International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

Use of waste bakelites in Flexible Pavement Construction

P. Dharani [1], Dr. R.N. Uma [2]

[1] Student, M.E. Construction Engineering & Management, Sri Ramakrishna Institute of Technology, Coimbatore, TamilNadu, India.
[2] Head of Department, Department of Civil Engineering, Sri Ramakrishna Institute of Technology, Coimbatore, TamilNadu, India.

---***---

***Abstract** - India has the second largest population of around 1.35 billion people, in which 60 million tonnes of wastes generated for every year. The generated wastes are classified into Organic wastes (biodegradable wastes), recyclable wastes (dry wastes) and biomedical wastes (hazardous wastes). Dump yards are the greatest urbanized problem in our country. Several forms of wastes plastics, bakelites, electronic wastes along with municipal solid wastes are dumped at landfill sites without proper disposals. The effects of dumping wastes cause pollution, fire hazards, health and safety risks, reduced property values and impacts on tourism. The waste bakelites are shredded into coarser and finer size particles with the help of the shredding machine. The aggregate and material tests were conducted to determine the strength characteristics of waste bakelite. Marshall stability test was conducted to find the optimum binder content, stability and flow values. This study helps to describe the application of waste bakelite for the betterment in the emerging construction field.*

***Key Words:** Aggregates test, Bituminous mix, Flexible pavement, Marshall Stability test, Waste bakelite*

1.INTRODUCTION

Plastics are the non-metallic substances which can be molded into different shapes and sizes. The plastics are manufactured from natural and synthetic resins. Generally classified into thermosets & thermoplastics. Thermosets are the cross-linked & strong chemical bonds, these are hard to recycle and cannot be softened by heating. Thermoplastics are the long, linear polymers that are weakly connected by chemical compounds, easy to recycle and can be softened by heating. The world's first synthetic plastic is **Bakelite** is a kind of **thermosetting** plastics, which was invented by American chemist Leo Hendrik Baekeland, New York in the year of 1903. It is formed from a condensation reaction of phenol and formaldehyde by using a basic catalyst. Owing to its electrical and chemical resistivity it is used in electrical components, insulation of wires, brake pads, kitchenware such as canisters and saucepan handles, etc.

A pavement consists of superimposed layers of processed materials above the natural soil sub-grade, whose function is to distribute the vehicle loads to the sub-grade. The pavement structure should have acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution. The pavement transmits the wheel and other moving loads to the subgrade soil.

Flexible pavement is composed of a bituminous material surface course (coating surface) and base and subbase courses. The design of flexible pavement is based on the characteristics of load distribution on a layered system. It transmits the load to the subgrade through a combination of layers. It distributes the load over a relatively smaller area of the subgrade beneath.

Rigid pavement is composed of cement concrete with or without reinforcement and prestressed concrete slabs. The pavement design is based on the stress distribution which occurs due to bending of slabs and temperature variations in the rigid pavement.

1.1 Need for this study

i. To use the waste bakelite as an alternative sub-base course in flexible pavement.
ii. To find the optimum amount of bakelite added to the bitumen by performing tests on different mix proportions.

1.2 Scope of this study

The scope of this study is to utilize the waste bakelite derived from the waste source into a useful material in the construction field.

2.MATERIALS & METHODS

2.1 Materials

Aggregates: Aggregates such as gravel, crushed stones, sand, quarry dust, etc. are used as sub-base and base course materials in flexible pavement. The aggregates size of 20 mm is used in sub-base course and aggregate size which is less than 20 mm are used in base course layers.

Major aggregate tests should be conducted to determine the characteristics of the aggregates on loading.

Bakelite: Bakelite is a kind of synthetic plastic. The properties of bakelite are: Strong and durable, it is resistant to heat, most chemicals & solvents. The colour range is limited to black or brown. It can be moulded very quickly, decreasing production time. It does not conduct electricity. Less in weight.

Bitumen: Bitumen is a viscous material, due to its excellent binding property it is added to the mixes to improve the stability and durability of the pavement.

2.2 Methodology

Collection of waste bakelite from the waste source

↓

Shredding & Classification of waste bakelite

↓

IS Standard testing of aggregates, bitumen and waste bakelite

↓

Preparation of marshall specimens with different proportions (addition of waste bakelite)

↓

Testing of bituminous mixes by using Marshall apparatus

↓

Determination of optimum binder content

↓

Results, Conclusions & Recommendations

2.3 Processing of waste bakelite

The collected waste bakelites have some irregularities such as shapes and finishes are not in perfect dimensions. For the further works, the material should be shredded into small pieces with the help of a shredding machine.

