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Bituminous Pavement Recycling by Using Reclaimed Asphalt Pavement (RAP) & Filler Materials

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***Abstract*-The centre of this study is concentrated on introducing the lean ideas in asphalt pavement construction particularly in the Quality control (QC) process in HMA. HMA comprises of nearly 95% of aggregate, gravel or sand, filler and these ingredients are binding together with bitumen a by-product from crude oil industry. The aim of this study is to compare the strength in terms of stability and flow value of Conventional & Non-conventional mix by Marshal Stability test. The present study relates Usage of RAP to reduce the fresh aggregate in the proposed Mix without influencing the properties of mix, from the test results we are adopting 8 % RAP with 92 % fresh aggregate for NCM mixes.VG 30 grade bitumen is used as binder and Maximum aggregate size (MAS) 13.0 mm and Nominal Maximum Aggregate size (NMAS) 10.0 mm. sand stone is used as filler for conventional & non-conventional mixes. 1 % lime in the weight of bitumen used as antistripping agent to minimise moisture susceptibility or to increase the resistance to moisture sensitivity of the proposed mix. From this study we are observed NCM –II shows better results than other Non-conventional mixes, the stability values are slightly lesser than conventional mix.**

Keywords – Bituminous concrete, Reclaimed Asphalt Pavement (RAP), Optimum Binder Content, Stone Dust, Non-Conventional Mix (NCM), Antistripping Agent.

I. INTRODUCTION

RAP is a technique by which bituminous pavements are built using reclaimed materials extracted from existing pavements. A study of past research paper illustrated that different percentages of RAP has been used in the construction of bituminous pavement varying from 5 to 70%. In rare cases up to 80% of RAP has been effectively used. The construction of a new bituminous pavement or overlays includes a vast consumption of aggregates of different sizes along with binder.

Reused asphalt pavement is helpful to stayaway from the utilization of new aggregate since it diminishes the utilization of new aggregate and the quantity of new asphalt binder required it creation of hot mix asphalt. The utilization of reclaimed asphalt pavement with bitumen binder it moderates energy, lower transportation cost and jam inexhaustible and non-sustainable energy. Utilizing Reclaimed asphalt pavement reduces the amount of waste material and the non-inexhaustible normal sources, for example, new aggregate and binder. Subsequently Reclaimed asphalt pavement makes a cycle that lessens the utilization of natural resources and assembles the bituminous solid asphalt. So, by using reclaimed asphalt pavement (RAP) material in virgin mix the strength, durability, stability, load bearing capacity can be increased. This study shows the use of RAP in the virgin mix increases the pavement performance; provide low-cost road sand make the environment eco-friendly.

A. Objective

- To determine the Suitability of RAP and stone dust as an additive in Hot Mix Asphalt.
- To calculate the stability, flow value and volumetric properties of bituminous mixes with and without addition of RAP and Stone dust for BC grade1.

- To investigate the OBC by performing Marshall Stability test for conventional, non-conventional mixes.
- To investigate resistance to moisture sensitivity of test specimens with and without antistripping agent.

B. Scope

- To determine the essential properties of aggregates and bitumen.
- To study the strength and stability of the pavement.
- To investigate the effect or impact of RAP materials on the BC mix.
- To study the strength characteristics of RAP materials.
- The RAP materials have numerous substantial properties which makes a Consequence and expanding impact to construction works.

II. LITERATURE REVIEW

Anil Kumar Yadava et.al. concluded that Bituminous pavement recycling technology is still not common in India and other developing countries because the guidelines and standards are not sufficient [1]. The benefits of using the RAP include the introduction shortly of floor recycling technologies. Therefore, the characterization and performance assessment of reclaimed asphalt (RAP) is a major area. The information derived from the evaluation of the material is used to help select the type & quantity or recycling additive to be used and to evaluate the need for additional components for fixing any defects in the current paving system Result. Md. Akhtar Hossain et.Al. [2], calculated that the effect of Water Submergence on the Physical characteristics of bituminous mixes by means of (RAP) Reclaimed Asphalt Pavement. The key function of this study is to determine the effect of water on the utilization of reclaimed asphalt pavement materials in bituminous mix and to determine the optimum % of reclaimed asphalt pavement materials with fresh pavement materials and optimum periods of water submergence according to the Marshall Mix design conditions based on medium traffic condition. To accomplish the objectives of this investigation the basic properties tests were executed on the experimented materials and then bitumenbinder content evaluated for 100% fresh aggregate. The various percentages of RAP material in asphalt mixtures are 0%, 10%, 20%, 30% and 40%. Marshall Criteria was fulfilled up to 20%. After that the specimen prepared with 20% RAP material was submerged in water at 0, 5, 10, 15 and 20 days. Optimum periods of water submergence were 15 days on the basis of Marshall Mix design criteria.

