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Effect of Compaction Temperature on Durability of Bituminous Concrete

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***Abstract*: The properties of Hot Mix Asphalt (HMA) paving materials depend upon the mixing and compaction temperatures. In the present study, the effect of compaction temperature on the durability parameters of Bituminous Concrete (BC) paving mix was carried out. Mix design of BC by Marshall Method using VG-30 grade bitumen was carried out.**

Five series of samples at compaction temperature 140˚C, 125˚C, 110˚C, 95˚C and 80˚C were prepared and tested for durability parameters such as Marshall Quotient, Tensile Strength Ratio and Permeability in the laboratory. The test results of samples at 125˚C, 110˚C, 95˚C and 80˚C were compared with the results obtained at compaction temperature of 140°C. On the basis of test results, it has been observed that there is minor variation in the properties of mixture by decreasing the compaction temperature from 125˚C to 110˚C, however drastic change in the properties has been observed as compaction temperature falls below 110˚C. On the basis of this study it has been concluded that if the compaction temperature falls below 110˚C, durability parameters of the mix deteriorate drastically.

Keyword: Bituminous Concrete, Compaction Temperature, Marshall Quotient, Indirect Tensile Strength (ITS), Tensile Strength Ratio (TSR), Permeability.

I. INTRODUCTION

Bituminous Concrete is a type of HMA used as wearing course in the flexible pavement. The properties of compacted layer of bituminous mixes depend upon the compaction temperature of mix. There are several case studies in which the surface course failed due to laying and compacting of the bituminous layers at lower temperatures than specified temperature.

Saedi Houman (2012) conducted study to determine the effect of temperature on volumetric properties of HMA. On the basis of test results, author concluded that best temperature for compaction of HMA is 145˚C. Vasconcelos et.al (2012) studied the effect of low temperature on Indirect Tensile Strength of asphalt mixtures by using normal bitumen, polymer modified bitumen, asphalt rubber and elvaloy and concluded that the mix with polymer modified asphalt showed highest tensile strength. Mehndiratta et.al (2007) evaluated the effect of mixing and compaction temperature on Marshall Parameters of three types of bituminous mixes i.e. Dense Graded Bituminous Macadam (DBM), Bituminous Concrete (BC) and Semi Dense Bituminous Macadam (SDBC) at twenty temperature combinations. The authors concluded that Marshall Stability decreases and porosity increases as mixing and compaction temperature decreases. Ahmed Hassan Youness (2005) investigated the effect of temperature on Hot Mix Asphalt (HMA) at compaction temperature of 140˚C, 110˚C and 80˚C. It was observed that there is a very slight variation in properties of HMA up to 110˚C but after further reducing temperature, the properties changes drastically.

In view of the literature review, it has been observed that effect of compaction temperature on Marshall Parameters of HMA had been done by various researchers but durability parameters did not studied by anyone. Therefore present study was planned with the following objectives:

A. To find variation in Marshall Quotient, Tensile Strength Ratio and Permeability of BC mix at different compaction temperatures.
B. To arrive at acceptable value of compaction temperature for BC mixes without degrading the durability parameters.

II. METHODOLOGY AND EXPERIMENTAL WORK

A. Methodology

In the present study, the effect of compaction temperature on durability of Bituminous Concrete (BC) mix was examined. Stone aggregates of size 20mm, 10mm and crusher dust were collected from a local crusher and bitumen of grade VG-30 was procured from a vendor. The physical properties of aggregates and bitumen were determined as per relevant IS codes and test values were compared from MoRTH specifications.

Sieve analysis of aggregates and stone dust was carried out. Proportioning of aggregates was done for Bituminous Concrete (BC), Grading 1 as prescribed in MoRTH. The design of BC was carried out by Marshall Stability method and Optimum Binder Content (OBC) was determined corresponding to maximum bulk density, maximum stability and 4% air voids.

At OBC, five series of Marshall Specimens at compaction temperature of 140˚C, 125˚C, 110˚C, 95˚C & 80˚C were prepared. The characterization of materials and Marshall Stability test results had been published elsewhere and results of further experimental work to find Marshall Quotient, TSR and permeability of the mix, has been discussed in the present paper.

