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EXPERIMENTAL INVESTIGATION OF BITUMINOUS CONCRETE GRADE - II BY USING RECYCLED AGGREGATE COATED WITH WASTE PLASTIC

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Abstract: Recycling of waste material is a recent technique aims to change the waste material into new Products to reduce the pollution and detrimental effect on the environment and reduce the demand of new fresh natural sources. Plastic bags and Recycled asphalt Aggregate are samples of these waste materials can be re-used in road construction. Over one million bags are used every minute worldwide, whereas, aggregate is consist of about 90% of asphalt mixture and can be obtained as RAA from milling of road infrastructure construction. This paper presents laboratory tests results of using waste plastic and RAA in production of asphalt mixture. Since the waste plastic attached to RAA particles contribute to lower theirdensity and increase the wearing and tearing strength, the waste plastic are used to enhance the engineering properties of asphalt mixture and consume these large amount of waste material. The results showed that Waste Plastic Asphalt mix (WPAM) containing 100% RAA produces higher Marshall Stability, higher retained stability and higher indirect tensile strength compared with conventional mix. The percent of the increase for Marshall Stability, for Marshall retained stability

Keywords: Asphalt mix, Road construction, Marshall Stability; Waste plastic;RecycledAsphalt aggregates; environment; Waste management

CHAPTER 1

INTRODUCTION

1.1 GENERAL

A good road network is a critical infrastructure requirement for rapid economic growth. It provides connectivity to remote areas; provides accessibility to markets, schools, and hospitals; and opens up backward regions to trade and investment. Roads play an important role in inter-modal transport development, through links with airports, railway stations, and ports. Road network in India aggregates to about 4.2 million kilometers.

Due to urbanization and the growing population, the day to day requirements are also increasing which has led to the development of various industries which in turn has increased the generation of plastic waste on a large scale. All the sectors of the economy are revolutionized due to the use of plastic. Plastic waste poses a major problem for their disposal and thus have a great impact on the environment. Various techniques are being researched about for the effective disposal of the plastic waste. Researchers have showed that plastic can be used for the construction of bituminous roads as well, in fact plastic imparts more strength to the aggregates in comparison to the natural aggregates. In this project, aggregates will be coated with various proportions of plastic and certain tests will be performed on the plastic-coated aggregates. Finally, the results will be compared and analyzed based on the conventional properties of aggregates. The Marshall method of mix design will be used for the determination of optimum bitumen content using VG-30 grade of bitumen which will be further used for the design of flexible bituminous pavement. The various experiments have been carried out whether the waste plastic can be reused productively. The various literature indicated that the waste plastic when added to hot aggregates will form a fine coat of plastic over the aggregate and such aggregates when mixed with binder is found to have higher strength, higher resistance and better performance over a period of time. Along with bitumen, use waste plastic increases its life and smoothness.

The necessary part of the construction is the requirement and availability of raw materials (i.e. aggregates, stone or rocks, lime, bricks, stone, cement, steel, aluminum, wood, etc..) both words are frolicking important role in construction because both words are dependent on the natural resources according to requirement or availability of project. One of the most commonly required raw materials in construction is coarse and fine aggregate. In highways, the construction of Pavement layers like GSB, WMM, DBM, BC ,DLC, and PQC are depend on coarse & fine aggregates only. Nowadays the number of quarries gone below the water table. Which is increasing due to the rising demand of aggregates. Where there is an immense scarcity of natural aggregates, it is important to move to a sustainable approach to offset the utilization of natural aggregates and one of the best alternatives is to utilize recycled aggregate. India has the extensive road network, the second largest in world after US. Recycled Asphalt Pavement (RAP) is the term given to removed or reprocessed pavement materials containing asphalt and aggregates. These materials are generated when asphalt pavements are removed for reconstruction, resurfacing or to obtain access to buried utilities.

Studies have shown that up to 50% of RAP has been used as part replacement of granular sub-base and wet mix macadam (WMM) in various projects of National Highway Development Plan (NHDP) in India. Recycling of milled bituminous material has been gaining popularity in India in recent times due to several successful trials in selected projects. In this study we are aiming to use the recycled asphalt pavement in Bituminous concrete along with the waste plastic.

In all other respects, hot mix-plant recycling is just like normal hot mix construction. Not more than 50% of the reclaimed material is used, though a widely accepted percentage is only 30) and the thickness in which it can be laid is typically 100 mm.

1.2 OBJECTIVES

- Experimental Study of Bituminous Concrete Grade - II by using recycled aggregate coated with Waste Plastic.

1**.2.1 Specific Objectives**

- To Studyand comparison properties of natural aggregate, RAAand plastic coated RAA.
- To study the properties of bitumen as IS 73.
- Study of Waste plastic and its property requirements according to Bituminous work.

1.3 NEED OF THE STUDY

RAP is one material that has been extensively recycled. RAP is created when existing asphalt concrete surfacing is milled or completely removed. The effective utilization of reclaimed asphalt pavement waste in the bituminous pavement can overcome its disposal issue. Nowadays only 5 to 7 percent of recycled aggregates are only used for reconstruction purposes as the quality of aggregate is inconsistent, strength wise. This experimental study is about to increase the usage of available recycled material for construction purpose in order to increase the constancy in strength of recycled aggregate. This will help to reduce usage of fresh aggregate from quarries and increase the usage of recycled asphalt aggregate. It will help to reduce the project cost. Because cost consideration of raw materials will affect the project economically. Therefore if pavement industry use the existing already extracted aggregates as recycled aggregate instead of finding and destroying the new resource, which will may help to the retain natural resources of nation, and help the nation to grow economically and organically.

The Disposal of plastic waste in an environment is considered to be a big problem. Plastic waste has many bad impacts on soil, surface water, groundwater, and air (due to burning). Scientists and researchers are doing a major concentration on this area to use/reduce plastic waste. Govt. had a ban on the single use of plastic. Daily plastic waste collection is in millions of tones. Which is a major issue to manage and dispose by municipals. Plastic use in road construction increases the strength and performance of the road. Using Reclaimed Asphalt pavement and the use of waste plastic in road construction can shove environmental problems up to great extent

1.4 SCOPE OF THE STUDY

- Grade of Bitumen using in this study is VG30
- The source of RAA used in the study is milled material from state highway roadsThissur, kerala.

- The natural aggregates taken for the study at Thissurkerala

The source of waste plastic is collected from Thissurkerala

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

In the construction of flexible pavements, bitumen plays the role of binding the aggregate together by coating over the aggregate. It also helps to improve the strength and life of road pavement. But its resistance towards water is poor. A common method to improve the quality of bitumen is by modifying the rheological properties of bitumenby blending with synthetic polymers like rubber and plastics. Use of plastic waste in the bitumen is similar to polymer modified bitumen. The blending of recycled LDPE to asphalt mixtures required no modification to existing plant facilities or technology. Polymer modified bitumen has better resistance to temperature, water etc. This modified bitumen is one of the important construction materials for flexible Road pavement since 90's, considerable research has been carried out to determine the suitability of plastic waste modifiers in construction of bituminous mixes.

Recycled asphalt pavement is useful to avoid the use of fresh aggregate because it reduce the use of fresh aggregate and the amount of fresh asphalt binder required it production of hot mix asphalt. The use of reclaimed asphalt pavement with asphalt binder it conserves energy, lower transportation cost and preserves renewable and nonrenewable resources. Using Reclaimed asphalt pavement decrease the amount of waste material and the nonrenewable natural sources such as fresh aggregate and asphalt binder. Hence Reclaimed asphalt pavement creates a cycle that reduces the use of natural resources and builds the bituminous concrete pavement. This research is useful for engineers, contractors and other who are involved in the specification and construction of bituminous concrete pavement. (AlokGoyal, 2017)

2.2 REVIEW OF JOURNALS

2.2.1 Plastic modified bituminous mix

Nowadays, waste plastic disposal is an issue of major concern worldwide because plastic does not decay and therefore is increasing in volume. A way to tackle this problem is to utilize this waste plastic. This alternative not only reduces the quantity of waste plastic but also conserves both material and energy and provides a comparatively simple way to make a considerable reduction in the overall volume of waste plastic. An environmental friendly and economical approach for the effective utilization of waste plastic in the bituminous concrete mix by the dry process through a comparative laboratory study is needed. Marshall Method of mix design was adopted using 60/70 grade bitumen and aggregate gradation of nominal maximum aggregate size 13.2 mm to find the optimum binder content and optimum plastic content for the bituminous concrete mix and a comparison is made between conventional BC mix and plastic coated aggregate mix with different plastic contents. It is concluded that the addition of waste plastic to bituminous mix improve the Marshall properties of the mix. (Raghvendra Jadon, 2016)

An increase in population with a tremendous growth rate, the disposal of large amounts of non- decaying waste materials becomes a great concern in developing and developed countries. Also, due to an increase in traffic volumes and loading repetitions, surface distress was observed in most of the asphalt roads. Therefore, recycling waste plastic into a new product is a solution. A cleaned, dried, and grind waste plastic bag is introduced to the asphalt mixture from 6–18% with a 3% increment by the weight of optimum bitumen content for each nominal maximum aggregate size. A total, 171 Marshall and indirect tensile strength samples were prepared. From the test result, the optimum waste plastic bag replacement of 17, 13, and 7% are obtained for 9.5, 12.5, and 19 mm nominal maximum aggregate sizes respectively. From the comprehensive experimental results, its concluded that asphalt mixtures mixed with the optimum amount of waste plastic bag, Marshall stability and tensile strength ratio results can increase on average by 8 % and 4 % respectively. (NakachewAssefa, 2021)