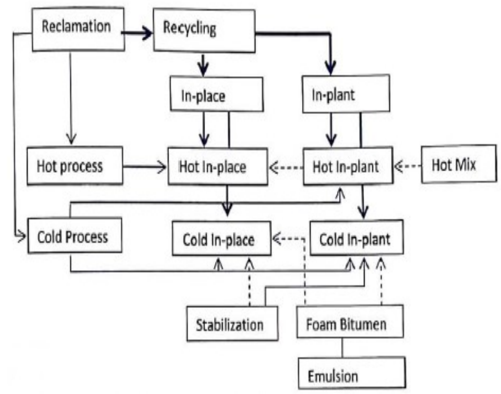
- V.K. Singh et.Al. [3], concluded that Good practice consists of maintaining and protecting the pavement coverings so as not to require significant rehabilitation. That is not always the case for several reasons. Often a severely damaged asphalt surface is not completely rehabilitated. Cracking may have progressed to such a degree that it takes a more violent approach. Complete removal & replacement is not required; in-site materials of the old floor can be reused and have value. Full depth reclamation (FDR) is an effective way of restoration of these plots. The horizontal tensile strain at the bottom of the bituminous layer is 10.2 $x10^{-6}$ & vertical compressive strain on subgrade is 160.0 $x10^{-6}$ which shows that the pavement is in very good condition & remaining life of pavement is 2 to 3 times its design life. Ahmad M. Abu Abdo et. al [4], summaries that in 1973 however, the RAP was first used with a small %age because the impact on the efficiency of asphalt mixes was not understandable. A higher proportion (e.g., > 50%) is used to minimize costs, reduce natural resources, and use old asphalt flooring removed. The key concern of mixing RAP in modern asphalt mixtures is the effect of the resistance to permanent deformation (rutting), weariness cracks, and thermal cracks of these mixtures. Jaspreet Singh et.Al. [5], The objective of this study is to understand the importance of using RAP for the construction of bituminous pavements. From this study and from previous research papers it can be concluded that using RAP is advantageous as reclaimed asphalt pavement mixes can yield results equal or even higher than virgin mixes. If calculated and implemented appropriately RAP mixes have a constructive effect on various parameters like Marshall Stability, moisture resistance and density. This paper presents the importance of using RAP mixes. RAP is a new technology with the help of which bituminous pavements can be

- constructed at a reduced cost as it involves the usage of old bituminous pavement materials. Also, it ensures optimization of resources and supports sustainable development. Optimal percentage of RAP depends upon the composition of reclaimed bituminous material and type of layer in which it is to be used. Though 20%- 50% are mostly adopted. S.M. Mahlongo et al [6], tried to used 100% RAP for sustainable construction and road rehabilitation. In compliance with the South African requirements, the characteristics of recovered material have been tested. Recovered aggregates fall within the envelope and the recovered binder is 5.3% for continuously graded mixes.

III. METHODS OF RECYCLING

The Method of recycling as per IRC are as follows: 120-2015 [7].

1. HOT IN PLACE RECYCLING (HIR)
2. COLD IN PLACE RECYCLING (CIR)
3. HOT IN PLANT RECYCLING (HIP)
4. COLD IN PLANT RECYCLING (CIP)
5. FULL DEPTH OF RECLAMATION (FDR)



IV. MATERIALS

The following materials are used in constructing the road surface courses are:

1. Aggregates
2. Bitumen
3. Filler Materials

Along with these materials the RAP is used which considerable reduced the amount of virgin aggregate. To make the impervious compacted mix, bitumen is added in adequate quantity and will have acceptable elastic properties. The aggregates are classified as Coarse Aggregate (particles which are retained on 4.75 mm sieve), Fine aggregate (particles which are passing through 4.75 mm sieve and retained on 75µ sieve) and Fillers (passing through .075 mm sieve).

