International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 06, June-2019

A Study on the Use of RAP and Sugarcane Bagasse Ash in GSB

Lalit Kumar[1], S.N.Sachdeva[2]

[1] *M.Tech student, Department of Civil Engineering, National Institute of Technology Kurukshetra, Haryana-136119, India,*

[2] *Professor, Department of Civil Engineering, National Institute of Technology, Kurukshetra, Haryana-136119, India,*

Abstract- This paper presents the study on the use of RAP and Sugarcane Bagasse Ash in GSB. The study has been done to check the suitability of waste materials in road construction. This will help in getting the economy in road construction as well as saving the environment degradation in terms of reduction in mining and less air pollution. Construction of roads and highways involve huge amount of money and materials, mainly with the use of aggregates. As millions tones of fresh aggregates are used in road construction and considering their scarcity, replacement of part of the fresh aggregate with reclaimed asphalt pavement (RAP) and sugarcane bagasse ash (SCBA) is considered in the present study. The present study discusses the suitability and applicability of RAP and SCBA when used in blends with fresh aggregates for road construction. Performance of these blend are measured by performing various laboratory tests such as compaction test and California Bearing Ratio (CBR) on Granular Sub Base (GSB). The test results indicate that virgin aggregate can be replaced by RAP and SCBA and provided satisfactory geotechnical results to be used in GSB.

Keywords— California bearing ratio (CBR); Modified proctor test; Granular sub base (GSB); Reclaimed asphalt pavement (RAP); Sugarcane bagasse ash (SCBA).

I. INTRODUCTION

Transportation plays a vital role in development of the human civilization. Transportation in India is accomplished by roadways, railways, airways and waterways. Among these modes of transportation, roadways are major components of transportation system. India's road network of 5.6 million kilometres is second largest road network in the world. In the rise of industrial development and increasing population, the demand for adequate provisions of transportation facilities and the maintenance of the existing ones are enormously increasing even as the availability of good and adequate material for road construction is grossly inadequate and in most cases, lacking. The increasing industrial activities have generated large volume of wastes requiring disposal with its attendant environmental problems. To reduce the disposal problem associated with these wastes generation, they are recycled to generated alternative materials for highway constructions.

Aggregate materials that are widely used in road construction and maintenance applications, prepare pavement working platform, or construct flexible pavement foundation layers are increasingly scarce and expensive. Materials alone cost more than 60% of the total construction cost, out of which aggregate cost component is approximately 30%. About 15,000 t of natural aggregates are being used to build every 1 km of highway in India. In the U.S., about 1,300 million tons of natural aggregates are being used annually in the construction of pavement (Mallick and Veeraragavan, 2010).

In India, more than 90% of the roads are of flexible type. Water damage is the most important factor which affects adversely the performance of flexible pavements. In the flexible type pavement, the granular sub-base (GSB) is placed on top of the sub-grade and beneath the base course in a road structure, its function is to drain out the water which might enter because of stripping of asphalt and to transfer the wheel load to the sub-grade layer.

II. IMPORTANCE OF STUDY

The present study check the suitability of the sugarcane bagasse ash (SCBA) and reclaimed asphalt pavement (RAP) in the granular sub base (GSB) where SCBA is generated from combustion of fibrous residue of sugarcane and RAP is generated when asphalt pavements are removed for reconstruction, resurfacing of the previous asphalt pavement. This will facilitate the saving of conventional natural aggregates (gravels, sand/ stone dust) and save the environmental degradation in terms of reduced mining and less pollution. All over the world millions of tons of mineral aggregates are used for highway construction and maintenance. Gravels and sand are the major road construction materials. However, depending upon the location, local materials of similar engineering properties may also have to be used for highway construction and maintenance works because of financial and environmental reasons. It is well known fact that the naturally occurring material are fast depleting because of their over exploitation to meet the huge demand for construction of infrastructure projects.

