UTILISATION OF RECLAIMED ASPHALT PAVEMENT IN FLEXIBLE PAVEMENT

A

PROJECT REPORT

Submitted in partial fulfilment of the requirements for the Degree

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled **“UTILISATION OF RECLAIMED ASPHALT PAVEMENT IN FLEXIBLE”** submitted for partial fulfilment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Dr. AAKASH GUPTA.** This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled "**UTILISATION OF RECLAIMED ASPHALT PAVEMENT IN FLEXIBLE"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology and in Civil Engineering submitted to the Department of civil engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Sumit Kumar (161607)** & **Seraj Habib (161663)** during a period from Aug 2019 to May 2020 under the supervision and guidance of **Dr. AAKASH GUPTA,** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

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ABSTRACT

In this research, an attempt has been made to test the feasibility of use of RAP aggregate for improving properties of granular mixes. RAP aggregate were partially and fully replaced with fresh aggregate in different proportions to test various properties. In order to evaluate the suitability of mix proportions, fresh aggregate were partially and fully replaced with RAP aggregate in varying percentage of 0%, 20%, 40%, 60% and 70%. It has been expected that the outcome will be favourable for the construction of granular sub base.

. There is a lot of wastage produced annually because of roads rehabilitation and reconstruction. Thinking about the shortage of new total, partial and full supplying of new total with reclaimed asphalt pavement aggregate was considered in the present research work. Development of the street is very cost serious. Materials alone cost over 60% of the complete development cost, out of which total cost segment is roughly 30%.

CONTENTS

LIST OF ABBREVIATIONS

RAP	Reclaimed Asphalt Pavement
VA	Virgin Aggregate
ASTM -	American Society of Testing and Materials
BM -	Bituminous Macadam
CBR -	California Bearing Ratio
GSB -	Granular Sub-base
IRC -	Indian Roads Congress
MoRTH -	Ministry of Road Transport & Highways
NHAI -	National Highway Authority of India
OMC-	Optimum Moisture Content
VDF -	Vehicle Damage Factor
WBM -	Water Bound Macadam
WMM -	Wet Mix Macadam

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CHAPTER-1

INTRODUCTION

1.1 General

Mobility is a basic human need. From the times immemorial, everyone travels either for food or leisure. Transportation plays a major role in the development of the human civilization. Growth of automobile has brought many problems like accidents, environmental degradation etc. Transportation in India is accomplished by roadways, railways, waterways and airways. Among these 4 modes of transportation, roadways or highways serve major percentage of freight and passenger transportation in the country and road transportation provides maximum flexibility to the passengers and it serves door to door connection. India's road network of 4.69 million kilometers (according to 2013 data) is the second largest road network in the world. A proper network of roadways will help in development of economic, social, political and cultural fields of the country as a whole. Based on function, the roads are classified as:

- Express ways
- National highways
- State highways
- Major district roads
- Other district roads
- Village roads

Pavements are classified as Flexible and Rigid pavements depending upon their structural behaviour. The roads are generally constructed in different layers. The various layers of a flexible pavement are sub grade, sub base, base and surface course, whereas the rigid pavement consists of sub grade, base course and cement concrete slab.

The use of supplementary aggregate material is essential in developing low-cost construction and ecological benefits, especially in developing countries. It was roughly calculated that the construction industry in India produce about 120-140 lakh tons of wastes annually. Utilization of reused total isn't extremely normal in India and other creating nations. There is tremendous prerequisite of the. To advance quick improvement of the framework. So as to diminish the utilization of new total, reused total can be utilized as a substitution material. The general advancement of a nation relies upon a decent and all around associated street organize.

1.2 Background

Existing asphalt pavement materials are commonly removed during reconstruction. Once removed and processed, the pavement material becomes RAP, which have costly asphalt binder and aggregate (see figure 1.1). RAP is generally used as an aggregate and virgin asphalt binder substitute in recycled asphalt paving, but it is also used as a granular base or sub base, stabilized base aggregate, and embankment or fill material. RAP is a high-quality material that can replace more expensive virgin aggregates and binders.

Figure 1.1 Reclaimed Asphalt Pavement

1.3 OBJECTIVES OF THE PROJECT

The main goal of the research work are outlined as below.

1. To examination the impact of substitution of fresh aggregate with RAP aggregate in varying proportion of 0% to 70% of total aggregate with increment of 10% on compaction and strength characteristics of the GSB mixes.

2. To determine the properties of materials namely fresh aggregate, Reclaimed Asphalt Pavement aggregate and stone dust used in the study

3. To determine the maximum dry density (MDD), optimum moisture content (OMC) and CBR value of the GSB mixes prepared with virgin aggregate mixed with varying proportion of RAP aggregate

1.4 Scope of the Study

Fresh aggregate are replaced with Reclaimed Asphalt Pavement aggregate in various proportions, 0%,20%, 40% 60% and 70%, for testing the compaction, strength and permeability characteristics of the GSB mixes. The results of the study are applicable only to the materials used and specified characteristics studied in this work. However, the methodology can be applied to other similar materials as well and the expected results may also be similar and compatible.

1.5 STRUCTURE OF THE REPORT

The work undertaken for the dissertation has been presented in 6 chapters.
Chapter 1 **"Introduction"** examines about the significance of the subject, targets of the examination and extent of the investigation**.**

Chapter 2 **"Literature** Review" includes the historical background of the study and relevant retrospective research.

Chapter 3 **"Materials"** includes the physical requirements of Granular sub base.

Chapter 4 "**Methodology of the Study**" describes the procurement of material and test procedures as per IRC and MoRTH specifications.

Chapter 5 "**Results and Discussion"** depicts examination of test outcomes.

Chapter 6 "**Conclusion**" includes various conclusions based upon the study.

CHAPTER-2

LITERATURE REVIEW

2.1 INTRODUCTION

In view of significant role of recycled construction material and technology in the development of urban infrastructure, the Technology Information Forecasting and Assessment Council (TIFAC) had commissioned a techno-market survey on "Utilization of waste from construction industry". The focus of their study was to assess the present scenario of the Indian construction industry on the possibility of the recycling of construction and demolition (C&D) wastes. The survey was targeted towards the housing/building sector and road construction segment. According to findings of the survey, the most dominant reason for not adopting recycling of waste from construction industry is 'Not aware of the recycling techniques". Acceptability of recycled materials is hampered due to a poor image associated with recycling activity in India. Customer specifications do not permit use of materials recycled from waste. Cost of disposal of waste from construction industry to landfill has direct bearing on recycling operations. Low dumping costs prevalent in India also act as a barrier to recycling activities. Imposition of charge on sanitary landfill can induce builders and owners to divert the waste for recycling. So many researchers have worked on recycled aggregate for improving mix properties of granular sub base.

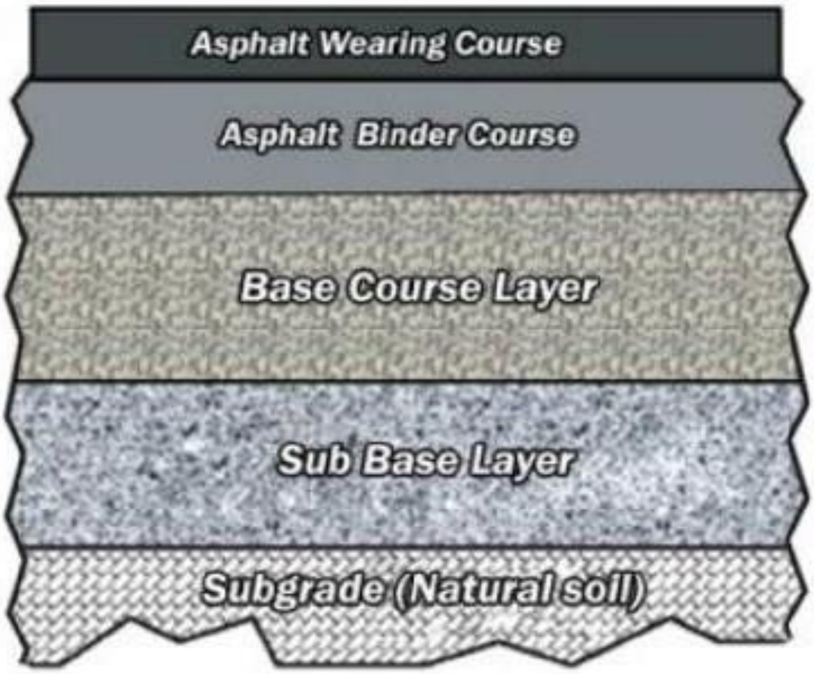

Figure-2.1 Typical flexible pavement

2.2 REVIEWS

Praveen Berwal and Praveen Aggarwal (2014)

conducted water absorption test, specific gravity test, aggregate impact value test and modified proctor test for compaction and CBR test and finally concluded that Values of Maximum dry density and Optimum moisture content of RAP mixes are nearly equal to values for virgin aggregate. Maximum dry density for Granular sub base is found to be 2.06 and 2.04g/cc in case of virgin aggregate and recycled aggregate respectively. And Aggregate impact value and water absorption values are within the permissible limits. Permeability results show that the permeability of recycled aggregate is more than the fresh aggregate. Finally, they reported that we can use RAP aggregate of 50% in GSB.

Khusbhu M Yyas and Shruti B Khara (2013)

conducted gradation test, Water absorption, Specific gravity test, Aggregate impact value(AIV) test and flakiness and elongation test for RAP aggregate as per MORTH and concluded that specific gravity ranges from 2.8 to 3, water absorption ranges from 0.3% to 2%, aggregate impact value is 15.28% (Max. 30%) and combined flakiness and elongated index value is 27.64% (Max.30%) and Recycled aggregate did not satisfy the gradation requirements as per MORTH and they stated that due to the action of crushing and aging large size of aggregate were deficient in the mix.

Taha (1999) studied about blended mixes of Virgin aggregate and RAP aggregate and stated that maximum dry density, CBR are decreased and there is no change in optimum moisture content whereas permeability is increased with increasing content of RAP aggregate. And CBR value for a 100% RAP mix was reported as 11% but when RAP content reduced to 80% in the mix, the CBR value increased to 26%.

Macgregor (1999) studied about blended RAP with both dense, graded, crushed stone and gravel-borrow sub base at RAP percentages ranging from 0 to 50%. Results shown that there is no variation of hydraulic conductivity when crushed stone blended with RAP aggregate whereas hydraulic conductivity is decreased with varying percentage of RAP aggregate when gravel-borrow sub base blended with RAP aggregate. From this study they concluded that one can observe that from one study we can’t decide whether the addition of RAP will affect the conductivity of the blend unless the aggregate are similar. And modulus of resilience is increased with increasing percent of RAP aggregate.

