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EVALUATION STUDIES ON EGGSHELL POWDER AND FLYASH STABILIZED RECLAIMED ASPHALT PAVEMENT AS BASE COURSE

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Abstract-- Reclaimed Asphalt Pavement (RAP) has been on global research interest in the recent past. A RAP material in pavement base courses has proven to be a viable alternative not only conserve the natural resources but also to reduce the environment pollution and land filling. Previous researchers proved that RAP can be successfully used in various pavement layers. The current study presents the results of a laboratory evaluation of Fly-ash stabilized RAP and RAP-Virgin aggregate blends as base material. OMC, MDD and CBR tests were conducted on the following on the following RAP/ virgin aggregate mixtures: 100/0, 80/20 and 60/40. To develop a potential base mix, RAP: VA mixes stabilized with Eggshell powder stabilized Fly- ash was considered. Results indicate that eggshell powder stabilized Fly-ash is proposed to increase the Maximum Dry density (MDD) and CBR of RAP: VA mix. A 100% RAP cannot be used directly in base / sub base layers because RAP material has a very low or limited bonding as the particles are coated with aged bitumen. Resilient Modulus is also calculated from the predicted equation as per IRC. The results indicate that the RAP which is used for this study is not recommended for high volume roads.

Keywords - Reclaimed asphalt pavement, OMC, MDD, CBR, M_r., Eggshell powder.

I. INTRODUCTION

Reclaimed asphalt pavement (RAP) is a bituminous concrete material removed and/or milled from pavements undergoing reconstruction or resurfacing. The amount of RAP produced from the milling of distressed flexible pavements is very limited till date in India due to non availability of proper guidelines /specifications on recycling and evaluation of reclaimed materials, where as in the developed countries bituminous material is the most recycled material in the construction industry.

Roads are an important component of the world’s transportation infrastructure and economy, thus necessitating sustainable design and construction methodologies to ensure optimized pavement construction.

Nearly 15000tons of natural aggregates are required to build every kilometre stretch of a highway in INDIA, as reported by the central intelligence agency, USA in 2012. In the US, annually about 1300 million tons of natural aggregates are being used in the pavement. The pavement industry is not only consuming huge amounts of natural resources worldwide but is also responsible for the global energy consumption, air pollution, greenhouse gas production and fossil fuel burning across the world. If not addressed the problem, we face adverse effects. One of the alternatives available is to recycle the existing distressed pavements and use the reclaimed materials in new pavement construction. RAP material obtained through the process of recycling/milling of existing distressed bituminous pavement.

Furthermore, the cost of virgin aggregates is alarming and necessitates the use of high percentages of recycled materials in pavement construction. The utilization of reclaimed asphalt pavement material in road construction has been proven to reduce the amount of construction, energy and carbon credits with equal or better performance with nominal stabilization. Reclaimed Asphalt Pavement (RAP) cannot be used as it is (100%) because of its poor gradation and bonding properties.. Besides, calcium based stabilizers such as lime or cement are expected to performance of RAP in pavement layers.

Fly ash being abundant, making more productive use of it will result in considerable environment benefits, such as reducing land, air pollution and water pollution. Several attempts have been made to use the RAP materials by replacing some portion of virgin aggregates in the base/sub base layers with or without stabilization.

Taha et al (2002) studied the effect of cement stabilization on strength properties of RAP: VA mixes. It was observed that UC strength increases with increase in cement content. Addition of VA to RAP improved the UCS of the mix. It was concluded that the ability of RAP to function as a structural component of the pavement is more pronounced when it is stabilized with the cement rather than when blending with only virgin aggregate.

Taha et al (2003) conducted series of UCS tests on cement kiln dust (CKD) stabilized RAP: VA mixes. Tests were performed on 100, 90, 80 and 0% RAP with varying dosages of CKD from 0 to 20%. It was concluded from the study that UCS and Maximum dry density (MDD) increases as VA and CKD increases.

G.Anisha et al (2017) conducted an experimental investigation on effect of Fly ash on Eggshell powder. Results show that Fly-ash and Egg shell could be very conveniently used in structural concrete.

A OBJECTIVES OF THE STUDY

- The main objective of this research is to investigate the use of Eggshell powder and fly ash stabilized RAP:VA blends in high quantities for a stabilized base course of flexible pavements based on the Indian pavement failure criteria. Hence, it is required to check the strength, stiffness and durability aspects criteria against Indian roads congress specifications. To accomplish this, the following tasks were performed.
- To promote utilization of large quantities of RAP in pavement base courses as a sustainable green product.
- To classify the materials and moisture content and dry density relationships.
- To determine the compaction characteristics of the materials.
- To determine the CBR and $M_{r.}$ values with and without Eggshell powder.

II. MATERIALS USED

The strength, stiffness and durability of any mix greatly depend upon the physical and chemical properties of the ingredients used. Hence, it is necessary to determine the basic properties of all the materials to be used in a pavement layer.

A RECLAIMED ASPHALT PAVEMENT (RAP):

RAP material used in this study was collected from an ongoing project at Vijayawada in the state of Andhra Pradesh on NH65 previously it was called NH9. To reduce the sampling bias, samples were collected randomly at four different locations. Collected RAP is binned according to their sizes. A typical RAP material used in this study is shown in figure 3.1.

