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Utilization of Industrial Waste in the Construction of Flexible Pavement by Marshall Method

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ABSTRACT

The disposals of changed industrial wastes pose environmental struggle to the society as many of them are non-biodegradable. India having the huge network of industries and many more are being established since it is a just beginning country. With each momentary year several million metric tons of waste is getting improved. As the usage of road increases the use of original ingredients also increases. The addition of several other secondary objects and industrial waste may be a boon in preserving natural reserves and conventional materials. These materials have been evaluated and investigate for practicing and utilizing in various ways in construction industry. Many equipment like plastic waste, scrap tires, mine wastes, crushed glass, foundry sand etc. This study aim to give a significant expression on the use of blast furnace slag which is an industrial waste- by product in the construction of pavement.

CHAPTER 1

1.INTRODUCTION

India is one amongst the top 10 countries in terms of industrial increase resulting in an enormous production of industrial waste. The rate of industrialized waste is growing faster than the rate of globalization. This waste removal has become a grave problem today which is threatening the environment and extinction of resources.

The two types of pavement structure generally used are I) Flexible Pavement II) Rigid Pavement. Wastes from different sources can be collected and the materials such as foundry sand, iron slag, steel slag, glass waste, ceramic waste etc., can be used. The slag is of two types i.e., blast furnace slag and steel creation slag. The blast furnace slag is obtained by melting the separated from blast furnace that produces iron.

For each ton of iron around 290kg of slag is created. This study aims at reducing the cost of construction of flexible pavements.

CAPTER 2

2. LITREATURE REVIEW

2.1 Review: 1

Sagar C et al; Utilization of Waste Materials in Flexible footpath Construction 2018

The waste additional in the bituminous mixes can increase the stability and density of the mix which is designed for the look course .It is found that, the stability is increased twice, when compared to the normal bituminous mix i.e. with adding throw away materials. Due to use of waste materials the cost reduction is up to 25 % when compare to ordinary bitumen.

2.2Review:2

S. Rajesekaran, Dr. R. Vasudevan, Dr. Samuvel Paulraj has be study "Reuse of Waste Plastic covered Aggregate-Bitumen Mix Composite for Road Application-Green method" **(2013).**

Waste plastics both by domestic and industrialized sector scan be used in the production of asphalt mix. Waste plastic, mainly used for packing are made up of polyethylene, polypropylene, polystyrene this softening varies between 110◦c-140◦c and they do not manufactureany harm gases during heating but the softened plastics have tendency to from a film similar to structure over the aggregate when they sprayed over the hot aggregate @ 160◦c. this PCA bitumen mix showed improved binding property and less wet property and it also showed higher Marshall stability value in the range of 18-20KN and load bearing capability of the roadisincreasedby100%.Theroads laid since 2002 using PCA bitumen mixes are performing well. This added more worth to the dry process as this process helps to dispose 80 % of waste polymers usefully by an eco-friendly method and also it reduced the cost to approximately Rs.3000/km of single lane road as ondate.

2.3Review:3

H.K.Sharma,has conducted test on "Utilization of Waste Plastic in Construction of Pavement"**(2014**).

He found that Waste plastics-as binder and modifier at 130°Cusing Thermo gravimetric study

there is no gas evolution in the temperature range of 130-180°C. Moreover, the softened plastics have a binding belongings. Hence, the molten plastics equipment can be used a sabinder and/or they can be mixed with binder like bitumen to enhance their binding property. This may be a fine modifier for the bitumen, used for road construction. The uses of plastic waste help in substantially getting better the abrasion and slip resistance of flexible pavement and also allow to obtain values of split tensile strength satisfied the specified limits while plastic waste content is beyond 30% by weight of mix up. If the consistent.