III. MATERIALS AND METHODOLOGY

Methodology of the present study includes various experiments carried out on natural aggregates, RAP, SCBA and mix proportions of SCBA and RAP in natural aggregates to determine the suitability of SCBA and RAP in road constructions. These experiments are performed in the Transportation lab of Civil Engineering Department, NIT Kurukshetra.

A. MATERIALS USED

The present study takes into consideration only grading III of the GSB as specified by the MoRTH and following materials have been used.
1. Fresh aggregates
2. Sugarcane bagasse ash (SCBA)
3. Reclaimed asphalt pavement (RAP) aggregates
4. Stone dust

Sugarcane Bagasse Ash (SCBA)

Bahurudeen A. et. al. (2015), India is the second largest country in the world in sugar production next to Brazil. India contributes 15% of the total sugar production in the world. Sugarcane bagasse ash (SCBA) is obtained from the combustion as by-product from boilers of sugar mills.The total bagasse ash availability in India is calculated to be about 44220 tons/day. In India, Uttar Pradesh state is the leading producer of bagasse ash producing a quantity of 17160 tons/day. Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh etc. are the other major producers of bagasse ash in India. In India, state wise bagasse ash generation is represented in table I.

Table I State Wise Bagasse Ash Generation

S.No.	State	SCBA (%)
1.	Uttar Pradesh	39
2.	Maharashtra	24
3.	Karnataka	9
4.	Tamil Nadu	7
5.	Andhra Pradesh	5

The Physical properties of SCBA are shown in following table II.

Table II Physical Properties of SCBA

S.No.	Parameters	Values
1.	Density	1.50 gm/cm3
2.	Surface area	5140 cm2/gm
3.	Colour	Reddish grey
4.	Lime content	4.52-12.66%
5.	Al2O3+Fe2O3+SiO2	60-75%
6.	Loss of ignition	4.73-5.0%

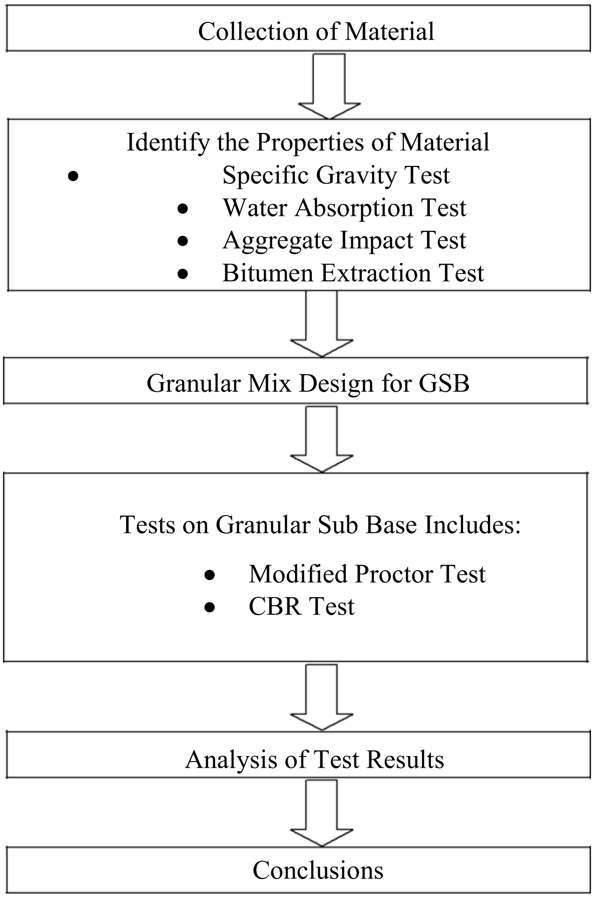
Reclaimed Asphalt Pavement (RAP)

RAP is 100% recyclable material. RAP aggregate can be used as partial and full replacement of fresh aggregate, in construction of road which reduces the cost of the project.
It was estimated that the construction industry in India generates about 12-14 million tons of wastes annually. Use of recycled aggregate is not very common in India and other developing countries. In U.S., more than 50 million tons of asphalt paving mixture is milled annually and the majority is recycled into new asphalt mixtures. The physical properties of RAP are shown in table III.

