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A REVIEW ON USE OF RECLAIMED ASPHALT PAVEMENT (RAP) AND ADDITIVES ON PERFORMANCE OF ASPHALT CONCRETE

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Abstract— The utilization of Reclaimed Asphalt Pavement (RAP) in the production of new bituminous mixtures is progressive step in this era where waste generation is at its peak level. RAP utilization helps in reduction of construction wastes and thus ensures sustainable use of virgin assets. The main intension of this literature is to find out the significance of consuming RAP and other additives which are generally considered as waste products from previous research papers. The present paper provides an overview of the previous works done regarding how the RAP is used with Used Mobile Engine Oil (UMEO) and Plastic waste to form a bituminous pavements. It can be concluded that utilization of RAP and additives can provide satisfactory results within limits. The present study also shows if calculated appropriately RAP additives mixes can be used to yield sustainable pavement when checked under various parameters like Marshall Stability and density. The present study is also concerned with the tests and techniques that must be followed to get maximum results, as suggested by various researchers.

Keywords— Density, Marshall Stability, Plastic waste, Reclaimed Asphalt Pavement (RAP), Used Mobile Engine Oil (UMEO).

1. Introduction

In today's world, the waste production is greatest obstacle to tackle. The production of waste material boosted up since industrial revolution. The wastes are produced from every field from plastic waste to construction waste. The rate of production of new products cause immense pressure on resources and become hub of pollution to environment. Maximum researches were conducted to increase the use of waste materials so that pressure on virgin resources can be minimized.

1.1 Reclaimed Asphalt Pavement (RAP)

RAP is a method prominent in European countries by which bituminous road surface are built using the material reclaimed from the existing roads. RAP includes old age materials to reuse again to form new pavement. Using old materials to some percentage can minimize the cost of the project and helps to save new aggregates. In India, the technology which come forth in recent years is RAP. The use of this technology is steadily gaining popularity with the increase in progressing tools. RAP is basically the removed part of the pavement when the pavement goes for reconstruction. The intension of using RAP is to maintain the standards mentioned in the codes recommended by the BIS. According to an announcement by Federal Highway Administration (FHWA) in US, 73 of the 91million metric tons of distorted asphalt pavements is used as RAP in making new roads, shoulders and pavement surface.

1.2 Used Mobile Engine Oil

Used Mobile Engine Oil (UMEO) is a rejuvenator which is used to restore or regain oils in old age material which were lost by materials while used once. Here the UMEO is studied with RAP or with pavement. The behavior of UMEO in pavements is studied and the focus is to understand the effect of it on the road pavements. The studies conducted by Zaumanis et al. suggested that the value for UMEO can be used in between 16-25% for Superpave PG tests. The studies presented by Adnan M. et al. performed research with UMEO and the used 10-20% dosage in various percentages in their WMA mix. The properties of diesel engine from various sources has been observed and is noted down.

Table 1.1: Properties of diesel Engine Oil

Properties	Value
Viscosity index, Minimum.	110
Pour point, C, Maximum.	-21
Sulphated ash, %Weight, Max	0.68
Kinematic viscosity, cent Stoke (100 ^{0}C)	13.5-16
Colour	Red
Kinematic viscosity, centistoke (at 40 ^{0}C)	13
TBN, mgKOH/g, Minimum	4.1
Flash point, (COC) C, Minimum	200

Source: IGC, 2009, Guntur, India

1.3 Waste plastic

Waste plastic is leading problem in day today world. In India, this problem is growing at very alarming rate and its ill effects of these waste materials are severe that cannot be ignored. There are various types of plastic polymers like polypropylene (PP), High-density polyethylene (HDPE), low-density polyethylene (LDPE), Polyethylene (PE), polyvinyl chloride (PVC). The plastic waste produced is a non-biodegradable, thus its elimination should be tackled as early as possible. A recent study shows the total plastic production in Europe at 49MT (in 2003).USA, China, India and Eastern Europe being the largest consumers of plastic additives (nearly 80%). It has been found out that India is the third largest consumer market of plastic.

