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UTILIZATION OF WASTE MATERIAL FOR BASE COURSE OF FLEXIBLE PAVEMENT BY MARSHALL METHOD

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ABSTRACT

Over the last decade, there has been a dramatic increase within the use of recycled materials/by-products as alternative eco-materials in pavement construction on widely varying estimates. This increase is thanks to the scarcity and depletion of the natural resources and therefore the need of huge material quantities for the development of pavement layers. Leaving the waste materials to the climate straightforwardly can cause natural issues. Henceforth the reuse of waste has been in current mechanical pattern. Marble is one among the significant waste materials used in the improvement business. An experimental study to evaluate the use of marble waste as fine aggregates in road pavement is presented in this paper. The fine aggregates is replaced by marble waste in 10%, 20%, 30%, 40% to decide the ideal level of substitution and is subjected to marshall stability test and other volumetric properties are determined. Marshal mix design showed that modified mixes result in higher stability. It was determined that 20% replacement was found to be the optimum percentage for replacement.

Keywords: Marble Waste, Marshall Mix Design, Marshall Stability.

I. INTRODUCTION

In recent decades, the expansion in industrial production and consequent increase in consumption has led to a quick decrease of obtainable natural resources. Then again, a high volume of creation has produced a lot of waste materials which unfavorably affect the climate. Many countries and international establishments are working for brand new regulations on the way to minimize and reuse the generated waste.

One of the main waste generating industries is the construction and marble production industry. The waste produced can be utilized in the roadway asphalt plan methodology. To fulfill the pressure from the development business, total quarries are causing quick natural crumbling and unrecoverable harms. Marble dust is one such material which might be used to replace the fine aggregates. Aggregates from waste marble may satisfy to meet the large demand for aggregates by the highway construction industry.

The work targets examining the utilization of waste marble as aggregates in the bituminous mix design procedure. The utilization of waste marble aggregates can reduce the construction cost and also encourage the environmental protection.

1.1. Need for present study

1. Marble Waste materials are major environmental problem, which is a threat to the environment.
2. Using waste material during construction of pavement will reduce the cost of the project.
3. With rise in waste product all over the world, we can use substitute certain percentage of waste material in construction of flexible pavement and other construction projects.

1.2. Objectives

1. To evaluate the impact of usage of marble waste as fine aggregate in base course layer of the flexible pavements.
2. To substitute 10%, 20%, 30% and 40% of fine aggregates by marble waste.
3. To find the marshall stability value and other volumetric properties.

II. LITERATURE REVIEW

2.1 Review: 1

Satish Chandra, Praveen Kumar, Berhanu Abesha Feyissa has conducted an experiment on "Use of Marble Dust in Road Construction"(**2001**)

In this study, marble waste was used in the construction of bituminous road pavement. Tests like marshall stability tests and compression test were conducted. The results showed increase in the marshall stability when marble waste was used. Hence it was concluded that the behaviour of bituminous pavement with marble dust showed better strength value.

2.2 Review: 2

Lilian Ribeiro de Rezende, José Camapum de Carvalho has been studied on "The use of quarry waste in pavement construction"**(2003)**

In this study, marble quarry waste was used as the main material for the base layer of flexible pavements. The material was characterized by laboratory tests, to evaluate its utilization potential. The results indicated that the quarry waste has a reasonable potential for use as construction material for the base layer of flexible pavements.

2.3 Review: 3

P Priya, K Archana, C Gohila, R Saraswathi has conducted an experiment on "Utilization of Waste Plastic in Flexible Pavement with Marble Chips as Aggregate"**(2017)**

In this study, marble chip partially replaced the aggregates in the bituminous layer of flexible pavement. Various tests are performed on the bituminous mix to examine the strength of the pavement. The Marshall stability tests are conducted and the results obtained through these test give considerable stability in pavement.