2.4Review:4

DR.Manju, Sathya. S, Sheema. K has been study on "use of plastic ravage bituminous footpath"**(2017).**

This paper reveals that the utilization of waste plastic in bituminous mix enhance its properties and strength. Titanium Di-oxide is used as burn absorbent material, which will absorb the smoke from vehicle. Addition of waste plastic in structure reduces the plastic shrinkage and drying shrinkage. Dry process is carried out for mixing procedure .The plastic pavement scan with stand heavy traffic and are durable than elastic pavements. The stability of modified bitumen (10% bitumen replaced by plastic) is higher than the nominal bitumen. The use of plastic will reduce the bitumen content by10% increase the strength and performance of the road. The smoke absorbent material (titanium dioxide) by 10% of polymer content can reduce vehicular pollution. Thus the use of waste plastic improve the abrasion and slip opposition of bitumen pavement.

2.5Review:5

Vishal Rasal, L Nokfho K, P.M.Wale, Mrunalini Kasar, Anjali Thorat, Raunak Solanki, Ishan Dharmadikari, have been study on

"trial Study on Modified Bituminous Mix with Waste High mass Polyethylene and Crumb Rubber"**(2018).**

This paper presents an attempt taken to produce modified bituminous mix and covered aggregates. Aggregate were covered with 6, 8, 10% of High density polyethylene (HDPE) and 8, 10, 12% of crumb rubber and were mixed with bitumen. Different mould are prepared with changed combination and compared with conventional bitumen mix by conduct Marshall Stability test to check its strong point, flow appeal and stability value. The dense based macadam (DBM) mix was considered for Marshall Stability test use VG 30 grade. Dry process (polymer coating of aggregates)is more helpful as compared to wet process(adding polymer in the binder) for the industrialized modified mixtures, as it can accommodate higher amount of waste plastic as modifier and result most stable mixture. Penetration value and soften points of plain bitumen can be improved by modifying it with addition of crumb rubber. Optimum percentage of rubber was found to be8%and10% of HDPE gives more satisfied results comparing to conventional bitumen. Use of waste plastic in construction of bituminous road helps to improve strength, life of road, resistance to temperature and water

CAPTER 3

3. OBJECTIVES

This study promote the usage of industrial wastes to decrease the cost of construction of flexible pavements and helps in preserving the natural reserves.

- To study the usage of steel slag and try easing the cost of construction of flexible pavements.
- To study the physical property of steel slag.
- To find out the percentage of steel slag.
- To study the property of bituminous mix & to find a result for disposal in a helpful way.
- To study the difference in the Marshall Stability value.

CHAPTER 4

4. METHODOLOGY

4.1 Steel slag

Slag is generated as a by-product throughout the industrialized of pig iron & steel. During the process of making of pig iron (in the blast furnace) and production of steel (in steel melting shop), slag is produced as a by-product by the action of fluxes upon gangue materials with the iron ores. The slag primarily consists of silicon, calcium, aluminum, iron, magnesium & manganese in various combinations. Under controlled cooling slag becomes hard and dense, which can achieve the required strength to sustain weighty loads thus making it specially suitable for use in road construction.

4.2 Bitumen

There are many way in which bitumen can be used. They are like seal, flat roofs, water proofing stuff. But mostly 70% of asphalt / bitumen is used in road construction. It acts as the paste or binder to aggregate mix and creates the asphalt concrete. VG 30 grade of bitumen is use in this assignment.

FIG:1 BITUMEN

The engineering properties of bitumen which are obtained from the tests of ductility, softening point, penetration test, flash test, fire test, and specific gravity test are revealed in the following table:

4.3 Aggregates

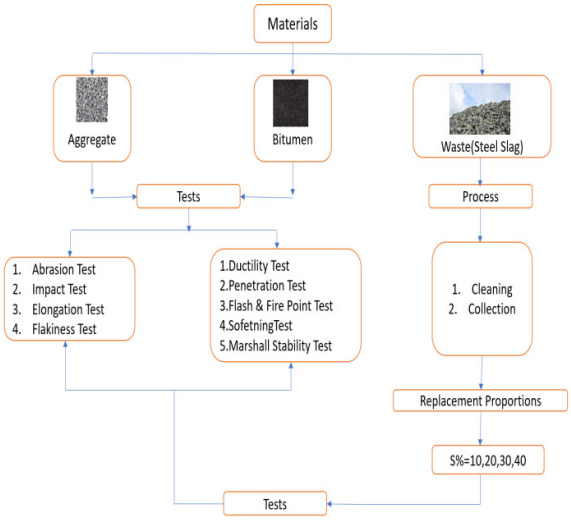
Aggregates are widely used in civil constructions like roads, foundations, railway roads and drainages. Aggregates are natural materials which are obtained by mining and blasting into certain sizes. It has excellent compressive strength property.

