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Analysis of characteristics behaviour of locally existing material in pavement sub base

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ABSTRACT

Base materials that meet specifications are getting more difficult to get in many regions of the United States. As a result, higher quality materials have to be hauled long distances. This act would significantly increase the costs associated with roadway construction and subsequent maintenance and rehabilitation. Low quality or out-of-specification materials are usually available from local sources. If through appropriate treatment of the materials or/and structural design, the optimum use of local materials can be permitted, the construction can be accelerated and significant monetary benefits can be realized Most of the pavement design guidelines are based on the assumption that aggregates are important ingredients of the pavement structure. However, availability of good quality aggregates may be a constraint in some locations. To transport good quality aggregates from a long distance may not be economically feasible. Due to the excessive investment and maintenance cost, new methods of design had to be sought and new building materials are introduced. Some researchers tried with soil, which is available everywhere. The engineering properties of soil were modified using certain treatment. At the same time, various waste products are created by several industrial plants. These waste products could be used in the road construction projects after following certain treatment procedure. By treating natural soil or fly-ash, or by addition of certain materials to it, new road construction Each highway was divided into three sections with different materials in the subbase and base layers, such as fine lateritic soil, fine lateritic soil stabilized with lime, and a mixture of fine lateritic soil and crushed rock. The compaction characteristics were evaluated in laboratory tests. From the time the segments were constructed (in 1998 and 2000) until 2001, the stress-strain behavior of the paving structures was evaluated by in situ tests, such as the plate-bearing, Benkelman beam, and falling weight deflect to meter tests. From the results, conclusions were drawn about which of the chosen materials showed the best performance in mechanical behavior.

Keywords: *Pavement sub base, Road construction, Material specifications.*

1. INTRODUCTION

The performance of sub base depends on many factors such as structural adequacy of the pavements, properties of materials used, traffic loading, climatic conditions and construction practices. Previous research has found that much of the distress experienced in flexible pavements can be traced to the problems encountered in base materials. Normally, the use of high-quality base materials is required for pavement construction and rehabilitation to comply with the standard specifications. However, the reserves of high-quality materials are diminishing in some regions and the long-distance hauled-in materials would result in high transportation costs. This situation has required the use of local sources of base materials in pavement construction.

1.1 Characterization of slag

As regards characterization of slag is concerned, its chemical composition and phase compositions were determined. The presence of any toxic or heavy metals was studied both in the slag as well as in the leachate water collected from the slag. Several analytical techniques and their methodology used for the above are briefly discussed.

1.2 Compressive Strength Test

Table 1 Compressive strength for sub base

Serial number	Without moorum	0.1% Moorum	0.2% Moorum	0.3% Moorum
1	15.68	16.69	21.49	21.21
2	15.29	16.29	20.78	22.49
3	15.35	16.31	21.79	22.07

1.3 Compacting Factor Test Result

Table 2 Shows the Compacting Factor for all the samples of steel slag used

Types	Partially compacted (M1) kilograms	Fully compacted (M2) kilograms	Compacting Factor
Without Slag	9.726	10.413	0.95
Steel Slag	12.041	12.462	0.97

