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Assessment on Adding Kota Stone Waste (KSW) Instead of Aggregate in Bituminous Concrete

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Abstract—*The continues increment in roadway movement in blend with insufficient maintenance due to paucity of funds has resulted in deterioration of road network in India .To improve this proper maintenance, effective and superior roadway design, use of higher quality materials and use of effective and modern construction techniques should be placed into practice to be during previous three decades around the world it has been tested that change of the bituminous binding with many types of additives enhances the properties and life of bituminous concrete pavements. This present examination was done to propose the utilization of Kota stone waste (KSW) in bituminous blend of adaptable asphalts so as to give a strategy for safe transfer of stone with a specific end goal to counter ecological contamination too. Physical properties of regular and Kota stone waste totals were looked at The Marshall method of mix design was adopted using VG-30 grade bitumen for natural aggregates and Kota stone waste aggregate (KSW). Marshall Specimens were prepared at bitumen content ranging from 4. 5 % to 6% with an increase of 0. 5% by weight of aggregates and with Kota stone content of 0%, 20%, 40%, 60%, 80% and 100% by weight of optimum bitumen content. Marshall stability , voids in mineral ,Air void (Vv) and Voids loaded with bitumen (VFB) were resolved and comparison with natural aggregates bituminous concrete mixes. Test results appear sensible the comparative analysis of the physical properties of the aggregates are within define limits.*

Keywords*: Optimum bitumen content, Marshall Stability, Air voids.*

1. INTRODUCTION

Quick increase in traffic inserts and drastic variations in weather conditions have compelled the technologists to upgrade the specifications for bituminous combinations to acquire higher mechanical steadiness for bituminous concrete roads. As the limits of upgrading bituminous concrete integrates with conventional mixes has reached out so there should be a modification of bituminous mixes Changes of bituminous mixes has its own advantages such as decreased thermal susceptibility and rutting, minimization of low temperature cracking, increased adhesion to the mixture, increased tire traction etc.

Bituminous Concrete: Bituminous mixes contains mineral aggregates, filler and perfect binder added to a hot mix plant and laid at hot condition results in a superior form of asphaltic pavement well graded aggregates& filler resulting in maximum density when mixed with optimum binder content. The amount of aggregate in asphalt mixture is generally 90 to 95 percent by weight and 75 to 85 percent by volume and they are generally} they are primarily responsible for the load holding capacity of pavement. This kind of mix shows a high stability and its life is about 6-8 years. Excellent grading material and low air voids (3-5%) is responsible for its highly impervious nature. As a result of better interlocking, high density and flexural modulus of flexibility it can support largest traffic density and axle load. The loads are spread downwards and out, resulting in reduced challenges on layer beneath. Anticipated to high degree of control in grading, proportioning of materials and the binder content, a better non-slipping surface is obtained.

2. LITERATURE REVIEW

Evaluates the effect of marble dust and granite dust on the properties of asphalt-filler matrix in HMA. These fillers are hydrophobic in nature. Strong bond is formed because of more fatigue strength and their constant nature. These fillers can be used in the range of 4 to 5.5% in asphalt mix. It is recommended to use it for low volume roads. Since, marble dust was used as filler on the basis of filler/bitumen ratio increases according to [**1],** marble dust as filler in HMA increase Marshall Stability, and flow value of Indirect Tensile Strength. On similar ground Kota stone industry produces both solid waste as well as stone slurry waste. During the process of cutting, in that original stone waste mass is lost by 25% in the form of dust **[2]** RMA was replaced by virgin aggregates (VA) at rates of 15, 25, 40, and 60% in HMA. The result shows that using RMA in asphalt mixtures increased optimum binder content decreased Fatigue.

Life with negligible difference. As in this heading, Marble waste used as fine aggregate with variations ranging from 0 to 100% at an interval of 50%. It was concluded that 100% RMA can be used as fine aggregate on the basis of Marshall Stability and flow values. On similar ground [**3]**.

3. OBJECTIVE

To do comparative study of natural aggregate and Kota stone waste as aggregate in flexible pavement.

To minimize problems induced by Kota stone waste by successful recycling as road pavement material.

Learning about various testing of aggregate and bitumen pavement.

Design of pavement on the basis of Marshall Test result and comparison.

Minimize the construction cost of road by using stone waste as replacement for aggregate.

4. MATERIAL, PROPERTIES AND PROCEDURE

The materials used for preparation of the bituminous mix were[4]

Aggregate was obtained from local areas. In order to get required gradation three grades of aggregates (ABC) were chosen. Different proportions are shown below:

Aggregate A- 14%

Aggregate B- 23%

Aggregate C- 08%

Stone dust-55%

Filler- 2 %

Physical properties of the aggregates were tested in laboratory. The test results and grading curve are shown below in table-1 and Fig- 1

Aggregate Gradation: Aggregate gradation that satisfies the requirements of IRC 111-2009 for grading-1 was selected. From Figure-1 below, it can be observed that the selected aggregate gradation is within the specified range for hot asphalt mix design

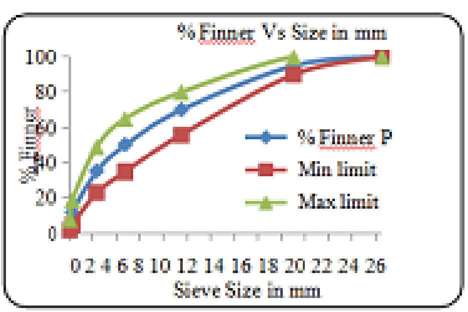

Fig. 1: Gradation Curve for aggregates

This became responsible for higher fraction of crushing of aggregates compared to skinny coating of waste plastic (7% and 9%). for this reason a better crushing fee, and Los angles abrasion value was placed at a higher p.c (11%) of plastic coating over aggregates compared to lesser proportion of plastic coating. thanks to waste plastic coating relative density was increased. owing to waste plastic coating.[5]