Mandal et a1. (2002) stated that up to some amount of replacement of (RAP) aggregate in the mix causes slight increment in the compressive strength. They also reported that the properties and characteristics of RAP aggregate have sufficient deficiency when compared to fresh aggregate.

Sireesh Saride et al. (2014) studied about stabilization of (RAP) aggregate with dy ash with varying dosages of 10, 20, 30 and 40% for both replacement and addition method and cured at 1, 7 and 28days to test their strength properties. And concluded that (OMC) is increased and (MDD) is decreased as percent of fly ash increases. And decrease in MDD is about 9% for replacement method where as 5% for addition method. Modulus of resilience and unconfined compressive strength are increased up to 40% addition fly ash. The permissible value of resilient modulus (450 MPa) of the fly ash treated RAP mixes meet the specification laid down by IRC-37, 2012. However, the mix has not met the UC strength requirement of 4.5 MPa.

Veresh Pratap Singh et at. (2014) found that the use of RAP aggregate in road construction in (GSB) and **(WMM)** not only used to achieve economy in the road projects, but also reduces mining pollution. They investigated the mix properties with varying percentages of RAP aggregate of 0, 10, 20, 30, 40 and 50% And maximum values of maximum dry density (MDD) and California bearing ratio (CBR) are obtained with addition of 30% of reclaimed asphalt pavement aggregate and which is less than 0.01g/cc and 0.5% respectively with no addition of RAP aggregate to virgin aggregate. And recycling material obtained from the demolished projects which in turn reduce the cost of transporting the material to the land fill and also cost of disposal.

2.3 Gaps in literature

- The researchers have not covered comprehensively the effect of addition of RAP aggregate on permeability and strength characteristics of the Granular sub base of Grading VI.
- Moreover, no study has been conducted on RAP aggregate obtained from a demolishing Bituminous Macadam (95 mm thick) road from CHAMBAGHAT, SOLAN which has been taken up as the RAP material for their study.
- Literature is available for the utilization of RAP aggregate for improving the properties of Granular sub base of Grading III.
- . RAP aggregate obtained from different sources have different properties like RAP aggregate from bituminous macadam, dense bituminous macadam and premix carpet and literature is not available for the effect of source of RAP aggregate on properties of GSB.

CHAPTER-3
MATERIAL

3.1 GENERAL

The RAP aggregate were collected from road site near SOLAN and fresh aggregate obtained from a construction site at CHAMBAGHAT, SOLAN. The materials used for the research work are Fresh aggregate, Reclaimed Asphalt Pavement aggregate and the Stone dust.

3.2 MATERIAL USED

3.2.1 Reclaimed asphalt pavement (RAP) aggregate

Recycled aggregate has inferior relative density and more water absorption capacity when compared with virgin aggregate. There are two methods of sorting or cleaning of recycled aggregate. First one is dry separation method which involves removal of lighter matter from heavier stony materials by means of blowing air and second one is wet separation method in which low density impurities are separated by water jets or float-sink tank and finally fabricates very clean aggregate. Reclaimed asphalt pavement materials are generated when asphalt pavements are removed for reconstruction, resurfacing, or to obtain access to buried utilities.

3.3 STANDARD SPECIFICATION

The standard specifications relating to GSB (Grading III and VI) have been followed as given in MORTH (Ministry of Road Transport and Highways) specifications for Roads and Bridge Works (2013). Aggregate are used in various layers of pavement like Granular sub base, Water bound macadam, Wet mix macadam and various bituminous and concrete layers. Keeping the objective of this study in view, the use of reclaimed asphalt pavement aggregate in GSB (grading III and VI) has been focused.

3.3.1 Granular Sub Base (GSB)

The material shall be laid in one or more layers as sub base or upper sub base and lower sub base. These are composed of broken stone aggregate. It is desirable to use smaller size graded aggregate at sub base course instead of boulder stones. The work consists of laying and compacting the well graded material on the prepared sub grade in accordance with the requirements of these specifications. GSB is used as sub base course in one or more layers of the pavement. It serves the purpose of separation and drainage of the pavement layers.

3.3.1.1 Materials

The material should be free from organic or other deleterious constituents. material used for GSB should be well graded material consisting of natural sands, moorum, gravel, crushed stone or combination above materials depending upon the grading. Material like brick metal, kankar and crushed concrete, can be used in lower sub base course.

3.3.1.2 PHYSICAL REQUIREMENTS

The value of water absorption should not be more than 2%, There are six gradings are available for Granular Sub-Base as per MoRTH Specifications latest revision. Grading III & IV are used as lower sub-base (Separation layer) and Grading V & VI can be used as sub-base come drainage layer. The GSB Gradings are described in the following Table 3.1.

Table 3.1 Different Gradation of Granular Sub Base

IS Sieve		By percentage weight passing the sieve				
	Grading I	Grading II	Grading III	Grading IV	Grading V	Grading VI
75	100	-	-	-	100	
53	80-100	100	100	100	80-100	100
26.5	55-90	70-100	55-75	50-80	55-90	75-100
9.5	35-65	50-80	-	-	35-65	55-75
4.75	25-55	40-65	10-30	15-35	25-50	30-55
2.36	20-40	35-50	-	-	10-20	10-25
0.425	10-15	10—15	-	-	5	0-8
0.075	<5	<5	<5	<5	-	0-3

CHAPTER-4

MATERIALS AND METHODS

4.1 General

Methodology of the present research work included, the various experiments carried out on Fresh aggregate, Reclaimed Asphalt Pavement aggregate and obtaining right proportions of fresh aggregate and RAP aggregate that ensures the suitability of RAP aggregate in road construction. The experimental investigations were carried out in Transportation Lab of Civil Engineering Department

4.2 Material Properties

Materials required for the construction of Granular sub base (GSB) of grading III & grading VI examination of virgin Aggregates (VA), stone dust and reclaimed asphalt pavement (RAP)

4.3 Granular sub base (GSB)

GSB is used as sub base course in one or more layers of the pavement. It serves the purpose of separation and drainage of the pavement layers. The material shall be laid in one or more layers as sub base or upper sub base and lower sub base. The material used for GSB should be well graded material consisting of natural sands, moorum, gravel, crushed stone or combination above materials depending upon the grading Material like brick metal, kankar and crushed concrete, can be used in lower sub base course. The material should be free from organic or other deleterious constituents.

4.4 TESTING PROGRAM

For determine the characteristics of these (GSB), there are different tests has done.

- Modified proctor test
- CBR test

Test on stone dust:-

specific gravity test

4.5 WORK PLAN

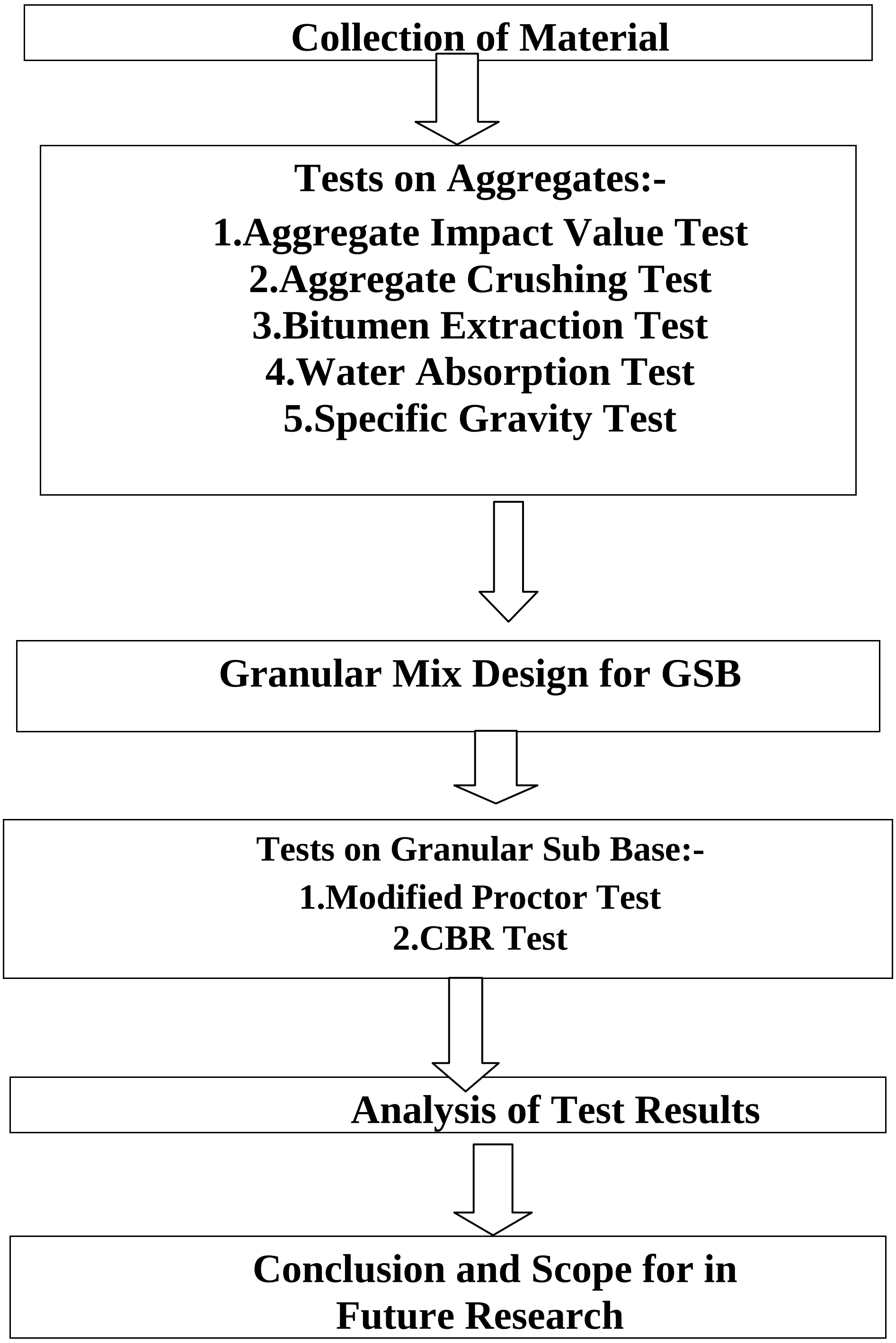

Fig 4.1 Methodology of the study

4.6 DESCRIPTION OF EXPERIMENTAL METHODS

4.6.1 Aggregate impact value test

AIM:

To determine the impact value of the aggregate.