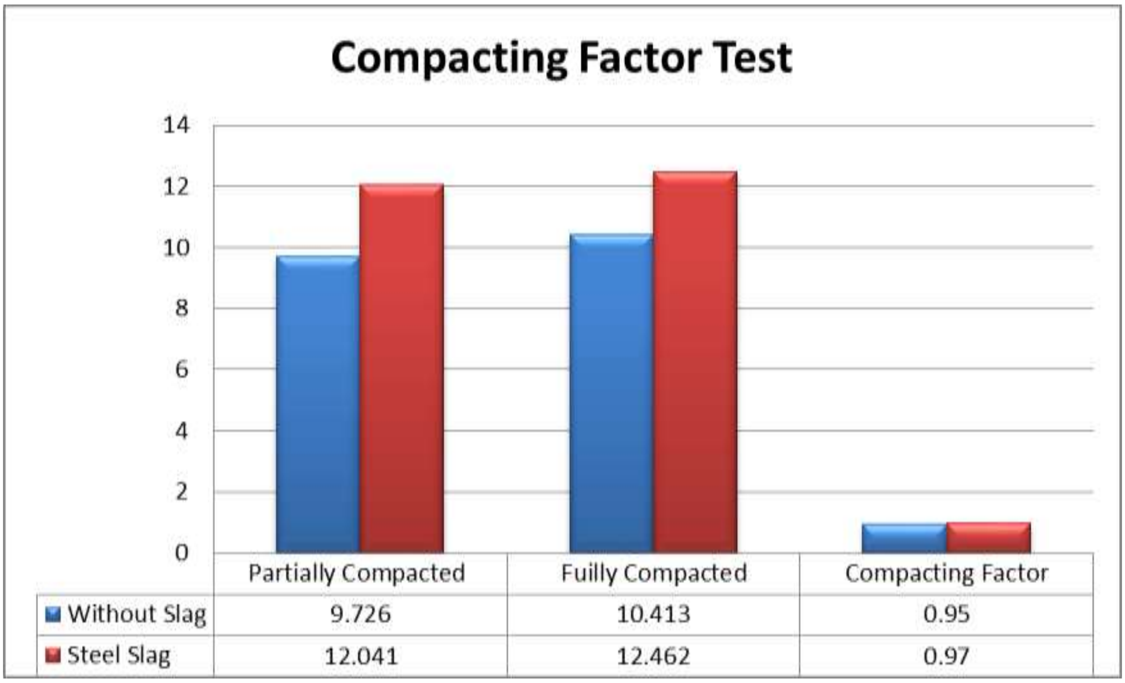

Figure 1: Chart of compacting Factor for all the samples of slag used

Slag is a self-compacting material and this test determines its ability to compact itself dropping from a set height. Slag can be dropped from large heights and this test shows these properties by the amount of compaction obtained from simply allowing the steel slag to drop.

1.4 Water absorption

The water absorption was studied and the average water absorption values of 6 samples obtained are shown in the tabular form. Shows the data of 28 days water absorption obtained. Table 10 gives the 28 days water absorption of Steel Slag and Moorum with the maximum nominal size of aggregates 8mm. The 28 days water absorption was also plotted as shown in an overall decrease in the water absorption was observed with the addition of Steel Slag and Moorum.

Table 3 Water Absorption Test of Sub Base (0 % moorum & slag)

Specimen No	Dry Weight (Kg)	Moist Weight (Kg)	Water Absorption in %	Average Water Absorption %
1	2.615	2.835	8.41	7.63
2	2.575	2.765	7.37	
3	2.530	2.710	7.11	

Table 4 Water Absorption Test of Sub Base (3 % moorum & slag)

Specimen No	Dry Weight (Kg)	Moist Weight (Kg)	Water Absorption in %	Average Water Absorption %
1	2.65	2.80	5.6	6.06
2	2.73	2.90	6.22	
3	2.60	2.76	6.4	

Table 5 Water Absorption Test of Sub Base (5 % moorum & slag)

Specimen No	Dry Weight (Kg)	Moist Weight (Kg)	Water Absorption in %	Average Water Absorption %
1	2.72	2.870	5.51	5.41
2	2.960	3.120	5.40	
3	2.830	2.980	5.30	