Fig -1: Processing & Classification of waste bakelite

3.TESTING OF MATERIALS

The preliminary testing of materials such as coarse aggregates, fine aggregates, waste bakelite and bitumen were tested to know about their performance characteristics and strength.

1) Aggregate Impact Value: This test gives a relative measure of the resistance of an aggregate to sudden impact. The test is carried out on the whole of aggregates, which passes on 12.5mm and retained on 10mm IS sieve. After the completion of impact load, the same process is repeated for the same sample. The weight of dry sample and weight of the sample after impact loading passing through 2.36 mm is noted.

2) Aggregate Crushing Strength test: The test is carried out to determine the aggregate crushing value of coarse aggregate. The material passing 12.5 mm IS sieve and retained on 10 mm IS sieve. The material is placed on a cylinder in three equal layers, each layer being tamped 25 times by a plunger. The load is released and the material is removed from the cylinder and sieved on 2.36 mm IS sieve. The fraction passing through sieve will be weighed.

3) Los Angeles Abrasion test: This method is carried out to determine the abrasion value of the coarse aggregates. The abrasion machine consists of a hollow steel cylinder, closed at both ends. At the completion of the test, the material shall be discharged from the machine and a preliminary separation of the sample made on a sieve coarser than the 1.70-mm IS Sieve. The finer portion shall then be sieved on a 1.70-mm IS Sieve.

4) Bulk Density of Aggregates: This method is carried out to determine the unit weight or bulk density of aggregates. The test shall normally be carried. out on dry material when determining the voids, but when bulking tests are required material with a given percentage of moisture may be used.

5) Specific Gravity of Aggregates: The test is carried out in pycnometer bottle in order to determine the specific gravity of finer size aggregates and finer waste bakelite particles. The water absorption of the aggregates can be determined by placing the samples in an oven for 24 hours.

6) Softening point of the bitumen: Softening Point of a bituminous material is defined as the temperature at which it gradually changes from semi solid to liquid state on the application of heat. It is carried out by Ring and Ball apparatus.

7) Penetration test: Penetration test is used to measure the consistency of semi solid bitumen, to classify them into standard grades. The test is carried out with standard penetrometer loaded with the needle.

8) Ductility Test: Ductility is the property of a material by virtue of which, a material elongates when subjected to tension before breaking (failure). This can be tested in an experimental set up with briquette mould by pulling their clips at the both ends.

9) Specific Gravity of the bitumen: Specific gravity of the bitumen is as similar to the specific gravity of aggregates. The bitumen is used instead of the aggregate in the test. The pycnometer method is followed.

10) Marshall Stability test: The Marshall stability and flow test provides the performance prediction measure for the Marshall mix design method. The stability test measures the maximum load of the test specimen at a loading rate of 50.8 mm/minute. Load is applied to the test specimen until it fails and the maximum load is taken as the

stability. The dial gauge is attached which measures the specimen's plastic flow (deformation) due to the loading. The flow value is recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load is recorded.

3.1 Testing Figures


Fig -2 & 3: Preparation of hot bitumen & Extraction of bituminous specimen from the mould


Fig -4 & 5: Specimen after 24 hours curing period & Marshall testing Apparatus

4.TEST RESULTS

Table -1: Test results of aggregate and bitumen

Name of the tests	Test results		Standard Values	Codal Provisions
	Con.aggregate	Waste Bakelite		
Aggregate Impact Value	21.7 %	10.44 %	Max 24%	IS: 2386-4 (1963)
Aggregate Crushing Value	33.24 %	21.8 %	Max 30%	IS: 2386-4 (1963)
Los Angel's Abrasion Value	48.94 %	15 %	Max 30%	IS: 2386-4 (1963)
Bulk density of aggregates	1577.8 kg/m³	1003.3kg/m³	-	IS: 2386-3 (1963)
Specific gravity of aggregates	2.58	1.38	-	IS: 2386-3 (1963)
Softening point of bitumen	46.4°C		45-55°C	IS: 1205 (1978)
Penetration test	65.6 mm		60-70 mm	IS: 1203 (1978)
Ductility test	98.3 cm		Min 75cm	IS: 1208 (1978)
Specific gravity of bitumen	1.01		Min 0.99	IS: 1202 (1978)

Marshall Stability Test: The optimum binder content of the bituminous mixes, marshall stability and flow values and marshall properties of the mix can be determined by performing Marshall Stability Test. Aggregate grading was done within MORTH specifications for 3 type of proportions (10%, 20% and 30% of shredded waste bakelite in the size of 9.5mm, 4.75mm & 2.36 mm) in bituminous mixes. Each sample is tested as per specifications and the observations are made.