Figure 3.1: Presents the RAP used in the present study

B FLY ASH:

Fly ash is the by- product of coal combustion collected by the mechanical or electrostatic precipitator (ESP) before the flue gases reach the chimneys of thermal power stations. The physical and chemical properties of Fly ash are shown in table 3.2.

Table 3.2 Physical and chemical properties of Fly ash.

Parameters	Fly-ash	Constituent Elements	Content (%)
Grane size	Major fine sand/silt and small per cent of clay size particles	Silicon Oxide (SiO_2)	92.68
Specific Gravity	1.6-2.6	Aluminum Oxide (Al_2O_3)	0.69
Water holding capacity	40-60	Potassium Oxide (K_2O)	0.26
Bulk density (g/cc)	0.9-1.3	Calcium Oxide (Ca O)	02-0.8
Plasticity	Lower/non plastic	Magnesium oxide (Mg O)	0.2-0.8
Shrinkage limit	Higher	Sodium oxide (Na_2O)	0.35
Free swell	Lower	Moisture	0.78
		Loss of ignition (LOI)	41.84

Courtesy of National Rural Roads Development Agency.

C EGG SHELL POWDER:

Egg shell which is made of calcium is thrown away as a waste. When the calcium carbonate is heated a binding material called Calcium Oxide (Lime) is obtained. As lime is the major compound of Portland cement, eggshell powder can be used as partial replacement of fine aggregates. The Egg shell used is shown in figure 3.3.

Figure 3.3 Presents the Egg shell powder used.

Table 3.3 Chemical properties of Egg shell powder.

Property	Value
Real density (g/cc)	2.47
Hydroscopic moisture (%)	1.1
pH(H_2 O)	8.3
Cation Exchange Capacity (meq/100)	9.52
Potassium(K)	12
Calcium(Ca)	50.2
Mg	12.0
Al	0.0
H+AI	0.0
Na	21.0
Organic Matter (%)	5.36
Organic Carbon (%)	3.11
S-SO_4 Content (ppm)	39.0

III. LABORATORY STUDIES

The laboratory studies were carried out on the RAP material, Fly ash, RAP: VA: FA mix and RAP: VA: FA: ESP mix.

A ASPHALT CONTENT

Asphalt content present in the RAP material governs the strength and stiffness of the mix through interfacial and surface properties. The influence is even more when the RAP content in the mix is high. Hence, it is important to determine the amount of asphalt present in the RAP material. Asphalt content is calculated according to ASTM D 2172. For this purpose solvent extraction method was used in which a solvent such as benzene, toluene, ethylene chloride or trichloroethylene can be used to dissolve and separate asphalt from the RAP material. RAP material of known weight was taken and was soaked in Benzene for 24 hours. The solution was then passed through a filter paper not to lose the fines. Later, the aggregates were oven dried and weighed. Asphalt content test is conducted for 20mm RAP and 12.5mm RAP size and the values are at table 5.

Asphalt content = $\frac{Weight\ loss}{Initial\ weight} * 100$

Figure 4.1 RAP materials before and after extraction of asphalt content.

B SPECIFIC GRAVITY OF RAP

It was determined in accordance with IS: 2386 (part III) by using wire basket method. The test is conducted for 12.5mm RAP size. The Specific gravity of 12.5mm is shown in table 5.

$$\text{Specific gravity} = \frac{A}{B-C}$$

Where,

A =Weight of oven dry specimen in air

B =Weight of saturated surface –dry specimen in air

C =Weight of saturated specimen in water.

C SPECIFIC GRAVITY OF FLY ASH

Specific gravity of fly ash was determined in accordance with IS 2720 (part III). The specific gravity of Fly-ash is observed as 2.14.

$$\text{Specific gravity} = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}.$$

Where,

W_1 =Weight of empty bottle.

W_2 =Weight of bottle + dry fly ash.

W_3 =Weight of bottle+ fly ash + kerosene.

W_4=Weight of bottle kerosene.

D COMPACTION CHARACTERISTICS OF FLY ASH

The Compaction tests was performed on Fly ash to determine the Dry density and Moisture content in accordance with IS 2720 (part VII) .The standard proctor compaction test was performed in a mould having 100mm diameter and 127mm height. The fly ash was compacted in 3 layers, giving 25 blows each with a rammer of weight 2.7kg having a drop height of 300m. The maximum dry density (MDD) of Fly-ash occurs at 1.29g/cc at 20%OMC shown in table 5.1 and graph is shown in Fig 6.

E COMPACTION CHARACTERISTICS OF RAP: VA: FLY ASH

The modified proctor compaction tests were performed on Fly ash treated with RAP: VA to determine the Maximum dry density (MDD) and Optimum moisture content (OMC) in accordance with IS 2720 part VIII. Compaction is done for 100RAP:0VA, 80RAP:20VA, 60RAP:40VA with (0, 10, 20, 30, and 40) % of Fly-ash. It was observed 100RAP:0VA:20FA, 80RAP:20VA:10FA and 60RAP:40VA:10FA as Optimum mix for future study.

F CALIFORNIA BEARING RATIO TEST

The California bearing ratio test was conducted for the samples of 100RAP:0VA, 80RAP:20VA, 60RAP:40VA, with various percentages of Fly ash and also calculated CBR values for Optimum mix with Eggshell powder. The test was conducted under a constant strain rate of 1.25mm/min. The proving ring reading is noted for 50 divisions, and loading was continued until 3 (or) more readings are decreasing (or) constant. The test was conducted at Optimum moisture content. The samples were tested in soaked condition. The values are shown in table 5.3.1, 5.3.2 and 5.3.3.