Voids were sealed and hence no water absorption as observed and aggregates became tougher and stronger, hence no loss of aggregate fraction was observed during soundness test. Due to waste plastic coating a strong adhesion force between plastic coated aggregate and bitumen, no stripping of bitumen was observed after 24 hours of immersion.[6]

Table 1: Grading requirement for mineral

Table-3 Properties of penetration grade bitumen

Properties Tested	Test Method	Results	Remarks
Penetration(100 gram, 5 seconds at 25°C) (1/10th of mm)	IS 1203-1978	93	Satisfactory
Softening point, °C(Ring and Ball Apparatus)	IS 1205-1978	56.8	Satisfactory
Ductility at 27°C(5cm/ minute pull) cm	IS 1208-1978	86	Satisfactory
Specific gravity at 27°C	IS 1202-1978	1.02	Satisfactory
Viscosity in seconds	IS 1206-1978	50	Satisfactory
Flash Point	IS 1209-1981	272°C	Satisfactory
Fire Point	IS 1209-1981	286°C	Satisfactory
Grade of binder	VG-10		

B- Bitumen: The bitumen used in the experiment was VG-10 grade and was tested in the laboratory for basic tests, ductility, softening point, penetration specific gravity and viscosity Results are shown in table-1 below.

C- Mineral Filler: Filler might comprise of at last separated mineral, for example, hydrated lime or Bond. The utilization on hydrated lime is empowered as a result of its great hostile to stripping and against oxidant properties. The degree of filler is appeared in D-Modifiers (Plastic waste), The handled waste Plastic convey sacks of low thickness polyethylene (LDPE) and high thickness polyethylene (HDPE).

Table 2: Properties of Aggregate

Description of tests	Percentage of kota stone waste by weight of OBC					Specifications IRC:1 11-2009
	100%	20% (PCA)	40 %	60%	80%	
Aggregate Crushing strength value	17.53	20.68	19.35	18.46	18.23	Max30 %
Impact value	23.98	26.13	25.54	24.8%	18.23%	Max 30%
Specific gravity value	2.63	2.7	2.8	2.85	2.86	2.5-3.0
Flakiness Index value	13.52%.	12.38%	12.45%	12.55%	12.58%	Max35 %
Elongation index value	10.35%	11.3%	11.5%	11.9%	12.35%	Max 35 %
Los Angeles Abrasion Value	16.32	15.45%	13.22%	12.5%	11.12%	Max 30%
Water absorption value	0.68	Nil	Nil	Nil	Nil	Max 2%
Soundness value	9%	Nil	Nil	Nil	Nil	Max 12 %
Stripping value	1.1%	Nil	Nil	Nil	Nil	Max 5%

articles from the garbage of local area in the shredded form were used as additive. The shredded waste plastic was cut into pieces of uniform size passing through 2.36 mm IS sieve and retained on 600 µ IS sieve. Thickness ranging between 10 µ to 30 µ.[7]

Marshall Mix design: In the present research the aggregate mix was heated to 140- 175°C and the shredded plastic waste was added to the aggregate in specified percentage. The waste plastic initially coats the heated aggregates. In next stage heated bitumen at specified temperature was added to the aggregates and the plastic coated aggregate was mixed with hot bitumen for 15 second and in result modified bituminous was made by weight of mix and plastic were added in different percentages to the mix by weight of bitumen.[8]

Design of bitumen concrete mix: in this study the addition of bitumen was made by weight of mix and plastic were added in different percentages (5%, 7%, 9%, 11%, 13%, and 15%) to the mix by weight of bitumen. The Marshall samples were prepared of both conventional and plastic modified bituminous mixes and the prescribed tests were performed. When the Marshall specimen are kept in water shower at 60±1ºC for 24±1 hours called conditioned specimen and the specimen kept thermostatically specimen .[9] Plots of bitumen content against volumetric properties were drawn for all mixes. OBC for each mix was calculated by taking the mean of bitumen content values corresponding to Maximum stability, maximum density and 4%air void [10]

Table 3: Properties of Bitumen

S. No	Tests	Results	Specified limit
1	Penetration test	68	50-70
2	Ductility test	100	min40
3	Softening point	47	40 to 55
4	Specific gravity	0.99	min0.99

5. METHODOLOGY

6. RESULT AND DISCUSSION

Table 4: Aggregate Gradation for BC

	20 mm		10mm		6mm		Stone dust		filler			
Sieve size in mm	% pass	Trial	% pass	% to be used	% pass	% to be used	% pass	% to be used		Combined	mid	Morth specification
		14 %		23 %		8%		55 %	2 %			
19	100	14	100	23	100	8	100	55	2	100	100	100
13.2	53.75	7.525	100	23	100	8	100	55	2	93.525	95	90-100

9.5	18.14	2.5396	98.71	22.7033	87	6.96	100	55	2	87.2029	79	70-88
4.75	1.22	0.1708	40.57	9.3311	21.81	1.7448	99.05	54.4775	2	65.7242	62	53-71
2.36	0	0	24.24	5.5752	12.81	1.0248	86.35	47.4925	2	54.0925	50	42-58
1.18	0	0	13.57	3.1211	6	0.48	54.75	30.1125	2	33.7136	41	34-48
0.6	0	0	10.24	2.3552	5.29	0.4232	44.3	24.365	2	27.1434	32	26-38
0.3	0	0	7.9	1.817	4.76	0.3808	35.45	19.4975	2	21.6953	23	18-28
0.15	0	0	5.76	1.3248	3.62	0.2896	26.3	14.465	2	16.0794	16	18-28
0.075	0	0	3.1	0.713	1.57	0.1256	13.4	7.37	2	8.2086	7	10-Apr