Table 2 - Addition of waste bakelites in size of 9.5mm

Sample No	% of waste bakelite in 9.5 mm size	Bitumen Content %	Stability (kN)	Flow (mm)	Air Voids %	VMA %	VFB %
1	0%	5.5	12.1	3.06	5.3	18	75
2	10%	5.5	13.2	3.044	4.3	16	73.13
3	20%	5.5	12.15	2.12	3.805	11.54	75.23
4	30%	5.5	6.15	2.66	2.07	11.56	84.8

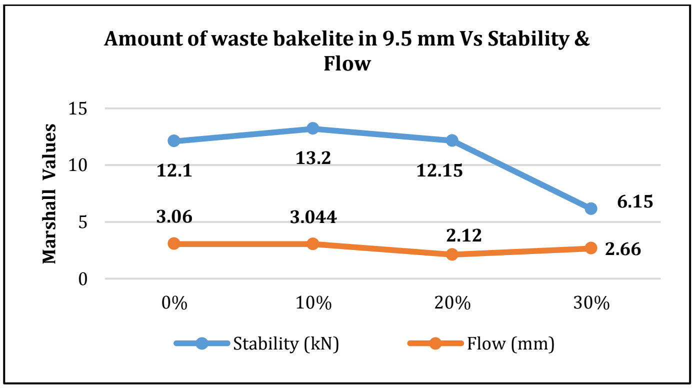

Chart -1: Amount of waste bakelite in 9.5mm Vs Stability Vs Flow

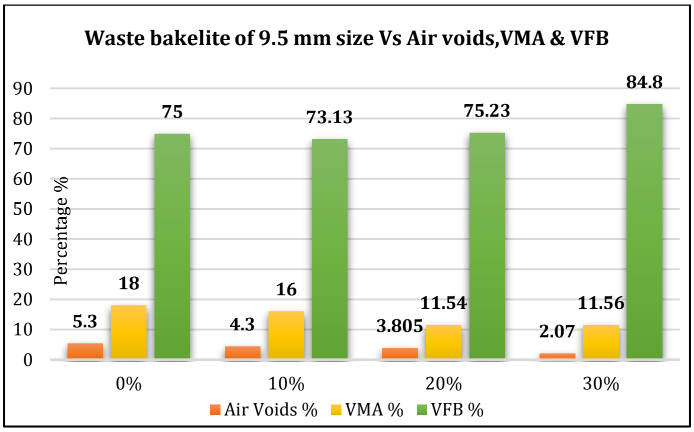

Chart -2: Amount of waste bakelite in 9.5mm Vs Air voids %, VMA & VFB

From Chart 1 & 2, the results show that on the addition of waste bakelite of 9.5 mm sizes in the bituminous mix, the marshall values were gradually increasing on 10% (13.2kN, 3.04mm, 4.3%,16% & 73.13%) and 20% (12.15kN, 2.12mm, 3.805%, 11.54% &75.23%) of waste bakelite & on the addition 30% (6.15kN,2.66mm,2.07%,11.56% & 84.8%) of waste bakelite causes decrease in marshall values.

Table 3 - Addition of waste bakelites in size of 4.75mm

Sample No	% of waste bakelite in 2.36 mm size	Bitumen Content %	Stability (kN)	Flow (mm)	Air Voids %	VMA %	VFB %
1	0%	5.5	12.1	3.06	5.3	18	75
2	10%	5.5	11.15	2.936	3.02	14.98	79.8
3	20%	5.5	8.12	2.96	3.75	11.76	75.8
4	30%	5.5	7.18	3.09	2.02	11.81	85.4