G PREDICTION OF RESILIENT MODULUS FROM CBR %:

Since the equipment used for conducting resilient modulus is quite expensive and highly skilled technicians are required for conducting the experiment. On the other hand CBR had become a popular test for characterizing the sub grade strength because of its simplicity and efficiency. So, it was deemed necessary to correlate the CBR with resilient modulus. The earliest of such correlations was developed by Heukelom and Klomp is given an equation. The Indian Roads Congress adopted a relationship by combining Heukelom and Klomp equation and the TRL equation.

$E\ (M\ Pa) = 17.6 * CBR^{0.64}\ (CBR > 5)$.

IV. RESULTS AND DISCUSSIONS

Table 5: Presents the Asphalt content, Specific gravity of RAP Material of different sizes.

Experiment Name	Result
Asphalt content (for 20mm RAP)	4.09%
Asphalt content(for 12.5mm RAP)	3.885%
Average Moisture content (10mm RAP)	1.59%
Average moisture content (4.75mm RAP)	1.61%
Specific gravity of RAP	2.85

Table 5.1: OMC and MDD of FA

% of Water Content	MDD(g/cc)
10.96	1.09
11.87	1.13
13.28	1.16
14.81	1.20
16.31	1.24
20.3	**1.29**
28.74	1.21
39.8	1.12

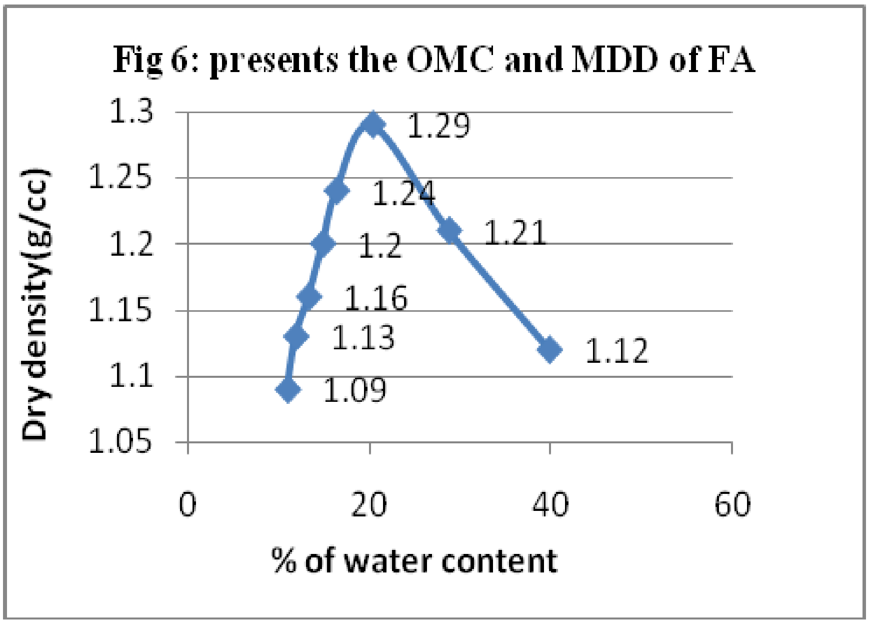

Figure 6: OMC vs. MDD graph of FA

Table 5.3.1: Presents the OMC, MDD and CBR values of 100RAP:0VA with various % of FA

Mix proportions	OMC (%)	MDD(g/cc)	CBR (%)
100RAP:0VA:0FA	5.1	2.00	25
100RAP:0VA:10FA	5.6	2.04	38
100RAP:0VA:20FA	**6.0**	**2.07**	**49**
100RAP:0VA:30FA	6.3	2.05	42
100RAP:0VA:40FA	6.6	2.03	36

Table 5.3.2: Presents the OMC, MDD and CBR values of 80RAP:20VA with various % of FA

Mix proportions	OMC (%)	MDD(g/cc)	CBR (%)
80RAP:20VA:0FA	5.6	2.06	44
80RAP:20VA:10FA	**6.0**	**2.14**	**68**
80RAP:20VA:20FA	6.4	2.12	62
80RAP:20VA:30FA	6.8	2.10	57
80RAP:20VA:40FA	7.0	2.08	51

Table 5.3.3: Presents the OMC, MDD and CBR values of 60RAP:40VA with various % of FA

Mix proportions	OMC (%)	MDD(g/cc)	CBR (%)
60RAP:40VA:0FA	5.8	2.11	61
60RAP:40VA:10FA	**6.4**	**2.19**	**78**
60RAP:40VA:20FA	6.8	2.16	72
60RAP:40VA:30FA	7.2	2.14	68
60RAP:40VA:40FA	7.4	2.10	57

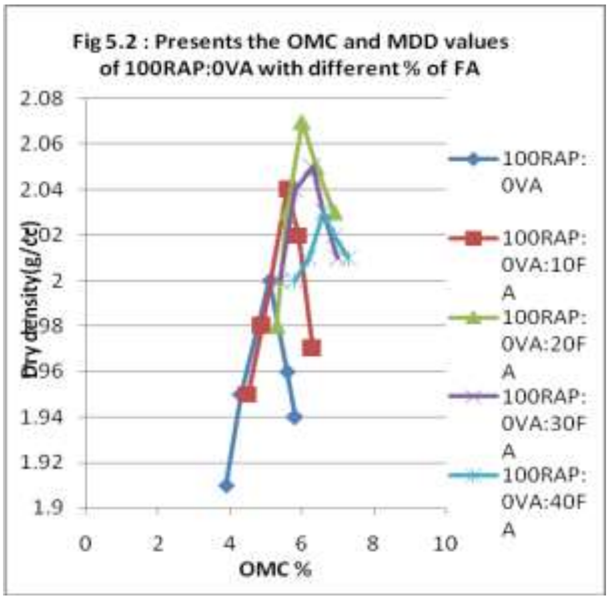

Figure 5.2: OMC and MDD values of 100RAP:0VA With various % of FA.

