International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

COPY RIGHT

IJIEMR Transactions, online available on 30 May 2017.
Link : http://www.ijiemr.org/downloads.php?vol=Volume-6&issue=ISSUE-3

Title: A Study of Dense Grade Bituminous Mixes With Coal Ash And Sisal Fibre For Improved Perrformance.

Volume 06, Issue 03, Pages: 453 – 466.

Paper Authors

VENKATA PRAVALLIKA GANDHA, S.ESWAR.
Pydah College of engineering

USE THIS BARCODE TO ACCESS YOUR ONLINE PAPER

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

A STUDY OF DENSE GRADE BITUMINOUS MIXES WITH COAL ASH AND SISAL FIBRE FOR IMPROVED PERRFORMANCE

VENKATA PRAVALLIKA GANDHA[1]; S.ESWAR[2]
[1]PG Scholar, Pydah College of engineering, Kakinada, India
[2]Asst professor, Pydah College of engineering, Kakinada, India
E-Mail: pravallikagandha@gmail.com, eswar@pydah.edu.in

ABSTRACT

In the present study, dense graded bituminous mix specimens are prepared using natural aggregate as coarse aggregates, bottom ash as fine aggregates, fly ash as filler and sisal fiber as additive. Proportion of aggregate for dense graded bituminous macadam (DBM) grading has been considered as per MORTH (2013) having nominal maximum aggregates size (NMAS) 26.5 mm. To strengthen the mix, slow setting emulsion (SS1) coated sisal fiber is added in varying percentage of 0, 0.25%, 0.5%, 0.75%, and 1% by weight of the mix, with different length variations such as 5mm, 10 mm, 15 mm and 20 mm. At the initial stage of the research, specimens were prepared with two types of paving bitumen i.e. VG30 and VG10, out of which the initial trials resulted better Marshall characteristics with VG30 bitumen and hence was considered for subsequent study. Detailed study with Marshall test results were used to determine the marshal characteristics, optimum binder content and also optimum fiber content including the optimum length of fiber. Marshall stability as high as 15kN was obtained with optimum bitumen content of 5.57%, with optimum fiber content of 0.5% with optimum fiber length of 10 mm. Further, for delivering the performances of the pavement, various performance tests were also conducted such as moisture susceptibility test, indirect tensile strength (ITS), creep test and tensile strength ratio of bitumen mixes. It is finally observed that not only satisfactory, but also much improved engineering properties result with coal ash as fine aggregate and filler, stabilized with natural sisal fiber duly coated with SS-1 emulsion in advance. Utilization of non-conventional aggregate like coal ash and natural fiber together thus may help to find a new way of bituminous pavement construction. The coal ash dumping which is a serious concern to everyone in respect of its disposal and environmental pollution, can find one way for its reuse in an economical way by substituting natural resources of sand and stone dust.

Key Words: **Bottom ash, Fly ash, Sisal fiber, Emulsion, Indirect tensile strength, Static creep test, Tensile strength ratio.**

1. INTRODUCTION

1.1 INTRODUCTION

Asphalts or parkways or streets are viewed as nation's spine, whereupon its rise and advance rely on upon. All nations regularly have a progression of projects for building another street frameworks or rising the current one. Development of both adaptable and unbending asphalt incorporate a gross measure of speculation to achieve better execution situated and smooth nature of asphalt that will persist for long time. In India, where parkways are considered as the essential capacity of transportation, Government of India have been contributing an enormous measure of cash for building up the asphalt development and upkeep. An itemized building study may hold critical measure of speculation and asphalt materials, which thusly accomplish a solid execution of the in-administration parkway. As to asphalt, two noteworthy realities are taken into contemplations i.e. asphalt outline and blend plan. The present research study is centered around designing property of bituminous mixes arranged from exchange or nonconventional materials. The formal mix design method was first made possible by Habbard field method, which was originally developed for the sand-bituminous mixture. But one of the focal limitation of this technique was its incompatible of handling large aggregates. Later on, a project engineer Francis Hveem of California Department of Highways, developed an instrument called Hveem stabilometer to calculate the possible stability of the mixture. At the early stage, Hveem did not have any experience to estimate the amount of optimum bitumen that will just be right for mix design. He adopted the surface area calculation concept used for cement concrete mix design, to assess the quantity of bitumen vital for the mixture. On the other hand, Bruce Marshall developed equipment to test stability as well as deflection of the bituminous mixture. It was adopted by the US Army Corpse of Engineers in 1930’s and successively adapted in 1940’s and 50’s