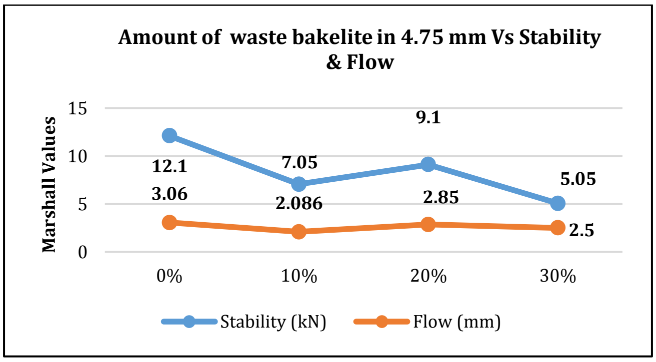

Chart -3: Amount of waste bakelite in 4.75mm Vs Stability Vs Flow

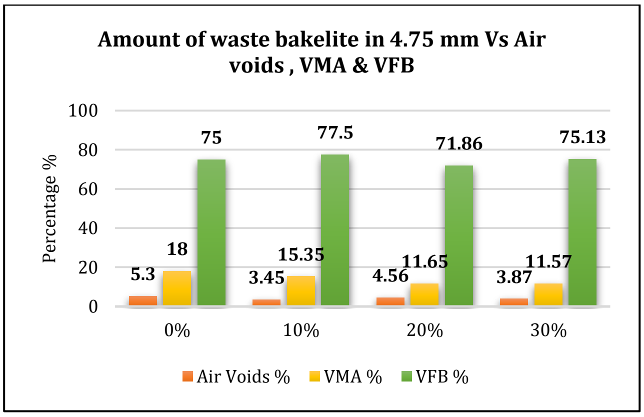

Chart -4: Amount of waste bakelite in 4.75mm Vs Air voids, VMA & VFB

From Chart 3 & 4, the results show that on the addition of waste bakelite of 4.75 mm sizes in the bituminous mix, the marshall values were gradually increasing on 20% (9.1kN, 2.85mm, 4.56%,11.65% & 71.86%) of waste bakelite & on the addition 10% (7.05kN,2.086mm,3.45%,15.35% &77.5%) & 30% (6.15kN,2.66mm,2.07%,11.56% & 84.8%) of waste bakelite causes decrease in marshall values.

Table 4 - Addition of waste bakelites in size of 2.36mm

Sample No	% of waste bakelite in 4.75 mm size	Bitumen Content %	Stability (kN)	Flow (mm)	Air Voids %	VMA %	VFB %
1	0%	5.5	12.1	3.06	5.3	18	75
2	10%	5.5	7.05	2.086	3.45	15.35	77.5
3	20%	5.5	9.10	2.85	4.56	11.65	71.86
4	30%	5.5	5.05	2.5	3.87	11.57	75.13

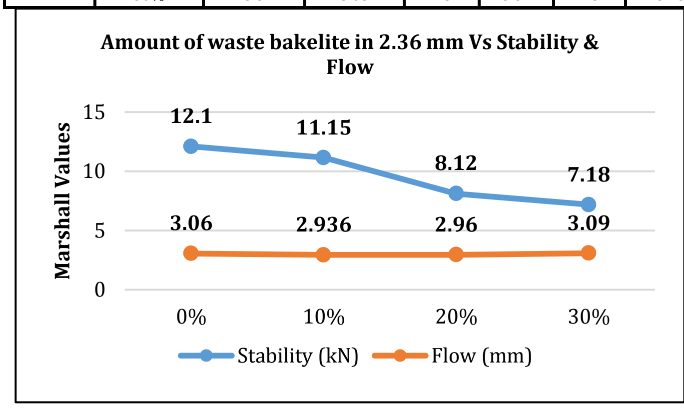

Chart -5: Amount of waste bakelite in 2.36mm Vs Stability Vs Flow

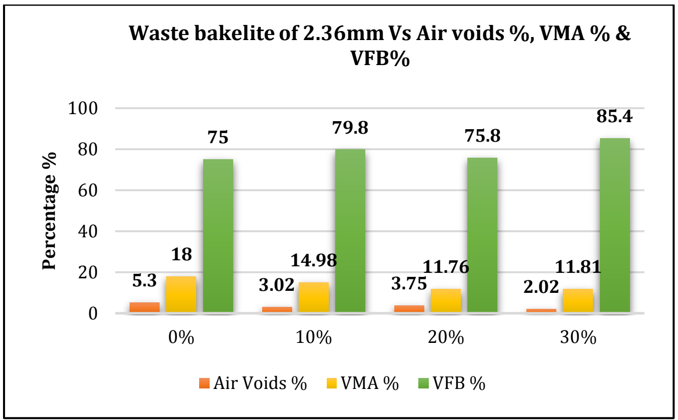

Chart -6: Amount of waste bakelite in 2.36mm Vs Air voids, VMA & VFB

From Chart 5 & 6, the results show that on the addition of waste bakelite of 2.36 mm sizes in the bituminous mix, the marshall values were gradually increasing on 10% (11.15kN, 2.936mm, 3.02%,14.98% & 79.8%) & 20% (8.12kN,2.96mm,3.75%,11.76% &75.8%) of waste bakelite & on the addition 30% (7.18kN,3.09mm,2.02%,11.81% & 85.8%) of waste bakelite causes decrease in marshall values.