FIG:2 AGGREGATES

4.5 Gradation of Aggregates

Gradation has major impact on the performance of mix design. By gradation the voids are decreased by filling the smaller particles in between the voids created by large particles. Gradation of aggregates is done according to MoRTH specifications Section: 500

4.6.FLOWCHART



WORK CARRIED OUT WITH RESULTS

- **Test on Aggregates**

-Aggregate Crushing Strength

-Abrasion Test

-Impact Test

-Flakiness and Elongation Index Test

-Specific Gravity and Water Absorption

- **Test on Bitumen**

-Specific Gravity Test for Bitumen

-Penetration Test On Bitumen

-Viscosity Test

- Fire& Flash Point Test

-Softening Test

- **Test on Steel Slag**

-Aggregate Crushing Strength

-Abrasion Test

-Impact Test

-Flakiness and Elongation Index Test

-Specific Gravity and Water Absorption

Tabel no1. TEST ON AGGREGATE

SL .NO	PARTICULER	RESULTS
1	SPECIFIC GRAVITY	2.67
2	WATER ABSORPTION	0.60%
3	ANGULARITY NO	7.56
4	IMPACT TEST	17.95%
5	TEST ON FLAKINESS	15.18%
6	ELONGATION TEST	12.50%
7	CRUSHING STRENGHT	24%
8	LOSS ANGELES ABRASION TEST	30%

Table no2. TEST OF 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

Table no3. TESTS ON STEEL SLAG

SL .NO	PARTICULER	RESULTS
1	SPECIFIC GRAVITY	2.67
2	WATER ABSORPTION	0.8%
3	ANGULARITY NO	7.56
4	IMPACT TEST	30.00%
5	FLAKINESS TEST	13.18%
6	ELONGATION TEST	14.50%
7	CRUSHING STRENGHT	28.30%
8	LOS ANGELES ABRASION TEST	32%

Table no4. COMPARISION B/W STANDARD AND OBTAINED RESULTS FOR 20% OF REPLACEMENT OF STEEL SLAG IN COURSE AGGREGATE.

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
19	100	100	0	0	0	0	0	0	0	0	0	0
13.2	90-100	95	5	60	15	45	30	30	45	15	60	0
9.5	70-88	79	16	192	15	177	30	162	45	147	60	132
4.75	53-71	62	17	204	16	188	31	173	46	158	61	143
2.36	42=58	50	12	144		144		144		144		144
1.18	34-48	41	9	108		108		108		108		108
0.6	26-38	32	9	108		108		108		108		108
0.3	18-28	23	9	108		108		108		108		108
0.15	12-20	16	7	84		84		84		84		84
0.05	4-10	7	9	108		108		108		108		108
			93	1116		1116		1116		1116		1116
		Dust	7	84		84		84		84		84
			Total	1200	1200		1200		1200		1200	

Table no5 .TABLE 500-8 PHYSICAL REQ FOR COARSE AGGREGATES FOR DENSE BITUMINOUS MACADAM .

SL.NO	PROPERTIES	Std. VISCOSITY GRADE PAVING BITUMEN	OBTAINED RESULTS
1	COMPACTION LEVEL	75 BLOWS ON EACH FACE OF SAMPLE	
2	MINIMUM STABILITY (KN@600C)	9.0	20.18
3	MARSHALL FLOW (mm)	2-4	5.66
4	MARSHALL QUOTIENT	2-5	3.76
5	% OF AIR VOIDS	3-5	3.23
6	%OF VOIDS FILLED WITH BITUMEN (VFB)	65-75	78
7	% VOIDS IN MINERAL AGGREGATES (VMA)	12-13	14.72