V. TEST RESULTS FOR MATERIALS

Table I

Test on virgin aggregates

S.No	TESTS	RESULTS
1.	Aggregate Impact Value	19.3%
2.	Aggregate Crushing Value	26.5%
3.	Aggregate Abrasion Value	17.5%
4.	Flakiness and Elongation Index	25.6%
5.	Specific Gravity	2.65
6.	Water Absorption	0.56%

Table II

RAP material test result

S.No	TESTS	RESULTS
1.	Aggregate Impact Value	21.6%
2.	Aggregate Crushing Value	27.2%
3.	Aggregate Abrasion Value	19.7%
4.	Flakiness and Elongation Index	27.8%
5.	Specific Gravity	2.65
6.	Water Absorption	1.22%

VI. GRADATION OF AGGREGATE

Grading of aggregate should be done before mix design. For this purpose, sieve analysis of aggregates has been done having size 19mm,13.2 mm,4.75 mm, 2.36 mm, 1.18 mm, 300um, 75 microns, and stone dust. Grading requirement of BC for this study should satisfy the MORTH. The aggregate gradation should be in the desired limits and within the desired limit as per MORTH table 500-7 for bitumen content of Grade 1[8].

Table III

Test Results on Bitumen

S.No	TESTS	RESULTS
1.	Penetration test @ 25° C	65
2.	Softening point° C	53
3.	Flash Point° C	245
4.	Fire Pont° C	260
5.	Specific Gravity	1.05
6.	Ductility @ 27° C	85

VII. MARSHALL MIX DESIGN

Using this method, a compacted, cylinder specimen of bituminous mixture tests its resistance to plastic deformation when the specimen is diametrically loaded at a specimen deformation rate of 50 mm/minute. The Marshall method of mixing design has two main features.

1. Analysis of density-void.
2. checking of stability-flow.

The Marshall stability of the mixture is defined as the specimen's maximum load at the standard temperature of 60° C. The flux value is the deformation of the test specimen to the maximum load during loading. A flow of 0.25 mm is measured. In this test, the optimum binder content is sought for type and the expected traffic intensity of the aggregate mix.

Table IV

Material Requirement for One Sample as per Gradation

Material	Weight in (gms)	Specific gravity
Bitumen	60.00	1.05
13mm	178.68	2.75
10mm	283.68	2.72
6mm	226.92	2.65
Stone dust	488.04	2.60
Filler (lime powder)	22.68	2.50

Table V

Conventional & Non – conventional bituminous mixes at 4% optimum binder content

Properties	Virgin Mix (0 % RAP)	RAP			Criteria as per MORTH
		8%	16%	24%	
OBC %	4	4	4	4	
Stability KN	11.30	12.05	12.29	11.89	9 KN minimum
Flow, mm	3.10	2.93	2.37	2.72	2 – 4 mm
Air voids %	4.00	5.86	5.72	5.65	3 – 6 %
Bulk density	2.280	2.376	2.381	2.375	-
V_b	8.68	8.73	8.75	8.78	-
VMA %	14.06	15.32	15.67	15.83	12 – 18 %
VFB %	71.55	72.56	72.25	73.12	65 – 75 %

Table VI

Conventional & Non – conventional bituminous mixes at 4.5% optimum binder content

Properties	Virgin Mix (0 % RAP)	RAP			Criteria as per MORTH
		8%	16%	24%	
OBC %	4.5	4.5	4.5	4.5	
Stability KN	10.84	11.62	10.93	11.25	9 KN minimum
Flow, mm	3.16	3.36	2.46	2.87	2 – 4 mm
Air voids %	4.05	4.65	4.26	4.67	3 – 6 %
Bulk density	2.300	2.375	2.371	2.378	-
V_b	9.85	9.92	9.75	9.95	-
VMA %	14.22	14.77	14.56	14.80	12 – 18 %
VFB %	71.52	71.85	71.18	72.20	65 – 75 %

Table VII

Conventional & Non – conventional bituminous mixes at 5% optimum binder content

Properties	Virgin Mix (0 % RAP)	RAP			Criteria as per MORTH
		8%	16%	24%	
OBC %	5	5	5	5	
Stability KN	14.07	14.32	14.85	15.42	9 KN minimum
Flow, mm	3.03	3.42	2.89	2.62	2 – 4 mm
Air voids %	4.12	4.76	4.94	4.70	3 – 6 %
Bulk density	2.304	2.377	2.379	2.371	-
V_b	10.97	11.05	11.22	11.08	-
VMA %	14.07	14.97	14.74	14.83	12 – 18 %
VFB %	70.72	70.95	71.55	71.25	65 – 75 %