Table 1.2: Types of Plastic

Polymer	Primary Application	Recovery (%)	Recycling Status	Use of Recycled Plastics
Polyethylene terepthalate (PET)	Soft drink and mineral water bottles, textile fibers, processed meat packages, peanut butter jars, pillow, and sleeping bag filling	26	Frequently recycled	Multi-layer detergent bottles, soft drink bottles, and packaging
High-density polyethylene (HDPE)	Milk, water, juice, cream bottles, and shopping bottles	6	Often recycled	Crates, detergent bottles, irrigation pipes, and buckets
Low-density polyethylene (LDPE)	Shopping and garbage bags, cups, and black plastic sheets	0.1	Rarely recycled	Packaging, sheets for nursery, and film for industry
Polyvinyl chloride (PVC)	Automobile seat covers, bottles, shoe soles, electricity pipes, cooking oil bottles, food wrap materials, and building materials		Rarely recycled	Floor materials and covering materials
Polypropylene (PP)	Snack food wrap, straws, car batteries, drinking straws, disposable syringes, medicine bottles, and car seats, batteries, and bumpers	6	Occasionally recycled	Buckets and worm factories
Polystyrene (PS)	Pharmaceutical bottles, disposable cups, packaging materials, laboratory ware, and certain electronic uses	0.1	Rarely recycled	Office accessories, spools, and CD boxes

Source: T. Banerjee (2009)

Signalized Intersection

Signalised intersections are generally installed at intersections of major roads. It usually involves several approach lanes on each leg. People on foot are sensitive road users and regardless of their definite description in traffic events, pedestrian involved harm and death are overrepresented in traffic accidents. The essential point of transport road safety policy is the pedestrians' safety, especially in urban areas. In order to minimize the accidents and raise the road level for both pedestrians and drivers, intersections with high traffic flows should be signalized.

The major verifiable truth in road safety issue is the pedestrian's illegitimate crossing behaviour. The main concern includes the following:

- Usually the pedestrians cross the streets without taking care of the incoming traffic, because their concentration is disturbed.
- Main mistake that pedestrians make is that of traffic gaps.
- Sometimes due to the inadequacy of space on sidewalks, pedestrians walk across the street.
- Moreover, the crosser-bye's sometimes do not follow the traffic light indications.

There are various factors that affect the pedestrians walking and crossing behaviour at signalized intersection. It includes; the physical environment (e.g., road width, type of street), road user variables (e.g., demographic characteristics) and social factors (e.g. the number of pedestrians in the group who are trying to cross).

Several studies have inspected differences in pedestrian behaviour by gender and age. It has been observed that male pedestrians tend to violate traffic rules more frequently than females and are more likely to cross in risky situations. Similarly, youths and adolescent pedestrians commit violations more than older road users, who express greater cautiousness and appreciation for the traffic signals at controlled pedestrian crossings. Another perspective that influences the crossing behaviour of pedestrians is their motives for compliance with road safety laws. In addition, fewer studies have focused on the factors affecting the compliance rate.

2. OBJECTIVES OF THE STUDY

The aim of the study is to Use of Reclaimed Asphalt Pavement (RAP) and additives on performance of Asphalt Concrete Mix. The main objectives of this study are as follows:-

a. To recognize the properties of additives on the concrete mix.
b. To summarize the tests and the limits which are required for an idealized layer.
c. To identify the optimum content of RAP which can be used with virgin aggregates to form an asphalt concrete mix.

3. LITERATURE REVIEW

Studies on RAP

Mohologo S. et al. (2014) [1] examined the usage of 100% of Reclaimed Asphalt Pavement for road construction. The sample was collected from South African province whose age is 20years. Virgin Bitumen of grade 50/60 was added which plays a part of rejuvenator at 0 %, 0.3% and 0.6% to RAP. Tests conducted on the mix were Marshall Test, Indirect Tensile Strength (ITS), fatigue resistance and workability. The results showed that void ratio increased while ITS meet the minimum required specification. Moreover, fatigue resistance of mixture increased with increase in bitumen content.

