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Experimental Investigation on Partial Replacement of Bakelite powder as a fine Aggregate in Bituminous Mix

Sahebagouda R Patil*[1], Ushe Y Neeralakeri*[2], Kishan Neelkhant Nagannavar*[3], Krishna*[4], Dr.Vinay A*[5]

**1,2,3,4 UG Students , Department of Civil Engineering, Dayananda Sagar College of Engineering, Bangalore-560078, Karnataka, India.*
**5 Associate Professor, Department of Civil Engineering, Dayananda Sagar College of Engineering, Bangalore-560078, Karnataka, India.*

A B S T R A C T

India is a growing country depending on infrastructure and transport system, materials used to lay Bituminous paved roads and concrete pavements in our project we are trying to transform the bituminous mixture by slowly replacing bakelite powder as a fine aggregate, a viewing point of use of Bakelite powder in Bituminous mix gives a good result. Mixing bakelite powder with bituminous mixture also prolongs the life of the pavement. And the use of Bakelite powder prolongs the life of the pavements for a long time. It has a three-dimensional structure and is a naturally amorphous polymer. It provides strength, toughness and durability.

Keywords: Bakelite powder, Bitumen,

1. INTRODUCTION

Electronic waste products contain a variety of electrical and electronic components. The average waste generation generation was approximately 400,000 tons of waste per year and is expected to grow by 15% - 20% per annum. Includes garbage from items such as cell phones, laptops, stereo, washing machines, typewriters and other household items. Electronic waste products fall into the category of hazardous and non-hazardous materials. In particular, it contains non-ferrous metals and iron ore. It also contains a number of toxic substances that can cause serious problems for human health and the environment if not treated properly. Different types of e-waste require proper disposal, otherwise they can cause serious health-related problems for people. The recycling of e-waste can reclaim part that can be used in a Bakelite way. It can also be used in asphalt mixing to improve its performance. This is often used to improve engineering facilities and the health of bituminous roads. In this way we can reap economic benefits and reduce the environmental impact of waste.

1.1. Bakelite

1.2. Bakelite is a trademark of phenol-formaldehyde. The first plastic made of synthetic materials. Bakelite is a type of thermosetting plastic formed by the condensation reaction of phenol containing formaldehyde. Belgian-American chemist Leo Barkeland founded Bakelite in 1907. In 1993, the American Chemical Society recognized its importance as the world's first synthetic plastic. It has high performance engineering properties and is cheap. Bakelite in powder form is shown in Fig.

* *Corresponding author..*
E-mail address: krishnarao94510@gmail.com

2. MATERIAL

2.1. Bitumen

In this study the vg 30 grade is used to prepare the samples for experiment as per (IRC: 111- 2009)

2.2. Fine Aggregate

In this investigation fine aggregate as per IS:383 Specification. Fine aggregates should be clean, hard, durable, dry and free from dust and deleterious matter.

2.3. Waste Bakelite

In this investigation waste Bakelite was used in powder form.

2.4. Filler

The filler were used as per MORTH specifications.