APPARATUS:

Coarse aggregate from various sources, Impact testing machine, Spanner, Balance

Fig 4.2 Aggregate impact machine

PROCEDURE:

- The test sample consisted of aggregate passing through IS sieve 12.5 mm and retained on the IS sieve 10 mm. The test sample was dried in oven for the period of four hours at the temperature of 100 to l10°C and cooled.
- The aggregate were filled in a cylindrical measure about one third of full depth and tamped with 25 strokes with round edge of the tamping rod. Further similar quantity of aggregate was placed in measure by giving 25 strokes as above. Finally the cylindrical measure was filled to overflowing, tamped 25 times and excess aggregate stroke off using the tamping rod as straight edge.

The net weight of aggregate in cylindrical measure was measured to nearest gram and denoted it as A. And the weight of the aggregate was used for carrying out duplicate test on the same material.

- The impact machine was placed on the level plate or block so that machine was in position, rigid and hammer guide columns were vertical. The cup was fixed in position on the base of the machine and transferred the whole test sample into cup and compacted by single tamping of 25 strokes with the tamping rod.
- The hammer was raised until its lower face was 38cm above the upper surface of the test sample in the cup and allowed to fall freely on the test sample. And the test sample was subjected to total number of blows of 15 and such blows each being delivered at an interval of not less than one second.
- And the crushed test sample was removed from the cup and sieved on 2.36mm sieve and weighed the material to nearest gram having accuracy of 0.19 and denoted it as B. And also weighed the material retained on 2.36mm sieve.

CALCULATIONS:

Aggregate impact value is the ratio of the weight of fines formed to the total weight of the sample and it is expressed in terms of percentage.

Aggregate Impact Value (AIV) = $\frac{\mathbf{B}}{\mathbf{A}}$ ***100**

Where,

A - Total weight of oven dried sample

B - Weight of material passing through 2.36mm

sieve

Table 4.1 permissible limit of aggregate impact value for different pavement layer

S.No	Type Of Pavement	Requirement Of Aggregate Impact Value (%)
1	WET MIX MACADAM(WBM)	30 % max
2	BITUMINOUS MACADAM(BM)	30% max
3	DENCE BITUMINOUS MACADAM(DBM)	30% max
4	WATER BOUND MACADAM	30% max

4.6.2 DETERMINATION OF SPECIFIC GRAVITY

AIM:

Determine the specific gravity of the stone dust.

APPARATUS REQUIRED:

Pycnometer with hole, weighing Balance,.

PROCEDURE:

- pycnometer bottle was cleaned and dried. The empty weight of the bottle was measured to the nearest 0.1 gram and denoted it as W_1. The pictorial diagram of the pycnometer bottle as shown below in Fig 4.3.
- The cap was marked and Pycnometer with a vertical line parallel to the axis of the Pycnometer to ensure that the cap was screwed to the same mark each time.
- Around 200g of oven dried sample of stone dust was taken in to the bottle. The cap was screwed. The weight taken and be value of W_2.
- stone dust in pycnometer was filled with sufficient water and stirred with glass rod without any air bubbles. The bottle was shaken continuously to remove entrapped air in the bottle.
- The vacuum pump was connected to remove the still any entrapped air in the bottle for the time period of around 10 minutes for coarse grained soils.
- The vacuum pump was disconnected and weight bottle filled with water and stone dust and denoted it as W_3.The bottle was emptied and filled with water without any entrapped air, and take weight of the bottle filled water and denoted it as $W_{4.}$

Fig 4.3 pycnometer Bottle

CALCULATIONS:

Specific gravity of soil = Density of water at 27°C / Weight of water if equal volume

= **(**$W_2 – W_1$) / (W_4 -W_1)**-** ($W_3 – W_{2)}$

= **(**$W_2 – W_1$) / (W_2 -W_1)**-** ($W_3 – W_{4)}$

Where

W_1 = Weight of empty pycnometer

W_2=Weight of pycnometer + Stone dust

W_3 = Weight of pycnometer + Stone dust + Water

W_4 =Weight of pycnometer + **Water**

4.6.3 Water Absorption Test

Theory

Water content of aggregate/soil is an important parameter which significantly influences the behaviour of cohesive soils. Water content of aggregate can be determined by several methods. The methods are listed below:

- Oven drying Method
- Pycnometer Method
- Sand bath Method
- Rapid moisture meter Method
- Buoyancy balance Method

Water absorption and specific gravity of coarse aggregate is determined as per IS: 2386, Part III- 1963.

Apparatus

Wire Basket of not more than 6.3mm mesh or perforated contained of Convenient size with thin wire hangers for suspending it from the balance.

- A thermostatically controlled oven capable to maintain the temperature of 100°C to 110°C.
- Dry absorbent cloths and shallow tray.
- A balance of capacity about 5kg, to weigh accurate to 0.5g and of such a type and shape as to permit weighing the sample container when suspended in water.

Fig 4.4 wire bucket

Procedure

- About 2 kg of the aggregate sample was washed thoroughly to remove fines, dust, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22 to 32°C with a cover of at least 50mm of water above the top of the basket. Immediately after immersion, the entrapped air was removed from the sample by lifting the basket containing it 25mm above the base of the tank and allowing to drop to 25 times at the rate of about one drop per second. And then the basket and aggregate were remaining completely immersed in water for a period of 24 hours afterwards. The basket and the sample shall then be jolted and weighed in water and denoted it as A_1 grams.

- The basket and the aggregate were then removed from the water and allowed to drain for a few minutes, after which the aggregate were transferred to one of the dry absorbent clothes, and then transferred it to another absorbent cloth to ensure no further moisture and the empty basket shall be returned to the water and take the weight of basket in water, denoted it as A_2 grams. The aggregate were spread on second clothe and exposed to atmosphere, away from the direct sun light till it appeared to be completely surface dry. And weighed the aggregate and denoted it as B grams.

- The aggregate were placed in oven for 24 hours maintaining temperature around 100 to 110℃.

- And then it was removed from the oven, cooled and take the weight of the aggregate and denoted it as C gram.

Calculation

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

Water Absorption (%) = $\frac{B-C}{C} * 100$

Where,

A = $(A_1 - A_2)$. Weight of the saturated sample in water.

B = Weight of surface dry sample

C = Weight of oven dry sample

4.6.4 CALCULATION OF BITUMEN CONTENT

AIM:

This test is used to determine the binder content in the asphalt mix by cold solvent extraction.

APPARATUREQUIRED:

Centrifuge apparatus, Trichloroethyleneor Benzene

PROCEDURE:

- Exactly 500 grams of representative sample was taken and placed in the bowl extraction apparatus (A) and added benzene to the sample until was completely submerged.
- The filter paper was placed over the bowl.
- The cover of the bowl was clamped tightly and placed the beaker under the drainpipe to collect the extract.
- Sufficient time (not more than an hour) was allowed for the solvent to disintegrate the sample before running the centrifuge.
- The centrifuge was made run slowly and then gradually increased the speed to a maximum of 3600 rpm. The pictorial view of centrifuge extractor as shown below in Fig 4.5
- The centrifuge was made rim until the bitumen and benzene were drained out completely. The machine was stopped, removed the *cover* and added 200ml of benzene to the material in the extraction bowl and the extraction was done in the same process as described above.
- The process was repeated three times till the extraction was clear and not darker than a light straw colour.
- The material was collected trom the bowl Of the extraction and dried it to constant weight in the oven at a temperature of l05^{0}C to ll0^{0}C for 24 hours and cooled to room temperature.
- The oven dried sample was weighed.

Fig 4.5 Bitumen extraction test machine

CALCULATION: Calculate the percentage of binder in the bituminous mix sample as follows:

Percentage of Binder = $[W_1 – (W_2 + W_3 + W_4) /W_1] \times 100$

Where

W_1 = Weight of the sample, g

W_2 = Weight of the sample after extraction, g

W_3 = Weight of the fine material recovered from the extract, g

W_4 = Increase in weight of filter ring, g

4.6.5 calculation of OMC :-

The optimum moisture content is the moisture content at which a given type of soil becomes most dense and achieves its maximum dry density by removal of air voids from the soil structure. The relationship between maximum dry density and optimum moisture content of the soil can be obtained from soil compaction curve which is further obtained from standard proctor compaction test. Thus this relationship helps in calculating the optimum water content of soil at which maximum dry density can be attained through its compaction.

Figure 4.6 Proctor mould for OMC determination

Modified Proctor Test

Theory

Compaction is accomplished by decrease in the volume of air, as strong and water are for all intents and purposes incompressible. motivation behind a research facility compaction test is to decide the perfect measure of blending water to be utilized while compacting the example in the field and the subsequent level of thickness can be normal from compaction at ideal dampness content. Compaction is the procedure by which soil particles are stuffed all the more intently together by unique stacking, for example, moving, packing or vibration. It is accomplished through the decrease of air voids with almost no adjustment in water substance of soil. As it were, compaction is the procedure's to pack soil mass into littler volume along these lines expanding its dry thickness and improving its designing properties. Some about attachment less soils conservative sufficiently in the standard test in spite of the fact that as a rule the water thickness bend isn't very much characterized. This procedure is satisfactory for cohesive soils but does not lend itself well to the study of the compaction characteristics of clean sands or gravels which displace easily when struck with rammer.

APPRATUS

1.Weighing balances -One of 10kg capacity accurate up to lg and other of 200g capacity accurate up to 0.01g.

2. A cylindrical metal mould with a capacity of 2250ml and internal diameter of l50mm. The mould shall be fitted with a detachable collar and base plate.

3.Set of sieves.

4.A metal hammer of 4.9 kg weight and having diameter of 50.8mm which will be drop freely from height of 450mm

5.A thermostatically controlled oven capable to maintain the temperature of 100 to ll0°C.

6.Steel straight edge having about 30cm in length and having one beveled edge.

7.Mixing tools.