B. *Experimental Work*

1) *General:* The physical properties of aggregates and bitumen were determined in the laboratory which has been shown in Table 1 and Table 2 respectively. The test results of aggregates and bitumen are within the specified limits of MoRTH.

TABLE 1
TEST RESULTS OF AGGREGATES

Properties	Test Method	Obtained Values	IS Specifications
Grain Size Analysis	IS 2386 Part 1	3.18	Maximum 5% passing 0.075mm
Flakiness and Elongation Index	IS 2386 Part 1	25.6	Maximum 35% Combined
Impact Value	IS 2386 Part 4	22.4	Maximum 24%
Abrasion Value	IS 2386 Part 4	25.7	Maximum 30%
Water Absorption	IS 2386 Part 3	0.48	Maximum 2%
Specific Gravity	IS 2386 Part 3	2.55 (20mm)	2.5-3
		2.58 (10mm)	
		2.60 (Stone Dust)	

TABLE 2
TEST RESULTS OF BITUMEN

Test	Test Method	Test Results	Specifications as per IS 73 (2007)
Ductility	IS - 1208	100cm	Minimum 40cm
Specific Gravity	IS - 1202	1.01	Minimum 0.99
Softening Point	IS - 1205	52˚C	>47˚C
Viscosity	IS - 1206	385cST	Minimum 350cST

2) *Gradation Considered for Bituminous Mix:* For Bituminous Concrete, Grade 1 was selected as per MoRTH specifications. The required grading for the mix is as given in Table 3. The graphical representation of achieved gradation along with upper & lower limits has been shown in Figure 1. The Figure shows that achieved gradation is well within upper and lower limits of MoRTH.

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TABLE 3
COMPOSITION OF BITUMINOUS CONCRETE LAYER, GRADING 1 (MORTH-2013)

Sieve Size mm	20mm (30%)	10mm (30%)	Stone Dust (40%)	Obtained Gradation	Desired Gradation
26.5	30.00	30.00	40.00	100.00	100
19	27.88	30.00	40.00	97.88	90-100
13.2	7.40	27.15	40.00	74.55	59-79
9.5	1.07	22.65	40.00	63.72	52-72
4.75	0.00	14.31	30.23	44.54	35-55
2.36	0.00	11.07	20.68	31.75	28-44
1.18	0.00	8.03	15.42	23.45	20-34
0.6	0.00	6.44	11.12	17.56	15-27
0.3	0.00	4.37	7.72	12.09	10-20
0.150	0.00	2.61	4.20	6.81	5-13
0.075	0.00	1.14	2.04	3.18	2-8

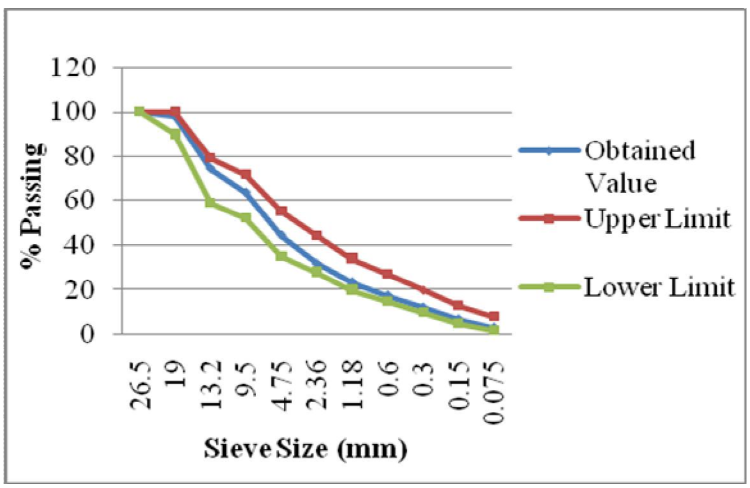

Fig. 1 Gradation of Aggregates

III. ANALYSIS OF RESULTS

The Optimum Binder Content (OBC) and Marshall Stability Test results had been published elsewhere. The OBC comes out to be 5.3%, by weight of mix which satisfies the minimum bitumen content of 5.2% as specified by MoRTH. The durability aspect of BC mix i.e. Marshall Quotient, Permeability and Tensile Strength Ratio (TSR) were determined as discussed below:

A. *Experimental Work to show effect of compaction temperature on Marshall Parameters*

1) *Marshall Stability Test Results:* The Marshall parameters on different series of compaction temperature are as shown in Table 4.

