CHARACTERIZATION OF LIMESTONE WASTE FOR CONSTRUCTION OF FLEXIBLE PAVEMENT

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Abstract

This paper reports about the survey work carried out to determine the total limestone waste generated at the quarry sites located in seven villages of Chittapurtaluk in Gulbarga district and also experimental investigation carried out on this limestone waste to find out its feasibility for construction of flexible pavement layers. From the survey work carried out at seven villages of Chittapurtaluka it was observed that about 70 lakh tonnes of waste would be produced every year. Characterization of this limestone waste by conducting laboratory studies to find out its feasibility for road construction would help to reduce the demand-supply gap for aggregates, conserve depleting sources of good quality stone aggregate and decrease environmental degradation due to excessive quarrying activities. Laboratory investigation includes determination of physical properties of limestone waste aggregates, preparation of job mix formulae for Granular Sub Base (GSB) and Wet Mix Macadam (WMM) layers, Modified proctor compaction test to evaluate maximum dry density and optimum moisture content on WMM and GSB mixes, CBR test and Direct Shear test on GSB mixes. Laboratory results were compared with conventional Basalt aggregates. Results reveals that lime stone aggregates fulfill the requirements of MoRT&H-2001 and can completely replace the conventional aggregate like Basalt in GSB and WMM layers.

Keywords: *Lime stone Waste, Basalt, GSB, WMM and Job mix Formulae.*

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1. INTRODUCTION

1.1 General

The excessive use of conventional construction material for construction of roads and buildings leads to fast depletion of existing resources in the country. These materials are non renewable, if construction activities continues in the present pace, in a near future no resources of conventional construction material will be available, in view of scarcity of crushed rock aggregates and its high unit cost due to higher lead charges have led the engineers to search for non conventional and waste materials produced at quarry sites of lime stone, industrial waste, construction and demolition waste, lateritic soil and other marginal materials available in the country.

In Gulbarga district particularly in different villages of Chittapur, Sedam and JewargiTalukas are well known for production of slabs and tiles. During quarrying of these slabs and tiles a large amount of waste is produced. Dumping of this huge waste has occupied a large area around the quarry sites and large mounds of this waste have been formed. In order to calculate lime stone waste generated from these quarry sites,site visits have been done to seven villages in Chittapurtaluka namely Shahabad, Raoor, Malgatti, Wadi, Hongunta, Tharnalli, WaddarWada. From this it is observed that each quarry sites varies from 3000sq.ft to 4000sq.ft. Each quarry produces on an average 50% waste, life of each quarry varies from 3 to 6 months. As per calculation waste of 6 tonnes per day is produced from each quarry site. The total quarried area in these seven villages is about 577910sq.meters and total waste generated would be around 70 lakh tonnes every year. Similar type of quarries are available in different villages of Sedam and Jewargitaluka, if these are also considered around 150 to 175 lakh tonnes of waste would be generated from Gulbarga district alone. A huge quantity of this lime stone waste is anticipated from different lime stone belts located in the country. In view of this it is very much essential to characterize this lime stone waste and find out its feasibility for construction of base and sub base of flexible pavements so that it solves disposal problem. In the present study an attempt has been made to characterize two categories of wastes generated from these quarries namely muddy and non muddy waste by carrying out laboratory investigation for the construction of base and sub base courses of flexible pavements.

1.2 Objectives

1. To characterize Limestone stone waste to use it in the base and sub base courses of flexible pavement construction.
2. To determine specified proportioning, grading, density and strength requirements for the construction of GSB and WMM layers of flexible pavements using lime stone wastes.
3. To analyze the cost in order to know the savings in terms of conventional materials.

2. LITERATURE REVIEW

Vittal et al [1] carried out experimental investigation on construction and demolition (C and D) waste produced in Delhi city as a marginal material for construction of different layers of flexible pavement such as GSB, Base and surface. Delhi city produces about 3000tonnes of C and D waste. They crushed this waste into three categories 20mm to 6.3mm, 6.3 mm nominal size and powdered construction and demolition waste was undertaken and they found C and D waste can be used in Sub Base, Base and surface but it was found that it is uneconomical to use in surface as bitumen required was too high.

Wakchaure et al [2] carried out experimental study by using steel plant waste such as slag. Air cooled slag acts as a igneous rock after cooling, it is used as concrete aggregate and found that it can be used in granular sub base and base course and is economical material for use in the road constructions.

