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Analysis of Steel as Partial Replacement for Aggregate for Road Construction

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ABSTRACT: Roads make a crucial contribution to an economic development and growth and bring important social benefits. They are of vital important in order to make the nation grow and develop. So, by keeping this in mind, Steel Slag Road came in construction, there is no blasting, drilling, or any crushing to obtain steel slag as it is material waste coming out of steel industry which is further processed and then converted in the form of aggregates material used for constructions.

The use of steel slag as a sustainable substitute for conventional building materials in the construction of roads is the subject of this study. The purpose of the study is to find the ideal mix design for maximum performance as well as to assess the viability of employing steel slag as an aggregate in road construction. To assess the performance of the asphalt mixtures containing steel slag and to quantify the physical and mechanical characteristics of the steel slag aggregate, the technique includes laboratory testing. The study's findings indicate that steel slag can be used as a partial replacement for conventional aggregates in road construction with good outcomes in terms of performance and financial gains.

So, in our project we have tried to use steel slag as replacement of aggregates by performing tests on it we are aiming that road construction may become more economical and road becomes more durable as compared to conventional road construction.

KEYWORDS: steel slag, physical and mechanical characteristics, conventional, mix design.

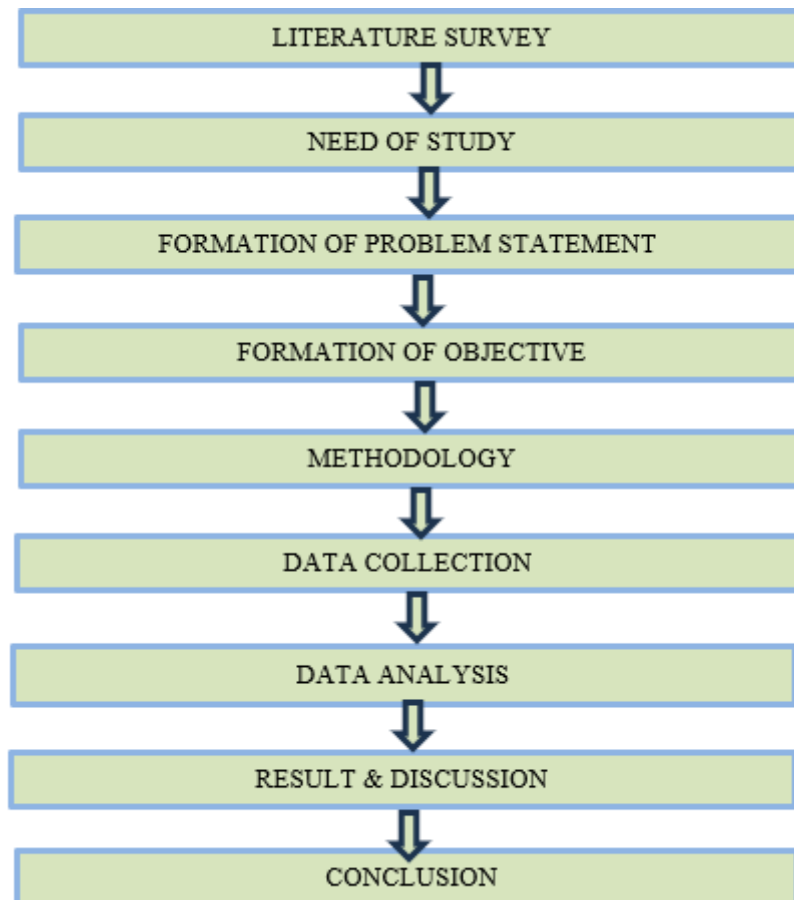
I. INTRODUCTION

Aggregates are natural resources that are finite and non-renewable. The extraction of aggregates from quarries can have a significant environmental impact, including habitat destruction and landscape alteration. By using alternative materials as partial or complete replacement, we can reduce the demand for virgin aggregates, helping to conserve these finite resources. Reducing material costs is especially important for local governments and municipalities with limited budgets. Incorporating waste materials and alternative aggregates into road construction aligns with sustainability goals and practices. The utilization of waste materials, such as steel slag which provides an environmentally friendly way to manage the waste along with conservation of the natural Aggregate extraction and transportation can lead to greenhouse gas emissions and other environmental impacts.

II. RELATED WORK

The basic aim of this research is to utilize the waste generated from steel industries i.e., steel slag in road construction so that it can reduce the construction cost and make road construction more economical. Also, it has several other advantages such as it is ecofriendly, durable etc. So, in this report we are going to conduct various tests on steel slag aggregate bituminous mixture and on natural aggregate bituminous mixture to study comparative analysis between conventional road construction method and road construction by using steel slag. the use of natural aggregate in the Asphalt layer of road pavement is seen as a wasteful use of a finite natural resource. Therefore, the use of waste (secondary) materials is recognized as being of benefit to both environment and society. Of the various waste materials, the steel slag can be considered reasonable alternative sources of aggregate for asphalt mixture productions.