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TABLE 4
MARSHALL STABILITY TEST RESULTS

Compaction Temperature (°C)	Bulk Density	Air Voids (%)	VMA (%)	VFB (%)	Stability (kN)	Flow (mm)
140	2.28	4.25	16.89	74.83	13.11	2.78
125	2.27	4.67	17.26	72.96	12.84	2.97
110	2.26	4.97	17.52	71.64	10.56	3.98
95	2.07	12.93	24.43	47.09	5.78	4.75
80	2.03	14.96	26.19	42.89	2.66	6.35

2) *Marshall Quotient:* Marshall Quotient values are a good indicator of the mixture resistance to rutting and are directly related to creep stiffness. The range of Marshall Quotient as per MoRTH specifications is 2 – 5 (kN/mm). The relationship between Marshall Quotient and compaction temperature is shown in Figure 2. On decreasing compaction temperature from 140°C to 125°C, there is a small change of 8.3% in Marshall Quotient. On further reducing compaction temperature, the value further decreases. But below 110°C, the value of Marshall Quotient violates the specification of MoRTH.

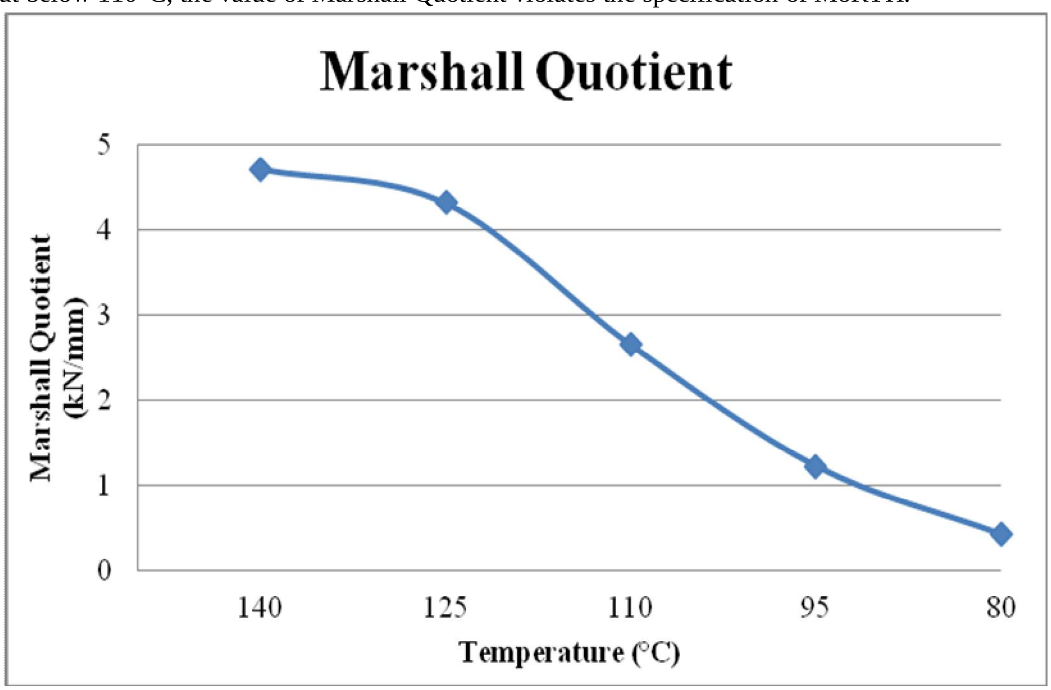

Fig. 2 Graphical Representation of Marshall Quotient

3) *Tensile Strength Ratio (TSR):* TSR is a measure of water sensitivity. Relation between compaction temperature and TSR is shown Figure 3. According to MoRTH specifications, the TSR must be minimum of 80%. Upto 110˚C, the value is above 80%. On reducing compaction temperature below 110˚C the value decreases at a drastic rate.