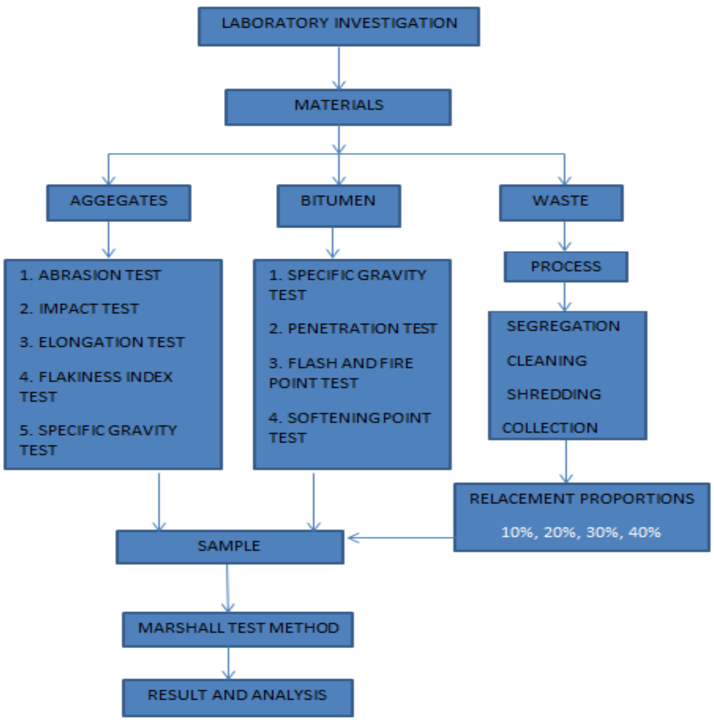
2.4 Review: 4

Lakshmi H. S has conducted an experiment on "Partial replacement of fine and coarse aggregate by using marble powder and demolished waste"**(2017)**

This study summarizes the replacement of fine aggregate with waste marble powder attains maximum compressive strength. Up to 20% replacement of fine aggregate and coarse aggregate with waste marble powder and demolished waste there is an increase in all mechanical properties.

III. METHODOLOGY

3.1 FLOWCHART



3.2 MATERIALS

3.2.1 Bitumen

Bitumen is commonly known as asphalt cement or asphalt. It is mainly used as binder mixed with aggregate particles to form bituminous concrete. Here we have used 60/70 grade bitumen.

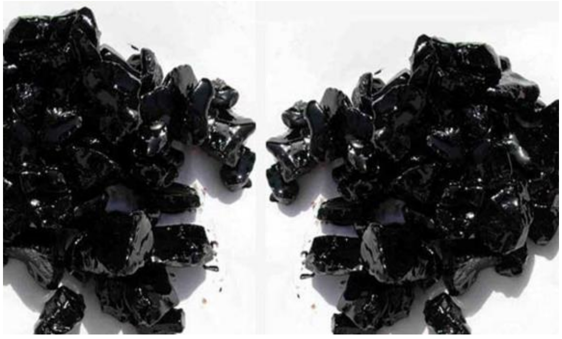


Fig-1: Bitumen

3.2.2 Fine aggregates

Fine aggregates shall consist of crushed or naturally occurring material, or the combination of the two, passing 2.36mm sieve and retained on the 75 micron sieve.

Fig-2: Fine aggregates

3.2.3 Coarse aggregates

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on 4.75 sieve.

Fig-3: Coarse aggregates

3.2.4 Waste marble powder

Marble is a transformative translucent stone. Unadulterated marble is clear and white and can take various shadings through different synthetic and actual that happen inside it. Financially, it covers numerous sorts of rocks that are sturdy when cleaned. Marble squanders can be partitioned into those from quarries and ventures. Characteristic conditions found in quarries, like blames, breaks, and cuts, can make it almost unimaginable for squares to be gotten. This prompts the rise of waste materials. Another sort is marble dust squanders that are experienced in C&D squander.

