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Volume 09, Issue 08, Pages: 120-133

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IMPACT OF MORSEL ELASTIC ADJUSTED BITUMEN ON PULVERIZING OF REUSING TOTALS IN HOT BLEND BLACK-TOP

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ABSTRACT

This paper presents essential eventual outcomes of an investigation that explores the chance of using sums reused from regular turn of events and devastation wastes for amassing thick looked into hot mixed asphalts (HMA) to be used in turnpikes with low or medium traffic volume. Past results exhibited that the attempted material fulfills all Brazilian rule requirements for use in base layers, yet it was slanted to grain pummeling, what is a huge concern because of HMA. It is accepted that balanced dark top flexible spreads may help with easing this conceivable issue. In order to check this hypothesis, a couple of models were prepared using covers with different whole or piece versatile (0, 10 and 20%). The compaction imperativeness was furthermore investigated by changing the amount of blows (35, 50, and 75) during the Marshall Compaction tests. The results were dismembered the extent that Marshall Degradation Index and show that the particle crushing is lessened with growing proportion of piece versatile.

1. INTRODUCTION

1.1 GENERAL

Pavement designers have one goal in mind to carry the traffic load smoothly, reliably and cost effectively for a long period of time. We know that in order to accomplish that goal, a pavement has to meet several criteria. It has to distribute the applied load over a wide enough area so that it does not fail the underlying soil support system. It has to be durable to withstand the abrasive nature of the traffic, and environmental conditions. It has to resist damage so that it does not have to be repaired or replaced within a reasonable life span. It needs to be strong. Stone Matrix Asphalt (SMA) is a gap-graded mixture, have a better stone to stone contact which gives better strength to the mixture. In this research work aggregate used as per the MoRTH specification which was taken from a same lot. The samples are made with aggregate with different gradation, filler (cement) and binder (bitumen 30).

Most of the studies reveal that there associated engineering benefits using modified bitumen with sasobit as an additive (called as WMAs) over conventional hot-mix asphalt (HMA). It was also observed from the literature that low temperature mix

(SMA) has a better performance that of HMA mixes. Globe efforts are being put forward to shield our environment from release of harmful gases obtained through HMA. CO2 is the part of our natural environment however is produced from combustion of coal, gas, and petroleum products. To avoid considerable impact of CO2 emissions in future on our environment, efforts are made to decrease these harmful gases. The use of stone mix asphalt will able to reduce the release of harmful gases in environment and the use of sisel fiber will protect deploying of natural resources.

1.2 RECYCLE AGGREGATES

The production of demolition and construction waste has been increasing at a gradual rate in recent years. The amount of landfill available to contain this material has been decreasing, and the need to find appropriate disposal locations has been of increasing concern. Recycling programs offer a viable solution. The use of these materials as recycled base course in new roadway construction has become more common in the last twenty years, with some municipalities reporting as much as 400,000 tons of recycled materials used in this manner. Recycled roadway materials are typically generated and reused at the same construction site, providing increased savings in both money and time. It has been speculated that in some municipalities recycled materials costs less to use than conventional crushed-stone base material by as much as 30%. Despite the increased acceptance of recycled base materials, research concerning the mechanical properties and durability of such materials has been lacking. The most widely used recycled materials are recycled asphalt pavement (RAP) and recycled concrete aggregate (RCA). RAP is produced by removing and reprocessing existing asphalt pavement, and RCA is the product of the demolition of concrete structures such as buildings, roads and runways. The production of RA and RCA results in an aggregate that is well graded and of high quality. The aggregates in RA are coated with asphalt cement that reduces the water absorption qualities of the material. In contrast, the aggregates in RCA are coated with a cementations paste that increases the water absorption qualities of the material.

1.3 OBJECTIVE

The following objectives have been selected for the present investigation.

a) To evaluate the characteristics of virgin HMA on marshal.
b) To appraise the characteristics of HMA prepared with the inclusion of recycled aggregate at different proportions for marshal.
c) To ascertain the mixing crumb rubber of HMA.
d) To estimate the properties of resilient modulus, tensile strain of virgin HMA mixes and recycled aggregate added HMA.

2. REVIEW OF LITERATURE

2.1 General:

Major quantity of research was carried worldwide over the last few decades through various organizations and researchers for design and characterization of bituminous mixes. Critical bituminous pavement distresses have been identified and efforts were made to correlate binder, aggregate and mix characteristics of the bituminous pavement to develop different distresses. Bituminous layers normally fail due to load associated distresses like fatigue cracking permanent deformation temperature and moisture too affect the performance of bituminous layers considerably.