3. EXPERIMENTAL INVESTIGATION

3.1 Preparation of Limestone Waste For Laboratory Investigation

A non muddy material was collected and crushed mechanically. Muddy material was collected, cleaned and crushed manually (hand crushed). To get aggregates of 40mm and down, 20mm and down, 10mm and down, dust and mineral filler.

3.2 Material

1. Crushed basalt coarse aggregates of 40mm and down(A), 20mm and down(B), 10mm and down(C), fine aggregate(D) and mineral filler(E) (75µ passing).
2. Crushed Non Muddy limestone waste coarse aggregates of 40mm and down(A), 20mm and down(B), 10mm and down(C), fine aggregates(D) and mineral filler(E) (75µ passing).
3. Crushed Muddy limestone waste coarse aggregate of 40mm and down(A), 20mm and down(B), 10mm and down(C), fine aggregate(D) and mineral filler(E) (75µ passing).

3.3 Physical Properties Of Aggregates

Physical tests were carried out on coarse aggregates obtained, physical properties of aggregates from muddy lime stone waste, non muddy lime stone waste and basalt aggregates results are shown in table 1.

Table 1 physical property of aggregates

Property		Test Results			Requirements as per MoRT&H-2001 [3]	
		Muddy lime stone	Non Muddy lime stone	Basalt	GSB	WMM
Water Absorption (%)		00.10	00.15	00.50	2%(max)	-
Specific gravity	CA	02.73	02.65	02.89	2.5 -3.2	2.5 – 3.2
	FA	02.66	02.60	02.50		
	MF	02.50	02.50	02.60		
10% fines value(soaked), KN		168.00	145.00	180.00	50KN (min)	
Aggregate Impact value (%)		17.20	20.00	17.85	30%(max)	30%(max)
Combined Index (%)		35.13	30.00	32.88	30%(max)	30%(max)
Liquid limit 425µ passing(%)		19.64	18.77	20.00	25%(max)	-
Plasticity Index on 425µ passing (%)		Non Plastic	Non Plastic	Non Plastic	6%(max)	-

From the above table we can observe that limestone waste aggregates are less porous than basalt, from specific gravity of coarse aggregate we come to know that Basalt is stronger when compared to limestone waste, also it is evident from 10% fines value test. Even though the muddy limestone waste combined index exceeds the MoRT&H-2001 specification it can be used in Granular Sub Base (GSB) and WMM layers of flexible pavements as it has given good CBR value. The liquid limit of limestone waste is less than basalt this indicates that limestone waste is more free draining material and has potential for its utilization in sub base and base. As all the physical properties of limestone waste fulfill MoRT&H-2001 specification these aggregates can be used in WMM and GSB layers in place of conventional material like Basalt.

3.4 Development of Job Mix Formula for GSB Mix of Grade 2, Coarse Grading

This involves determination of following parameters

1. Blend Proportion of aggregates
2. Modified Proctor compaction test
3. CBR test

3.4.1 Determination Of Blend Proportions Of Aggregates

Sieve analysis was carried out on three types of coarse aggregates, fine aggregate like dust and mineral filler. Percentages passing were determined on different sieves. Blend proportion was determined by using Rothfutch's and trail and error method. The obtained gradation for blend proportion and desired gradation as per MoRT&H-2001 specifications is shown in Table 2.

Table 2 Details of obtained gradation for GSB mix

Is Seive Designation (mm)	Obtained Gradation (percent by weight passing)			Grading II As Per MoRT&H-2001
	Non muddy	Muddy	Basalt	(percent by weight passing)
75.00	100.00	100.00	100.00	-
53.00	100.00	100.00	100.00	100
26.50	69.45	77.13	79.80	50-80
09.50	46.07	40.47	44.80	-
04.75	27.93	30.25	32.68	15-35
02.36	26.85	20.78	27.96	-
0.425	17.16	8.82	12.46	-
0.075	04.59	05.44	06.59	<10

Blend proportions:

Muddy limestone = 0.17A+0.23B+0.30C+0.26D+0.04E (1)

Non muddy limestone = 0.10A+0.32B+0.31C+0.23D+0.04E (2)

Basalt = 0.25A+0.23B+0.20C+0.28D+0.04E (3)

3.4.2 Modified Proctor Compaction Test

This was conducted as per IS:2720-part-8 [4], by mixing aggregates as per job mix formulae and different percentage of water is mixed and compacted in 5 layers by giving 56 blows on each layer from 4.8kg rammer.