Fig-4: Marble powder

3.3 TESTS AND RESULTS

3.3.1 Test on agregates:

- **Abrasion test** is administered to check the hardness property of aggregates. The principle of Los Angeles abrasion test is to seek out the percentage wear due to relative rubbing action between the aggregate and steel balls used as abrasive charge.
- **Impact testing** is performed to determine the impact resistance or toughness of materials by calculating the amount of energy absorbed during fracture.
- **Specific gravity test** is conducted to determine the ratio of weight of aggregate to the weight of equal volume of water.
- **Water absorption test** is conducted to determine the water holding capacity of the coarse and fine aggregates.
- **Elongation index test** is used to determine the particle shape of the aggregate and each particle shape being preferred under specific conditions. It is the percentage by weight of elongated particles in a sample.
- **Flakiness index test** is used to determine the particle shape of the aggregate and each particle shape being preferred under specific conditions. It is the percentage by weight of flaky particles in a sample.
- **Angularity test** is conducted to determine the angularity number i.e. the absence of roundedness or the degree of angularity of the aggregate specimen.
- **Aggregate crushing test** on the aggregates gives a relative measure of the resistance of an aggregate crushing under gradually applied compressive load.

Table no 01. Tests on aggregates

SL .NO	PARTICULER	RESULTS
1	SPECIFIC GRAVITY	2.56%
2	WATER ABSORPTION	0.59%
3	ANGULARITY NO	7.35
4	IMPACT TEST	18.01%
5	FLAKINESS TEST	15.02%
6	ELONGATION TEST	12.15%
7	CRUSHING STRENGHT	23.5%
8	LOS ANGELES ABRASION TEST	29%

3.3.2 Tests on bitumen

- **Penetration test** determines the hardness or softness of bitumen by measuring the depth in millimeter to which a standard loaded needle will penetrate vertically.

- **Flash and Fire point test** is conducted to determine the flash point and fire point of the bitumen. The flash point is the lowest temperature at which the vapour of substance momentarily takes fire in the form of a flash under specified condition of test. The fire point is the lowest temperature at which the material gets ignited and burns under specified condition of test.
- **Softening point test** denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of test.
- **Specific gravity test** is conducted to determine the ratio of the mass of a given volume of the material at 25 °C to that of an equal volume of water at the same temperature.

Table no 02. Tests on bitumen

SL .NO	PARTICULER	RESULTS
1	SPECIFIC GRAVITY	1.012
2	PENETRATION TEST	42.75 mm
3	FLASH &FIRE POINT TEST	315-340°C
4	SOFTNING POINT	51.5°C

3.3.3 Marshall Method Of Mix Design:

The Marshall mix design method consists of 6 basic steps:

1. Aggregate selection.
2. Asphalt binder selection.
3. Sample preparation (including compaction).
4. Stability determination .
5. Density and voids calculations.
6. Optimum asphalt binder content selection.

Fig-5: Heating of aggregates

Fig-6: Adding the mixture to the mould

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Fig-7: Mixing of bitumen

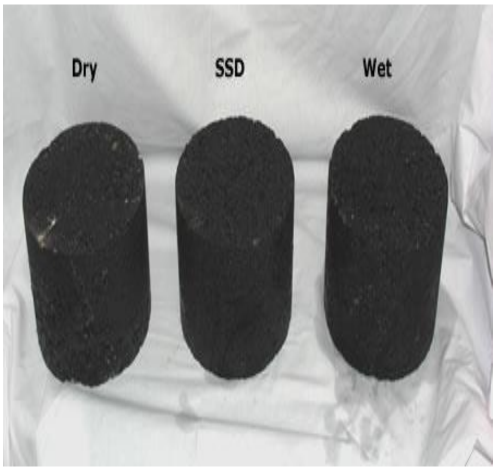

Fig-8: Molded specimen

Fig-9: Marshall stability test

From the Marshall Stability test we get the following properties

a) % of air voids (Vv).

b) Specific gravity (Gt).

c) % volume of bitumen (Vb).

d) Bulk specific gravity (Gm).

e) % voids in mixed aggregates (VMA).

f) Voids filled with bitumen (VFB).

Graphs are plotted between bitumen content vs Gm, Vv, Stability, Flow, and VFB which are show in result and discussion section below.

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Table03. Physical requirement of aggregates for dense graded bituminous macadam.