2.2 Review of Past Work:

Daniel and La (2005) has explained on mechanistic and volumetric properties of asphalt mixtures with recycled asphalt pavement. His research examines how the addition of RAP its changes in volumetric and mechanistic properties of asphalt mixtures. A superior asphalt performance pavement (SUPERPAVE) 19 mm mixture containing 0% RAP was used in his study to evaluating properties of mixes containing 15%, 25%, and 40% RAP. The VMA and VFB of the RAP mixtures increased at the 25% and 40% levels, and there was also an influence of pre-heating time on the volumetric properties. The dynamic modulus of the processed RAP mixtures increased from the control to 15% RAP level, but the 25% and 40% RAP mixtures had dynamic modulus curves similar to the control mixture in both tension and compression.

Bradely et.al. (2004) studied Utilization of waste fibres in stone matrix asphalt mixtures. They used carpet, tire and polyester fibres to improve the strength and stability of mixture compared to cellulose fibre. They found no difference in moisture susceptibility and permanent deformation in SMA mix containing waste fibres as compared to SMA mix containing cellulose or mineral fibre.

Kamaraj C., G. Kumar, G. Sharma, P.K. Jain and K.V. Babu (2004) carried laboratory study using natural rubber powder with 80/100 bitumen in SMA by wet process as well as dense graded bituminous mix with cellulose fibre and stone dust and lime stone as filler and found its suitability as SMA mix through various tests.

Punith V.S., Sridhar R., Bose Sunil, Kumar K.K., Veeraragavan A (2004) did a comparative study of SMA with asphalt concrete mix utilizing reclaimed polythene in the form of LDPE carry bags as stabilizing agent (3 mm size and 0.4%) .The test results indicated that the mix properties of both SMA and AC mixture are getting enhanced by the addition of reclaimed polythene as stabilizer showing better rut resistance, resistance to moisture damage, rutting, creep and aging.

Kristjans (2006) has evaluated on warm mix asphalt for cold weather paving condition. Increased environmental awareness and stricter emissions regulations have led to a development of warm mix asphalt (WMA) to reduce the high mixing temperatures of regular hot mix asphalt (HMA). Its benefits are reduction in energy consumption during production and reduced emissions during production and placement. His study explain that there are three methods used for development of WMA, WAM Foam, Aspha-min zeolite and Sasobit wax. All three methods will reduce the viscosity of the binder at a certain temperature range, allowing the aggregate to be fully coated at lower temperatures than in HMA production. He has investigated WMA's potential in cold weather conditions and specifically how Iceland, with such conditions, can benefit from it.

Brandon and Guthrie (2006) had performed laboratory characterization of recycled concrete for use as pavement base material.

Pankaj (2006) he had Explained environmental and field performance condition of the warm asphalt mixes technology with "ready to use" bitumen. His study as explained techniques to reduce the energy consumption by 35 % and CO2 emissions by 40 %.

Karasahin and Terzi (2007) he was carried out evaluation of marble waste dust in the mixture of asphaltic concrete. The results indicate performance of waste dust in asphalt mix. The results indicate that use of waste dust in asphalt mixture has increased the performance characteristics of asphaltic concrete.

Wasiuddin et al (2008) has explained the effect of Sasobit and Asppha-Min on wet ability and adhesion between asphalt binders and aggregates.

Muniandy R., Huat, B.B.K. (2006) used Cellulose oil palm fiber (COPF) and found fiber-modified binder showed improved rheological properties when cellulose fibers were preblended in PG64-22 binder with fiber proportions of 0.2%,0.4%,0.6%,0.8 %and 1.0% by weight of aggregates. It showed that the PG64-22 binder can be modified and raised to PG70-22 grade. The Cellulose oil palm fiber (COPF) was found to improve the diameteral fatigue performance of SMA deign mix. The fatigue life increased to a maximum at a fiber content of about 0.6%, whilst the tensile stress and stiffness also showed a similar trend in performance. The initial strains of the mix were lowest at a fiber content of 0.6%.