Table 3 Results of modified proctor compaction test for GSB

Sl. No.	Type of aggregate	Optimum moisture content (%)	Maximum dry density (gm/cc)
1.	Muddy limestone	7.50	2.26
2.	Non Muddy lime stone	6.10	2.31
3.	Basalt	6.10	2.47

From the above obtained results we can observe that limestone waste has gained a good maximum dry density. MDD achieved by basalt is 8.4% more when compared to muddy material. Muddy material has given a lesser maximum dry density this is due to the presence of more flaky and elongated material.

3.4.3 California Bearing Ratio Test

This test was conducted as per IS:2720-part-16 [5], by preparing CBR mould by blending the aggregates as per job mix formulae and moisture content corresponding to the 98% of maximum dry density was used so that uniform air voids content of 5% can be maintained (MoRT&H-2001 specification grading II).

From the table we can observe that limestone material has given a good CBR value hence these aggregates can be used in heavy traffic volume pavements.

Table 4 Results of CBR test for GSB mix

Sl. No.	Type of aggregate	CBR values (%)	Requirement as per MoRT&H-2001
1.	Muddy limestone	115.00	25% minimum
2.	Non Muddy lime stone	84.00	
3.	Basalt	156.00	

3.5 Development of Job Mix Formula for WMM Mix

3.5.1 Determination of Blend Proportions of Aggregates

Sieve analysis was carried out on three types of coarse aggregates, fine aggregate like dust and mineral filler. Percentages passing were determined on different sieves. Blend proportion was determined by using Rothfutch's and trail and error method. The obtained blend proportions are shown below which meets the desired gradation of WMM as per MoRT&H-2001 specification.

Blend Proportions:

Muddy limestone = 0.17A+0.23B+0.30C+0.26D+0.04E (4)

Non muddy limestone = 0.10A+0.26B+0.32C+0.28D+0.04E (5)

Basal = 0.20A+0.21B+0.28C+0.27D+0.04E (6)

3.5.2 Modified Proctor Compaction Test

This was conducted by mixing aggregates as per job mix formulae and different percentage of water is mixed and compacted in 5 layers by giving 56 blows on each layer from 4.8kg rammer.

Table 5 Results of modified proctor compaction test

Sl. No.	Type of aggregate	Optimum moisture content (%)	Maximum dry density (gm/cc)
1.	Muddy limestone	7.50	2.26
2.	Non Muddy lime stone	6.67	2.31
3.	Basalt	7.60	2.47

From the above obtained results we can observe that limestone waste has gained a good maximum dry density. MDD achieved by basalt is 8.4% more when compared to muddy material. Muddy material has given a lesser maximum dry density this is due to the presence of more flaky and elongated material.

3.6 Direct Shear Test

This test was conducted in the large direct shear test apparatus by mixing the aggregate as per blend proportion test was conducted on dry mix. It is difficult to compact the aggregate to MDD

Hence height of aggregates in the shear box kept so that we can compare the test results of limestone waste with the Basalt.

Table 6 Results of direct shear test for GSB mix

Sl. No.	Type of aggregate	Angle of internal friction (Φ) In degrees	Cohesion C, (KN/m2)
1.	Muddy lime stone	60	0
2.	Non Muddy limestone	60	0
3.	Basalt	58	0

From the above table we can observe that the mix is non cohesive and has got a good angle of internal friction which indicates a good interlocking between aggregates and develops good grain to grain contact and may exhibit good dispersion properties and which is desirable for base and sub base courses.

CONCLUSIONS

1. Limestone waste satisfies all the specifications of MoRT&H-2001 for different layers of flexible pavements such as GSB and WMM hence can completely replace basalt.
2. The CBR value of muddy material is 116%, Non muddy material is 84% and for basalt it is 157%. The CBR values of limestone waste are low compared to basalt but are quite high to use the limestone aggregates for the heavy traffic pavement construction.
3. Lime stone waste shows good interlocking properties when compared to basalt aggregates and hence it may exhibit excellent dispersion characteristics desired for base and sub base courses.
4. Limestone waste works out economical when compared to basalt as only transportation and processing charges are required this waste material is available at free of cost and also it solves disposal problem of limestone waste.

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