Sieve Size	% Passing	% Passing	% Retained	Weight (gms)	10 % SS	Wt of AGG	20% SS	Wt of AGG	30% SS	Wt of AGG	40% SS	Wt of AGG
26.5	100	100	0	0	0	0	0	0	0	0	0	0
19	71-95	83	17	204	20.4	183.6	40.8	163.2	61.2	142.8	81.6	122.4
13.2	56-80	68	15	180	18	162	36	144	54	126	72	108
4.75	38-54	46	22	264	26.4	237.6	52.8	211.2	79.2	184.8	105.6	158.4
2.36	28-42	35	11	132	13.2	118.8	26.4	105.6	39.6	92.4	52.8	79.2
0.3	7-21	14	21	252	25.2	226.8	50.4	201.6	75.6	176.4	100.8	151.2
0.075	2-8	23	9	108	10.8	97.2	21.6	86.4	32.4	75.6	43.2	64.8
			95	1140		1026		914		798		684
		Dust	5	60		62		60		60		60
			Total	1200	1200		1200		1200		1200	

Table 04. Calculation of specimen

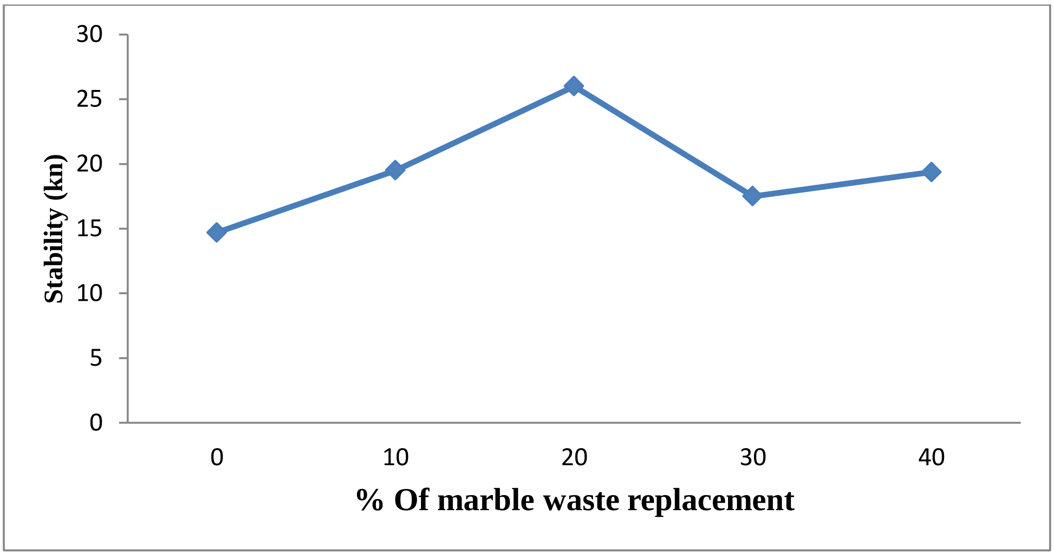
SL .N 0	%f BITUMEN	Weight Of sample In air(gms)	Weight of sample in water (gms)	Volume of sample (cc)	Bulk density (gm/cc)	Average bulk density (gm/cc)	Marshall stability (KN)	Average Marshall stability (KN)	Flow value (mm)	Average flow value (mm)	Marshall quotient (kn/mm)
0% MARBLE WASTE											
1	4.7	1200	697	540.54	2.22	2.30	14.3	14.7	4	4	3.57
2	4.7	1200	684	535.97	2.24		13.0		4		3.25
3	4.7	1245	697	558.29	2.23		16.8		4		4.2
10% MARBLE WASTE											
1	4.7	1229	7019	558.63	2.2	2.31	18.0	19.5	3	3.6	6
2	4.7	1243	717	567.5	2.19		19.5		5		3.9
3	4.7	1234	714	537.51	2.29		21.0		3		7
20% MARBLE WASTE											
1	4.7	1229	784	561.18	2.19	2.24	23.0	26	5	5.6	4.6
2	4.7	1250	732	559.40	2.23		26.0		5		5.2
3	4.7	1222	736	545.62	2.23		29.0		7		4.14
30% MARBLE WASTE											

