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POTHOLE REPAIR OF FLEXIBLE PAVEMENT USING EFFECTIVE MATERIALS

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ABSTRACT:

Roads are considered as one of the major ways for connecting with each other districts and also states. Since they are one of the direct contributors of growth in the economy of the country. There are certain threats which is faced by the roads. The biggest threat for road users is potholes. Potholes are the big holes appeared on the road which causes the problems, accidents for the road users due to pothole there are certain losses of life occurs in each year. This has become a big headache for the government and also for the authorities. So a certain solution for this has to be determined. In this study the effective repairing of potholes is carried out by a modified effective mix which is prepared by various waste materials such as crumb rubber, cardboard paper, plaster of Paris and cigarette butt. This mix can be adopted as a environmental and economical beneficial solution as it uses various waste materials. Reduce and reuse of materials are the major idea behind this proposal. Strength tests of aggregates, bitumen properties, material characteristics are also discussed and the mix with all the replacement materials which used as a replacement of aggregates are discussed in this paper. Replacement of aggregate by various waste materials helps in reducing the cost and also promoting reuse and recycle.

Keywords: potholes, accidents, modified effective mix, crumb rubber, cardboard paper, plaster of Paris and cigarette butt, reuse, recycle.

INTRODUCTION :

Using flexible foundations and layers of bitumen or asphalt, flexible pavements offer a flexible method to road construction. This design disperses stresses across a larger region by permitting some elasticity and deformation under traffic loads. In contrast to concrete-based rigid pavements, flexible pavements can be adjusted to various traffic and environmental conditions. The main benefits and characteristics of flexible pavements are examined in this introduction, which also lays the groundwork for a discussion of the typical issues they run into. Potholes are 'a depression or hollow in a road surface caused by wear or subsidence'. They are, very simply, parts of a road surface that have become damaged over time through cracking or wear. these potholes have to be well treated in order to avoid accidents as well as dangers. By repairing the potholes, the road becomes more effective, efficient and accident less. by using various waste materials, the economy is also served along with environmental positivity.

Fig.1 : Pothole

Waste materials as a replacement for Aggregates

Using waste materials as a replacement for aggregates in construction is a promising approach that can address both environmental and economic concerns. By substituting traditional aggregates with materials such as crumb rubber, cardboard paper, plaster of paris and cigarette butt reduce the demand for natural resources and decrease the amount of waste sent to landfills. Additionally, using waste materials in construction can help lower costs, as these materials are often less expensive than traditional aggregates. However, it is important to carefully assess the properties of the waste material to ensure that it meets the required standards for strength, durability, and safety. Despite some challenges, the use of waste materials as aggregates shows great potential for sustainable construction practices.

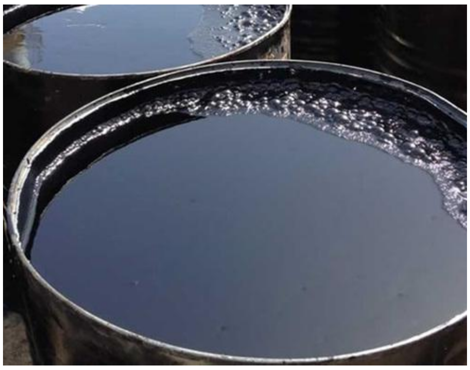
LITERATURE REVIEW

A paper on Physico-mechanical properties of asphalt concrete incorporated with encapsulated cigarette butts by Abbas Mohajerani, Yasin Tanriverdi, Bao Thachen, Kee Kong Wong, Ahmad Rezaei helped to understand about the encapsulation of cigarette butt with bitumen.Effect of crumb rubber production technology on performance of modified bitumen by C.Loderer, M.N.Partlr, L.D.Paulikokas talks about crumb rubber application on bitumen.Evaluating the dynamic stabilities of asphalt concrete mixtures incorporating plasterboard wastes by Dina kamal kuttah, Kenichi Sato, Chikashi Koga gaved an idea about using waste plaster of paris in bitumen.Pothole Repair Technology , A Review, International Journal for Scientific Research and Development by Tanuj Parmar, Prof. C.B. Mishra, Dr. Sangita, Prof. N. F. Umrigar gives clear picture about pothole and its repair. These papers helped to built or expand the mix to its best results.