Sample Preparation

For compaction test take the test sample, if the sample contains a particle size 40mm, do not use that aggregate directly so it can be replaced by equivalent weight of aggregate passing through IS sieve 19mm and retained on IS sieve 4.75mm. If percentage retained on 4.75 mm is more than 20% there is a need to conduct modified proctor test. In this research the percentage retained on 4.75mm was more than 20%, so modified proctor test was needed to be carried out for analyzing test specimens and the mix proportions of Fresh aggregate and Reclaimed asphalt pavement aggregate. For mix proportions, the fresh aggregate was replaced with RAP aggregate with varying proportion of 0%, 20%, 40%, 60% and 70%.

Procedure

- The mould and the base plate were cleaned and dried. The weight of mould with the base plate was taken to the nearest 1 gram as $\mathbf{W_1}$.
- The sample was taken and added water according to the sample requirement.
- The sample was placed in the mould in five different layers. The specimen was properly compacted with hammer by giving 56 blows to each layer. The blows were

being distributed uniformly.

- The collar was removed and trimmed off the excess soil projecting above the mould using a straight edge. The base plate and the mould were cleaned from outside.
- The weight sample with mould and base plate was noted nearest to lg and denoted it as $\mathbf{W_2}$
- The sample was taken for the water content determination from the top, middle and bottom portions. The sample was placed in oven for 24 hours. Dry weight of sample was taken.

Calculations

Weight of mould with base plate **= $\mathbf{W_1}$ gms**
Weight of moist sample with mould and base plate = W_2 gms
Volume of the mould = v cm^3

Bulk density of sample, $\gamma = \frac{W1-W2}{V}$ g/cc

Water content of specimen, w $= \frac{\text{(wet weight —dry weight)}}{\text{Dry weight}}$

Dry density of sample, $\gamma d = \frac{\gamma}{1+\frac{w}{100}}$ g/cc

4.6.6 California Bearing Ratio (CBR)

Theory

This is the most generally utilized technique for the plan of adaptable asphalt. This is the essential site test performed by estimating the complete required to infiltrate soil or total with an of standard zone. The deliberate weight is then separated by the constrain required to accomplish an equivalent entrance on a standard squashed stone material. It is the ratio of force per unit area required to penetrate the test sample with standard circular piston at the rate of 1.25 mm/min to that required for the relating entrance of a standard material. The heap esteems to cause 2.5 mm and 5.0 mm infiltration are recorded. These heaps are communicated as a level of standard burden an incentive at a particular miss happening levels to acquire CBR esteem. The standard values obtained from the average of a large number of tests carried out on California standard aggregate or crushed stones are 1370 and 2055kg

(70 and $105kg/cm^2$ respectively at 2.5 and 5.0 mm penetration.

Apparatus

Barrel shaped CBR form having inside distance across 150 mm and 175 mm in tallness, furnished with a separable punctured base plate 10 mm thick and a separable neckline of stature having 50mm. Diameter of spacer disc is 148 mm and height is of 47.7 mm

hammers. Weight 4.9 kg with a drop 450 mm. Surcharge weights of 2.3 kg each having a central hole 53 mm in diameter, having whole diameter of 147 mm.

- Loading machine: With a capacity of atleast 5000 kg and equipped with a movable head that travels at an uniform rate of 1.25 mm/min. Complete with load indiCating device shown in Fig 4.7 below.

Fig 4.7 CBR testing machine

Procedure:-

- The sample was sieved through 19 mm IS sieve. Material passing through 19 mm sieve only was allowed in the test. However material of size more than 19 mm, it can be replaced by weight of equivalent amount of material passing through 19 mm IS sieve but retained on IS sieve 4.75 mm.
- 5kg of sample was taken and mixed it thoroughly with required amount of water i.e. optimum moisture content.
- The collar was fixed to the top of the mould and also fixed the base plate tightly. The spacer disc was inserted over the base plate and ensured that central hole of the disc was at the lower face. The filter paper was placed over the spacer disc.

  The sample was placed in the mould and compacted using light compaction rammer or the heavy compaction rammer accordingly. For light compaction the sample is compacted in three layers by giving 56 blows to each layer by using 4.9 kg rammer with height of fall 450mm. And for heavy compaction sample is compacted in five layers. After compaction, the extension collar was removed and trimmed off the excess material on the top of the mould, carefully with straight edge. The holes formed due to removal of coarse aggregate were filled with small size particles and levelled.
- The base plate was loosened and removed the spacer disc carefully and placed the filter paper on the base plate, upside down the mould with the compacted sample.
- The perforated disc was placed on the top of the specimen along with extension stem, then placed the surcharge weight of 2.5kg and kept the mould in water tank for soaking of 96 hours.
- After soaking period, the mould was removed from the tank and allowed it to drain off for 15 minutes. The excess water on the mould was removed without disturbing the specimen.
- The mould containing specimen with the base plate was placed in position on the testing machine. The penetration plunger was set at the centre of the specimen and ensured that plunger was in contact with specimen. The dial gauge was set to zero.
- The load was applied on the plunger such that penetration rate of 1.25 mm/min. The load corresponding penetration of 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5mm was recorded.

CALCULATION

CBR value is:

$$CBR,\% = \frac{Load\ or\ pressure\ sustained\ by\ the\ specimen\ at\ 2.5\ or\ 5\ mm\ penetration}{load\ or\ pressure\ sustained\ by\ standard\ aggregate\ at\ the\ corresponding\ level} * 100$$

Mostly CBR value for penetration 2.5 mm which is greater than 5 mm is reported as the CBR value of the material. However, if the CBR value obtained from the test at 5 mm penetration is more than that 2.5 mm, then process is repeated for verifying. If the verify test gives same results, the greater value calculated at 5 mm penetration is noted as CBR value of the material. The average CBR value of three test specimens is reported to the first decimal place, as the CBR value of the material. If the variation of CBR value between the three sample is more than standard limits, tests should be proce ed again. on additional three samples and the average CBR value of six specimens is accepted.

CHAPTER-5

RESULTS AND DISCUSSION

5.1 General

The results obtained have been analyzed with reference to MORTH recommendations. The tests have been conducted as per relevant guidelines of IRC, IS codes and MoRTH specifications.The milled material of RAP used in the study is obtained from the scrapped 95 mm bituminous macadam (BM) layer from CHAMBA GHAT,SOLAN. aggregate and mix proportions of virgin aggregate and reclaimed asphalt pavement aggregate in the laboratory to evaluate various properties of material and GSB (Granular sub base) mixes selected for the study.

5.2 AGGREGATE IMPACT TEST

The aggregate impact test is for evaluate the toughness of aggregate or the resistance of the aggregate to fracture under repeated impacts. It was carried out for both virgin and reclaimed asphalt pavement aggregate.

Table 5.1 AGGREGATE IMPACT VALUE

Type of aggregate	Aggregate impact value(%)
Virgin aggregate	17.01
Rap aggregate	15.1

Aggregate impact value of virgin aggregate and rap aggregate is 17.01% and 15.1% .values are within permissible limit of maximum 30% as per MoRTH specifications for granular layer. Rap aggregate impact value is less than virgin aggregate impact value May be **due to the binder coating present** on the RAP aggregate.

5.3 SPECIFIC GRAVITY TEST

Pycnometer bottle was used, for finding out specific gravity of fine aggregate & buoyancy balance method is used for finding specific gravity of coarse aggregate.

Table 5.2 SPECIFIC GRAVITY OF MATERIAL

Type of aggregate	Specific gravity
Virgin aggregate 20 mm	2.53
Virgin aggregate 10 mm	2.57
Rap aggregate	2.2
Stone dust	2.51

Specific gravity of RAP aggregate is much less than that of fresh aggregate. This is certainly because of RAP aggregate have **undergone series of loading of wearing and tearing** in the past.

5.4 WATER ABSORPTION TEST

specific gravity of RAP aggregate is much less than that of fresh aggregate This is certainly because of RAP aggregate have **undergone series of loading of wearing and tearing** in the past.

Table-5.3 water absorption of virgin aggregate and RAP aggregate

Type of aggregate	Water absorption (%)
Virgin aggregate 20 mm	.55
Virgin aggregate 10 mm	.53
Stone dust	1.02
Rap aggregate	.98

5.5 BITUMEN EXTRACTION TEST

Amount of binder content present in the RAP aggregate

Table 5.4 Binder Content Of RAP Aggregate

Type of aggregate	**Binder content**
Rap aggregate	**1.99%**

5.6 Mix Formula For Granular Sub Base(GSB)

materials like natural sand, moorum, gravel, crushed stone or combination of these materials are being used**.** The main objective of the granular mix design is to proportion the aggregate to meet the gradation requirement and to achieve desired maximum density.

5.7 GRANULAR MIX DESIGN

5.7.1 Mix Design For GSB Grading

Mix design of granular sub base with different type of materials is prepared by trial and error method. There are 6 grading available for GSB as per MORTH Specifications latest revision. Grading III & IV are used as lower sub-base (Separation layer) and Grading V & VI can be used as upper sub-base (Drainage layer). Mix design for GSB grading III and grading VI without RAP aggregate and with RAP aggregate.

Table-5.5 Mix design of GSB for grading III without RAP aggregate

Sieve size (mm)	**% by weight of passing**						
	40 mm (A)	**20 mm (B)**	**10 mm (C)**	**SD (D)**	**Required Grading As Per (MORTH)**		**Proportion A:B:C:D 44:15:16:25**
					Lower Limit	**Upper Limit**	
53	**100**	**100**	**100**	**100**	**100**	**100**	**100**
26.5	**23.4**	**100**	**100**	**100**	**55**	**75**	**66.29**
4.75	**0**	**0**	**9.7**	**95.7**	**10**	**30**	**24.61**
.075	**0**	**0**	**0**	**3.9**	**<5**	**<5**	**.0936**

Table 5.6 Input Value Of Graph For 0%RAP

s.no	Sieve size(mm)	Lower limit	Upper limit	Proportion A:B:C:D 44:15:16:25
1	0	0	0	0
2	.075	<5	<5	.936
3	4.75	10	30	24.61
4	26.5	55	75	66.29
5	53	100	100	100