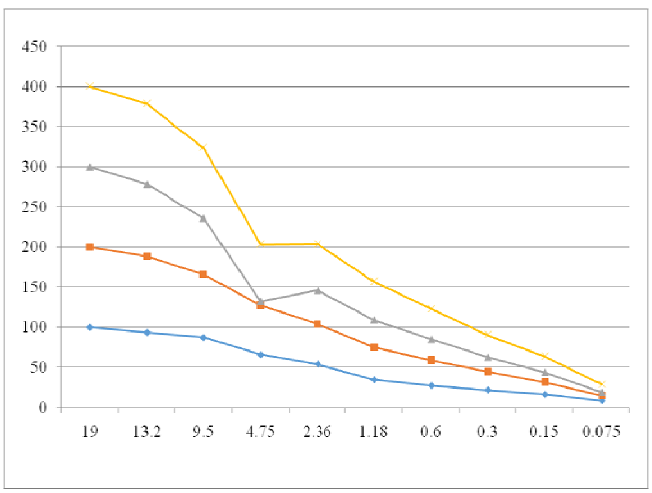

Fig. 1: Gradation of aggregate

Table 5: Properties of BC (II) (20%Conventional Aggregate & 80% Kota Stone)

%BITUMEN CONTENT	Wa	Ww	Volume	Density (gm)	Gt	Vv	Vb	VMA	VFB	Flow Value	Stability	C.F.	Net Stability (kg)
4	1115	660.2	450	2.47	2.72	7.95	4.33	17.85	55	3	3.1	1.14	940.92
4	1118	661.4	451.2	2.47	2.72	8.2	4.31	17.76	56.5	3.2	3.4	1.14	1030.312
4.5	1125	663	453.5	2.48	2.71	6.51	10.57	18.3	58.4	3.4	3.6	1.14	1100.24
4.5	1130	664.2	454.5	2.48	2.7	8.28	10.6	19.04	58.4	3.7	3.9	1.14	1190.62
5	1135	665	455	2.49	2.7	5.52	11.8	17.9	62.5	3	3.2	1.14	970.384
5	1140	665.6	455.5	2.5	2.68	5.42	11.7	17.95	63.4	3	3.1	1.14	940.92