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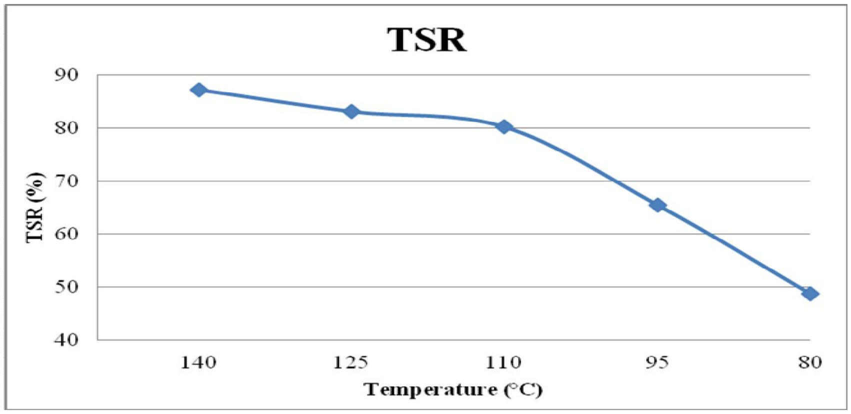


Fig. 3 Graphical Representation of TSR

4) Permeability

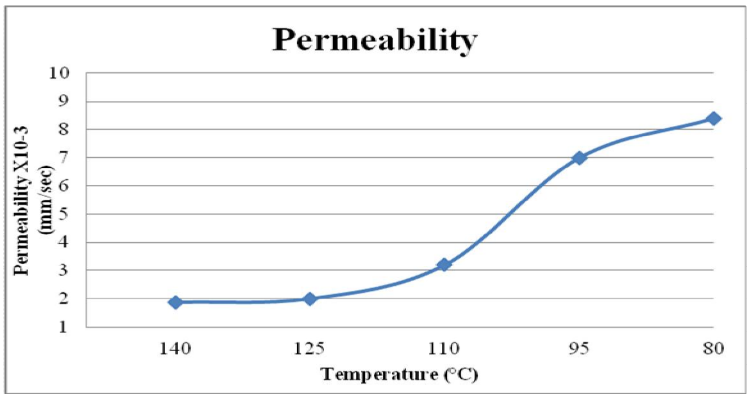


Fig. 4 Graphical Representation of Permeability

Relation between compaction temperature and Permeability is shown in Figure 4. The pavement surface layer must be impermeable to protect the structure from any surface infiltration. The permeability test apparatus was designed in the laboratory which was based on falling head permeability test method. The permeability test apparatus is shown in Figure 5.