2 LITURATURE REVIEW

R. E. Long and R.W. Floyd (1982) studied that aggregate shortages and increased transportation costs have greatly increased prices of related construction items in areas of Texas which is not blessed with natural aggregates. Some natural aggregates are not performing up to expectations as documented by stripping, rutting and other visual signs of pavement distress noted throughout the Department. Because of these spiralling construction costs and need to field evaluate bottom ash, District 1, supported by the Materials and Tests Division, decided to construct three field test pavements substituting bottom ash for part of the natural aggregates in hot mix asphaltic concrete (HMAC). David q. Hun sucker (1992) led an exploratory bituminous surface overlay, which was set in October 1987 on state route 3 in Lawrence County, Kentucky. The exploratory area used base fiery remains aggregate, limestone and common sand aggregate. Musselman et al. (1994) played out a two year show extend has been started where base cinder was utilized as a half substitute aggregate in a black-top asphalt. The exhibit extend incorporates critical testing of conceivable ecological impacts and asphalt execution both in the research facility and at the show roadway. Information was accumulated which incorporate logical information on groundwater and surface water quality effects, surface keep running off and suction lysimeter tests. Physical roadway execution was observed through remote detecting utilizing strain resistance and temperature tests and additionally in situ and ruinous asphalt examination.

3. RAW MATERIALS AND EXPERIMENTAL INVESTIGATION

3.1 Materials Used

A bituminous mix is made from aggregate, graded from maximum fraction to smaller fraction (usually less than 25mm IS sieve to the mineral filler, smaller than 0.075mm IS sieve), which are blended with bitumen binder to form a consistent mixture.

In this study following materials are taken in to consideration to prepare the bituminous mix.

- Stone chips (as coarse aggregate)
- Bottom ash (as fine aggregate)
- Fly ash (as mineral filler)
- VG-30 (as bitumen binder)
- Sisal fiber (as additives)
- SS-1 emulsion (as fiber coating agent)

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

3.1.1 Aggregate

Coarse aggregates comprised of stone chips were procured from a nearby crusher and were stored by sieving in to different sizes. For this study, stone chips comprising coarse aggregate fractions and upper size fractions of fine aggregates ranged from 26.5 mm to 0.3 mm were used as shown in Figure 3.3. For lower fractions of fine aggregates and mineral filler, bottom ash and fly ash were respectively used to the extent of 9% and 5% by weight of total mix. Bottom ash was procured from the nearby NSPCL thermal power plant (shown in Figure 3.2), while fly ash was collected from the nearby Adhunik Metaliks Power plant (shown in Figure 3.1). The physical properties of coarse aggregates and fine aggregates which are primarily required for paving are given in Table3.1.

Figure 3.1 Fly ash

Figure 3.2 Bottom ash

Figure 3.3 Stone chips

Table 3.1 Physical property of coarse aggregate and fine

Property	Code specification	Test Result	
		Natural Aggregate	Bottom ash
Aggregate impact value, %	IS:2386 part-IV	14	-
Aggregate crushing value, %	IS:2386 part-IV	13.5	-
Los Angles Abrasion test, %	IS:2386 part-IV	18	-
Soundness test (five cycle in sodium sulphate), %	IS:2386 part-V	3	8.2
Flakiness index, %	IS:2386 part-I	11.9	-
Elongation index, %	IS:2386 part-I	12.5	-
Water absorption, %	IS:2386 part-III	0.14	10.75
Specific gravity	IS:2386 part-III	2.7	2

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

3.1.2 Bitumen

The paving bitumen grade VG-30 (VG-viscosity grade) was used in this experimental study. Initially, two bitumen grades such as VG-30 and VG-10 were used to study the Marshall characteristics of mixes with the materials considered. These initial trials resulted better Marshall characteristics, especially the Marshall stability in respect of mixes made up of bottom ash, fly ash and emulsion coated fiber with VG-30 bitumen as binder. The physical characteristics of VG-30 bitumen tested as per IS standards are given in Table-3.2.