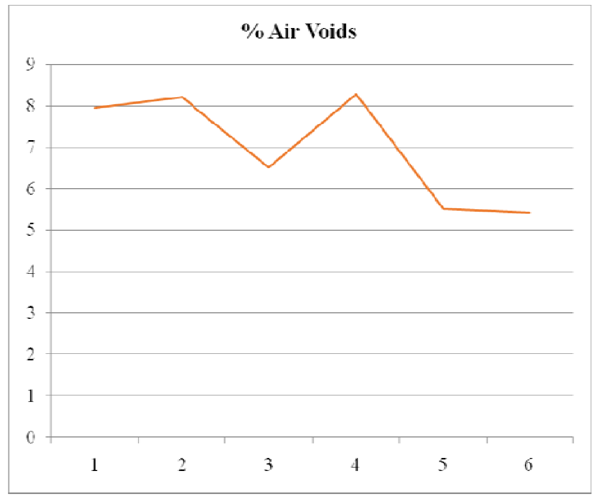

Fig. 2: Air voids vs. binder content

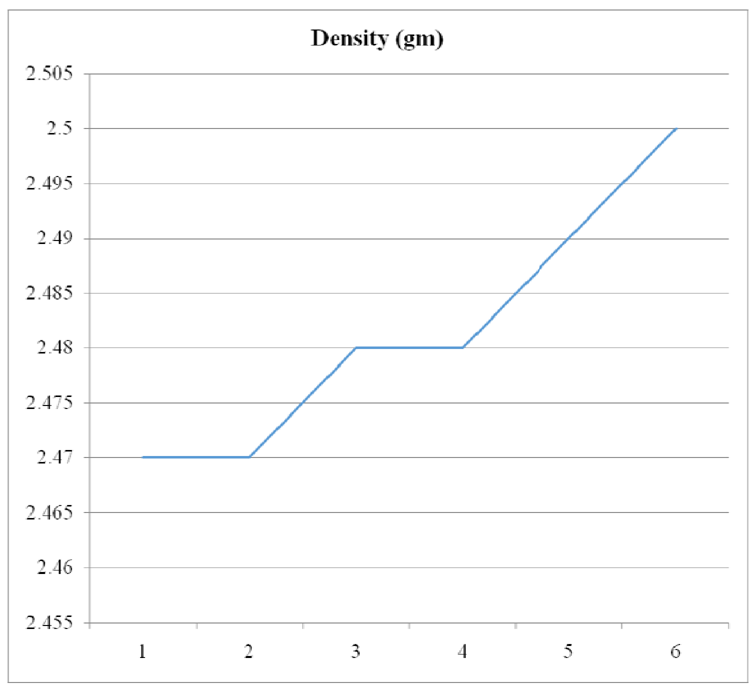

Fig. 3: Density vs. binder content

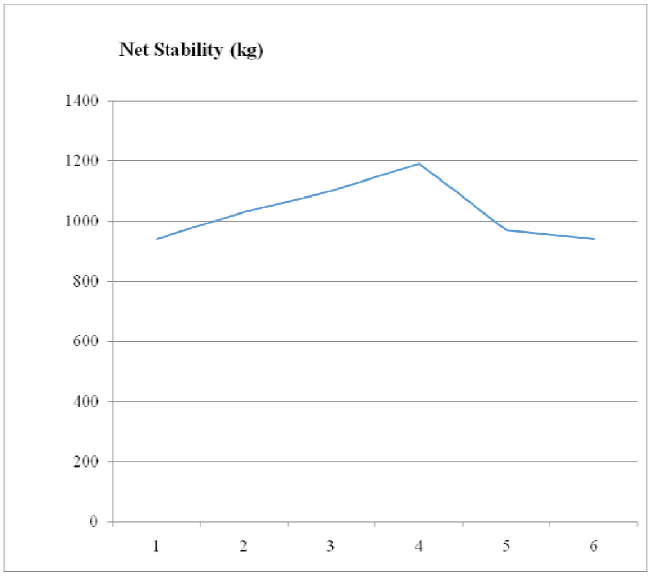

Fig. 4: Stability vs. binder content

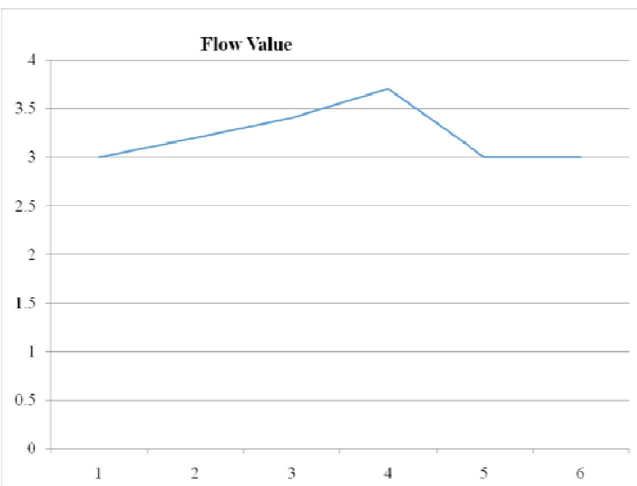

Fig. 5: Flow content vs. binder content

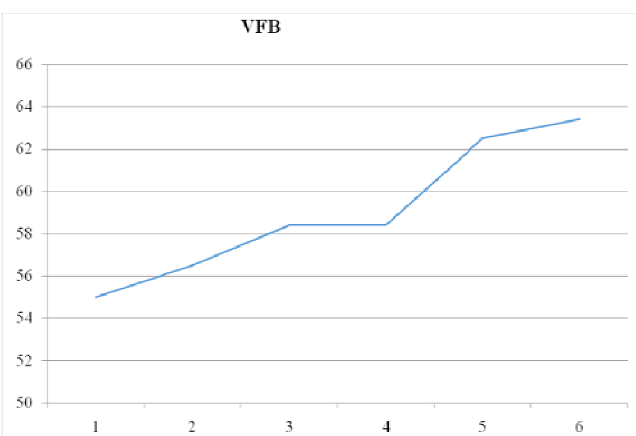

Fig. 6: VFB vs. binder content

Table 6: Properties of BC(Ii) (40%Conventional Aggregate & 60% Kota Stone)

% BITUMEN CONTENT	Wa	Ww	Volume	Density (gm)	Gt	Vv	Vb	VMA	VFB	Flow Value	Stability	C.F.	Net Stability (kg)
5.5	1140	667.5	470.5	2.42	2.6	6.2	12.5	17.85	65.2	4	3.1	1.14	942.92
5.5	1192	701.5	490.5	2.43	2.6	5.5	12.1	17.76	66.99	3.7	3.1	1.14	1004.848
6	1145	675	470	2.43	2.55	4.45	14.05	18.3	75.21	4.3	3.0	1.14	1004.848
6	1150	672.5	475.8	2.4	2.55	4.9	13.9	19.04	72.08	3.9	3.2	1.19	1035.312
6.5	1160	674.5	472.3	2.45	2.53	3.6	15.1	17.9	78.95	4.8	3.3	1.14	1066.775
6.5	1135.5	679	480	2.36	2.53	4.3	14.85	17.95	75.77	4.6	3.1	1.14	974.384