1	4.7	1240	750	556.05	2.23	2.27	15.7	17.5	5	4.6	3.14
2	4.7	1248	740	564.70	2.21		23.3		6		3.88
3	4.7	1244	737	567.51	2.25		13.7		3		4.56
40% MARBLE WASTE											
1	4.7	1239	743	559.40	2.21	2.32	21.1	19.36	5	4.5	3.01
2	4.7	1230	775	559.09	2.2		24.5		4.5		3.5
3	4.7	1244	770	560.36	2.22		23.5		4		3.35

Average Marshall quotient (kn/mm)	Theoretical specific gravity (Gt)	Average (Gt)	Mean specific gravity (Gm)	Average (Gm)	Volume of voids (Vv%)	Average (Vv%)	Voids in mineral aggregate (VMA%)	Average (VMA%)	Voids filled with bitumen (VFB%)	Averag (VFB%
0% MARBLE WASTE										
3.67	2.3	2.3	2.22	2.23	3.47	3.06	15.14	14.92	77.08	79.45
	2.3		2.24		2.69		14.88		81.92	
	2.3		2.23		3.04		14.74		79.37	
10% MARBLE WASTE										
5.6	2.3	2.3	2.2	2.22	4.34	4.47	16.03	16.24	72.92	72.46
	2.3		2.19		4.78		16.29		70.65	
	2.3		2.29		4.3		16.42		73.81	
20% MARBLE WASTE										
4.64	2.3	2.3	2.19	2.21	4.78	3.62	16.42	15.35	70.88	76.61
	2.3		2.23		3.04		14.69		79.30	
	2.3		2.23		3.04		14.96		79.67	
30% MARBLE WASTE										
3.86	2.3	2.3	2.23	2.21	3.04	3.76	14.79	15.03	79.44	75.60
	2.3		2.21		3.9		15.47		74.78	
	2.3		2.20		4.34		14.84		72.60	
40% MARBLE WASTE										
3.28	2.3	2.3	2.21	2.21	3.9	4.19	15.55	15.85	74.91	73.59
	2.3		2.2		3.9		15.58		74.96	
	2.3		2.22		4.78		16.44		70.9	

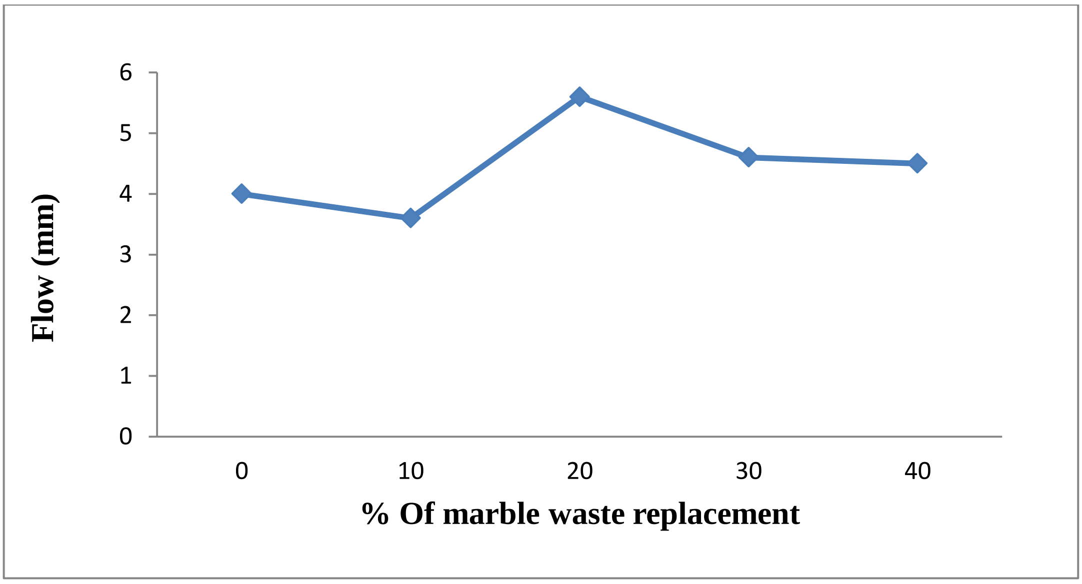
3.4 GRAPHICAL REPRESENTATION

a. Graph of marshall stability vs % of marble waste replacement;



