Use of Recycled Premix Chipping Carpet (RPCC) for Rural Road Construction

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Abstract: ***The major factor affecting cost of road construction is cost of aggregates and binder materials. The study determines the suitability of recycled material in road construction. This will help in achieving economy in road construction as well as saving on environment degradation in term of reduced mining and less pollution. Construction and maintenance of roads and highways involve use of specified gradation of aggregates and properties of the binder. Replacing a part of the virgin mix with recycled aggregate is an optimal solution provided the recycled mix retains desirable strength and durable functions of the mix. This paper deals with use of recycled premix chipping carpet for rural road construction.***

Index Terms: Premix chipping carpet, Recycled mix.

I. INTRODUCTION

Rural roads in India form a substantial portion of the Indian road network. The roads are poor in shape and specifications affecting the rural life quality and mobility. These roads include other district roads (ODR) and village roads (VR). The premix chipping is an important layer in construction of rural roads. Open graded premix chipping carpet consists of coarse aggregates of 12.5 mm and 10 mm sieve sizes, premixed with bitumen binder are compacted to a thickness of 20mm to serve as a surface course of the pavement. Being open graded construction the PMC is to be invariably covered by a suitable seal coat such as premixed sand bituminous mix. The roads undertaken for the study are PMGSY proposed rural roads.

The Pradhan Mantri Gram SadakYojana (PMGSY) (IAST: Pradhan Mantri Gram SaḍakYojana) is a nationwide plan in India to provide good all-weather road connectivity to unconnected villages. The Recycling of aggregate is a process in which used aggregate is reused for new road construction. Recycled aggregate used in the present study is obtained from the debris of dismantled roads. The major function of the pavement is to transfer wheel load to the sub grade. In this load transfer mechanism aggregates have to bear stresses occurring due to the wheel loads on the pavement and on the surface course, they also have to resist wear due to abrasive action of traffic. Therefore the properties of aggregate are of considerable significance to the highway engineers. The aggregates are categorized based on their size, shape, texture and gradation for different pavement mixes by various agencies like ASTM, BIS, ISIand IRC.

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Recycling is driven by increasing customer demand for sustainable products, aggregates companies are now competing in the field of sustainability in order to maintain their market share. An additional driver for increased use of recycled materials is the reduction of embodied carbon used in extraction and processing of primary aggregates [3]. This can lead to significant long term cost savings in fuel efficiency and transportation charges.

II. OBJECTIVES

The main objective of the study is:

To identify the maximum allowable percentage of RAP that can be added to Pre-mix chipping carpet.

To identify the strength variations of the Recycled Mix for the selection of optimum proportion of recycled aggregates.

III. SCOPE OF THE STUDY

The scope of the study is limited to pre-mix chipping carpet rural road construction under PMGSY, India.

IV. LITERATURE STUDY

The use of recycled aggregates not only reduced cost of road construction but also improved eco-friendly environment.

Aravind K (2011) [1] studied the various hot mix recycling rehabilitation techniques intended for recycling and combined with required quantity of virgin asphalt binder and new aggregates in a hot mix plant. It deals with comparable performance to that of conventional mixes and better quality control. It studies the variation in properties of virgin mix and recycled mix like stiffness modulus, indirect tensile strength, fatigue and rutting performance by varying the percentage of RAP content.

Dr. Praveen Aggarwal (2014) [2] studied to suitability of recycled material in GSB layer for road construction. The study deals comparison of CBR, permeability and dry density tests results of virgin and recycled mix of various RAP content. The suitable percentage of RAP was found to be 15% of the recycled mix.

M. Abukhettala (2012) [3] Studied the rate of utilizing reclaimed asphalt pavement in HMA and base material in Ontarioas low as 8% of the total recycled material used in year between 2008 and 2010.

The study also specify the modification to the binder grade in the asphalt mixture, especially the low temperature grade, does not need much concern when RAP is used in less than 15% of the total weight of the mixtures.

The effect of introducing RAP into the binder course mix was evaluated through a series of laboratory tests including the Marshall Test, Indirect Tensile Stiffness Modulus Test, Indirect Tensile Fatigue Test and Water Sensitivity Test.

V. METHODOLOGY

Methodology adopted for the present study consists of

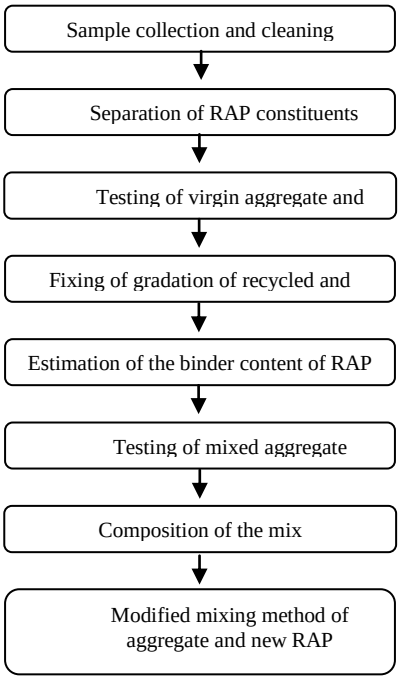

Fig. 1.Flow chart of methodology.