MATERIAL

Bitumen: Bitumen is a petroleum derivative that is semi-solid or liquid, black, and sticky with high viscosity. It might be a refined product or it might be found in natural deposits. Bitumen is mostly utilised (70%) in road building, where it is combined with aggregate particles as a binder to make asphalt concrete. Bitumen usually comprises of 80% carbon by weight, 10% hydrogen, 6% sulphur, and between 5 and 25% of asphaltenes scattered in 90% to 65% of maltenes at the molecular level. Maltenes is the continuous phase and asphaltenes is the scattered phase in the typical colloid model. Most refined bitumen is utilised in the building industry, usually as a component of asphalt and roofing goods. VG 30 bitumen is used in this project.

Fig.2: bitumen



Aggregates: When combined with a binding medium (such as water, bitumen, Portland cement, lime, etc.) to create compound materials (such bituminous concrete and Portland cement concrete), mineral components including sand, gravel, and crushed stone are referred to as aggregates. In general, aggregate makes up between 70 and 80 percent of Portland cement concrete and 92 to 96% of bituminous concrete by volume. In addition, base and sub-base courses for both flexible and rigid pavements are made of aggregate.

Fig.3: Aggregate

Cigarette Butt: these are the wastes obtained after smoking the cigarette. The filter portion after the use is taken for the experiment. Cigarette butts are often littered and can harm the environment because of the chemicals and plastic fibers they contain. The butt is a waste material which is a huge waste in number but not in weight because they are light weight . collecting for this sample requires many number of samples which may collected by kepting a collection box in various shops who sell cigarettes. The collected cigarette butts paper coating is not needed for this , so remove the coating at the first step itself.

Fig.4: removing paper from cigarette butt

Plaster of paris waste : Plaster of Paris is a fast-setting gypsum plaster made of a fine white powder (calcium sulfate hemihydrate). When moistened and allowed to dry, it hardens. Unlike plastic, plaster of Paris is a hard white substance formed by adding water to powdered and partly dehydrated gypsum, similar to cement or concrete. Its setting is due to rehydration and conversion back into gypsum, causing slight expansion (1%) in volume. This property is useful in asphalt mix, as it helps protect the road surface from additional pressure from daily activities, ensuring proper stability and healing of the hard surface.

Fig.5: Plaster of Paris waste

Crumb Rubber : Crumb rubber typically refers to recycled rubber obtained from old automotive and truck tires. Two main methods are used to produce crumb rubber: ambient mechanical grinding and cryogenic grinding. The cryogenic process is costlier but yields smoother and smaller crumbs. Waste tires can be utilized as aggregate by mixing them with bitumen. The focus was on incorporating shredded waste crumb rubber into aggregate and assessing various mix properties such as impact value, abrasion value, crushing value, and the characteristics of crumb rubber aggregate.

Fig.6 : Crumb Rubber

Cardboard Paper : Cardboard paper, often simply called cardboard, is a thick and stiff paperboard material. It is usually made from recycled paper pulp or wood fibers. Cardboard is commonly used in packaging due to its strength and durability. It comes in various forms, including corrugated cardboard (with a fluted layer between two flat layers) and solid cardboard (a single layer). This card board paper are collected and used in this experiment.

Fig.7 :Cardboard Paper

METHOD

Test on Aggregates

Various tests on aggregates are carried out and the results are tabulated.