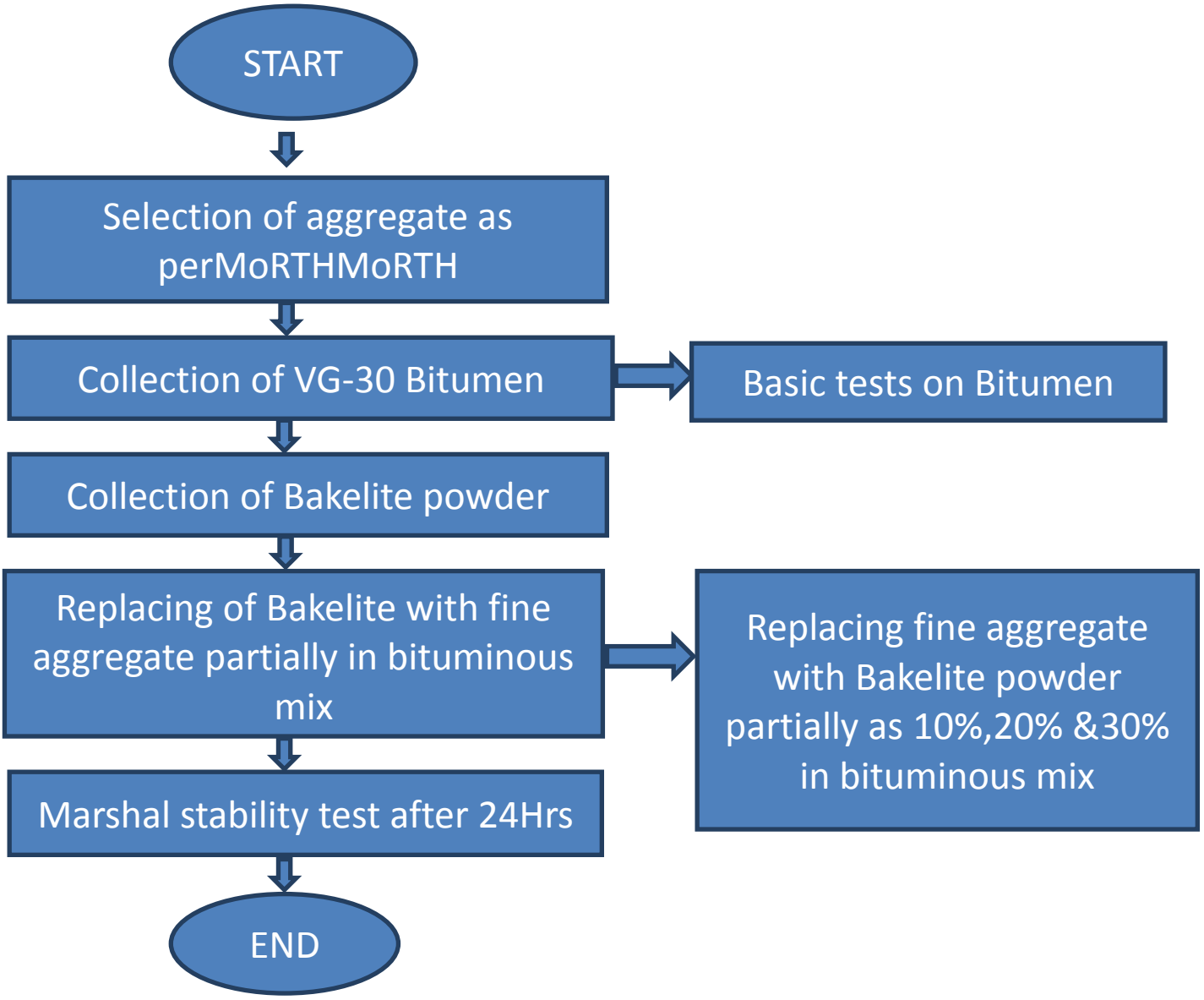
2.5. Coarse Aggregate

The Coarse aggregate were used as per MORTH specifications.

3. OBJECTIVES

1. To check the suitability of utilization of Bakelite powder in Bituminous mixture.
2. To evaluate design properties of Bakelite based Bitumen mix.
3. To evaluate mechanical properties (Marshal Stability

4. Methodology



5. Literature Review

5.1 **Akshay Gupta, Avani Chopra**, Comparative Study Of Conventional And Bakelite Modified Bituminious Mix
Utilization of waste Bakelite help in minimizing the disposal problem.
The life and dynamics of flexible pedals are superior to that of conventional paved surfaces and increase the properties of the bitumen mixture.
The entry value is very low at 1.75% which indicates a significant improvement in shear resistance at high temperatures and a very high softening point of 1.75% Bakelite indicates better aging resistance.

5.2 **Sudarshan V , Dr Suresh G**, Laboratory Performance Studies Of Bituminous Concrete Mix Prepared Using Copper Slag As Partial Replacement Of Fine Aggregate.
Increasing value for Marshall stability, Bulk density and VFB in bituminous concrete mixtures by high percentage exchanges combined with copper slag.