Using the waste plastic as a coated material to the aggregates, properties of aggregates were improved with different Waste plastics. It is showed better values than conventional aggregates. By this the poor quality of aggregates will be improved by using plastic as a modifier and can be used in construction. The water absorption property has decreased and by this there will be less porosity and provide better resistance to water and water stagnation. Plastic coated aggregate exhibit good nature in abrasive charge and in impact tests. The use of the innovative technology not only strengthened the road construction but also increased the road life as well as will help to improve the environment and also creating a source of income. (K. L. A.V. Harnadh, 2015)

The plastic mixed with bitumen and aggregates is used for the better performance of the roads. The polymer coated on aggregates reduces the voids and moisture absorption. This results in the reduction of ruts and there is no pothole formation. The plastic pavement can withstand heavy traffic and are durable than flexible pavement. The use of plastic mix will reduce the bitumen content by 10% and increases the strength and performance of the road. This new technology is eco-friendly. (R. Manju, 2017)

Plastic drink bottles, single-use plastic bags and other waste plastics have a significant impact on the environment. Consequently, there is global interest in recycling and reuse of waste plastics. Significant progress has been made towards the incorporation of waste plastics into building and construction materials, although this has focused mainly on cement and concrete applications. Three type recycled plastic products for bituminous binder extension and modification in asphalt mixtures are commercially available. Using a drymixing process, shredded and pelletized recycled waste plastics replace 6% of the binder volume. Comparative laboratory testing of two typical UK asphalt mixtures indicated that asphalt containing the recycled waste plastic products showed improved deformation resistance and fracture resistance compared to conventional 40/60 penetration grade binder. (Greg White, 2018)

Greg White (2018) Recycled waste plastic for extending and modifying asphalt binders, 8th Symposium on Pavement Surface Characteristics: SURF 2018 – Vehicle to Road Connectivity Brisbane, Queensland

2.2.2 RAP Modified Bituminous Mix

A good road network is a critical infrastructure requirement for rapid economic growth. It provides connectivity to remote areas; provides accessibility to markets, schools, and hospitals; and opens up backward regions to trade and investment. Roads play an important role in intermodal transport development, through links with airports, railway stations, and ports. Construction of roads consumes a large amount of bitumen and aggregates. To produce such materials a large amount of energy is required. Also the dumping of old extracted layer of asphalt pavement is of major concern. So here the concept of using Recycled asphalt pavement has been implemented in the work. Use of RAP aggregates along with the new/ fresh aggregates will reduce the use of new material for construction of flexible pavement. Also it will cut down the cost of construction. The use of RAP (Reclaimed Asphalt Pavement) material in the construction of new Pavement (Dense Bituminous Macadam Grade – II) will considerably reduce the use of fresh aggregate in the construction. Use of RAP satisfies the design requirement as per Marshall mix method. (Prabhakar Kumar, 2019)

When the materials are removed from the existing flexible pavement, during resurfacing or reconstruction operations, then the removed materials are known as Reclaimed asphalt pavement. It contains valuable asphalt binder and aggregate. From various researcher's, every year 80 percent of Reclaimed asphalt pavement was recycled. Therefore RAP is the most frequently used recycled material .RAP is used as an aggregate with the fresh asphalt binder in recycled asphalt pavement. It is not only used on surface course but also granular base and sub base course. It can be used in other construction application; hence RAP is a valuable, high quality material. (AlokGoyal, 2017)

2.3 PROPERTIES OF AGGREGATE

Properties of aggregates depend upon the combination of minerals which is made up of by naturally and we can able to identify the type of aggregateby identifying the physical and optical structure of the mineral present in the aggregate,measuring the mechanical properties of aggregate as Per IS 2386 we can able to categorize aggregate by compare the requirements according to Morth 5th revision clause 400,500,600,900 etc., IRC: 15 and IRC: 44, the list properties mentioned in the Table No.1 of natural aggregates were observed in this study

ROPERTIES OF AGGREGATE

SL.No	Test Parameters of Aggregates	Specification / Reference aggregates
1	Particle size and shape	IS 2386-1963 part 1
2	Specific gravity, density,	IS 2386-1963 part 3
3	water absorption	
4	Mechanical properties	IS 2386-1963 part 4
5	Soundness	IS 2386-1963 part 5
6	Alkali aggregate reactivity	IS 2386-1963 part 7

7	Petrographic examination	IS 2386-1963 part 8
8	Sand equivalent of fine aggregate	IS 2720-1976 part 37

Test Parameters of Aggregates Table No -1

2.4TYPICAL THERMOPLASTIC AND THERMOSET Depending on their physical properties, they may be classified as thermoplastic and thermosetting materials. Thermoplastic materials can be formed into desired shapes under heat and pressure and become solids on cooling. On subjected to the same Conditions of heat and pressure, they can be remolded. Thermosetting materials which once shaped cannot be softened /remolded by the application of heat. The examples of some Typical Thermoplastic and Thermosetting materials are tabulated in Table No-2

Typical Thermoplastic and Thermoset

SL.No	Thermoplastics	Thermoset
1	Polyethylene Teryphthalate (PET)	Bakelite
2	Polypropylene (PP)	Epoxy
3	Polyvinyl acetate (PVA)	Melamine
4	Polyvinyl chloride (PVC)	Polyester
5	Polystyrene (PS)	Polyurethane
6	Low-density polyethylene (LDPE)	Urea – Formaldehyde
7	High density polyethylene (HDPE)	Alkyd

Typical Thermoplastic and Thermoset Table No -2

2.5 PLASTIC CONSUMPTION & GENERATION OF PLASTIC WASTE

A material that contains one or more organic polymers of large molecular weight, solid in its finish state and at some state while manufacturing or processing into finished articles, can be shaped by its flow is termed as plastic. Plastic constitutes two major categories of plastics; (i) Thermoplastics and (ii) Thermoset plastics. The thermoplastics constitute 80% and the thermoset constitutes approximately 20% of total postconsumer plastics waste generated. The following table describes the average municipal solid waste production from 0.21 to 0.50 Kg per capita per day in India as mentioned in the table No- 3.

2.5.1 MUNICIPAL SOLID WASTE IN INDIAN CITIES

SL.No	Population Range in millions	Average per capita values
1	0.1 to 0.5	0.21
2	0.5 to 1.0	0.25

3	1.0 to 2.0	0.27
4	2.0 to 5.0	0.35
5	5 above	0.50

Municipal solid waste in Indian cities Table No -3

2.6 WASTE PLASTIC AND ITS SOURCE

Polymers can also be classified according to their chemical sources. According to Sources of plastic, there are four general groups: Cellulose Plastics, Synthetic Resin Plastics, Protein Plastics, Natural Resins, Elastomers and Fibers. Table 4 gives the Source of waste plastic generation. Only plastic confirming to Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), PET and Polyurethane shall only be used in Pavement construction. PVC, PET and Polyurethane not to be used. However all types of Waste plastics cannot be used for road construction.

SOURCE OF WASTE PLASTIC GENERATION

SL.No	Waste plastic	Origin
1	Low-Density Polyethylene (LDPE)	Carry bags, sacks, milk pouches, bin lining, cosmetic And detergent bottles.
2	High-Density Polyethylene (HDPE	Carry bags, bottle caps, household articles, etc.
3	Polyethylene Terephthalate (PET)	Drinking water bottles etc.
4	Polypropylene (PP)	Bottle caps and closures, wrappers of detergent, biscuit, wafer packets, and microwave trays for readymade meals, etc.,
5	Polystyrene (PS)	Yogurt pots, clear egg packs, bottle caps. Foamed Polystyrene: food trays, egg boxes, disposable cups, protective packaging, etc.
6	Polyvinyl Chloride (PVC)	Mineral water bottles, credit cards, toys, pipes and gutters; electrical fittings, furniture, folders, and pens, medical disposables; etc.

Source of waste plastic generation. Table No -4

There are two processes namely dry process and wet process for manufacturing bituminous mixes using waste plastic. In the dry process, processed waste plastic is added in appropriate physical form like shredding or in the form of pellets in hot aggregates to ensure efficient and accurate addition of plastic without affecting its functionality. But in the wet process, processed waste plastic in the form of powder is added in the hot bitumen.

2.7MARSHALL MIX DESIGN

The mix design (wetmix) determines the optimum bitumen content. This is preceded by the dry mix design discussed in the previous chapter. There are many methods available for mix design vary in the size of the test specimen, compaction, and other test specifications. Marshall Method of mix design is the most popular one and is discussed below.

2.7.1 Overview This test procedure is used in designing and evaluating bituminous paving mixes is extensively used in routine test programmes for the paving jobs. Thereare two major features of the Marshall method of designing mixes namely, density – voids analysis and stability – flow test.