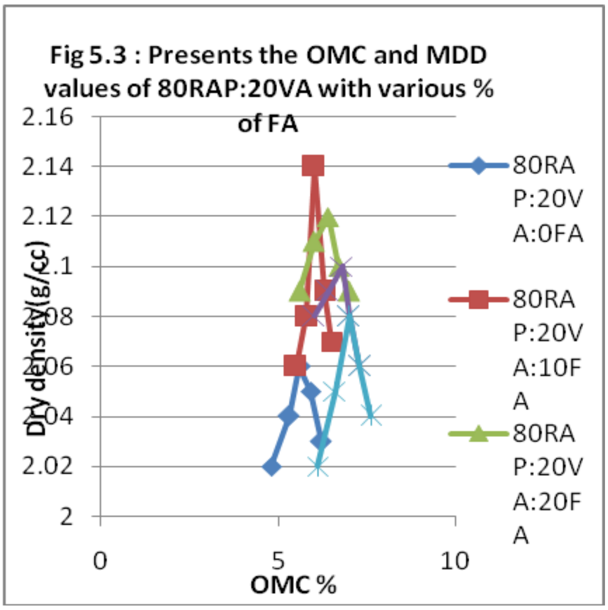

Figure 5.3: OMC and MDD values of 80RAP:20VA With various % of FA.

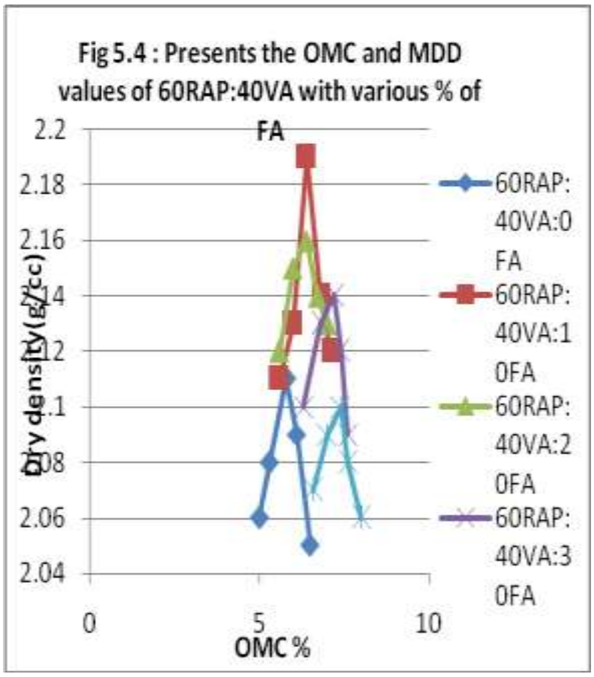

Figure 5.4: OMC and MDD values of Mix With various % of FA.