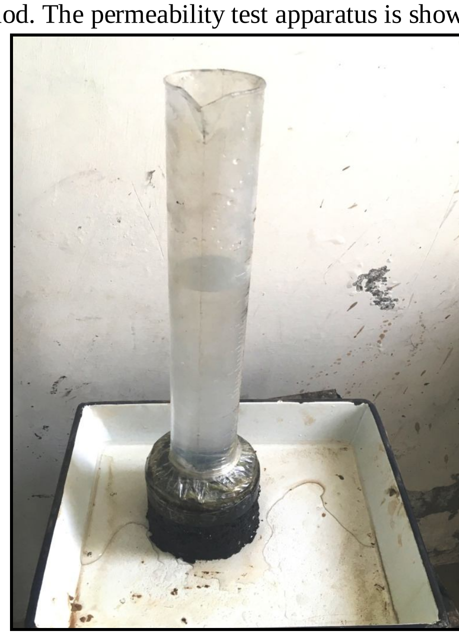


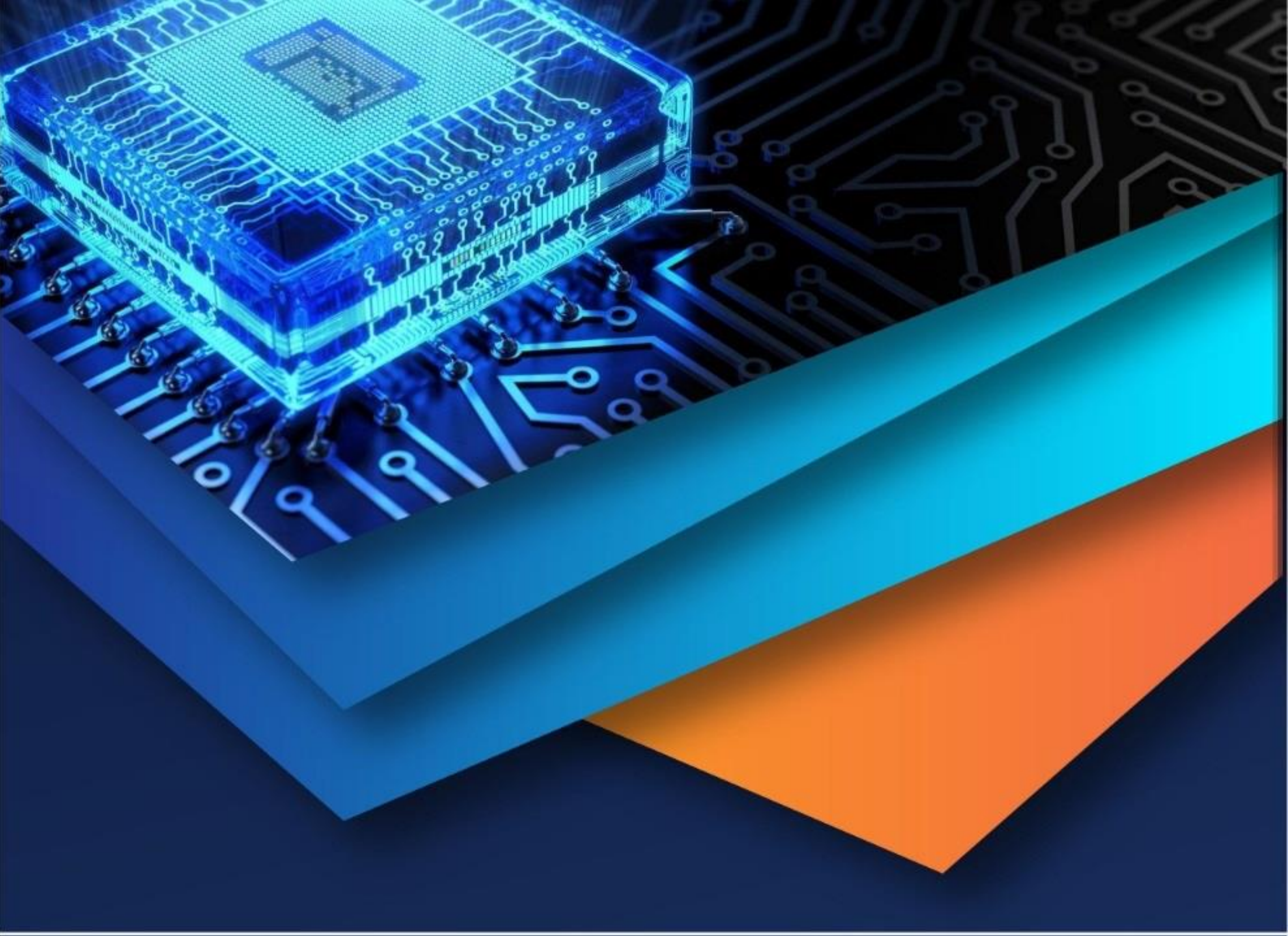
Fig. 5 Permeability test of Bituminous Samples

IV. CONCLUSION

On the basis of above study, it is concluded that best suitable compaction temperature of Bituminous Concrete (BC) is 140˚C but in any circumstances it should not go below 110˚C. Up to a compaction temperature of 110˚C, the values of Marshall Quotient and TSR are within the limits specified by MoRTH. There are no specifications given in MoRTH regarding the permeability of Bituminous mixes but on reducing the compaction temperature below 110˚C permeability increases at a very high rate. This may lead to breakage of bonding between the bitumen and aggregate particles and may also lead to damage of lower layers of the pavement.