III. METHODOLOGY



IV. NEED OF STUDY

Aggregates are natural resources that are finite and non-renewable. The extraction of aggregates from quarries can have a significant environmental impact, including habitat destruction and landscape alteration. By using alternative materials as partial or complete replacement, we can reduce the demand for virgin aggregates, helping to conserve these finite resources. Reducing material costs is especially important for local governments and municipalities with limited budgets. Incorporating waste materials and alternative aggregates into road construction aligns with sustainability goals and practices. The utilization of waste materials, such as steel slag which provides an environmentally friendly way to manage the waste along with conservation of the natural Aggregate extraction and transportation can lead to greenhouse gas emissions and other environmental impacts.

V. FORMATION OF PROBLEM STATEMENT

The is need of alternative to the aggregates so that we can reduce the demand for virgin aggregates, helping to conserve these finite resources. In this research the use of steel slag as a partial replacement to the aggregates would be done. Wherein the analysis would be carried out by comparing the test result of aggregate with combination designed for partial replacement by steel and by comparing the martial stability value for optimum bitumen contain obtained for bituminous mix with natural aggregates and optimum value of combinations designed.

VI. FORMATION OF OBJECTIVES

The utilization of waste materials like steel slag in flexible pavement construction offers several objectives that align with sustainability, resource conservation, and economic efficiency.

- Selection of Materials as a Partial replacement to Aggregate in case of Road Construction.

- Analysis of Material Selected with respect to Conventional Aggregate

VII. COMBINATION OF MATERIAL AS PARTIAL REPLACEMENT OF AGGREGATE

Table.1.Percent Combination of Material

Combination	Aggregate % + Steel Slag %
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Combination

Table.2. Percent Combination of Aggregate and Steel Slag

Aggregate %	Steel Slag %
95	5
90	10
85	15
80	20
75	25
60	30
And so on till the desired property value will increase	

Bin 1 30% = 360 grams				Bin 2 35% = 420 grams			Bin 3 35% = 420 grams			
Sieve	% Passing of 1200 grams	Blend %	Gram Passing	% Passing of 1200 grams	Blend %	Gram Passing	% Passing of 1200 grams	Blend %	Gram Passing	
26.5	100	30	360	100	35	420	100	35	420	
19	77.75	23.32	279.84	100	35	420	100	35	420	
13.2	5.25	1.57	18.84	98	34.3	411.6	100	35	420	
4.75	0	0	0	0.33	0.11	1.32	81	28.35	340.2	341.52
2.36	0	0	0	0	0	0	41.1	14.38	172.56	172.56
0.3	0	0	0	0	0	0	6.83	2.39	28.68	28.68
0.075	0	0	0	0	0	0	2.92	1.02	12.24	12.24

Gradation of aggregate by Trail and Error method

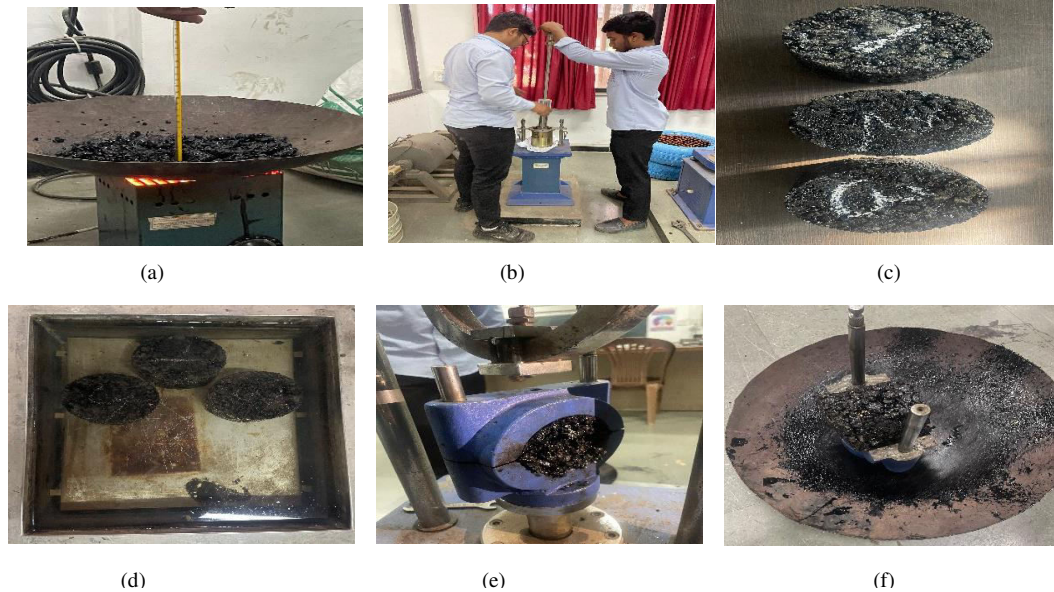
Figures shows the segregation carried out for material .