SI. No.	Tests Conducted	Values obtained	IS Specification and allowable limit	Inference
1	Stripping Value	0	IS:2386, range between 2.5-3	The obtained value is 0
2	Impact Value	17.13%	IS 2386(PART IV)-1963	The obtained value is in the range 10-20%
3	Crushing Value	17.65%	IS 2386(PART IV)-1963	The obtained value has not exceeded 30
4	Combined Elongation & Flakiness Index	19.55%	IS 2386(PART I)-1963	The obtained combined value has not exceeded 35%
5	Specific Gravity & Water Absorption	2.87 & 0.34	IS 2386(PART III)-1963	The obtained value is in the range 2.5-3 & less than 2%
6	Abrasion resistance	6.1%	IS 2386(PART IV)-1963	The obtained value is within the range
7	Angularity number	10	IS 2386(PART I)-1963	The obtained value is in the range 7-10

Table 1 : Various tests on aggregates

Test on Bitumen

Bitumen tests and their results are as follows

SI. No.	Tests Conducted	Values obtained	IS Specificationand Allowable limit	Inference
1	Penetration Test	56	IS:1203-1978, Range between 50/70grade.	The obtained value is in between 50-70
2	Specific gravity	1.034	IS: 1202-1987, specific gravity of pure bitumen lies between 0.97-1.02.	The obtained value is 1.034, which is beyond the limit.
3	Ductility Test	56mm	IS:1203-1978, the bitumen belongs to minimum ductility value of 50 mm	The obtained value is higher than minimum(50mm).
4	Viscosity	40 minutes	IS:4013-1988, Not less than 30minutes	The obtained value is notless than 30minutes.
5	Softening Point	47°C	IS: 1205-1978, the softening point varies for different grades of bitumen.	The obtained value belongs to VG30.

Table 2 : Various tests on Bitumen

Marshall stability test

Specimen preparation

The test aims to assess the strength and flexibility of bitumen paving blocks used in road construction, following IRC 29 guidelines. Aggregates of varying sizes are sieved, with 1200 grams dried in an oven. Bitumen, weighing 5%, 5.5%, and 6% of the aggregate weight, is heated to 150°C and then applied to the aggregates at 170°C. The coated aggregates are placed in a grease-coated mold and compacted with a 640-gram hammer for 75 blows on each side. The sample with mould is allowed to rest for 24 hours .

Test procedure

the sample is extracted hydraulically from the mould. After ejecting the sample from the mould its weight, height and diameter are taken. Then it is placed in water and the weight in water is taken. Then after 20 minutes the sample is allow to dry in room conditions and after drying it is placed in stability apparatus and the dial gauges are attached. The deflection and the flow value is obtained from the dial gauges.

Fig. 8: specimen preparation

Marshall Mix Design Specification

The stability, flow value and voids filled with bitumen are checked with Marshall mix design chart given below. Mixes with very high stability value and low flowvalue are not desirable as the pavements constructed with such mixes are likely todevelop cracks due to heavy moving loads.

Test Property	Specified Value
Marshall stability, kg	340 (minimum)
Flow value, 0.25 mm units	8.17
Percent air voids in the mix (Va), %	3-5
Voids filled with bitumen (VFB), %	75-85

Table 3 : Marshall Mix Design Specification

To find optimum bitumen content

to obtain optimum bitumen content various percentage of bitumen added to 1200 gm of each sample.

Mould number	Weight of aggregate in gm	Percentage bitumen added	Weight of bitumen in gm
1	1200	5	60
2	1200	5.5	66
3	1200	6	72
4	1200	6.5	78
5	1200	7	84

Table 4 : finding optimum bitumen content

Optimum percentage of various materials

By taking this bitumen content as optimum, various materials added to this in various proportions and by using each proportion different samples are maded. From the above optimum percentage of material which can be replaced the aggregates are obtained by the same bitumen content. After preparing the moulds the marshall stability of each sample is carried out.