REFERENCES

[1] Youness Ahmed Hassan, "Methodology for determining most suitable compaction temperatures for hot mix asphalt". Journal of Engineering Sciences, Vol. 33, No. 4, pp. 1235-1253, July 2005.
[2] Mendiratta H.C., Kumar Praveen, "Effect of Mixing and Compaction temperatures on Marshall Parameters of Bituminous mixes". IRC technical papers, April-June 2007.
[3] Saedi Houman, "Assessment of Compaction Temperatures on Hot Mix Asphalt (HMA) properties". International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering Vol. 6, No. 2, 2012.
[4] Vasconcelos Kamilla L, Bemuccil Bariani Liedi, Chaves Mario Jose, "Effect of Temperature on the Indirect Tensile Strength Test of Asphalt Mixtures". 5th Eurasphalt & Eurobitume Congress, 13-15th June 2012.
[5] Afaf A.H.M, "Effect of Aggregate Gradation and Type on Hot Asphalt Concrete Mix Properties". Journal of Engineering Sciences, Vol. 42, No. 3, pp. 567-574, May 2014.
[6] Manjunath K.R., Kumar Dheeraj N, G.S Thippeswamy, "Performance and Evaluation on Marshall Stability Properties of Warm Mix Asphalt Using Evotherm and Cecabase Rt-A Chemical Additive". International Journal of Engineering Trends and Technology (IJETT), Vol. 12, No. 8, June 2014.
[7] Sarkar Dipankar, Pal Manish, Sarkar Ashoke K., Mishra Umesh, "Evaluation of properties of Bituminous Concrete prepared from Brick-Stone mix aggregates". Advances in Materials Science and Engineering, Volume 2016.
[8] Lodhi Deepesh Kumar Singh, Yadav R.K., "Effect of Gradation of Aggregates on Marshall Properties of DBM Mix Design". International Journal of Engineering Research and Science & Technology, ISSN: 2319-5991, Vol. 5, No. 2, May 2016.
[9] Julaganti Ashok, Choudhary Rajan, Porwal S.S, Kumar Abhinay, "Effect of Reduction in Production Temperatures on Properties of Bituminous Mixes with an Organic WMA Additive". International Journal of Engineering Sciences & Research Technology, pp. 433-442, February 2017.
[10] Mohamed A.A, Boulbibane M, "Effect of Asphalt Mixture Compaction on Stability and Volumetric Properties of ACW14".
[11] IS 2386-1: "Methods of Test for Aggregates for Concrete, Part 1: Particle Size and Shape", Bureau of Indian Standards, New Delhi, India.
[12] IS 2386-3: "Methods of Test for Aggregates for Concrete, Part 3: Specific gravity, density, voids, absorption and bulking", Bureau of Indian Standards, New Delhi, India.
[13] IS 2386-4: "Methods of Test for Aggregates for Concrete, Part 4: Mechanical Properties" Bureau of Indian Standards, New Delhi, India.
[14] IS 1202: "Determining Specific Gravity of bitumen", Bureau of Indian Standards, New Delhi, India.
[15] IS 1205: "Determining Softening Point of bitumen", Bureau of Indian Standards, New Delhi, India.
[16] IS 1206: "Determining Viscosity of bitumen", Bureau of Indian Standards, New Delhi, India.
[17] IS 1203: "Determining Ductility of bitumen", Bureau of Indian Standards, New Delhi, India.
[18] IS: 73 (2006), "Paving Bitumen – Specification", Bureau of Indian Standards, New Delhi, India.
[19] Ministry of Roads Transport and Highways (MoRTH) (2013), "Specifications for Road and Bridges Works", Fifth Revision, Indian Road Congress, New Delhi.
[20] ASTM, "Standard test method for Marshall Stability and flow of bituminous mixtures," ASTM D6927-06, ASTM International, West Conshohocken, Pa, USA, 2006.
[21] Khanna S.K. and Justo C.E.G, Highway Material testing (Laboratory Manual), Nemchand and Bros, Roorkee 1997.



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