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%)	Average (VFB%)
0% STEEL SLAG										
2.25	2.26	2.26	2.16	2.17	4.42	3.68	15.75	15.05	71.93	75.70
	2.26		2.17		3.98		15.33		74.00	
	2.26		2.20		2.65		14.09		81.17	
10% STEEL SLAG										
3.01	2.26	2.26	2.18	2.18	3.53	3.53	14.84	14.89	76.21	76.30
	2.26		2.18		3.53		15.01		76.48	
	2.26		2.18		3.53		14.84		76.21	
20% STEEL SLAG										
3.76	2.26	2.26	2.19	2.186	3.09	3.23	14.59	14.72	78.82	78.00
	2.26		2.19		3.09		14.56		78.77	
	2.26		2.18		3.53		15.01		76.48	
30% STEEL SLAG										
4.19	2.26	2.26	2.18	2.183	3.53	3.38	15.01	14.87	76.48	77.26
	2.26		2.18		3.53		15.01		76.48	
	2.26		2.19		3.09		14.59		78.82	
40% STEEL SLAG										
4.42	2.26	2.26	2.2	2.196	2.65	2.79	14.26	14.37	81.41	80.55
	2.26		2.2		2.65		14.13		81.24	
	2.26		2.19		3.09		14.72		79.00	

Table 6. Calculation of specimen

SL.N0	%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% STEEL SLAG											
1	5.5	1245	677	576.75	2.15	2.18	11.99	13.82	6	6.16	1.99
2	5.5	1249	697	576.75	2.16		15.05		7		2.15
3	5.5	1257	704	570.5	2.24		14.44		5.5		2.62
10% STEEL SLAG											
1	5.5	1259	696	576.75	2.18	2.19	15.06	14.50	7.5	5.16	2.00
2	5.5	1240	694	568.5	2.18		16.78		4.5		3.72
3	5.5	1242	698	568.5	2.21		11.68		3.5		3.33
20% STEEL SLAG											
1	5.5	1244	692	568.5	2.18	2.19	22.13	20.18	7	5.66	3.16
2	5.5	1247	690	568.5	2.19		16.90		3.5		4.82
3	5.5	1240	685	568.5	2.21		21.52		6.5		3.31
30% STEEL SLAG											
1	5.5	1240	698	568.5	2.24	2.23	17.51	16.41	4	4.16	4.37
2	5.5	1242	698	568.5	2.2		15.55		5.5		2.82
3	5.5	1244	706	568.5	2.25		16.17		3		5.39
40% STEEL SLAG											
1	5.5	1238	690	560.38	2.24	2.22	11.00	10.85	1.5	3.00	7.33
2	5.5	1252	704	568.5	2.23		10.32		3		3.44
3	5.5	1230	674	560.38	2.2		11.25		4.5		2.5

Marshall Stability;

Marshall Stability is performed to find out the stability and flow values of specimen.

1. A specimen is ready according to MORTH specifications Section 500.
2. From the Marshall Stability test we get the following properties
    a) % of air voids (Vv).
    b) Specific gravity. (Gt).
    c) % vol of bitumen (Vb).
    d) Bulk specific gravity. (Gm).
    e) % void in mixe aggregates (VMA).
    f) Voids fill with bitumen (VFB).
3. Graphs are plot between bitumen content vs Gm, Vv, Stability, Flow, and VFB which are explain in result and discussion segment below.

CALCULATIONS

0% OF STEEL SLAG

SAMPLE 1

Theoretical specific gravity

$(Gt)=\frac{W1+W2+W3+W4}{\frac{W1}{G1}+\frac{W2}{G2}+\frac{W3}{G3}+\frac{W4}{G4}}=\frac{456+660+84+66}{\frac{456}{2.67}+\frac{660}{2.3}+\frac{84}{2.3}+\frac{66}{1.01}}=2.26$

Mean specific gravity (Gm) $=\frac{\text{weight of sample}}{\text{volume of sample}}/$ unit weight of water $=\frac{1245}{576.75}/1=2.16$

Volume of void (Vv%) $=\frac{Gt-Gm}{Gt}x100=\frac{2.26-2.16}{2.26}x100=4.42\%$

Volume of bitumen (Vb%) $=\frac{Wb}{W}X\frac{Gm}{Gb}x100=\frac{66}{1245}X\frac{2.16}{1.01}x100=11.33\%$