Mould number	material	Percentage of material	Weight of material in gm
M1	Plaster of Paris	4	48
M2		5	60
M3		6	72
M4	Crumb Rubber	2	24
M5		3	36
M6		4	48
M7	Cigarette Butt	2	24
M8		3	36
M9		4	48
M10	Card Board paper	2	24
M11		3	36
M12		4	48

Table 5 : Optimum percentage of various materials

Field test

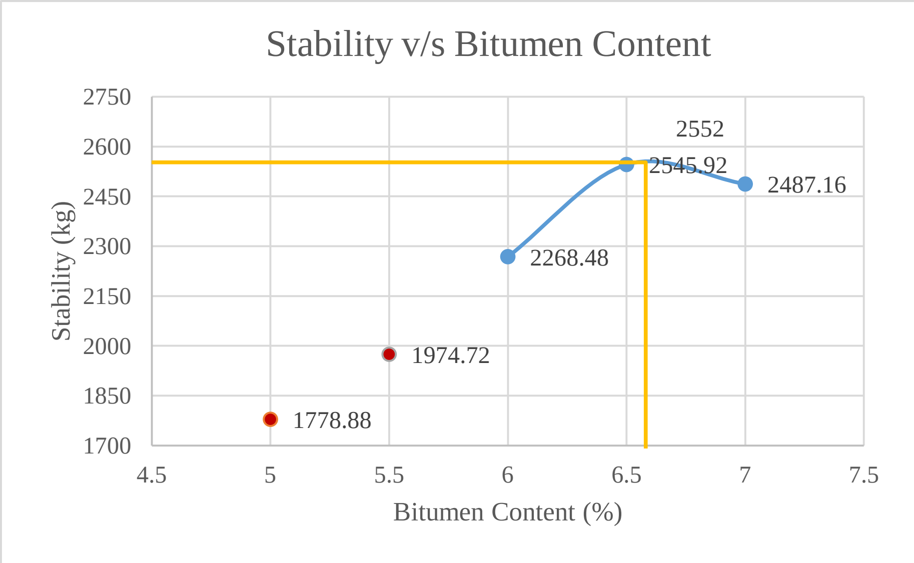
field test is carried out by the new bituminous concrete mix by combining all the materials with their maximum stability given sample among the three samples.

RESULTS AND DISCUSSIONS

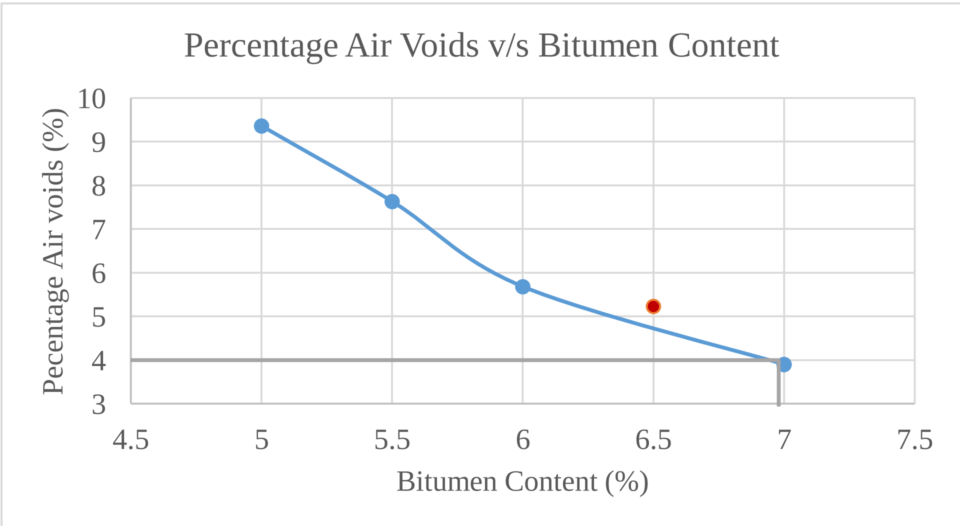
The results obtained for various bitumen content is in table.