Table III. Physical Properties of RAP

S.No.	Parameters	Values
1.	Unit Weight (Kg/m³)	1900- 2250
2.	Moisture Content	Max 3- 5%
3.	Asphalt Content	5- 6%
4.	Asphalt Penetration(%) at 25°C	10-80
5.	Compacted Unit Weight (Kg/m³)	1500- 1950
6.	California Bearing Ratio (CBR)	100% RAP : 20-25%

B. FLOW DIAGRAM OF METHODOLOGY



***C.* Collection of Samples:** The samples of natural aggregate were collected from laboratory of NIT Kurukshetra, Haryana, sample of reclaimed asphalt pavement (RAP) materials were collected from a stockpile near Pipli- Ladwa road, Kurukshetra, Haryana and sugarcane bagasse ash from The Shahabad Cooperative Sugar Mills Ltd., Shahabad Kurukshetra Haryana.

IV. RESULTS

A series of tests are conducted in the laboratory for evaluation of various properties of materials selected for the study. All these tests have been conducted as per the guidelines of IS codes and MoRTH recommendations and the values obtained have been analysed and discussed with reference to MoRTH specifications.

A. AGGREGATE IMPACT VALUE (AIV)

The aggregate impact value test is performed in the laboratory on aggregates and the values obtained from the tests are shown in table IV.

TABLE IV Aggregate impact value for Fresh aggregate and RAP aggregate

S.No.	**Type of Aggregate**	**Aggregate Impact Value (AIV)**
1.	Fresh aggregate	17.62%
2.	RAP aggregate	14.21%

From table IV, it is observed that the value obtained for fresh aggregate and RAP aggregate is within the permissible limit of maximum 30% as per MoRTH specifications for granular layer.

B. SPECIFIC GRAVITY

The pycnometer bottle test is performed in the laboratory to find out the specific gravity of fresh aggregate, RAP, stone dust, SCBSA and the values obtained from the tests are shown in table V.

Table V. Specific gravity of materials

S.No.	Type of Material	Specific Gravity
1.	Fresh Aggregate	2.68
2.	RAP	2.51
3.	Stone Dust	2.55
4.	SCBA	1.50

From table V, it is observed that specific gravity of RAP and SCBA is less than that of fresh aggregate. This may be due to fact that the RAP aggregate have undergone series of loading of wearing and tearing in the past.

C. WATER ABSORPTION TEST

The water absorption test is performed in the laboratory on aggregates, the values obtained from the tests are shown in table VI.

TABLE VI Water absorption of fresh aggregate and RAP aggregate

S.No.	Type of Aggregate	Water Absorption
1.	Fresh Aggregate (mix of 20 and 10 mm)	0.60
2.	Fine aggregate (stone dust)	1.16
3.	RAP aggregate	1.20

From table VI, it is observed that water absorption of RAP aggregate is more than that of fresh aggregate. This may be due to the fact that the RAP aggregate have more intra-particle voids/cracks.

D. BITUMEN EXTRACTION TEST

This test is carried out to determine the amount of binder content present in the RAP aggregates and results are shown in table VII.

Table VII Binder content of RAP aggregate

Type of Aggregate	Binder content
RAP aggregate	2.60

E. GRANULAR MIX DESIGN

Granular mix design is done for combining and proportioning of aggregates to obtain the required gradation, as we are using the GSB grading III of MORTH, the sieving should be done as per the specified grading.

Based on this grading, proportioning of the materials has been carried out. Groups are made by varying the percentage of RAP and SCBA. Table VIII shows the representation of groups.