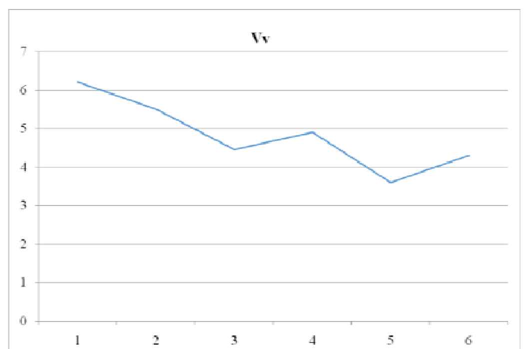

Fig. 7: Air Voids vs. Binder Content

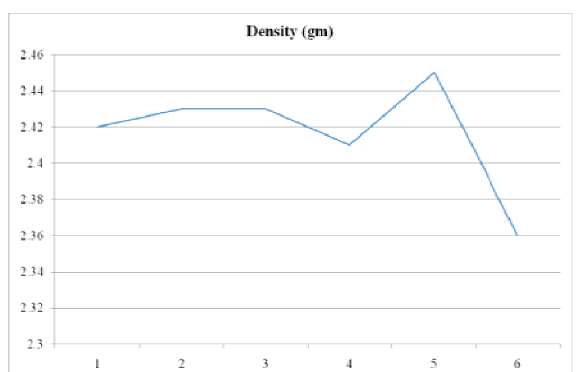

Fig. 8: Density vs. Binder Content

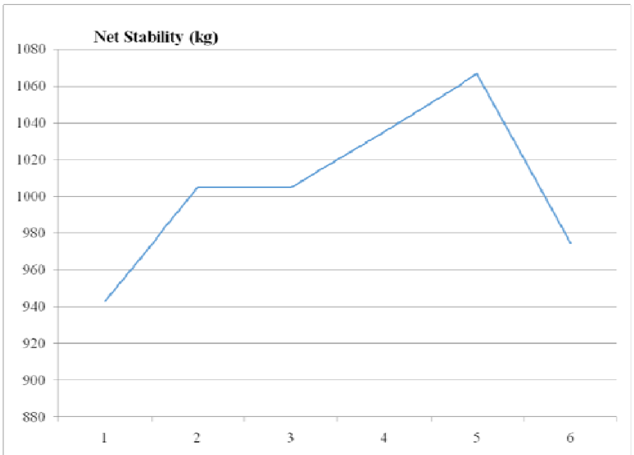

Fig. 9: Stability vs. Binder Content

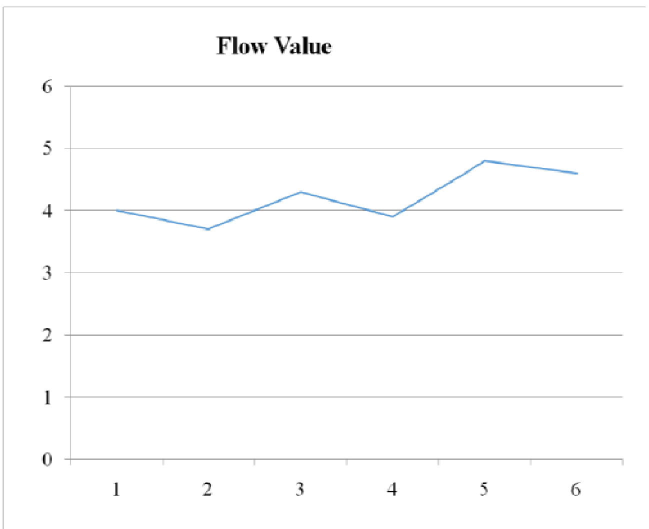

Fig. 10: Flow Content vs. Binder Content

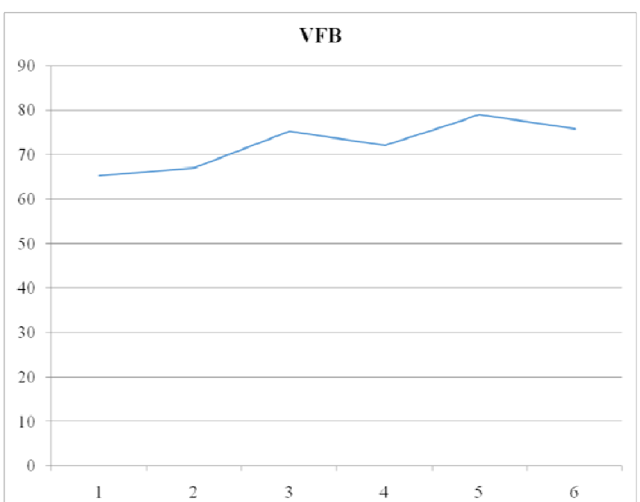

Fig. 11: VFB vs. Binder Content

Table 7: Properties of BC (Ii) (60%Conventional Aggregate & 40% Kota Stone)

% BITUMEN CONTENT	Wa	Ww	Volume	Density (gm)	Gt	Vv	Vb	VMA	VFB	Flow Value	Stability	C.F.	Net Stability (kg)
5.5	1150	670.5	486.5	2.36	2.5	6.05	12.8	18.95	68.2	4.2	2.9	1.14	941.95
5.5	1199	704.5	499.5	2.4	2.5	5.35	12.3	18.2	69.5	4.9	3.1	1.14	1005.95
6	1152	680	484	2.38	2.48	4.3	14.2	18.8	77.5	4.4	3.1	1.14	1005.95
6	1158	681.5	488	2.37	2.48	4.55	14.1	19.5	75.6	4.1	3.2	1.14	1036.9
6.5	1158	981.5	485.5	2.38	2.46	3.5	15.5	19.55	81.25	5	3.3	1.14	1067.5
6.5	1168	684	488	2.39	2.45	4.2	15.1	19.62	79.56	4.8	3	1.19	975.2