Sample No.	Bitumen content (%)	Bulk specific gravity of mix (Gm)	Stability value (kg)	Air voids (%)	Voids filled with bitumen (%)	Flow value (0.25mm units)
1	5.0	2.51	1778.88	5.17	11.55	5.74
2	5.5	2.46	1974.72	6.5	12.65	6.36
3	6.0	2.50	2268.48	4	13.68	7.14
4	6.5	2.42	2545.92	6.61	14.28	7.56
5	7.0	2.35	2487.16	9.36	14.86	8.01

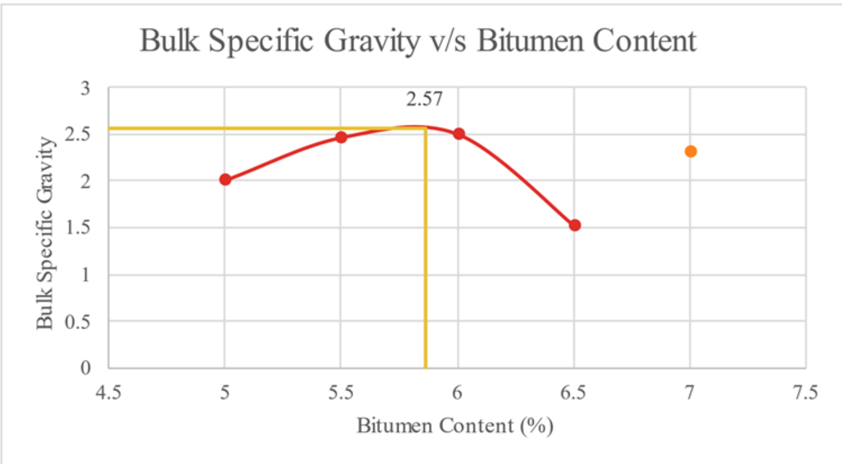
Table 5 : The results obtained for various bitumen content



Graph 1: Stability v/s Bitumen Content



Graph 2: Percentage of Bitumen vs Volume of Air Voids (V_a)



Graph 3: Percentage of Bitumen vs Unit Weight

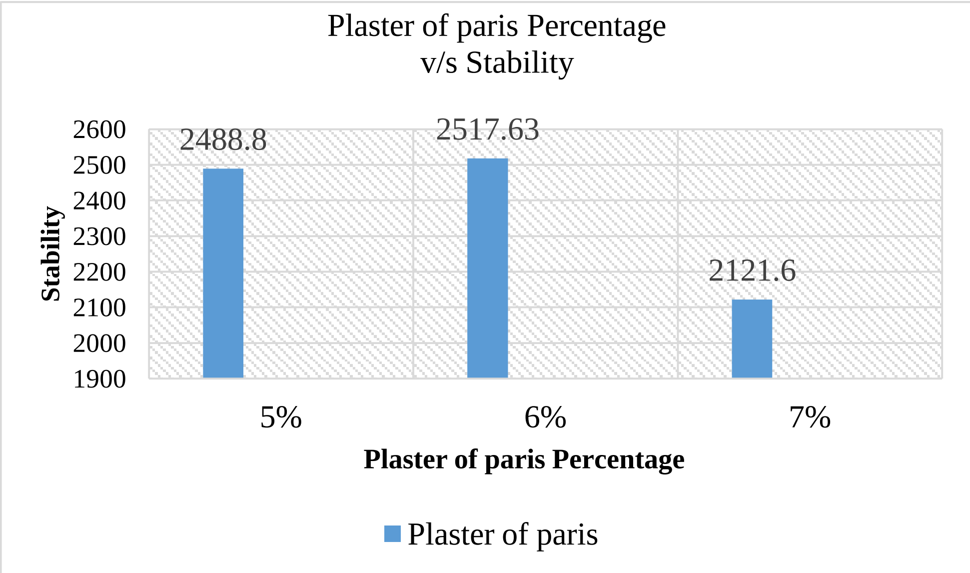
From the above graphs , % bitumen for maximum stability, % bitumen for max bulk density and % bitumen for mid point range of air void gives the optimum binder content. Hence the obtained value is 6.45%.