Table VIII Representation of Groups

Group	% of SCBA	% of RAP	Representation of Group
Base Group	0	0	G00
Group 1	0	10,20,30,40	G01,G02,G03,G04
Group 2	5,10,15	0	G05,G10,G15
Group 3	5	10,20,30	G21,G22,G23
Group 4	10	10,20,30	G31,G32,G33
Group 5	15	10,20,30	G41,G42,G43

F. MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT

Modified Proctor Test has been performed in the laboratory to determine the maximum dry density and optimum moisture content of different groups and the obtained values are shown in table IX.

Table IX Modified Proctor Test Results for GSB Grading III

Group	**Maximum dry density (g/cc)**	**Optimum moisture content (%)**
G00	2.232	5.4
G01	2.220	5.7
G02	2.227	5.9
G03	2.231	6.1
G04	2.234	6.4
G05	2.229	6.9
G10	2.126	7.2
G15	1.978	7.5
G21	2.221	6.8
G22	2.231	7.1
G23	2.228	7.6
G31	2.217	7.3
G32	2.224	7.0
G33	2.230	7.5
G41	2.201	7.2
G42	2.121	6.9
G43	1.986	7.3

From the table IX, it is observed that The OMC is increased with increase in proportion of RAP and SCBA. The MDD is found to decrease with increase in proportion of RAP and SCBA, may be because of low specific gravity of RAP aggregates and SCBA.

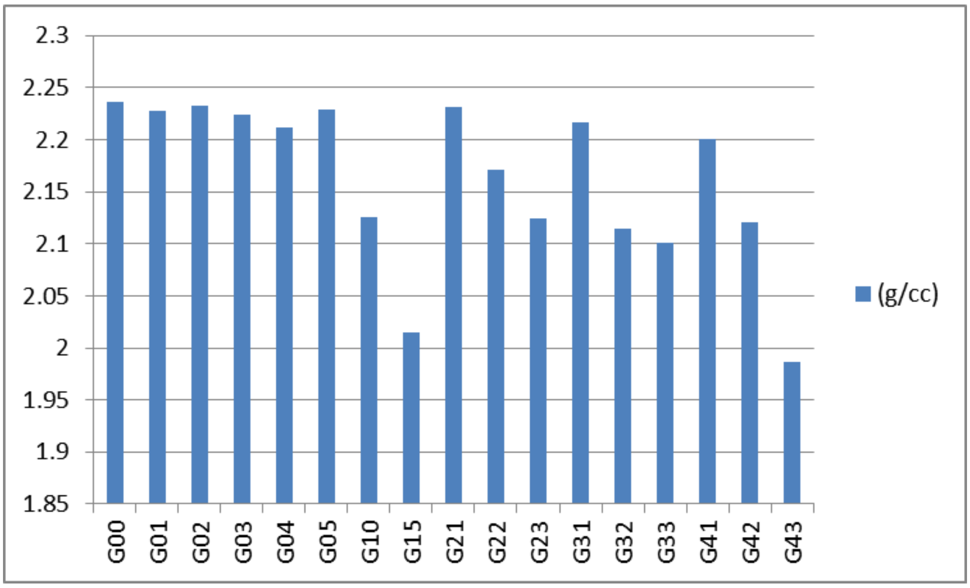


Figure I MDD values for different groups GSB mix

The values obtained from results for maximum dry density is represented in bar diagram as shown in Figure I.

4.7 CALIFORNIA BEARING RATIO

CBR values are shown in table X.

Table X CBR Test Results for GSB Grading III

Group	CBR value (%)
G00	44.12
G01	43.21
G02	43.18
G03	42.04
G04	40.07
G05	38.54
G10	35.62
G15	33.25
G21	38.41
G22	37.48
G23	35.32
G31	38.14
G32	38.87
G33	36.08
G41	37.85
G42	36.06
G43	34.13

From the table X, it is observed that CBR value decreases with increase proportion of RAP and SCBA.