Kumar Pawan, Chandra Satish and Bose Sunil (2007) tried to use an indigenous fiber in SMA Mix by taking low viscosity binder coated jute fiber instead of the traditionally used fibers and compared the result with the imported cellulose fiber, using 60/70 grade bitumen and found optimum fiber percentage as 0.3% of the mixture. Jute fiber showed equivalent results to imported patented fibers as indicated by Marshall stability test, permanent deformation test and fatigue life test. Aging index of the mix prepared with jute fiber showed better result than patented fiber.

Shaopeng Wu et al. (2007) used slag after 3 year of ageing with PG76-22 modified binder, lime stone filler, short chopped polyester fiber (3%) for the SMA mix in Marshall method and found it to be suitable for use.

Chui-Te Chiu, Li-Cheng Lu, (2007) used asphalt rubber (AR),produced by blending ground tire rubber (GTR) (i) 30% of a coarse GTR with a maximum size of #20 sieve and (ii)20% of a fine with a maximum size of #30 sieve with an asphalt, as a binder for SMA and found AR-SMA mixtures were not significantly different from conventional SMA in terms of moisture susceptibility and showed better

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rutting resistance than that of conventional dense graded mixture.

Yongjie Xue, Haobo Hou, Shujing Zhu, Jin Zha (2008) used municipal solid waste incinerator (MSWI) fly ash as a partial replacement of fine aggregate or mineral filler and BOF Slag as part of coarse aggregate with polyester fiber of 6.35 mm in length obtained from recycled raw materials, PG76-22 binder in the SMA mix and performed Marshall and superpave method of design and found it's suitability for use in the SMA mix.

Hebhoub et al (2011) the authors studied the important of consumption is growing need for aggregates because of the growth in industrial production and this situation has led to a fast decrease of available resources. On the other hand, a high volume of marble production has generated a considerable amount of waste materials; almost 70% of this mineral gets wasted in the mining, processing and polishing stages which have a serious impact on the environment. The results shows that the mechanical properties of concrete specimens produced using the marble wastes were found to conform to the concrete production standards and the substitution of natural aggregates by waste marble aggregates up to 75% of any formulation is beneficial for the asphalt concrete

Yoon et al (2011) had performed laboratory investigations Hot Mix Asphalt (HMA) base Layer Aggregate using Recycled Concrete Aggregate (RCA). The results of HMA mixtures using RCA has quantitatively evaluated for its applicability HMA material. Evaluating the Marshall test properties of each mixture, it is also concluded that the dynamic loading in the Marshall test compaction method possibly causes friction in the RCA of the asphalt mixtures and, therefore, leads to an underestimation of the engineering properties of HMA with RCA.

3. MATERIAL AND METHODOLOGY

3.1 Aggregate:

The aggregates the vast majority of which are held on 4.75mm IS sieve and contains just that a lot of fine material as is allowed by the code specifications are termed as coarse aggregates. The coarse aggregates may be crushed gravel or stone obtained by the crushing of gravel or hard stone; uncrushed gravel or stone resulting from natural disintegration of rock and partially crushed gravel or stone obtained as a product of the blending of the naturally disintegrated and crushed aggregates. In our case crushed stone was used with a nominal maximum size of 20 mm and specific gravity of 2.78.

Table-1: Graduation of aggregates for BC grade – II

IS Sieve Size (mm)	Cumulative % by weight of Total Aggregate Passing	Midpoint Gradation Percent Passing
26.5	--	--
19.0	100	100
13.2	79-100	89.5
9.5	70-88	79
4.75	53-71	62
2.36	42-58	50
1.18	34-48	41
0.6	26-38	32
0.3	18-28	23
0.15	12-20	16
0.075	4-10	7

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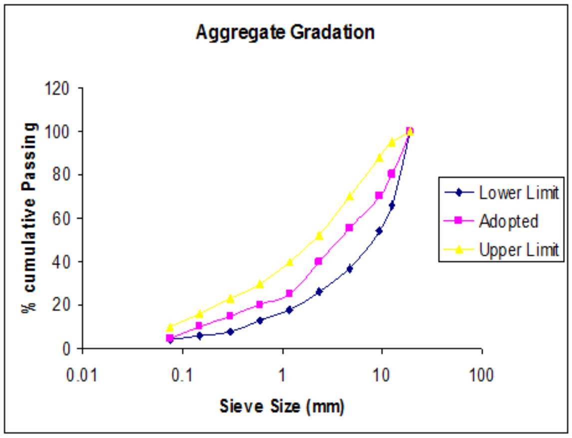

Fig-2: Aggregate Gradation for BC mix grade - II

3.3 Bitumen:

The use of the particular bitumen quality predominantly depends on climate and traffic conditions. Paving grade bitumen and polymer modified bitumen is specified by Indian standard.