The flow rate and air permeability decreased with the addition of copper slag as a substitute for the aggregate component in the bituminous concrete mix. There is a slight variation in the content of Optimum Bitumen content with the addition of copper slag as changing the part of the fine mixture in bituminous concrete mixing.

5.3 **Saqib Shabir , Er. Deepak Kumar**, Comparative Analysis of Conventional and Baklite Modified Bituminious Mix.
The concept of mixing plastic waste with bitumen, can help with recycling and reducing waste disposal. It is a non-perishable product and encourages engineers to grow the infrastructure and economy of the country by using these materials in the construction industry. Some waste is emitted by gasoline and land charges could cause environmental damage. This study estimates that waste can be used as an antiseptic agent, that waste can be used in the construction of a flexible pedestrian system to improve efficiency and both will continue to have some degree of conditional change and violence against heavy traffic.

5.4 **S.Sakthi Sasmitha, Dr.R.N.Uma,** A Critical Review on the Application of Bakelite as a Partial Replacement of Fine and Coarse Aggregate.
Current research reveals the properties and uses of Bakelite as a building material in bricks, paver blocks, and solid blocks with appropriate meanings. The use of waste in the construction industry creates a challenging and efficient operation and development of the construction industry. The inclusion of plastic waste in building materials provides a solid component of cost and light weight in construction that alters the strength and durability of the material. This research helps to develop a recyclable material (Bakelite waste) to combine fines and coils to reduce waste disposal that creates a waste management problem.

5.5 P. **Dharani , Dr. R.N. Uma**, Use of waste bakelites in Flexible Pavement Construction.
The high content of bituminous mix binder is found in up to 20% of waste bakelite marshall prices and marshallic structures can be increased by all sizes 9.5mm, 4.75mm, 2.36mm. This study concludes with the addition of bakelite waste into a bituminous mixture providing better performance than regular aggregates. Therefore, contaminated bakelites help reduce the combined use, which can be used in the construction of a flexible road in the coming years.

5.6 **R. Manju et al.** [2017] usage of plastic wastes in a bituminous pavement.
Plastic debris collected from garbage cans, is cut and added as a composite and packaged material in bitumen. Necessary tests for aggregates and bitumen were performed to determine the major characteristics and energy parameters. Concluding that plastic waste roads are stronger than flexible roads and can be used in severe traffic situations, TiO2 has been increased by 10% to reduce traffic pollution.

5.7 **Himanshu Hanurmesh Rivankar et al.** [2016] formation of layers in the road pavement structure and material requirements for the road pavements.
The paper concludes that plastics can be used in combination with bituminous alloys to improve road performance by reducing its repair costs.

5.8 **Brajesh Mishra** [2016] use of plastic wastes in bituminous mixes of flexible pavement by wet and dry processes.
tests were performed to evaluate features and their effectiveness. This paper concludes that waste plastics are mixed, reducing the amount of void present in aggregates and can be used as conversion agents in bitumen.

5.9 **Geenu J Thachampuram and Prof. (Dr) Mathews M Paul** [2018] have done research with the aim of minimizing plastic waste and improving the eco-friendly environment. Includes the replacement of part of Bakelite (E-plastic waste) as good compounds from 10% to 25% with an increase of 5% and 40% of recycled amount and 60% of natural aggregate used as aggregate coarse, and the cubes are discarded and tested. E-plastic waste was converted to 20% of the total amount of concrete. The paper concludes that 15% of the bakelite was filled to form a thick concrete and the maximum compressive strength of the bakelite concrete cube was obtained at 15% of the bakelite return.

5.10 **Akhilesh Yadav & Ruchi Chandrakar** [2017] indicates that plastic waste can be used in road construction to reduce waste storage facilities in the city. The plastic road increases the durability and strength of the road. Waste plastics are reduced in size by a dry and wet process and mixed with bitumen. This paper concludes that the modified bitumen polymer provides better performance, reduces corrosion, piercing and no hollow formation.