(a)

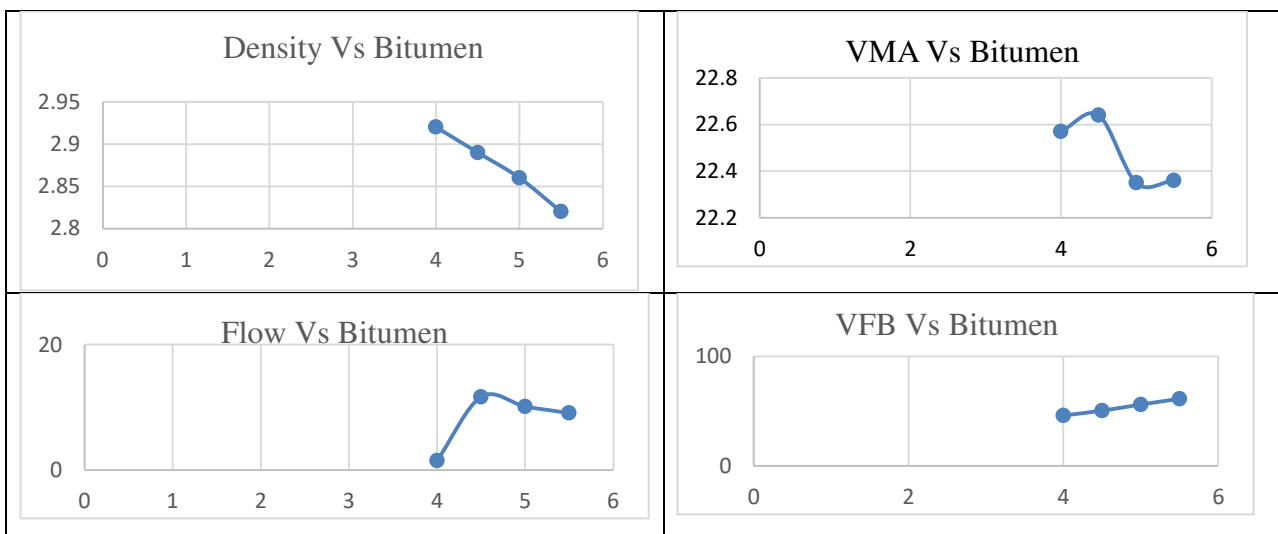
(b)

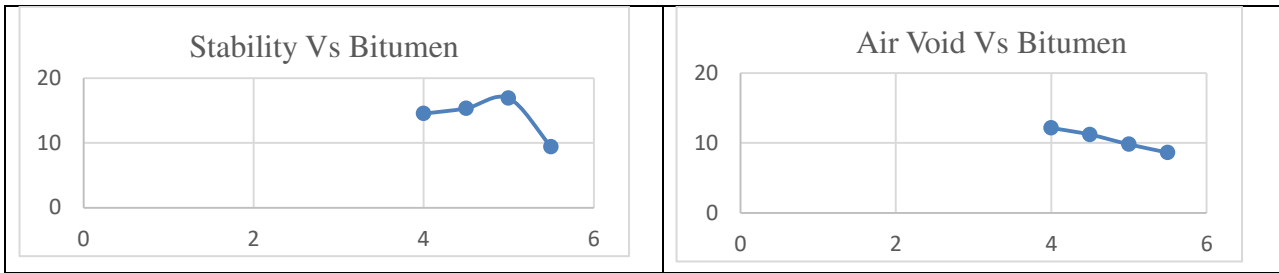
Fig. a, b, c, d, e, f are the experiment carried out for analysis of steel slag as partial replacement of aggregate for road construction .