Table 3.2 Physical property of binder.

Physical Properties	IS Code	Test Result
Penetration at 25^{o}C/100gm/5s, 0.01mm	IS:1203-1978	45
Softening Point, ^{o}C	IS:1205-1978	45.5
Specific gravity, at 27^{o}C	IS:1203-1978	1.01
Absolute viscosity, Brookfield at 160^{o}C, Centi Poise	ASTM D 4402	200

3.1.3 Additives (Sisal Fiber)

The sisal fiber, a naturally and locally available product has been used as a modifier for improving the engineering properties of conventional DBM mixtures. In this experimental work sisal fibers were coated with slow setting emulsion (SS-1) and stored at 110^{o}C in hot air oven for 24hrs. Emulsion coating was considered considering the organic nature of the material. Sisal fiber is a cellulose fiber having soft yellowish color. The sisal fiber used in this study is shown in Figure.3.4 (a). It is durable, anti-static and recyclable. The physical and chemical property of sisal fiber is given in Table -3.3.

Figure 3.4 (a) Sisal fiber used.

Figure 3.4 (b) Sisal fiber plant [15]

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

Table 3.3 Physical and chemical property of sisal fiber.

Chemical composition	
Composition	**Test result**
Cellulose, %	64
Hemicellulose, %	13
Lignin, %	9.7
Waxes, %	2.2
Physical property	
Property	**Test result**
Density, gm/cc	1.52
Tensile strength, MPa	520-630
Young's modulus, MPa	9.4-2.0
Elongation at break, %	2.0-2.5

3.2 Experimental Design The adopted gradation for DBM sample has been considered as specified in MORTH (2013) and is given in Table-3.4. Throughout the experimental study the aggregate gradation given in Table 3.4 was followed, and the following tests were performed.

Table 3.4 Gradation of Aggregate.

Sieve size (mm)	Adopted gradation (% Passing)	Specified limit (as per MORTH, 2013) (% Passing)
37.5	100	100
26.5	95	90-100
19	83	72-95
13.2	68	55-80
4.75	46	37-54
2.36	35	29-42
0.3	14	8-21
0.075	5	3-8

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

3.2.1 Design mix

The DBM blends were set up as per the Marshall method determined in ASTM D6927-2015. All elements of blend, for example, coarse aggregates, fine aggregates, filler, fiber and VG-30 bitumen were blended in a predefined system. Before setting up the specimens, filaments were covered with SS-1 emulsion and put away in a hot air broiler at 1100C as appeared in Figure 3.6. Covered fiber are put away for 24 hours to guarantee legitimate covering around every fiber and to deplete down additional bitumen that may hold fast to fiber, as appeared in Figure 3.6. At that point the strands were cut into indicated lengths of around 5mm, 10mm, 15mm and 20mm as given in figure 3.7. The aggregates and bitumen were warmed independently to the blending temperature of 1550C to 1600C. The temperature of the aggregates was kept up 100C higher than that of the cover. Required quantities of bitumen VG-30 and coated emulsion fiber pieces were added to the pre-heated aggregates and thoroughly mixed as shown in Figure 3.8.

Figure 3.5 Coating of emulsion on fiber.

Figure 3.6 Oven dry coated fiber.

Figure 3.7 Cutting of coated fiber.

Figure 3.8 Addition and mixing of fiber

International Journal for Innovative
Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

(a) (b) (c) (d)

Figure 3.9

(a) Pouring of mixture in mould, (b) Compaction of mixture in progress, (c) DBM samples, (d) Marshall test in progress

3.2.2 Static indirect tensile test

Static indirect tensile test of bituminous mixes was performed in accordance to ASTM D 6931 (2007) to assess the resistance to thermal cracking for a Marshall cylindrical specimen that is loaded in vertical diametrical plane as shown in figure 3.10. This tests were carried out on DBM specimen which were prepared at their optimum binder content, optimum fiber content and optimum fiber length as calculated from Marshall propeties analysis.

Figure 3.10 Loading and failure pattern of indirect tensile strength test.