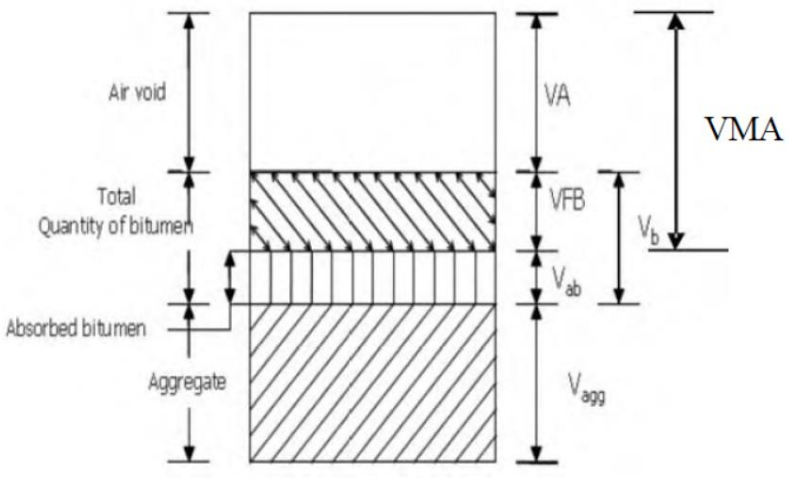
Strength is measured in terms of the 'Marshall's Stability' of the mix followingthe specification ASTM D 1559 (2004), which is defined as the maximum load carriedby a compacted specimen at a standard test temperature of 60°C. In this testcompressive loading was applied on the specimen at the rate of 50.8 mm/min till itwas broken. The temperature 60°C represents the weakest condition for a bituminous pavement. The flexibility is measured in terms of the 'flow value' which is measured bythe change in diameter of the sample in the direction of load application between thestart of loading and at the time of maximum load. During the loading, an attached dial gauge measures the specimen's plastic flow (deformation) due to the loading. The flow value is recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load is recorded. The associated plastic flow of specimen at material failure is called flow value.

The density- voids analysis is done using the volumetric properties of the mix,which will be described in the following sub sections.

2.7.2 Volumetric properties

Fundamentally, mix design is meant to determine the volume of bitumen, binder and aggregates necessary to produce a mixture with the desired properties (Roberts et al., 1996). Since weight measurements are typically much easier, weightsare taken and then converted to volume by using specific gravities. The following is a discussion of the important volumetric properties of bituminous mixtures.

The properties that are to be considered, include the theoretical maximum specific gravity G_{mm}, the bulk specific gravity of the mix G_{mb}, percentage air voids V_A, percentage volume of bitumen V_b, percentage void in mineral aggregate VMA and percentage voids filled with bitumen VFB.



Volumetric properties Fig No.1

2.7.3 Specimen preparation

Approximately 1200gm of aggregates and filler is heated to a temperature of 175-190℃. Bitumen is heated to a temperature of 121-125℃ with the first trial percentage of bitumen (say 3.5 or 4% by weight of the mineral aggregates). The heated aggregates and bitumen are thoroughly mixed at a temperature of 154 - 160℃. The mix is placed in a preheated mould andcompacted by a rammer with 75 blows on either side at temperature of 138℃ to 149℃. The weight of mixed aggregates taken for the preparation of the specimen may be suitably altered to obtain a compacted thickness of 63.5+/-3 mm. Vary the bitumen content in the next trial by +0:5% and repeat the above procedure. Number of trials are predetermined. The prepared mould is loaded in the Marshall Test setup as shown in the figure No.2

Marshall testing machine Fig No.2

2.7.4 Role of volumetric parameters of mix

Bitumen holds the aggregates in position, and the load is taken by the aggregate mass through the contact points. If all the voids are filled with bitumen, the one to one contact of the aggregate particles may lose, and then the load is transmitted by hydrostatic pressure through bitumen, and hence the strength of the mix reduces.That is why stability of the mix starts reducing when bitumen content is increased further beyond a certain value. During summer season, bitumen softens and occupies the void space between the aggregates and if void is unavailable, bleeding is caused. Thus, some amount of void is necessary in a bituminous mix, even after the final stage of compaction. However excess void will make the mix weak from its elastic modulus and fatigue life considerations. Evaluation and selection of aggregate gradation to achieve thespecified minimum VMA is the most difficult and time-consuming step in the mix design process.

2.7.5 Properties of the mix The properties that are of interest include the theoretical specific gravity G_t, the bulk specific gravity of the, mix G_m, percent air voids V_v, percent volume of bitumen V_b, percent void in mixed aggregate VMA and percent voids with bitumen VFB theoretical specific gravity of the mix G_t

Theoretical specific gravity G_t

It is the specific gravity without considering air voids, and is given by:

$$G_t = \frac{W1 + W2 + W3 + Wb}{\left(\frac{W1}{G1}\right) + \left(\frac{W2}{G2}\right) + \left(\frac{W3}{G3}\right) + \left(\frac{Wb}{Gb}\right)}$$

where, W_1 is the weight of coarse aggregate in the total mix, W_2 is the weight of fine aggregate in the total mix, W_3 is the weight of filler in the total mix, W_b is the weight of bitumen in the total mix, G_1 is the apparent specific gravity of coarse aggregate, G_2 is the apparent specific gravity of fine aggregate, G_3 is the apparent specific gravity of filler and G_b is the apparent specific gravity of bitumen.

Bulk specific gravity of mix G_m

The bulk specific gravity or the actual specific gravity of the mix G_m is the specific gravity considering air voids and is found out by.

$$G_m = \frac{Wm}{Wm - Ww}$$

where, W_m is the weight of mix in air, W_w is the weight of mix in water, Note that W_m-$W_w$gives the volume of the mix. Sometimes to get accurate bulk specific gravity, the specimen is coated with thin film of parafinwax, when weight is taken in the water. This, however requires to consider the weight and volume of wax in the calculations.

Air voids percent V_v

Air voids $V_v$is the percent of air voids by volume in the specimen and is given by:

$$V_v = \frac{(Gt - Gm)100}{Gt}$$

Percent volume of bitumen V_b

The volume of bitumen V_b is the percent of volume of bitumen to the total volume and given by:

$$V_b = \frac{(Wb/Gb)}{((W1+W2+W3+Wb)/Gm)}$$

where, W_1 is the weight of coarse aggregate in the total mix, W_2 is the weight of fine aggregate in the total mix, W_3 is the weight of filler in the total mix, W_b is the weight of bitumen in the total mix, $G_b$is the apparent specific gravity of bitumen, and $G_m$is the bulk specific gravity of mix given by equation

Voids in mineral aggregate VMA

Voids in mineral aggregate VMA is the volume of voids in the aggregates, and is the sum of air voids and volume of bitumen, and is calculated from

VMA = Vv + Vb

where, Vv is the percent air voids in the mix, given by equation 26.3. Advise percent bitumen content in the mix, given by equation

Voids filled with bitumen VFB

It is the voids in the mineral aggregate frame work filled with the bitumen, and is calculated as:

$$VFB = \frac{Vb}{VMA} \times 100$$

Where, Vb is percent bitumen content in the mix, given by equation 26.4. and VMA is the percent voids in the mineral aggregate, given by equation.

2.7.6 Determine Marshall Stability and Flow

Marshall Stability of a test specimen is the maximum load required to produce failure when the specimen is preheated to a prescribed temperature placed in a special test head and the load is applied at a constant strain (5 cm per minute). While the stability test is in progress dial gauge is used to measure the vertical deformation of the specimen. The deformation at the failure point expressed in units of 0.25 mm is called the Marshall Flow value of the specimen.

2.7.7 Prepare graphical plots

The average value of the above properties is determined for each mix with different bitumen content and the following graphical plots are prepared:

1. Binder content versus corrected Marshall Stability

2. Binder content versus Marshall Flow

3. Binder content versus percentage of void (V_v) in the total mix

4. Binder content versus voids filled with bitumen (VFB)

5. Binder content versus unit weight or bulk specific gravity (G_m)

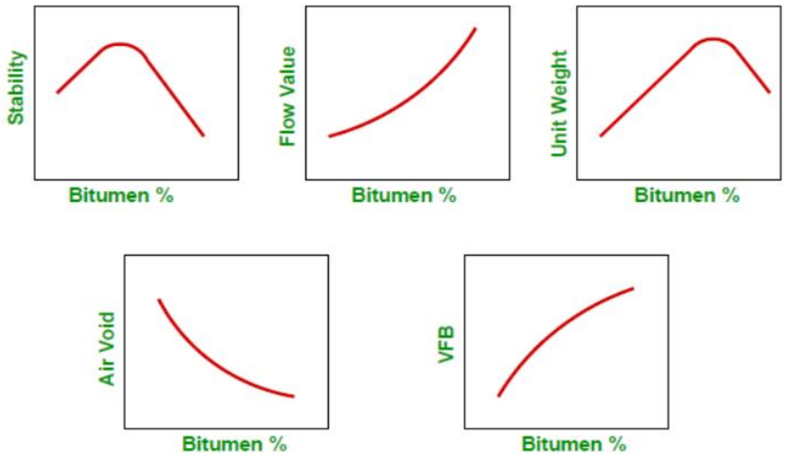


Fig No.3

Graphical representation properties of bituminous mix

2.7.8 Determine optimum bitumen content

Determine the optimum binder content for the mix design by taking average value of the following three bitumencontents found form the graphs obtained in the previous step.