5.11 **Johnson Kwabena Appiah et al.** [2017] demonstrates road construction in Ghana using Poly-Ethylene Terephthalate (PET) and High Density PolyEthylene (HDPE). Road construction materials are selected and tested in a laboratory. This concludes that when you add thermoplastic converters to normal bitumen to improve the elastic behavior of the tar. The study also showed that modified bitumen plastic waste has a good promise as an alternative recycling method for plastic waste management in Ghana, as well as a non-traditional, modified binder for road construction.

5.12 **Shubham Bansal et al.** [2017] describes the use of disposable materials as replacing part of the asphalt to create a modified commitment to making common bituminous concrete composite materials. Rubber and plastic are mixed with bitumen evenly and a binder test is performed. Blended experiments were performed to mix bituminous concrete and the content of the top binder was determined by marshalline analysis. This eliminates the use of rubber wheels and disposable plastic bottles enhancing the overall strength and durability of the BC compound by increasing its overall performance and may also prevent environmental pollution caused by dumping such waste on the ground.

5.13 **V.Rushendrareddy et al.** [2017] describes the paper which is related to the usage of waste plastics in flexible pavement. The waste plastics and bitumen are mixed and heated, the mixed bituminous plastic and aggregate is again heated and weighed. This paper concludes that bituminous plastics are used to increase the binding between aggregates, reduces the voids, prevents the moisture absorption and oxidation of bitumen by entrapped air.

5.14 **Axay Shah et al.** [2015] shows a paper on the use of non-recyclable waste, incineration and environmental degradation. All major bitumen tests are performed and the total polymer content is determined by the marshall stability point. This paper concludes that the behavior of modified polymer bitumen improves a variety of features, polluting polymers in the footprint improves road performance and reduces environmental pollution which is a cost-effective method.

5.15 **Mahesh M Barad** [2015] use of plastic in bituminous road construction,
experimental tests were performed to determine the properties of bitumen and aggregate properties associated with plastic. This paper concludes that the modified bitumen of polymer can be used in low percentages, aggregates attached to plastic prevent moisture absorption, rust, piercing and no pot hole formation.

6. Results and Discussions

6.1 Priliminary tests Conductes on Bitumen

SL NO	TETS	RESULTS	PERMISSIBLE VALUE (IS 1201-1220)
1	DUCTILITY	74cm	97cm
2	RING & BALL TEST (SOFTENING PONIT)	55˚C & 54 ˚C	56˚C
3	PENETRATION TEST	6.5mm	6.0-7.0mm
4	FLASH & FIRE POINT TEST	320˚C (FLASH) 340˚C (FIRE)	
5	VISCOSITY TEST	8 seconds	
6	SPECIFIC GRAVITY TEST	1.025	0.97-1.02

6.2 Test Results on Bakelite Powder

1. Specific gravity of Bakelite powder Obtained is **1.30**
2. Sieve Analysis, 2kg of sample taken, calculation of sample in below given table

IS Sieve no	Weight of Bakelite Powder Retained	Percentage Retained	Cummulative Percent Retained	Percentage of Passing
4.75 mm				
2.36 mm	403 gm	20.15	20.15	79.85
1.18 mm	501 gm	25.05	45.2	54.80
600 micron	485 gm	24.25	69.45	30.55
300 micron	452 gm	22.60	92.05	7.95
150 micron	71.8 gm	3.59	95.64	4.36
75 micron	39.5 gm	1.975	97.615	2.385
Pan	47.7 gm	2.385	100	0
	2000 gm			

IS : 383 - 1970

TABLE 4 FINE AGGREGATES
(*Clause* 4.3)

IS Sieve Designation	Percentage Passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4·75 mm	90-100	90-100	90-100	95-100
2·36 mm	60-95	75-100	85-100	95-100
1·18 mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