AGGREGATE

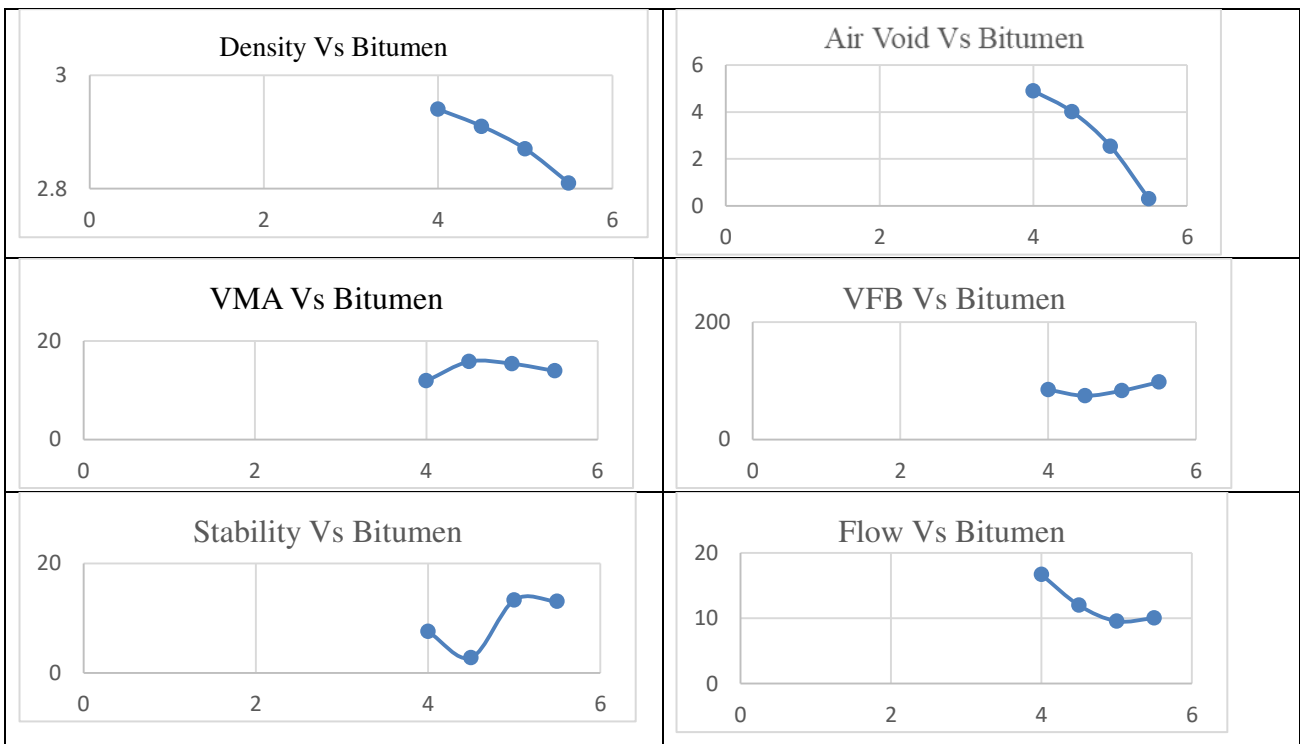
AGGREGATE						
BINDER CONTENT	DENSITY	AIR VOID	VMA	VFB	STABILITY	FLOW
4	2.92	12.16	22.57	46.11	14.53	1.48
4.5	2.89	11.2	22.64	50.52	15.36	11.67
5	2.86	9.81	22.35	56.12	16.91	10.13
5.5	2.82	8.63	22.36	61.39	9.4	9.08





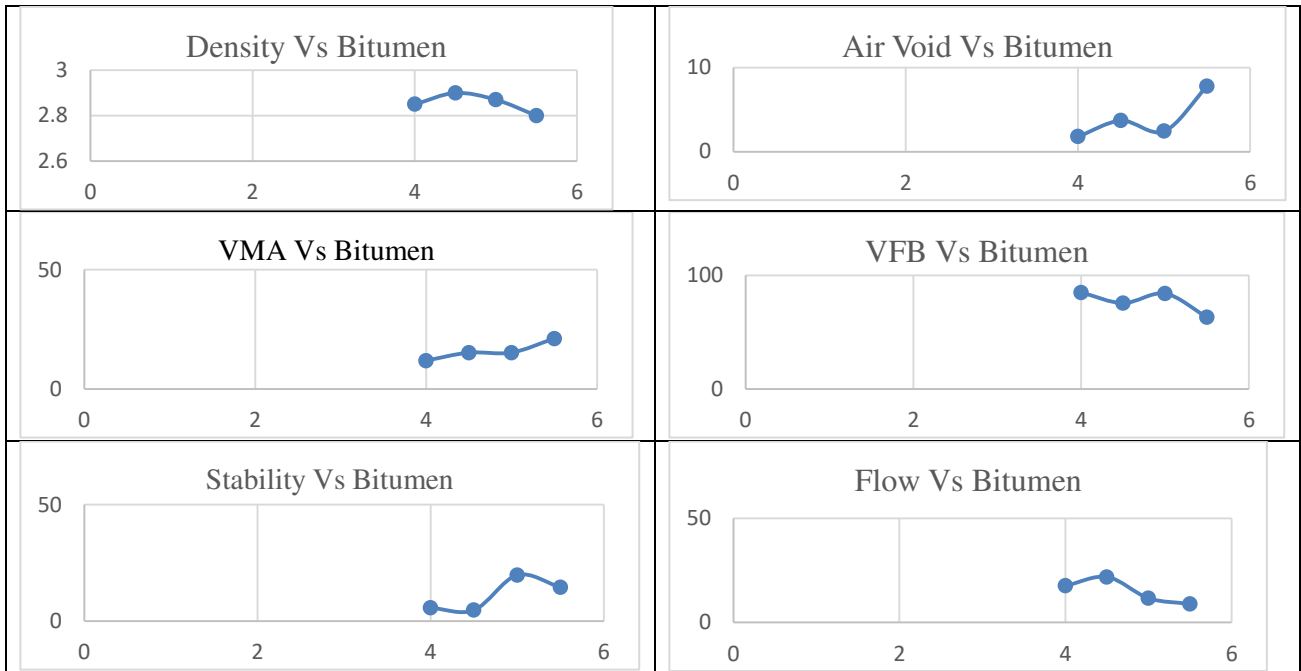
Aggregate with Steel slag (5% Replacement)