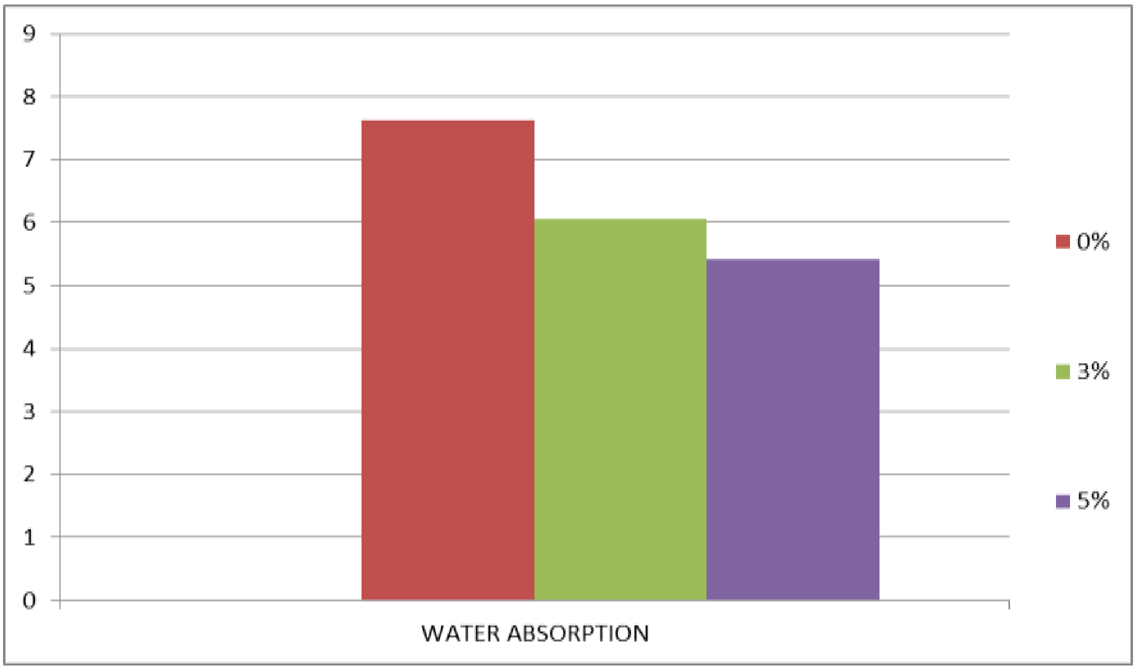

Fig 2: Water Absorption test graph in %

1.5 California Bearing Ratio Test

Objective

To determine the California bearing ratio by conducting a load penetration test in the laboratory.

Need and Scope

The California bearing ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.

This instruction sheet covers the laboratory method for the determination of C.B.R. of undisturbed and remoulded /compacted soil specimens, both in soaked as well as the unsoaked state.

Planning and Organization

Equipments and tool required.

1) Cylindrical mould with inside dia 150 mm and height 175 mm, provided with a detachable extension collar 50 mm height and a detachable perforated base plate 10 mm thick.

2) Spacer disc 148 mm in dia and 47.7 mm in height along with handle.

3) Metal rammers. Weight 2.6 kg with a drop of 310 mm (or) weight 4.89 kg a drop 450 mm.

4) Weights. One annular metal weight and several slotted weights weighing 2.5 kg each, 147 mm in dia, with a central hole 53 mm in diameter.

5) Loading machine. With a capacity of at least 5000 kg and equipped with a movable head or base that travels at an uniform rate of 1.25 mm/min. Complete with load indicating device.

6) Metal penetration piston 50 mm dia and minimum of 100 mm in length.

7) Two dial gauges reading to 0.01 mm.

8) Sieves. 4.75 mm and 20 mm I.S. Sieves.

9) Miscellaneous apparatus, such as a mixing bowl, straight edge, scales soaking tank or pan, drying oven, filter paper and containers.

Definition of C.B.R.

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

$$\text{C.B.R.} = \text{Test load/Standard load} \times 100$$

The following table gives the standard loads adopted for different penetrations for the standard material with a C.B.R. value of 100%

Table 6 Shows Penetrations for the standard material with a C.B.R. value

Penetration of plunger (mm)	Standard load (kg)
2.5	1370
5.0	2055
7.5	2630
10.0	3180
12.5	3600

The test may be performed on undisturbed specimens and on remoulded specimens which may be compacted either statically or dynamically.