Table-2 Bitumen Properties

Consistency characteristics	Laboratory values	Specifications (VG- 30)
Penetration at 25^{0}C	66.43	50-70
Softening point^{0}C	45.46	47
Ductility(cm)	49.32	50
Absolute viscosity(centipoises)	2376	2400
Kinematic viscosity(centistokes)	342	350

3.4 Crumb Rubber:

Crumb rubber is the name given to any material derived by reducing scrap tires or other rubber into uniform granules with the inherent reinforcing materials such as steel and fiber removed along with any other type of inert contaminants such as dust, glass, or rock

Fig-3: Crumb Rubber

3.6 Sample Preparation:

The bituminous concrete (BC) mix of grade – II is used for the study. The mix consists of defined percentages of coarse aggregates, fine aggregates and the filler material. The selection of percentages of different ingredients for preparation of BC mix of grade – II is in accordance of Ministry of Road Transport and Highways (MORTH) 5th revision (2013) of table 500 – 18. The adopted BC gradation is added with warm mix asphalt at different percentages (5% - 7% with an increment of 0.5%). Approximately 1200gm of aggregates mix is required for preparation of BC mix specimen. The dry mix of aggregates and filler material is preheated to test temperature of 150^{o}C and bitumen is added proportionately. The entire mix is prepared at temperature of 100^{o}C. The mix is placed in 100 diameter mould and compacted by rammer of weight 4.54kg for 75 blows on each side. The height of fall of rammer is 45.7 cm and compaction is carried through automatic compactor. The compacted specimen should have a thickness of 63.5mm.

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Fig-4: A Typical mould

4. RESULTS AND DISCUSSION

4.1 Marshall Parameters

The Marshall Test results for virgin aggregate mix are presented in Table-3. The results illustrate that the optimum binder content for virgin mix is obtained at 5.5%. Stability, air voids and density curves for virgin mix are shown in fig-5.

Table-3: Marshall Test Results for Virgin aggregate mix - BC grade - II

Bitumen (%)	Bulk density	Air voids (%)	VMA (%)	VFB (%)	Stability (N)
5.0	2.307	6.24	16.65	62.86	5366
5.5	2.356	4.04	16.11	71.12	13949
6.0	2.330	4.29	16.70	82.77	9604
6.5	2.318	4.23	17.57	85.62	5875
7.0	2.300	4.09	18.58	91.75	5540