3.2.3 Resistance to moisture damage (Tensile Strength Ratio (TSR)

The imperviousness to dampness vulnerability of bitumen mixes were measured by elasticity proportion. The test is like Static Indirect Tensile test just the example were set up in gyratory compactor with 7% air void and 150 mm measurement to 62.5 mm tallness example measurement as appeared in figure 3.11. Six example of equivalent avg. air void was arranged and partitioned into two subset. One subset was halfway soak to be dampness molded with refined water at room temperature utilizing a vacuum chamber by applying a fractional vacuum of 70 kPa or 525 mm Hg (20 in. Hg) for a brief span, for example, five min. after that the incompletely immersed tests are cured to be dampness molded in refined water at 60+1.0°C for 24 hour.

(a) **(b)** **(c)**

Figure 3.11

(a) Sample Prepared in gyratory compactor, (b) Moisture susceptibility test in progress, (c) Failure cracks in DBM sample.

3.2.4 Retained stability test

The loss of stability in bituminous mixes due to penetration of moisture are measure in the form of Retained stability test. This test also shows the sign of percentage striping of bitumen from aggregate. The test was conducted in accordance with the STP 204-22 with standard Marshall Samples, prepared according to the Marshall procedure specified in ASTM D6927-2015. Six specimen were prepared with 4% air void and divided into two subset. Each of the subset were conditioned with water at $60^{\pm}1^{0}$C for half an hour and 24 hours and tested in accordance to Marshall stability test. A minimum of 75% retained stability is required as per MORTH-2013 to claim the mixture can with stand moisture.

3.2.5 Static creep test

This test method is used to determine the resistance to permanent deformation of bituminous mixtures at specific temperatures. For Static Creep test sample were prepared at their optimum binder content, optimum fiber content and fiber length. The test was conducted as per Texas department of transportation (2005) specification. The specimens were placed in a hot air oven maintained at a temperature of 40°C for three to five hours prior to start of the

test. Then 125 lb. (556 N) load was applied for one hour followed by 1 min initial loading rest. This allows the loading platens to achieve more uniform contact with the specimen. The deformation was registered in each 5 min intervals starting from 0 min to 60 min by using a

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

dial gauge graduated in units of 0.002 mm. After then the load was removed and its recovery was registered up to next 5 min at 1 min intervals.

4. RESULT:

In this chapter the results and observations of the tests conducted are presented, analyzed and discussed. From the above Marshall property of DBM mix that is prepared with coal ash, it is observed that, coal ash cannot deliver satisfactory result when used alone. The stability and flow values are not within the specification made for DBM mix. Also the volumetric analysis such as air void, unit weight, VMA and VFB, are lagging behind the conventional mix. Therefore the Marshall propeties study is done by using coal ash and sisal fiber as an additive. The percentage of coal ash is taken as 14% as it shown better result than other coal ash content. The result graphs and table is shown below. The graphs were shown at 0.5% of fiber content.

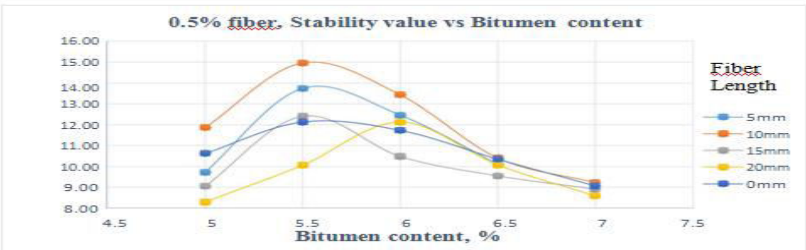
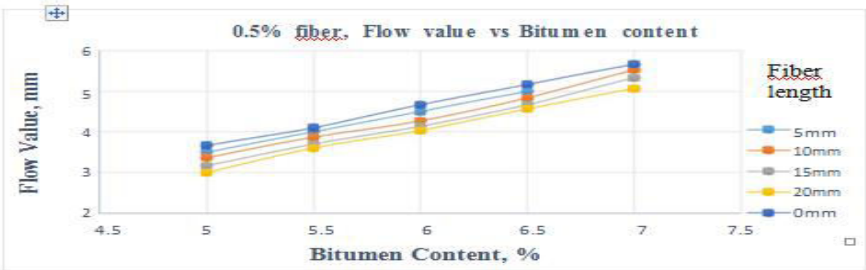


