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Re-use of Recycled Materials in Construction of Flexible Pavements by using Polymers

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Abstract

Bitumen, the sticky, gooey black stuff you sometimes see oozing out of hot road surfaces, is a valuable binding agent used in roads. What we do is collect old materials containing bitumen, most of this material comes from roads. Then, we shred it, heat it, drain off the molten bitumen, and sieve away all contaminants like glass fibers, wood and stones. We then mix the recycled bitumen with just a little bit of virgin bitumen and use the mixture to produce new roads of the same quality

It was quite difficult to control the exact temperature of the melting process. Too high and the bitumen is separated into other chemicals. To low and it does not seep out of the solid materials. We also had a hard time sieving it since it is really viscous and sticky. But we resolved all that issue and the recycling plant has been in operation since 2008.

It is mostly a matter of money. And that leads to three possible solutions. First, our recycling process could be subsidized. This is attractive from our point of view. Second, recycling bituminous materials could be made compulsory. This would probably work, but then you need a controlling system and inspectors. That is expensive. So, probably, the taxpayers would have to come up with the funding. Third solution, landfilling and burning bitumen in waste-to-energy plants could be taxed. Governments would undoubtedly like that, so policy makers will probably prefer this solution. But sadly it will make the relatively green energy from these plants more expensive.In recent years, applications of plastic wastes have been considered in road construction with great interest in many developing countries. The use of these materials in road making is based on technical, economic, and ecological criteria.

CHAPTER 1

INTRODUCTION

HISTORY OF ROADS

Street paving has been found from the first human settlements around 4000 BC in cities of the Indus valley civilization on the Indian subcontinent, such as Harappa and Mohenjo-Daro. The road builders of late 1800s depended on stone, gravel and sand for construction. Water is used as a binder to give some fineness to road surfaces. Roads in the towns were straight and long, intersecting one another at right angles. In urban areas it began to be worthwhile to build stone-paved streets and, in fact, the first paved streets valley civilization.

Recycling hot mix asphalt (HMA) material results in a reusable mixture of aggregate and asphalt binder known as reclaimed asphalt pavement (RAP). Recycling of asphalt pavements is a valuable approach for technical, economical, and environmental reasons (Kennedy et al. 1998). Using RAP has been favored over virgin materials in the light of the increasing cost of asphalt, the scarcity of quality aggregates, and the pressuring need to preserve the environment. Many state agencies have also reported significant savings when RAP is used (Page and Murphy 1987). Considering material and construction costs, it was estimated that using reclaimed HMA pavement provides a saving ranging from 14 to 34% for a RAP content varying between 20 to 50% (Kandhal and Mallick 1997). This analysis considered the cost of HMA at $11.90 per ton, which can only be considered as an indicator of the true savings when RAP is used at the present time.

The use of RAP also decreases the amount of waste produced and helps to resolve the disposal problems of highway construction materials, especially in large cities such as Chicago. In 1996, it was estimated that about 33% of all asphalt pavement in the United States was recycled into HMA (Sullivan 1996). In 2001, the Illinois Department of Transportation (IDOT) used 623,000 tons of RAP in highway construction and anticipates increasing its use in the near future (Griffiths and Krstulovich 2002). After more than 30 years since its first trial in Nevada and Texas, it appears that the use of RAP will not only be a beneficial alternative in the future but will also become a necessity to ensure economic competitiveness of flexible pavement construction.

To facilitate incorporating RAP in the design of HMA, many states have relied on blending charts developed by the Asphalt Institute in the late 1980s (Asphalt Institute 1989). Most states have also established limits on the maximum percentage of RAP that can be used, ranging typically between 10 to 50%. However, high percentages of RAP are not commonly used in practice. With the introduction of the SuperPaveTM HMA design procedure, many questions were raised about the proper method of incorporating RAP in the SuperPaveTM HMA. Despite the fact that the original SuperPaveTM HMA design procedure did not incorporate the use of RAP, many states have continued its use. In 1997, the Federal Highway Administration's RAP expert task force developed guidelines for the design of SuperPaveTM HMA containing RAP (Bukowski 1997). The developed methodology was based on a tiered approach to determine the level of testing required in the design of HMA containing RAP. These guidelines have been supported by the findings of the NCHRP research report 9-12 (McDaniel et al. 2000).