Table VIII

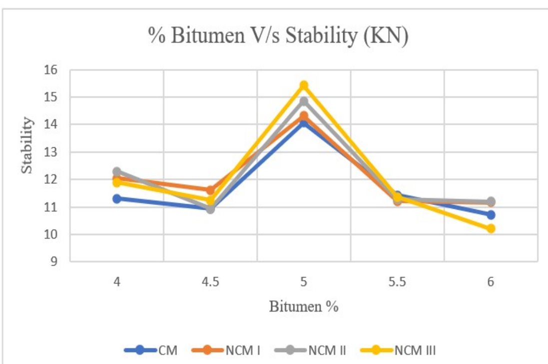
Conventional & Non – conventional bituminous mixes at 5.5% optimum binder content

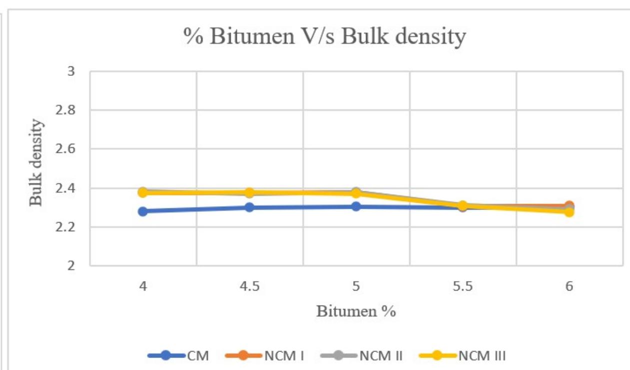
Properties	Virgin Mix (0 % RAP)	RAP			Criteria as per MORTH
		8%	16%	24%	
OBC %	5.5	5.5	5.5	5.5	
Stability KN	11.42	11.21	11.27	11.37	9 KN minimum
Flow, mm	3.13	3.54	3.16	2.67	2 – 4 mm
Air voids %	4.32	3.37	3.31	3.72	3 – 6 %
Bulk density	2.301	2.307	2.311	2.309	-
V_b	12.05	12.23	12.25	12.32	-
VMA %	14.14	14.35	14.47	14.52	12 – 18 %
VFB %	71.84	72.42	72.67	73.64	65 – 75 %

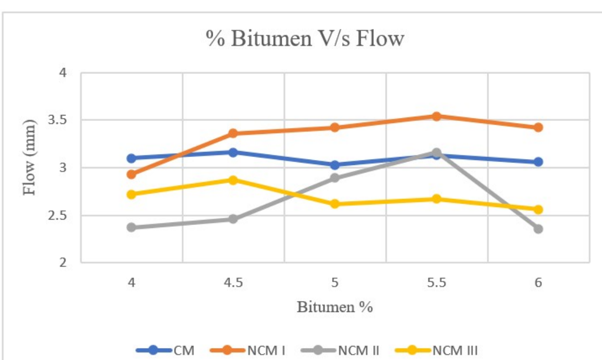
Table IX

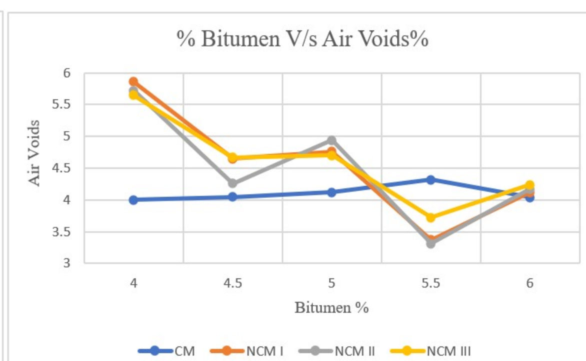
Conventional & Non – conventional bituminous mixes at 6% optimum binder content

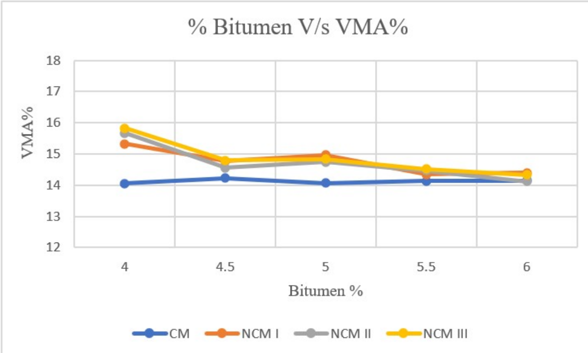
Properties	Virgin Mix (0 % RAP)	RAP			Criteria as per MORTH
		8%	16%	24%	
OBC %	6	6	6	6	
Stability KN	10.72	11.16	11.19	10.2	9 KN minimum
Flow, mm	3.06	3.42	2.36	2.56	2 – 4 mm
Air voids %	4.04	4.12	4.17	4.24	3 – 6 %
Bulk density	2.302	2.310	2.292	2.276	-
V_b	13.15	13.13	13.25	13.28	
VMA %	14.15	14.40	14.12	14.33	12 – 18 %
VFB %	71.45	71.86	71.90	72.10	65 – 75 %