Aggregate with Steel slag (5% Replacement)						
BITUMEN	DENSITY	AIR VOID	VMA	VFB	STABILITY	FLOW
4	2.94	4.9	11.88	85.03	7.56	16.68
4.5	2.91	4.02	15.8	74.57	2.81	11.98
5	2.87	2.55	15.37	83.43	13.32	9.56
5.5	2.81	0.31	13.91	97.78	13.08	10.02



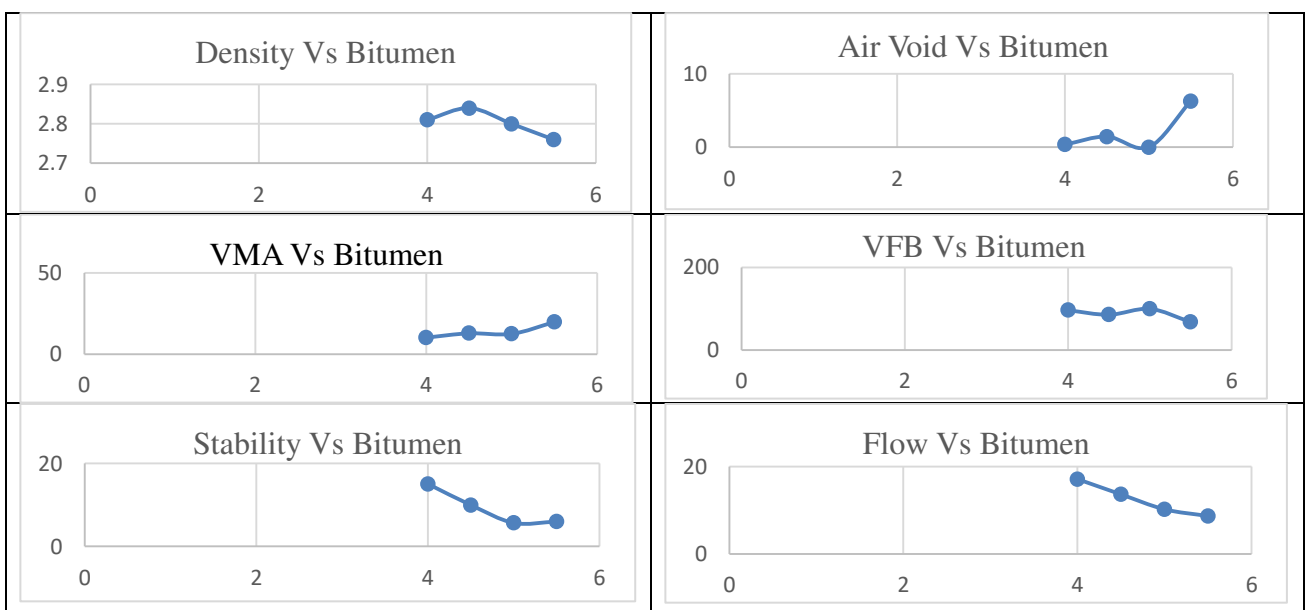
Aggregate with Steel slag (10% Replacement)

Aggregate with Steel slag (10% Replacement)						
BITUMEN	DENSITY	AIR VOID	VMA	VFB	STABILITY	FLOW
4	2.85	1.78	11.88	85.03	5.71	17.57
4.5	2.9	3.69	15.21	75.72	4.7	21.84
5	2.87	2.43	15.24	84.04	19.72	11.64
5.5	2.8	7.79	21.16	63.2	14.53	8.83