Mohamady A. et al. (2014) [2] examine the use of RAP (Reclaimed Asphalt Pavement) in highway and the optimum reclaimed percent. In this study various samples of different proportion of RAP and asphalt mixture were prepared and various fundamental tests are conducted over them. In Marshal Test optimum sample is generated and it is then tested against Indirect Tensile Strength and loss of stability tests. In this study it is found that 30% of RAP withstand majority of tests thus should be considered as optimum. Finally the study recommends that there should be more tests to be carried out in order to find out optimum reclaimed percentage in different conditions.

K. J. Thakur et al. (2014) [3] studied the Workable Stabilization of Recycled Asphalt Pavement (RAP) Bases. In this study, it is seen that Geocell, a three dimensional geosynthetic product can be used to stabilize RAP bases. The basic test like Plate Load test is carried over Unstabilized and Geocell stabilized RAP bases to estimate their properties like their stiffness, creep and permanent deformation. Fallouts displayed that Geocell significantly compact the creep and permanent deformations of the RAP bases but there is an increase in the resilient deformation and stiffness in the RAP bases. From this study it is seen that use of 100% of RAP with Geocell stabilizer can be used in base course in an effective way.

Huang S. and Turner T. (2014) [4] determines the Aging Characteristics of RAP Blend Binders. The samples of RAP is taken from Manitoba and South Carolina which were used in this study. In this study two rolled thin films with 15 and 50% reclaimed asphalt pavement (RAP) binder were dried in an oven to develop aging effect on the mixture. The samples are dried up to 2 days to 4, 8, and 12 weeks to study the aging characteristics. Results shows that the pattern of stiffness is linear with time means it increases with aging.

Sunil S. et al. (2014) [5] studied the performance of bituminous mixes with reclaimed asphalt pavement (RAP) materials through experimental means. This is actually a case study Tumkur to Chitradurga-NH4 in India. In this study, the ratio adopted is 10:90, 20:80, 30:70, and 40:60 for RAP to new aggregates. Tests like Marshall Mix design, static indirect tensile test, repeated load indirect tensile fatigue tests were conducted in the laboratory and the results were examined. Results shows that the Marshall Stability value goes on the decreasing with increasing RAP bitumen. The Virgin bitumen may fail to rejuvenate the RAP binder as its percentage increases. In ITS test, it was seen that the tensile strength ratio of new mix is lower than virgin bitumen but the minimum requirement is achieved, it also happen in Fatigue Cycle analysis as minimum criteria is achieved thus we can say it can resist deformation.

Ebrahim A. and Ibrahim E. (2015) [6] examine the use of reclaimed asphalt pavement in the flexible road surface and assessing the properties of fractional and total substitutes of aggregates by RAP on the mechanical and durability presentation of dense-graded HMA mixtures. Various laboratory tests including Marshall Test, indirect tensile strength test, granule adhesion test and important material tests were carried out on sequence of binder mixes comprising various percentages of RAP. In this study, Reclaimed Asphalt Pavement (RAP) was booked from Cairo to Alexandria agricultural road. Results in this study shows that there is significant improvement in the mechanical properties and the tensile strength is improved when RAP is used by great extent. The highest value is achieved when RAP content is 50% in mixture. The RAP content increases the adhesive bond strength of particle thus weight loss will be reduced and provides good performance over its service life.

Singh J. et al. (2015) [7] analysed the previous researches and try to evaluate the results and gaps under one heading. In this study we will try to get the ideal percentage of RAP that can be used in bituminous blend. But from various researches it has been seen that percentage of RAP used lies between 10%-70%. The results of certain tests which were carried out in previous researches are Marshall Stability, Impact Test, Compression test, Indirect Tensile Strength test etc. The results are studied with reclaimed materials with virgin materials that are mixed and an ideal percentage of RAP is defined. The formation of RAP mixture is performed in same conventional method as construction of bitumen mixture is carried out.