A. *Sample collection and cleaning*

The site selected for the study is PMGSY road Alanthara, Venjaramoodu Thiruvananthapuram. The road taken under the study is estimated for reconstruction and the raw materials including RAP and virgin aggregate are selected for study from the site. The aggregate is cleaned with cotton plug. Then it is cleaned with high pressure water jetting and it is dried in oven.

Fig.2.PMGSY road AlantharaVenjaramoodu.

B. *Separation of RAP constituents*

The bituminous mix is selected from the rural road site is taken for study. The mix is thoroughly washed by action of jet power washing. Relatively high pressure power washing units are commonly available. This high velocity water is great enough to dislodge dirt and debris. The chances of flakes and wear from accelerated washing should be taken care during washing. The poor washing techniques will accelerate the water absorption. The washed aggregate mix is thoroughly cleaned with cotton plug. It is then oven dried for 24 hrs at 105 to 110ºC. The process of separation of old aggregate binder mix is done mostly by heating and using CBE (centrifuge bitumen extractor). The bitumen is first treated with rejuvenators and aggregate mix is heated to around 175ºC where most of the bitumen is separated and remaining is treated in CBE. The bitumen mix after heating is mixed with Tricholoroethylene and rotated at specific speed and mix is separated.

C. *Testing of virgin aggregate and binder*

The aggregate properties of the virgin mix are evaluated. The various laboratory tests were done to evaluate the strength properties of the RAP. The gradation of RAP used is as per 14-2004 (Table 3 gives gradation of RAP used).

TABLE I: PHYSICAL PROPERTIES OF VIRGIN AGGREGATE (IRC 14-2004)

Test Description	Value	Range	Method of test
Abrasion Value	24%	Max 40%	IS:2386 (Part 4)
Impact Value	26%	Max 30%	IS:2386 (Part 2)
Stripping Value	0.5%	Max 10%	IS :2386 (Part 7)
Water absorption	0.2%	Max 2%	IS :2386 (Part 10)
Soundness (magnesium sulphate-5 cycles)	4.6%	Max 18 %	IS: 2386 (Part 9)
Bulk density	1786 kg/m3	Min 1120 kg/m3	IS:2386(Part 3)
Combined flakiness and elongation index	28	Max 30	IS: 2386 (Part 5)
Angularity	10	0-11	IS: 2386(Part 5)
Specific Gravity	2.76	2.6-2.9	IS :2386(Part 5)

The binder considered for the study is NRMB (Natural rubber modified bitumen). The following properties of the binder were tested.

TABLE II: PHYSICAL PROPERTIES OF VIRGIN BINDER (ASTM)

Test Description	Value	Range	Method of test
Softening point	58ºC	Min 50	ASTM D 36
Elastic Recovery ratio	39%	Min 35%	ASTM D 6085
Penetration	52 cm	50-90 cm	ASTM D 5
Viscosity	425 centipoise	2-6 poise	ASTM D 2170/ D4402
Specific Gravity	0.99	0.97-1	ASTM D 92

D. *Gradation of aggregates*

A sieve analysis (or gradation test) is a practice or procedure used to assess the particle size distribution of a granular material. The size distribution is often of critical importance to the way the material performs in use. A sieve analysis can be performed on any type of non-organic or organic granular materials including sands, crushed rock, clays, granite, feldspars, coal, soil a wide range of manufactured powders, grain and seeds, down to a minimum size depending on the exact method. The Combined gradation is obtained by mixing a known fraction of RAP with remaining fraction of virgin aggregates.

The combined gradation should satisfy the gradation range as per IRC 14-2004. The combined gradation of the aggregates can go up to 40% of the RAP which confirms to specified gradation.

TABLE III: GRADATION OF VIRGIN AGGREGATE AND RAP (IRC 14-2004 PART 2)

Sieve size	Percentage finer (%) (virgin aggregate)	Percentage finer (%) (RAP aggregate)	Combined Gradation (40%RAP)	Range
22.4	93.572	99.30	95.86	66-100
13.2	45.572	71.367	55.86	33-66
11.2	23.75	14.71	20.13	20-33
5.6	0.25	1	0.55	0-15

E. Testing of mixed aggregates

Various tests are performed to evaluate the strength of mixed aggregate. The test done in the study is impact test and Los Angeles abrasion test.

1. Impact test of mixed aggregate

The property of a material to resist impact is known as toughness. Due to movement of vehicle on road, the aggregates are subjected to impact resulting in a breakdown in to smaller pieces. The aggregates should therefore have sufficient toughness to resist their disintegration due to impact. This characteristic is measured by impact value test. The aggregate impact value is a measure of resistance to sudden impact or shock, which may differ from its resistance to gradually applied compressive load. The chief advantage of aggregate impact test is that the test equipment and the test procedure are quite simple and it determines the resistance to impact of stones simulating field condition. The test can be performed in a short time even at a construction site or at a quarry, as the apparatus is simple and portable. The maximum impact strength is obtained for the gradation containing 15% of RAP aggregate.