Voids in mineral aggregate (VMA) = Vv +Vb = 4.42+11.33 =15.75%

Voids filled with bitumen (VFB) $=\frac{Vb}{Vv+Vb}x100=\frac{11.33}{4.42+11.33}x100=71.93\%$

SAMPLE 2

Theoretical specific gravity (Gt)

$=\frac{W1+W2+W3+W4}{\frac{W1}{G1}+\frac{W2}{G2}+\frac{W3}{G3}+\frac{W4}{G4}}=\frac{456+660+84+66}{\frac{456}{2.67}+\frac{660}{2.3}+\frac{84}{2.3}+\frac{66}{1.01}}=2.26$

Mean specific gravity (Gm)

$=\frac{\text{weight of sample}}{\text{volume of sample}}/$ unit weight of water $=\frac{1249}{576.75}/1=2.17$

Volume of void (Vv%) $=\frac{Gt-Gm}{Gt}x100=\frac{2.26-2.17}{2.26}x100=3.98\%$

Volume of bitumen (Vb%) $=\frac{Wb}{W}X\frac{Gm}{Gb}x100=\frac{66}{1249}X\frac{2.17}{1.01}x100=11.35\%$

Voids in mineral aggregate (VMA) = Vv +Vb = 3.98+11.35 =15.33%

Voids filled with bitumen (VFB) $=\frac{Vb}{Vv+Vb}x100=\frac{11.35}{3.98+11.35}x100=74\%$

SAMPLE 3

Theoretical specific gravity (Gt)

$=\frac{W1+W2+W3+W4}{\frac{W1}{G1}+\frac{W2}{G2}+\frac{W3}{G3}+\frac{W4}{G4}}=\frac{456+660+84+66}{\frac{456}{2.67}+\frac{660}{2.3}+\frac{84}{2.3}+\frac{66}{1.01}}=2.26$

Mean specific gravity (Gm)

$=\frac{\text{weight of sample}}{\text{volume of sample}}/$ unit weight of water $=\frac{1257}{570.5}/1=2.2$

Volume of void (Vv%) $=\frac{Gt-Gm}{Gt}x100=\frac{2.26-2.2}{2.26}x100=2.65\%$

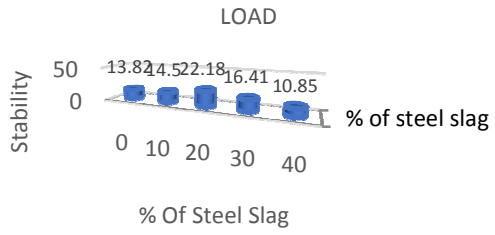
Volume of bitumen (Vb%) $=\frac{Wb}{W}X\frac{Gm}{Gb}x100=\frac{66}{1257}X\frac{2.2}{1.01}x100=11.43\%$

Voids in mineral aggregate (VMA) = Vv +Vb = 2.65+11.43 =14.09%

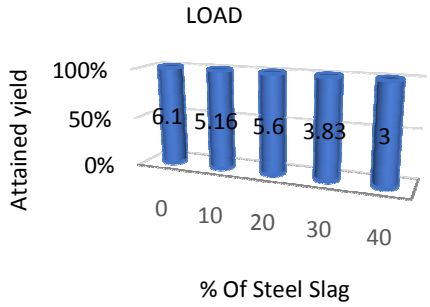
Voids filled with bitumen (VFB) $=\frac{Vb}{Vv+Vb}x100$

$=\frac{11.43}{2.65+11.43}x100 = 81.17\%$

GRAPH OF MARSHALL STABILITY VS % OF STEEL SLAG;



GRAPH OF FLOW VALUE VS % OF STEEL SLAG;



CHAPTER 5

5. CONCLUSION

Hence we conclude this project with following results:

1. In the graph of flow value, we can see clearly that 5.6 is the finest choice. The yield attained is at 20% of steel slag.

2. In the graph of Marshall Stability, we can see that the highest stability, that is 22.18 is at 20% of steel slag.

CHAPTER 6

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