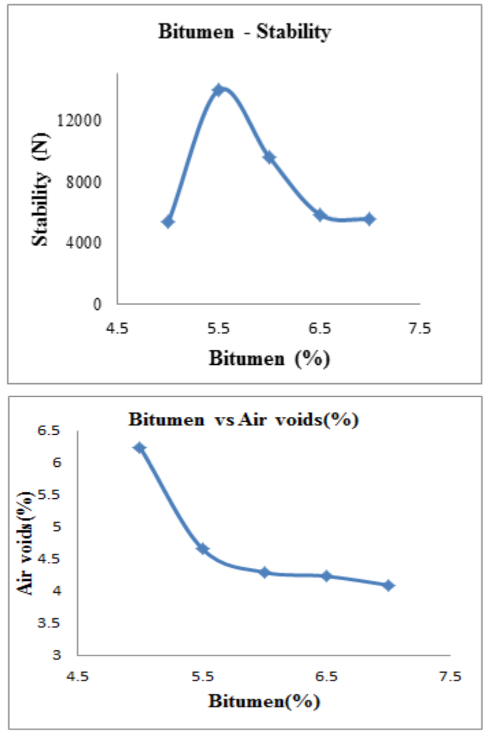

Fig-5: Variation of Bitumen Content for Stability and Air Voids

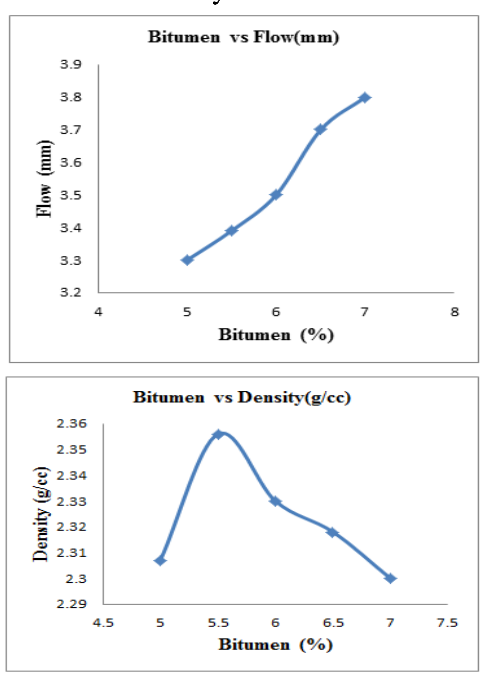

Fig-6: Variation of Bitumen Content for Flow and Density

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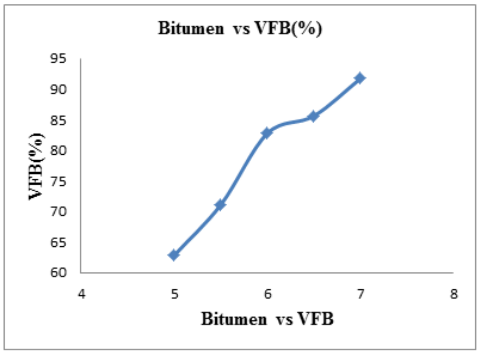

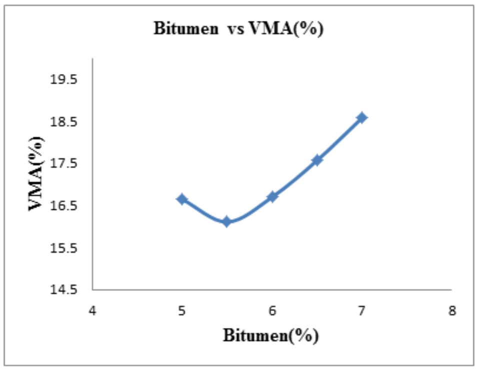

Fig-7: Variation of Bitumen Content for Stability & Air Voids

From the above figure it is observed that as binder content increases the stability value increase for a maximum (13949MPa) and air voids reduces from 5.5 To 4.4 for a binder content of 5.5% .

Recycled aggregate (RA) was added at defined proportions i.e. at 10%, 15% & 20% to the virgin aggregate mix for evaluation of RA with virgin mix. Marshal test results for different proportions of RA and varying bitumen content is shown in Table 4.4

Table-4: Marshall Test Results with the Recycled aggregate in Virgin mix - BC grade – II

	RA 10%				
Bitumen (%)	**Bulk density**	**Air voids (%)**	**VMA (%)**	**VFB (%)**	**Stability(N)**
5	2.334	5.51	15.21	68.31	5033
5.5	2.328	4.89	15.86	69.41	12178
6	2.374	4.47	14.63	83.32	5364
6.5	2.321	4.32	16.12	73.27	6766
7	2.369	4.23	15.74	86.07	4367
	RA 15%				
Bitumen (%)	**Bulk density**	**Air voids (%)**	**VMA (%)**	**VFB (%)**	**Stability(N)**
5	2.359	5.01	14.28	72.26	7168
5.5	2.337	4.66	15.53	71.74	17074
6	2.367	4.29	14.89	81.75	6323
6.5	2.322	4.21	16.09	73.94	6490
7	2.350	4.14	16.41	82.98	5743
	RA 20%				
Bitumen (%)	**Bulk density**	**Air voids (%)**	**VMA (%)**	**VFB (%)**	**Stability(N)**
5	2.366	4.79	14.02	75.98	11978
5.5	2.335	4.32	15.64	72.45	14733
6	2.324	4.27	16.79	72.54	6503
6.5	2.323	4.14	16.07	74.35	5330
7	2.378	4.02	15.43	90.48	6514

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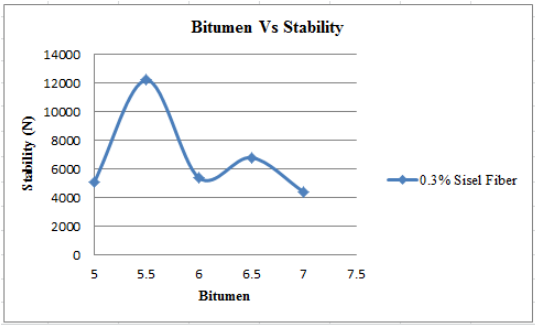