Fig 4.1 Variation of Stability value with bitumen content in 0.5% fiber content at different fiber length



ig

Fig 4.2 Variation of Flow value with bitumen content in 0.5% fiber content at different fiber length

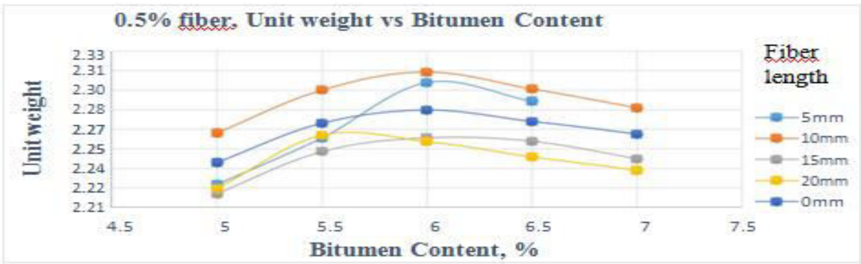


Fig 4.3 Variation of Unit weight value with bitumen content in 0.5% fiber content at different fiber length

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

Table 4.1 Marshall Properties Analysis

Fiber	**Fiber**		**Optimum**	**Flow**	**VA,**	**VMA,**	**VFB,**	
content,	**length,**	**OBC,**	**stability,**	**value,**	**%**	**%**	**%**	**Gmb**
%	**mm**	**%**	**kN**	**Mm**				
	0	5.50	11.50	3.15	2.40	15.30	84.00	2.33
	5	5.60	14.30	4.00	3.60	16.70	79.00	2.28
0.25	10	5.68	13.30	3.50	3.60	17.00	76.00	2.28
	15	5.77	12.90	3.80	3.10	16.60	80.00	2.27
	20	5.63	11.00	3.80	4.00	17.00	77.00	2.27
Fiber	Fiber		Optimum	Flow	VA,	VMA,	VFB,	
content,	length,	OBC,	stability,	value,	%	%	%	Gmb
%	mm	%	kN	Mm				
	0	5.70	11.30	3.15	2.40	15.30	84.00	2.33
0.5	5	5.67	13.70	3.85	2.90	17.10	75.00	2.26
	10	5.70	15.90	3.50	2.80	15.80	82.00	2.30
	15	5.90	11.40	3.60	4.30	17.60	76.00	2.25
	20	6.23	12.90	4.90	4.00	17.90	78.00	2.24
Fiber	Fiber		Optimum	Flow	VA,	VMA,	VFB,	
content,	length,	OBC,	stability,	value,	%	%	%	Gmb
%	mm	%	kN	Mm				
	0	5.60	11.40	3.15	2.40	15.40	84.00	2.33
0.75	5	5.90	12.20	3.70	3.60	17.40	80.00	2.26
	10	5.77	13.30	3.10	2.20	15.00	86.00	2.30
	15	6.00	12.50	3.40	4.00	17.00	78.00	2.25
	20	6.13	12.30	3.50	4.30	18.45	77.00	2.24
Fiber	Fiber		Optimum	Flow	VA,	VMA,	VFB,	
content,	length,	OBC,	stability,	value,	%	%	%	Gmb
%	mm	%	kN	Mm				
	0	5.60	11.40	3.15	2.30	15.30	84.00	2.33
1	5	5.93	12.30	4.20	3.60	17.60	80.00	2.24
	10	5.77	12.50	3.40	4.30	17.65	76.00	2.24
	15	5.55	13.40	3.20	2.80	16.10	82.00	2.28
	20	5.63	12.65	3.8	2.30	16.20	83.00	2.28

5. CONCLUSION

Based on experimental study the following conclusions were drawn,

1. From the aftereffects of the Marshall tests it was watched that the DBM mixes arranged with base cinder and fly fiery debris utilized separately in 300-75 micron sizes and passing 75 micron came about best mixes fulfilling the Marshall criteria when bitumen content, fiber substance and fiber length were 5.6%, 0.5% and 10mm individually.

2. It is likewise watched that Marshall solidness and stream qualities are very adequate when the coal fiery remains substance is inside 15%.

3. It is likewise watched that with increment in fiber substance and fiber length, air-void and stream reductions and Marshall Quotient expands which thus is because of higher strength esteem.

4. An increment in fiber substance and fiber length brought about higher prerequisite of ideal bitumen substance and emulsion for covering of the filaments.