Studies on RAP with Additives

Xiao F. et al. (2009) [8] studied Influences of crumb rubber size and type on reclaimed asphalt pavement (RAP) mixtures and its effects on various mixtures. In this study, they use three of rubber sizes and two rubber types with 25% RAP mixture. The experimental study helps in suggesting the by addition of crumbed rubber there occurs increase in

voids and improving rutting resistance in super pave design mix irrespective of rubber type and size. On the other hand there is no effect on Indirect Tensile strength test but extended the fatigue life of the modified mixture.

Abubakar J. et al (2014) [9] studied the effects of using filler like Rice Husk Ash in place of Ordinary Portland Cement with Reclaimed Asphalt Pavement. Materials used in this study are RAP from a stretch, fresh aggregates from Construction Company, 60/70 grade cutback bitumen, OPC and RHA. Marshal test is conducted to evaluate the mix and the results are noted down. Results describes that the addition of RHA as OPC mineral filler alternate with RAP resulted in decrease in Marshal Stability from 10.0 KN to 8.5 KN when RHA completely replaces OPC as mineral filler. On the other hand if the RHA content is increased the compacted density decreases but the voids will be greater than lower limit of 3% as specified by Asphalt Institute and also Indirect Tensile Strength Test meant for resistance to cracking it seen that if 25% RHA is used the tensile strength of 1150 N/mm2.

Bajpal R. et al. (2017) [10] studies about the construction of Flexible pavement using Plastic material along with bitumen. In this study, Plastic material used as a binder in the mixture. The coating of aggregate should be done with plastic material is the main objective of this study. Various laboratory and field test are carried out and data is calculated. Test like Abrasion test, stripping test etc. helps to develop fruitful results. Results show that coating of plastics improves Aggregate Impact Value, thus improving the quality of the aggregate, the percentage of wear and tear goes on decreasing with increase in plastic content in mixture.

Adnan M. and Shafi M. (2017) [11] studied the use of reclaimed asphalt pavement (RAP) in warm mix asphalt (WMA) pavements and examined the advantages of warm mix asphalt (WMA) pavements over Hot Mix Asphalt (HMA) pavements. In this study, it is described that the workability and stiffness issues will be addressed if WMA pavements is preferred over HMA pavements. It has been seen that the addition of chemical additive improves the fracture resistance of WMA mixture as compared to HMA. The use of additives like Sasobit increases workability of RAP by lowering viscosity. It has been seen that moisture susceptibility is an issue for WMA mixtures including RAP as enhances low mixing and compaction temperatures compared to HMA.

Adnan M. et al. (2018) [12] analysed the Warm Asphalt Mix with RAP on two different conditions one with rejuvenator and without rejuvenator. It has been found that without rejuvenator only 20% RAP could be used but with rejuvenator RAP can be used to higher limits up to 50 percent. The RAP and WMA mixes is tested under Marshal Stability, flow value, air voids, retained stability etc. The rejuvenator used here in this study is Used Mobile Engine Oil (UMEO).

4. CONCLUSIONS

In present study, numerous past works were fully studied and following conclusions were drawn on the basis if same:

1. The utilization of rejuvenators in reclaimed asphalt pavement materials enhances the resistance against cracking and it reduces the stiffness of aged binder.
2. With the inclusion of rejuvenators the moisture susceptibility and rutting résistance of mixtures gets improved.
3. Up to 70% RAP has shown good results when used for construction of new pavement. It has been seen that 30-50% RAP is generally used for most of the projects.
4. 100% utilization of RAP to prepare a bituminous mix is not enviable.
5. When treated with Plastic the quality of aggregates gets improved, thus percentage of wear and tear goes on decreasing with increase in Plastic content.
6. Using RAP lower the cost of project thus project becomes more economical.

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