TABLE IV: VARIATION OF IMPACT VALUE WRTRAP(%)

Percentage RAP	Impact value
5	28
10	27
15	**26**
20	28
25	29
30	29
35	30
40	31

2. Abrasion test on mixed aggregates

When vehicles move on the road, the soil particles present between the pneumatic tires and road surface causes abrasion of road aggregates. The steel rimmed wheels of animal driven vehicles also cause considerable abrasion of road surface. Therefore the aggregate should be hard enough to resist the abrasion. In order to test the suitability of road stones do resist the abrading action due to traffic, tests are carried out in the laboratory using Los Angeles Abrasion test.

TABLE V:

Percentage RAP	Abrasion value (%)
5	25
10	26
15	27
20	26
25	27
30	28
35	29
40	29

F. Determination of binder content of RAP

The bitumen content of the paving mixture can be found out using centrifugal bitumen extractor or annual centrifuge. Bitumen extractor is used for quantitative determination of bitumen paving mixes. This involves heating of bituminous sample until it starts crumbling and place it in extractors rotating bowl and add solvent. It uses the rotation of the rotor inside a centrifuge to separate bitumen and aggregate. The extractors centrifugal action forces liquid through a filter paper ring at bowls periphery and the process is repeated until the solvent expelled is clear in color. The remaining are weighted and graded before and after extractions. The binder content is determined.

The binder content is given by

$$b = \frac{W1-(W2+W3+W4)}{W1} * 10 \quad (1)$$

Where b - bitumen content (%)
W1 - weight of sample of RAP
W2- increase in weight of filter paper
W3 - weight of residue filtered from trichloroethylene solution
W4- weight of RAP after extraction
We get the value of b = 4.5%

G. Composition of the RPCC

From the previous results the various percentages of the composition of the RPCC is given by
% of virgin aggregates = 57.3
% of RAP aggregates = 38.2
% of virgin binder = 2.7
% of RAP binder = 1.8

H. Modifications in mixing ofRPCC

Conventional mixing involves heating of virgin and recycled aggregates in a rotating drum mixer where they are heated and mixed thoroughly and transferred to next mixing chamber where they are coated with bitumen. This chamber involves heating of binder and mixing with recycled mix through rotating drum action. This is not an effective method of mixing as in the case of mixing of old and new aggregates. The modification involves an additional mixing chamber for mixing and pre heating of the old aggregates. This hot mix of old aggregates is then transferred to mixer drum where they are mixed with preheated virgin aggregates and mixing process is continued like conventional mixing. This concept allows RAP to be preconditioned flashing of moisture in the drum also eliminate problems associated with scavenger system.

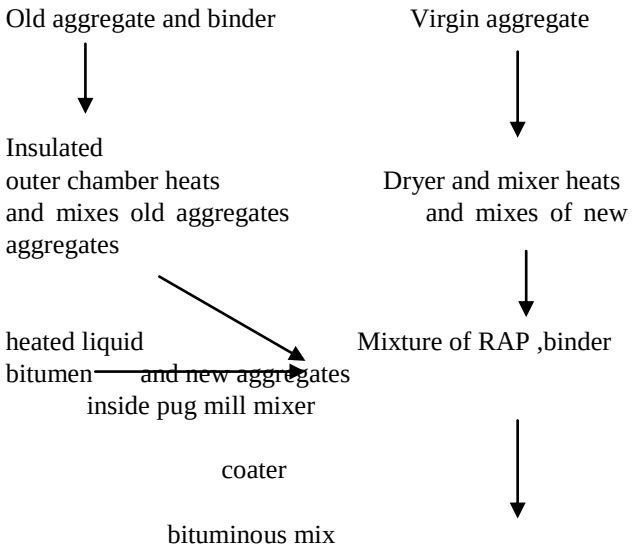

Fig.3.Modifications done in Conventional mixer.

Many years of research has led to the development of theories and methodologies in roadway capacity analysis in the developed countries. For example, the Highway Capacity Manual (*HCM*) developed in theUnited States of America describes roadway capacity.

VI. CONCLUSION

The premix chipping carpet used in village roads can be recycled. The RAP for the site selected village road, AlantharaVenjaramoodu Thiruvananthapuram can be recycled.The maximum percentage of RAP that can be added to the mix is 40% of the proportion. Any proportion beyond this RAP percentage does not satisfy the standard gradation.

In the study the maximum percentage of RAP added is 35% of the proportion. The proportion beyond this RAP percentage does not satisfy the strength criteria.

The conventional mixing of RAP with Virgin aggregates can be made more effective using modified RAP mixer.

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