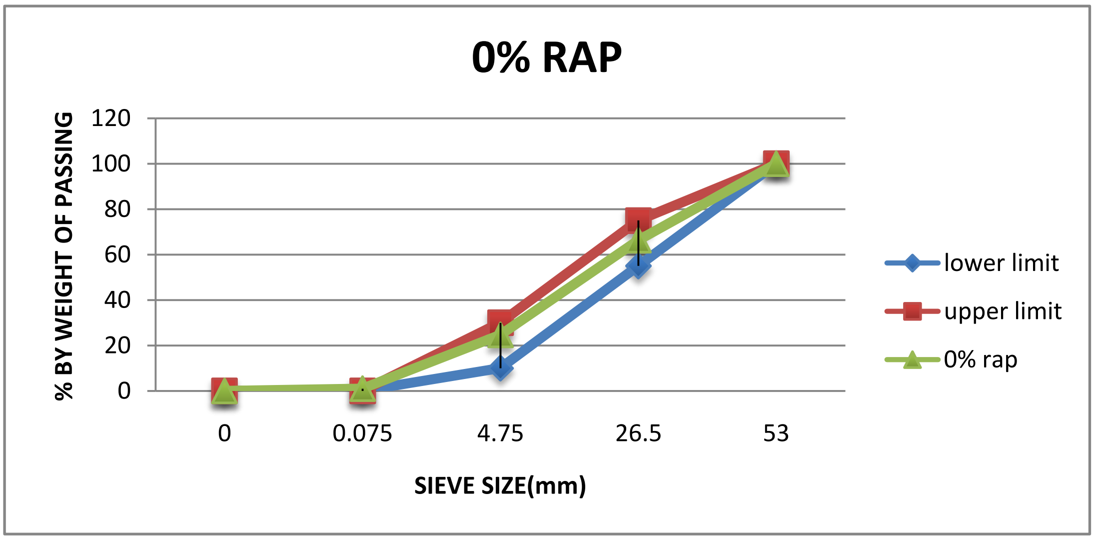

Fig 5.1 Proportioning For GSB For Grading III of 0% RAP

Table 5.7 Mix design of GSB for Grading III with RAP Aggregate 20% & 40%

Sieve size (mm)	**% by weight of passing**								
	40 mm (A)	**20 mm (B)**	**10 mm (C)**	**RAP (D)**	**SD (E)**	**Required Grading As Per (MORTH)**		**Proportion A:B:C:D:E 38:12:12:20:18**	**Proportion A:B:C:D:E 33:10:7:40:10**
						Lower Limit	**Upper Limit**		
53	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
26.5	**23.4**	**100**	**100**	**87.8**	**100**	**55**	**75**	**68.45**	**69.84**
4.75	**0**	**0**	**9.7**	**13.6**	**95.7**	**10**	**30**	**21.11**	**15.69**
.075	**0**	**0**	**0**	**.15**	**3.9**	**<5**	**<5**	**.732**	**.45**

Table-5.8 input value of graph for GSB Grading III with RAP Aggregate of 20%

s.no	Sieve size(mm)	Lower limit	Upper limit	Proportion A:B:C:D 38:12:12:20:18
1	0	0	0	0
2	.075	<5	<5	0.732
3	4.75	10	30	21.11
4	26.5	55	75	68.45
5	53	100	100	100

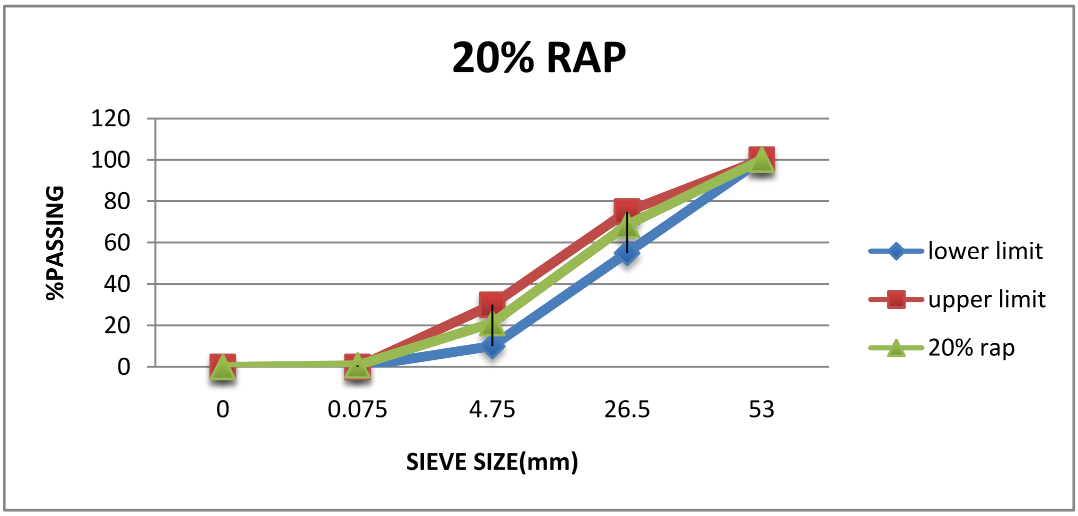

Fig 5.2 Proportioning For GSB For Grading III of 20% RAP

Table-5.9 input value of graph for GSB Grading III with RAP Aggregate of 40 %

s.no	Sieve size(mm)	Lower limit	Upper limit	Proportion A:B:C:D 33:10:7:40:10
1	0	0	0	0
2	.075	<5	<5	0.45
3	4.75	10	30	15.69
4	26.5	55	75	69.84
5	53	100	100	100

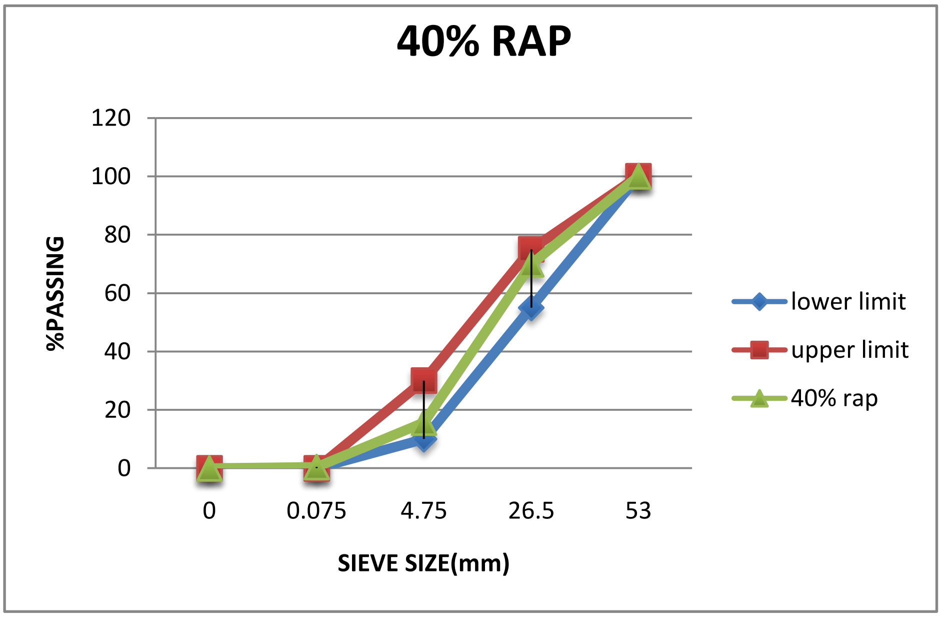

Fig 5.3 proportioning for GSB Grading III of 40 % of RAP

Table 5.10 Mix design of GSB for grading III with RAP aggregate 60% & 70%

Sieve size (mm)	**% by weight of passing**								
	40 mm (A)	**20 mm (B)**	**10 mm (C)**	**RAP (D)**	**SD (E)**	**Required Grading As Per (MORTH)**		**Proportion A:B:C:D:E 28:2:3:60:7**	**Proportion A:B:C:D:E 22:3:2:70:3**
						Lower Limit	**Upper Limit**		
53	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
26.5	**23.4**	**100**	**100**	**87.8**	**100**	**55**	**75**	**71.23**	**74.61**
4.75	**0**	**0**	**9.7**	**13.6**	**95.7**	**10**	**30**	**15.15**	**12.58**
.075	**0**	**0**	**0**	**.15**	**3.9**	**<5**	**<5**	**.363**	**.222**

Table 5.11 input value of graph for GSB Grading III with RAP Aggregate of 60 %

s. no	Sieve size(mm)	Lower limit	Upper limit	Proportion A:B:C:D 28:2:3:60:7
1	0	0	0	0
2	.075	<5	<5	0.363
3	4.75	10	30	15.15
4	26.5	55	75	71.23
5	53	100	100	100

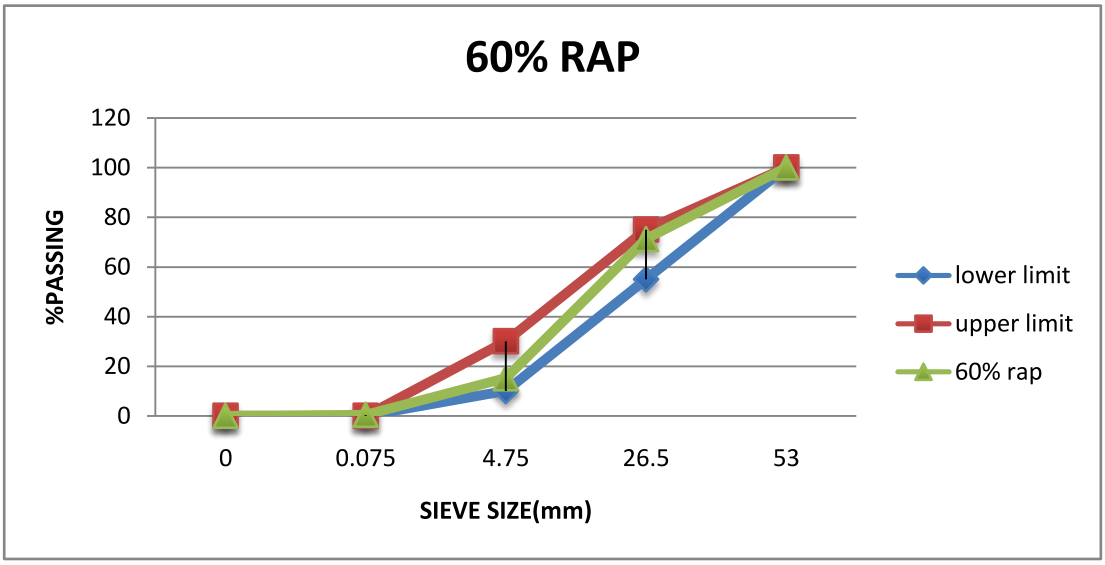

Fig 5.4 proportioning for GSB Grading III of 60 % of RAP

Table 5.12 input value of graph for GSB Grading III with RAP Aggregate of 70 %

s. no	Sieve size(mm)	Lower limit	Upper limit	Proportion A:B:C:D 22:3:2:70:3
1	0	0	0	0
2	.075	<5	<5	0.222
3	4.75	10	30	12.58
4	26.5	55	75	74.61
5	53	100	100	100