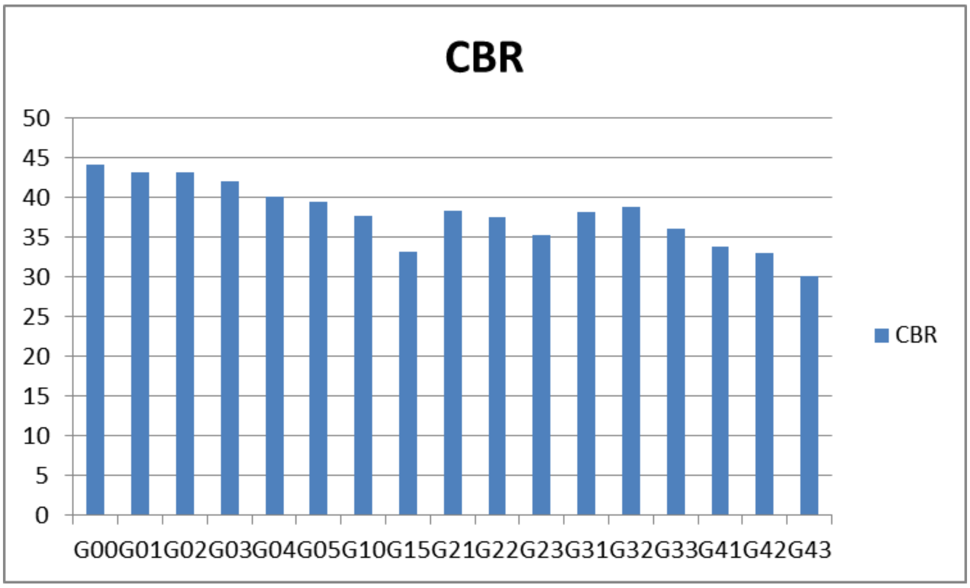


Figure II CBR values for different groups GSB mix

The values obtained from results for CBR is represented in bar diagram as shown in Figure II.

V. CONCLUSIONS

The major findings from the study are as following.

1. It is observed that the RAP aggregate and SCBA in combination to natural aggregate in various proportions can be easily used after blending to match the required grading as per MORTH specifications in the sub base courses of flexible pavements.

2. The increase in MDD with addition of RAP and SCBA up to certain proportion of RAP may be attributed to (i) better filling of voids of coarse and fine aggregate with RAP material, and (ii) easy and better orientation of bitumen coated RAP aggregate in the mix for a given compactive effort resulting in more density of the mix.
3. The CBR value of base mix was observed as 44.12%. CBR value decreases with increase in quantity of SCBA as well as RAP. The lowest value of CBR value was obtained as 33.25% for G15.
4. It is clear from the above investigation results that replacement of natural aggregate can be successfully done in sub base course of flexible pavements, resulting in a savings in construction cost.
5. Above all the problem of disposal of wastes can be easily solved and adverse effect on environment may be avoided by using the RAP aggregate and SCBA in flexible pavement construction.

REFERENCES

[1] Bahurudeen A. et. al. (2015) "Availability of sugarcane bagasse ash and potential for use as a supplementary cementitious material in concrete" Indian concrete journal
[2] Mallick, Veeraragavan (2010) "Sustainable pavement in India- the time to start is now" NBM and CW magazine 16 (3), 128-140.
[3] IS: 2720 (Part 8) -1980: Indian Standard Methods of Test for Soils: For water content – dry density relation using heavy compaction, Bureau of Indian Standards, New Delhi, India.
[4] IS: 2720 (Part 16) -1987: Indian Standard Methods of Test for Soils: laboratory determination of CBR, Bureau of Indian Standards, New Delhi, India.
[5] IS: 2720 (Part 17) -1987: Indian Standard Methods of Test for Soils: laboratory determination of Permeability, Bureau of Indian Standards, New Delhi, India.
[6] IS: 2386 (Part 3) -1963: Indian Standard Methods of Test for Aggregate for Concrete: Specific gravity, density, voids, absorption and Bulking, Bureau of Indian Standards, New Delhi, India.
[7] IS: 2386 (Part 4) -1963: Indian Standard Methods of Test for Aggregate for Concrete: Mechanical Properties. Bureau of Indian Standards, New Delhi, India.