1.6 Sieve size analysis of the slag

Table 7 Sieve size analysis of the slag, crushed aggregates, and moorum samples

Sieve Size (in mm)				Mean %age passing		
SLAG	**A40**	**A20**		**A10**	**A6**	**Moorum**
53.00	100.00	100.00	100.00	100.00	100.00	100
26.50	78.19	15.45	99.67	100.00	100.00	92.74
9.50	47.34	0.17	1.78	75.69	100.00	65.88
4.75	34.96	0.16	0.41	2.96	94.05	41.39
2.36	25.90	0.16	0.38	1.55	54.92	25.04
0.43	8.87	0.14	0.34	1.14	31.87	15.10
0.075	1.00	0.06	0.13	0.30	11.85	10.73

1.7 The blending of Slag and Crushed aggregates

Blending of slag and crushed aggregates were done to meet the requirements of GSB grading II (to be used in filter layer of GSB) and GSB grading IV (to be used in drainage layer of GSB) as per MoRTH specifications. After so many trials, the final proportion of the aggregates were found and are given in table 4.6.

Table 8 (a) Blending of the slag and crushed aggregates to meet the desired gradation for GSB Grading II

	Grading II Limits		BLENDING	
Sieve Size	**%passing (L)**	**%passing**	**(U)**	**Slag=76%+A6=24%**
53	100	100		100.00
26.5	70	100		83.42
9.5	50	80		59.98
4.75	40	65		49.14
2.36	30	50		32.87
0.425	10	15		14.39
0.075	0	5		3.60

Table 8 (b) Blending of the slag and crushed aggregates to meet the desired gradation for GSB Grading IV

	Grading IV Limits			BLENDING
Sieve Size	**%passing (L)**	**%passing**	**(U)**	**Slag=80%+A40=20%**
53	100	100		100.00
26.5	50	80		65.64
4.75	15	35		28.00
0.075	0	5		0.81

1.8 The blending of Moorum and Crushed aggregates

The blending of moorum and crushed aggregates was done to meet the requirements of GSB grading II for use in the cement treated base and the filter layer of sub-base. The proportions of materials were selected for which the grading was best fitted within the desired limits.

But in case of moorum, the fines content was found to be very high and during blending it was difficult to satisfy the limits of grading II taking the quantity of moorum more than 20 % of the total weight of aggregates. So the blending of moorum and crushed aggregates was tried not only to achieve a grading as close as possible to the desired grading of GSB grading II as per the MoRTH Specifications but also to satisfy the grading limits of cement stabilization as per the MoRTH Specifications as well as the grading requirements of cement bound base and sub-base materials (Grading III) as per IRC SP: 89 (2010).

Table 8 (c) Blending of moorum and crushed aggregates to meet the requirements of GSB Grading II as per the MoRTH Specifications

Grading II	**Limits for Granular Sub-base Materials**	
	(MoRTH Specification)	**BLENDING**
		Moorum=50%+A10=15%+
Sieve test	**%passing (L) %passing (U)**	**A6=35%**
53.80	100 100	100
26.5	70 100	96.37
9.5	50 80	79.29
4.75	40 65	54.06
2.36	30 50	31.97
0.425	10 15	18.88
0.075	0 5	9.56

The combination of slag and crushed aggregates, a combination of crushed aggregates as well as a combination of moorum and crushed aggregates in above proportions also gave satisfactory results. The specific gravity of the slag samples was found to be much higher as compared to that of crushed aggregates and moorum. Hence, the maximum dry density value was found to be very high. The corresponding optimum moisture content (OMC) value was also found to be more because of the high water absorption value. The impact values were found to be well within the regulatory level of 40% for use in road base or sub-base applications as per the Bureau of Indian Standards. The water absorption value of moorum was found to be more than 2 percent. Hence, the wet impact value of the combination of moorum and crushed aggregates was determined and found to be within the limits. The MDD values were found to be high in the case of both base and sub-base layer applications with 4 percent and 2.5 percent cement content (as a binder for stabilization) respectively.

2. FUTURE SCOPE

This section gives some of the works that can be taken as a further study-

1) Various combinations of the materials, like moorum, steel slag etc. can be tried and the mix which gives maximum fatigue life can be obtained.

2) Most economical combination of the layer thickness and material properties can be obtained by performing economic analysis.

3) Durability test can be performed to ensure the performance of stabilized layer.

4) Rutting equation can be developed for bituminous pavement with Sub base.

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