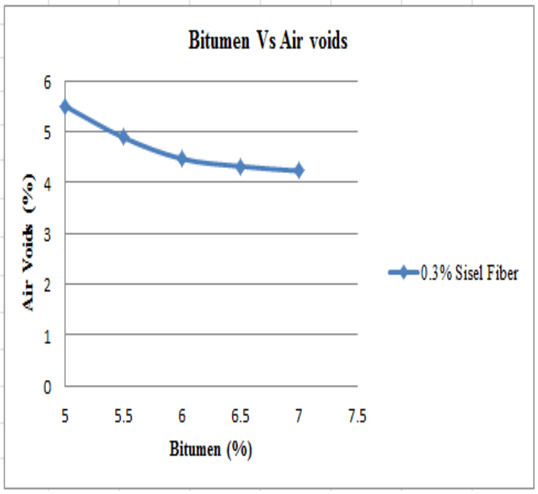

Fig-8: Variation of Bitumen Content for Stability & Air voids for RAmix.

4.2 Indirect Tensile Test:

The IDT values for recycled aggregate of HMA were found to be decreased and then increased with increase in binder content. Virgin HMA has also showed the same behaviour of the RA HMA mix. The maximum ITS observed in case of virgin warm mix asphalt moulds prepared at 100ºC was 711 kPa at 7.0% binder content. In case of 10% recycled warm mix asphalt moulds prepared at 100°C the maximum ITS observed was 1389.8 kPa at 6.5% binder content. The indirect tensile values for virgin HMA and recycled aggregate HMA are shown in table 5 & 6

Table-5: Indirect Tensile Strength Test Results for Marshal Samples of virgin HMA

Binder Content (%)	Bulk Density(g/cc)	Average Bulk Density(gm/cc)	Indirect Tensile Strength(KPa)	Average ITS (KPa)
5%	2.267	2.306	448.9	446.5
	2.340		444.5	
	2.311		446.3	
5.5 %	2.385	2.356	404.8	414.3
	2.365		370.1	
	2.320		468.1	
6%	2.354	2.369	452.6	434.5
	2.361		420.1	
	2.393		430.9	
6.5 %	2.383	2.374	677.2	602.8
	2.405		564.5	
	2.335		566.8	
7%	2.358	2.367	720.7	711.8
	2.364		710.7	
	2.380		704.2	

Table-6: Indirect Tensile Strength test results for marshal samples of different recycled aggregate proportions in HMA

Binder Content (%)	Recycle Aggregate (%)	Bulk Density(gm/cc)	Average Bulk Density(gm/cc)	Indirect Tensile Strength(KPa)	Average ITS (KPa)

5	10	2.341	2.334	838.3	805.7
		2.358		800.0	
		2.303		778.9	
	15	2.376	2.359	908.8	885.8
		2.380		904.0	
		2.322		844.7	
	20	2.345	2.366	517.7	523.4
		2.362		550.8	
		2.393		501.8	
5.5	10	2.392	2.364	310.1	376.3
		2.358		420.3	
		2.343		398.6	
	15	2.359	2.351	585.2	566.1
		2.345		545.4	
		2.348		567.7	
	20	2.383	2.349	516.2	513.4
		2.305		525.4	
		2.358		498.7	
6	10	2.383	2.374	448.1	453.9
		2.406		482.5	
		2.335		431.2	
	15	2.358	2.367	434.5	414.6
		2.364		387.3	
		2.381		420.7	
	20	2.353	2.314	336.9	358.3
		2.294		390.3	
		2.297		347.7	
6.5	10	2.325	2.352	1345.2	1389.8
		2.390		1415.0	
		2.340		1409.3	
	15	2.311	2.336	1206.0	1195.2
		2.374		1198.2	
		2.323		1186.4	
	20	2.359	2.353	1023.1	1005.3
		2.366		980.3	
		2.334		1012.6	
7	10	2.348	2.369	387.6	360.4
		2.393		356.9	
		2.367		336.9	
	15	2.354	2.350	386.2	364.4
		2.348		356.6	
		2.350		350.4	
	20	2.392	2.378	361.2	337.8
		2.405		346.3	
		2.337		305.9	

4.3 Resilience Modulus:

Repeated load test was performed on marshal samples for determination of resilient modulus which is accordance with D 7369 procedure as described by ASTM standards. Three specimens were casted for each mix, each specimen being 100 mm in diameter and 63.5 mm in height with a target void content of 4.66 & 4.04%. The specimens were subjected to a repeated constant load obtained from In-direct tensile test. Time of loading and rest period was considered as 0.1s & 0.9s at a standard test temperature of 35° C as specified in IRC -37 2012. It was observed from the test results that resilient modulus for asphalt mix is 2829 KPa at compaction temperature of 100°C. Also resilient modulus for sisel fiber of asphalt mix is 2868KPa. The test results resilient modulus is shown in table 7 & 8.