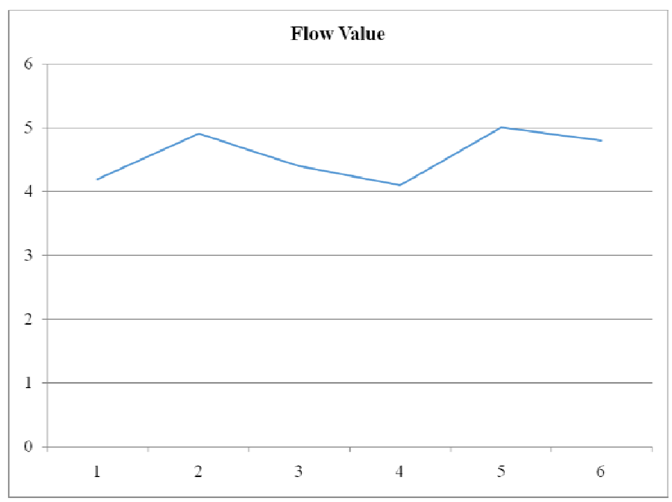

Fig. 12: Air Voids vs. Binder Content

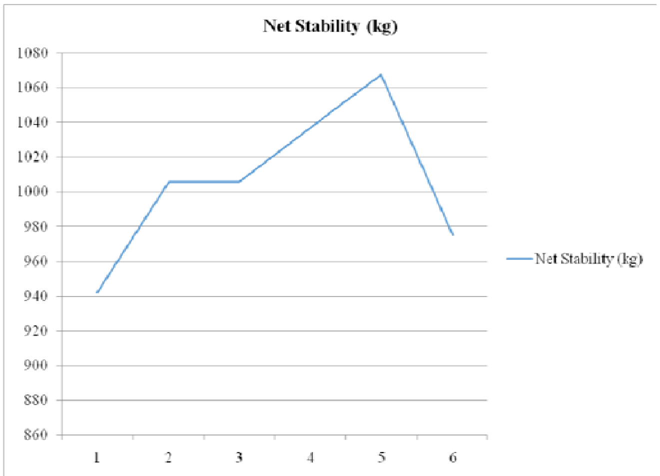

Fig. 13: Density vs. Binder Content

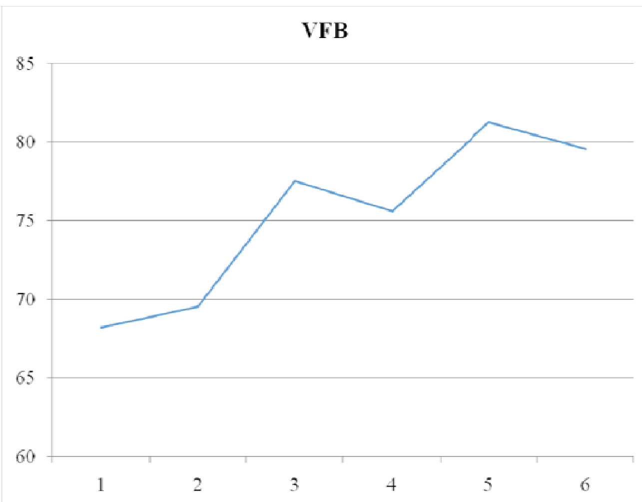

Fig. 14: Flow Value vs. Binder Content

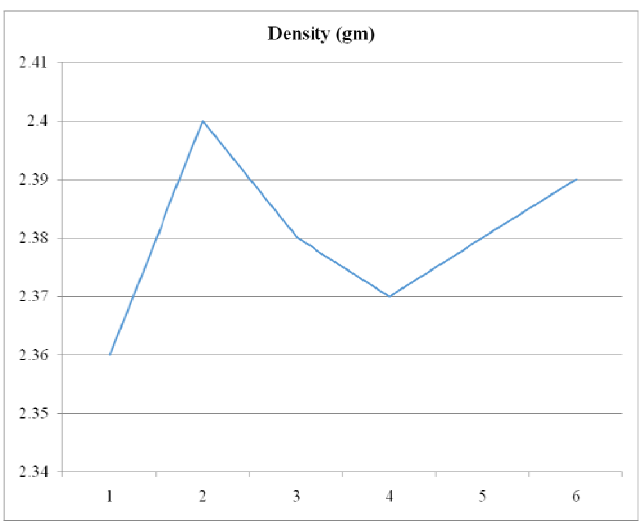

Fig. 15: Stability vs. Binder Content

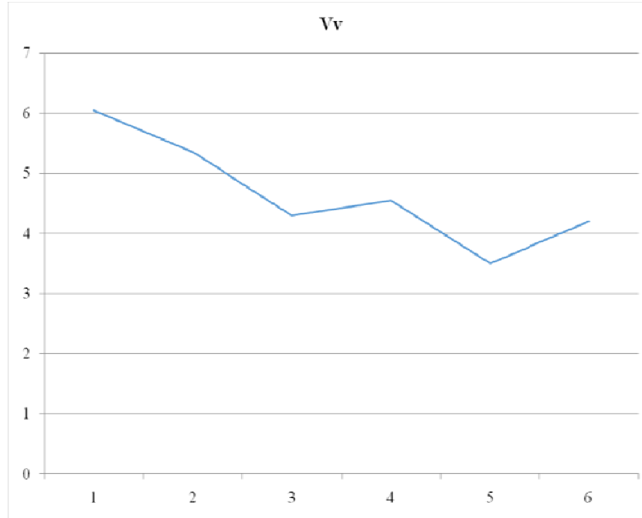

Fig. 16: VFB vs. Binder Content

TABLE 8: Properties of BC (II) (80%Conventional Aggregate & 20% Kota Stone)

%BITUMEIN CONTENT	Wa	Ww	Volume	Density (gm)	Gt	Vv	Vb	VMA	VFB	Flow Value	Stability	C.F.	Net Stability (kg)
5.4	1181	695	486	2.43	2.55	4.64	12.35	16.99	72.68	4.4	3.1	1.14	975.384
5.4	1173	680.5	492.5	2.38	2.55	6.57	12.18	18.74	64.96	4.3	3.5	1.14	1101.24
6	1144.5	671.5	473	2.42	2.52	4.16	14.09	18.25	77.23	4.5	3.9	1.14	1227.096
6	1148	673.5	474.5	2.42	2.52	4.17	14.05	18.22	77.13	4.3	4.2	1.14	1321.488
6.5	1149	671.5	477.5	2.41	2.51	3.95	15.13	19.08	79.27	4.9	3.3	1.14	1038.312
6.5	1145	672.5	472.5	2.42	2.51	3.28	15.29	18.56	82.35	5.1	3.8	1.14	1195.632