1. Binder content corresponding to maximum stability

2. Binder content corresponding to maximum bulk specific gravity (G_m)

3. Binder content corresponding to the median of designed limits of percent air voids (V_v) in the total mix(i.e. 4%)

The stability value, flow value, and VFB are checked with Marshall mix design specification chart givenin Table below. Mixes with very high stability value and low flow value are not desirable as the pavementsconstructed with such mixes are likely to develop cracks due to heavy moving loads.

The test parameters are required for waste plastic bituminous is given the Table no-5

SL.No	Requirements	Limits as per IRC 98
1	Minimum stability (kN at 60°C)	12
2	Minimum flow (mm)	2
3	Maximum flow (mm)	4
4	Marshall Quotient (kN/mm)	2.5-5
5	Compaction level (Number of blows)	75 blows on each side
6	Per cent air voids	3 - 5
7	Retained Stability (%)	90
8	VMA	15
9	VFB 65-75	65 -75
10	Quantity of Waste Plastic % by weight of bitumen	6 to 8 depending on low rainfall or high rainfall areas

Requirements for waste plastic mixed bituminous pavement layers Table No -5

2.8MILLING PROCESS OF ASPHALT PAVEMENT

Milling is the control removal of an existing pavement to a desired depth, using specially designed equipment having replaceable tungsten carbide cutting teeth mounted on a rotor drum driven by the power supplied by the milling machine. It is the most common way of reclaiming the bituminous pavement material. It is mostly used following a cold process, and hence commonly known as cold milling, though milling is done following hot process also in HIR. This section deals with cold milling only.
Important aspects to be considered in cold milling are the depth of milling, appropriate milling tools to govern the size of milled material, control of dust, collection and transportation of milled material, and stockpiling. Milling processes should be closely examined to make sure that the milled material is not contaminated with soil, base material, paving geotextilesother debris. This is particularly important for deep mills or milling on shoulders or widened roadways. Milled materials that become contaminated should be used only as shoulder material and should be stockpiled separately. A recommended maximum limit of 1% deleterious material should be used to evaluate reclaimed bituminous materials. The milled surface should also be inspected for “scabbing,” where thin, weakly bonded layers are left in place. If this is observed, the milling depth should be adjusted to remove the scab layer because, if allowed to remain in place, the performance of overlay will be poor.

The milled surface should be inspected for uniform texture. A non-uniform texture resulting from worn or broken tips on the milling drum can cause problems with compaction of thin overlays. It may also cause an unsafe surface for motorcycles if the milled surface remains open to traffic. In such cases, it should be ensured that riding surface is safe for motorcycles, by having a reasonable limit on peak to valley distance of the milled surface. The finished milled surface should be within 6-8 mm of a true profile grade both in transverse and longitudinal directions, when measured with a 3-m long straightedge as shown in the fig no.4

Pavement surface after milling Fig.No.4

If the milled surface is to be the final surface of the pavement, it should have either continuous or intermittent striations or any other pre-approved pattern which will provide an acceptable level of skid resistance. If pavement is to be constructed over the milled surface, it shall have a texture which will provide good bonding.

Milling machines transfers maximum energy on to milling drum in removing pavement layers by impacting the pavement with milling teeth mounted on a drum rotating at about 200 rpm. The impacts break up the pavement by ripping through the mastic and aggregate particles. Crushing of aggregate particles causes the gradation of the millings to be finerthan the gradation of the pavement layers in place. The final gradation required of the reclaimed bituminous materials (RBM) by milling can be obtained by controlling depth of milling cut, and speed of machine .Also Gradation bar on milling machine helps to control the cut size. The different size for milling the rotar is mentioned in fig no.5

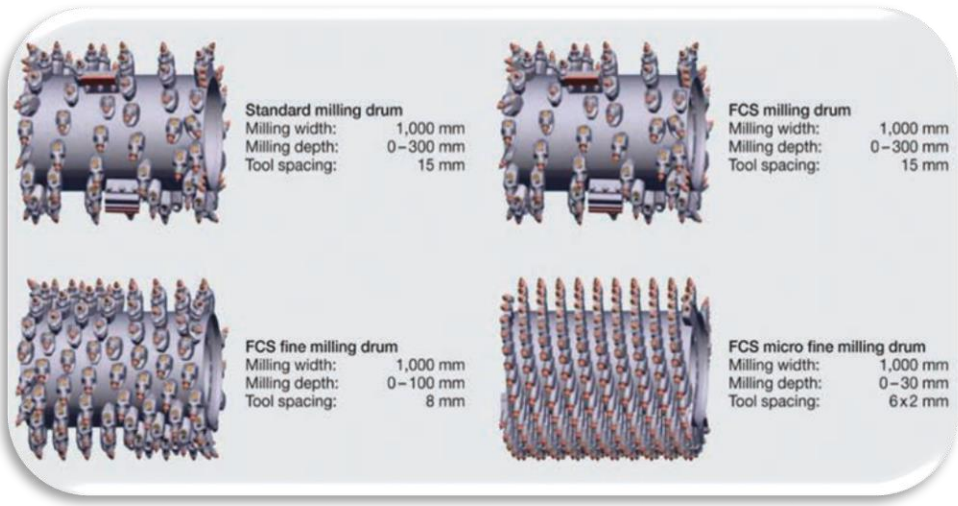
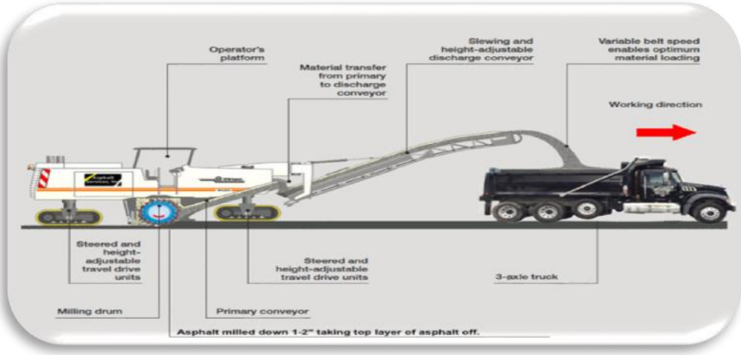


Fig No.5 DIFFERENT TYPES OF MILLING TEETH ON ROTAR

Typical Milling Operation as shown in fig no.6



Milling operation at site Fig no.6

ASPHALT AGGREGATE RECYCLING PROCESS

The recycling process of asphalt aggregate is explained through fig no 7

Asphalt aggregates recycling process Fig No.7

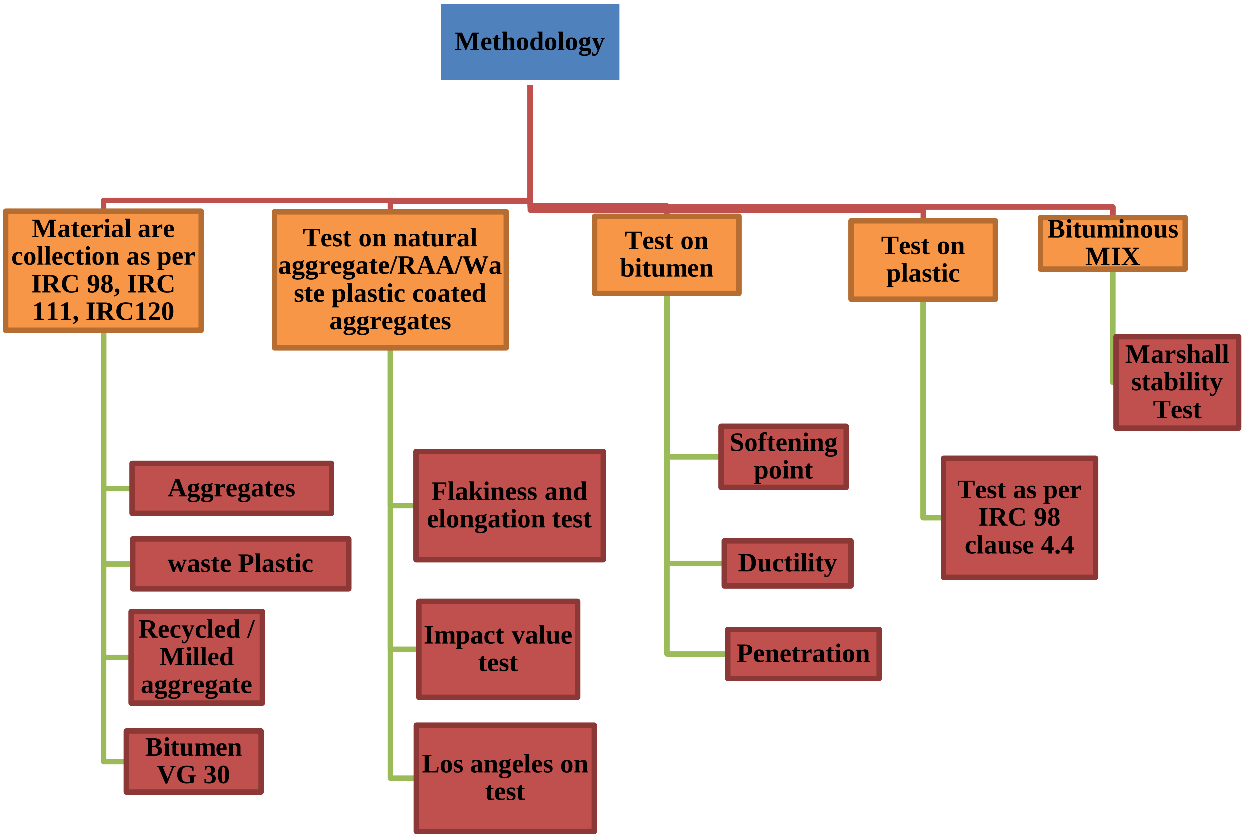
CHAPTER 3

METHODOLOGY

3.1 GENERAL

The laboratory tests in this research consist of four aspects.