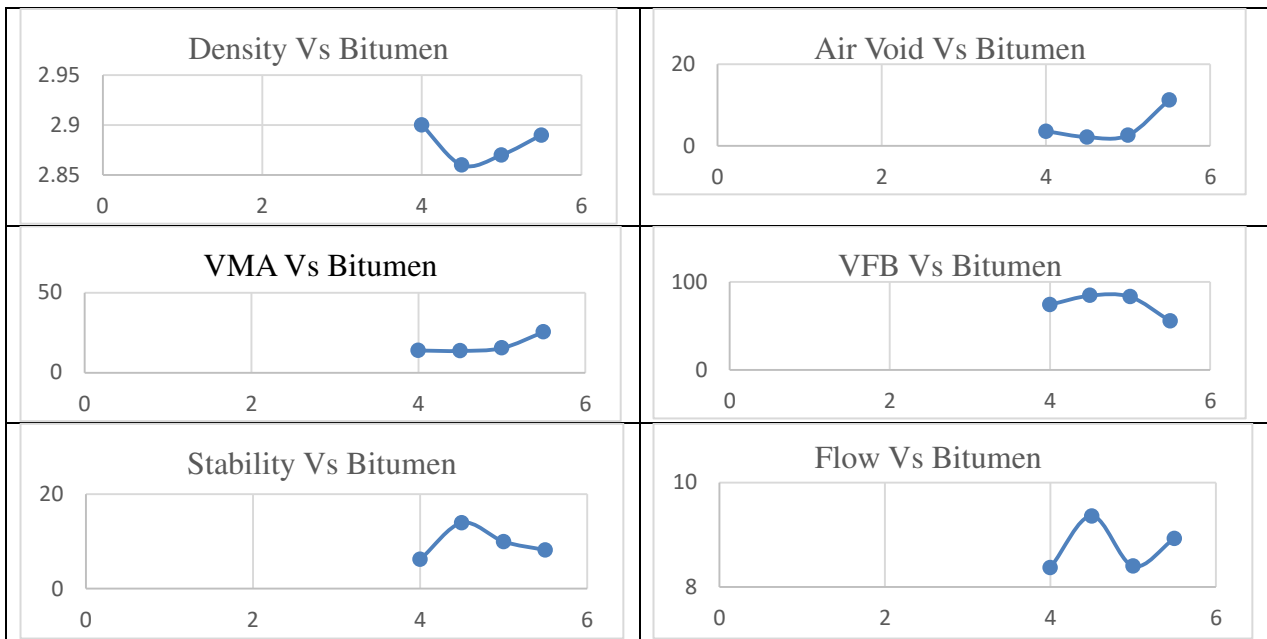
Aggregate with Steel slag (15% Replacement)

Aggregate with Steel slag (15% Replacement)						
BITUMEN	DENSITY	AIR VOID	VMA	VFB	STABILITY	FLOW
4	2.81	0.36	10.19	96.49	15.07	17.15
4.5	2.84	1.44	12.81	85.75	9.98	13.66
5	2.8	0.002	12.47	99.81	5.67	10.24
5.5	2.76	6.29	19.76	68.18	5.99	8.7



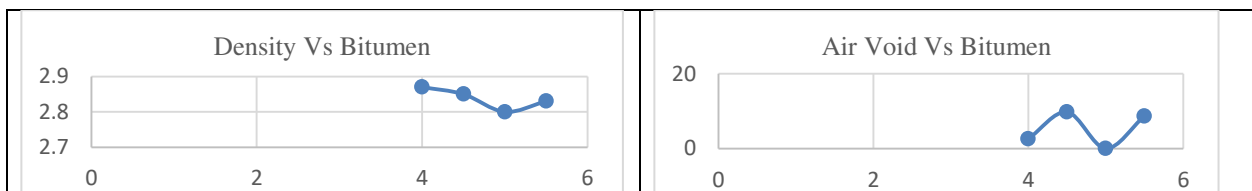
Aggregate with Filler (20% Replacement)

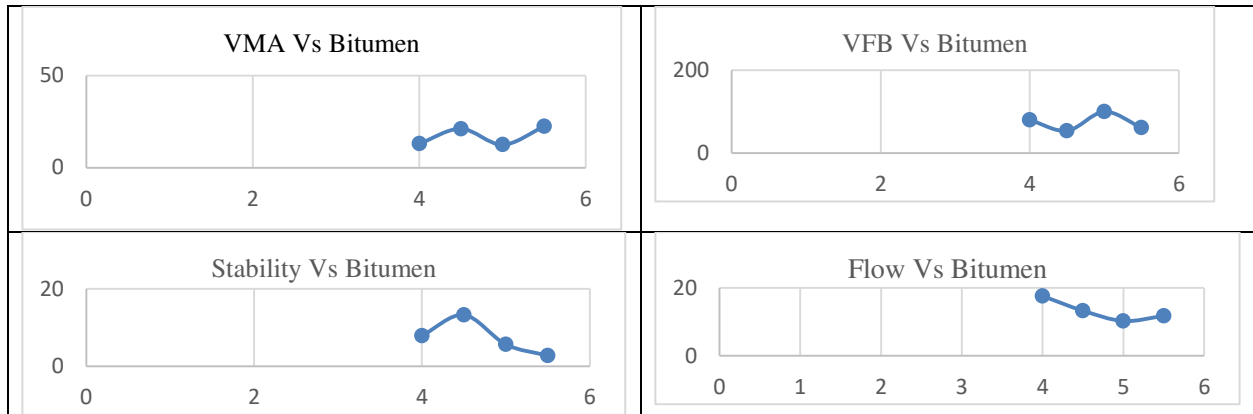
Aggregate with Steel slag (20% Replacement)						
BITUMEN	DENSITY	AIR VOID	VMA	VFB	STABILITY	FLOW
4	2.9	3.57	13.87	74.26	6.2	8.37
4.5	2.86	2.1	13.6	84.53	13.95	9.36
5	2.87	2.59	15.36	83.13	9.98	8.4
5.5	2.89	11.27	25.41	55.65	8.18	8.93



Aggregate with Filler (25% Replacement)