5.CONCLUSIONS

From the above test results, the optimum binder content of bituminous mix is found up to 20% addition of waste bakelite the marshall values and marshall properties have an increase with all the sizes of 9.5mm, 4.75mm, 2.36mm. This study concludes on the addition of waste bakelites in the bituminous mix gives a better performance than conventional aggregates. Hence, waste bakelites helps to decrease the aggregate consumption, it can be used in the construction of flexible pavement in the upcoming years.

REFERENCES

[1] Adnan Yousaf, Arshad Hussain, Muhammad Irfan, Muhammad Babar Khan and Anwaar Ahmed, "Performance Evaluation of Asphaltic Mixtures Using Bakelite", Life Science Journal, Volume 11, Issue 7, pp.481-488, 2014.

[2] Shubham Bansal, Anil Kumar Misra and Purnima Bajpai, "Evaluation of modified bituminous concrete mix developed using rubber and plastic waste materials", Science Direct International Journal of sustainable built environment, Volume 6, pp.442-44, 2017.

[3] Johnson Kwabena Appiah, Victor Nana Berk-Boateng and Trinity Ama Tagbor "Use of waste plastic materials for road construction in Ghana", Science Direct Case Studies in Construction Materials 6, pp.1-7, 2016.

[4] Utibe J. Nkanga, Johnson A. Joseph, Feyisayo V. Adams and Obioma U. Uche "Characterization of Bitumen/Plastic Blends for Flexible Pavement Application", Elsevier – Science Direct, Procedia Manufacturing 7, pp.490-496, 2017.

[5] Himanshu Hanurmesh Rivankar and Sangeeta Rivankar "Plastic Bitumen Mix Road", International Journal of Innovations in Engineering Research and Technology, Volume 03, Issue 11, 2016.

[6] Nopagon Usahanunth and Seree Tuprakay "The transformation of waste Bakelite to replace natural fine aggregate in cement mortar", Elsevier - Science Direct Case Studies - Construction Materials 6, pp.120–133, 2017.

[7] Brajesh Mishra "Use of plastic wastes in Bituminous mixes of flexible pavements by wet and dry methods: A Comparative Study", International Journal of Modern Engineering Research, Volume 6, Issue 3, pp.41-50, 2016.

[8] Geenu J Thachampuram and Prof. (Dr) Mathews M Paul "Behaviour of Recycled Coarse Aggregate Concrete with Bakelite as Fine Aggregate", International Research Journal of Engineering and Technology Volume 5 Issue 04, 2017.

[9] V. Rushendrareddy, T. Surendra and B. Rahul "Use of Waste Plastic in Flexible Pavements", International Journal of Civil Engineering and Technology, Volume 8, Issue 5, pp. 350–356, 2017.

[10] Shiva Prasad K, Manjunath K. R and K. V R Prasad "Study on Marshall Stability Properties of BC Mix Used in Road Construction by Adding waste plastic bottles", IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE), Volume 2, Issue 2, pp.12-23, 2012.

[11] Axay Shah, Amit Macwan, Farhan Vahora, Nirmal Patel & Nisarg Gajjar "Utilization of Waste Materials in Pavement Construction", International Research Journal of Engineering & Technology, Volume 2, Issue: 03, pp. 1204-1207, 2015.

[12] SK. Wasim Anwar "Experimental Investigations on Marshall and Modified Marshall Specimens by using Neat Bitumen", International Journal of Civil Engineering and Technology, 7(5), pp.409–419, 2016.

[13] Mahesh M Barad "Use of plastic in bituminous road construction, Journal of Information", Knowledge and Research in Civil Engineering, Volume 3, Issue: 3, pp.208-212, 2015.

[14] Parthik B.Nakrani, Khushbu Bhatt and Siddharth Gupte "Maintenance and Rehabilitation of Flexible Pavement", International Journal of Advances in Mechanical and Civil Engineering, Volume 4, Issue:4, pp.16-18, 2017.

[15] Mercy Joseph Poweth, Solly George and Jessy Paul "Study on Use of Plastic Waste in Road Construction", IJIRSET Vol 2, Issue 3, 2013.

[16] IS 2386 (I to IV) (1963): "Methods of Tests for Aggregates for Concrete"

[17] IS 1201 to 1220 (1978): "Methods for Testing Tar and Bituminous Materials"

[18] IRC 37 (2012): "Guidelines for the design of flexible pavements" [Third revision]

[19] MORTH (2013) – "Specifications for road and bridge works" [Fifth Revision]

[20] S.K.Khanna and C.E.G. Justo, "Highway Engineering", Nem Chand & Bros, 9th Edition.