3.According to IS 383-1970 Grading of Bakelite Powder is Zone 1

6.3 Test Results on Corse Aggregates

SL NO	TESTS	RESULTS	PERMISSIBLE VALUE	IS CODE
1	AGGREGATES CRUSHING VALUE	26%	30%	IS:2386(PART-IV)
2	IMPACT VALUE	21%	10-20 (STRONG) 20-30 (GOOD)	IS:2386(PART-IV)
3	SPECIFIC GRAVITY	2.65	2.5-3	IS:2386(PART-III)
4	WATER ABSORBTION	0.15	0.1-4%	IS:2386(PART-III)
5	LOS ANGELES ABRASION TEST	30%	30%	IS:2386(PART-IV)
6	FLAKINESS INDEX	12.69%	-	IS:2386(PART-I)
7	ELONGATED INDEX	5.74%	-	IS:2386(PART-I)

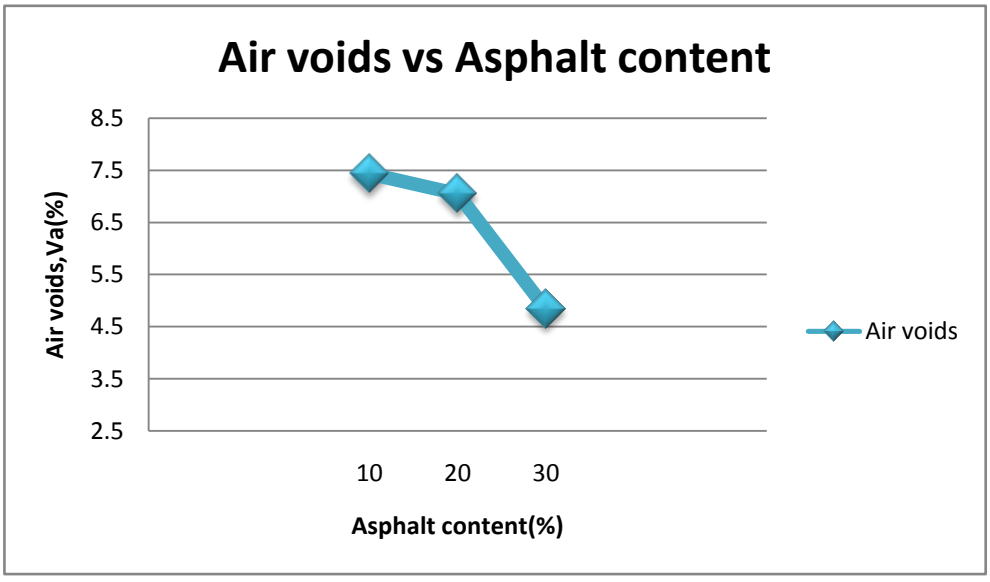
6.4 Aggregate Gradation

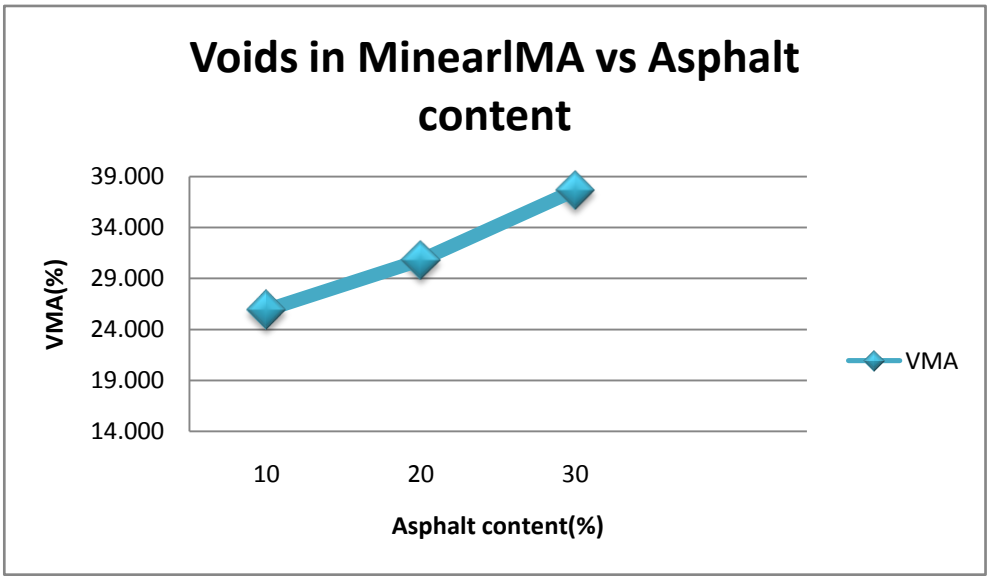
SIEVES	PASSING		%RETAINED	WEIGHT
19	100	100	0	0
13.2	90-100	95	5	60
9.5	70-88	79	16	192
4.75	53-71	62	17	204
2.36	42-58	50	12	144
1.18	34-48	41	9	108
0.6	26-38	32	9	108
0.3	18-28	23	9	108
0.15	12-20	16	7	84
0.075	4-10	17	9	108
			=93	
			7% DUST	=84
			=100	=1200gm