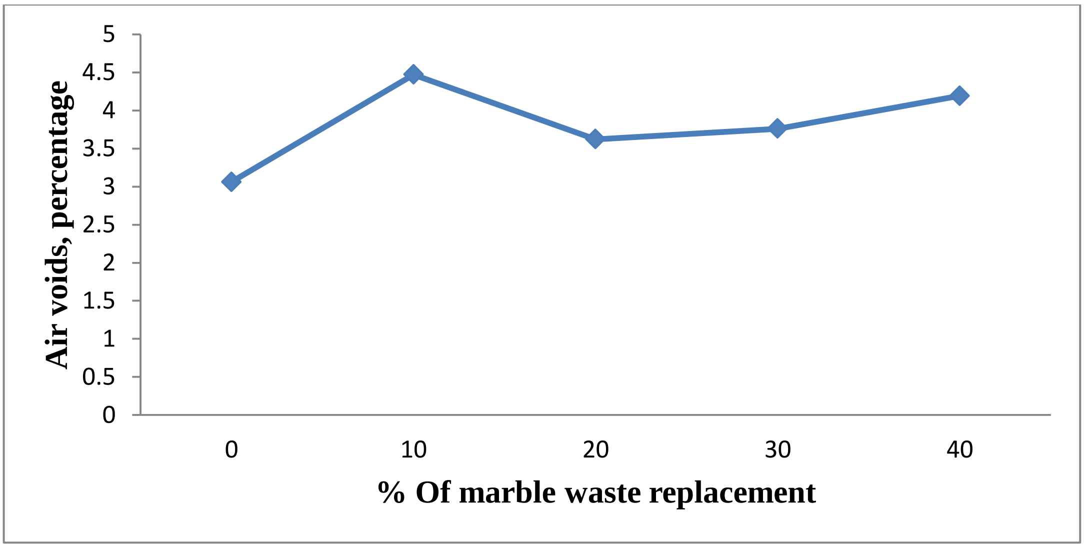
- The stability value is highest at 20% replacement.

b. Graph of marshall flow vs % of marble waste replacement;



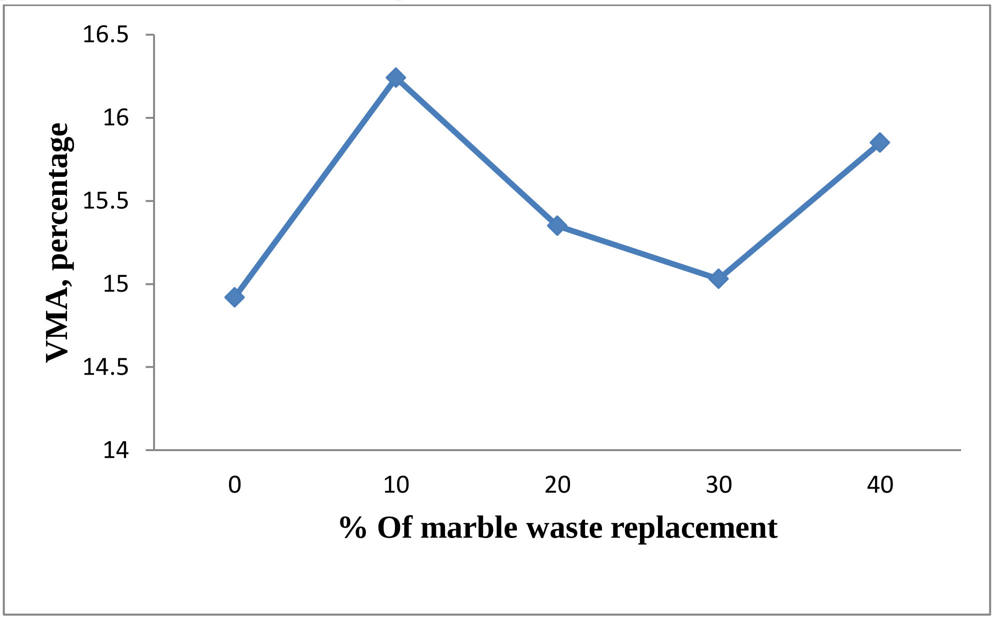
- The highest flow value is at 20% replacement.