1. Study on the properties of aggregate, RAA, plastic coated RAA
2. Test on bitumen.
3. Test on plastic
4. Behavioral study of waste plastic coated 100 % Recycled asphalt Aggregate in the bituminous mix.



Methodology flow chart Fig No.8

3.2 METHODOLOGY IN DETAIL

The preliminary test was conducted for all natural, recycled and waste plastic coated recycled aggregates, mentioned all above aggregates are collected this phase involves several tests according to the requirements IS specifications.

The waste plastic was collected and properly cleaned in order to ensure the quality of waste plastic, a different kind of proportions are taken for coating of aggregates for checking the properties.

In this waste plastic has been used in variations, 0.5%,1%,3%,6%,9% of waste plastic used for coating of recycled aggregate by the weight of aggregate which is of LDPE kind of waste plastics identification, for this test we have used 150gram of waste plastic. In the first step is the collection of plastic Then the process of plastic separation is done. The plastic is properly get washed and then get through cutting process. After this process, the melting process is done at 170 C. by mixing recycled aggregate. The process of mixture should be continuously in rotational motion. After this process the material is cool it down. After this process the aggregates are taken for testing.

The evaluation process for the aggregate mixes, bitumen, plastic included in this study are as follows.

- For Natural aggregate / recycled aggregate / recycled coated with waste plastic aggregate - Aggregate impact value test, los angles test, specific gravity and water absorption test, were carried out and the results were taken in to comparison.
- For Bitumen – Penetration, ductility, and softening point tests are conducted to ensure the properties of the Viscosity grade of bitumen
- For waste plastic – The test as per ASTM D 1238-2010, LDPE: 0.14-58 gm. /10 min,HDPE: 0.02-9.0 gm. /10 min and Gradation as per IRC -98

The properties and behavior of RAA material as a bituminous mix have to be evaluated by Marshall Stability testing. Whenever mixing of waste plastic with bituminous works generally, there are three different methods as follow:

3.2.1 WET PROCESS:

This process involves melting and mixing the waste plastic with hot bitumen a Round 150 0C using a bitumen mixer to get WPMB. The modified bitumen (WPMB) is added to the heated aggregate to get a WPMB Mix.

3.2.2 DRY PROCESS:

The aggregate mix is heated to 150-175°C The percentage of waste plastic is added in a safe way so that the waste plastic is not subjected to very high heat near the flame. This process is adopted for this research.

According to the above process, the aggregate was prepared and the rate of waste plastic coating for effective properties of aggregate was found by comparing an impact value test, and specific gravity test. Based on the results 1% of waste plastic is adopted to find and compare the properties of aggregate.

CHAPTER 4

DATA ANALYSIS

4.1GENERAL

Gradation test carried out for 20mm aggregate and the results are compared with the specifications of IS 383, are mentioned in the Table 6

4.2 SIEVE ANALYSIS FOR 20MM

IS SIEVE DESIGNATION(mm)	CUMULATIVE % OF		SPECIFICATION as per IS 383 - 2016 Respect of 20mm normal size aggregate (% passing)	
	RETAINED	PASSING	GRADED	SINGLE SIZE
40	0.00	100.00	100	100
20	18.60	81.40	90-100	85-100
12.5	89.20	10.80	--	--
10	97.90	2.10	25-55	0-20
4.75	99.60	0.40	0-10	0-5

Sieve analysis for 20mm Table No - 6

4.3 SIEVE ANALYSIS FOR 10MM

Gradation test carried out for 10mm aggregate and the results are compared with the specifications of IS 383 are mentioned in the Table -7

IS SIEVE DESIGNATION(mm)	CUMULATIVE % OF		SPECIFICATION as per IS 383 - 2016 Respect of 10mm normal size aggregate (% passing)	
	RETAINED	PASSING	GRADED	SINGLE SIZE
20	0.00	100	100	100
12.5	6.20	93.8	90-100	85-100
10	78.3	21.7	45-85	0-45
4.75	99.4	0.6	0-10	0-10

Sieve analysis for 20mm Table No-7

4.4 PROPERTIES OF COARSEAGGREGATE

Physical, mechanical and chemical properties of natural aggregates are observed and the results are mentioned in the table no 8.

Test conducted	Results		Requirements as per IS 383, IS 2386
	20mm	10mm	
Impact value (%)	28	26	
Crushing value	27	27	

Specific gravity		2.77	2.75	
Water absorption		0.60	0.68	
10% fine value		--	154.0	Minimum load is 50kn
Bulk density loose		1.48	1.54	
Bulk density Rodded		1.63	1.67	
Soundness (% by mass weight loss after 5 cycle with sodium sulphate solution)		0.98	1.12	Max 10%
Alkali aggregate reactivity	Reduction in alkalinity 1.0 NAOH	50	65	As per IS 2386 (part VII) 1963 Reaffirmed -2016 the sample falls under innocuous aggregate deleterious degree of alkali
	b) Silica dissolved	6.33	6.99	

Properties of Coarse aggregate Table No-8

4.5 PROPERTIES OF FINE AGGREGATE

Sand equivalent property of fine aggregate are observed for M.sand and the results are mentioned in the table no -9

Sl.No	Test parameter for fine aggregate	Result	Specification
1	Sand equivalent value % for	88	Requirement as pre Morth5th Revision clause no 505.2.3

Property of fine aggregate Table No-9

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4.6. BITUMEN GRADE

The bitumen VG 30 (BPCL-kochi) is collected from the project site which is located at Thissur Road, Kerala.

4.7 TEST PARAMETERS OF BITUEMN

There are a number of tests to assess the properties of bituminous materials. The following tests are usually conducted to evaluate different properties of bituminous materials are mentioned in the table no -10

1. Ductility test, 2. Softening point test, 3. Specific gravity test

4. Viscosity test

Characteristics of Bitumen	Specification of as per IS 73 for VG-30	Observed value of VG 30 bitumen
Penetration at 25˚C	50-70	62
Ductility at 25˚C, cm, min	40	95
Softening point, C, min	47	53.30
Specific gravity	--	1.026
Absolute Viscosity ratio at 60˚C, max	2400 -3600 Poise	2654 Poise

Properties of bitumen Table No-10

Milled / recycled aggregate sampling and testing are shown in fig no 9

Recycled / Milled aggregate gradation and testing in progress Fig No.9

4.8Properties of recycled aggregate

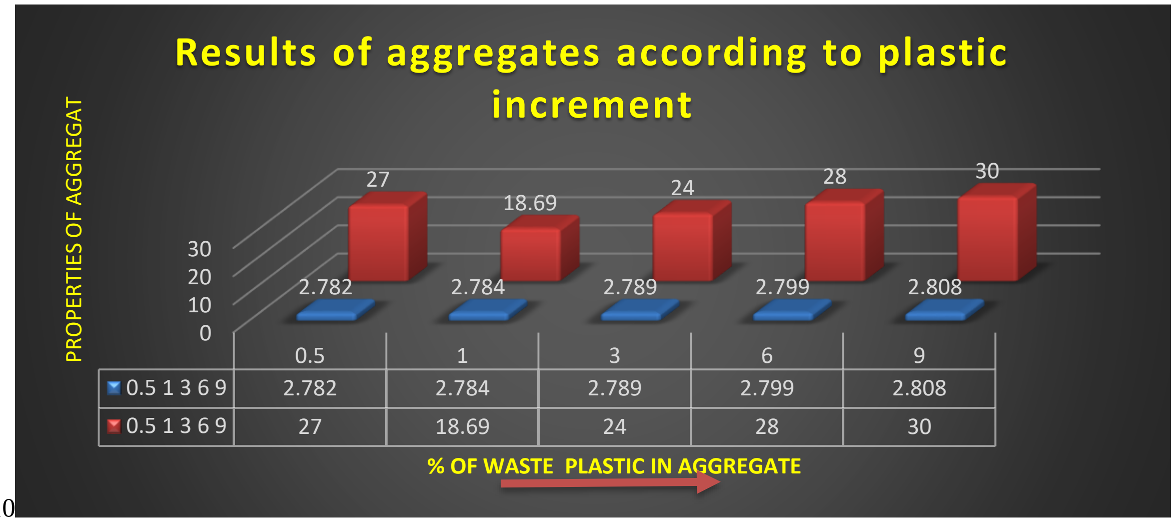
Milled material collected from stock yard of the road project site, and coated by waste plastic with different percentage, Aggregate impact value, specific gravity test was conducted, the results are mentioned in the table no 11

Percentage of waste plastic content	Recycled aggregate coated with waste plastic	
	Aggregate impact value (%)	Specific gravity g/cc
0.5	27.00	2.782
1	18.69	2.784
3	24.00	2.789
6	28.00	2.804