Despite recent advancements in the design of HMA containing RAP, many states including Illinois insert restrictions in their regulations to avoid durability problems related to the recycled materials. In 2000, the Illinois Department of Transportation allowed the use of RAP in SuperPaveTM HMA with a percentage varying between 0 to 30%; a maximum RAP percentage of 50% is allowed in HMA shoulders and stabilized sub-bases. Based on expert opinions, future specifications are expected to allow the use of RAP in highest-class HMA. On the other hand, many state agencies are taking a more aggressive approach by considering increasing the allowable percentages of RAP in HMA to take full advantage of this promising technology. For instance, up to 80% RAP has been used in some HMA with an acceptable level of performance (FHWA 1993). However, ensuring confidence in the design procedure and the success of using RAP would require addressing many durability concerns related to the interaction between virgin and recycled materials

One major factor that is still unclear is the level of interaction between aged and virgin asphalt binders. If RAP acts like a black rock, the aged and virgin binders will not interact. Hence, it would be assumed that RAP does not significantly change the virgin binder properties. In that case, the use of blending charts may be invalid. However, it is usually assumed that RAP does not act as a black rock and that the aged asphalt blends with the virgin binder during mixing. In fact, many design procedures including the IDOT design method assumes that all the aged binder is fully available in the mixture and would effectively contribute to the blend. This means that the amount of virgin asphalt binder can be reduced by the full amount of asphalt binder in the RAP for the percentage specified.

1.2.PAVEMENT

Pavement is the durable surface material laid down on an area intended to sustain vehicular or foot traffic, such as a road or walkway. In the past, gravel road surfaces, cobblestone and granite sets were extensively used, but these surfaces have mostly been replaced by asphalt or concrete.

There are two types of pavements.

1. Flexible pavement
2. Rigid Pavement
3. Composite Pavement

1.2.1Flexible Pavements

Flexible Pavement is so named as the pavement surface reflects the total deflection of all subsequent layers due to the traffic wheel load acting upon it. The flexible pavement design is based on the load distributing characteristics of a layered system. It transmits load to the sub grade through a combination of layers. Flexible pavement distributes load over a relatively smaller area of the sub grade beneath.

In order to have maximum advantage of flexible pavement, its material layers are arranged in order of descending load bearing capacity with the highest load bearing capacity material (and most expensive) on the top and the lowest load bearing capacity material (and least expensive) on the bottom. The typical flexible pavement structure consists of different layers.

Bituminous surface coarse (or) wearing course

This is the top layer that comes in contact with the wheels of vehicle. It is composed of one or more different Hot Mix Asphalt (HMA) sub layers.

Base course

This is the layer directly below the HMA later and generally consists of aggregate(either stabilized or un stabilized).

Sub base course

This is the layer (or layers) under the base layer. A sub base is not always need after describing these basis elements, this sections then discusses subsurface drainage and perpetual pavements.

Chapter 2

2.1. Recycled asphalt pavement

Recycled Asphalt Pavement (RAP) is encouraged to be used in the construction of new roadways and pavements. Its use reduces cost and environmental impacts of road construction by reusing existing asphalt pavement. In Minnesota existing asphalt pavement material is often crushed and blended with other aggregates to create aggregate base or shouldering materials or transported to an Asphalt plant, crushed, and incorporated into new asphalt material. Both strategies reduce demand for virgin aggregates. Incorporation into new asphalt material has the additional benefit of reducing demand for asphalt binder material. It is recognized that a greater benefit to the environment and economaddy can be realized when incorporated into new asphalt material. This document was developed as a reference for local agencies that have minimal knowledge of incorporating RAP material into new asphalt and would like to understand more.

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and asphalt binder known as reclaimed asphalt pavement (RAP). Recycling of asphalt pavements is a valuable approach for technical, economical, and environmental reasons (Kennedy et al. 1998). Using RAP has been favored over virgin materials in the light of the increasing cost of asphalt, the scarcity of quality aggregates, and the pressuring need to preserve the environment. Many state agencies have also reported significant savings when RAP is used (Page and Murphy 1987)

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However, high percentages of RAP are not commonly used in practice. With the introduction of the SuperPaveTM HMA design procedure, many questions were raised about the proper method of incorporating RAP in the SuperPaveTM HMA. Despite the fact that the original SuperPaveTM HMA design procedure did not incorporate the use of RAP, many states have continued its use. In 1997, the Federal Highway Administration's RAP expert task force developed guidelines for the design of SuperPaveTM HMA containing RAP (Bukowski 1997). The developed methodology was based on a tiered approach to determine the level of testing require\
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2.1.2.Asphalt recycling

- 97% of roads are surfaced with asphalt
- Most recycled resource in the world
  - By tonnage and percentage
  - 50 million tons of RAP is generated in every year
- Down cycling vs recycling
- 98% of states allow atleast 15% of RAP in new hot mix asphalt(HMA)
- 2.2. Polymers

The indigenous plastic invented by Alexander parks in (1862). In early years, the amount of plastic consumption is rapidly increased in such as bottles and polyethylene bags ,tea cups as many form of plastic use in various purpose. In the industrial revolution ,and its larger scale production plastic seemed to be a cheaper and effective raw material so, use in packing,automobile,electrical communication sector has been virtually revolutionized by the application of plastic.the use of plastic after consumption it severe problem to the environment and health hazard caused by improper disposal of plastic waste. its non-bio degradable product many researchers found that its take 4500 years to degradation

- The plastic road successful laid in Jambulingam street, Chennai in the year of 2002 ,by 60/70type of bitumen and polyethylene and poly propylene used in 12%. Its result seems no pot hole and no cracking & no rutting, no reveling and reduces the affect global warming and eco friendly tothe environment.