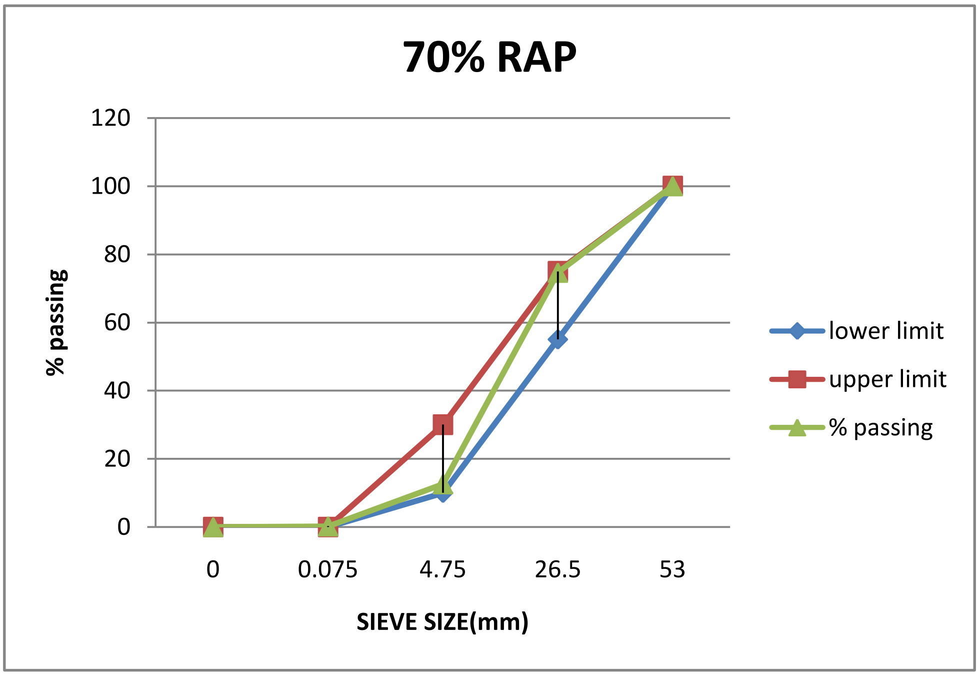

Fig 5.5 proportioning for GSB Grading III of 70 % of RAP

5.7.2 Mix design for GSB Grading VI

Table 5.13 Mix design of GSB for grading VI without RAP aggregate

Sieve size (mm)	**% by weight of passing**						
	40 mm(A)	**20 mm (B)**	**10 mm (C)**	**SD (D)**	**Required Grading**		
					Lower limit	**Upper limit**	**Proportion A:B:C:D 11:13:45:31**
75	**100**	**100**	**100**	**100**	**100**	**100**	**100**
53	**100**	**100**	**100**	**100**	**100**	**100**	**100**
26.5	**23.4**	**100**	**100**	**100**	**76**	**100**	**91.57**
9.5	**0**	**1.1**	**72.4**	**100**	**55**	**75**	**63.72**
4.75	**0**	**0**	**9.7**	**95.7**	**30**	**55**	**34.03**
2.36	**0**	**0**	**0**	**56.5**	**10**	**25**	**17.51**
.425	**0**	**0**	**0**	**23.4**	**0**	**8**	**7.25**
.075	**0**	**0**	**0**	**3.9**	**0**	**3**	**1.21**

Table 5.14 Input Value Of Graph For 0%RAP

sieve size(mm)	lower limit	upper limit	0% rap
0	0	0	0
0.075	0	3	1.21
0.425	0	8	7.25
2.36	10	25	17.51
4.75	30	55	34.03
9.5	55	75	63.72
26.5	76	100	91.57
53	100	100	100
75	100	100	100

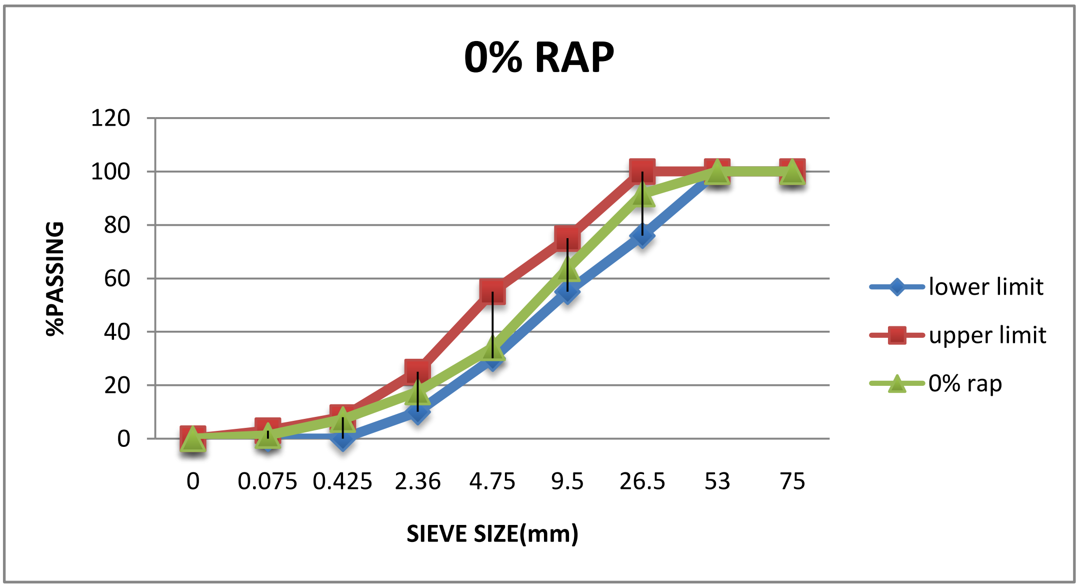

Fig 5.6 Proportioning For GSB For Grading VI of 0% RAP

Table 5.15 Mix design of GSB for grading III with RAP aggregate 20% & 40%

Sieve size (mm)	% by weight of passing								
	40 mm (A)	20 mm (B)	10 mm (C)	RAP (D)	SD (E)	Required Grading		Proportion A:B:C:D:E 5:5:40:20:30	Proportion A:B:C:D:E 3:2:25:40:30
						Lower limit	Upper limit		
75	100	100	100	100	100	100	100	100	100
53	100	100	100	100	100	100	100	100	100
26.5	23.4	100	100	87.8	100	76	100	93.73	92.82
9.5	0	1.1	72.4	39.3	100	55	75	66.87	63.84
4.75	0	0	9.7	13.6	95.7	30	55	35.31	36.57
2.36	0	0	0	4.5	56.5	10	25	17.85	18.75
.425	0	0	0	.75	23.4	0	8	7.17	7.32
.075	0	0	0	.15	3.9	0	3	1.2	1.23

Table 5.16 Input Value Of Graph For 20%RAP

sieve size(mm)	lower limit	upper limit	20% rap
0	0	0	0
0.075	0	3	1.2
0.425	0	8	7.17
2.36	10	25	17.85
4.75	30	55	35.31
9.5	55	75	66.87
26.5	76	100	93.73
53	100	100	100
75	100	100	100

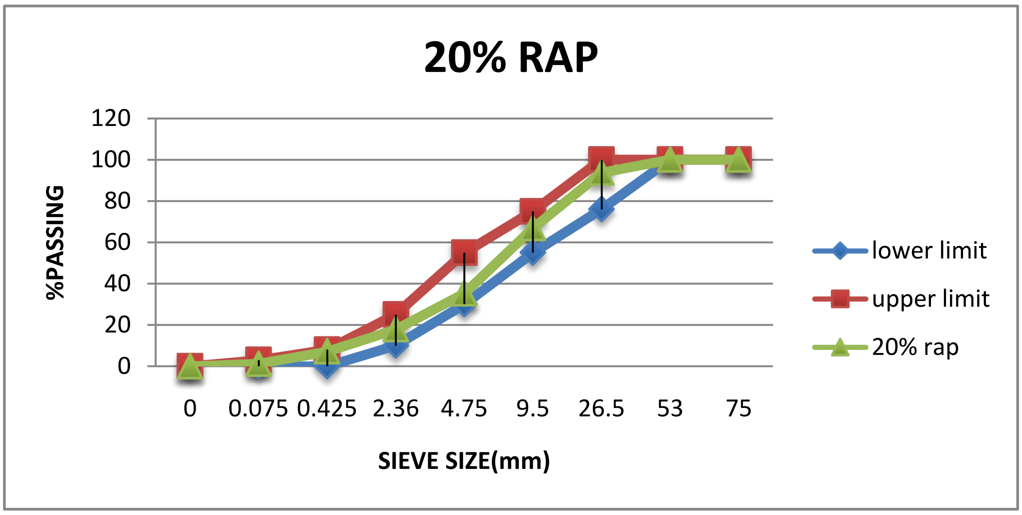

Fig 5.7 proportioning for GSB VI Grading of 20% of RAP

Table 5.17 Input Value Of Graph For 40%RAP

sieve size(mm)	lower limit	upper limit	40% rap
0	0	0	0
0.075	0	3	1.23
0.425	0	8	7.32
2.36	10	25	18.75
4.75	30	55	36.57
9.5	55	75	63.84
26.5	76	100	92.82
53	100	100	100
75	100	100	100