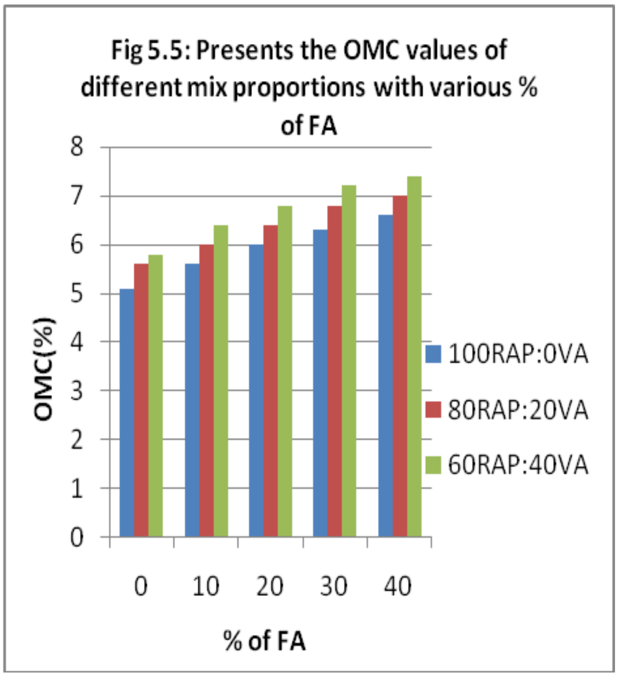

Figure 5.5: OMC values of mix proportions With various % of FA

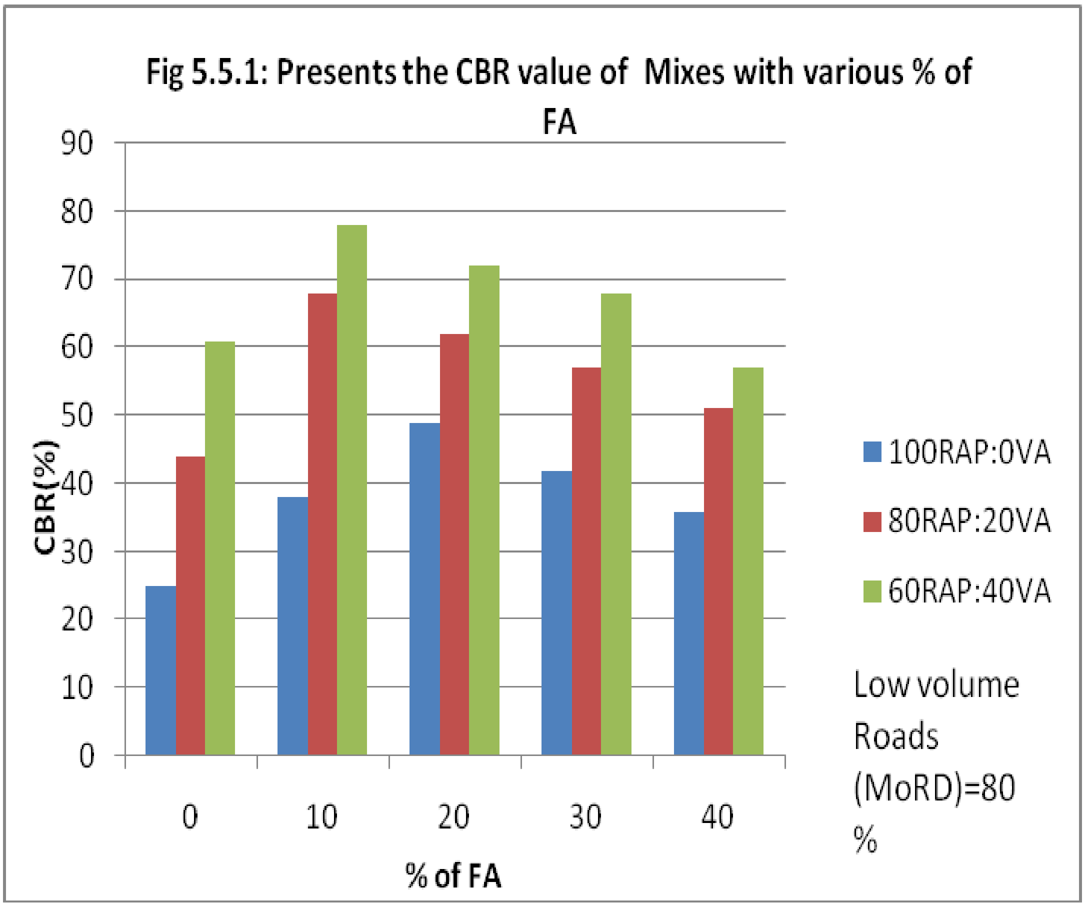

Fig 5.5.1: Presents the CBR values of the mixes with various % of FA

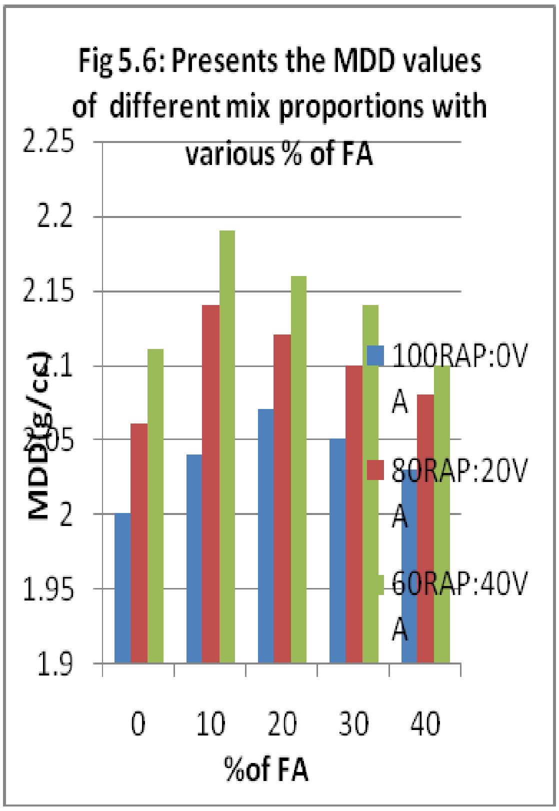

Figure 5.6: MDD values of mix proportions With various % of FA

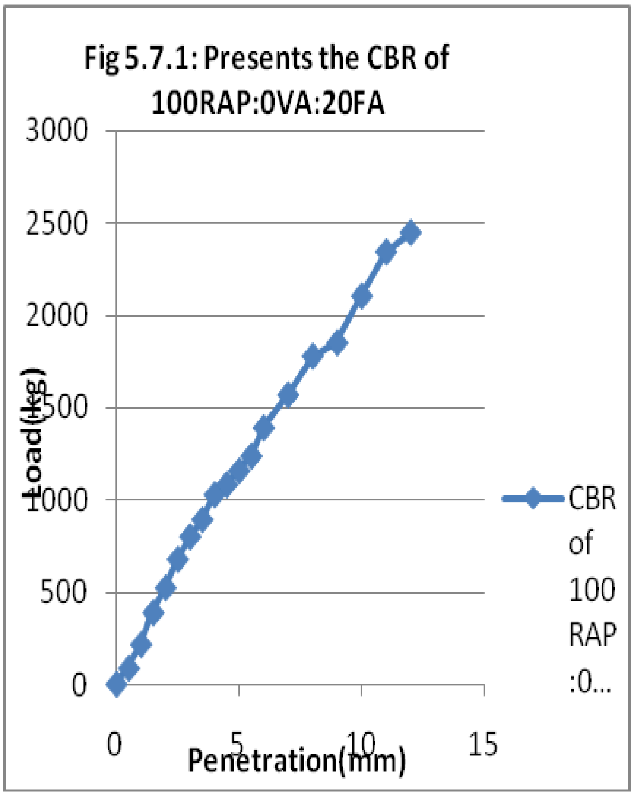

Figure 5.7.1: CBR value of 100RAP:0VA:20FA

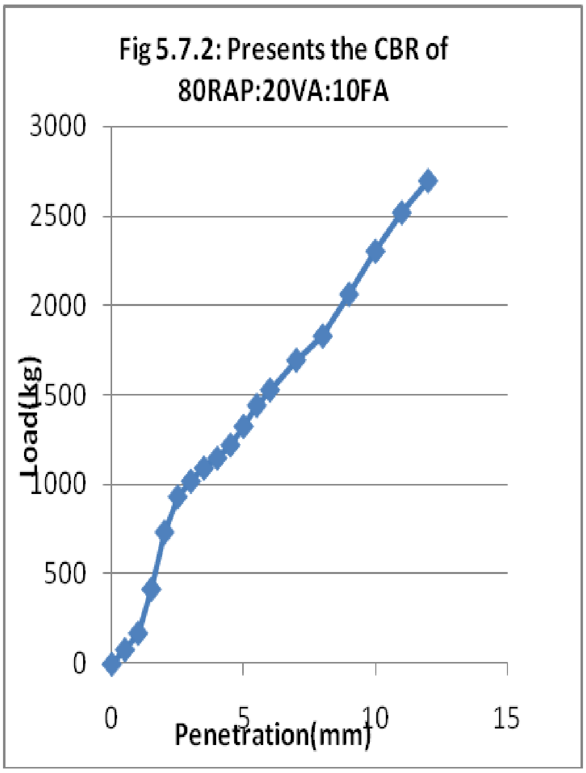

Figure 5.7.2: CBR value of 80RAP:20VA:20FA.

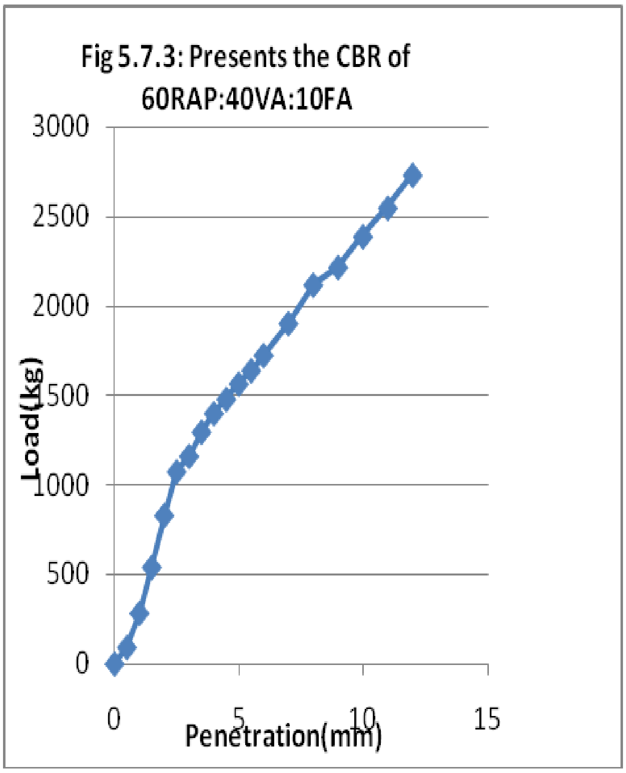

Fig 5.7.3: CBR value of 60RAP:40VA:20FA.

Table 5.4.1: Presents the OMC, MDD and CBR values of the mix with various % of ESP

Mix proportions	**OMC (%)**	**MDD(g/cc)**	**CBR (%)**
100RAP:0VA:20FA:0ESP	6.3	2.07	49
100RAP:0VA:20FA:3ESP	6.8	2.09	55
100RAP:0VA:20FA:5ESP	7.5	2.11	61
100RAP:0VA:20FA:7ESP	**8.2**	**2.14**	**68**
100RAP:0VA:20FA:9ESP	8.8	2.12	62

Table 5.4.2: Presents the OMC, MDD and CBR values of the mix with various % of ESP

Mix proportion	OMC (%)	MDD(g/cc)	CBR (%)
80RAP:20VA:10FA:0ESP	6.4	2.14	68
80RAP:20VA:10FA:3ESP	7.0	2.17	74
80RAP:20VA:10FA:5ESP	**7.9**	**2.20**	**81**
80RAP:20VA:10FA:7ESP	8.5	2.16	72
80RAP:20VA:10FA:9ESP	8.9	2.14	68

Table 5.4.3: Presents the OMC, MDD and CBR values of the mix with various % of ESP