CHAPTER 3

Test on reclaimed aggregate

Aggregate impact value test [IS: 2386(part4)1963]

Aim: To determine the aggregate impact value of given reclaimed aggeregate

Apparatus required: Impact testing machine, cylinder, tamping rod, IS Sieve 12.5mm, 10mm and 2.36mm, balance.

Procedure:

The test sample consists of reclaimed aggregates passing 12.5mm sieve and retained on 10mm sieve and dried in an oven for 4 hours at a temperature of 100oC to 110oCThe reclaimed aggregates are filled up to about 1/3 full in the cylindrical measure and tamped 25 times with rounded end of the tamping rod. The rest of the cylindrical measure is filled by two layers and each layer being tamped 25 times. The overflow of aggregates in cylindrically measure is cut off by tamping rod using it has a straight edge. Then the entire aggregate sample in a measuring cylinder is weighed nearing to 0.01gm. The aggregates from the cylindrical measure are carefully transferred into the cup which is firmly fixed in position on the base plate of machine. Then it is tamped 25 times.

The hammer is raised until its lower face is 38cm above the upper surface of aggregate in the cup and allowed to fall freely on the aggregates. The test sample is subjected to a total of 15 such blows each being delivered at an interval of not less than one second. The crushed aggregate is than removed from the cup and the whole of it is sieved on 2.36 mm sieve until no significant amount passes. The fraction passing the sieve is weighed accurate to 0.1gm. Repeat the above steps with other fresh sample. Let the original weight of the oven dry sample be W1gm and the weight of fraction passing 2.36mm IS sieve be W2gm. Then aggregate impact value is

Result: The mean A.I.V is <u>10.79%</u>

CHAPTER 5

Marshall Stability test:

In marshal stability test, the deformation of specimen of bituminous mixture is measured when the same load is applied. This test procedure is used in designing and evaluating bituminous paving mixes. The marshal stability of mix is defined as a maximum load carried by a compacted specimen.

This test procedure is used in designing and evaluating bituminous paving mixes and is extensively used in routine test programmes for the paving jobs. There are 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 following the specification ASTM D 1559 (2004), which is defined as the maximum load carried by a compacted specimen at a standard test temperature of 60°C.

In this test compressive loading was applied on the specimen at the rate of 50.8 mm/min till it was 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 by the change in diameter of the sample in the direction of load application between the start 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 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.

BITUMINOUS CONCRETE TEST RESULT

- Demoulding of specimens by Marshal Stability equipment.
- Testing can done before by taking weights of the specimen is explained detailed below

Weights of specimen:

NO	% of plastic added to specimens	Dry Wt.	Wet Wt.	SSD (Saturated surface dry)	Volume (SSD-Wet)	Density (Vol/Dry)
1	0%	1258	748	1262	514	2.447
2	0%	1254	746	1258	512	2.450
3	0%	1257	748	1261	513	2.450
4	10%	1257	737	1261	524	2.40
5	10%	1255	741	1258	517	2.427
6	10%	1261	738	1264	526	2.397
7	15%	1258	736	1262	526	2.39
8	15%	1257	735	1260	525	2.38
9	15%	1259	734	1262	526	2.38
10	20%	1259	736	1264	528	2.384
11	20%	1259	731	1263	532	2.366
12	20%	1255	730	1258	528	2.376

MARSHAL STABILITY TEST REPORT FOR BC:

S.NO	% Of Plastic	STABILITY (KN)	TEST (Kgs)	FLOW
1	0%	110	1122	4

2	0%	120	1224	4
3	0%	105	1071	3.5
4	10%	125	1275	3
5	10%	127	1295.4	5
6	10%	100	1020	3.5
7	15%	133	1356.6	3.5
8	15%	126	1285.2	3.2
9	15%	105	1071	2.8
10	20%	140	1428	4
11	20%	120	1224	2
12	20%	105	1071	5

RESULT:

NORMAL: Average Marshal Stability result is **1139 kgs** and Flow value is **3.83**

PLASTIC 10%: Average Marshal Stability result is **1196.8 kgs** and Flow value is **3.83**

PLASTIC 15%: Average Marshal Stability result is **1237.6 kgs** and Flow value is **3.17**

PLASTIC 20%: Average Marshal Stability result is **1241 kgs** and Flow value is **3.67**

CONCLUSION:

- Its shows that with the increases of waste plastic in bitumen increases the properties of aggregate and bitumen.
- Use of waste plastic in flexible pavement shows good result when compared with conventional flexible pavements.
- The optimum use of plastic can be done up to 20%
- This has added more value in minimizing the disposal of plastic waste as an eco-friendly
- Using of waste plastic in flexible pavement increase the durability, strength, and reduced the pot holes
- Plastic has lower cost
- this plastic roads are eco-friendly.

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