c. Graph of air voids vs % of marble waste replacement;



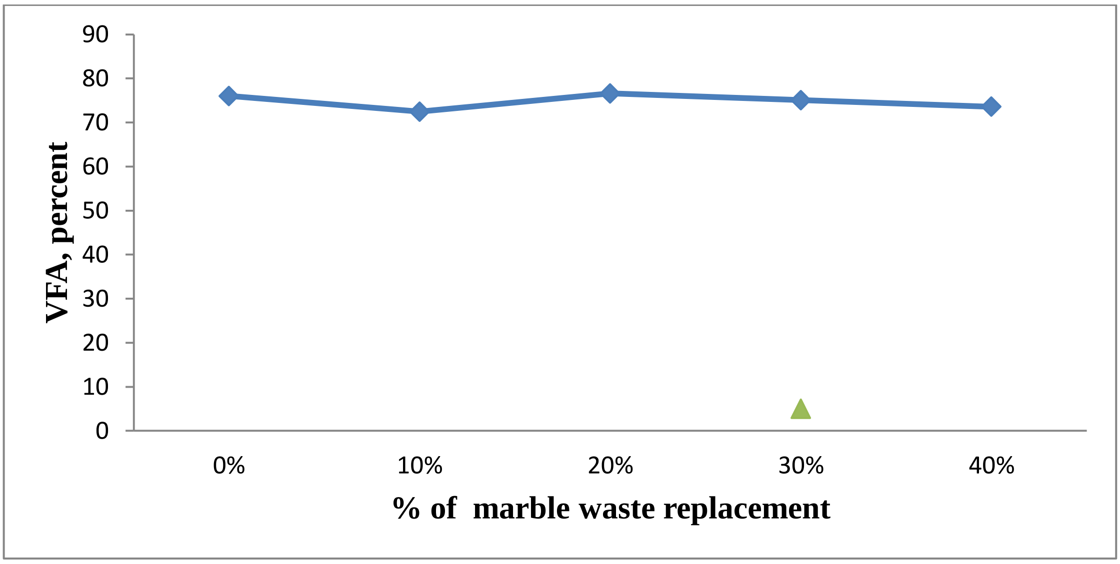
- The lowest percentage of air voids when waste is used is at 20% replacement.

d. Graph of VMA vs % of marble waste replacement;



- The lowest value of VMA when marble waste is used is at 30% replacement.

e. Graph of VFA vs % of marble waste replacement;



- The highest value of VFA is at 20% replacement.

IV. CONCLUSION

1. In the graph of flow value, we see clearly that 5.6 is the maximum value. The yield attained is at 20% of marble waste.
2. In the graph of Marshall Stability, we see that the highest stability i.e, 26 is at 20% of marble waste.
3. The waste added in the bituminous mixes can increase the stability and density of the mix which is designed for the base course.
4. The optimum percentage for replacement of fine aggregates by marble waste is found to be 20%.

Hence marble waste can be used as a construction material in the context of the sustainable environment instead of being an environmental pollution.

SCOPE OF FUTURE STUDIES

1. The studies can be implemented for other grades of bitumen.

2. Other waste materials like foundry sand, ceramic waste, glass cullet etc. can be taken for replacing with fine aggregates.
3. Other test method like benkelman beam method, rebound deflection method can be carried out.

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