Observation of marshall stablity of various waste materials

Plaster of paris:

Sample No.	Bitumen content (%)	Height of sample (cm)	Diameter of sample (cm)	Volume of sample (cm^3)	Correction factor	Stability value (corrected) kg	Flow value (0.25mm units)
1	6.45	6.35	10	498.72	1.00	2488.80	5.94
		6.25	9.8	471.43	1.04	2517.63	7.98
		6.40	10	502.65	0.96	2121.60	7.02

Table 6: observation table for marshall stability and flow value of plaster of paris

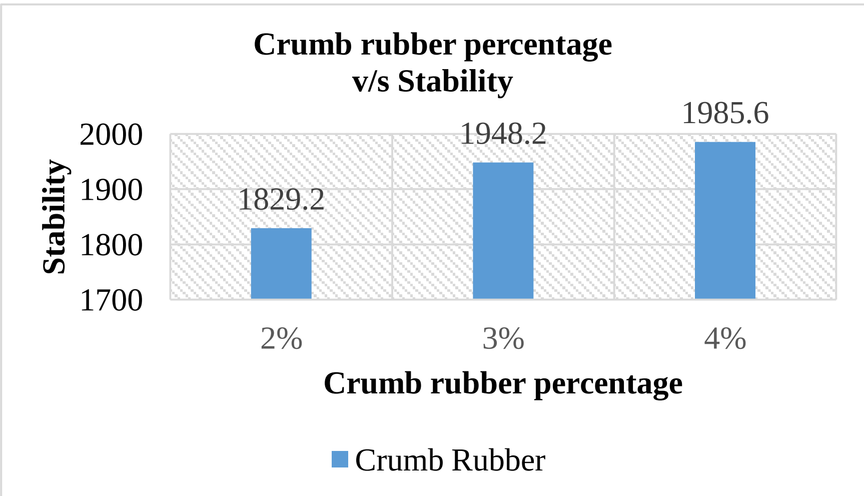


Graph 4: Plaster of paris Percentage v/s Stability

Crumb rubber:

Sample No.	Bitumen content (%)	Height of sample (cm)	Diameter of sample (cm)	Volume of sample (cm^3)	Correction factor	Stability value (corrected) kg	Flow value (0.25mm units)
1	6.45	6.35	10.10	508.75	1.00	1829.2	5.91
		6.30	10.20	514.79	1.04	1948.2	5.94
		6.35	9.90	488.80	1.00	1985.6	6.12

Table 7: observation table for marshall stability and flow value of crumb rubber

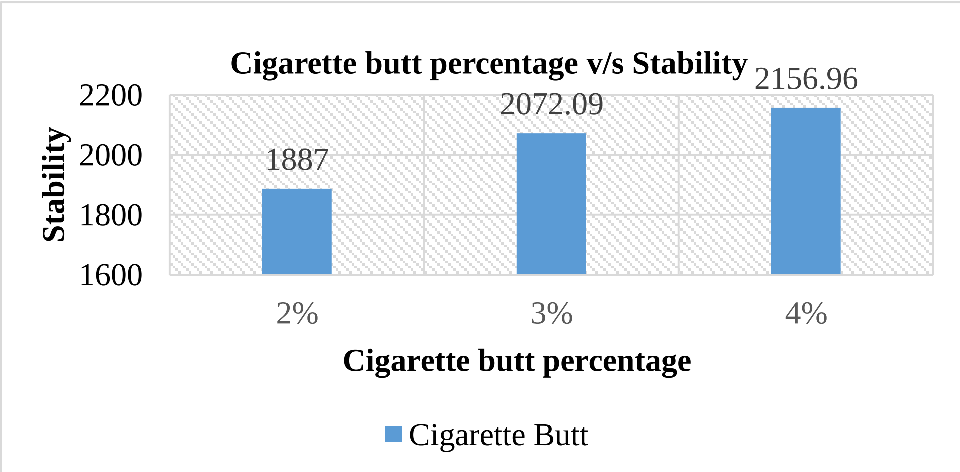


Graph 5: Crumb rubber percentage v/s Stability

Cigarette butt:

Sample No.	Bitumen content (%)	Height of sample (cm)	Diameter of sample (cm)	Volume of sample (cm^3)	Correction factor	Stability value (corrected) kg	Flow value (0.25mm units)
1	6.45	6.35	10.10	508.75	1.00	1829.2	5.91
		6.30	10.20	514.79	1.04	1948.2	5.94
		6.35	9.90	488.80	1.00	1985.6	6.12

Table 8: observation table for marshall stability and flow value of cigarette butt

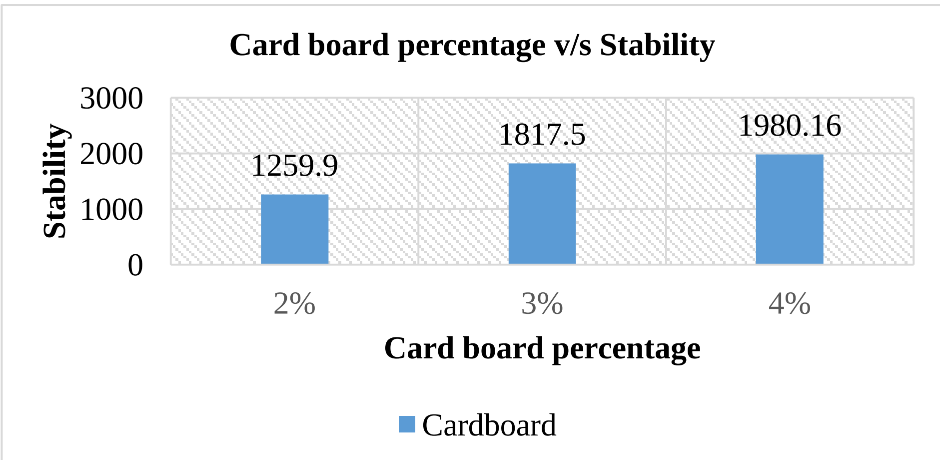


Graph 6: Cigarette butt percentage v/s Stability

Cardboard:

Sample No.	Bitumen content (%)	Height of sample (cm)	Diameter of sample (cm)	Volume of sample (cm^3)	Correction factor	Stability value (corrected) kg	Flow value (0.25mm units)
1	6.45	6.40	9.80	482.74	0.96	1259.90	9.17
		6.30	10.00	494.80	1.04	1817.50	12.14
		6.30	10.00	494.80	1.04	1980.16	13.10

Table 9: observation table for marshall stability and flow value of cardboard



Modified sample:

Sample no	Filler material & percentage	Weight of filler materials(g)	Height of sample(cm)	Dia(cm)	Volume(cm3)	Correction factor	Stablity (kg)	Flow value(mm)
1	Plaster of paris(6%)	72	6.4	10.2	522.69	0.96	2676.48	7.14
2	Crumb rubber(4%)	48						
3	Cigarette butt(4%)	48						
4	Card Board(4%)	48						

Table 10: observation table for of modified sample -marshall stability and flow value

comparison between unmodified and modified mix

	Unmodified mix	**Modified mix**	**Specified values**
Marshall stability (kg)	2552	2676.48	340(minimum)
Flow value (mm)	7.9	7.14	8-17
Air voids (%)	4.9	4.92	3-5
Voids filled with bitumen (%)	75.65	70.73	75-85

The stability value of modified mix is higher than the normal bituminous concrete and values are within the specified range. Hence it balances the strength and durability and an ideal solution for pothole repairing

Results of Field test

Visual observation after the application of the mix have carried out. The observations of 5days, 15 days and 20 days gave a satisfactory result. The materials were not separated and there were no cracks occurred . so the mix can be used for small pothole filling applications.

Fig. 9: Observation after applying

Fig. 10: observation after 5 days

Fig 11: observation after 10 days

Fig. 12; observation after 20 days

CONCLUSIONS:

According to marshall stability test, the marshall value has become maximum at 6.45%. when experimented with 6% plaster of paris the stability value was maximum. For cigarette butt, cardboard,crumb rubber the maximum stability value was given by 4% of materials for the same bitumen content or 6.45%.

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