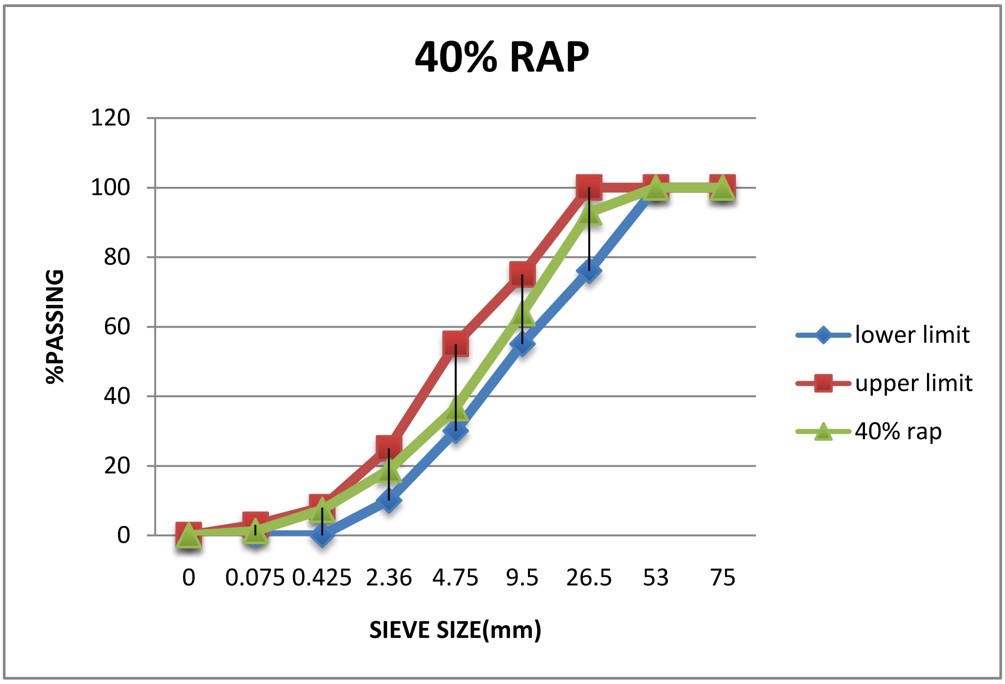

Fig 5.8 proportioning for GSB VI Grading of 40% of RAP

Table 5.18 Mix design of GSB for grading VI with RAP aggregate 60% & 70%

Sieve size (mm)	**% by weight of passing**								
	40 mm (A)	**20 mm (B)**	**10 mm (C)**	**RAP (D)**	**SD (E)**	**Required Grading**		**Proportion A:B:C:D:E 2:3:16:50:29**	**Proportion A:B:C:D:E 3:2:25:40:30**
						Lower limit	**Upper limit**		
75	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
53	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
26.5	**23.4**	**100**	**100**	**87.8**	**100**	**76**	**100**	**92.68**	**91.46**
9.5	**0**	**1.1**	**72.4**	**39.3**	**100**	**55**	**75**	**59.44**	**57.51**
4.75	**0**	**0**	**9.7**	**13.6**	**95.7**	**30**	**55**	**33.54**	**38.23**
2.36	**0**	**0**	**0**	**4.5**	**56.5**	**10**	**25**	**16.82**	**20.1**
.425	**0**	**0**	**0**	**.75**	**23.4**	**0**	**8**	**6.3**	**7.45**
.075	**0**	**0**	**0**	**.15**	**3.9**	**0**	**3**	**1.065**	**1.275**

Table 5.19 Input Value Of Graph For 60%RAP

sieve size(mm)	lower limit	upper limit	60% rap
0	0	0	0
0.075	0	3	1.065
0.425	0	8	6.3
2.36	10	25	16.82
4.75	30	55	33.54
9.5	55	75	59.44
26.5	76	100	92.68
53	100	100	100
75	100	100	100

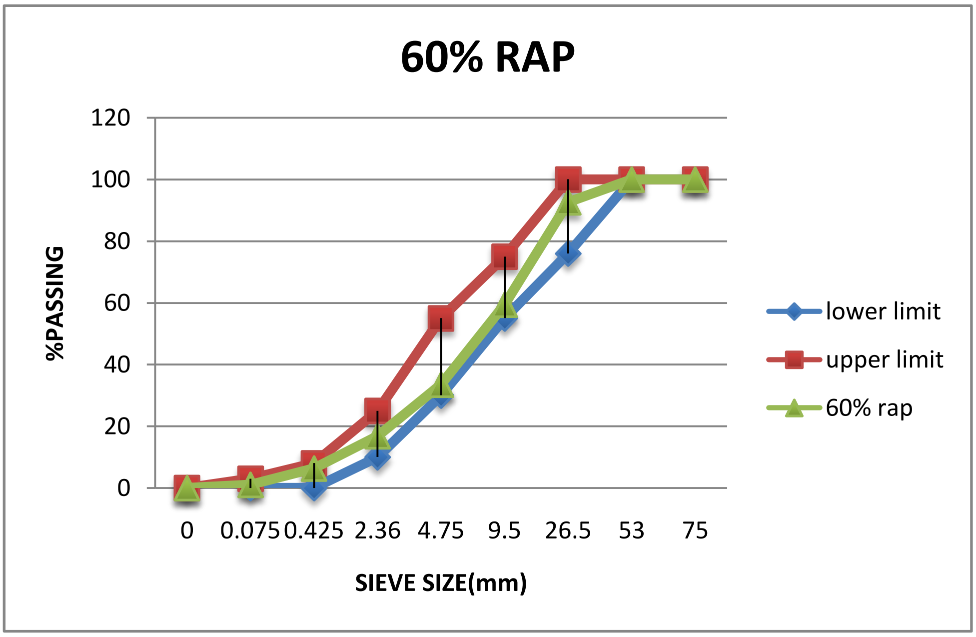

Fig 5.9 proportioning for GSB VI Grading of 60% of RAP

Table 5.20 Input Value Of Graph For 70%RAP

sieve size(mm)	lower limit	upper limit	70% rap
0	0	0	0
0.075	0	3	1.275
0.425	0	8	7.45
2.36	10	25	20.1
4.75	30	55	38.23
9.5	55	75	57.51
26.5	76	100	91.46
53	100	100	100
75	100	100	100

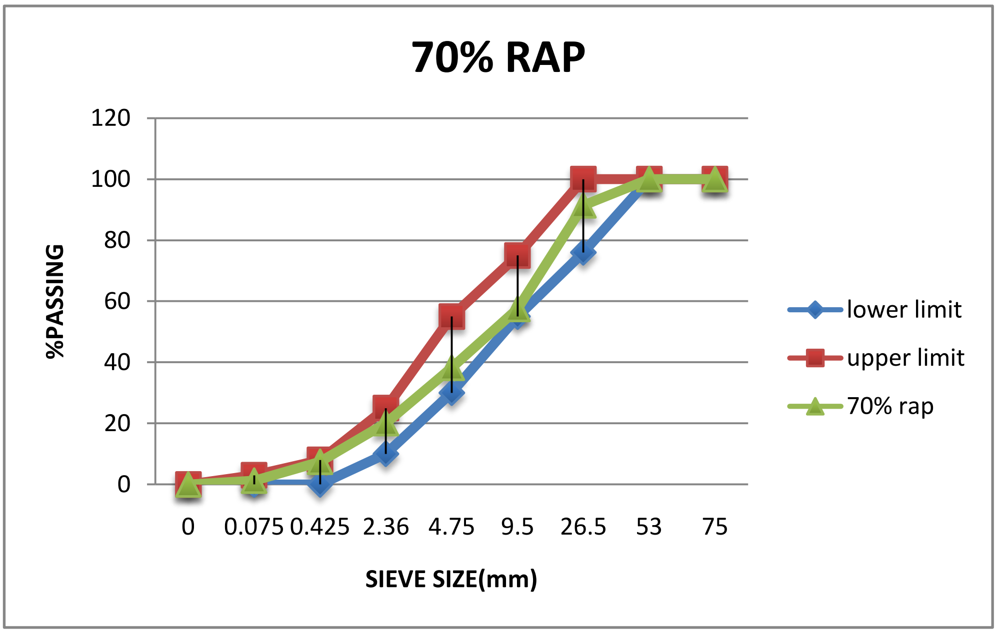

Fig 5.10 proportioning for GSB VI Grading of 70% of RAP

5.8 Test on GSB Mixes

5.8.1 SAMPLE PREPARATION

Samples were prepared using different sizes of materials as per the mix design and fresh aggregate were replaced by reclaimed asphalt pavement aggregate with varying percentages of 0%, 20%, 40%, 60% & 70%.

5.8.2 MODIFIED PROCTOR TEST

To obtain the graphical relationship of the "DRY DENSITY" to "MOISTURE CONTENT" in the form of "COMPACTION CURVE"

For determining the values of optimum moisture content (OMC) and maximum dry density (MDD)

It gives idea about how much water should be add in field to get maximum degree of denseness

5.8.2.1 Modified proctor test results for GSB grading III

Table 5.21 Input value of graph for percentage of RAP vs MDD

Percentage of RAP(%)	Optimum moisture content (%)	Maximum dry density
0 %	5.4	2.221
20%	5.9	2.231
40%	6.4	2.256
60%	6.8	2.198
70%	6.9	2.114

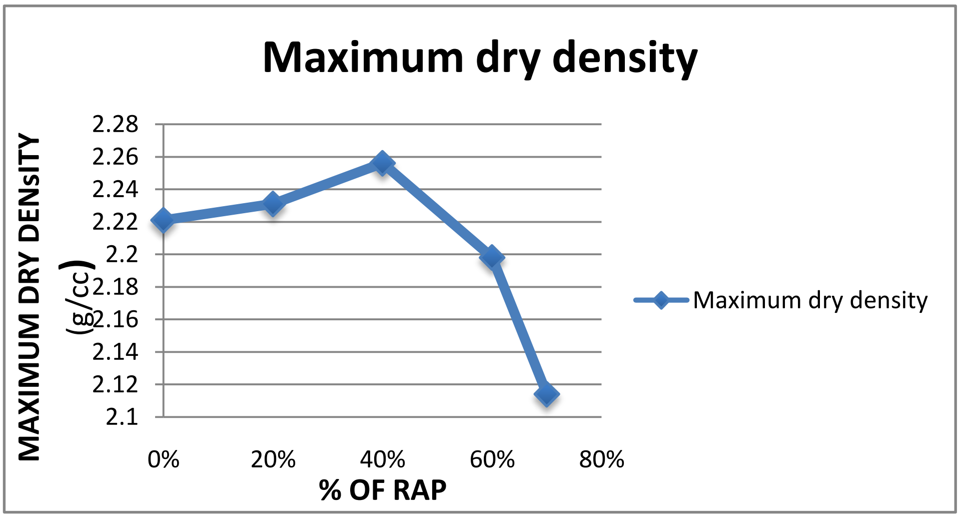

Fig 5.11 Variation of MDD with different % of RAP for GSB grading III

Observation:-

The value of maximum dry density of GSB mixes increased with increase in % of RAP aggregate till 40% after that it decreased. The value of **MDD however is more than the MDD of the virgin aggregate blend even up to 50% of RAP**. Due to this use of RAP up to 50% is **advantage** in GSB III mix.