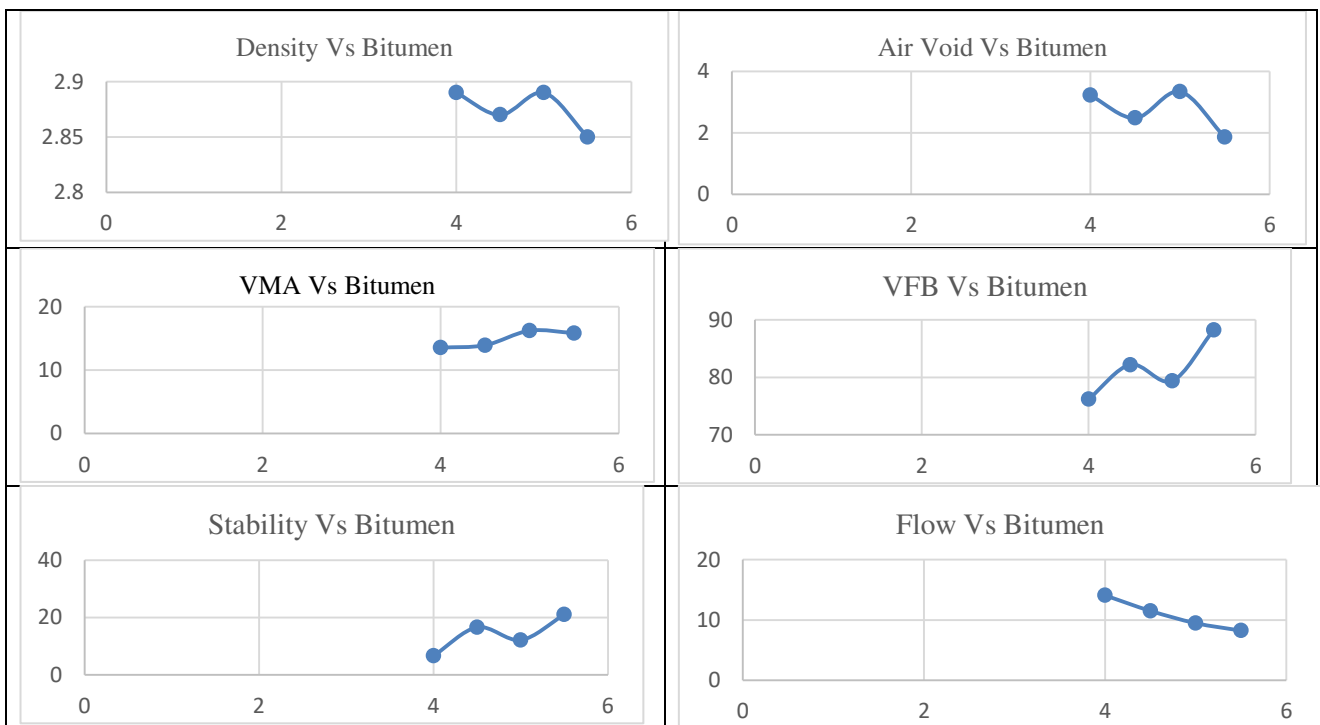
Aggregate with Filler (25% Replacement)						
BITUMEN	DENSITY	AIR VOID	VMA	VFB	SATBILITY	FLOW
4	2.87	2.6	12.98	79.95	7.94	17.6
4.5	2.85	9.76	21.13	53.81	13.27	13.26
5	2.8	0.02	12.47	99.81	5.67	10.24
5.5	2.83	8.71	22.35	61.01	2.75	11.73





Aggregate with Filler (30% Replacement)

Aggregate with Steel slag (30% Replacement)						
BITUMEN	DENSITY	AIR VOID	VMA	VFB	SBILITY	FLOW
4	2.89	3.22	13.52	76.19	6.63	14.08
4.5	2.87	2.48	13.91	82.19	16.57	11.51
5	2.89	3.34	16.2	79.37	12.16	9.47
5.5	2.85	1.86	15.82	88.27	21.03	8.23



Comparison of Aggregate with Steel Slag

Bitumen %	Aggregate				
	Air Voids %	VMA %	VFB %	Load(Kg)	Flow(mm)
4	12.16	22.57	46.11	1482.64	1.48
4.5	12.16	23.81	48.92	1566.66	11.67
5	12.16	25.04	51.44	1724.8	10.13



5.5	12.16	26.27	53.7	958.77	9.08
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Parameters obtained for BC Mix Design using VG 30 Grade Bitumen for aggregate.