9	30.00	2.808

Details of RAA coated with waste plastic Table No – 11

From the comparison study different percentage of waste plastic was added to recycled asphalt aggregates and found 1% of waste plastic indicated the tested values are well with in specification limits and showing high strength is shown in the fig

10 

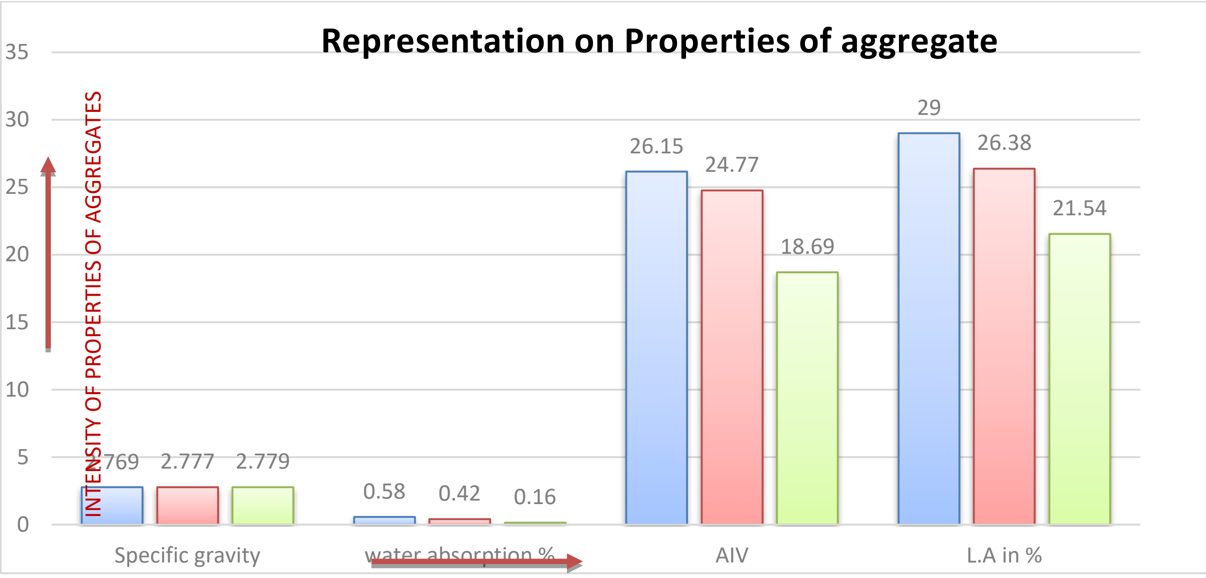
Graphical representation of test results FigNo.10

4.9 COMPARISON STUDY OF PHYSICAL AND MECHANICAL PROPERTIES OF AGGREGATE

Based on the aggregate impact value test 1% of waste plastic coated is adapted for performing and Comparison on properties of plastic-coated aggregate with recycled aggregate and fresh aggregate are shown in table no 12

SL.No	Test Parameters of Aggregates	Specification / Reference	Fresh aggregates	Recycled aggregates	1% Plastic coated Recycled aggregates
1.	Specific gravity	IS 2386-3	2.769	2.777	2.779
2.	water absorption %	IS 2386-3	0.58	0.42	0.160
3.	Impact value in %	IS 2386-4	26.15	24.77	18.69
4.	L.A in %	IS 2386-4	29.00	26.38	21.54

Comparison of properties of aggregates Table No – 12



Comparison test result of RAA/Natural aggregate/PCRAA on test results Fig No.11

4.10 GRADATION RESULT OF WASTIC PLASTIC

Waste plastic gradation was carried out according to IRC 98 and the observed results are satisfy the specification results are as mentioned in the table no 13

SIEVE ANALYSIS OF WASTE PLASTIC			
(As per IRC 98)			
Sample No	1	Date of sampling	13.02.2023
Source	Road Project site Thissur, kerala	Sampled By	Jointly
Location	QC laboratory	Date of testing	13.02.2023
Type of Material	waste plastic	Tested By	Jointly
Proposed use	Bituminous Mix	Wt. of sample (gm)	1000

IS Sieve size (mm)	Weight retained (gm)	Cumulative retained Weight (gm)	% of Cumulative retained Weight	% of passing	As per IRC 98 Specification Limits
(1)	(2)	(3)	(4)	(5)	(6)
2.36	0	0	0.00	100.0	100
0.60	992	992	99.20	0.8	0-1

Gradation of waste plastic Table No – 13

5. Marshall Test Data As per MS 2 with Natural aggregate

Location	Thissur, kerala	Sp. Gr. of Bitumen (Gb)	1.02	No. of Blows	75 each side
Type of Bitumen	VG30	Bulk Sp. Gr. of Aggregate (Gsb) :	2.780	Hammer Weight	4.5 Kg
Type of watste plastic	LDPE	Effective Sp. Gr. of Composite Aggregate (Gse)	2.78	Proving Ring Correction Factor :	6.54
Source of Bitumen	BPCL	Source of Aggregates	Natural aggregate	Purpose	BC grade 2

% Bit. By Weight of Mix	Wt . Of Specimen			Volume (cc)	Bulk Sp. Gr. (Gmb)	Max Sp. Gr. (Gmm)	Air Voids VA (%)	Voids in Mineral Agg. VMA (%)	Voids Filled with Bitumen VFB(%)	Stability				Flow
	in air (gm)	in water (gm)	SSD in air (gm)							Dial Reading	Stability (KG)	Correctoin factor	Stability (KN)	Flow (mm)
A	C	D	E	F = E - D	G = C / F	H	I	J	K	L	M = L × C.F.	N	O = M × N × 9.81	P
5.00	1189.0	688.0	1192.0	504.0	2.359					165	1079	1.09	11.53	2.8
	1190.0	684.0	1193.0	509.0	2.338					162	1059	1.04	10.80	2.9
	1190.0	686.0	1194.0	508.0	2.343					163	1066	1.09	11.39	2.8
					2.347	2.459	4.57	19.81	76.91				11.24	**2.8**
5.20	1190.0	699.0	1193.0	494.0	2.409					170	1112	1.09	11.88	3.0
	1192.0	692.0	1194.0	502.0	2.375					171	1118	1.09	11.95	3.2
	1192.0	693.0	1196.0	503.0	2.370					169	1105	1.09	11.81	3.0
					2.384	2.520	5.38	18.69	71.21				11.88	**3.1**
5.40	1193.0	704.0	1195.0	491.0	2.430					180	1177	1.09	12.58	3.9
	1194.0	703.0	1195.0	492.0	2.427					182	1190	1.09	12.72	3.4
	1198.0	702.0	1199.0	497.0	2.410					180	1177	1.09	12.58	3.6
					2.422	2.543	4.74	17.57	73.00				12.63	**3.6**
5.60	1194.0	705.0	1196.0	491.0	2.432					160	1046	1.09	11.18	3.9
	1190.0	706.0	1194.0	488.0	2.439					159	1040	1.09	11.11	3.9
	1192.0	705.0	1195.0	490.0	2.433					162	1059	1.09	11.32	3.8
					2.434	2.535	3.97	17.34	77.09				11.21	**3.9**
5.80	1192.0	706.0	1195.0	489.0	2.438					155	1014	1.09	10.83	4.1
	1190.0	708.0	1196.0	488.0	2.439					159	1040	1.09	11.11	4.0
	1194.0	707.0	1196.0	489.0	2.442					156	1020	1.09	10.90	4.2
					2.439	2.527	3.47	17.35	79.99				10.95	**4.1**

Marshall Test Data As per MS 2 with Natural aggregate Table No - 14

6. Marshall Test Data As per MS 2 with Reycled Asphat Aggregate coated with 1 % of waste plastic and 0.5% of replacing of bitumen

Location	Thissur, kerala	Sp. Gr. of Bitumen (Gb)	1.02	No. of Blows	75 each side
Type of Bitumen	VG 30	Bulk Sp. Gr. of Aggregate (Gsb) :	2.781	Hammer Weight	4.5 Kg
Type of watste plastic	LDPE	Effective Sp. Gr. of Composite Aggregate (Gse)	2.781	Proving Ring Correction Factor (C.F.) :	6.54
Source of Bitumen	BPCL	Source of Aggregates	Milled aggregate	Purpose	BC grade 2