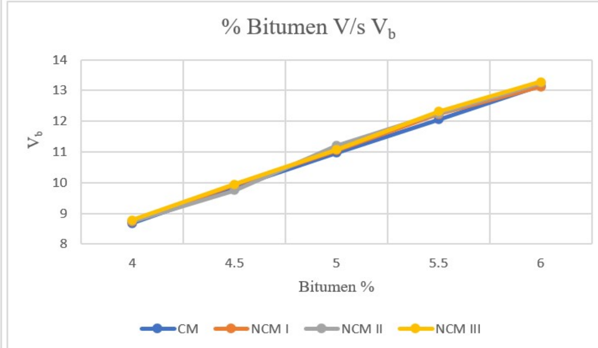


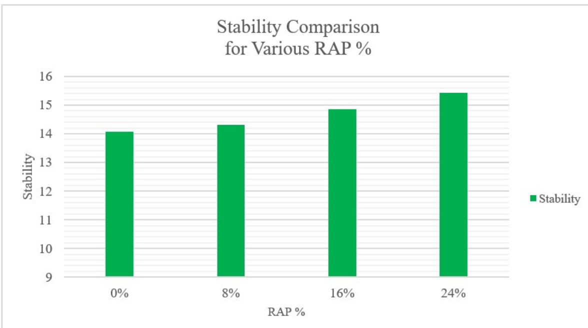


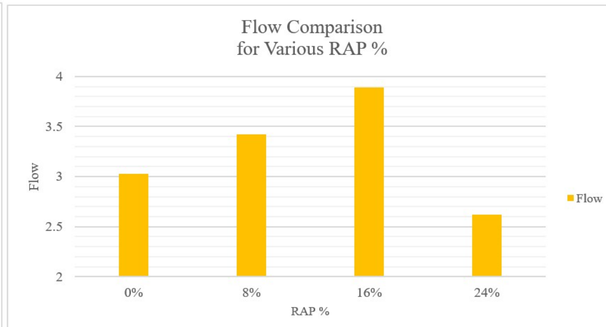


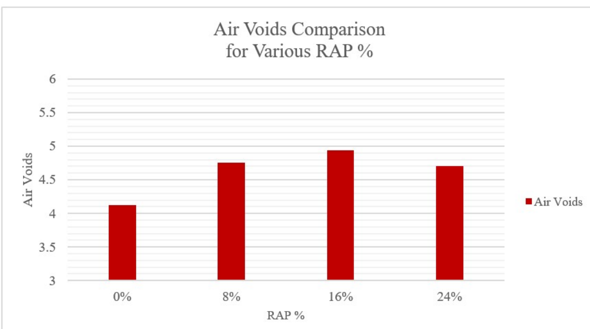


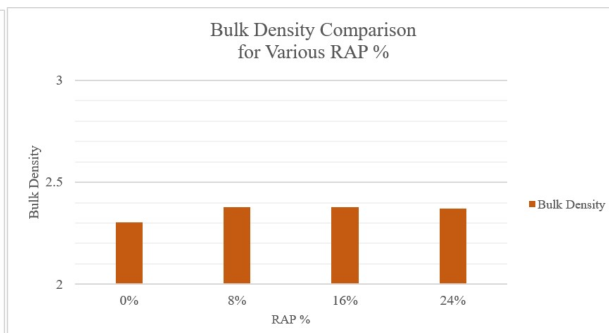

% Bitumen V/s VMA%
VMA%
Bitumen %
18 17 16 15 14 13 12
4 4.5 5 5.5 6
CM
NCM I
NCM II
NCM III