Aggregate with Steel Slag					
Replacement of Steel Slag (%)	Air Voids %	VMA %	VFB %	Load(Kg)	Flow(mm)
4% Bitumen					
5	4.90	15.15	67.68	770.97	16.68
10	1.78	11.88	85.03	583.17	17.57
15	0.36	10.19	96.49	1537	17.15
20	3.57	13.87	74.26	632.59	8.37
25	2.6	12.98	79.95	810.5	17.6
30	3.22	13.52	76.19	677.07	14.08
Bitumen 4.5%					
5	4.02	15.8	74.57	286.64	11.98
10	3.69	15.21	75.72	479.38	21.84
15	1.44	12.81	88.75	1018.07	13.66
20	2.1	13.6	884.53	1423.33	9.36
25	9.76	21.13	53.81	1354.14	13.26
30	2.48	13.91	82.19	1690.2	11.51
Bitumen 5%					
5	2.55	15.37	83.43	1359.08	9.56
10	2.43	15.24	84.04	2011.44	11.64
15	0.2	12.72	98.46	1462.87	10.69
20	2.59	15.36	83.13	1018.07	8.4
25	0.02	12.47	99.81	578.22	10.24
30	3.34	16.2	79.37	1240.47	9.47
Bitumen 5.5%					
5	0.31	13.91	97.78	1334.38	10.02
10	7.79	21.16	63.20	1482.64	8.83
15	6.29	19.76	68.18	1611.135	8.70
20	11.27	25.41	55.65	835.2205	8.93
25	8.71	22.35	61.01	286.6437	11.73
30	1.86	15.82	88.27	2144.886	8.23

Parameters obtained for BC Mix Design using VG 30 Grade Bitumen for aggregate with partial replacement of steel slag

VIII. RESULT and DISCUSSION

Result of bituminous concrete mix design using VG- 30 grade bitumen for aggregate with partial replacement of steel slag

Table . Comparison of aggregate with partial replacement of steel slag

Bitumen %	Aggregate		Replacement with Steel Slag		
	Load (Kg)	Flow (mm)	Steel Slag %	Load (Kg)	Flow (mm)
4	1482.64	1.48	5	770.97	16.68
			10	583.17	17.57
			15	1537	17.15
			20	632.59	8.37
			25	810.5	17.6
			30	677.07	14.08
4.5	1566.66	11.67	5	286.64	11.98
			10	479.38	21.84

			15	1018.07	13.66
			20	1423.33	9.36
			25	1354.14	13.26
			30	1690.2	11.51
5	1724.8	10.13	5	1359.08	9.56
			10	2011.44	11.64
			15	1462.87	10.69
			20	1018.07	8.4
			25	578.22	10.24
5.5	958.77	9.08	30	1240.47	9.47
			5	1334.38	10.02
			10	1482.64	8.83
			15	1611.135	8.70
			20	835.2205	8.93
			25	286.6437	11.73
			30	2144.886	8.23

- The combination of only aggregates mixed with bitumen shows stability value of 1482.64 kg with 1.48 mm flow value at 4 % bitumen content. The combination of aggregates and partial replacement of 15 % steel slag mixed with bitumen shows maximum stability value of 1537 kg with 17.15 mm flow value at 4% bitumen content.
- The combination of only aggregates mixed with bitumen shows stability value of 1566.66 kg with 11.67 mm flow value at 4.5 % bitumen content. The combination of aggregates and partial replacement of 30 % steel slag mixed with bitumen shows maximum stability value of 1690.2 kg with 11.51 mm flow value at 4.5% bitumen content.
- The combination of only aggregates mixed with bitumen shows stability value of 1724.8 kg with 10.13 mm flow value at 5 % bitumen content. The combination of aggregates and partial replacement of 10 % steel slag mixed with bitumen shows maximum stability value of 2011.44 kg with 11.64 mm flow value at 5% bitumen content.
- The combination of only aggregates mixed with bitumen shows stability value of 958.77 kg with 9.08 mm flow value at 5.5 % bitumen content. The combination of aggregates and partial replacement of 30 % steel slag mixed with bitumen shows maximum stability value of 2144.88 kg with 8.23 mm flow value at 5.5% bitumen content.
- Finally out of the above cases discussed the combination of only aggregates mixed with bitumen shows maximum stability value of 1724.8 kg with 10.13 mm flow value at 5 % bitumen content. The combination of aggregates and partial replacement of steel slag mixed with bitumen shows maximum stability value of 2144.886 kg with 8.23mm flow value at 5.5 % bitumen content.

IX. CONCLUSION

As there is need of sustainable development when it comes to deployment of large infrastructure projects. These projects consume a huge amount of natural resources there by increasing the burden in environment. The present study uses steel slag a bi-product of steel industry as a partial replacement to fine aggregates which are used as fillers in case of road construction.

The evaluation for this study is typically revolving around the parameters of marshal stability value test ie; stability value and flow value. Different combinations of aggregates and steel slag as taken in consideration with varying bitumen content gives varying results. The combination of only aggregates mixed with bitumen shows maximum stability value of 1724.8 kg with 10.13 mm flow value at 5 % bitumen content. The combination of aggregates and partial replacement of steel slag mixed with bitumen shows maximum stability value of 2144.886 kg with 8.23mm flow value at 5.5 % bitumen content. Here as seen in the results no such linear variation is seen in case of stability value and flow value. The nonlinear variation in case of stability value and flow value needs to be further evaluated by studying the lacunas in process followed if any.

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