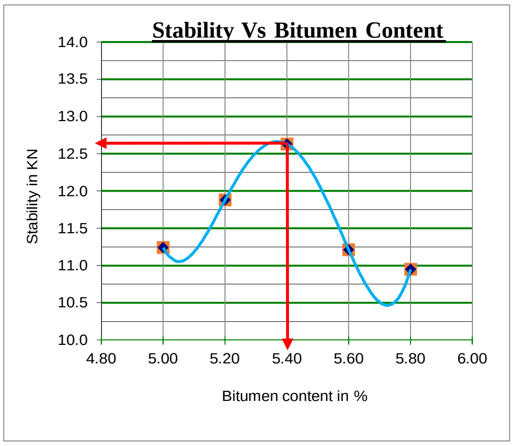
% of Bitumen = Along with 1% wast plastic replacing 0.5% of bitumen By Weight of Mix as binder content	Wt . Of Specimen			Volume (cc)	Bulk Sp. Gr. (Gmb)	Max Sp. Gr. (Gmm)	Air Voids VA (%)	Voids in Mineral Agg. VMA (%)	Voids Filled with Bitumen VFB(%)	Stability				Flow
	in air (gm)	in water (gm)	SSD in air (gm)							Dial Reading	Stability (KG)	Correlation Ratio	Stability (KN)	Flow (mm)
A	C	D	E	F = E - D	G = C / F	H	I	J	K	L	M = L × C.F.	N	O = M × N × 9.81	P
5.00	1192.0	698.0	1193.0	495.0	2.408					189	1236	1.09	13.21	2.7
	1193.0	700.0	1196.0	496.0	2.405					192	1256	1.09	13.42	3.1
	1190.0	699.0	1194.0	495.0	2.404					193	1262	1.09	13.49	2.9
					2.406	2.560	6.02	13.49	55.35				13.37	**2.9**
5.20	1194.0	703.0	1197.0	494.0	2.417					214	1400	1.09	14.96	3.4
	1190.0	702.0	1194.0	492.0	2.419					216	1413	1.09	15.10	3.6
	1192.0	704.0	1196.0	492.0	2.423					215	1406	1.09	15.03	3.8
					2.419	2.542	4.82	17.52	72.50				15.03	**3.6**
5.40	1192.0	704.0	1195.0	491.0	2.428					210	1373	1.09	14.68	3.8
	1191.0	703.0	1193.0	490.0	2.431					212	1386	1.09	14.82	3.9
	1188.0	702.0	1192.0	490.0	2.424					211	1380	1.09	14.75	4.0
					2.428	2.535	4.24	17.42	75.68				14.75	**3.9**
5.60	1194.0	708.0	1196.0	488.0	2.447					203	1328	1.09	14.19	3.9
	1192.0	706.0	1195.0	489.0	2.438					204	1334	1.09	14.26	3.9
	1190.0	706.0	1194.0	488.0	2.439					203	1328	1.09	14.19	3.8
					2.441	2.527	3.40	17.14	80.14				14.21	**3.9**
5.80	1191.0	704.0	1195.0	491.0	2.426					186	1216	1.09	13.00	4.1
	1193.0	703.0	1196.0	493.0	2.420					187	1223	1.09	13.07	4.3
	1194.0	706.0	1196.0	490.0	2.437					188	1230	1.09	13.14	4.6
					2.427	2.520	3.67	17.78	79.33				13.07	**4.3**

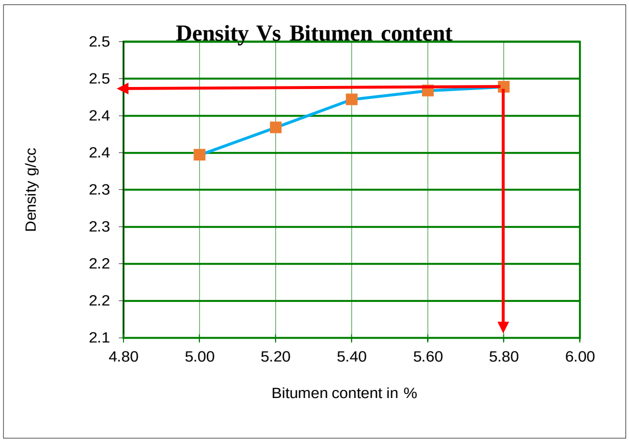
Marshall Test Data As per MS 2 with Reycled Asphat Aggregate coated with 1 % of waste plastic and 0.5% of replacing of bitumen Table No - 15

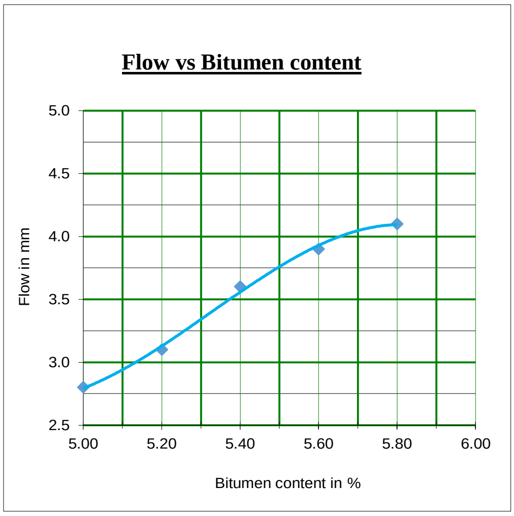
7. TEST PROPERTY OF BITUMINOUS CONCRETE NATURAL AGGREGATE

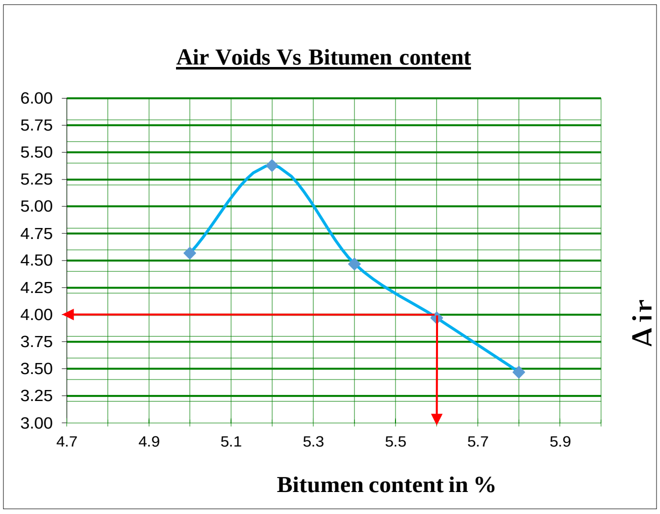
Bitumen content in %	Stability in KN	Density in g/cc	Flow in mm	Air Voids in %	VMA in %	VFB in %
5.00	11.24	2.347	2.8	4.57	19.81	76.91
5.20	11.88	2.384	3.1	5.38	18.69	71.21
5.40	12.63	2.422	3.6	4.47	17.57	73.00
5.60	11.21	2.434	3.9	3.97	17.34	77.09
5.80	10.95	2.439	4.1	3.47	17.34	79.99

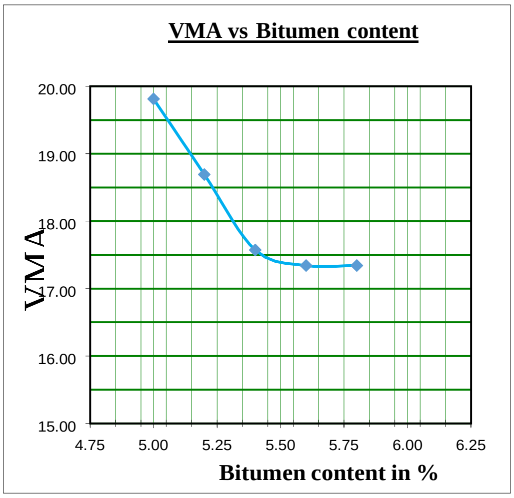
TEST PROPERTY OF BITUMINOUS CONCRETE NATURAL AGGREGATE Table No - 16

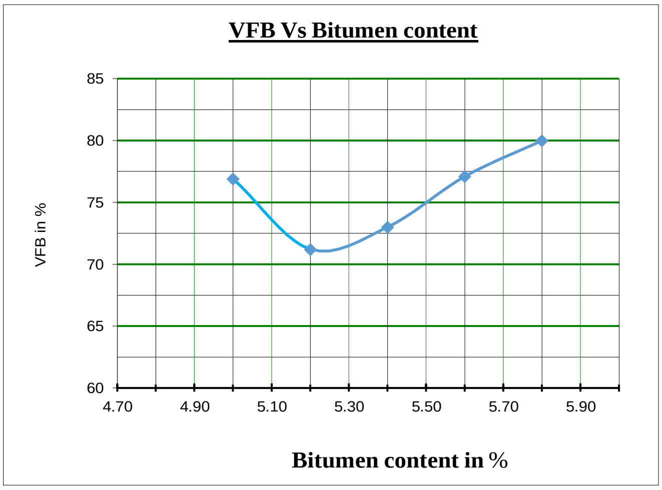








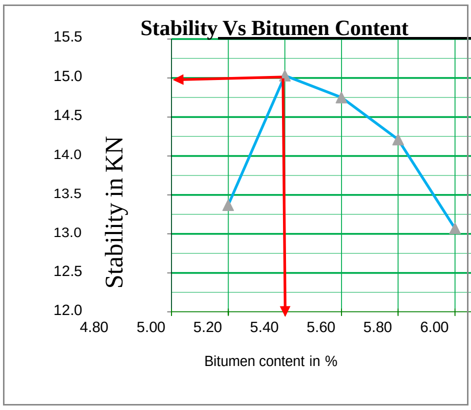


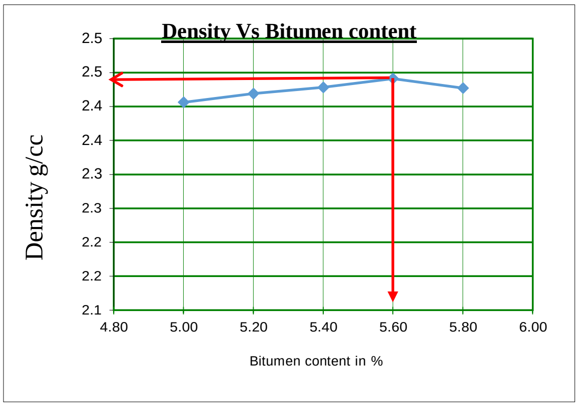


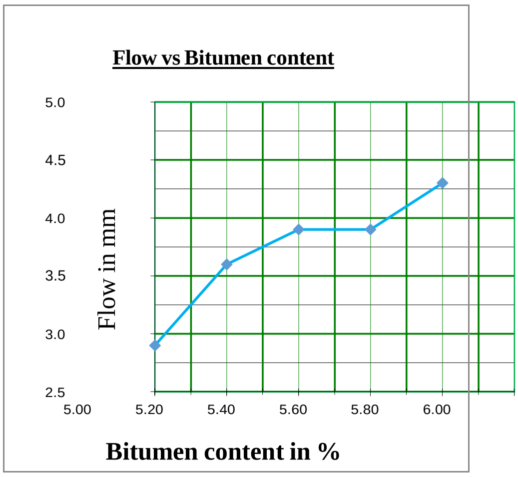
8. TEST PROPERTY OF BITUMINOUS CONCRETE RECYCLED ASPHALT AGGREGATE COATED WITH 1% WASTE PLASTIC AND 0.5% REPLACING OF BITUMEN BY EXISTING RAA BITUMEN CONTENT