Table-7: Resilient Modulus for Marshal samples for Virgin HMA

Binder Content (%	**Spec. No**	**Load (N)**	**Horizontal deformat**	**Tensile Stress (KPa)**	**Resilient Modulus(KPa)**	**Initial Tensile Str**

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)			ion (µ m)			ain
5	1	392.2(	1.4	448.9	2610	316
	2	392.2(	1.6	444.5	2464	369
	3	392.2(	1.6	446.3	2546	359
5.5	4	490.33	2.0	404.8	2546	325
	5	490.33	1.8	370.1	2738	277
	6	490.33	1.8	468.1	2829	339
6	7	490.33	1.2	452.6	2763	335
	8	490.33	1.8	420.1	2621	328
	9	490.33	1.2	430.9	2439	362
6.5	10	539.36	2.0	677.2	2710	512
	11	539.36	2.0	564.5	2801	413
	12	539.36	1.8	566.8	2564	453
7	13	588.39	2.0	720.7	2727	541
	14	588.39	1.8	710.7	2798	520
	15	588.39	2.0	704.2	2678	539

Table-8: Resilient Modulus for Marshal Samples of Recycled aggregate of HMA

Binder Content (%)	Aggregate (%)	Load (N)	Horizontal deformation(µ m)	Tensile Stress (KPa)	Resilient Modulus (KPa)	Initial Tensile Strain
5	10	784.53	2.6	805.7	2779	594
	15	882.59	3.0	885.8	2801	648
	20	490.33	1.8	523.4	2688	399
5.5	10	392.26	1.6	376.3	2506	307
	15	588.39	2.0	566.1	2868	404
	20	490.33	1.8	513.4	2771	379
6	10	490.33	1.9	453.9	2784	334
	15	392.26	1.4	414.6	2725	311
	20	392.26	1.4	358.3	2664	275
6.5	10	1372.	4.5	1389.	2758	1033

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		00		8		
	15	1176.00	4.0	1195.2	2626	933
	20	1078.00	4.0	1005.3	2753	748
7	10	392.26	1.4	360.4	2801	263
	15	392.26	1.6	364.4	2664	280
	20	392.26	1.4	337.8	2752	251

CONCLUSION

Based on the laboratory experimental test results, the following conclusions are drawn

- The results of Marshall Compaction in the unbound recycled aggregate effectively showed a high level of particle crushing reflected in a Marshall Degradation Index (IDM) increasing from around 7.0% for 35 blows to 8.5% for the 75 blows. The grain size distribution curve shifted towards the center of the desired gradation envelope, thus showing the correct strategy of starting at its upper (coarser) limit.
- The bound aggregate in the HMA shows a decrease of particle crushing due to the viscous damping effect of the asphalt binder. The IDML (with binder) of all HMA varied between 5% and 6.5%. These degradation indices were little or not dependent on the energy employed, but dependent on the amount of crumb rubber in the modified asphalt binder.
- It is observed that HMA can be successful laid at lower temperature (100ºC) having stability value of 13949 N for Virgin mix. Recycled aggregate at 15% has improved its stability value for 17074 N.
- A series of binder course mixtures incorporating recycled aggregate were tested and inveterate that mechanical properties have close relation to the virgin mix. It is observed that the mixture containing 15% RAP and 5.5% binder displayed a 2% increase in stiffness.
- The resilient modulus for virgin mix HMA is of 2829 MPa and that of recycled aggregate HMA is 2868 MPa. This infers that the addition of 15% recycled aggregate to virgin mix has slightly enhanced the modulus values when conducted at 350C.
- The mechanical test results infer that recycled aggregate can be used as a viable alternative aggregate material.
- Indirect tensile values are improved for 10 % recycled aggregate of 6.5% binder content.
- Tensile strength values are slightly higher for 15 % RA of 5.5% binder content.
- Pavement construction with recycled aggregate can provide a cost effective approach for aggregate resources and decreases the threats for demolishing of

natural resources, thereby protecting the environment's sustainable development.

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