Mix proportions	OMC (%)	MDD(g/cc)	CBR (%)
60RAP:40VA:10FA:0ESP	6.8	2.19	78
60RAP:40VA:10FA:3ESP	7.5	2.20	81
60RAP:40VA:10FA:5ESP	**8.0**	**2.21**	**85**
60RAP:40VA:10FA:7ESP	8.4	2.18	76
60RAP:40VA:10FA:9ESP	8.8	2.15	70

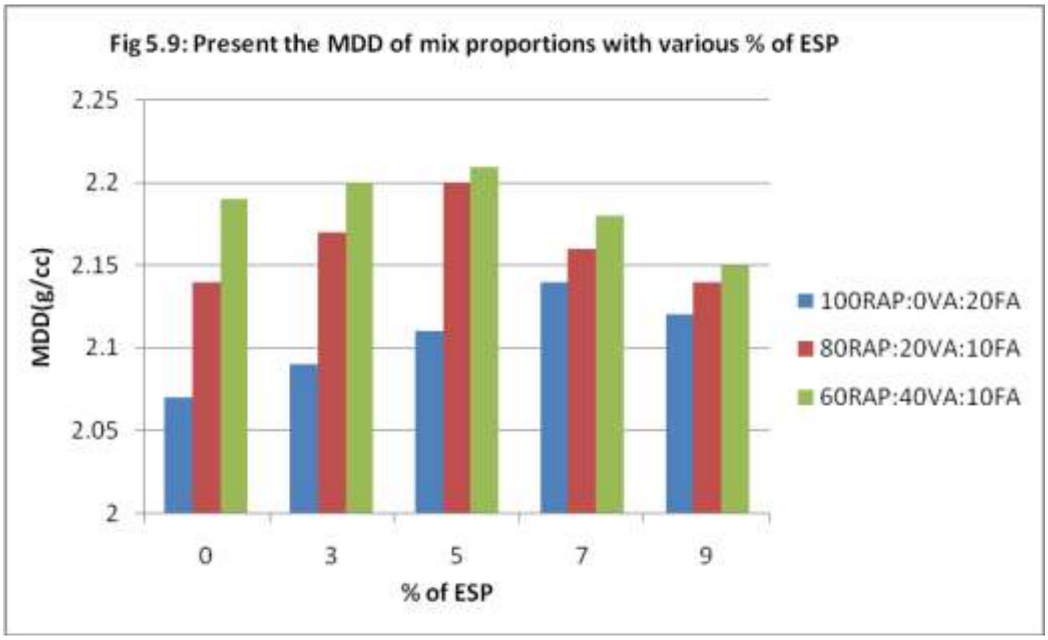

Fig 5.9: Presents the MDD of mix proportions with various % of ESP

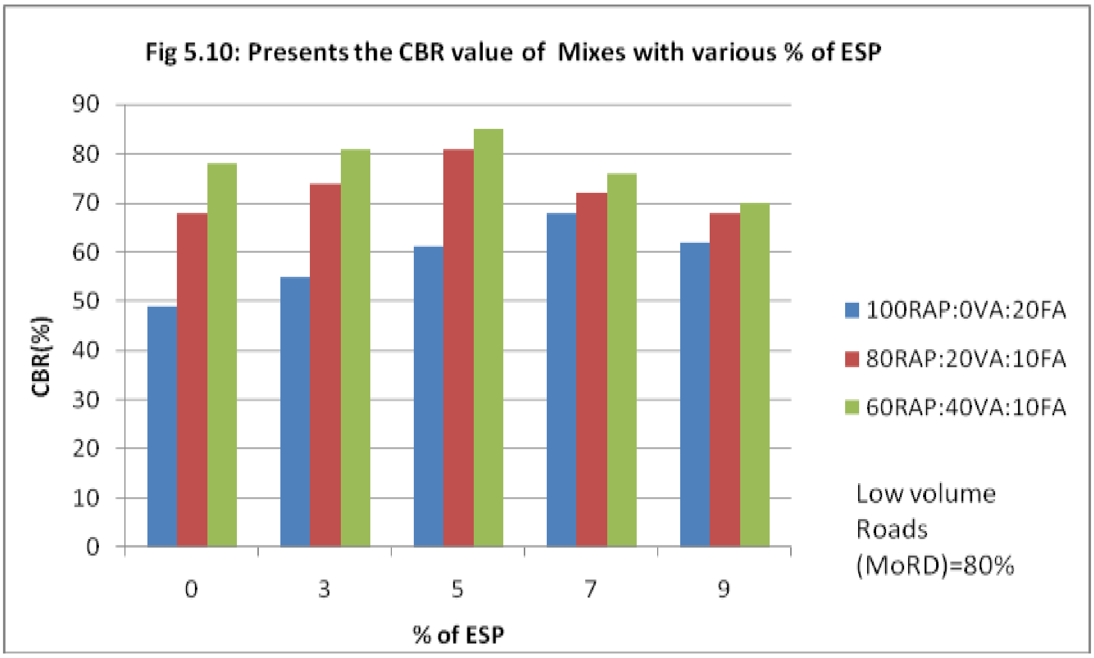

Fig 5.10: Presents the CBR value of different mix with various % of ESP

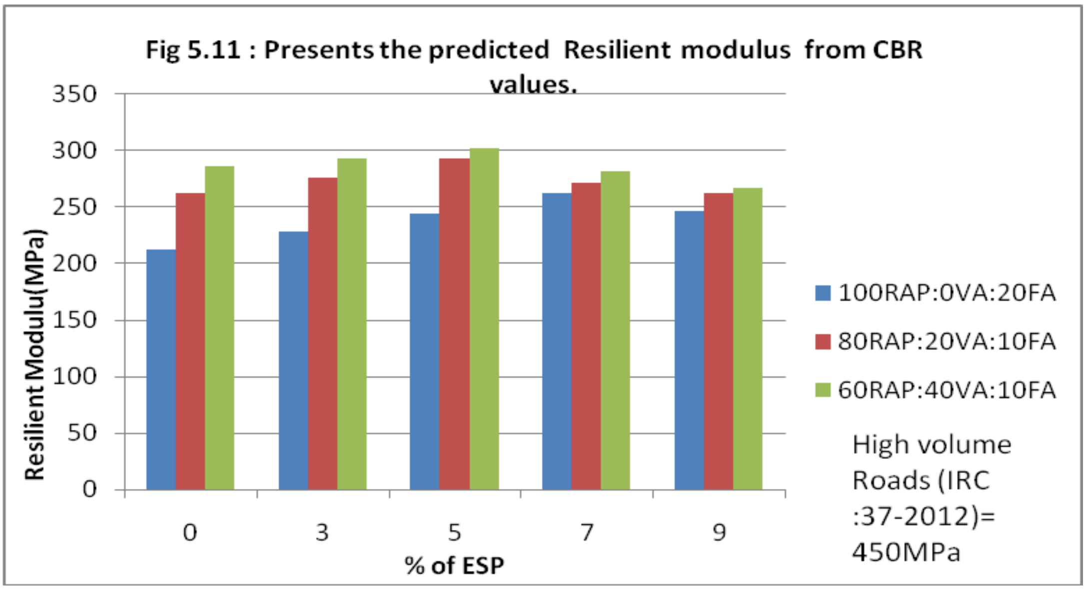

Fig 5.11: Presents the Predicted Resilient Modulus from CBR% of different mix with various % of ESP

V CONCLUSION:

- The moisture content and dry density are calculated for 100RAP:0VA, 80RAP:20VA, and 60RAP:40VA with various percentages of Fly ash (0, 10, 20, 30 and 40).
- California Bearing Ratio is also calculated for 100RAP:0VA, 80RAP:20VA and 60RAP:40VA with various percentages of Fly ash (0, 10, 20, 30, and 40) and it is observed that 100RAP:0VA:20FA, 80RAP:20VA:10FA and 60RAP:40VA:10FA are Optimum mix for further study. Low CBR value of 25% was observed for 100%RAP. The CBR value increases with increase in the fly ash dosage. The increase in CBR is about 24% as the fly ash dosage increased from 0 to 20% the reason for increasing in CBR is attributed to higher pozzolonic reactions between the RAP and Flash.
- It can also be observed that there was a tremendous increase in CBR with addition of VA. Possible reasons for this increase in CBR may be due to better load transfer between particles of VA and RAP.
- California Bearing Ratio values of Optimum mix didn't get required value for low volume roads according to MoRD so to get the required CBR values of the mixes are stabilized with Eggshell powder.