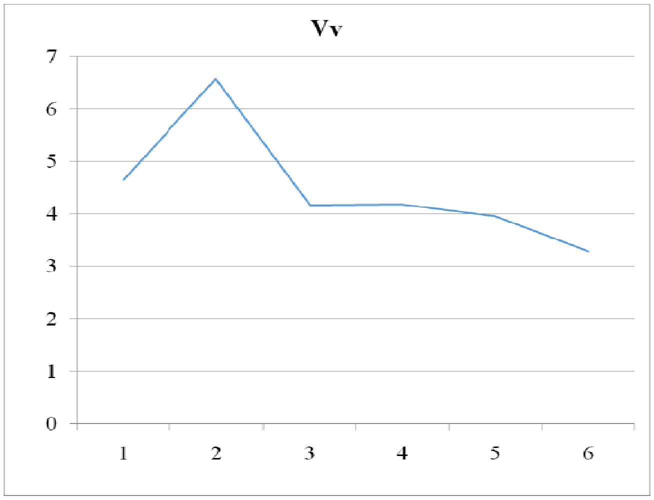

Fig. 17: Air Voids vs. Binder Content

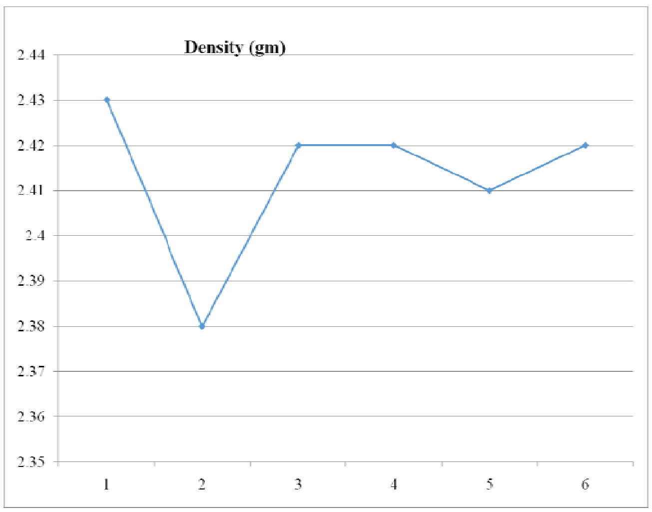

Fig. 18: Density vs. Binder Content

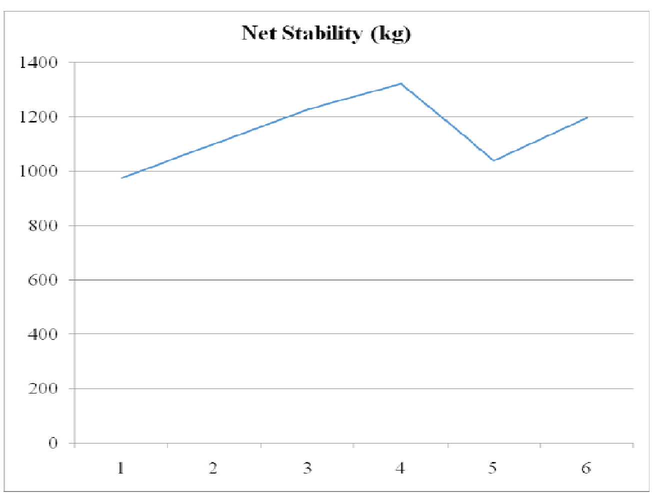

Fig. 19: Stability vs. Binder Content

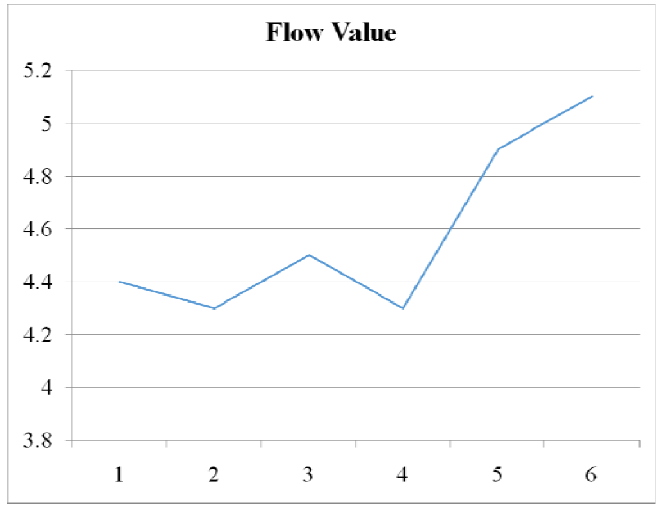

Fig. 20: Stability vs. Binder Content

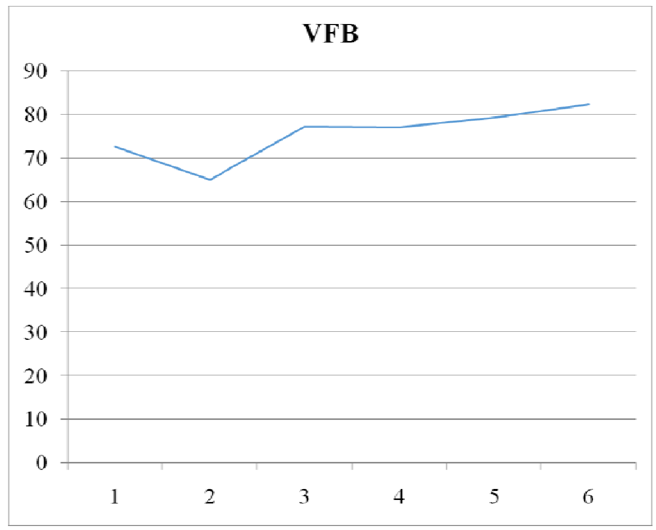

Fig. 21: VFB vs. Binder Content

Table 9: Properties of BC (II) (KSW)

%BITUMEIN CONTENT	Wa	Ww	Volume	Density (gm)	Gt	Vv	Vb	VMA	VFB	Flow Value	Stability	C.F.	Net Stability (kg)
5.4	1144	663.5	480.5	2.38	2.56	7	12.49	19.49	64.07	3	3	1.14	943.92
5.4	1147	662	485	2.36	2.56	7.62	12.37	19.99	61.88	4.1	3.2	1.14	1006.848
6	1145.5	659.5	486	2.36	2.54	7.11	13.72	20.82	65.87	4.6	3.6	1.14	1132.704

6	1148	669.5	478.5	2.4	2.54	5.44	13.93	19.38	71.9	4.2	3.8	1.14	1195.632
6.5	1140	667	47	2.41	2.52	4.31	15.27	19.58	77.97	4.8	3.2	1.14	1006.848
6.5	1166	679.5	486.5	2.4	2.52	4.85	14.85	19.69	75.38	4.9	3.3	1.14	1038.312