5. From the roundabout elasticity test it is seen that the backhanded rigidity of test expanded because of the expansion of emulsion covered fiber and coal fiery remains, which gives an astounding building property for DBM test to persevere through warm splitting.

6. It is likewise watched the utilization of emulsion covered fiber, coal fiery debris or both in DBM blend builds the imperviousness to dampness incited harms decided regarding rigidity proportion and held solidness values.

6. REFERENCES

1. AASHTO T 283, "Standard method of test for resistance of compacted asphalt mixtures to moisture-induced damage", American association of state highway and transportation officials.

2. Ali, N., Chan, J. S., Simms, S., Bushman, R., & Bergan, A. T.; "*Mechanistic evaluation of fly ash asphalt concrete mixtures*". Journal of Materials in Civil Engineering, (1996), *8*(1), 19-25.

3. Al-Suhaibani, A. S., & Tons, E. T.; "*Properties of fly ash-extended-asphalt concrete mixes.*" Transportation Research, (1991).

4. ASTM D 1559, “Test method for resistance of plastic flow of bituminous mixtures using Marshall Apparatus”, American society for testing and materials.

5. ASTM D 6931, “Indirect Tensile (IDT) Strength for bituminous mixtures”, American society for testing and materials, (2007).

6. ASTM D 792, “Standard test methods for density and specific gravity of plastic by displacement”, American society for testing and materials, (2008).

7. Boyes, A. J.; “*Reducing moisture damage in asphalt mixes using recycled waste additives*”

8. Diss. California Polytechnic State University, San Luis Obispo, (2011).

9. Chakroborty, P., & Das, A. “Principles of Transportation Engineering”, Prentice Hall of India,

10. New Delhi, (2010), pp 294-299.

11. Colonna, P.; Berloco, N., Ranieri, V., & Shuler, S. T. (2012), “*Application of bottom ash for pavement binder course.*”, Procedia-Social and Behavioral Sciences 53 (2012): 961-971.

12. Gunalaan, V.; “*Performance On Coal Bottom Ash In Hot Mix Asphalt*” International

13. Journal of Research in Engineering and Technology, (Aug 2013) eISSN: 2319-1163 | pISSN: 2321-7308.

14. Hadiwardoyo, S. P.; *“Evaluation of the addition of short coconut fibers on the*

15. *characteristics of asphalt mixtures.”* Civil and Environmental Research 3.4 (2013): 63-73.

16. :http://www.themartincompanies.com/sites/themartincompanies.com/files/asphalt/pds/SS-1.pdf.)

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

17. http://textilelearner.blogspot.in/2013/01/sisal-fiber-properties-of-sisal-fiber.html

18. http://www.civil.iitb.ac.in/~vmtom/1100_LnTse/407_lnTse/plain/img13.png

19. http://www.google.co.in/imgres?imgurl=http://www.mellausisal.co.uk/img/environmentl/agave.jpg&imgrefurl=http://www.mellausisal.co.uk/about/environmental_statement&h=26&w=400&tbnid=YCOsLX5KgxSLM:&zoom=1&docid=gkrbNH2Xf9aBM&ei=fFRpVYXXN om3uATy7IDwDA&tbm=isch&ved=0CCEQMygFMAU

20. Hunsucker, D. Q.; *"Design and Performance of a Bituminous Surface Mixture Containing*

21. *Bottom Ash Aggregate."* (1992).

22. IS: 2386, "Methods of test for aggregates for concrete (P - I): Particle size and shape",

23. Bureau of Indian Standards, New Delhi, (1963).

24. IS: 2386, "Methods of test for aggregates for concrete (P-III): Specific Gravity, Density,

25. Voids, Absorption, Bulking", Bureau of Indian Standards, New Delhi, (1963).

26. IS: 2386, "Methods of test for aggregates for concrete (P-IV): Mechanical Properties",

27. Bureau of Indian Standards, New Delhi, (1963).

28. IS: 1203, "Methods for testing tar and bituminous materials: determination of penetration",

29. Bureau of Indian Standards, New Delhi, (1978).

30. IS: 1205, "Methods for testing tar and bituminous materials: determination of softening point", Bureau of Indian Standards, New Delhi, (1978).