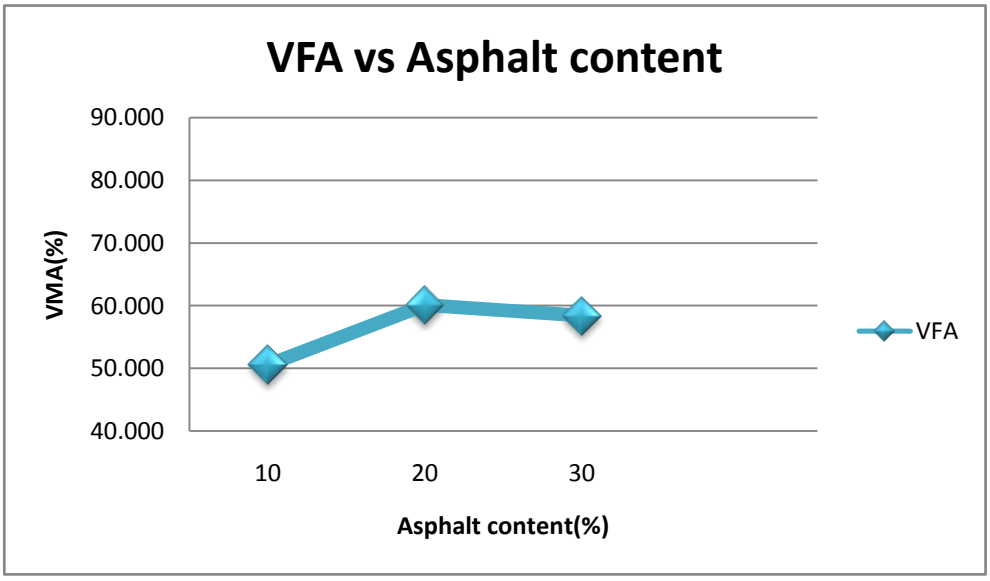
Bakelite Powder was partially replaced by 10%, 20%, 30% for the fine aggregates passing through 4.75mm sieve according to the weight of fine aggregates gradation.