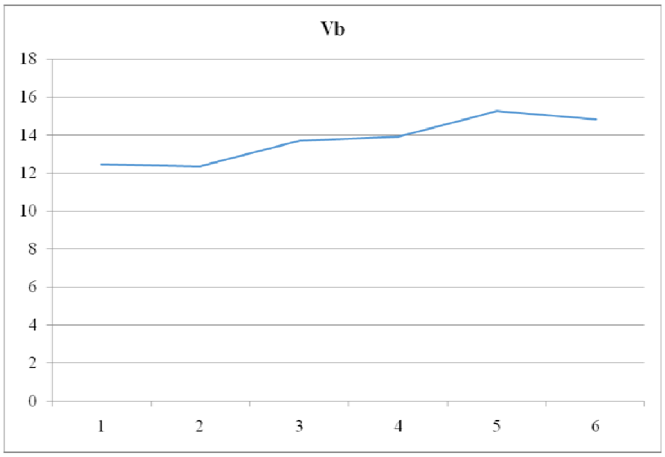

Fig. 22: Air Voids vs. Binder Content

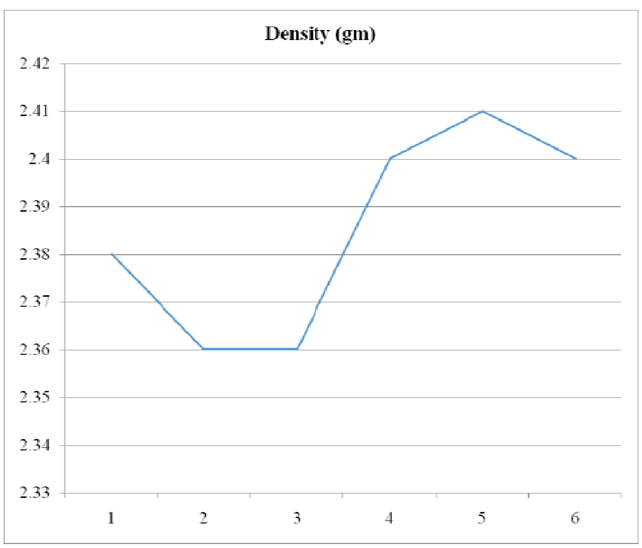

Fig. 23: Density vs. Binder Content

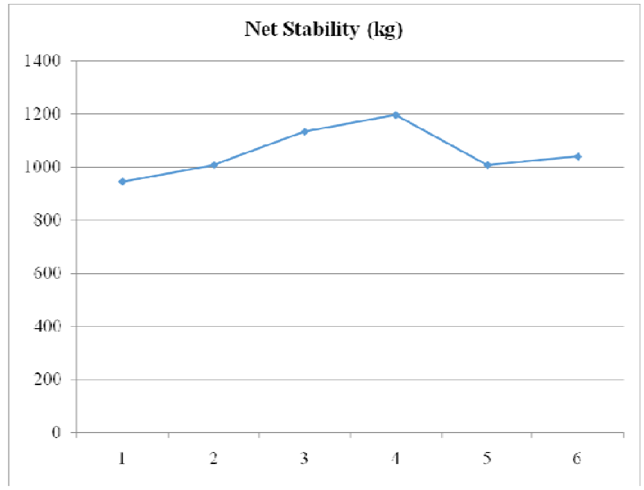

Fig. 24: Stability vs. Binder Content

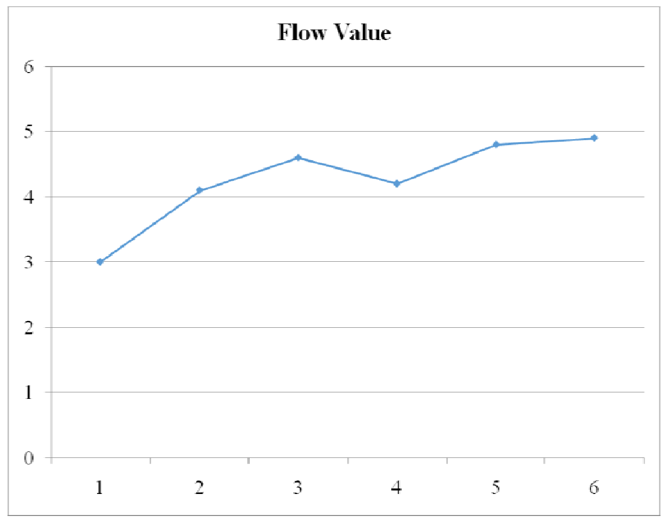

Fig. 25: Stability vs. Binder Content

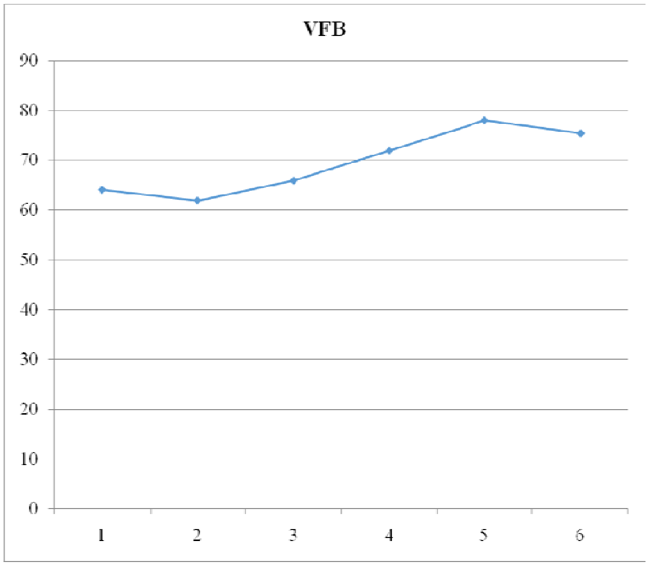

Fig. 26: VFB vs. Binder Content

7. CONCLUSION

Based on the experimental evidences following conclusion were drawn.

Kota Stone waste aggregate required the physical properties that qualify these aggregate to be used in bituminous concrete.

As per Marshall Test result conventional aggregate can be fully replaced with KSW.

The use of KSW in BC not only reduces the cost but also improve environment. It is hoped that in future we will have strong, durable and eco-friendly pavements in which we use KSW.

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