS 2720-pt 8. The results are shown in Table 4.

TABLE 4: MDD and OMCfor GSB GRADE-I

GSB GRADE-I	
OMC(%)	MDD(gm/cc)
2.9	2.09
3.3	2.1
3.5	2.06
3.7	2.05

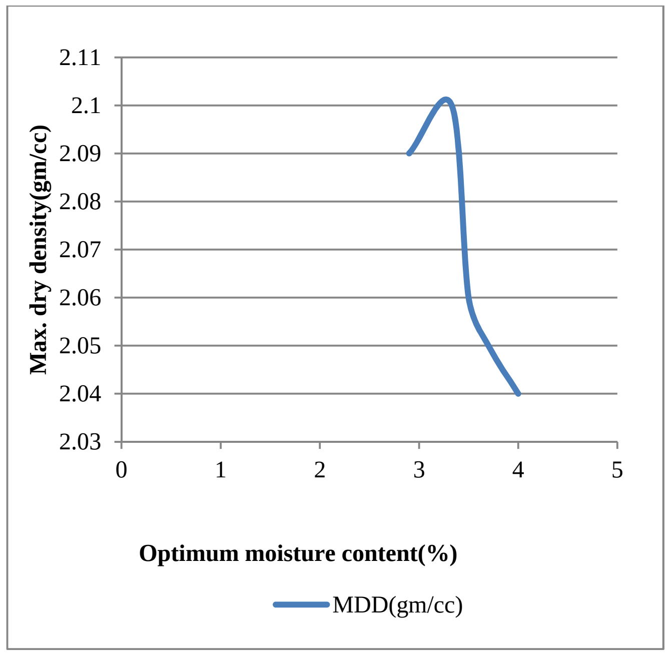

Fig. 1: MDD and OMC for GSB GRADE-I

MDD of the GSB material is found to be 2.1 g/cc at an OMC of 3.3%.

CBR Value: To know the strength of GSB, CBR test is conducted on GSB granular mix as per IS 2720-pt 16 under soaked conditions. The CBR value at 2.5 mm penetration level is found out to be 31%.

Permeability: To know the coefficient of permeability, falling head permeability test wasperformed on GSB Grade-I.coefficient of permeability(**k**)is calculated as

$$K = 2.303al * \frac{log\left(\frac{h1}{h2}\right)}{At}$$

Where,

a = Area of mould in square meter

A =Area of sample in square meter
t = Time in second
L = length in meter
h1 = level of upstream edge at t = 0
h2 = level of upstream edge after time 't'

Values used are:

a = 176.7 cm^2
t = 540 sec
L = .130m
h1= .45m
h2= .30m
A = 176.7 cm2

coefficient of permeability(k) is found to be 8.4 m/day.

4. RESULTS AND DISSCUSION

- The aggregates of size 53mm, 40mm, 20mm, 10mm and stone dust mixed in proportion 15% : 15% : 20% : 20% : 30% satisfied the specified gradation of GSB Grade-I.
- The maximum dry density of GSB mix is 2.1gm/cc at Optimum Moisture Content of3.3%.
- The CBR value of GSB mix under soaked conditions was 31% and it satisfied the srength requirement of GSB specified by MORTH.
- Coefficient of permeability of value obtained by experiment is 8.4m/day. As per IRC 58-2015 [2], Federal Highway Administration (FHA) of USA recommends a minimum permeability of 300 m per day for drainage layer for high volume roads, and AASHTO 93 [2,3] recommends a minimum permeability of 350 m /day for granular sub base drainage layer. It shows that grading-1 of GSB as recommended by MORTH [1] cannot be used as drainage layer.

5. CONCLUSION

The laboratory investigations conducted in the study indicate that grading-1 of GSB as specified by MORTH meets the strength requirement of CBR but fails to meet the permeability requirement of AASHTO and FHA as specified in IRC:58-2015. The grading-1 of GSB, therefore, should be used with caution over subgrade consisting of fine grained soil where permeability of GSB is one of the main requirements for effective drainage and proper functioning of the pavement.

REFERENCES

[1] MORTH Specifications for Road and Bridge Works, V Edition, 2013.

[2] IC:58-2015, Guidelines for the Design of Plain Jointed Rigid Pavements for Highways, Indian Roads Congress, New Delhi.

[3] AASHTO (1993), AASHTO Guide for the Design of Pavement Structures, American Association of State Highway and Transport Officials, Washington DC.