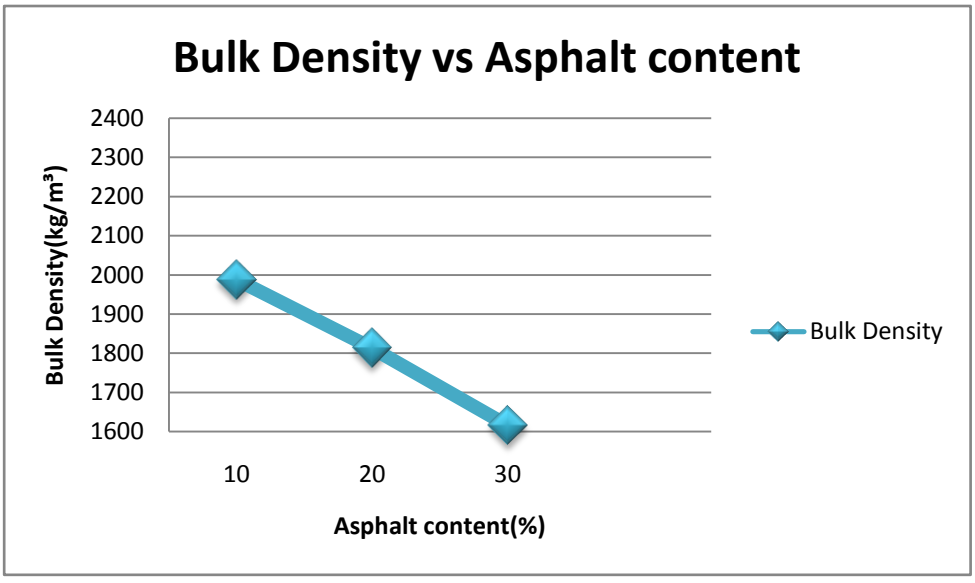
6.5 Marshal Properties of Modified Bituminous Mix With Partial Replacement of Bakelite powder with FA

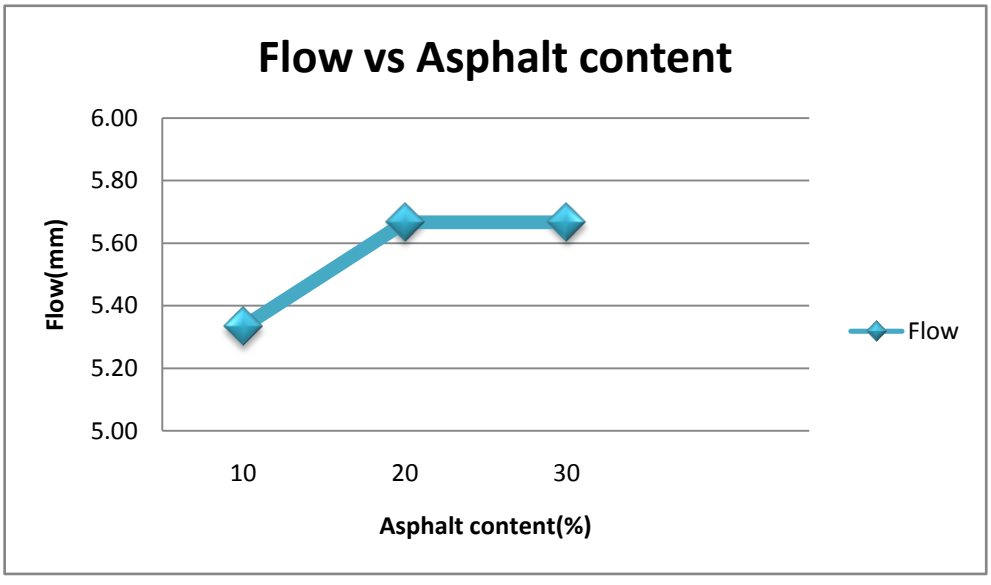
Description	10				20				30			
Specimen name	A1	A2	A3	Avg	B1	B2	B3	Avg	C1	C2	C3	Avg
Thickness(mm)	100	100	100	100	100	100	100	100	100	100	100	100
Height(mm)	72	70.3	73.67	71.99	72.3	66.3	69	69.20	66.3	69	68.67	67.99
Volume (cm^3)	565.20	551.86	578.31	565.12	567.56	520.46	541.65	543.22	520.46	541.65	539.06	533.72
Wt. In air(g)	1229	1170	1198	1199	1162	1028	1093	1094.333	916	989	993	966
Wt. In water(g)	628	587	572	595.67	532	460	480	490.6667	341	370	393	368
Dial reading	238	190	198	208.67	133	120	135	129.33	55	52	327	144.6667
Flow(mm)	5	7	4	5.33	6	5	6	5.67	3	6	8	5.67
Stability Value(kN)	13.075	10.438	10.877	11.463	7.306	6.592	7.416	7.105	3.021	2.857	17.964	7.000
Bulk density(kg/m^3)	2044.925	2006.861	1913.738	1987.293	1844.444	1809.859	1783.034	1812.811	1593.043	1597.738	1655	1615.385
Theoretical density(kg/m^3)	2279.535	2279.535	2279.535	2279.535	2066.85	2066.85	2066.85	2066.85	1915.616	1915.616	1915.616	1915.616
Percent Air Voids, Va(%)	10.292	11.962	16.047	12.820	10.761	12.434	13.732	12.291	16.839	16.594	13.605	15.673
Volume of Asphalt Vb(%)	20.048	9.838	9.381	13.089	36.166	9.759	9.614	18.513	46.854	9.398	9.735	21.996
Percent voids in Mineral Agg.VMA(%)	30.340	21.799	25.428	25.909	46.926	22.193	23.346	30.804	63.693	25.992	23.340	37.669
Percent voids in Asphalt VFA(%)	66.078	45.128	36.893	50.519	77.069	43.974	41.182	60.099	73.562	36.158	41.711	58.393