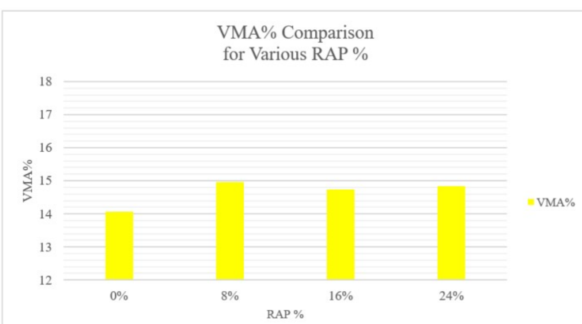

% Bitumen V/s V$_b$
V$_b$
Bitumen %
14 13 12 11 10 9 8
4 4.5 5 5.5 6
CM
NCM I
NCM II
NCM III

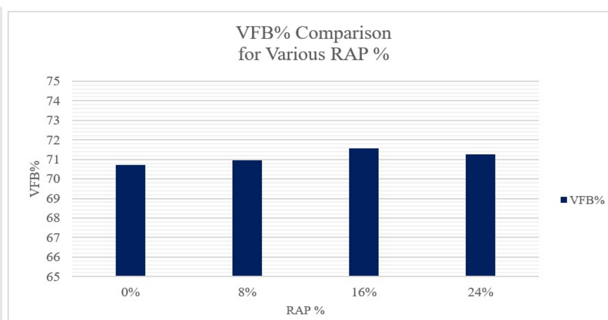

Stability Comparison
for Various RAP %
Stability
RAP %
16 15 14 13 12 11 10 9
0% 8% 16% 24%
Stability

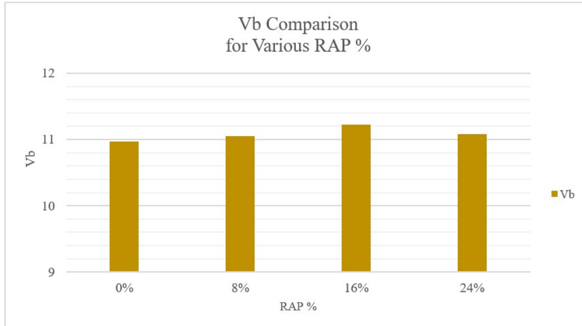

Flow Comparison
for Various RAP %
Flow
RAP %
4 3.5 3 2.5 2
0% 8% 16% 24%
Flow


Air Voids Comparison
for Various RAP %
Air Voids
RAP %
6 5.5 5 4.5 4 3.5 3
0% 8% 16% 24%
Air Voids


Bulk Density Comparison
for Various RAP %
Bulk Density
RAP %
3 2.5 2
0% 8% 16% 24%
Bulk Density


VMA% Comparison
for Various RAP %
VMA%
RAP %
18 17 16 15 14 13 12
0% 8% 16% 24%
VMA%


VFB% Comparison
for Various RAP %
VFB%
RAP %
75 74 73 72 71 70 69 68 67 66 65
0% 8% 16% 24%
VFB%



VIII. CONCLUSIONS

- The way that Optimum Binder Content stayed unaltered even subsequent to adding RAP materials demonstrates that the old cover completely mixed with new binder.
- Marshall specimens with 8% RAP diminishing the use of new binder content and the Stability values are more prominent than least Marshall Stability values.
- Densities of virgin mix at an optimum binder content of 5.5% were marginally lower than that of NCM-I (2.307 g/cc) by 0.21% followed by NCM-II (2.311 g/cc), NCM-III (2.309g/cc).
- The NCM-II, NCM-III flow values are very strong than the conventional mix, i.e. The values range from 2 mm to 4 mm, the correct range for BC Grade -1.
- VMA estimations of RAP mixes were higher than those of virgin mix. VMA Values were noticed most extreme for RAP 24% (15.83%) trailed by RAP 16% (15.67%) at an optimum bitumen content of 4%.
- VFB estimations of virgin bituminous mix were more prominent than those of RAP mixes. VFB value for 16% RAP material is 71.55 at an optimum bonder content of 5%. VFB value for fresh mix is 70.72.
- Compared to mixes of antistripping agents with an optimal 1% weight, antistripping agent mixtures (Lime) show less moisture resistance.

IX. FUTURE SCOPE

- Further examination can be completed for over 24 % of the RAP materials regarding decreasing the Virgin materials and their Marshall Properties, ITS and Fatigue test conduct can be assessed.
- Execution based test strategies can be completed are Static or Creep, Dynamic loading and Rutting tests to give exact and sensiblerelationship.
- Continued loading test can be conveyed for various Stress proportion from 8% to 100%.

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