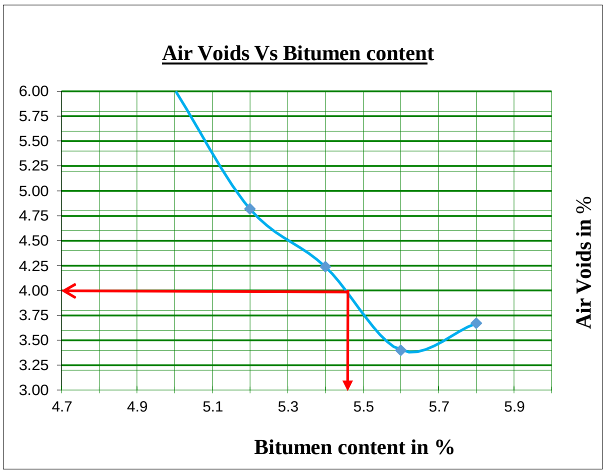
Bitumen content in %	Stability in KN	Density in g/cc	Flow in mm	Air Voids in %	VMA in %	VFB in %
5.00	13.37	2.406	2.9	6.02	13.49	55.35
5.20	15.03	2.419	3.6	4.82	17.52	72.50
5.40	14.75	2.428	3.9	4.24	17.42	75.68
5.60	14.21	2.441	3.9	3.40	17.14	80.14
5.80	13.07	2.427	4.3	3.67	17.78	79.33

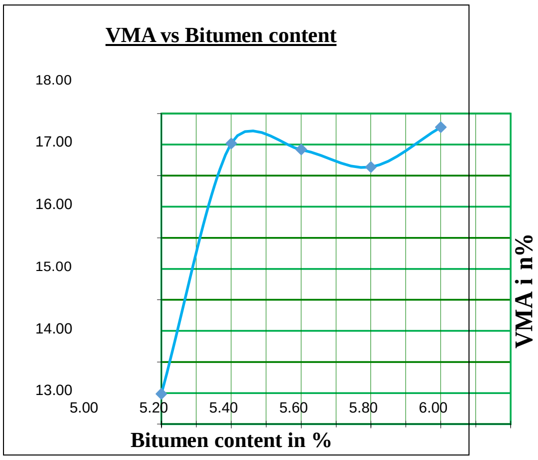
Table No - 17

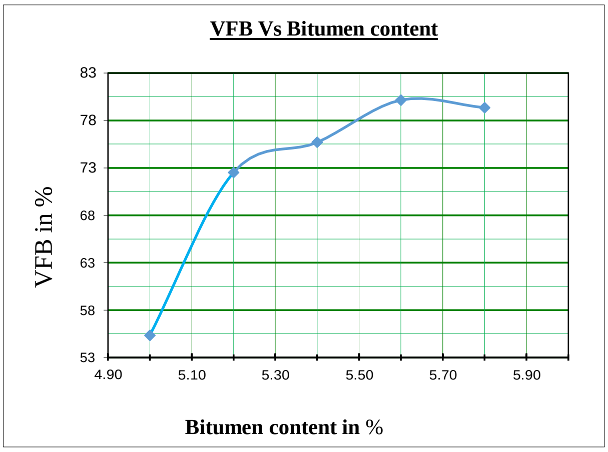












9. OBC FROM GRAPH

From Graph for natural aggregate

Binder at Maximum Density = 5.80% - - - - - - - - - - - - -(A)
Binder at Maximum Stability = 5.40% - - - - - - - - - - - - -(B)
Binder @4.0 % Of air Voids = 5.60% - - - - - - - - - - - - -(C)

$$OBC = \frac{A + B + C}{3} = \frac{5.80\% + 5.40\% + 5.60\%}{3}$$

OBC = 5.60%

From Graph for RAA

Binder at Maximum Density = 5.60% - - - - - - - - - - - - -(A)
Binder at Maximum Stability = 5.20% - - - - - - - - - - - - -(B)
Binder @4.0 % Of air Voids = 5.45% - - - - - - - - - - - - -(C)

$$OBC = \frac{A + B + C}{3} = \frac{5.60\% + 5.20\% + 5.45\%}{3}$$

OBC = 5.42%

OBC AFTER REPLACING BITUMEN FROM RAA

OBCA 4.92%

10. COST COMPARISON

General construction condition for expirement

GCC 1/ Design specification	Optimum percentage of plastic in the blend as per the test results is around 1% (% wt. of aggregate)	6%	
GCC 2	Generally, roads in India are constructed in basic width of 3.0 m, 3.75 m and 4.0 m, 10m (state highway)		
GCC 3	Consider 1 Km length road of width 3.75 m. it uses bitumen approx. 21300 Kg. (For new work) and 11925 Kg. (For Up gradation).		
GCC 4	For 3.75m width and 1km length road, amount of aggregates used in road construction (1 Km length x 3.75 m width): 3750 sq.m. x 12.5 Kg per sq.m. (avg.)	46875	Kg
GCC 5	Bitumen required for work (approx.). per Km	21300	Kg
Sl.No	**Component**	**Rate**	**Unit**
1	Cost of waste plastics	8	Rs / kg
2	Cost of processing	6	Rs / kg
3	Total cost of waste plastics	14	Rs / kg
4	Cost of Bitumen(VG30) per drum (200 Kg)	6800	Rs / 200 kg
5	Cost of Bitumen(VG30) per Kg	34	Rs / kg
6	For 3.75m width and 1km length road, amount of aggregates used in road construction as per GCC 4	46875	kg / km
7	Amount of waste plastic used in road as GCC 1	2812.5	kg / km
8	Total cost of waste plastic used in road using dry process	39375	Rs / km
9	Cost of Road (New)/Km including BBM, Carpet and Seal Coat:	1895000	km
10	Bitumen required for work (approx.). per Km	21300	kg / km
11	Cost of bitumen in new work per Km.	725000	Rs / km
12	Cost of Bitumen saved (2812.5Kg. equivalent to plastic used)	95625	Rs / km
13	Total savings per Km.: 95625 - 14*2812.5 = ₹56,250/-	56250	Rs / km

COST COMPARISON Table No - 18

CHAPTER 11

CONCLUSION

11.1 GENERAL

- This experimental study proved that the strength of Recycled asphalt aggregate strength is increased considerably by adding waste plastic.

- The experimental study on bituminous concrete grade - II utilizing recycled aggregate coated with waste plastic has demonstrated a notable enhancement in both stability and the overall life span of the pavement. The incorporation of waste plastic-coated aggregate proves to be an effective strategy, showcasing its potential to positively impact the performance and durability of pavements. Moreover, the effective cost consideration associated with this innovative approach suggests that not only does it offer structural benefits, but it also presents a cost-effective solution for road construction. This finding underscores the potential for sustainable practices and resource utilization in the construction industry, providing a dual advantage of improved pavement performance and reduced construction costs.

11.2 FINDINGS

- For this experiment waste plastic-coated recycled asphalt aggregate was taken for property development study and compared with natural aggregate and recycled asphalt aggregate.
- The experimental study of waste plastic coating is carried out successfully with the percentage of 0.5%, 1%, 3%, 6%, and 9%. In order to find the property development of RAA.
- From the experiment 1% of waste plastic coated RAA having the impact value of 18.69%, los angeles 21.54 % the obtained value are meet the requirements of bituminous concrete.(Morth specification clause 507, Table 500-16)
- The value obtained from waste plastic coated aggregate other than natural aggregate and RAA is suitable for carried out bituminous works.
- Hence the 1% waste plastic coated aggregate will be taken for the behavioral study of bituminous works requirement according to Morth specification of bituminous works.
- 1% waste plastic-coated recycled aggregate has demonstrated a substantial improvement in the stability of bituminous mix. This innovative approach not only

reduces bituminous consumption but also contributes to cost savings in raw materials. These findings highlight the potential for a sustainable and cost-effective solution in bituminous mix design, with positive implications for both structural performance and economic considerations in road construction.

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