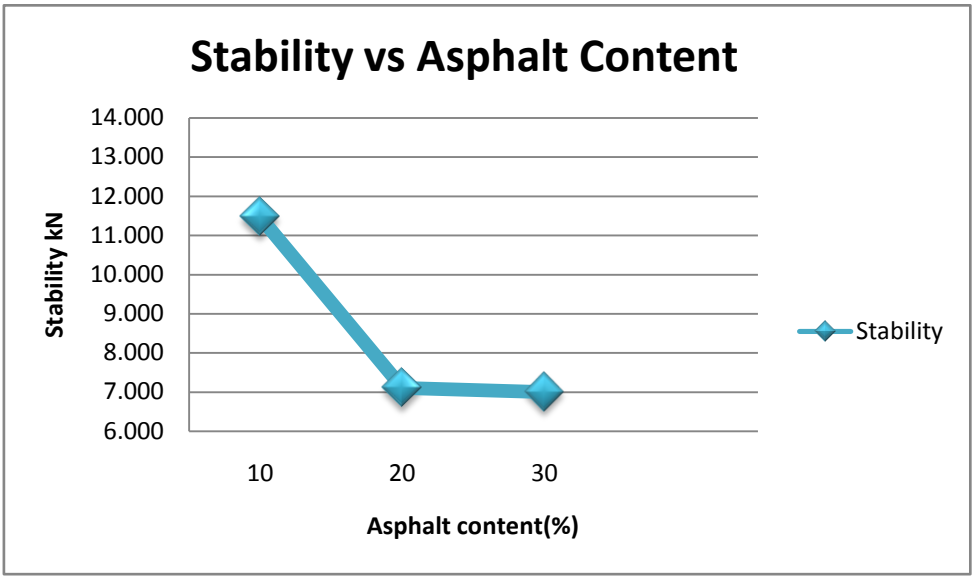



Voids in MinearlMA vs Asphalt content
39.000
34.000
29.000
24.000
19.000
14.000
VMA(%)
10
20
30
Asphalt content(%)
VMA


VFA vs Asphalt content
90.000
80.000
70.000
60.000
50.000
40.000
VMA(%)
10
20
30
Asphalt content(%)
VFA


Bulk Density vs Asphalt content
Bulk Density(kg/m³)
2400
2300
2200
2100
2000
1900
1800
1700
1600
10
20
30
Asphalt content(%)
Bulk Density


Flow vs Asphalt content
Flow(mm)
6.00
5.80
5.60
5.40
5.20
5.00
10
20
30
Asphalt content(%)
Flow



7. CONCLUSIONS

1. Optimum binder (Bitumen) content obtained is 5.5%
2. Increase in marshal stability value for modified Bituminous mix by Bakelite powder is 10%
3. Overall by conducting this experimental investigation on replacing Bakelite powder as fine aggregate partially, the waste bakelites can be used in flexible pavement constructions, hence the hazard can be avoided by some percent by utilizing them in our construction field.

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