The **OMC** value increases as we increase the % of **RAP**

5.8.2.2 Modified proctor test result for GSB grading VI

Table 5.22 Input value for MDD vs % of RAP

Percentage of RAP(%)	Optimum moisture content (%)	Maximum dry density
0 %	8.9	2.208
20%	9.2	2.260
40%	9.9	2.233
60%	10.3	2.206
70%	10.4	2.114

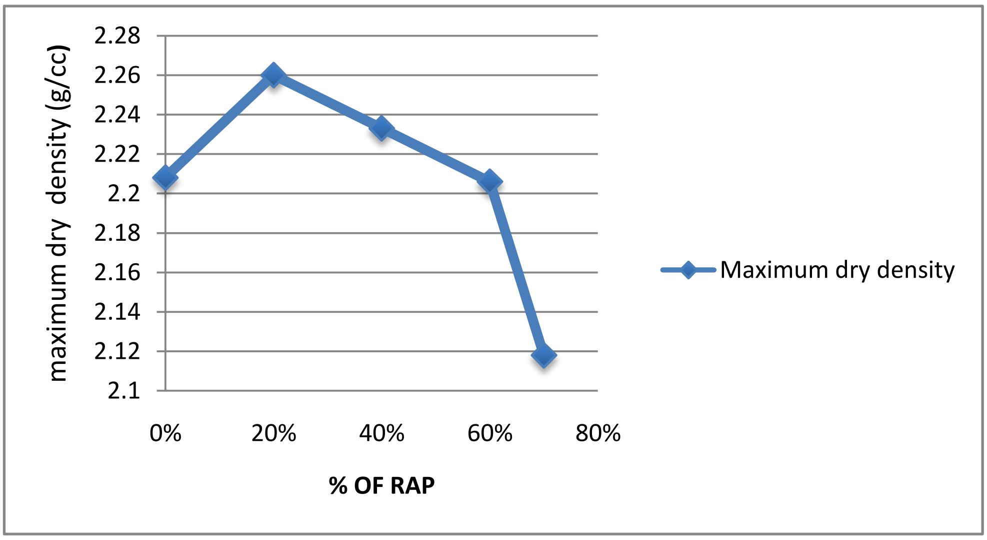

Fig 5.12 Variation of MDD with different % of RAP for GSB grading VI

Observation:-

The value of maximum dry density of **GSB** mixes increased with increase in % of RAP aggregate till 20% after that it decreased. The value of **MDD however is more than the MDD of the virgin aggregate blend even up to 50% of RAP**. Due to this use of RAP up to 50% is **advantage** in GSB VI mix.

The **OMC** value increases as we increase the % of **RAP.**

5.8.3 California bearing ratio test

5.8.3.1 CBR test results for GSB grading III

Table 5.23 Input value of graph for % of RAP vs CBR value (%)

% of RAP	CBR value(%)
0%	31.9
20%	32.9
40%	36
60%	29
70%	25.5

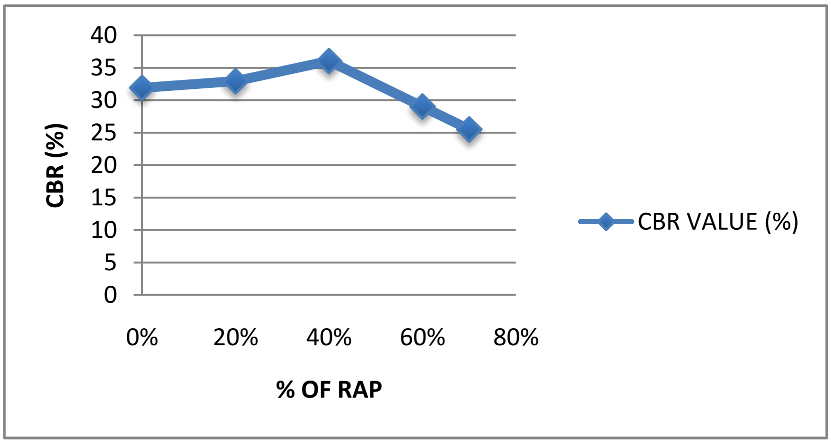

Fig 5.13 Variation of CBR value(%) vs % of RAP

OBSERVATION:-

CBR value of GSB mix increases with increase in % of RAP aggregate up to 40% after that it decreases so, use of RAP up to 40 % in GSB- III mixes is advantage.

5.8.3.2 CBR test results for GSB Grading VI

Table 5.24 CBR of GSB (Grading VI) mixes

% of RAP	CBR value(%)
0%	32
20%	33
40%	31
60%	28
70%	26

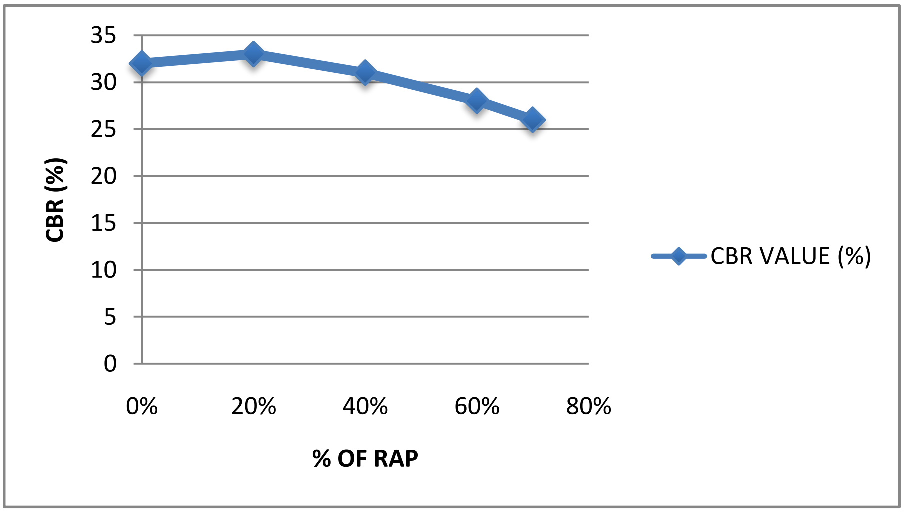

Fig 5.14 Variation of CBR value(%) vs % of RAP aggregate for GSB grading VI

Observation:-

CBR value of GSB mix increases with increase in % of RAP aggregate up to 20% after that it decreases, CBR value till 40% RAP is more than CBR of GSB mix without RAP so, use of RAP up to 40 % in GSB-VI mixes is advantage.

CHAPTER-6

CONCLUSION

6.1 CONCLUSION

The fresh aggregate of GSB layers are replaced by reclaimed asphalt pavement aggregate in varying proportion of 0%, 20%, 40%, 60% and 70% of the total aggregate. The main conclusions drawn from the study are:

1.Aggregate impact value of virgin aggregate and rap aggregate is 17.01% and 15.1% .values are within permissible limit of maximum 30% as per MORTH specifications for granular layer. Rap aggregate impact value is less than virgin aggregate impact value May be **due to the binder coating present** on the RAP aggregate.

2. specific gravity of RAP aggregate is much less than that of fresh aggregate. This is certainly because of RAP aggregate have **undergone series of loading of wearing and tearing** in the past.

3.Specific gravity of RAP aggregate is much less than that of fresh aggregate. This is certainly because of RAP aggregate have **undergone series of loading of wearing and tearing** in the past.

4. The value of maximum dry density of GSB mixes increased with increase in % of RAP aggregate till 40% after that it decreased. The value of **MDD however is more than the MDD of the virgin aggregate blend even up to 50% of RAP**. Due to this use of RAP up to 50% is **advantage** in GSB III mix.

5. The value of maximum dry density of **GSB** mixes increased with increase in % of RAP aggregate till 20% after that it decreased. The value of **MDD however is more than the MDD of the virgin aggregate blend even up to 50% of RAP**. Due to this use of RAP up to 50% is **advantage** in GSB VI mix.

7. The OMC value increases as we increase the % of RAP Modified proctor test result for GSB grading III & VI.

8. CBR value of GSB mix increases with increase in % of RAP aggregate up to 40% after that it decreases so, use of RAP up to 40 % in GSB- III mixes is advantage.

9. CBR value of GSB mix increases with increase in % of RAP aggregate up to 20% after that it decreases, CBR value till 40% RAP is more than CBR of GSB mix without RAP so, use of RAP up to 40 % in GSB-VI mixes is advantage.

REFERENCE

1. Ehsan Ali, Yogendra Kushwaha, 2015, "A Partial Replacement in natural aggreagate to recycled highway aggregate", ISSN: 2349-4506, January 2015.
2. Khushbu M Vyas, Shruti B Khara, 2013, "Technical feasibility of RAP in Ahmedabad BRTs corridor for base course", ISSN:0975-6760, vol.2, Issue 02, 2013.
3. Limbachiya, M.C Leelawat, Dhir R.K, 2000, "Use of recycled concrete aggregate", Material. Struct. 33:574-580.
4. Mandal S., Chakraborthy S., Gupta A., 2002, "Some studies on durability of recycled aggregate", Ind. ConcrJ. 76(6): 385-388.
5. Maulik Rao, Dr. N C Shah, 2014, "Utilisation of RAP (Reclaimed Asphalt Pavement) Material Obtained By Milling Process: With Several Options in Urban Area at Surat, Gujarat, India", Int. journal of engg research and applications, ISSN: 2248-9622, Vol.4, Issue 7, July 2014.
6. Parveen Berwal, Dr. Praveen Aggarwal, Dr. Rajesh Goel, 2014, "Use of Recycled Aggregate in Granular SubBase", International journal of innovative research in science and engineering, vol.3, issue 10, October 2014.
7. 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", Journal of material in civil engineering 2002.14:239-245.
8. Sagoe-Crentsil K, Brown T, 2002, "Guide for specification of recycled aggregate for concrete production-Final Report", CSIRO, Building, Construction and Engineering (Australia).
9. Sireesh Saride, Deepti Avirneni, Sarath Chandra Prasad Javvadi, 2014, "Evaluation of Fly ash Treated Reclaimed Asphalt Pavement for Base/Subbase Applications", Indian geotechnical society, November 2014.
10. Veresh Pratap Singh,Vivek Mishra,N.N. Harry, Y.K. Bind, 2014, "Utilization of Recycled Highway Aggregate by Replacing it with Natural Aggregate", Journal of Academia and Industrial research, Volume 3, Issue 6, 2014.
11. YogendraKushwaha, Arpan Herbert, Ehsan Ali, 2015, "Recycled Highway Aggregate as a Partial Replacement with Natural Aggregate", IJISET, Vol.2 Issue.1, January 2015.

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