- CBR of 100RAP:0VA:20FA, 80RAP:20VA:10FA and 60RAP:40VA:10FA are calculated by adding Eggshell powder of 0,3,5,7 and 9%.
- California Bearing Ratio (CBR) of 80RAP:20VA:10FA:5ESP, 60RAP:40VA:10FA:3ESP and 60RAP:40VA:10FA:5ESP satisfy the MoRD specifications of CBR and the material which I used in the study is useful only for Low volume roads.
- Predicted Resilient Modulus of 80RAP:20VA:10FA:5ESP, 60RAP:40VA:10FA:3ESP and 60RAP:40VA:0FA:5ESP are calculated and the RAP used in the project does not suitable for High Volume Roads (IRC 37-2012).
- Most importantly it drastically reduces the cost of construction thereby leading to sustainable and green pavements.

VI REFERENCES:

- Arulrajah, A, A., Piratheepan, J., Disfani, M. and Bo, M.W.(2013), " Resilient module response of recycled construction and demolition materials in pavement sub base applications." J. Mater. Civ. Eng.,25(10),1920-1928
- Sireesh S, Deepthi A, Someswar Rao T, Sarath Chandra Prasad J and Dayakar Babu R (2014) Evaluation of fly-ash treated reclaimed asphalt pavement for design of sustainable pavement bases.
- Pranshoo Solanki , Bharat Dash (2015) "Mechanical Properties of Concrete containing Recycled Asphalt Pavement and Class C Fly ash.
- Ramzi Taha, A.M.ASCE; Ali AL-Harthy; Khalid Al- Shamsi; Muamer Al- Zubeidi(2002) "Cement stabilization of Reclaimed Asphalt Pavement Aggregate for Road Bases and Sub bases.
- Taha R (2003) "Evaluation of cement kiln dust stabilized Reclaimed Asphalt Pavement aggregate systems in road bases.

- G.Anisha, A.Pavani (2017) "An Experimental Investigation of Effect of Fly ash on Egg shell powder.
- Mohamed Ansari M, Dinesh Kumar M, Milan Charles, Dr. Vani G "Replacement of Cement Using Eggshell powder.
- IRC: SP 72-2007 Guidelines for Design of flexible pavements for low volume roads. IRC, New Delhi.